No. 17-70196

**UNITED STATES COURT OF APPEALS
FOR THE NINTH CIRCUIT**

NATIONAL FAMILY FARM COALITION, *et al*.,

Petitioners,

v.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, *et al*.,

Respondents,

and

MONSANTO COMPANY,

Intervenor-Respondent.

ON PETITION FOR REVIEW FROM THE UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

PETITIONERS' EXCERPTS OF RECORD VOLUME I

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[2] Respondent United States Environmental Protection Agency (EPA) did not produce, but only provided hyperlinks to, publicly available documents. *See* ECF No. 63-3. For the Court's convenience, Petitioners have produced those hyperlinked documents in their entirety in the Excerpts of Record.

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[3] This e-mail contains a hyperlink to an online article. *See* David Bennett, *Might Dicamba be Affecting Pollinators*?, Delta Farm Press, Sept. 26, 2017. For the Court's convenience, Petitioners have produced this and other similarly hyperlinked articles in the Excerpts of Record.

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[4] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* Tom Polansek, *U.S. Regulator Aiming to Allow Controversial Herbicide Use with Safeguards*, Reuters, Sept. 20, 2017.

[5] This e-mail contains a hyperlink to an online article that Petitioners have reproduced in its entirety. *See* Donnelle Eller, *Iowa Farmer Makes Record Number of Pesticide Misuse Claims*, The Des Moines Register, Sept. 12, 2017.

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[7] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See EPA Responds to Dicamba Complaints*, Ag. Professional, Aug. 29, 2017.

[8] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* Kevin Bradley, *Off-target Movement of Dicamba in Missouri: Where Do We Go from Here?*, Integrated Pest Mgmt., Univ. Mo., Aug. 21, 2017.

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[9] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* David Koon, *Farmer vs. Farmer*, Ark. Times, Aug. 10, 2017.

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Final Registration of Dicamba on Dicamba-Tolerant Cotton and Soybean

Approved by: ______________________

Jack E.Housenger, Director
Office of Pesticide Programs

Date: 11/9/16

Summary

This document announces that the U.S. Environmental Protection Agency (the EPA or the agency) has granted a conditional registration under Section 3(c)(7)(B) of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) for the new uses of the herbicide dicamba for use on genetically-engineered (GE) cotton and GE soybean that have been engineered to be resistant to dicamba in the following states: Alabama, Arizona, Arkansas, Colorado, Delaware, Florida, Georgia, Illinois, Iowa, Indiana, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, West Virginia, and Wisconsin.

These new dicamba uses were originally proposed by the Monsanto Company to be added to the currently registered herbicide product M1691 (the EPA Registration Number 524-582). This is the specific formulation that was listed in the agency's Proposed Decision released for public comment earlier this year. Since the proposed decision was published, the agency also assessed a lower volatility dicamba formulation (M1768, with the brand name Xtendimax™ with VaporGrip™ Technology, the EPA Registration Number 524-617). the EPA expects the lower volatility formulation to further reduce the potential off site movement of generic dicamba formulations and is included in today's regulatory decision.

The M1768 product contains the same active ingredient as M1691, diglycolamine (DGA) salt of dicamba, and is to be used with equivalent application rates and the same application techniques. Because the two products contain the same active ingredient used at the same rates with the same methods, all of the environmental and human health assessments completed and made public in connection with the proposed registration decision for the M1691 apply to M1768. After assessing volatility studies conducted on the M1768 formulation (discussed later in this document), the EPA has determined that the new lower volatility formulation of M1768 offers the user a product with less potential to volatilize and move off the target area. The volatility analysis is included in the docket for this final decision. Therefore, the new uses were granted for the M1768 formulation.

This final decision document discusses several agency considerations of the new uses for dicamba on GE soybean and GE cotton, including discussions of human health and environmental risks associated with the new uses as well as the benefits associated with these uses. the EPA considered all relevant data associated with the active ingredient when assessing its risks. For example, the assessment for human health included the N, N-Bis-(3-aminopropyl) methylamine (BAPMA) salt of dicamba (M1768 contains the DGA salt of dicamba) because the data on the BAPMA salt was relevant to the analysis and presented the most conservative risk estimation to be used in each exposure scenario to be protective of all exposures of dicamba. But, when product specific considerations were necessary for the analysis, the EPA reviewed the effects of the DGA salt. For example, to determine appropriate spray drift buffers, the agency examined drift potential using studies conducted on the DGA salt formulation.

Under the Plant Protection Act, the United States Department of Agriculture (USDA) deregulated the GE cotton and GE soybean seeds tolerant to dicamba on January 15, 2015.

I. Chemical Information

Chemical Name: Dicamba (benzoic acid, 3,6-dichloro-2-methoxy-, aka 3,6-dichloro-*o*-anisic acid)

EPA PC Code: 128931

Chemical Abstract Service (CAS) Number: 104040-79-1

Mode of Action: Dicamba is in the Benzoic Acid family that is used post-emergence for selective control of broadleaf weeds. Like the phenoxy herbicides, dicamba mimics auxins, a type of plant hormone and causes abnormal cell growth by affecting cell division.

Registrant: Monsanto Company

Product: M1768 Herbicide (Xtendimax™ with VaporGrip™ Technology) EPA Registration Number 524-617

Background

On April 28, 2010 and July 30, 2012, respectively, the EPA received applications from the Monsanto Company (Monsanto) to register new uses of dicamba, as the DGA salt, on GE soybean and GE cotton. The application also requested the establishment of new tolerances for residues resulting from the new uses. The tolerances for these new uses have been established.

Dicamba is an active ingredient that is currently used through acid formulations and a variety of salt formulations, and is registered for a variety of food and feed uses. The new uses will expand the current timing of dicamba applications to post-emergence (over-the-top) applications to GE cotton and GE soybean crops. Until this registration, dicamba was only registered for use on preplant and pre-harvest soybeans and on preplant and postharvest cotton. It is important to note that using registered dicamba products on GE cotton or GE soybean crops that are not registered specifically for post-emergence use on GE cotton or GE soybean crops is inconsistent with the pesticide's labeling and a violation of FIFRA.

New Uses

Cotton

Dicamba products that are currently registered on conventional cotton are used for preplant, at-planting and/or pre-emergent treatments at application rates that range from 0.25 to 1.0 pounds acid equivalent (lb a.e.) dicamba per acre. The maximum annual application for all preplant, at planting and pre-emergence applications combined on conventional cotton is 1.0 lb a.e. dicamba per acre per season.

For the new use, for post-emergence (in-crop) application of dicamba for use on GE cotton, the maximum single in-crop application rate is 22 fluid ounces (0.5 lb a.e. dicamba) per acre. This rate is also the minimum single application in order to reduce the selection for resistant weeds. The total of all in-crop applications for GE cotton is 88 fluid ounces (2.0 lb a.e. dicamba) per acre per season.

For preplant, at-planting, and pre-emergence treatments to GE cotton, applications must be made with a minimum application rate of 22 fluid ounces (0.5 lb a.e. dicamba) per acre. The total for all preplant, at-planting, and pre-emergence applications must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre per season.

The combined total per year for all applications (preplant, at-planting, pre-emergence and post-emergence (in-crop) must not exceed 88 fluid ounces (2.0 lb a.e. dicamba) per acre. For example, if a preplant application of 44 fluid ounces (1.0 lb a.e. dicamba) per acre is made, then the combined total post-emergence (in-crop) annual applications must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre for GE cotton.

The minimum retreatment interval is 7 days; the pre-harvest interval for cottonseed including the livestock feeding of cotton gin by-products is 7 days.

Soybeans

Dicamba products that are currently registered on conventional soybeans are used for preplant, at-planting and/or pre-emergent treatments at application rates that range from 0.125 to 0.5 pounds acid equivalent (lb a.e.) dicamba per acre and for preharvest burndown treatments at 0.25 to 1.0 lb a.e. dicamba per acre. The maximum annual application for all preplant, at planting, pre-emergence, and preharvest burndown applications combined on conventional soybeans is 1.0 lb a.e. dicamba per acre per season.

For the new use for post-emergence (in-crop) application of this product to GE soybeans, the maximum single in-crop application rate is 22 fluid ounces (0.5 lb a.e. dicamba) per acre. This rate is also the minimum single application in order to reduce the selection for resistant weeds. The total for all in-crop applications for GE soybeans is 44 fluid ounces (1.0 lb a.e. dicamba) per acre per season.

For preplant, at-planting, pre-emergence, and preharvest burndown treatments to GE soybeans, applications must be made with a minimum application rate of 22 fluid ounces (0.5 lb a.e. dicamba) per acre. The total for all preplant, at-planting, pre-emergence, and preharvest applications must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre per season.

The combined total per year for all applications must not exceed 88 fluid ounces (2.0 lb a.e dicamba) per acre. The minimum retreatment interval is 7 days; the pre-harvest interval, including feeding of soybean hay, is 14 days (R1 Growth stage).

II. Human Health Risk

A summary of the human health risk assessment, *Dicamba and Dicamba BAPMA Salt: Human-Health Risk Assessment for Proposed Section 3 New Uses on Dicamba-tolerant Cotton and Soybean*, is provided below.

As stated earlier in this document, the data associated with the BAPMA salt were considered to be the most appropriate form to use for assessing the potential for risks to human health. In the human health risk assessment for dicamba, risks were assessed in a manner that protects human health from exposure to all forms of the chemical. This is a complex analysis because (1) there are a variety of different forms of dicamba that must be considered (e.g., dicamba acid, dicamba BAPMA salt, other dicamba salts such as DGA), (2) the data show greater toxicity for a major metabolite in foods (DCSA) relative to the parent compound, and (3) the different types of toxicity and potency with different routes of exposure (specifically, portal of entry effects observed in inhalation toxicity studies for BAPMA vs. other forms of dicamba).

When determining the safety of a pesticide, the EPA evaluates the available toxicity data and considers its validity, completeness, and reliability, as well as the relationship of the results of the studies to human risk. the EPA also considers available information concerning the variability of the sensitivities of major identifiable sub-groups of consumers, including infants and children. Once a pesticide's toxicological profile is determined, the EPA identifies toxicological points of departure (POD) and levels of concern (LOC) to use in evaluating the risk posed by human exposure to the pesticide. For hazards that have a threshold below which there is no appreciable risk, the toxicological POD is used as the basis for derivation of reference values for risk assessment. PODs are developed based on a careful analysis of the doses in each toxicological study to determine the dose at which no adverse effects are observed (the NOAEL) and the lowest dose at which adverse effects of concern are identified (the LOAEL). Uncertainty/safety factors are used in conjunction with the POD to calculate a safe exposure level - generally referred to as a population-adjusted dose (PAD) or a reference dose (RfD) - and a safe margin of exposure (MOE). For non-threshold risks (e.g., cancer), the agency assumes that any amount of exposure will lead to some degree of risk. Thus, the agency estimates risk in terms of the probability of an occurrence of the adverse effect expected in a lifetime (dicamba has been determined to be "not likely" to be carcinogenic and therefore a non-threshold approach does not apply in this case). For more information on the general principles the EPA uses in risk characterization and a complete description of the risk assessment process, see *http://www.epa.gov/pesticides/factsheets/riskassess.htm*.

The following risk assessment endpoints were selected for dicamba to be protective to all forms of the chemical.

- For the acute dietary assessment, the most sensitive, single-day toxic effect seen across the entire dicamba database was chosen for quantifying risks, i.e., maternal neurotoxic effects seen in a developmental toxicity study in which animals were dosed with the BAPMA salt. Although dietary exposure could occur from agricultural use of other salts of dicamba resulting in lower risk estimates, the assessment quantified risks assuming everyone exposed to dicamba would be exposed to the more toxic BAPMA salt to assure protection from all forms of the chemical.
- For the chronic dietary assessment, the endpoint was selected from a reproduction study in which animals were dosed with the DCSA metabolite (a plant metabolite), a compound much more chronically toxic than any of the parent dicamba acid or salts pesticides. Although chronic dietary exposure could occur from exposure to various salts of dicamba rather than just this metabolite, risks were estimated assuming all residues in foods were the more toxic metabolite, thus assuring protection from all forms of the chemical.
- For the inhalation exposure assessment, risks were quantified separately for the BAPMA salt vs. other forms of dicamba since the BAPMA salt is (1) only used in agricultural settings and residential inhalation exposures would therefore not be expected, and (2)

more toxic than other forms of dicamba with regard to portal of entry inhalation toxicity.

- Finally, we assessed the toxicity specific to the counter-ion of the BAPMA salt, i.e., BAPMA itself. Since the BAPMA salt shows increased toxicity via inhalation, the BAPMA was included in the aggregate risk assessment. The potential for increased risk resulting from this chemical was assessed and determined to be low relative to the toxicity from the parent compounds and DCSA; therefore, protecting for exposures to the parent compounds and DCSA will also protect for exposures to BAPMA itself.

A. Summary of Toxicological Effects

The toxicology database for dicamba is complete and sufficient for assessing the toxicity and characterizing the hazard of dicamba. Toxicology studies for dicamba acid, its salts [isopropylamine (IPA), diglycolamine (DGA), and N, N-Bis-(3-aminopropyl) methylamine (BAPMA)], and the plant metabolites [DCSA (3, 6-dichlorosalicylic acid) and DCGA (3, 6-dichlorogentisic acid] were all considered for risk assessment for these new uses. In scenarios where co-exposure to the various forms could occur, the most protective point of departure (POD) was utilized.

Dicamba acid has been classified as having a low acute toxicity via oral, dermal and inhalation routes (Acute Toxicity Categories III or IV). It is both an eye and dermal irritant (Toxicity Category II), but it is not a skin sensitizer.

Dicamba is classified as "not likely to be carcinogenic to humans" based upon the lack of evidence of carcinogenicity in mice and rats in the acid form when tested at adequate dose levels. The agency determined, based on review of epidemiological data (see Elizabeth Evans and Shanna Recore, *Dicamba: Tier I (Scoping) Review of Human Incidents and* Epidemiology, 11/10/15), that the existing data did not support a conclusion that links human cancer to dicamba exposure.

B. Toxicological Endpoints and Doses Used in the Human Health Risk Assessment

Once a pesticide's toxicological profile is determined, the EPA identifies toxicological Points of Departure (POD) and Levels of Concern (LOC) to use in evaluating the risk posed by human exposure to the pesticide. For hazards that have a threshold below which there is no appreciable risk, the toxicological POD is used as the basis for derivation of reference values for risk assessment. PODs are developed based on a careful analysis of the doses in each toxicological study to determine the dose at which no adverse effects are observed (the No Observed Adverse Effect Level (NOAEL)) and the lowest dose at which adverse effects of concern are identified (the Lowest Observed Adverse Effect Level (LOAEL)). Uncertainty factors (UF)/safety factors (SF) are used in conjunction with the POD to calculate a safe exposure level – generally referred to as a Population-adjusted Dose (PAD) or a Reference Dose (RfD) – and a safe Margin of Exposure (MOE). For non-threshold risks, the EPA assumes that any amount of exposure will lead to some degree of risk. Thus, the EPA estimates risk in terms of the probability of an occurrence of the adverse effect expected in a lifetime.

1. Acute Dietary

The acute dietary endpoint was selected from the dicamba BAPMA salt rat developmental toxicity study, which represents the most sensitive endpoint in the dicamba toxicology database resulting from a single-dose dietary exposure. The NOAEL is 29 mg/kg/day, and the LOAEL is 86 mg/kg/day based on ataxia, unsteady gait, and convulsions in female rats. This NOAEL POD is protective of acute effects of dicamba via the oral route of exposure to the general population, including infants and children. A separate acute dietary endpoint for reproductive females ages 13-49 is not required since no acute developmental toxicity effects were observed in the dicamba database. An uncertainly factor of 100X was applied with 10X for interspecies extrapolation from animal to human, and 10X for intraspecies variation in sensitivity amongst the human population. As discussed in Section C below, the Food Quality and Protection Act (FQPA) safety factor was reduced to 1X, resulting in an aRfD/aPAD of 0.29 mg/kg/day.

2. Chronic Dietary

The chronic dietary endpoint was selected from the DCSA plant metabolite reproduction toxicity study, which represents the most sensitive endpoint in the toxicology database resulting from repeated-dose dietary exposure. The NOAEL is 4 mg/kg/day, and the LOAEL is 37 mg/kg/day based on decreased pup weights. The NOAEL POD is protective of chronic effects of dicamba via the oral route of exposure to the general population, including infants and children. A 100X UF was applied (10X interspecies and 10X intraspecies), and as discussed in Section C below, the FQPA SF was reduced to 1X resulting in a cRfD/cPAD of 0.04 mg/kg/day.

3. Incidental Oral (Short- and Intermediate-Term)

The incidental oral endpoint was selected from the dicamba acid rat multi-generation reproductive toxicity study, which represents the most appropriate endpoint in the toxicology database for assessing short- (1 to 30 days) and intermediate-term (1 to 6 months) incidental oral (hand-to-mouth) exposure. The NOAEL is 136 mg/kg/day, with a LOAEL of 450 mg/kg/day based on impaired pup growth. A 100X UF was applied (10X interspecies and 10X intraspecies), and as discussed in Section C below, the FQPA SF was reduced to 1X resulting in a level of concern of 100.

4. Inhalation (All Durations)

For dicamba acid and the DGA salt inhalation risk assessment for short and intermediate term durations, the POD was based on the route-specific dicamba acid inhalation toxicity study in Wistar rats with a LOAEL of 0.050 mg/L based on local effects of hyperplasia in the lungs and lymph nodes (NOAEL = 0.005 mg/L, non-systemic, pulmonary regional deposited dose ratio (RDDR) = 0.590).

The standard interspecies extrapolation UF can be reduced from 10X to 3X for dicamba acid due to the calculation of human equivalent concentrations (HECs) accounting for pharmacokinetic (not pharmacodynamic) interspecies differences. Therefore, the LOC for dicamba acid inhalation exposures is for MOEs less than 30 (3X for interspecies extrapolation, 10X for intraspecies variation, and as discussed in Section C below, 1X for FQPA SF when applicable). The inhalation HEC results are listed in Appendix A.5.

5. Dermal (All Durations)

No dermal endpoint was selected since no adverse effects were observed in the subchronic dermal studies for dicamba acid, IPA salt, and DGA salt up to the limit dose.

6. Cancer

Dicamba is classified as "Not Likely to be Carcinogenic to Humans." This decision was based on the lack of findings in the cancer studies in rats and mice, which were tested at adequate dose levels to assess the carcinogenicity of dicamba. Mutagenicity studies generally did not demonstrate evidence of mutagenic potential for dicamba and the concern for genotoxicity in the acid form is low. Epidemiology studies were also examined, and no links were found to dicamba exposure and cancer. Additionally, the DCSA metabolite lacked findings of carcinogenicity in a chronic/carcinogenicity study in rats.

C. FQPA Safety Factor

The EPA has determined that the 10X FQPA Safety Factor for protection of infants and children, mentioned above, can be reduced to 1X for the acute and chronic dietary risk assessment for the following reasons and discussed in more detail below: (1) The toxicity database for dicamba is complete with respect to the required 870 guideline studies. (2) There is no evidence of increased susceptibility following *in utero* exposures to rats and rabbits and following pre and/or post-natal exposure to rats in a two-generation reproduction study. For the dicamba acid and BAPMA salt, no developmental toxicity was seen at the highest doses tested in the prenatal developmental studies with rats. (3) Consistent neurotoxic signs (e.g., ataxia, decreased motor activity, impaired righting reflex and gait) were observed in multiple studies in rats and rabbits. However, after considering the available toxicity data, the EPA determined that there is no need for a developmental neurotoxicity study or additional UFs to account for neurotoxicity due to the following: (i) although clinical signs of neurotoxicity were seen in pregnant animals, no evidence of developmental anomalies of the fetal nervous system were observed in the prenatal developmental toxicity studies, in either rats or rabbits, at maternally toxic doses up to 300 or 400 mg/kg/day, respectively; (ii) there was no evidence of behavioral or neurological effects on the offspring in the two-generation reproduction study in rats; (iii) the ventricular dilation of the brain in the combined chronic toxicity and carcinogenicity study in rats was only observed in females at the high dose after two years of exposure at doses of 127 mg/kg/day, but the significance of this observation is questionable, since no similar histopathological findings were seen in two sub-chronic neurotoxicity studies at the limit dose or other chronic studies.

There are no residual uncertainties identified in the exposure databases. The acute dietary food exposure assessment was performed using tolerance level residues and 100% crop treated assumptions. The chronic dietary food exposure assessment used average residues for crops, tolerances levels for livestock commodities, and percent crop treated assumptions for several registered uses. Conservative ground and surface water estimates calculated using the latest models were used. Similarly, conservative residential Standard Operating Procedure (SOPs) were used to assess post-application exposure of children as well as incidental oral exposure of toddlers. These assessments will not underestimate the exposure and risks posed by dicamba.

1. Completeness of the Toxicology Database

The toxicity database for dicamba is adequate to characterize the potential for prenatal or postnatal risk to infants and children. Acceptable rat and rabbit developmental toxicity studies, two rat 2-generation reproduction studies, and acute/subchronic neurotoxicity studies in rats are available.

2. Evidence of Neurotoxicity

There is evidence of neurotoxicity resulting from exposure to dicamba throughout the toxicology database (i.e., impaired gait, impaired righting reflex, ataxia, decreased motor activity, rigidity upon handling, etc). These signs of neurotoxicity were observed in multiple studies in rats and rabbits. However, after considering the available toxicity data, the agency determined that a developmental neurotoxicity study (DNT) is not required for the following reasons: (1) although clinical signs of neurotoxicity were seen in pregnant animals, no evidence of developmental anomalies of the fetal nervous system were observed in the prenatal developmental toxicity studies, in either rats or rabbits, at maternally toxic doses up to 300 or 400 mg/kg/day, respectively; (2) there was no evidence of behavioral or neurological effects on the offspring in the two-generation reproduction study in rats; (3) the ventricular dilation of the brain in the combined chronic toxicity and carcinogenicity study in rats was only observed in females at the high dose after two years of exposure at doses of 127 mg/kg/day, but the significance of this observation is questionable, since no similar histopathological finding was seen in two sub- chronic neurotoxicity study at the limit dose or other chronic studies.

3. Evidence of Sensitivity/Susceptibility in the Developing or Young Animal

There is no evidence of susceptibility to the young following *in utero* exposure to dicamba acid, dicamba BAPMA or DCSA. Quantitative offspring susceptibility was observed in the 2- generation reproduction study for the DCSA metabolite based on decreased pup weights, which occurred at a dose at which no parental effects were observed. However, the degree of concern for the susceptibility is low, because there is a well-established NOAEL for offspring toxicity in that study and DCSA has rapid clearance. Additionally, the current points of departure are health protective and therefore address the concern for offspring toxicity observed in the reproduction studies.

4. Residual Uncertainty in the Exposure Database

The residential exposure assessment assumes maximum label use rate as well as other conservative assumptions. The acute dietary exposure assessment is based on an exaggerated exposure scenario which assumes that all commodities being consumed retain tolerance level residues, and the chronic dietary exposure assessment assumes field trial residues in which the crops were treated using the use patterns likely to lead to maximum residues. Additionally, the drinking water estimates utilized conservative models (e.g., models using screening level assumptions). Therefore, the agency does not believe that exposure to dicamba will be underestimated.

D. Cumulative effects

The EPA has not made a common mechanism of toxicity finding for dicamba and any other substance, and dicamba does not appear to produce a toxic metabolite produced by other substances. Therefore, the EPA finds for this decision that dicamba does not have a common mechanism of toxicity with other substances. For information regarding the EPA's efforts to determine which chemicals have a common mechanism of toxicity and to evaluate the cumulative effects of such chemicals, see the policy statements released by the EPA's Office of Pesticide Programs concerning common mechanism determinations and procedures for cumulating effects from substances found to have a common mechanism on the EPA's website at https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/cumulative-assessment-risk-pesticides.

E. Dietary (Food + Drinking Water) Risk

Dicamba is a selective systemic herbicide used to control a variety of broadleaf weeds and registered for a variety of food/feed uses. Permanent tolerances for dicamba are established under 40 CFR § 180.227 for a wide variety of crops and livestock commodities. Acute and chronic aggregate dietary food and drinking water exposure and risk assessments were conducted using the Dietary Exposure Evaluation Model software with the Food Commodity Intake Database (DEEM-FCID) Version 3.16. This software uses 2003-2008 food consumption data from the U.S. Department of Agriculture's (USDA's) National Health and Nutrition Examination Survey, What We Eat in America, (NHANES/WWEIA).

1. Acute Dietary Risk

For acute exposure assessments, individual one-day food consumption data are used on an individual-by-individual basis. The reported consumption amounts of each food item are multiplied by a residue point estimate and summed to obtain a total daily pesticide exposure for a deterministic exposure assessment, or "matched" in multiple random pairings with residue values and then summed in a probabilistic assessment. The resulting distribution of exposures is expressed as a percentage of the aPAD on both a user basis (i.e., only those who reported eating relevant commodities/food forms) and a per-capita basis (i.e., those who reported eating the relevant commodities as well as those who did not). In accordance with the EPA policy, per capita exposure and risk are reported for analyses.

Risks are considered to be of no concern when they are less than 100% of the aPAD or cPAD, a value determined by dividing the POD for the most sensitive and pertinent toxicological effect for each exposure scenario by required uncertainty factors. The acute analysis was an unrefined determination which used tolerance level residues and assumed 100 percent crop treated (%CT) for all existing and new uses. The dietary exposure analyses that were performed result in acute dietary risk estimates that are below the agency's LOC for both food and water. For the U.S. population, the exposure was 0.042760 mg/kg/day, which utilized 15% of the acute population adjusted dose (aPAD) at the 95th percentile. The highest exposure and risk estimates were for all infants (<1 year old). At the 95th percentile, the exposure for all infants (<1 year old) was 0.089 mg/kg/day, which utilized 31% of the aPAD.

2. Chronic Dietary Risk

For chronic dietary exposure assessment, an estimate of the residue level in each food or food form (e.g., orange or orange juice) on the food commodity residue list is multiplied by the average daily consumption estimate for that food/food form to produce a residue intake estimate. The resulting residue intake estimate for each food/food form is summed with the residue intake estimates for all other food/food forms on the commodity residue list to arrive at the total average estimated exposure. Exposure is expressed in mg/kg body weight/day and as a percent of the cPAD. This procedure is performed for each population subgroup.

The chronic analysis was a partially refined determination which used average residues based on field trial studies for crops, tolerance levels for livestock commodities, and relevant % crop treated (CT) data for several existing uses. The chronic risk estimates for dicamba are below the agency's LOC for the general U.S. population and all population subgroups. The highest exposure and risk estimates were for the population subgroup of children ages 1-2 with a risk estimate for dicamba for food and water of 42% of the cPAD.

F. Residential (Non-Occupational) Exposure/Risk Characterization

There are no residential uses being established for dicamba with this current registration; however, there are existing residential uses of dicamba that have been reassessed in this document to reflect updates to the agency's 2012 Residential SOPs along with policy changes for body weight assumptions. The revision of residential exposures will impact the human health aggregate risk assessment for dicamba. Registered uses of dicamba include solid and liquid products in concentrates or ready-to-use sprays for use as spot and broadcast treatments on turf.

1. Residential Handler Exposure

Based on the currently registered uses, residential handlers may receive exposure to dicamba when mixing, loading and applying the pesticide to lawns and turf. Since there was no dermal hazard identified for dicamba, only inhalation risk estimates were quantitatively assessed. The inhalation risk estimates were based on the following application scenarios:

- Mix/Load/Apply Liquid with Hand-held Equipment
- Apply Ready-To-Use Sprays with Hand-held Equipment
- Load/Apply Granules with Hand-held Equipment

The MOEs for the exposure scenarios assessed range from 190 to 220,000. Since there is potential risk concern only when inhalation MOEs are less than a LOC of 30, residential handler exposures are not a concern.

2. Post-application Exposure

There is the potential for post-application exposure for individuals exposed as a result of being in an environment that has been previously treated with dicamba. Since no dermal hazard was identified for dicamba, the quantitative exposure/risk assessment for residential post-application exposures is based on the following scenarios:

- Children (1 to < 2 years old) incidental oral exposure to treated turf.
- Children (1 to < 2 years old) episodic granular ingestion exposure.

Since dicamba products registered for use on residential turf come in both liquid and granular formulations, both are accounted for in this assessment. The assessment of post-application exposure to liquid formulations is protective of exposure to solid formulations, except for the episodic granular ingestion scenario which was quantitatively assessed. The life stages selected for assessment are health protective for the exposures and risk estimates for any other potentially exposed life stages.

The post-application assessment for turf includes only the incidental oral routes of exposure. The series of assumptions and exposure factors that served as the basis for completing the residential post-application risk assessment are detailed in the 2012 Residential SOPs (https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/standard-operating-procedures-residential-pesticide). In addition, chemical-specific residue data were used in the assessment. The residential post-application risk estimates are not of concern for dicamba since all MOEs are greater than the LOC of 100 (the lowest MOE = 6600 for use of liquids on lawns).

3. Residential Bystander Post-application Inhalation Exposure

The potential exposure to bystanders from vapor phase dicamba residues emitted from treated fields has been evaluated for the new uses of dicamba on GE corn and GE soybean. Bystander exposure to dicamba emitted from treated fields depends on two main factors: 1) the rate at which these chemicals volatilize from a treated field (described as the off-gassing, emission or flux), and 2) how those vapors are dispersed in the air over and around the treated field. In general, volatilization can occur during the application process or thereafter. It can result from aerosols evaporating during application, while deposited sprays are still drying (possibly via co-distillation), or after as dried deposited residues volatilize.

Volatilization modeling for a single day was completed using the Probabilistic Exposure and Risk model for Fumigants (PERFUM). There are a variety of factors that potentially affect the emission rates of dicamba and subsequent offsite transport including: field condition (bare soil, growing or mature crop canopy), field parameters (soil type, moisture, etc.), formulation type, meteorological conditions, and application scenario (rate, method).

A chemical-specific flux study was used to estimate a flux rate of 0.0004 $ug/m^2/s$ for dicamba. This flux rate, along with an assumption of a single 40-acre field, and using Bradenton, FL meteorological data from Bradenton, FL were used with PERFUM to estimate risk.

The field volatility study suggests that volatilization of dicamba from treated crops does occur, which could result in bystander exposure. Although a more recent volatility study conducted using the M1768 formulation was submitted and reviewed, which demonstrated comparable potential for volatility as described in greater detail in the document entitled *Review of EFED Actions and Recent Data Submissions Associated with Spray and Vapor Drift of the Proposed Section 3 New Uses on Dicamba-Tolerant Soybean and Cotton* available in the docket for this action, that study was not available at the time this Human Health assessment was developed. Results of PERFUM modeling using the Bradenton, FL study however, indicate that airborne concentrations are negligible, and even at the edge of the treated fields risk estimates for potential human bystander exposure are not of concern.

4. Spray Drift

Without considering mitigation measures, it is reasonable to assume that spray drift may be a potential source of exposure to residents nearby to spraying operations. Off-target movement of pesticides can occur via many types of pathways and it is governed by a variety of factors. Sprays that are released and do not deposit in the application area end up off-target and can lead to exposures to those it may directly contact. They can also deposit on surfaces where contact with residues can eventually lead to indirect exposures (*e.g.*, children playing on lawns where residues have deposited next to treated fields). The potential risk estimates from these residues are calculated using drift modeling coupled with methods employed for residential risk assessments for turf products.

The approach to be used for quantitatively incorporating spray drift into risk assessments is based on a premise of compliant applications which, by definition, should not result in direct exposures to individuals because of existing label language and other regulatory requirements intended to prevent them. Direct exposures would include inhalation of the spray plume or being sprayed directly. Rather, the exposures addressed here occur indirectly through contact with impacted areas, such as residential lawns, when compliant applications are conducted. Given this premise, exposures for children (1 to 2 years old) and adults who have contact with turf where residues are assumed to have deposited via spray drift thus resulting in an indirect exposure are the focus of this analysis, analogous to how exposures to turf products are considered in risk assessment.

Several dicamba products have existing labels for use on turf, thus it was considered whether the risk assessment for that use would be considered protective of any type of exposure that would be associated with spray drift. Because the registered residential uses on turf result in exposure greater than potential exposure from spray drift, no new residential assessment needs to be completed. If the maximum application rate on crops adjusted by the amount of drift expected is less than or equal to existing turf application rates, the existing turf assessment is considered protective of spray drift exposure. The maximum single application rate of dicamba for this new use is 1 lb a.e./A. The highest degree of spray drift noted for any application method immediately adjacent to a treated field (Tier 1 output from the aerial application using fine to medium spray quality) results in a deposition fraction of 0.26 of the application rate. This spray drift fraction estimation differs from that used for environmental exposures because, unlike environmental risk assessment that uses estimations to determine exposures at the edge of the treated field, estimations for human health risk assessment are used to assess the average deposition over a wide area of lawn. For the purposes of the new uses on dicamba, this is considered a screening level assumption since the new use is for groundboom applications only. A quantitative spray drift assessment for dicamba is not required because the maximum application rate to a crop/target site multiplied by the adjustment factor for drift of 0.26 is less than the maximum direct spray residential turf application rate of 1 lb a.e./A for any dicamba products. The turf post-application MOEs have been previously assessed, are based on the revised SOPs for Residential Exposure Assessment, and were not found to be of concern, as noted above.

5. Aggregate Risk Assessment

In accordance with the Federal Food, Drug, and Cosmetic Act (FFDCA), the EPA must consider and aggregate (add) pesticide exposures and risks from three major sources: food, drinking water, and residential exposures. In an aggregate assessment, exposures from relevant sources are added together and compared to quantitative estimates of hazard, or the risks themselves can be aggregated. When aggregating exposures and risks from various sources, the EPA considers both the route and duration of exposure. Since residential exposure is expected, aggregate exposure consists of exposure from residential, food and drinking water sources.

Acute and chronic aggregate risks include only dietary exposure from food and drinking water sources. Since there are residential uses, short-term aggregate risks were assessed which include contributions from food, drinking water, and residential exposure. Intermediate-term aggregate risks were not considered as residential exposure is not expected to occur for more than 30 days. Cancer aggregate risk was not quantified since dicamba is not a carcinogen. A common oxicological endpoint of concern was not identified for short-, intermediate- or long-term durations via the oral, dermal, or inhalation routes. Therefore, the aggregate exposure risk assessment should include exposure across the oral routes only, as appropriate for the populations of concern (i.e., food and water for adults; and food, water and incidental oral for children).

a. Acute Aggregate Risk

The acute aggregate risk assessment includes only food and water exposure; therefore, the acute dietary (food and drinking water) assessment represents acute aggregate risk. The acute dietary exposure assessment was conducted using tolerance-level residues, DEEM default processing factors and 100% crop-treated information for all registered and new use sites. Drinking water values were incorporated directly into the assessment. The most highly exposed population subgroup is all infants (<1 year old; 31% of the aPAD). The acute dietary exposure estimates are not of concern for the general U.S. population or any population subgroup.

b. Short-term Aggregate Risk

The short-term aggregate risk assessment includes food, water and residential exposure. The resulting short-term aggregate risks are not of concern for children (MOEs > LOC 100). For adults, since there was no dermal hazard identified in the route-specific dermal studies and the inhalation effects were not systemic, the chronic dietary assessment is protective for short-term aggregate risks.

c. Long-term Aggregate Risk

The chronic (long-term) aggregate risk assessment includes only food and water exposure. The chronic dietary analysis was a partially refined determination which used average residues based on field trial studies for crops, tolerance levels for livestock commodities, and relevant percent crop treated (CT) data for several existing uses. The chronic risk estimates for dicamba are below the agency's LOC for the general U.S. population and all population subgroups. The highest exposure and risk estimates were for the population subgroup of children ages 1-2 with a risk estimate for dicamba for food and water of 42% of the cPAD.

6. Occupational Risk Assessment

a. Short- and Intermediate-term Handler Risk

The EPA uses the term occupational handler to describe people who mix, load and/or apply pesticides professionally (e.g., farmers, professional pesticide applicators). Based on the anticipated use patterns and current labeling, types of equipment and techniques that can potentially be used (e.g., mixing/loading liquids for ground boom application, and applying sprays by ground boom equipment), occupational handler exposure is expected from the new uses.

The occupational handler risk estimates are not of concern (i.e., MOEs > LOC of 30) for all of the scenarios for the use of dicamba on GE cotton and GE soybean. At baseline personal protective equipment (PPE) (i.e., no respirator), the occupational handler inhalation MOEs are 380 for mixer/loaders and 250 for applicators using ground boom equipment.

b. Short- and Intermediate-term Post-application Risk

The EPA uses the term post-application to describe exposures that occur when individuals are present in an environment that has been previously treated with a pesticide (also referred to as reentry exposure). Such exposures may occur when workers enter previously treated areas to perform job functions, including activities related to crop production, such as scouting for pests or harvesting. Post-application exposure levels vary over time and depend on such things as the type of activity, the nature of the crop or target that was treated, the type of pesticide application, and the chemical's degradation properties. In addition, the timing of pesticide applications, relative to harvest activities, can greatly reduce the potential for post-application exposure.

i. Dermal Post-application Risk

There is no potential hazard via the dermal route for dicamba; therefore, a quantitative occupational post-application dermal risk assessment was not completed.

ii. Inhalation Post Application Risk

There are multiple potential sources of post-application inhalation exposure to individuals performing post-application activities in previously treated fields. These potential sources include volatilization of pesticides and resuspension of dusts and/or particulates that contain pesticides. The agency sought expert advice and input on issues related to volatilization of pesticides from its Federal Insecticide, Fungicide, and Rodenticide Act Scientific Advisory Panel (SAP) in December 2009, and received the SAP's final report on March 2, 2010 (http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0687-0037. The agency has evaluated the SAP report and has developed a Volatilization Screening Tool and a subsequent Volatilization Screening Analysis (https://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2014-0219-0002). During Registration Review, the agency will utilize this analysis to determine if additional data (i.e., flux studies, route-specific inhalation toxicological studies) or further analysis is required for the active ingredient dicamba, generically.

In addition, the agency is continuing to evaluate the available post-application inhalation exposure data generated by the Agricultural Reentry Task Force. Given these two efforts, the agency will continue to identify the need for and, subsequently, the way to incorporate occupational post-application inhalation exposure into the agency's risk assessments.

III. Environmental Risk

A summary of the environmental fate and ecological effects, and potential environmental risks from the use of dicamba on GE soybean and GE cotton is provided below. More detailed discussions can be found in the agency documents titled:

- *Ecological Risk Assessment for Dicamba and its Degradate, 3,6-dichlorosalicylic acid (DCSA), for the Proposed New Use on Dicamba-Tolerant Soybean (MON87708)* and
- *Ecological Risk Assessment for Dicamba DGA Salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA), for the Proposed Post-Emergence New Use on Dicamba-Tolerant Cotton (MON 87701),* and its addendums entitled,
- *Addendum to the Environmental Fate and Ecological Risk Assessment for the Section 3 New Use of Dicamba on Dicamba-Tolerant Soybean* and
- *Dicamba DGA; Second Addendum to the Environmental Fate and Ecological Risk Assessment for Dicamba DGA salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA) for the Section 3 New Use on Dicamba-Tolerant Soybean* and
- *M-1691 Herbicide, EPA Reg. No. 524-582 (Active Ingredient: Dicamba Diglycolamine Salt) and M-1768 herbicide, EPA Reg. No. 524-617 (AI: Diglycolamine Salt with VaporGrip™) – Review of EFED Actions and Recent Data Submissions Associated with Spray and Vapor Drift of the Proposed Section 3 New Uses on Dicamba-Tolerant Soybean and Cotton*.

These documents are in docket number EPA-HQ-OPP-2016-0187, available at regulation.gov. A fuller description of how these potential risks are assessed can be found at: https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/ecological-risk-assessment-pesticides-technical.

A. Environmental Fate

1. Degradation

Dicamba is generally stable to abiotic processes, and is more persistent under anaerobic conditions. It is stable to abiotic hydrolysis at all pH levels and photodegrades slowly in water and soil. Under anaerobic soil conditions, the dicamba parent molecule has a half-life of 141 days. It is not persistent under aerobic conditions; aerobic soil metabolism is the main degradative process for dicamba, with a half-life of 6 days. Dicamba was found in two acceptable field dissipation studies in soil segments deeper than 10 cm with half-lives ranging from 4.4 to 19.8 days. In aquatic systems, dicamba degrades more rapidly when sediment is present and has an aerobic soil metabolism half-life in sediment-water system of ~24 days.

The major degradate of dicamba is 3,6-dichlorosalicylic acid (DCSA). It is persistent when formed under anaerobic conditions, comprising more than 60% of the applied dose after 365 days of anaerobic incubation in sediment-pond water system. DCSA is not persistent when formed under aerobic conditions and degrades roughly at the same rate as the parent dicamba with a half-life of 8.2 days. Like the parent molecule, DCSA is mobile and was also found in the two acceptable field studies in soil segments deeper than 10 cm. If it were to reach anaerobic groundwater, it would likely persist; however, the EPA does not expect DCSA to reach groundwater at levels that would be of concern. DCSA is formed in aerobic soil under laboratory conditions at the maximum of 17.4 % of the applied parent dose. Other minor dicamba degradates of concern are DCGA and 5-OH-dicamba, and both are less toxic than the parent molecule and DCSA. The formation of DCGA in the laboratory studies did not exceed 3.64%, and the formation of 5-OH dicamba did not exceed 1.9 % in soil-water system during anaerobic aquatic degradation of dicamba under laboratory conditions. DCSA was also a major metabolite in plant metabolism and magnitude of residue studies for GE soybean and cotton, comprising approximately 80% and 20%, respectively, of dicamba-related residues in plant tissues for these crops.

2. Mobility

Dicamba is very soluble and mobile. Without considering mitigation measures on the product label, possible pathways for reaching surface water include field/site runoff, spray drift during application, and vapor drift from volatilization. It is not expected to bioaccumulate in aquatic organisms as it is an anion at environmental pHs. Since dicamba is not persistent under aerobic conditions, very little dicamba is expected to reach groundwater. The major degradate of dicamba, DCSA, is persistent under anaerobic conditions; however, the EPA does not expect DCSA to reach groundwater at levels that would be of concern. Without considering mitigation measures, the major route of exposure to non-target organisms is likely spray drift and runoff. While multiple literature studies show that there is potential for high vapor drift for certain dicamba salts and formulations from soybean fields resulting in non-target plant injury, the available dicamba M1768 formulation volatility research the agency has reviewed indicates that non-target plant biomass and yield will not be affected by use of the M1768 formulation. The assessments, which can be found in the docket for this action, related to these routes of exposure are described in the sections below.

3. Runoff

The agency considered the potential effects due to runoff and developed mitigation to limit off-site runoff that is reflected in the approved labeling for these new uses (e.g., Do not make application of this product if rain is expected in the next 24 hours.). A component of the model used to assess terrestrial risk assumes that the mass of pesticide running off the treated field is directly related to the pesticide's solubility in water. In the case of dicamba DGA salt, the dissociated salt yields highly soluble dicamba acid. The model assumes that the high solubility of the acid results in a runoff mass of 5 percent of the field-applied mass, which is considered to be a highly conservative estimate because the model does not account for loss of chemical from degradation, partitioning, or the temporal aspects of runoff (e.g., a rain event following application that exceeds soil's field capacity).

4. Spray Drift

Without consideration of mitigation measures on the approved label, the agency considers spray drift exposure to be the principal risk issue to be considered with these new uses, owing to a variety of lines of evidence, including past experience with other dicamba formulations. In addition, visual observations of off-field plant damage have been reported following applications of currently registered dicamba products (not containing the same labeling restrictions), likely the result of subsequent spray drift and/or volatilization of dicamba residues.

The agency used a weight of evidence approach incorporating spray drift modeling, a spray drift droplet deposition study, and raw data from field trials to determine an appropriate in-field buffer to avoid dicamba exposure to non-target organisms (e.g., endangered plants). The EPA determined that the label must specify that nozzles must be used that produce extra-course and ultra-course droplet spectra for application to reduce the potential for spray drift. The approved labeling for this action contains these restrictions. Based on the weight of evidence approach, the EPA also determined that labels must include language to maintain an in-field buffer (downwind at the time of application) of 110 feet when applying at the 0.5 lb a.e./A application rate and 220 feet when applying at the 1.0 lb a.e./A application rate in order to restrict the movement of residues to the field. Using these buffers, expected residues at the field's edge from spray drift would be below apical endpoints for the most sensitive tested species (i.e., NOAEC for soybean plant height). The approved labeling for this action includes these restrictions.

5. Volatilization

After reviewing submitted data relating to the volatility of dicamba, and at the time the EPA proposed these new uses, the agency had concerns regarding the volatility of dicamba and possible post-application, vapor-phase off-site transport that might damage non-target plants. Monsanto responded to these concerns with an additional submission post-proposal that acknowledged the long-recognized volatility of dicamba acid and described measurements of the volatilization in the different formulations.

Based on field volatility (flux) studies (conducted in accordance with the label conditions such as nozzle and ground speed limitations) and laboratory vapor-phase toxicity and exposure (humidome) studies, the 110-foot omnidirectional buffer for volatilization is no longer warranted for the dicamba DGA plus VaporGrip™ (M1768) formulation, because the expected exposure at field's edge is less than the NOAEC for plant risk.

The EPA's buffer is determined by evaluation of plant toxicity data required under FIFRA and conducted under GLP conditions where apical endpoints (plant height and yield) are used as measures of plant growth and reproduction. Once the no observed adverse effect concentration (NOAEC) was determined for the most sensitive endpoint (i.e., plant height) for the most sensitive plant species tested (i.e., soybeans), the EPA uses field studies and modeling to determine the distance from site of application to where the NOAEC is not expected to be exceeded. It is further noted that the labels for the new uses will specify a spray nozzle and pressure combination that is expected to reduce drift of the herbicide, which are drift reduction measures not on the previously registered dicamba formulations and could also influence the size of a protective buffer.

B. Ecological Risk

Ecological risk characterization integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. The process of integrating the results of exposure with the ecotoxicity data is called the risk quotient method. For this method, risk quotients (RQs) are calculated by dividing exposure estimates by ecotoxicity values, both acute and chronic (RQ = Exposure/Toxicity). RQs are then compared to the EPA's levels of concern (LOCs). The LOCs are criteria used by the agency to indicate potential risk to non-target organisms. The criteria indicate whether a pesticide, when used as directed, has the potential to cause adverse effects to non-target organisms.

For terrestrial animals, the agency's acute risk LOCs are set at 0.5 for non-listed species and 0.1 for listed species. For aquatic animals, acute risk LOCs are also set at 0.5 for non-listed species but for listed species, they are set at 0.05. The chronic risk LOC is set at 1.0 for both terrestrial and aquatic animals. For plants, acute risk LOCs are set at 1 for both non-listed and listed species. The potential difference in sensitivity for listed plant species compared to non-listed plant species is addressed through the use of different toxicity endpoints in the RQ equation [the concentration causing effects to 25% of the test population (EC25) for non-listed plants vs the NOAEC or concentration causing effects to 5% of the test population (EC05) for listed species]. Chronic risk is not assessed for plants.

Dicamba is currently registered for use on several food and non-food use sites, including conventional cotton and soybean. The new uses on GE soybeans and GE cotton expand the timing of applications from only pre-emergence and pre-harvest for soybeans and only pre-emergence and post-harvest for cotton to allowing post-emergence over-the-top applications on these GE crops. The maximum yearly application rates would remain 2.0 lb a.e./A for both cotton and soybeans. However, as detailed in section I of this document, the applicator could now split the 2.0 lb a.e./A between pre-emergence and post-emergence applications.

The EPA has a specific process based on sound science that it follows when assessing risks to listed species for pesticides like dicamba that will be used on seeds that have been genetically modified to be tolerant to the pesticide. The agency begins with a screening-level assessment that includes a basic ecological risk assessment based on its 2004 Overview of the Ecological Risk Assessment Process document. [USEPA, 2004, available at http://www.epa.gov/oppfead1/endanger/litstatus/riskasses.htm]. That assessment uses broad default assumptions to establish estimated environmental concentrations of particular pesticides. If the screening - level assessment results in a determination that no levels of concern are exceeded, the EPA concludes its analysis. On the other hand, where the screening-level assessment does not rule out potential effects (exceedances of the level of concern) based on the broad default assumptions, the EPA then uses increasingly specific methods and exposure models to refine its estimated environmental concentrations at the species-specific level.

The results of the screening-level risk assessments indicate that the RQs do not exceed the agency's LOC for terrestrial invertebrates (including pollinators), freshwater fish, aquatic-phase amphibians, estuarine/marine fish, freshwater invertebrates, or estuarine/marine invertebrates for either acute or chronic exposures. Acute RQs for aquatic plants and mammals, and chronic RQs for birds, reptiles, and terrestrial-phase amphibians also do not exceed the agency's LOC. The screening-level assessment uses broad default assumptions to establish estimated environmental concentrations of particular pesticides. It does not make effects determinations related to any particular listed species. Instead, species-specific assessments are conducted for effects determinations. A more detailed description can be found in Section IV below.

For both GE cotton and GE soybeans, based on the new maximum application rates, the screening-level analysis indicates that risks for acute exposure to listed and non-listed birds, and listed and non-listed terrestrial dicot plant species, result in RQs that exceed the agency's LOCs. For soybeans, there is also a potential for direct adverse effects to birds and mammals from chronic exposure to the dicamba degradate DCSA. Though the rates are similar to those in currently registered dicamba pesticide products, the potential for ecological concerns is related to the potential increase in acres treated with dicamba products, resulting in additional acres with residues of DCSA in GE soybeans. Before considering mitigation measures, the EPA also found a potential for increased susceptibility of direct adverse effects to late season plants from spray drift.

While concern levels are exceeded in the screening-level assessment, further refinement, as discussed below, suggest that risks are lower and confined to the treated field under the mitigations imposed on the registration. Risks above the level of concern remain for terrestrial plants and animals on the treated field; comparison of the risk to benefits associated with the new use are described in Section VIII.

1. Risk to Birds

For birds, the screening-level assessment (which assumed that 100% of diet is from the treated field) indicated that the RQs exceeded the agency's LOCs on an acute basis for both GE soybean and GE cotton. More specifically, the screening-level assessment found that the acute LOCs are exceeded for listed and non-listed birds, with a maximum acute dose-based RQ of 2.21 for small birds consuming short grass. Chronic LOCs were also exceeded for birds feeding on DCSA residues in GE soybeans, with a maximum chronic dietary RQ of 1.7 for small birds consuming GE soybean forage/hay.

The agency's screening-level assessment employed residue estimates based on reasonable upper bound modeling assumptions for dicamba DGA residues on food items consumed by birds. These residue estimates have been developed for a variety of wildlife food items, and are based on measured residues from a large number of field trials on many pesticides. The agency's assessment also used the maximum labeled rate of the pesticide and the empirical maximum measured concentrations for DCSA residues in GE soybeans and cotton plants to determine the RQ values. To represent a maximum, or "worst-case" estimate of risk, these high-end exposure estimates for a variety of food items were compared, across a variety of body weights and sizes, to the most sensitive oral dose toxicity endpoint in order to generate RQs. Some of these RQs exceeded the LOC. While the LOCs were exceeded, further consideration of all lines of evidence shows that risks under more realistic use scenarios are expected to be lower. For example, high-end dicamba residues compared to endpoints from toxicity studies using chemicals incorporated in the animal's diet do not trigger concerns. This suggests that dicamba consumed in the diet may be less available than assumed using dose-based exposures. Expected field exposure is more likely to be accounted for by the dietary studies that did not indicate risk exceeding levels of concern rather than the acute oral dose studies where risk exceeding thresholds of concern was indicated. As mentioned above, the screening-level analysis assumes that 100% of the diet comes from the treated field which may overestimate total dicamba ingestion.

Further, more frequently expected residues levels, such as mean or median estimates of exposure, would be lower by a factor of two or more, suggesting that residues are often not likely to trigger concerns for many food items. In addition, estimates of exposure in screening-level assessments are the maximum levels expected, and represent residues at the actual point of application, right on the field. The exposure analysis in this screening-level risk assessment indicates that the transport of dicamba off-field by spray drift decreases with distance, suggesting that exposures to dicamba, and therefore associated risks, can be substantially lower for organisms that are off the treated field. With this last line of evidence in mind, the pesticide label requires an in-field 110 to 220-foot downwind buffer to eliminate off-site exposure above threshold levels that would trigger risk concern for birds (buffer is discussed in more detail in the "Risk to Plants" section, below). Exposures to DCSA residues are only expected for birds feeding on GE plants on the field, and are not expected off the field (since DCSA formation is only a result of dicamba tolerant-plant metabolism).

2.Risk to Mammals

For parent dicamba, none of the RQs for mammals exceed any of the agency's LOCs. Acute RQs range from <0.01 to 0.04 and chronic RQs range from 0.01 to 0.84. However, the screening-level assessment using the maximum exposure values from empirical datasets for DCSA residues in GE soybean resulted in exceedances of the chronic LOC for all size classes of mammals consuming soybean forage and hay, or consuming insects that had consumed soybean tissues with DCSA residues. These RQs range from 1.1 to 3.3. The screening-level assessment using the maximum exposure values from empirical data for DCSA residues in GE cotton did not result in exceedances of the chronic LOC for any mammal (chronic RQs ranged from <0.01 to 0.34).

The agency's screening-level assessment employed residue estimates based on reasonable upper bound modeling assumptions for dicamba residues, the maximum labeled rate of the pesticide, and the empirical maximum measured concentrations for DCSA residues in GE soybeans and GE cotton plants to determine the RQ values. the EPA further considered more realistic residue estimates and other lines of evidence, such as food preferences and foraging ranges relative to distance from the site of application. This analysis showed reduced concerns for adverse effects because larger mammals have more varied diets and larger home ranges where feeding is more likely to occur well away from treatment areas. As described in the section for risk to birds, the screening-level assessment assumes that 100% of the diet comes from the treated field.

Consideration of these lines of evidence also produces reduced risk estimates for small herbivorous mammals, due to reduced exposure, but does not reduce risk estimates for these organisms to the point that concern levels are not exceeded. As in the case for birds, the pesticide label requires an in-field 110 to 220-foot downwind buffer eliminate off-site exposure above threshold levels that would trigger risk concern for mammals (buffer is discussed in more detail in the "Risk to Plants" section, below). Exposures to DCSA residues are only expected for mammals feeding on GE plants on the field, and are not expected off the field.

3. Risk to Plants

For aquatic plants, the only RQ that would exceed an agency LOC of 1.0 is for any listed non-vascular aquatic plants for the parent dicamba, with an RQ of 8.5. However, there are currently no listed non-vascular aquatic plants.

Dicamba exposure to terrestrial and semi-aquatic plants was estimated through modeling for plants residing near a use area that may be exposed via runoff and/or spray drift. Only a single application at the maximum rate for a particular use and compound-specific solubility information is considered, because it is assumed that for plants, toxic effects are likely to manifest shortly after the initial exposure, and that subsequent exposures do not contribute to the response. Hence, estimates are based on application rate, the solubility factor, and default assumptions of drift.

For a single application of dicamba at the maximum label rate for the new uses, the RQs exceeded the LOC (1.0) for terrestrial dicots due to spray drift (without mitigation measures), and for dicots in semi-aquatic areas due to runoff and spray drift (without mitigation measures). The RQs for dicots in semi-aquatic areas were 4.15 for non-listed species and 7.58 for listed species. The RQs for spray drift were 19.49 for non-listed species of dicots and 38.31 for listed species of dicots. The RQs for dicots in dry areas were 0.49 for non-listed species and 0.89 for listed species which are both less than the LOC for plants of 1.0.

Although the RQ analysis indicated there may be risks to plants from runoff and spray drift, studies conducted on the dicamba DGA formulation demonstrates that the approved labeling restrictions will keep the product on the field, thereby reducing spray drift off field. These determinations were made after reviewing additional registrant submitted studies for a refined spray drift analysis using the specific Tee Jet® TT11004 nozzles and a change in the formulation to be registered. The analysis indicates that the dicamba product applied through the specific Tee Jet® TT11004 nozzle is protective of plants from exposures of the M1768 Herbicide when an in-field 110 to 220-foot downwind buffer is incorporated between the application equipment and the edges of the treated field. Therefore, potential risks to plants from spray drift is mitigated by requiring a 110-220 foot (depending on application rate) buffer downwind at the time of application.

4. Synergism

The agency views synergism to be a rare event and intends to follow the National Research Council's recommendation for government agencies to proceed with estimating effects of pesticide mixtures with the assumption that the components have additive effects[1] in the absence of any data to support the hypothesis of a synergistic interaction between pesticide active ingredients. However, data is being cited in connection with patent claims submitted to the U.S. Patent and Trademark Office (USPTO) for claims of synergism for specific combinations of dicamba with other herbicides.

The EPA is aware that a common agricultural practice involves tank mixing of pesticides, resulting in the co-occurrence of chemical stressors to non-target plants including endangered species. This phenomenon has been described in academic research as well as patent application filings with the USPTO where the combined mixture is sometimes claimed to have enhanced activity or synergistic effects. The endpoints in these patent application studies were based on visual observations of weed control and injury, and so were not directly applicable to the EPA's quantitative risk assessment process for plants, in which measures of sub-lethal effects (plant height and weight) serve as sensitive effects thresholds for risk estimation purposes. The EPA believes this quantitative

[1] The phrase 'additive effects' is used when the effect of the combination of chemicals can be estimated directly from the sum of the scaled exposure levels (dose addition) or of the responses (response addition) of the individual components.

approach is very reliable for the purpose of potential toxicity to plants.

The agency is continuing its work with that information in order to better understand the scope of these uncertainties for these specific combinations and to develop an approach that best manages the potential risks while still maintaining the important benefits derived from tank mixing. While evaluation of these data are still in progress, the agency is requiring that the end-use product label allow only tank mixing with other herbicides in combinations that have not been granted patents for synergistic behavior at the time of this registration. For prohibited combinations, if the EPA determines that sufficient data do not exist to support synergistic effects with a particular active ingredient, or if the agency has evaluated data that is more directly applicable to the agency's quantitative risk assessment process for plants that demonstrates that no increased toxicity to plants exists and are therefore not of concern, that ingredient may then be allowed in tank mix combinations. A list of acceptable tank mixes will be maintained by Monsanto on their already established website, www.xtendimaxapplicationrequirements.com

IV. Endangered Species for Dicamba Diglycolamine Salt (DGA)

Below is a summary of the endangered species assessments for dicamba (DGA). More detailed discussions can be found in the EPA documents titled, *Addendum to Dicamba Diglycolamine Salt (DGA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 16 states (Arkansas, Illinois, Iowa, Indiana, Kansas, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin); Addendum to Dicamba Diglycolamine (DGA) Salt Section 3 Risk Assessment: Endangered Species Effects Determinations for Dicamba DGA on Herbicide-Tolerant Cotton and Soybean in 7 U.S. States: AL, GA, KY, MI, NC, SC, and TX;* and *Addendum to Dicamba Diglycolamine (DGA) Salt Section 3 Risk Assessment: Endangered Species Effects Determinations for Dicamba DGA on Herbicide-Tolerant Cotton and Soy in 11 U.S. States: AZ, CO, DE, FL, MD, NM, NJ, NY, PA, VA and WV.* These documents are in the docket for this final decision.

In the screening-level risk assessment performed for the new application timing of dicamba (DGA) on GE cotton and GE soybean to be resistant to dicamba, the EPA determined that levels of concern were not exceeded for mammals (acute) and (chronic- for cotton use only), birds, reptiles, and terrestrial-phase amphibians (chronic from parent dicamba or DCSA degradate from use on cotton), terrestrial insects, freshwater fish, aquatic-phase amphibians (acute and chronic), estuarine/marine fish (acute and chronic), freshwater invertebrates (acute and chronic), estuarine/marine invertebrates (acute and chronic), and aquatic plants (vascular and non-vascular). However, potential indirect effect risk concerns were identified for any species that have dependencies (e.g., food, shelter, and habitat) on mammals, birds, reptiles, terrestrial-phase amphibians, or terrestrial plants that are directly affected.

The EPA has a specific process based on sound science that it follows when assessing risks to listed species for pesticides like dicamba that will be used on GE seeds to be resistant to the pesticide. The agency begins with a screening-level assessment that includes a basic ecological risk assessment consistent with its 2004 Overview of the Ecological Risk Assessment Process document. [USEPA, 2004, available at species/ecological-risk-assessment-process-under-endangered-species-act]. That assessment uses broad default assumptions to establish estimated environmental concentrations of particular pesticides. If the screening-level assessment results in a determination that no levels of concern are exceeded, the EPA concludes its analysis. On the other hand, where the screening-level assessment does not rule out potential effects (exceedances of the level of concern) based on the broad default assumptions, the EPA then uses increasingly specific methods and exposure models to refine its estimated environmental exposures. At each step, the EPA compares the more refined exposures to the toxicity of the pesticide active ingredient to determine whether the pesticide exceeds levels of concern established for listed aquatic and terrestrial species. The EPA determines that there is "no effect" on listed species if, at any step in the screening-level assessment, no levels of concern are exceeded. If, after performing all of the steps in the screening-level assessment, a pesticide still exceeds the agency's levels of concern for listed species, the EPA then conducts a species-specific refined assessment to make effects determinations for individual listed species. The refined assessment, unlike the screening-level assessment, takes account of species' habitats and behaviors to determine whether any listed species may be affected by use of the pesticide.

The screening-level risk assessment generates a series of taxonomic (e.g., mammals, birds, fish, etc.) risk quotients (RQs) that are the ratio of estimated exposures to acute and chronic effects endpoints. These RQs are then compared to the EPA established levels of concern (LOCs) to determine if risks to any taxonomic group are of concern. The LOCs address risks for both acute and chronic effects. Acute effects LOCs range from 0.05 for aquatic animals that are federally-listed threatened or endangered species (listed species) to 0.5 for aquatic non-listed animal species and 0.1 to 0.5 for terrestrial animals for listed and non-listed species. The LOC for chronic effects for all animal taxa (listed and non-listed) is 1. Plant risks are handled in a similar manner, but with different toxicity thresholds (NOAEC/EC_{05} and EC_{25}, respectively) used in RQ calculation for listed and non-listed species and an LOC of 1 used to interpret the RQ. As described above, if the screening-level assessment shows that an RQ exceeds either the acute or chronic LOC, a concern for direct toxic effects is identified for that particular taxon and a species-specific assessment is necessary to make an effects determination. On the other hand, if RQs fall below the LOC, a No Effect determination is identified for the corresponding taxon.

This registration for dicamba has been finalized for registration for use in the states of Alabama, Arkansas, Arizona, Colorado, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Mexico, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, West Virginia, and Wisconsin. Additional states may be added to the labeling once an acceptable assessment of listed species is completed for any such state.

Based on the EPA's LOCATES v.2.4.0 database and information from the U.S. Fish and Wildlife Service (USFWS), the EPA identified the listed species that are inside the "action area" (area of concern where use of pesticide may result in exposure to endangered species) associated with the new cotton and soybean uses within a total of 34 states.

The following criteria are used to make a species-specific effects determination:

- For listed individuals inside the action area but not part of an affected taxa nor relying on the affected taxa for services involving food, shelter, biological mediated resources necessary for survival and reproduction, use of a pesticide would be determined to have NO EFFECT.
- For listed individuals outside the action area, use of a pesticide would be determined to have NO EFFECT.
- Listed individuals inside the action area may either fall into the NO EFFECT or MAY EFFECT categories depending upon their specific biological needs and circumstances of exposure.
- Those that fall under the MAY EFFECT category are found to be either LIKELY or NOT LIKELY TO ADVERSELY AFFECT the listed species.
  A NOT LIKELY TO ADVERSELY AFFECT determination is made using criteria that categorizes the effect as insignificant, highly uncertain, or wholly beneficial
- A NOT LIKELY TO ADVERSELY AFFECT determination is made using criteria that categorizes the effect as insignificant, highly uncertain, or wholly beneficial.

Spray drift label mitigation language including an in-field spray drift buffer of 110 feet (for the 0.5 lb/A rate) and 220 feet (for the 1.0 lb/A rate) downwind at the time of application is expected to limit off site transport of dicamba DGA through spray drift. Therefore, the EPA expects that exposure will remain confined to the dicamba (DGA) treated field. Consequently, the EPA concluded a NO EFFECT determination for all but 24 species originally identified as potentially at-risk (in the screening-level assessment) because they are not expected to occur on cotton and soybean fields.

The 24 remaining listed species that were not ruled out because their range contains areas that include treated fields were considered in more depth in the EPA's refined endangered species assessments. Species-specific biological information along with dicamba (DGA) use patterns were also considered. After utilizing processes such as refined modeling incorporating species-specific information and migration habits, the EPA made a determination that exposure occurring on the field would have "may affects" (either "unlikely to adversely affect" or "likely to adversely affect" on 3 species (the Eskimo Curlew, the Spring Creek Bladderpod in Wilson county, TN, and the Audubon Crested Caracara in Palm Beach county, FL) within the States covered by this final decision. The EPA initiated informal consultation with the U.S. Fish and Wildlife Service (FWS) for the Eskimo curlew. The FWS concurred with the "unlikely to adversely affect" determination and no further action need be taken relative to this species. Furthermore, to address the remaining effects, the registrant submitted revised labeling and the EPA approved the labeling that prohibits application in both Wilson county, TN and Palm Beach county, FL. Therefore, the EPA makes no effect determinations for all listed species that are expected to be on the treated fields.

Additionally, the agency considered the potential effects attributed to runoff. As refined modeling predictions indicate that expected exposures from runoff (sheet flow) are below the most sensitive toxicological endpoint thresholds, the EPA's analysis also supports a no effects determination for runoff exposure for off-field listed plants for the new labeled use of dicamba DGA. To further protect species off the treated field against runoff, rainfast mitigation is required on the label ("Do not irrigate treated fields for at least 24 hours after application of this product. Do not make application of this product if rain is expected in the next 24 hours.").

V. Resistance Management

The emergence of herbicide resistant weeds is an increasing problem that has become a significant issue to growers. This has led to a concern that the use of dicamba on GE crops may result in over-reliance on dicamba and result in a larger number of resistant weeds. Currently, in certain areas of the United States there are populations of Kochia and prickly lettuce known to be resistant to dicamba. Kochia infests millions of acres of soybean and cotton and, in addition, glyphosate-resistant biotypes have been identified in Kansas and Nebraska.

In an effort to address these issues, the EPA is requiring, as a term of registration, that Monsanto develop an Herbicide Resistance Management (HRM) plan that will promote herbicide resistance management efforts by growers, the registrant, and others. The plan mandates that Monsanto must investigate any reports of lack of performance. Dicamba users who experience a lack of performance can obtain direct support from Monsanto through a toll free telephone number that is identified on the label to get advice on how to resolve any uncontrolled weeds.

"Lack of performance" refers to inadequate weed control with various possible causes, including, but not limited to: application rate, stage of weed growth, environmental conditions, herbicide resistance, plugged nozzle, boom shut off, tank dilution, post-application weed flush, unexpected rainfall event, weed misidentification, etc. It can be challenging to distinguish emerging weed resistance from other causes at an early stage. Therefore, the EPA has identified criteria that should be used to evaluate instances of "lack of performance" to determine if they do in fact constitute "likely herbicide resistance." These "likely herbicide resistance" criteria are: (1) failure to control a weed species normally controlled by the herbicide at the dose applied, especially if control is achieved on adjacent weeds; or (2) a spreading patch of uncontrolled plants of a particular weed species; or (3) surviving plants mixed with controlled individuals of the same species (Norsworthy, et al., 2012). The identification of any of these criteria in the field indicates that "likely herbicide resistance" is present. The responsibilities of the registrant if "likely herbicide resistance" is found are discussed below.

Researchers, extension specialists, growers, USDA, and other leaders involved with pest management all acknowledge the importance of scouting (e.g., monitoring the fields) in herbicide resistance management. For the new uses, the labeling states that fields should be scouted before application of dicamba to identify the weed species present as well as their stage of growth. Fields also should be scouted after each application to identify lack of performance that may be the early signs of resistance. Additionally, the labeling states that in the event that a user encounters lack of performance they should report this to Monsanto or its representative using the toll-free number identified on the label.

When a lack of performance is identified and reported to the registrant, Monsanto or its representative must investigate and conduct a site visit if needed to evaluate the lack of performance using decision criteria identified by leading weed science experts in order to determine if "likely herbicide resistance" is present (also termed "possible resistance" by Norsworthy et al., 2012). A report of lack of herbicide performance to Monsanto will be the trigger to start this investigation.

When Monsanto or its representative applies the Norsworthy, et al., criteria cited above, and likely herbicide resistance is identified, Monsanto must proactively engage with the grower to control and contain likely resistant weeds in the infested area. This may be accomplished by re-treating with an herbicide or using mechanical control methods. After implementing these measures, Monsanto must follow-up with the growers, with the growers' permission, to determine if the likely resistant weeds have been controlled. Monsanto must also annually report to the EPA findings of likely herbicide resistance. In addition, prior to implementing control measures, Monsanto must make best efforts to obtain samples of the likely herbicide resistant weeds and/or seeds, and as soon as practicable, laboratory or greenhouse testing must be initiated in order to confirm whether resistance is the reason for the lack of herbicide efficacy.

Beginning January 15, 2018, on or before January 15th of each year thereafter, Monsanto must submit annual summary reports to the EPA. These reports must include a summary of the number of instances of likely and confirmed resistance by weed species, crop, and state. These reports will also summarize the status of laboratory or greenhouse testing for resistance. The annual reports will also address the disposition of incidents of likely or confirmed resistance reported in previous years.

Monsanto must report annually any inability to control likely resistant weeds to relevant stakeholders. To accomplish this, Monsanto must establish a website to facilitate delivery of resistance information to users.
Several best management practices that are designed to help users avoid initial occurrences of weed resistance appear on the final dicamba product label listed under the Herbicide Resistance Management heading of the label. These practices are discussed in Section VIII.B.3 of this document.

Refer to Section VIII.C below for the EPA's terms of registration to address the issue of weed resistance.

VI. Response to Comments

The agency received 21,710 comments in response to the public participation process (Docket ID: the EPA-HQ-OPP-2016-0187) regarding the EPA's proposed decision for the application to register the use of dicamba on GE cotton and GE soybeans. Comments received were both in favor of and opposed to the decision to register the new uses which will provide growers with additional tools to control broadleaf weeds. The EPA welcomes input from the public during the decision process when registering significant new uses, and is committed to reviewing the comments received and determining whether changes or further mitigation are necessary to meet the applicable statutory standards. the EPA reviewed and evaluated the comments received during the comment period before issuing this final regulatory decision. Since many of the comments covered similar concerns, the comments were grouped into major topic areas. Please see *Response to Public Comments Received Regarding the New Use of Dicamba on Dicamba-Tolerant Cotton and Soybeans* dated November 7, 2016 for the agency's response to these comments.

VII. Benefits

Growers throughout the United States have experienced yield and economic losses due to weeds developing resistance to the herbicide glyphosate and other heavily used herbicides. The need for additional tools to manage these resistant weeds has become important as resistance to both glyphosate and other herbicides has become a significant financial, production and pest management issue for many cotton and soybean growers. Weeds such as marestail, giant ragweed, common waterhemp, and Palmer amaranth can be difficult to control during the crop growing season. Previously registered uses of dicamba only allow for pre-plant application and post-harvest application in cotton for conventional or conservation tillage systems. Similarly, the previously registered uses of dicamba on soybeans only allows for preplant application along with a pre-harvest broadcast or spot treatment application. New postemergence uses of dicamba will expand weed management options on GE cotton and GE soybeans by providing an additional mechanism of action during the growing season. Dicamba used during the season will target new flushes of weeds, thereby reducing populations of these weeds and particularly will help reduce seed banks. Postemergence use of dicamba will expand options for weed control in cotton and soybeans and enable control of broadleaf weeds, including glyphosate-resistant biotypes.

VIII. Registration Decision

In accordance with FIFRA, the EPA only registers a pesticide when it finds that the use will not cause unreasonable adverse effects on man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of the pesticide. Under FIFRA, the EPA is charged with balancing the uncertainties and risks posed by a pesticide against the benefits associated with the use of the pesticide. The EPA must determine if the benefits in light of its use outweigh the risks in order for the agency to register a pesticide.

In the case for the new uses of dicamba on GE soybeans and GE cotton, and in consideration of all best available data and assessment methods, the EPA determines that its decision to register these uses meets the requirements of FIFRA. The database submitted to support the assessment of human health risk is sufficient for a full hazard evaluation and is considered complete and adequate to evaluate risks to infants and children. The agency has not identified any risks of concern in regards to human health, including all population subgroups, or for occupational handlers.

In terms of ecological risk, some LOCs were exceeded for certain birds, reptiles, amphibians, and mammals that may be in the treated fields. These assessments included conservative risk estimates using screening-level (worst case) assumptions that are unlikely to apply to the majority of the birds, reptiles, amphibians, and mammals that are outside of the treatment area. For example, it is assumed that animals would forage for food exclusively in the treated area consuming only the treated crop, neither of which is likely to be true. Additionally, the protections afforded by the labeling, such as the requirement of infield buffers, would reduce the likelihood of spray drift and volatilization that could affect organisms located beyond the treated field. Because of these additional restrictions, the EPA expects these uses to have less environmental impact than other currently registered products that do not require the same buffers. It is also noted that, if further refinements that included more realistic exposure scenarios were conducted, these risks would likely fall below the agency's levels of concern.

On the benefits side of the analysis, use of dicamba on GE soybeans and GE cotton is expected to become an important part of a resistance management strategy for these crops. Soybeans and cotton are extremely important agricultural commodities in the United States and the world. According to the USDA's National Agricultural Statistics Service, soybeans are grown on approximately 85 million acres and cotton is grown on approximately 9 million acres. USDA's Economic Research Service describes soybeans as the world's largest source of animal protein feed and the second largest source of vegetable oil, and describes cotton as one of the most important textile fibers in the world, accounting for around 35 percent of total world fiber use. The United States is the world's leading soybean producer and exporter, and together with China and India provide two-thirds of the world's cotton. USDA estimates the gross value of soybean production at approximately 48 billion dollars in the United States, and soybean is grown throughout the United States with more than 80 percent of the United States soybean acreage concentrated in the upper Midwest. The gross cotton production is estimated by USDA at over 6 billion dollars in the United States, and is grown in 17 states in the United States. However, resistance to glyphosate, the current market leader in soybeans and cotton, is having severe economic consequences in soybean and cotton production. The Weed Science Society of America and other weed control experts warn that the problem of glyphosate resistance is increasing, and that significant economic consequences will continue to increase without effective alternatives for weed control.

Consequentially, use of dicamba on GE soybeans and GE cotton is beneficial as it provides an effective tool to treat especially noxious weeds, such as marestail, giant ragweed, common waterhemp, and Palmer amaranth, including glyphosate-resistant biotypes that threaten soybean and cotton production today. By adding an effective tool to combat glyphosate-resistant weeds, dicamba can help reduce this difficult weed pressure and aid significantly in production, reducing economic losses to GE soybean and GE cotton growers. In addition, effective treatment of glyphosate-resistant weeds can help control the spread of resistance. And, as stated previously, using dicamba for these uses according to the approved labeling restrictions will include further beneficial protections such as in-field buffers, best practice requirements for drift management and application techniques, and active resistance management stewardship of weed populations.

The EPA finds these benefits important. Furthermore, this regulatory decision includes a number of requirements that are expected to effectively limit concerns for off field risk. This registration action is only for a product confirmed by data to be a lower volatility formulation. In addition, the label requires very specific and rigorous drift mitigation measures, including in-field buffers, aerial application prohibitions, boom height requirements, specific nozzle and spray pressure requirements, and wind and tractor speed limitations. These mitigations are known to profoundly impact any drift potential from pesticide application. In aggregate, these formulations and labeling requirements are expected to eliminate any offsite exposures and effectively prevent risk potential to people and non-target species.

After weighing all the risks of concern against the benefits of the new uses, the EPA finds that when the mitigation measures for these uses are applied, the benefits of the use of the pesticide outweighs any remaining minimal risks, if they exist at all. Therefore, registering these new uses will not generally cause unreasonable adverse effects on human health or the environment. the EPA believes that the available data and scientific assessments as well as the overall considerations for benefits for weed management in these important crops support a FIFRA Section 3(c)(7)(B) registration finding for the new uses. Although the EPA proposed registering dicamba under FIFRA section 3(c)(5), new data requirements have been identified through registration review that will be applicable to all dicamba products (and all uses), therefore the agency is registering these new uses under FIFRA section 3(c)(7)(B).

A. Data Requirements

Although there are currently no outstanding data require to support the final registration of this action, the EPA has identified data that will be required in connection with Registration Review activities for dicamba. Those requirements will be applicable to dicamba uses and products in general and would be handled in accordance with the registration review process.

B. Labeling Requirements

The following labeling is included in the final supplemental labels unless otherwise noted below.

1. Worker Protection

(Although the following Worker Protection labeling applies to the new uses, it is not included in the new supplemental labeling. This labeling can be found in the previously accepted master labeling that was accepted by the agency on May 1, 2014 for this product.)

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your state or tribe, consult the agency responsible for pesticide regulation.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 24 hours.

PPE required for mixers, loaders, applicators and other handlers is:

- Long-sleeved shirt and long pants
- Chemical-resistant gloves
- Shoes plus socks

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is:

- Coveralls worn over short sleeved shirt and short pants
- Chemical-resistant footwear plus socks
- Chemical-resistant gloves made of any waterproof material
- Chemical-resistant headgear for overhead exposure
- Protective eyewear

2. Environmental Hazards

(Although the following Environmental Hazards labeling applies to the new uses, it is not included in the new supplemental labeling. This labeling can be found in the previously accepted master labeling that was accepted by the agency on September 18, 2013 for this product.)

Do not apply directly to water, to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters or rinsate. Apply this product only as directed on the label.

This chemical is known to leach through soil into ground water under certain conditions as a result of agricultural use. Use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in ground water contamination.

3. Resistance Management

To aid in the prevention of developing weeds resistant to this product, the following steps should be followed:

- Scout fields before application to ensure herbicides and rates will be appropriate for the weed species and weed sizes present.
- Apply full rates of M1768 Herbicide for the most difficult to control weed in the field at the specified time (correct weed size) to minimize weed escapes.
- Scout fields after application to detect weed escapes or shifts in weed species.
- Report any incidence of non-performance of this product against a particular weed species to your Monsanto retailer, representative or call 1-844-RRXTEND.
- If resistance is suspected, treat weed escapes with an herbicide having a mode of action other than Group 4 and/or use non-chemical methods to remove escapes, as practical, with the goal of preventing further seed production.

Additionally, users should follow as many of the following herbicide resistance management practices as practicable:

- Use a broad spectrum soil-applied herbicide with other modes of action as a foundation in a weed control program.
- Utilize sequential applications of herbicides with alternative modes of action.
- Rotate the use of this product with non-Group 4 herbicides.
- Incorporate non-chemical weed control practices, such as mechanical cultivation, crop rotation, cover crops and weed-free crop seeds, as part of an integrated weed control program.
- Thoroughly clean plant residues from equipment before leaving fields suspected to contain resistant weeds.
- Avoid using more than two applications of dicamba and any other Group 4 herbicides within a single growing season,
- Manage weeds in and around fields, during and after harvest to reduce weed seed production.

4. Spray Drift Management

Nozzle type:

Use only Tee Jet® TTI11004 nozzle with a maximum operating pressure of 63 psi when applying XtendiMax™ With VaporGrip™ Technology or any other approved nozzle found at www.xtendimaxapplicationrequirements.com. Do not use any other nozzle and pressure combination not specifically listed on this website. www.xtendimaxapplicationrequirements.com

Spray Volume:

Apply this product in a minimum of 10 gallons of spray solution per acre. Use a higher spray volume when treating dense vegetation.

Equipment Ground Speed:

Select a ground speed that will deliver the desired spray volume while maintaining the desired spray pressure, but do not exceed a ground speed of 15 miles per hour. Slower speeds generally result in better spray coverage and deposition on the target area.

Spray boom Height:

Spray at the appropriate boom height based on nozzle selection and nozzle spacing, but do not exceed a boom height of 24 inches above target pest or crop canopy. Set boom to lowest effective height over the target pest or crop canopy based on equipment manufacturer's directions. Automated boom height controllers are recommended with large booms to better maintain optimum nozzle to canopy height.

Temperature and Humidity:

When making applications in low relative humidity or temperatures above 91 degrees Fahrenheit, set up equipment to produce larger droplets to compensate for evaporation. Larger droplets have a lower surface to volume ratio and can be impacted less by temperature and humidity. Droplet evaporation is most severe when conditions are both hot and dry.

Temperature Inversions:

Do not apply this product during a temperature inversion. Off-target movement potential can be high during a temperature inversion. During a temperature inversion, the atmosphere is very stable and vertical air mixing is restricted, which can cause small, suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light variable winds common during inversions. Temperature inversions are characterized by increasing temperatures with altitude and are common on evenings and nights with limited cloud cover and light to no wind. Cooling of air at the earth's surface takes place and warmer air is trapped above it. They can begin to form as the sun sets and often continue into the morning. Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing. The inversion will often dissipate with increased winds (above 3 MPH) or at sunrise when the surface air begins to warm (generally 3°F from morning low).

Wind Speed:

Drift potential is lowest between wind speeds of 3 to 10 miles per hour. Do not apply at wind speeds greater than 15 mph. A chart is included in the product label that lists the appropriate wind speeds and application conditions and restrictions.

5. Protection of Sensitive Areas:

Buffer

Maintain a 110 foot downwind buffer (when applying 22 fluid ounces of this product per acre) or a 220 foot downwind buffer (when applying 44 fluid ounces of this product per acre) between the last treated row and the closest downwind edge (in the direction in which the wind is blowing). If any of the following areas below are directly adjacent to the treated field, the areas listed below can be considered part of the buffer distance.

To maintain this required buffer zone:

- No application swath can be initiated in, or into an area that is within the applicable buffer distance.

The following areas may be included in the buffer distance calculation when adjacent to field edges:

- Roads, paved or gravel surfaces.
- Planted agricultural fields containing: corn, dicamba tolerant cotton, dicamba tolerant soybean, sorghum, proso millet, small grains and sugarcane. If the applicator intends to include such crops as dicamba tolerant cotton and/or dicamba tolerant soybeans in the buffer distance calculation, the applicator must confirm the crops are in fact dicamba tolerant and not conventional cotton and/or soybeans.
- Agricultural fields that have been prepared for planting.
- Areas covered by the footprint of a building, silo, or other man made structure with walls and or roof.

Susceptible Plants:

Do not apply under circumstances where spray drift may occur to food, forage, or other plantings that might be damaged or the crops thereof rendered unfit for sale, use or consumption. Do not allow contact of herbicide with foliage, green stems, exposed non- woody roots of crops, and desirable plants, including beans, cotton, flowers, fruit trees, grapes, ornamentals, peas, potato, soybean, sunflower, tobacco, tomato, and other broadleaf plants, because severe injury or destruction may result, including plants in a greenhouse. Small amounts of spray drift that may not be visible may injure susceptible broadleaf plants.

Applicators are required to ensure that they are aware of the proximity to sensitive areas, and to avoid potential adverse effects from off-target movement of M1768 Herbicide. Before making an application, the applicator must survey the application site for neighboring sensitive areas prior to application. The applicator should also consult sensitive crop registries for locating sensitive areas where available.

Failure to follow the requirements in this label could result in severe injury or destruction to desirable sensitive broadleaf crops and trees when contacting their roots, stems or foliage.

Specifically, commercially grown tomatoes and other fruiting vegetables (EPA crop group 8), cucurbits (EPA crop group 9), and grapes are sensitive to dicamba. In order to prevent unintended damage from any drift of this product, do not apply this product when the wind is blowing towards adjacent commercially grown sensitive crops.

6. Application Restrictions:

- Do not apply this product aerially.
- Do not tank mix any other herbicides with M1768 Herbicide.
- Do not make an application of the product if rain is expected in the next 24 hours.
- The maximum combined quantity of this product that may be applied for all preplant, at-planting, and preemergence applications is 44 fluid ounces (1.0 lb a.e. dicamba) per acre per season for both cotton and soybeans.
- The maximum application rate for a single, preplant, at-planting, or preemergence application must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre for both cotton and soybeans.
- The combined total application rate from crop emergence up to R1 must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre for soybeans per year.
- The combined total application rate from crop emergence up to 7 days' pre-harvest must not exceed 88 fluid ounce (2.0lb a.e dicamba) per acre for cotton per year.
- All applications for both cotton and soybeans must not exceed 88 fluid ounces (2.0 lb a.e dicamba) per acre per year.

C. Registration Terms

The EPA has determined that certain registration terms are needed to ensure that likely weed resistance as discussed in section V will be adequately addressed. The EPA believes that it is important to address likely weed resistance and not wait until confirmation that resistance has been found. The EPA is basing the final registration terms on a list of criteria, presented in the peer-reviewed publication, Norsworthy, et al., "Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations," *Weed Science* 2012 Special Issue: 31–62 (Norsworthy criteria).

1. Herbicide Resistance Management (HRM) Plan

The EPA is issuing this registration with a term that requires Monsanto to have an Herbicide Resistance Management (HRM) Plan for M1768 Herbicide. The HRM Plan will focus on educating growers on the appropriate use of the M1768 Herbicide and the associated dicamba-tolerant seeds. The EPA is requiring that the HRM plan include the following measures that will reduce the potential for the development of weed resistance.

a. Investigation

The EPA is requiring that Monsanto or its representative investigate reports of lack of herbicide efficacy as reported by users following "scouting." When investigating any reports of lack of herbicide efficacy, Monsanto or its representative must make an effort to evaluate the field for "likely resistance" by applying the "Norsworthy criteria."

b. Remediation

If "likely resistance" is found, Monsanto must engage with the grower to control and prevent the spread of likely resistant weeds in the affected area. Monsanto must provide the grower with specific information and recommendations to control and contain likely resistant weeds, including retreatment and/or other nonchemical controls, as appropriate, and if requested by the grower, Monsanto will assist the grower in implementing those additional weed control measures. Additionally, Monsanto must routinely collect plant material for further testing.

c. Annual Reporting of Herbicide Resistance to the EPA

Monsanto must submit annual summary reports to the EPA that include a summary of the number of instances of likely and confirmed weed resistance by weed species, crop, and state. The annual reports must include summaries of the status of laboratory or greenhouse testing for resistance. The annual reports will also address the disposition of incidents of likely or confirmed resistance reported in previous years. These reports will not replace or supplement adverse effects reporting required under FIFRA § 6(a)(2).

d. Reporting of Likely Resistance to other Interested Parties

Monsanto must inform growers and other stakeholders of cases of likely resistance that are not resolved by the application of additional weed control measures.

e. Education

Monsanto must develop an education program that will provide growers with the best available information on herbicide resistance management.

D. Registration Expiration

The issue of weed resistance is an extremely important issue to keep under control and can be very fast moving. Also, the EPA is aware of reports of off-site incidents potentially due to the illegal use of dicamba products that do not employ the lower volatility formulation of dicamba DGA plus VaporGrip™ (M-1768) on GE cotton and GE soybean. Although the EPA finds that herbicide resistance is adequately addressed by the required herbicide resistance plan and does not expect off-site incidents to occur due to the specific measures required (described above) to this registration, the agency is requiring expiration dates that will ensure that the EPA retains the ability to easily modify the registration or allow the registration to terminate if necessary.

Specifically, this registration automatically expires on November 9, 2018, unless the EPA determines before that date that off-site incidents are not occurring at unacceptable frequencies or levels. If this automatic expiration date is amended (in whatever way the EPA determines is appropriate at the time), it shall not be amended to a date later than November 9, 2021, by which date this registration will automatically expire unless the EPA determines before that date that herbicide resistance to dicamba is not occurring at unacceptable frequencies or levels, and that off-site incidents are not occurring at unacceptable frequencies or levels.

E. Geographic Limitation on Use of Dicamba M1768 Herbicide

The EPA is issuing these new uses only to be sold and used in Alabama, Arizona, Arkansas, Colorado, Delaware, Florida, Georgia, Illinois, Iowa, Indiana, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, West Virginia, and Wisconsin.

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[i] Norsworthy, J. K., Ward, S. M., Shaw, D. R., Llewellyn, R. S., Nichols, R. L., Webster, T. M., Bradley, K. W., Frisvold, G., Powles, S. B., Burgos, N. R., Witt, W. W., Barrett, M. 2012. Reducing the risks of herbicide resistance: Best Management Practices and Recommendations. Weed Science Special Issue: 31-62. http://wssajournals.org/doi/pdf/10.1614/WS-D-11-00155.1

ACCEPTED
11/09/2016
Under the Federal Insecticide, Fungicide and Rodenticide Act as amended, for the pesticide registered under
EPA Reg. No. 524-617

SUPPLEMENTAL LABELING

READ THE ENTIRE LABEL FOR XTENDIMAX™ WITH VAPORGRIP™ TECHNOLOGY BEFORE PROCEEDING WITH THE USE DIRECTIONS CONTAINED IN THIS SUPPLEMENTAL LABELING.

When using XtendiMax™ With VaporGrip™ Technology as permitted according to this supplemental labeling, read and follow all applicable directions, restrictions, and precautions on the container label and booklet provided with the product container and on this supplemental labeling. This supplemental labeling must be in the possession of the user at the time of pesticide application.

This supplemental label expires on 11/09/2018 and must not be used or distributed after this date.

XtendiMax™ With VaporGrip™ Technology

EPA Reg. No. 524-617

GROUP	4	HERBICIDE

FOR PREEMERGENCE AND POSTEMERGENCE USE ON ROUNDUP READY 2 XTEND® SOYBEANS

Keep out of reach of children

CAUTION!

In case of an emergency involving this product, call collect, day or night, 314-694-4000.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in any manner inconsistent with its labeling.

This labeling must be in the possession of the user at the time of herbicide application.

ROUNDUP READY 2 XTEND® SOYBEANS CONTAIN A PATENTED GENE THAT PROVIDES TOLERANCE TO DICAMBA, THE ACTIVE INGREDIENT IN THIS PRODUCT.

THIS PRODUCT WILL CAUSE SEVERE CROP INJURY OR DESTRUCTION AND YIELD LOSS IF APPLIED TO SOYBEANS THAT ARE NOT DICAMBA TOLERANT, INCLUDING SOYBEANS WITH A TRAIT ENGINEERED TO CONFER TOLERANCE TO AUXIN HERBICIDES OTHER THAN DICAMBA. FOLLOW THE REQUIREMENTS SET FORTH HEREIN TO PREVENT SEVERE CROP INJURY OR DESTRUCTION AND YIELD LOSS. CONTACT WITH FOLIAGE, GREEN STEMS, OR FRUIT OF CROPS, OR ANY DESIRABLE PLANTS THAT DO NOT CONTAIN A DICAMBA TOLERANCE GENE OR ARE NOT NATURALLY TOLERANT TO DICAMBA, COULD RESULT IN SEVERE PLANT INJURY OR DESTRUCTION.

Information on Roundup Ready 2 Xtend® Soybeans can be obtained from your seed supplier or Monsanto representative. Roundup Ready 2 Xtend® Soybeans must be purchased from an authorized licensed seed supplier.

The instructions contained in this Monsanto Supplemental Label include all applications of XtendiMax™ With VaporGrip™ Technology that may be made to Roundup Ready 2 Xtend® Soybeans during the cropping season. DO NOT combine these instructions with other instructions in the "SOYBEAN" Section of any other XtendiMax™ With VaporGrip™ Technology label for use over crops that do not contain the dicamba tolerance trait.

Note: Roundup Ready 2 Xtend® Soybeans and methods of controlling weeds and applying dicamba in a Roundup Ready 2 Xtend® Soybean crop are protected under U.S. patent law. No license to use Roundup Ready 2 Xtend® Soybeans are granted or implied with the purchase of this herbicide product. Roundup Ready 2 Xtend® Soybeans are owned by Monsanto and a license must be obtained from Monsanto before using it. Contact your Authorized Monsanto Retailer for information on obtaining a license to Roundup Ready 2 Xtend® Soybeans.

See the "PRODUCT INFORMATION" and "APPLICATION EQUIPMENT AND TECHNIQUES" sections of the XtendiMax™ With VaporGrip™ Technology product label for important use information. In the event that there are any inconsistencies with the directions for use between this supplemental label and any other labeling for this product, follow the directions for use on this supplemental label.

Training and education on proper pesticide application is encouraged. Applicators should visit www.xtendimaxapplicationrequirements.com for training information and opportunities relative to this product.

TYPES OF APPLICATIONS: Preplant; At-Planting; Preemergence; Postemergence (In-crop)

XtendiMax™ With VaporGrip™ Technology is approved by U.S. EPA to be used in the following states, subject to county restriction as noted: Alabama, Arkansas, Arizona, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin.

Restrictions

- Do not apply this product aerially.
- Do not make application of this product if rain is expected in the next 24 hours.

USE INSTRUCTIONS

Apply this product in a minimum of 10 gallons of spray solution per acre as a broadcast application. For best performance, control weeds early when they are less than 4 inches. Timely application will improve control and reduce weed competition. Refer to the following table for maximum application rates of this product with Roundup Ready 2 Xtend® Soybeans.

Maximum Application Rates	
Combined total per year for all applications	88 fluid ounces per acre (2.0 lb. a.e. dicamba per acre)
Total of all Burndown/Early preplant, Preplant, At-Planting, and Preemergence applications	44 fluid ounces per acre (1.0 lb. a.e. dicamba per acre)
Total of all In-crop applications from emergence up to and including beginning bloom (R1 stage soybeans)	44 fluid ounces per acre (1.0 lb. a.e. dicamba per acre)
Maximum In-crop, single application	22 fluid ounces per acre (0.5 lb. a.e. dicamba per acre)

a.e. – acid equivalent

Refer to Table 1 of the XtendiMax™ With VaporGrip™ Technology label booklet for application rates for weed type and growth stage controlled by this product. Maximum in-crop application rate should be used when treating tough to control weeds, dense vegetative growth or weeds with a well-established root system.

Preplant, At-Planting, Preemergence

USE INSTRUCTIONS: This product may be used to control broadleaf weeds and may be applied before, during or immediately after planting Roundup Ready 2 Xtend® Soybeans. Refer to the "WEEDS CONTROLLED" section of the label booklet for XtendiMax™ With VaporGrip™ Technology for specific weeds controlled.

RESTRICTIONS: The maximum combined quantity of this product that may be applied for all preplant, at-planting, and preemergence applications is 44 fluid ounces (1.0 lb a.e. dicamba) per acre per season. The maximum application rate for a single, preplant, at-planting, or preemergence application must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre. Do not apply less than 22 fluid ounces (0.5 lb a.e. dicamba) per acre.

Postemergence (In-crop)

USE INSTRUCTIONS: This product may be used to control broadleaf weeds in Roundup Ready 2 Xtend® Soybeans. In-crop applications of this product can be made from emergence (cracking) up to and including beginning bloom (R1 growth stage of soybeans). Do not make in-crop applications of this product after beginning bloom (R1 growth stage of soybeans). The maximum and minimum rate for any single, in-crop application is 22 fluid ounces (0.5 lb a.e. dicamba) per acre. Using the appropriate application rate may reduce the selection for resistant weeds. For best performance, control weeds early when they are less than 4 inches. Monsanto Company does not warrant product performance of applications to labeled weeds greater than 4 inches in height.

A second application of this product up to the R1 crop growth stage may be necessary to control new flushes of weeds. Allow at least 7 days between applications. For best results, apply XtendiMax™ With VaporGrip™ Technology after some weed re-growth has occurred.

Application of this product postemergence and under stressful environments may cause temporary loss of turgor, a response commonly described as leaf droop in Roundup Ready 2 Xtend® Soybeans. Typically, affected plants recover in 1-3 days depending on the level of droop and environmental conditions.

RESTRICTIONS:

- The combined total application rate from crop emergence up to R1 must not exceed 44 fluid ounces (1.0 lb. a.e. dicamba) per acre.
- The maximum single, in-crop application rate must not exceed 22 fluid ounces (0.5 lb. a.e. dicamba) per acre.
- The combined total per year for all applications must not exceed 88 fluid ounces (2.0 lb. a.e. dicamba) per acre.
- Allow at least 7 days between final application and harvest or feeding of soybean forage.
- Allow at least 14 days between final application and harvest or feeding of soybean hay.

TANK-MIXING INSTRUCTIONS

XtendiMax™ With VaporGrip™ Technology may only be tank-mixed with products that have been tested and found not to adversely affect the offsite movement potential of XtendiMax™ With VaporGrip™ Technology. A list of those products may be found at www.xtendimaxapplicationrequirements.com. DO NOT tank mix any product with XtendiMax™ With VaporGrip™ Technology unless:

1. You check the list of tested products found not to adversely affect the offsite movement potential of XtendiMax™ With VaporGrip™ Technology at www.xtendimaxapplicationrequirements.com no more than 7 days before applying XtendiMax™ With VaporGrip™ Technology; and
2. The intended tank-mix product is identified on the list of tested products; and
3. The intended products are not prohibited on either this supplemental label or the label of the tank mix product.
4. Additional Warnings and Restrictions:

    - Some COC, HSOC and MSO adjuvants may cause a temporary crop response.
    - Do not tank mix products containing ammonium salts such as ammonium sulfate and urea ammonium nitrate.
    - Drift reduction agents (DRAs) can minimize the percentage of driftable fines. However, the applicator must check www.xtendimaxapplicationrequirements.com to determine if the DRA is listed and check with the DRA manufacturer to determine if the DRAs will work effectively with the approved spray nozzle, spray pressure, and the desired spray solution.

TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, MONSANTO MAKES NO RECOMMENDATION OR WARRANTY HEREIN REGARDING THE USE OF ANY PRODUCT THAT MAY APPEAR ON THE WEBSITE REFERENCED ABOVE, REGARDLESS OF WHETHER SUCH PRODUCT IS USED ALONE OR IN A TANK MIX WITH XTENDIMAX™ WITH VAPORGRIP™ TECHNOLOGY. BUYER AND ALL USERS ARE SOLELY RESPONSIBLE FOR ANY LACK OF PERFORMANCE, LOSS, OR DAMAGE IN CONNECTION WITH THE USE OR HANDLING OF ANY SUCH PRODUCT ALONE OR IN A TANK MIX WITH XTENDIMAX™ WITH VAPORGRIP™ TECHNOLOGY. See the section titled "LIMIT OF WARRANTY AND LIABILITY" herein for more information.

WEED RESISTANCE MANAGEMENT

Some naturally occurring weed biotypes that are tolerant (resistant) to dicamba may exist due to genetic variability in a weed population. Where resistant biotypes exist, the repeated use of herbicides with the same sites of action can lead to the selection for resistant weeds. Certain agronomic practices can delay or reduce the likelihood that resistant weed populations will develop and can be utilized to manage weed resistance once it occurs.

Do not use less than 22 fluid ounces per acre (0.5 lb a.e./A) of this product in a single application. Using the appropriate application rate can minimize the selection for resistant weeds.

Proactively implementing diversified weed control strategies to minimize selection for weed populations resistant to one or more herbicides is a best practice. A diversified weed management program may include the use of multiple herbicides with different sites of action and overlapping weed spectrum with or without tillage operations and/or other cultural practices. Research has demonstrated that using the labeled rate and directions for use is important to delay the selection for resistance.

The continued effectiveness of this product depends on the successful management of the weed resistance program; therefore, it is very important to perform the following actions.

To aid in the prevention of developing weeds resistant to this product, the following steps should be followed where practical:

- Scout fields before application to ensure herbicides and rates will be appropriate for the weed species and weed sizes present.
- Apply full rates of XtendiMax™ With VaporGrip™ Technology for the most difficult to control weed in the field at the specified time (correct weed size) to minimize weed escapes.
- Scout fields after application to detect weed escapes or shifts in weed species.
- Report any incidence of non-performance of this product against a particular weed species to your Monsanto retailer, representative or call 1-844-RRXTEND.
- If resistance is suspected, treat weed escapes with an herbicide having a site of action other than Group 4 and/or use non-chemical methods to remove escapes, as practical, with the goal of preventing further seed production.

Additionally, users should follow as many of the following herbicide resistance management practices as is practical:

- Use a broad spectrum soil-applied herbicide with other sites of action as a foundation in a weed control program.
- Utilize sequential applications of herbicides with alternative sites of action.
- Rotate the use of this product with non-Group 4 herbicides.
- Avoid making more than two applications of dicamba and any other Group 4 herbicides within a single growing season unless mixed with another mechanism of action with an overlapping spectrum for the difficult to control weeds.
- Incorporate non-chemical weed control practices, such as mechanical cultivation, crop rotation, cover crops and weed-free crop seeds, as part of an integrated weed control program.
- Thoroughly clean plant residues from equipment before leaving fields suspected to contain resistant weeds.
- Manage weeds in and around fields, during and after harvest to reduce weed seed production.

Contact the local agricultural extension service, Monsanto representative, agricultural retailer or crop consultant for further guidance on weed control practices as needed.

APPLICATION EQUIPMENT AND TECHNIQUES

DO NOT APPLY THIS PRODUCT TO ROUNDUP READY 2 XTEND® SOYBEANS USING AERIAL SPRAY EQUIPMENT.

Apply this product using properly maintained and calibrated equipment capable of delivering the desired volumes.

SPRAY DRIFT MANAGEMENT

Do not allow herbicide solution to mist, drip, drift or splash onto desirable vegetation because severe injury or destruction to desirable broadleaf plants could result. The following drift management requirements must be followed.

Controlling Droplet Size

Drift potential may be reduced by applying large droplets that provide sufficient coverage and control. Applying larger droplets can reduce drift potential, but will not prevent drift if the application is made improperly, or under unfavorable environmental conditions (see the **“Wind Speed and Direction”, “Temperature and Humidity”** and **“Temperature Inversions”** sections of this label).

- **Nozzle type.** Use only Tee Jet® TTI11004 nozzle with a maximum operating pressure of 63 psi when applying XtendiMax™ With VaporGrip™ Technology or any other approved nozzle found at www.xtendimaxapplicationrequirements.com. Do not use any other nozzle and pressure combination not specifically listed on this website.

- **Hooded Sprayers.** Using a hooded sprayer in combination with approved nozzles may further reduce drift potential.

- **Spray Volume.** Apply this product in a minimum of 10 gallons of spray solution per acre. Use a higher spray volume when treating dense vegetation. Higher spray volumes may also allow the use of larger nozzle orifices (sizes) which produce coarser spray droplets.

- **Equipment Ground Speed.** Select a ground speed that will deliver the desired spray volume while maintaining the desired spray pressure, but do not exceed a ground speed of 15 miles per hour. Slower speeds generally result in better spray coverage and deposition on the target area.

- **Spray boom Height.** Spray at the appropriate boom height based on nozzle selection and nozzle spacing, but do not exceed a boom height of 24 inches above target pest or crop canopy. Set boom to lowest effective height over the target pest or crop canopy based on equipment manufacturer's directions. Automated boom height controllers are recommended with large booms to better maintain optimum nozzle to canopy height. Excessive boom height will increase the drift potential.

Temperature and Humidity
When making applications in low relative humidity or temperatures above 91 degrees Fahrenheit, set up equipment to produce larger droplets to compensate for evaporation. Larger droplets have a lower surface to volume ratio and can be impacted less by temperature and humidity. Droplet evaporation is most severe when conditions are both hot and dry.

Temperature Inversions
Do not apply this product during a temperature inversion. Drift potential can be high during a temperature inversion.

- During a temperature inversion, the atmosphere is very stable and vertical air mixing is restricted, which can cause small, suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light variable winds common during inversions.
- Temperature inversions are characterized by increasing temperatures with altitude and are common on evenings and nights with limited cloud cover and light to no wind. Cooling of air at the earth's surface takes place and warmer air is trapped above it. They can begin to form as the sun sets and often continue into the morning.
- Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing.
- The inversion will often dissipate with increased winds (above 3 mph) or at sunrise when the surface air begins to warm (generally 3°F from morning low).

Wind Speed and Direction

- Drift potential is lowest between wind speeds of 3 to 10 miles per hour.
- Do not apply at wind speeds greater than 15 mph.
- For XtendiMax™ With VaporGrip™ Technology wind speed and direction restrictions see below table:

Wind speed	Application conditions and restrictions
<3 mph	Do not apply XtendiMax™ With VaporGrip™ Technology.
3-10 mph	Optimum application conditions for XtendiMax™ With VaporGrip™ Technology provided all other application requirements in this label are met.
>10 – 15 mph	Do not apply product when wind is blowing toward non-target sensitive crops.
> 15 mph	Do not apply XtendiMax™ With VaporGrip™ Technology.

NOTE: Local terrain can influence wind patterns. Every applicator must be familiar with local wind patterns and how they affect drift.

PROTECTION OF SENSITIVE AREAS

Maintain a 110 foot downwind buffer (when applying 22 fluid ounces of this product per acre) or a 220 foot downwind buffer (when applying 44 fluid ounces of this product per acre) between the last treated row and the closest downwind edge (in the direction in which the wind is blowing). If any of the following areas below are directly adjacent to the treated field, the areas listed below can be considered part of the buffer distance.

To maintain this required buffer zone:

- No application swath can be initiated in, or into an area that is within the applicable buffer distance.

The following areas may be included in the buffer distance calculation when adjacent to field edges:

- Roads, paved or gravel surfaces,
- Planted agricultural fields containing: corn, dicamba tolerant cotton, dicamba tolerant soybean, sorghum, proso millet, small grains and sugarcane. If the applicator intends to include such crops as dicamba tolerant cotton and/or dicamba tolerant soybeans in the buffer distance calculation, the applicator must confirm the crops are in fact dicamba tolerant and not conventional cotton and/or soybeans.
- Agricultural fields that have been prepared for planting.
- Areas covered by the footprint of a building, silo, or other man made structure with walls and or roof.

Non-target Susceptible Crops

Failure to follow the requirements in this label could result in severe injury or destruction to desirable sensitive broadleaf crops and trees when contacting their roots, stems or foliage.

- Do not apply under circumstances where drift may occur to food, forage, or other plantings that might be damaged or the crops thereof rendered unfit for sale, use or consumption.

- Do not allow contact of herbicide with foliage, green stems, exposed non-woody roots of crops, and desirable plants, including beans, cotton, flowers, fruit trees, grapes, ornamentals, peas, potato, soybean, sunflower, tobacco, tomato, and other broadleaf plants because severe injury or destruction may result, including plants in a greenhouse.

- Small amounts of dicamba that may not be visible may injure susceptible broadleaf plants.

- Applicators are required to ensure that they are aware of the proximity to non-target susceptible crops, and to avoid potential adverse effects from drift of XtendiMax™ with VaporGrip™ Technology.

Before making an application, the applicator must survey the application site for neighboring non-target susceptible crops. The applicator must also consult sensitive crop registries to identify any commercial specialty or certified organic crops that may be located near the application site.

DO NOT APPLY this product when the wind is blowing toward adjacent commercially grown dicamba sensitive crops, including but not limited to, commercially grown tomatoes and other fruiting vegetables (EPA crop group 8), cucurbits (EPA crop group 9), and grapes.

Application Awareness

AVOIDING SPRAY DRIFT AT THE APPLICATION SITE IS THE RESPONSIBILITY OF THE APPLICATOR

The interaction of equipment and weather related factors must be monitored to maximize performance and on-target spray deposition. The applicator is responsible for considering all of these factors when making a spray decision. The applicator is responsible for compliance with state and local pesticide regulations, including any state or local pesticide drift regulations.

Proper spray system equipment cleanout
Minute quantities of dicamba may cause injury to non-dicamba-tolerant soybeans and other sensitive crops (see the "Non-target Susceptible Crops" section of this label for more information).
Clean equipment immediately after using this product using a triple rinse procedure as follows:

1. After spraying, drain the sprayer (including boom and lines) immediately. Do not allow the spray solution to remain in the spray boom lines overnight prior to flushing.
2. Flush tank, hoses, boom and nozzles with clean water.
3. Inspect and clean all strainers, screens and filters.
4. Prepare a cleaning solution with a commercial detergent or sprayer cleaner or ammonia according to the manufacturer's directions.

5. Take care to wash all parts of the tank, including the inside top surface. Start agitation in the sprayer and thoroughly recirculate the cleaning solution for at least 15 minutes. All visible deposits must be removed from the spraying system.
6. Flush hoses, spray lines and nozzles for at least 1 minute with the cleaning solution.
7. Repeat above steps for two additional times to accomplish an effective triple rinse.
8. Remove nozzles, screens and strainers and clean separately in the cleaning solution after completing the above procedures.
9. Appropriately dispose of rinsate from steps 1-7 in compliance with all applicable laws and regulations.
10. Drain sump, filter and lines.
11. Rinse the complete spraying system with clean water.

All rinse water must be disposed of in compliance with local, state, and federal requirements.

CROP ROTATIONAL RESTRICTIONS

No rotational cropping restrictions apply when rotating to Roundup Ready 2 Xtend® Soybeans or Bollgard II® XtendFlex® Cotton. For other crops the interval between application and planting rotational crop is given below. When counting days from the application of this product, do not count days when the ground is frozen. Planting at intervals less than specified below may result in crop injury. Moisture is essential for the degradation of this herbicide in soil. If dry weather prevails, use cultivation to allow herbicide contact with moist soil.

Planting/replanting restrictions for XtendiMax™ With VaporGrip™ Technology applications of 33 fluid ounces per acre or less
For corn, cotton (except Bollgard II® XtendFlex® Cotton), sorghum, and soybean (except Roundup Ready 2 Xtend® Soybeans), follow the planting restrictions in the directions for use for preplant application in **Section 10. Crop-Specific Information** of the label booklet. Do not plant barley, oat, wheat, and other grass seedings for 15 days for every 11 fluid ounces of this product applied per acre east of the Mississippi River and 22 days for every 11 fluid ounces per acre applied west of the Mississippi River. No planting restrictions apply beyond 120 days after application of this product.

Planting/replanting restrictions for applications of more than 33 fluid ounces and up to 44 fluid ounces of XtendiMax™ With VaporGrip™ Technology per acre
Wait a minimum of 120 days after application of this product before planting corn, sorghum and cotton (except Bollgard II® XtendFlex® Cotton) east of the Rocky Mountains and before planting all other crops (except Roundup Ready 2 Xtend® Soybeans) grown in areas receiving 30 inches or more rainfall annually. Wait a minimum of 180 days before planting crops in areas with less than 30 inches of annual rainfall. Wait a minimum of 30 days for every 22 fluid ounces of this product applied per acre before planting barley, oat, wheat, and other grass seedings east of the Mississippi River and 45 days for every 22 fluid ounces of this product applied per acre west of the Mississippi River.

LIMIT OF WARRANTY AND LIABILITY

Monsanto Company ("Company") warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes set forth in this supplemental label ("Directions") when used in accordance with the Directions under the conditions described therein. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, NO OTHER EXPRESS WARRANTY OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE. This warranty is also subject to the conditions and limitations stated herein. Specifically, and without limiting the foregoing, MONSANTO MAKES NO RECCOMENDATION OR WARRANTY HEREIN REGARDING THE USE OF ANY PRODUCTS THAT MAY APPEAR ON THE WEBSITE REFERENCED IN THE TANK-MIXING INSTRUCTIONS HEREIN, REGARDLESS OF WHETHER SUCH PRODUCT IS USED ALONE OR IN A TANK MIX WITH XTENDIMAX™ WITH VAPORGRIP™ TECHNOLOGY. BUYER AND ALL USERS ARE SOLELY RESPONSIBLE FOR ANY LACK OF PERFORMANCE, LOSS, OR DAMAGE IN CONNECTION WITH THE USE OR HANDLING OF ANY SUCH PRODUCT ALONE OR IN A TANK MIX WITH XTENDIMAX™ WITH VAPORGRIP™ TECHNOLOGY.

Buyer and all users shall promptly notify this Company of any claims whether based in contract, negligence, strict liability, tort, or otherwise.

To the extent consistent with applicable law, buyer and all users are responsible for all loss or damage from use or handling which results from conditions beyond the control of this Company, including, but not limited to, incompatibility with products other than those expressly recommended by Company in the Directions, application to or contact with desirable vegetation, failure of this product to control weed biotypes which develop resistance to dicamba, unusual weather, weather conditions which are outside the range considered normal at the application site and for the time period when the product is applied, as well as weather conditions which are outside the application ranges set forth in the Directions, application in any manner not explicitly set forth in the Directions, moisture conditions outside the moisture range specified in the Directions, or the presence of products other than those expressly recommended by Company in the Directions in or on the soil, crop or treated vegetation.

This Company does not warrant any product reformulated or repackaged from this product except in accordance with this Company's stewardship requirements and with express written permission from this Company.

For in-crop (over-the-top) uses on crops within the Roundup Ready® Xtend™ Crop System, crop safety and weed control performance are not warranted by Company when this product is used in conjunction with "brown bag" or "bin run" seed saved from previous year's production and replanted.

TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE LIMIT OF THE LIABILITY OF THIS COMPANY OR ANY OTHER SELLER FOR ANY AND ALL LOSSES, INJURIES OR DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT (INCLUDING CLAIMS BASED IN CONTRACT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT OR OTHERWISE) SHALL BE THE PURCHASE PRICE PAID BY THE USER OR BUYER FOR THE QUANTITY OF THIS PRODUCT INVOLVED, OR, AT THE ELECTION OF THIS COMPANY OR ANY OTHER SELLER, THE REPLACEMENT OF SUCH QUANTITY, OR, IF NOT ACQUIRED BY PURCHASE, REPLACEMENT OF SUCH QUANTITY. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, IN NO EVENT SHALL THIS COMPANY OR ANY OTHER SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES.

Upon opening and using this product, buyer and all users are deemed to have accepted the terms of this LIMIT OF WARRANTY AND LIABILITY which may not be varied by any verbal or written agreement.

These terms apply to this supplemental labeling and if these terms are not acceptable, return the product unopened at once.

MONSANTO COMPANY
800 N. LINDBERGH BLVD.
ST. LOUIS, MISSOURI 63167 USA

[*INSERT DATE*]

[*INSERT PRINT PLATE NUMBER*]

[*INSERT SUPPLEMENTAL LABEL EXPIRATION DATE*]

ACCEPTED
11/09/2016
Under the Federal Insecticide, Fungicide and Rodenticide Act as amended, for the pesticide registered under
EPA Reg. No. 524-617

SUPPLEMENTAL LABELING

READ THE ENTIRE LABEL FOR XTENDIMAX™ WITH VAPORGRIP™ TECHNOLOGY BEFORE PROCEEDING WITH THE USE DIRECTIONS CONTAINED IN THIS SUPPLEMENTAL LABELING.

When using XtendiMax™ With VaporGrip™ Technology as permitted according to this supplemental labeling, read and follow all applicable directions, restrictions, and precautions on the container label and booklet provided with the product container and on this supplemental labeling. This supplemental labeling must be in the possession of the user at the time of pesticide application.

This supplemental label expires on 11/09/2018 and must not be used or distributed after this date.

XtendiMax™ With VaporGrip™ Technology

EPA Reg. No. 524-617

GROUP	4	HERBICIDE

FOR PREEMERGENCE AND POSTEMERGENCE USE ON BOLLGARD II® XTENDFLEX® COTTON

Keep out of reach of children

CAUTION!

In case of an emergency involving this product, call collect, day or night, 314-694-4000.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in any manner inconsistent with its labeling.

This labeling must be in the possession of the user at the time of herbicide application.

BOLLGARD II® XTENDFLEX® COTTON CONTAINS A PATENTED GENE THAT PROVIDES TOLERANCE TO DICAMBA, THE ACTIVE INGREDIENT IN THIS PRODUCT. THIS PRODUCT WILL CAUSE SEVERE CROP INJURY OR DESTRUCTION AND YIELD LOSS IF APPLIED TO COTTON THAT IS NOT DICAMBA TOLERANT, INCLUDING COTTON WITH A TRAIT ENGINEERED TO CONFER TOLERANCE TO AUXIN HERBICIDES OTHER THAN DICAMBA. FOLLOW THE REQUIREMENTS SET FORTH HEREIN TO PREVENT SEVERE CROP INJURY OR DESTRUCTION AND YIELD LOSS. CONTACT WITH FOLIAGE, GREEN STEMS, OR FRUIT OF CROPS, OR ANY DESIRABLE PLANTS THAT DO NOT CONTAIN A DICAMBA TOLERANCE GENE OR ARE NOT NATURALLY TOLERANT TO DICAMBA, COULD RESULT IN SEVERE PLANT INJURY OR DESTRUCTION.

Information on Bollgard II® XtendFlex® Cotton can be obtained from your seed supplier or Monsanto representative. Bollgard II® XtendFlex® Cotton must be purchased from an authorized licensed seed supplier.

The instructions contained in this Monsanto Supplemental Label include all applications of XtendiMax™ With VaporGrip™ Technology that may be made to Bollgard II® XtendFlex® Cotton during the cropping season. DO NOT combine these instructions with other instructions in the "COTTON" Section of any other XtendiMax™ With VaporGrip™ Technology label for use over crops that do not contain the dicamba tolerance trait.

Note: Bollgard II® XtendFlex® Cotton and methods of controlling weeds and applying dicamba in a Bollgard II® XtendFlex® Cotton crop are protected under U.S. patent law. A license to use Bollgard II® XtendFlex® Cotton seed must be obtained prior to use. No license to use Bollgard II® XtendFlex® Cotton is granted or implied with the purchase of this herbicide product. Bollgard II® XtendFlex® Cotton is owned by Monsanto and a license must be obtained from Monsanto before using it. Contact your Authorized Monsanto Retailer for information on obtaining a license to Bollgard II® XtendFlex® Cotton.

See the "PRODUCT INFORMATION" and "APPLICATION EQUIPMENT AND TECHNIQUES" sections of the XtendiMax™ With VaporGrip™ Technology product label for important use information. In the event that there are any inconsistencies with the directions for use between this supplemental label and any other labeling for this product, follow the directions for use on this supplemental label.

Training and education on proper pesticide application is encouraged. Applicators should visit www.xtendimaxapplicationrequirements.com for training information and opportunities relevant to this product.

TYPES OF APPLICATIONS: Preplant; At-Planting; Preemergence; Postemergence (In-crop)

XtendiMax™ With VaporGrip™ Technology is approved by U.S. EPA to be used in the following states, subject to county restriction as noted: Alabama, Arkansas, Arizona, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin.

Restrictions

- Do not apply this product aerially.
- Do not make application of this product if rain is expected in the next 24 hours.

USE INSTRUCTIONS
Apply this product in a minimum of 10 gallons of spray solution per acre as a broadcast application. For best performance, control weeds early when they are less than 4 inches. Timely application will improve control and reduce weed competition. Refer to the following table for maximum application rates of this product with Bollgard II® XtendFlex® Cotton.

Maximum Application Rates	
Combined total per year for all applications	88 fluid ounces per acre (2.0 lb. a.e. dicamba per acre)
Total of all Preplant, At-Planting, and Preemergence applications	44 fluid ounces per acre (1.0 lb. a.e. dicamba per acre)
Total of all In-crop applications from emergence up to 7 days pre-harvest	88 fluid ounces per acre (2.0 lb. a.e. dicamba per acre)
Maximum In-crop, single application	22 fluid ounces per acre (0.5 lb. a.e. dicamba per acre)

a.e. – acid equivalent

Refer to Table 1 of the XtendiMax™ With VaporGrip™ Technology label booklet for application rates for weed type and growth stage controlled by this product. Maximum in-crop application rate should be used when treating tough to control weeds, dense vegetative growth or weeds with a well-established root system.

Preplant, At-Planting, Preemergence
USE INSTRUCTIONS: This product may be used to control broadleaf weeds and may be applied before, during or immediately after planting Bollgard II® XtendFlex® Cotton. Refer to the "WEEDS CONTROLLED" section of the label booklet for XtendiMax™ With VaporGrip™ Technology for specific weeds controlled.

RESTRICTIONS: The maximum combined quantity of this product that may be applied for all preplant, at-planting, and preemergence applications is 44 fluid ounces (1.0 lb a.e. dicamba) per acre per season. The maximum application rate for a single, preplant, at-planting, or preemergence application must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre. Do not apply less than 22 fluid ounces (0.5 lb a.e. dicamba) per acre.

Postemergence (In-crop)
USE INSTRUCTIONS: This product may be used to control broadleaf weeds in Bollgard II® XtendFlex® Cotton. In-crop applications of this product can be made from emergence up to 7 days prior to harvest. The maximum and minimum rate for any single, in-crop application is 22 fluid ounces (0.5 lb a.e. dicamba) per acre. Using the appropriate application rate may reduce the selection for resistant weeds. For best performance, control weeds early when they are less than 4 inches. Monsanto Company does not warrant product performance of applications to

labeled weeds greater than 4 inches in height. Sequential applications of this product may be necessary to control new flushes of weeds or on tough-to-control weeds. Allow at least 7 days between applications. A pre-harvest application of this product may be made up to 7 days before harvest.

Postemergence applications of this product mixed with adjuvants may cause a leaf response to Bollgard II® XtendFlex® Cotton. The symptoms usually appear as necrotic spots on fully expanded leaves. To reduce the incidence and severity of the necrosis, consider increasing the spray volume to 15 GPA or greater and lower adjuvant rates. EC-based products that are tank mixed with products containing dicamba may increase the severity of the leaf damage.

RESTRICTIONS:

- The combined total applied from crop emergence up to 7 days prior to harvest must not exceed 88 fluid ounces (2.0 lb a.e. dicamba) per acre.
- The maximum single, in-crop application rate must not exceed 22 fluid ounces (0.5 lb a.e. dicamba).
- The combined total per year for all applications must not exceed 88 fluid ounces (2.0 lb a.e. dicamba) per acre. For example, if a preplant application of 44 fluid ounces (1.0 lb a.e. dicamba) per acre was made, then the combined total in-crop applications must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre.
- Allow at least 7 days between applications and allow at least 7 days between final application and harvest or feeding of cottonseed and cotton gin by-products.

TANK-MIXING INSTRUCTIONS

XtendiMax™ With VaporGrip™ Technology may only be tank-mixed with products that have been tested and found not to adversely affect the offsite movement potential of XtendiMax™ With VaporGrip™ Technology. A list of those products may be found at www.xtendimaxapplicationrequirements.com. DO NOT tank mix any product with XtendiMax™ With VaporGrip™ Technology unless:

1. You check the list of tested products found not to adversely affect the offsite movement potential of XtendiMax™ With VaporGrip™ Technology at www.xtendimaxapplicationrequirements.com no more than 7 days before applying XtendiMax™ With VaporGrip™ Technology; and
2. The intended tank-mix product is identified on the list of tested products; and
3. The intended products are not prohibited on either this supplemental label or the label of the tank mix product.

4. Additional Warnings and Restrictions:

- Some COC, HSOC and MSO adjuvants may cause a temporary crop response.
- Do not tank mix products containing ammonium salts such as ammonium sulfate and urea ammonium nitrate.
- Drift reduction agents (DRAs) can minimize the percentage of driftable fines. However, the applicator must check www.xtendimaxapplicationrequirements.com to determine if the DRA is listed and check with the DRA manufacturer to determine if the DRAs will work effectively with the approved spray nozzle, spray pressure, and the desired spray solution.

TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, MONSANTO MAKES NO RECOMMENDATION OR WARRANTY HEREIN REGARDING THE USE OF ANY PRODUCT THAT MAY APPEAR ON THE WEBSITE REFERENCED ABOVE, REGARDLESS OF WHETHER SUCH PRODUCT IS USED ALONE OR IN A TANK MIX WITH XTENDIMAX™ WITH VAPORGRIP™ TECHNOLOGY. BUYER AND ALL USERS ARE SOLELY RESPONSIBLE FOR ANY LACK OF PERFORMANCE, LOSS, OR DAMAGE IN CONNECTION WITH THE USE OR HANDLING OF ANY SUCH PRODUCT ALONE OR IN A TANK MIX WITH XTENDIMAX™ WITH VAPORGRIP™ TECHNOLOGY. See the section titled "LIMIT OF WARRANTY AND LIABILITY" herein for more information.

WEED RESISTANCE MANAGEMENT

Some naturally occurring weed biotypes that are tolerant (resistant) to dicamba may exist due to genetic variability in a weed population. Where resistant biotypes exist, the repeated use of herbicides with the same sites of action can lead to the selection for resistant weeds. Certain agronomic practices can delay or reduce the likelihood that resistant weed populations will develop and can be utilized to manage weed resistance once it occurs.

Do not use less than 22 fluid ounces per acre (0.5 lb a.e./A) of this product in a single application. Using the appropriate application rate can minimize the selection for resistant weeds.

Proactively implementing diversified weed control strategies to minimize selection for weed populations resistant to one or more herbicides is a best practice. A diversified weed management program may include the use of multiple herbicides with different sites of action and overlapping weed spectrum with or without tillage operations and/or other cultural practices. Research has demonstrated that using the labeled rate and directions for use is important to delay the selection for resistance.

The continued effectiveness of this product depends on the successful management of the weed resistance program; therefore, it is very important to perform the following actions.

To aid in the prevention of developing weeds resistant to this product, the following steps should be followed where practical:

- Scout fields before application to ensure herbicides and rates will be appropriate for the weed species and weed sizes present.
- Apply full rates of XtendiMax™ With VaporGrip™ Technology for the most difficult to control weed in the field at the specified time (correct weed size) to minimize weed escapes.
- Scout fields after application to detect weed escapes or shifts in weed species.
- Report any incidence of non-performance of this product against a particular weed species to your Monsanto retailer, representative or call 1-844-RRXTEND.
- If resistance is suspected, treat weed escapes with an herbicide having a site of action other than Group 4 and/or use non-chemical methods to remove escapes, as practical, with the goal of preventing further seed production.

Additionally, users should follow as many of the following herbicide resistance management practices as is practical:

- Use a broad spectrum soil-applied herbicide with other sites of action as a foundation in a weed control program.
- Utilize sequential applications of herbicides with alternative sites of action.
- Rotate the use of this product with non-Group 4 herbicides.
- Avoid making more than two applications of dicamba and any other Group 4 herbicides within a single growing season unless mixed with another mechanism of action with an overlapping spectrum for the difficult to control weeds.
- Incorporate non-chemical weed control practices, such as mechanical cultivation, crop rotation, cover crops and weed-free crop seeds, as part of an integrated weed control program.
- Thoroughly clean plant residues from equipment before leaving fields suspected to contain resistant weeds.
- Manage weeds in and around fields, during and after harvest to reduce weed seed production.

Contact the local agricultural extension service, Monsanto representative, agricultural retailer or crop consultant for further guidance on weed control practices as needed.

APPLICATION EQUIPMENT AND TECHNIQUES

DO NOT APPLY THIS PRODUCT TO BOLLGARD II® XTENDFLEX® COTTON USING AERIAL SPRAY EQUIPMENT.

Apply this product using properly maintained and calibrated equipment capable of delivering the desired volumes.

SPRAY DRIFT MANAGEMENT

Do not allow herbicide solution to mist, drip, drift or splash onto desirable vegetation because severe injury or destruction to desirable broadleaf plants could result. The following drift management requirements must be followed.

Controlling Droplet Size

Off-target movement potential may be reduced by applying large droplets that provide sufficient coverage and control. Applying larger droplets can reduce drift potential, but will not prevent off-target movement if the application is made improperly, or under unfavorable environmental conditions (see the **"Wind Speed and Direction"**, **"Temperature and Humidity"** and **"Temperature Inversions"** sections of this label).

- **Nozzle type.** Use only Tee Jet® TTI11004 nozzle with a maximum operating pressure of 63 psi when applying XtendiMax™ With VaporGrip™ Technology or any other approved nozzle found at www.xtendimaxapplicationrequirements.com. Do not use any other nozzle and pressure combination not specifically listed on this website.

- **Hooded Sprayers.** Using a hooded sprayer in combination with approved nozzles may further reduce drift potential.

- **Spray Volume.** Apply this product in a minimum of 10 gallons of spray solution per acre. Use a higher spray volume when treating dense vegetation. Higher spray volumes may also allow the use of larger nozzle orifices (sizes) which produce coarser spray droplets.

- **Equipment Ground Speed.** Select a ground speed that will deliver the desired spray volume while maintaining the desired spray pressure, but do not exceed a ground speed of 15 miles per hour. Slower speeds generally result in better spray coverage and deposition on the target area.

- **Spray boom Height.** Spray at the appropriate boom height based on nozzle selection and nozzle spacing, but do not exceed a boom height of 24 inches above target pest or crop canopy. Set boom to lowest effective height over the target pest or crop canopy based on equipment manufacturer's directions. Automated boom height controllers are recommended with large booms to better maintain optimum nozzle to canopy height. Excessive boom height will increase the potential for drift.

Temperature and Humidity
When making applications in low relative humidity or temperatures above 91 degrees Fahrenheit, set up equipment to produce larger droplets to compensate for evaporation. Larger droplets have a lower surface to volume ratio and can be impacted less by temperature and humidity. Droplet evaporation is most severe when conditions are both hot and dry.

Temperature Inversions
Do not apply this product during a temperature inversion. Drift potential can be high during a temperature inversion.

- During a temperature inversion, the atmosphere is very stable and vertical air mixing is restricted, which can cause small, suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light variable winds common during inversions.
- Temperature inversions are characterized by increasing temperatures with altitude and are common on evenings and nights with limited cloud cover and light to no wind. Cooling of air at the earth's surface takes place and warmer air is trapped above it. They can begin to form as the sun sets and often continue into the morning.
- Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing.
- The inversion will often dissipate with increased winds (above 3 MPH) or at sunrise when the surface air begins to warm (generally 3°F from morning low).

Wind Speed and Direction

- Drift potential is lowest between wind speeds of 3 to 10 miles per hour.
- Do not apply at wind speeds greater than 15 mph.
- For XtendiMax™ With VaporGrip™ Technology wind speed and direction restrictions see below table:

Wind speed	Application conditions and restrictions
<3 mph	Do not apply XtendiMax™ With VaporGrip™ Technology.
3-10 mph	Optimum application conditions for XtendiMax™ With VaporGrip™ Technology provided all other application requirements in this label are met.
>10 – 15 mph	Do not apply product when wind is blowing toward non-target sensitive crops.
> 15 mph	Do not apply XtendiMax™ With VaporGrip™ Technology.

NOTE: Local terrain can influence wind patterns. Every applicator must be familiar with local wind patterns and how they affect drift.

PROTECTION OF SENSITIVE AREAS

Maintain a 110 foot downwind buffer (when applying 22 fluid ounces of this product per acre) or a 220 foot downwind buffer (when applying 44 fluid ounces of this product per acre) between the last treated row and the closest downwind edge (in the direction in which the wind is blowing). If any of the following areas below are directly adjacent to the treated field, the areas listed below can be considered part of the buffer distance.

To maintain this required buffer zone:

- No application swath can be initiated in, or into an area that is within the applicable buffer distance.

The following areas may be included in the buffer distance calculation when adjacent to field edges:

- Roads, paved or gravel surfaces,
- Planted agricultural fields containing: corn, dicamba tolerant cotton, dicamba tolerant soybean, sorghum, proso millet, small grains and sugarcane. If the applicator intends to include such crops as dicamba tolerant cotton and/or dicamba tolerant soybeans in the buffer distance calculation, the applicator must confirm the crops are in fact dicamba tolerant and not conventional cotton and/or soybeans.
- Agricultural fields that have been prepared for planting.
- Areas covered by the footprint of a building, silo, or other man made structure with walls and or roof.

Non-target Susceptible Crops

Failure to follow the requirements in this label could result in severe injury or destruction to desirable sensitive broadleaf crops and trees when contacting their roots, stems or foliage.

- Do not apply under circumstances where off-target movement may occur to food, forage, or other plantings that might be damaged or the crops thereof rendered unfit for sale, use or consumption.

- Do not allow contact of herbicide with foliage, green stems, exposed non-woody roots of crops, and desirable plants, including beans, cotton, flowers, fruit trees, grapes, ornamentals, peas, potato, soybean, sunflower, tobacco, tomato, and other broadleaf plants because severe injury or destruction may result, including plants in a greenhouse.

- Small amounts of dicamba that may not be visible may injure susceptible broadleaf plants.

- Applicators are required to ensure that they are aware of the proximity to non-target susceptible crops, and to avoid potential adverse effects from drift of XtendiMax™ With VaporGrip™ Technology.

Before making an application, the applicator must survey the application site for neighboring non-target susceptible crops. The applicator must also consult sensitive crop registries to identify any commercial specialty or certified organic crops that may be located near the application site.

DO NOT APPLY this product when the wind is blowing toward adjacent commercially grown dicamba sensitive crops, including but not limited to, commercially grown tomatoes and other fruiting vegetables (EPA crop group 8), cucurbits (EPA crop group 9), and grapes.

Application Awareness

AVOIDING SPRAY DRIFT AT THE APPLICATION SITE IS THE RESPONSIBILITY OF THE APPLICATOR

The interaction of equipment and weather related factors must be monitored to maximize performance and on-target spray deposition. The applicator is responsible for considering all of these factors when making a spray decision. The applicator is responsible for compliance with state and local pesticide regulations, including any state or local pesticide drift regulations.

Proper spray system equipment cleanout
Minute quantities of dicamba may cause injury to non-dicamba-tolerant soybeans and other sensitive crops (see the “Non-target Susceptible Crops” section of this label for more information).
Clean equipment immediately after using this product, using a triple rinse procedure as follows:

1. After spraying, drain the sprayer (including boom and lines) immediately. Do not allow the spray solution to remain in the spray boom lines overnight prior to flushing.
2. Flush tank, hoses, boom and nozzles with clean water.
3. Inspect and clean all strainers, screens and filters.
4. Prepare a cleaning solution with a commercial detergent or sprayer cleaner or ammonia according to the manufacturer’s directions.
5. Take care to wash all parts of the tank, including the inside top surface. Start agitation in the sprayer and thoroughly recirculate the cleaning solution for at least 15 minutes. All visible deposits must be removed from the spraying system.
6. Flush hoses, spray lines and nozzles for at least 1 minute with the cleaning solution.
7. Repeat above steps for two additional times to accomplish an effective triple rinse.
8. Remove nozzles, screens and strainers and clean separately in the cleaning solution after completing the above procedures.

9. Appropriately dispose of rinsate from steps 1-7 in compliance with all applicable laws and regulations.
10. Drain sump, filter and lines.
11. Rinse the complete spraying system with clean water.

All rinse water must be disposed of in compliance with local, state, and federal requirements.

CROP ROTATIONAL RESTRICTIONS
No rotational cropping restrictions apply when rotating to Roundup Ready® 2 Xtend™ Soybeans or Bollgard II® XtendFlex® Cotton. For other crops the interval between application and planting rotational crop is given below. When counting days from the application of this product, do not count days when the ground is frozen. Planting at intervals less than specified below may result in crop injury. Moisture is essential for the degradation of this herbicide in soil. If dry weather prevails, use cultivation to allow herbicide contact with moist soil.

Planting/replanting restrictions for XtendiMax™ With VaporGrip™ Technology applications of 33 fluid ounces per acre or less
For corn, cotton (except Bollgard II® XtendFlex® Cotton), sorghum, and soybean (except Roundup Ready® 2 Xtend™ Soybean), follow the planting restrictions in the directions for use for preplant application in **Section 10. Crop-Specific Information** of the label booklet. Do not plant barley, oat, wheat, and other grass seedings for 15 days for every 11 fluid ounces of this product applied per acre east of the Mississippi River and 22 days for every 11 fluid ounces per acre applied west of the Mississippi River. No planting restrictions apply beyond 120 days after application of this product.

Planting/replanting restrictions for applications of more than 33 fluid ounces and up to 44 fluid ounces of XtendiMax™ With VaporGrip™ Technology per acre
Wait a minimum of 120 days after application of this product before planting corn, sorghum and cotton (except Bollgard II® XtendFlex® Cotton) east of the Rocky Mountains and before planting all other crops (except Roundup Ready® 2 Xtend™ Soybean) grown in areas receiving 30 inches or more rainfall annually. Wait a minimum of 180 days before planting crops in areas with less than 30 inches of annual rainfall. Wait a minimum of 30 days for every 22 fluid ounces of this product applied per acre before planting barley, oat, wheat, and other grass seedings east of the Mississippi River and 45 days for every 22 fluid ounces of this product applied per acre west of the Mississippi River.

LIMIT OF WARRANTY AND LIABILITY

Monsanto Company (“Company”) warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes set forth in this supplemental label (“Directions”) when used in accordance with the Directions under the conditions described therein. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, NO OTHER EXPRESS WARRANTY OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE. This warranty is also subject to the conditions and limitations stated herein. Specifically, and without limiting the foregoing, MONSANTO MAKES NO RECCOMENDATION OR WARRANTY HEREIN REGARDING THE USE OF ANY PRODUCTS THAT MAY APPEAR ON THE WEBSITE REFERENCED IN THE TANK-MIXING INSTRUCTIONS HEREIN, REGARDLESS OF WHETHER SUCH PRODUCT IS USED ALONE OR IN A TANK MIX WITH XTENDIMAX™ WITH VAPORGRIP™ TECHNOLOGY. BUYER AND ALL USERS ARE SOLELY RESPONSIBLE FOR ANY LACK OF PERFORMANCE, LOSS, OR DAMAGE IN CONNECTION WITH THE USE OR HANDLING OF ANY SUCH PRODUCT ALONE OR IN A TANK MIX WITH XTENDIMAX™ WITH VAPORGRIP™ TECHNOLOGY.

Buyer and all users shall promptly notify this Company of any claims whether based in contract, negligence, strict liability, tort, or otherwise.

To the extent consistent with applicable law, buyer and all users are responsible for all loss or damage from use or handling which results from conditions beyond the control of this Company, including, but not limited to, incompatibility with products other than those expressly recommended by Company in the Directions, application to or contact with desirable vegetation, failure of this product to control weed biotypes which develop resistance to dicamba, unusual weather, weather conditions which are outside the range considered normal at the application site and for the time period when the product is applied, as well as weather conditions which are outside the application ranges set forth in the Directions, application in any manner not explicitly set forth in the Directions, moisture conditions outside the moisture range specified in the Directions, or the presence of products other than those expressly recommended by Company in the Directions in or on the soil, crop or treated vegetation.

This Company does not warrant any product reformulated or repackaged from this product except in accordance with this Company's stewardship requirements and with express written permission from this Company.

For in-crop (over-the-top) uses on crops within the Roundup Ready Xtend® Crop System, crop safety and weed control performance are not warranted by Company when this product is used in conjunction with "brown bag" or "bin run" seed saved from previous year's production and replanted.

TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE LIMIT OF THE LIABILITY OF THIS COMPANY OR ANY OTHER SELLER FOR ANY AND ALL LOSSES, INJURIES OR DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT (INCLUDING CLAIMS BASED IN CONTRACT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT OR OTHERWISE) SHALL BE THE PURCHASE PRICE PAID BY THE USER OR BUYER FOR THE QUANTITY OF THIS PRODUCT INVOLVED, OR, AT THE ELECTION OF THIS COMPANY OR ANY OTHER SELLER, THE REPLACEMENT OF SUCH QUANTITY, OR, IF NOT ACQUIRED BY PURCHASE, REPLACEMENT OF SUCH QUANTITY. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, IN NO EVENT SHALL THIS COMPANY OR ANY OTHER SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES.
Upon opening and using this product, buyer and all users are deemed to have accepted the terms of this LIMIT OF WARRANTY AND LIABILITY which may not be varied by any verbal or written agreement.

These terms apply to this supplemental labeling and if these terms are not acceptable, return the product unopened at once.

MONSANTO COMPANY
800 N. LINDBERGH BLVD.
ST. LOUIS, MISSOURI 63167 USA

[*INSERT DATE*]

[*INSERT PRINT PLATE NUMBER*]

[*INSERT SUPPLEMENTAL LABEL EXPIRATION DATE*]

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

November 9, 2016

Dr. James Nyangulu
U.S. Agency Regulatory Affairs Manager
Monsanto Company
1300 I St., NW
Washington, DC 20005

Subject: PRIA Label Amendment – Adding new uses on dicamba-resistant cotton and soybeans
Product Name: M1768 Herbicide
Alternate Brand Name: Xtendimax™ with VaporGrip™ Technology
EPA Registration Number: 524-617
Application Dates: 10/21/2016, 4/12/2016, and 11/19/2015, respectively
Decision Number: 522837, 516207, and 511766

Dear Dr. Nyangulu:

1. The application referred to above, submitted in connection with registration under the Federal Insecticide, Fungicide and Rodenticide Act, as amended, is acceptable under FIFRA Section 3(c)(7)(B) subject to the following conditions:

2. You must submit and/or cite all data required for registration/reregistration/registration review of your product under FIFRA when the Agency requires all registrants of similar products to submit such data.

3. Be aware that proposed data requirements have been identified in a Preliminary Work Plan under Docket ID EPA-HQ-OPP-2016-0223-0010 at www.regulations.gov . For more information on these proposed data requirements, you may contact the Chemical Review Manager in the Pesticide Re-Evaluation Division.

4. This registration will automatically expire on 11/09/2018.

5. You must maintain a website at http://Xtendimaxapplicationrequirements.com. That website will include a list of products that have been tested pursuant to Appendix A and found, based upon such testing, not to adversely affect the spray drift properties of Xtendimax™ with VaporGrip™ Technology. The website will identify a testing protocol, consistent with Appendix A, that is appropriate for determining whether the tested product will adversely affect the drift properties of Xtendimax™ with VaporGrip™ Technology. . The website will state that any person seeking to have a product added to the list must perform a study either pursuant to the testing protocol identified on the website or another protocol that has been approved for the particular

purpose by EPA, and must submit the test data and results, along with a certification that the studies were performed either pursuant to the testing protocols identified on the website or pursuant to another protocol(s) approved by EPA and that the results of the testing support adding the product to the list of products tested and found not to adversely affect the spray drift properties of Xtendimax™ with VaporGrip™ Technology, to EPA. EPA will notify you when the Agency determines that a product has been certified to be appropriately added to the list, and you will add appropriately certified products to the list no more than 90 days after you receive such notice from EPA. Testing of Tank-Mix Products must be conducted in compliance with procedures as stated forth in Appendix A.

6. All test data relating to the impact of tank-mixing any product with Xtendimax™ with VaporGrip™ Technology on drift properties of Xtendimax™ with VaporGrip™ Technology generated by you or somebody working for you must be submitted to EPA, along with a certification indicating whether the study was performed either pursuant to the testing protocols identified on the website or pursuant to other protocols approved by EPA and whether the results of the testing support adding the product to the list of products tested and found not to adversely affect the spray drift properties of Xtendimax™ with VaporGrip™ Technology, at the following address: Chief of Environmental Risk Branch 1, Environmental Fate and Effects Division, Office of Pesticide Programs. If the certification states that the study was performed either pursuant to the testing protocol identified on the website or pursuant to another protocol approved by EPA, and the results of the testing support adding the product to the list of products tested and found not to adversely affect the spray drift properties of Xtendimax™ with VaporGrip™, you may add the product to the list.

7. The prohibition of using products in a tank-mix with Xtendimax™ with VaporGrip™ Technology unless the product used is contained on the list at Xtendimaxapplicationrequirements.com, and the identification of the website address, shall be included in educational and information materials developed for Xtendimax™ with VaporGrip™ Technology, including the materials identified in Appendix D, Section B(l).

8. You must develop and follow an Herbicide Resistance Management Plan (HRM) as laid out in Appendix D regarding grower agreements, field detection and remediation, education, evaluation, reporting, and best management practices (BMPs).

A stamped copy of your labeling is enclosed for your records. This labeling supersedes all previously accepted labeling. You must submit one (1) copy of the final printed labeling before you release the product for shipment with the new labeling. In accordance with 40 CFR 152.130(c), you may distribute or sell this product under the previously approved labeling for 18 months from the date of this letter. After 18 months, you may only distribute or sell this product if it bears this new revised labeling or subsequently approved labeling. “To distribute or sell” is defined under FIFRA section 2(gg) and its implementing regulation at 40 CFR 152.3.

Should you wish to add/retain a reference to the company's website on your label, then please be aware that the website becomes labeling under the Federal Insecticide Fungicide and Rodenticide Act and is subject to review by the Agency. If the website is false or misleading, the product would be misbranded and unlawful to sell or distribute under FIFRA section 12(a)(1)(E). 40 CFR 156.10(a)(5) list examples of statements EPA may consider false or misleading. In addition, regardless of whether a website is referenced on your product's label, claims made on the website may not substantially differ from those claims approved through the registration process. Therefore, should the Agency find or if it is brought to our attention that a website contains false or misleading statements or claims substantially differing from the EPA approved registration, the website will be referred to the EPA's Office of Enforcement and Compliance.

Your release for shipment of the product constitutes acceptance of these conditions. If you fail to satisfy these data requirements, EPA will consider appropriate regulatory action including, among other things, cancellation under FIFRA section 6(e). If you have any questions, please contact Grant Rowland by phone at 703-347-0254, or via email at Rowland.grant@epa.gov.

Sincerely,

Daniel Kenny, Chief
Herbicide Branch
Registration Division (7505P)
Office of Pesticide Programs

Enclosure

APPENDIX A

Testing of Tank Mix Products for Spray Drift Properties

Products proposed for tank-mixing with may be added to the list of products that will not adversely affect the spray drift properties of Xtendimax™ with VaporGrip™ Technology contained on the web site if a study is performed under the testing conditions set forth below; the test information is reported as set forth below; and the results are interpreted as set forth below and the interpretation supports adding the tested product to the list of products that will not adversely affect the spray drift properties of Xtendimax™ with VaporGrip™ Technology:

Testing Conditions

Spray chamber test using conditions described in ASTM E-2798-11; or Wind Tunnel test using conditions described in EPA Final Generic Verification Protocol for Testing Pesticide Application Spray
Drift Reduction Technologies for Row and Field Crops (September 2013)

Testing Media:	Xtendimax™ with VaporGrip™ Technology + Xtendimax™ with VaporGrip™ Technology Proposed Tank Mix Product
Test Nozzle:	Tee Jet® TTI 11004 at 63 psi
Number of Replicates:	3 for each tested medium

Reporting

Validation information as summarized in Appendix B

Full droplet spectrum to be reported for each replicate of each tested medium

Perform AGDISP (8.26) modeling run for each replicate droplet spectrum for each tested medium (AGDISP input parameters described in Appendix C)

Establish 110 foot (0.5 lb ae/A rate) or 220 foot (1.0 lb ae/A rate) spray drift deposition estimates from AGDISP run on each replicate for each tested medium

Establish mean and standard deviation of 110 foot (0.5 lb ae/A rate) or 220 foot (1.0 lb ae/A rate) deposition for the 3 replicates of each tested medium

One-tail (upper bound) t-test (p=Q.l) to determine if proposed tank-mix product is above Xtendimax™ with VaporGrip™ Technology 110 foot (0.5 lb ae/A rate) or 220 foot (1.0 lb ae/A rate) spray drift deposition

Interpretation of Results

If mean 110 foot (0.5 lb ae/A rate) or 220 foot (1.0 lb ae/A rate) deposition for proposed tank-mix product is not.statistically greater than mean 110 foot deposition for Xtendimax™ with VaporGrip™ Technology , proposed tank-mix product can be added to the list of products that will not adversely affect the spray drift properties of Xtendimax™ with VaporGrip™ Technology contained on the web site. If mean 110 foot (0.5 lb ae/A rate) or 220 foot (1.0 lb ae/A rate) deposition for proposed tank-mix product is statistically greater than mean 110 foot (0.5 lb ae/A rate) or 220 foot (1.0 lb ae/A rate) deposition for Xtendimax™ with VaporGrip™ Technology, proposed tank-mix product cannot be added to the list of products that will not adversely affect the spray drift properties of Xtendimax™ with VaporGrip™ Technology contained on the web site.

Results from other testing protocols will be acceptable for adding products to the list of products that will not adversely affect the spray drift properties of Xtendimax™ with VaporGrip™ Technology provided that EPA has determined in writing that such other protocol is appropriate for such purpose.

APPENDIX B

Validation Criteria

a. Detailed information of instrument setting and measurements
- The distance from the nozzle.tips to the laser settings
- Measurements of airspeed and flow rate of liquid

b. Detailed information of test substances
- Volume composition and density of Xtendimax™ with VaporGrip™ Technology formulation and tank mixes

c. Summary of the entire spray output distribution for each nozzle/tank mixes with statistical analysis ofreplicates.

d. Graphical outputs of Sympatec Helos laser diffraction particle size analyzer FOR individual spectrum

Report of DvO.l (SD), DvO.5 (SD), and DV0.9 (SD) as well as mean % fines of (< 141pm SD)

APPENDIX C
AGDISP Input Parameters

Parameter	Value	Comments
Application Method Section		
Method	Ground	
Nozzle Type	Flat fan (Default)	The direct use of the DSD overrides the use of "nozzle type"
Boom Pressure	63 psi	If nozzles/tank mixes were tested at 63 psi. It has to be consistent with tank mix as well as Xtendimax™with VaporGrip™ Technology for both TeeJet® and AIXR nozzles
Release Height	3 ft	Default
Spray Lines	20	Default
Meteorology Section		
Wind Type	Single height	Default
Wind Speed	15 mph	Under bound from label
Wind Direction	-90 deg	Worst-case and default
Temperature	65 F	Default
Relative Humidity	50%	Default
Surface Section		
Angles	0	Default
Canopy	None	Default
Surface Roughness	0.12 ft	Mean of "crops" cover type
Application Technique Section		
Nozzles	54, even spacing	Standard boom setup
DSD	From wind tunnel results, imported in library	
Atmospheric stability	Strong	Default
Swath Section		
Swath width	90 ft	Standard boom
Swath displacement	0 ft	Worst-case
Spray Material Section		
Spray volume rate	10 gal/A	From label
Volatile/nonvolatile fraction	M 1768 at 1.72% v/v	To calculate volatile/nonvolatile fraction in the tank mix for the model input, provide detailed information of the tested formulations and tank mixes. See sample calculation, below[1]

[1]The tested mixture was 1.72% (v/v) M-1768. M-1768 has a density of 10.2 lb/gal and contains 42.8% (w/v) dicamba DGA salt (2.9 lb acid equivalent/gal).
For example, a 10-gallon batch would contain the following:
M-1768 1.71% * 10 gal = 0.172 gal ; 0.172 gal * 10.2 lb/gal = 1.753 lb
Water 10 gal (1280 fl oz) – 22 fl oz = 1258 fl oz = 82.0157 lb
Total weight 1.753 lb + 82.016 lb = 83.769 lb
Active ingredient fraction: 1.753 lb * 42.8% a.i. = 0.75 lb; 0.75 lb/83.769 lb = 0.00896 (dimensionless)
Non-volatile fraction: 0.00896/0.428 = 0.021 (dimensionless)

APPENDIX D

HERBICIDE RESISTANCE MANAGEMENT PLAN

Monsanto (MON) must:

A. Field Detection and Remediation Components:

1. Develop and implement an education program for growers, as set forth under the "Educational / Informational Component," below, that identifies appropriate best management practices (BMPs), as set forth under the "Best Management Practices (BMPs) Component," below, to avoid and control weed resistance, and that conveys to growers the importance of complying with BMPs. Such BMPs shall include that fields must be scouted after application to confirm herbicide effectiveness, and that users should report any incidence of lack of efficacy of this product against a particular weed species to Monsanto or a Monsanto representative.

2. If any grower informs you of a lack of herbicide efficacy, then you or your representative must make an effort to evaluate the field for "likely resistance" to M1768 herbicide for each specific species for which lack of herbicide efficacy is reported by applying the criteria set forth in Norsworthy, *et al*., "Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations," Weed Science 2012 Special Issue:31–62 (*hereinafter* "Norsworthy criteria")[1] in each specific state until resistance to dicamba is confirmed for a specific weed species in that state using acceptable scientific methods. However, for each grower, you must continue to provide stewardship about resistance management throughout their use of this product. If resistance to dicamba is confirmed in a specific state for a specific weed species, then MON must immediately report such confirmation to EPA and need no longer investigate reports of lack of herbicide efficacy regarding that specific species in that specific state, but MON must continue to make an effort to help address of lack of herbicide efficacy regarding any other weed species in any such state;
3. Keep records of all field evaluations for "likely resistance" for a period of 3 years, and make such copies available to EPA upon request; and
4. If one or more of the Norsworthy criteria are met, then for a weed species not already confirmed to be resistant to dicamba in that specific state, Monsanto will:
   a. Provide the grower with specific information and recommendations to control and contain likely resistant weeds, including retreatment and/or other non-chemical controls,

[1] The Norsworthy "likely herbicide resistance" criteria are: (1) failure to control a weed species normally controlled by the herbicide at the dose applied, especially if control is achieved on adjacent weeds; or (2) a spreading patch of uncontrolled plants of a particular weed species; or (3) surviving plants mixed with controlled individuals of the same species. The identification of any of these criteria in the field indicates that "likely herbicide resistance" is present.

as appropriate. If requested by the grower, MON or their agent will become actively involved in implementation of weed control measures;

b. Request, at the time of the initial determination that one or more of the Norsworthy criteria are met and prior to any application of alternative control practices, that the grower provide you with access to the relevant field(s) to collect specimens of the likely resistant weeds (potted specimens or seeds) for further evaluation in the greenhouse or laboratory, and so collect such specimens if possible (or, alternatively, request that the grower provide such specimens to you, at your expense);

c. Commence greenhouse or laboratory studies to confirm resistance as soon as practicable following sample collection;

d. To the extent possible, contact or visit the grower in an appropriate timeframe after implementation of the additional weed control measures in order to evaluate success of such measures; and

e. If the additional weed control measures were not successful in controlling the likely resistant weeds, then:

   i. Work with the grower to determine the reason(s) why the additional control measures were not successful;

   ii. Report annually the inability to control the likely resistant weeds to relevant stakeholders; and

   iii. Offer to further assist the grower in controlling and containing the likely resistant weeds, including retreatment and/or other non-chemical controls, as appropriate.

B. Educational / Informational Component:

1. Develop and implement an education program for growers that includes the following elements:

   a. The education program shall identify appropriate best management practices (BMPs), set forth under the "Best Management Practices (BMPs) Component," below, to avoid and control weed resistance, and shall convey to growers the importance of complying with BMPs;

   b. The education program shall include at least one written communication regarding herbicide resistance management each year, directed to users of M1768 herbicide for use over-the-top on dicamba tolerant soybean or cotton; and

   c. You must make the education program available to MON sales representatives for distribution to growers.

2. Provide to EPA the original education program within three months of the issuance of this registration.

C. Evaluation Component:

1. Monsanto will annually conduct a survey directed to users of M1768 herbicide for use over-the-top of dicamba tolerant soybean or cotton. This survey must be based on a statistically representative sample. The sample size and geographical resolution should be adequate to allow analysis of responses within regions, between regions, and across the United States. This survey shall evaluate, at a minimum, the following:

   a. Growers' adherence to the terms of the M1768 Use Directions and Label Restrictions, and

   b. Whether growers have encountered any perceived issue with non-performance or lack of efficacy of M1768 herbicide and, if so, how growers have responded.

2. Utilize the results from the survey described in paragraph 1 of this section to annually review, and modify as appropriate for the upcoming growing season, the following:

   a. Efforts aimed at achieving adoption of BMP's;

   b. Responses to incidents of likely resistance and confirmed resistance; and

   c. The education program. At the initiative of either EPA or MON, EPA and MON shall consult about possible modifications of the education program.

D. Reporting Component:

1. Submit annual reports to EPA by January 15 of each year, beginning on January 15, 2018. Such reports shall include:

   a. Annual sales of M1768 herbicide by state;

   b. The first annual report shall include the current education program and associated materials, and subsequent annual reports shall include updates of any aspect of the education program and associated materials that have materially changed since submission of the previous annual report;

   c. Summary of your efforts aimed at achieving implementation of BMP's;

   d. Summary of your determinations as to whether any reported lack of herbicide efficacy was "likely resistance," your follow-up actions taken, and, if available, the ultimate outcome (e.g., evaluation of success of additional weed control measures) regarding each case of "likely resistance." In the annual report, MON will list the cases of likely resistance by county and state.

   e. The results of the annual survey described in paragraph 1 under "Evaluation Component," above, including whether growers are implementing herbicide resistance

BMPs, and a summary of your annual review and possible modification – based on that survey – of the education program, , and response to reports of likely resistance, described in paragraph 2 under "Evaluation Component," above; and

f. Summary of the status of any laboratory and greenhouse testing performed by, or at the direction of, Monsanto following up on incidents of likely resistance, performed in the previous year. Data pertaining to such testing need not be included in the annual reports, but such data must be made available to EPA upon request.

1. Following your submission of the annual report, you shall meet with the EPA at EPA's request in order to evaluate and consider the information contained in the report.
2.

E. Best Management Practices (BMPs) Component:

1. Best management practices (BMPs) must be identified in your education program. Growers will be advised of BMP's in product literature, educational materials and training. The following are examples of BMPs:

a. Regarding crop selection and cultural practices:

i. Understand the biology of the weeds present.

ii. Use a diversified approach toward weed management focused on preventing weed seed production and reducing the number of weed seeds in the soil seed-bank.

iii. Emphasize cultural practices that suppress weeds by using crop competitiveness.

iv. Plant into weed free fields, keep fields as weed free as possible, and note areas where weeds were a problem in prior seasons.

v. Incorporate additional weed control practices whenever possible, such as mechanical cultivation, biological management practices, crop rotation, and weed-free crop seeds, as part of an integrated weed control program.

vi. Do not allow weed escapes to produce seeds, roots or tubers.

vii. Manage weed seed at harvest and post-harvest to prevent a buildup of the weed seed-bank.

viii. Prevent field-to-field and within-field movement of weed seed or vegetative propagules.

ix. Thoroughly clean plant residues from equipment before leaving fields.

x. Prevent an influx of weeds into the field by managing field borders.

xi. Fields must be scouted before application to ensure that herbicides and application rates will be appropriate for the weed species and weed sizes present.

xii. Fields must be scouted after application to confirm herbicide effectiveness and to detect weed escapes.

xiii. If resistance is suspected, treat weed escapes with an alternate mode of action or use non-chemical methods to remove escapes.

b. Regarding herbicide selection:

i. Use a broad spectrum soil applied herbicide with a mechanism of action that differs from this product as a foundation in a weed control program.

ii. A broad spectrum weed control program should consider all of the weeds present in the field. Weeds should be identified through scouting and field history.

iii. Difficult to control weeds may require sequential applications of herbicides with alternative mechanisms of action.

iv. Fields with difficult to control weeds should be rotated to crops that allow the use of herbicides with alternative mechanisms of action.

v. Apply full rates of this herbicide for the most difficult to control weed in the field. Applications should be made when weeds are at the correct size to minimize weed escapes.

vi. Do not use more than two applications of this herbicide or any herbicide with the same mechanism of action within a single growing season unless mixed with another mechanism of action herbicide with overlapping spectrum for the difficult to control weeds.

vii. Report any incidence of lack of efficacy of this product against a particular weed species to Monsanto or a Monsanto representative.

This list may be updated or revised as new information becomes available.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

October 12, 2017

Thomas Marvin
Director, Federal Regulatory Affairs
Monsanto Company
1300 I (Eye) Street, NW – Suite 450 East
Washington, DC 20005

Subject: Registration Amendment – Label Amendment to Change Directions for Use and additional Terms and Conditions to the Registration as Registered on November 9, 2016 for Use on Dicamba-tolerant Cotton and Dicamba-tolerant Soybeans
Product Name: M1768 HERBICIDE (Xtendimax with Vaporgrip Technology)
EPA Registration Number: 524-617
Application Date: October 4th, 2017
Decision Number: 534662

Dear Mr. Marvin,

In response to the high number of crop damage incidents reported to EPA since June 2017, Monsanto submitted a label amendment to change the directions for use on its product as well as a request to amend its registration to include additional terms and conditions. EPA approves the labeling proposed by Monsanto as well as the additional terms and conditions of registration. EPA has determined that the M1768 Herbicide (EPA reg. no. 524-617, Xtendimax with Vaporgrip Technology) labeling and registration continue to meet the standard of registration with the requested amendment as it did on November 9, 2016 when EPA registered these new uses. The amendment approved through this letter includes additional restrictions further minimizing off-field movement of the active ingredient dicamba and do not affect the conclusions in the supporting assessment of risk. EPA accordingly continues to rely on all the assessments that supported the new uses, and therefore does not require a revised endangered species effects determination, nor any other new risk assessment. This approval contains registration terms and conditions that are in addition to the conditions set forth in the new use approval granted on November 9, 2016. These terms and conditions do not supersede any conditions that were previously imposed on this registration and supported by risk assessments found in the following docket EPA-HQ-OPP-2016-0187. Therefore, Monsanto continues to be subject to existing conditions on its registration and any deadlines connected with them, including but not limited to the automatic expiration date of November 9, 2018. The amended label referred to above, submitted in connection with registration under the Federal Insecticide, Fungicide and Rodenticide Act, as amended, is acceptable under FIFRA Section 3(c)(7)(B) subject to the following additional terms and conditions to ensure that the new labeling is provided at the point of sale for the 2018 use season:

A stamped copy of your labeling is enclosed for your records. This labeling supersedes all previously accepted labeling including all supplemental labels.

1. Immediately, for product currently in retail inventories, in the distribution chain (packaged and released for shipment), and product that will be manufactured before new glossy label booklets are available will be relabeled with a Sticker and a New Label.

   - Sticker will contain the following information:
     - "Restricted Use Pesticide";
     - "Product cannot be used if user does not possess new label(ing) that can be found at www.xtendimaxapplicationrequirements.com; and
     - "User must comply in all respects with new label(ing), regardless of any contrary language on existing label."
   - New label will be provided to accompany each stickered product as well as publication to Monsanto's website www.xtendimaxapplicationrequirements.com.

2. The next label printing of this product, which should occur as soon as practicable, must use this approved labeling unless subsequent changes have been approved. You must submit one copy of the final printed labeling before you release the product for shipment with the new labeling. After the next printing, you may only distribute or sell this product if it bears this new revised labeling or subsequently approved labeling. "To distribute or sell" is defined under FIFRA section 2(gg) and its implementing regulation at 40 CFR 152.3. In order to assure the new labeling is implemented for use in the 2018 application season, the appended terms and conditions (listed here) have been added to the existing terms and conditions of this registration. Monsanto, the registrant, will:

   - As soon as new labeling (glossy booklets) become available, affix the new label to XtendiMax products at the time of manufacture in registered facilities.
   - Notify EPA, within one week of the booklet becoming available, of the date the booklet became available. All product manufactured after the booklet is available must contain the new glossy label.
   - For other XtendiMax products – whether in retail inventories, in the distribution chain, or for which manufacturing will occur before new glossy label booklets become available – produce and distribute sufficient quantities of stickers and new paper labels to update product (recognizing that stickering must occur in a registered establishment).
   - Inform retailers of the need to sticker and supply new labels for products currently in inventory and products received with the former label as well as provide specific instructions to the retailers that are registered establishments on how to affix the sticker on the label and provide the new paper label at time of purchase.
   - Inform retailers that are not yet EPA registered establishments about the importance of stickering the products currently in their inventory and products received with the former label and that stickering and providing the new labels can only occur in an EPA registered establishment; inform retailers of the process for establishment registration and reporting; and communicate that retailers should not sell product until stickering is appropriately conducted.

- Inform retailers who do not intend to become registered establishments the importance of the new labeling and to contact Monsanto immediately, so that Monsanto can reclaim the retailer inventory and provide replacement product with labeling updated in a registered establishment. Communicate that retailers should not sell product until stickering is appropriately conducted.
- Provide a copy to EPA of the communications used to inform retailers and others as described above.
- Provide access to new label through an internet webpage located at www.xtendimaxapplicationrequirements.com.

Please be aware that by adding/retaining a reference to the company's website on your label, the website becomes labeling under the Federal Insecticide Fungicide and Rodenticide Act and is subject to review by the Agency. If the website is false or misleading, the product would be misbranded and unlawful to sell or distribute under FIFRA section 12(a)(1)(E). 40 CFR 156.10(a)(5) list examples of statements EPA may consider false or misleading. In addition, regardless of whether a website is referenced on your product's label, claims made on the website may not substantially differ from those claims approved through the registration process. Therefore, should the Agency find or if it is brought to our attention that a website contains false or misleading statements or claims substantially differing from the EPA approved registration, the website will be referred to the EPA's Office of Enforcement and Compliance.

A stamped copy of your labeling is enclosed for your records. This labeling supersedes all previously accepted labeling including all supplemental labels. The new labeling and terms and conditions of registration are hereby granted. As with the November 9, 2016 new use approvals for use of Xtendimax with VaporGrip™ Technology on dicamba-tolerant cotton and dicamba-tolerant soybeans, if these conditions are not complied with, the registration will be subject to cancellation in accordance with FIFRA section 6.

If you have any questions, please contact me by phone at 703-305-1243, or via email at montague.kathryn@epa.gov.

Sincerely,

Kathryn V. Montague

Kathryn Montague, Product Manager 23
Herbicide Branch
Registration Division (7505P)
Office of Pesticide Programs

Enclosure(s)

MASTER LABEL FOR EPA REG. NO. 524-617

RESTRICTED USE PESTICIDE

For retail sale to and use only by Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification

This labeling expires on 11/09/2018, unless the U.S. EPA determines before that date that off-site incidents are not occurring at unacceptable frequencies or levels. Do not use or distribute this product after 11/09/2018, unless you visit www.xtendimaxapplicationrequirements.com and can verify that EPA has amended this expiration date.

ACCEPTED
10/12/2017
Under the Federal Insecticide, Fungicide and Rodenticide Act as amended, for the pesticide registered under
EPA Reg. No. 524-617

Primary Brand Name:
M1768 Herbicide

Alternate Brand Name:
Xtendimax® With VaporGrip® Technology

GROUP	4	HERBICIDE

ACTIVE INGREDIENT:

Diglycolamine salt of dicamba (3,6-dichloro-*o*-anisic acid)* 42.8%
OTHER INGREDIENTS: 57.2%

TOTAL: 100.0%

* contains 29.0%, 3,6-dichloro-*o*-anisic acid (2.9 pounds acid equivalent per U.S. gallon or 350 grams per liter).

RESTRICTED USE PESTICIDE

For retail sale to and use only by Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification

XtendiMax® With VaporGrip® Technology

Complete Directions for Use

This labeling expires on 11/09/2018, unless the U.S. EPA determines before that date that off-site incidents are not occurring at unacceptable frequencies or levels. Do not use or distribute this product after 11/09/2018, unless you visit www.xtendimaxapplicationrequirements.com and can verify that EPA has amended this expiration date.

EPA Reg. Number: 524-617

For weed control in asparagus, conservation reserve programs, corn, cotton, fallow croplands, general farmstead (noncropland), sorghum, grass grown for seed, hay, proso millet, pasture, rangeland, small grains, sod farms and farmstead turf, soybean, sugarcane, cotton with XtendFlex Technology, and Roundup Ready 2 Xtend Soybean.

GROUP	**4**	**HERBICIDE**

This label supersedes any previously issued labeling for this product, including previously issued supplemental labeling.

XtendiMax® With VaporGrip® Technology is approved by U.S. EPA for all uses specified on this label in the following states, subject to county restriction as noted: Alabama, Arkansas, Arizona, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin.

Check the registration status of each product in each state before using.

READ THE ENTIRE LABEL FOR **XTENDIMAX® WITH VAPORGRIP® TECHNOLOGY** BEFORE PROCEEDING WITH THE USE DIRECTIONS CONTAINED IN THIS LABEL

READ AND FOLLOW ALL APPLICABLE DIRECTIONS, RESTRICTIONS, AND PRECAUTIONS ON THE CONTAINER LABEL AND BOOKLET AND WWW.XTENDIMAXAPPLICATIONREQUIREMENTS.COM.

Read the "LIMIT OF WARRANTY AND LIABILITY" statement at the end of the label before buying or using. If terms are not acceptable, return at once unopened.

Net contents:

EPA Establishment No.:

CONTENTS

1.0 INGREDIENTS

ACTIVE INGREDIENT:

Diglycolamine salt of dicamba (3,6-dichloro-*o*-anisic acid)* 42.8%
OTHER INGREDIENTS: 57.2%

TOTAL: 100.0%
* contains 29.0%, 3,6-dichloro-*o*-anisic acid (2.9 pounds acid equivalent per U.S. gallon or 350 grams per liter).

GROUP	4	HERBICIDE

2.0 IMPORTANT PHONE NUMBERS

1. FOR PRODUCT INFORMATION OR ASSISTANCE IN USING THIS PRODUCT, CALL TOLL-FREE, 1-800-332-3111.
2. IN CASE OF AN EMERGENCY INVOLVING THIS HERBICIDE PRODUCT, OR FOR MEDICAL ASSISTANCE, CALL COLLECT, DAY OR NIGHT, (314)-694-4000.

IN CASE OF SPILL:

Steps to be taken in case material is released or spilled:

Dike and contain the spill with inert material (sand, earth, etc.) and transfer liquid and solid diking material to separate containers for disposal. Remove contaminated clothing, and wash affected skin areas with soap and water. Wash clothing before re-use. Keep the spill out of all sewers and open bodies of water.

3.0 PRECAUTIONARY STATEMENTS

3.1 Hazards to Humans and Domestic Animals

Keep out of reach of children.

CAUTION!

Causes moderate eye irritation. Avoid contact with eyes or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet.

FIRST AID	
IF IN EYES	• Hold eye open and rinse slowly and gently with water for 15 to 20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
IF SWALLOWED:	• Call a poison control center or doctor immediately for treatment advice. • Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by a poison control center or doctor. • Do not give anything by mouth to an unconscious person.
IF ON SKIN OR CLOTHING:	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15 to 20 minutes.

	• Call a poison control center or doctor for treatment advice.

- Have the product container or label with you when calling a poison control center or doctor, or going for treatment.
- You can call **(314) 694-4000**, collect day or night, for emergency medical treatment information.
- This product is identified as **XtendiMax® With VaporGrip® Technology, EPA Registration No. 524-617.**

PERSONAL PROTECTIVE EQUIPMENT (PPE)

All mixers, loaders, applicators and other handlers must wear:

- Long-sleeved shirt and long pants
- Waterproof gloves
- Shoes plus socks

See "Engineering Controls Statement" for additional requirements.
Follow the manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry.

ENGINEERING CONTROLS STATEMENT

When handlers use closed systems, or enclosed cabs in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240 (d) (4-6)], the handler PPE requirements may be reduced or modified as specified in the WPS.

IMPORTANT: When reduced PPE is worn because a closed system is being used, handlers must be provided all PPE specified above for "all mixers, loaders, applicators and other handlers" and have such PPE immediately available for use in an emergency, such as a spill or equipment breakdown.

USER SAFETY RECOMMENDATIONS

Users should:

- Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.
- Remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

3.2 Environmental Hazards

Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters or rinsate. Apply this product only as directed on the label.

This chemical is known to leach through soil into ground water under certain conditions as a result of agricultural use. Use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in ground water contamination.

Ground and Surface Water Protection

Point source contamination - To prevent point source contamination, do not mix or load this pesticide product within 50 feet of wells (including abandoned wells and drainage wells), sink holes, perennial or intermittent streams and rivers, and natural or impounded lakes and reservoirs. Do not apply pesticide product within 50 feet of wells. This setback does not apply to properly capped or plugged abandoned wells and does not apply to impervious pad or properly diked mixing/loading areas as described below.

Mixing, loading, rinsing, or washing operations performed within 50 feet of a well are allowed only when conducted on an impervious pad constructed to withstand the weight of the heaviest load that may be on or move across the pad. The pad must be self-contained to prevent surface water flow over or from the pad. The pad capacity must be maintained at 110% that of the largest pesticide container or application equipment used on the pad and have sufficient capacity to contain all product spills, equipment or container leaks, equipment wash waters, and rainwater that may fall on the pad. The containment capacity does not apply to vehicles delivering pesticide shipments to the mixing/loading site. States may have in effect additional requirements regarding wellhead setbacks and operational containment.

Care must be taken when using this product to prevent: a) back siphoning into wells, b) spills or c) improper disposal of excess pesticide, spray mixtures or rinsates. Check valves or anti-siphoning devices must be used on all mixing equipment.

Movement by surface runoff or through soil - Do not apply under conditions which favor runoff. Do not apply to impervious substrates such as paved or highly compacted surfaces in areas with high potential for ground water contamination. Ground water contamination may occur in areas where soils are permeable or coarse and ground water is near the surface. Do not apply to soils classified as sand with less than 3% organic matter and where ground water depth is shallow. To minimize the possibility of ground water contamination, carefully follow application rate recommendations as affected by soil type in the Crop Specific Information section of this label.

Movement by water erosion of treated soil - Do not apply or incorporate this product through any type of irrigation equipment nor by flood or furrow irrigation. Ensure treated areas have received at least one-half inch rainfall (or irrigation) before using tailwater for subsequent irrigation of other fields.

Endangered Species Concerns
The use of any pesticide in a manner that may kill or otherwise harm an endangered species or adversely modify their habitat is a violation of federal law.

3.3 Physical or Chemical Hazards

Do not store or heat near oxidizing agents, hazardous chemical reaction may occur.

4.0 DIRECTIONS FOR USE

It is a violation of Federal law to use this product in any manner inconsistent with its labeling. This product can only be used in accordance with the Directions for Use on this label. This labeling must be in the user's possession during application.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulations.

This is a restricted use pesticide.

4.1 Training

Prior to applying this product in the 2018 growing season and each growing season thereafter, applicator(s) must complete dicamba or auxin-specific training. If training is available and required by the state where the applicator intends to apply this product, the applicator must complete that training. If the state where the application is intended does not require auxin or dicamba-specific training, then the applicator must complete dicamba or auxin-specific training provided by one of the following sources: a) a registrant of a dicamba product approved for in-crop use with dicamba-tolerant crops, or b) a state or state-authorized provider.

4.2 Record Keeping

Record keeping is required for applications of this product. **The certified applicator must keep the following records for a period of two years**; records must be generated as soon as practical but no later than 14 days after application and a record must be kept for each application of Xtendimax with VaporGrip Technology. Records must be made available to State Pesticide Control Official(s), USDA, and EPA upon request. An example form summarizing record keeping requirements can be found on www.xtendimaxapplicationrequirements.com.

1. All Items required by 7 CFR Part 110 (RECORDKEEPING ON RESTRICTED USE PESTICIDES BY CERTIFIED APPLICATORS) including:
    a. The brand or product name
    b. The EPA registration number
    c. The total amount applied
    d. The month, day, and year
    e. The location of the application
    f. The crop, commodity, stored product, or site
    g. The size of treated area
    h. The name of the certified applicator
    i. The certification number of the certified applicator
2. Training: Date and provider of required training completed and proof of completion.
3. Receipts of Purchase: Receipts or copies for the purchase of this product.
4. Product Label: A copy of this product label, and any state special local needs label that supplements this label.
5. Buffer Requirement: Record of the buffer distance calculation and any areas included within the buffer distance calculations as allowed in Section 9.1.4.a.
6. Susceptible Crops Awareness: Record that a sensitive crop registry was consulted; or document surveying neighboring fields for any susceptible crops prior to application. At a minimum, records must include the name of the sensitive crop registry and the date it was consulted or the survey of neighboring fields and the date conducted (read Section 9.1.4.b for additional information).
7. Start and Finish Times of Each Application: Record of the time at which the application started and the time when the application finished.
8. Application Timing: Record of the type of application (for example: pre-emergence, post-emergence) and number of days after planting if post-emergence.
9. Air Temperature: Record of the air temperature in degrees Fahrenheit at the start and completion of each application.
10. Wind Speed and Direction: Record of the wind speed and direction (the direction from which the wind is blowing) at boom height at the start and completion of each application of this product (Read Section 9.1.1 for information on wind speed).
11. Nozzle and Pressure: Record of the spray nozzle manufacturer/brand, type, orifice size, and operating pressure used during each application of this product (Read Section 9.1.1 for information on nozzles and pressures.)
12. Tank Mix Products: Record of the brand names and EPA registration numbers (if available) for all products (pesticides, adjuvants, and other products) that were tank mixed with this product for each application (Read Section 8.0 for more information on tank mixing.)
13. Spray System Cleanout: Record of compliance with the section of this label titled Section 9.5: Proper Spray System Equipment Cleanout. At a minimum, records must include the confirmation that the spray system was clean before using this product and that the post-application cleanout was completed in accordance with Section 9.5.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about Personal Protective Equipment (PPE), and restricted-entry intervals. The requirements in this box only apply to uses of this product that are covered by the WPS.

Do not enter or allow worker entry into treated areas during the restricted-entry interval (REI) of 24 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as, plants, soil, or water is:

- Coveralls worn over short-sleeved shirt and short pants
- Chemical-resistant footwear plus socks
- Waterproof gloves
- Chemical-resistant headgear for overhead exposure
- Protective eyewear

NON-AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses.

Do not enter or allow people (or pets) to enter the treated area until sprays have dried. Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Do not enter or allow other people or pets to enter until sprays have dried.

5.0 STORAGE AND DISPOSAL

Proper pesticide storage and disposal are essential to protect against exposure to people and the environment due to leaks and spills, excess product or waste, and vandalism. Do not allow this product to contaminate water, foodstuffs, feed or seed by storage and disposal. Open dumping is prohibited. This product may not be mixed, loaded, or used within 50 feet of all wells including abandoned wells, drainage wells, and sinkholes. This setback does not apply to properly capped or plugged abandoned wells and does not apply to impervious pad or properly diked mixing/loading areas as described above

5.1 Pesticide Storage

Groundwater contamination may be reduced by diking and flooring of permanent liquid bulk storage sites with an impermeable material. Spillage or leakage should be contained and absorbed with clay granules, sawdust, or equivalent material for disposal.
Store in original container in a well-ventilated and away from food, pet food, feed, seed, fertilizers, and veterinary supplies. Avoid cross-contamination with other pesticides. Keep container closed to prevent spills and contamination.

5.2 Pesticide Disposal

To avoid wastes, use all material in this container, including rinsate, by application according to label directions. If wastes cannot be avoided, offer remaining product to a waste disposal facility or pesticide

disposal program. Such programs are often run by state or local governments or by industry. All disposal must be in accordance with applicable federal, state and local regulations and procedures.
[*Alternate PESTICIDE DISPOSAL statement for transport vehicles only:* To avoid wastes, empty as much product from this transport vehicle as possible for repackaging or use in accordance with label directions. If wastes cannot be avoided, offer remaining product or rinsate to a waste disposal facility or pesticide disposal program. All disposal must be in accordance with applicable federal, state and local regulations and procedures.]

5.3 Container Handling and Disposal

[*Optional label statement if applicable*: See container label for container handling and disposal instructions and refilling limitations.]

[*CONTAINER HANDLING AND DISPOSAL STATEMENTS AND REFILLING LIMITATIONS FOR CONTAINER LABELS*]

[*CONTAINER HANDLING AND DISPOSAL STATEMENT AND REFILLING LIMITATION FOR NONREFILLABLE RIGID CONTAINERS OF LESS THAN 1-GALLON CAPACITY*]

Nonrefillable container. Do not reuse or refill this container.

[*Alternate container statement:* Nonrefillable container. Do not reuse this container to hold materials other than pesticides or dilute pesticides (rinsate). After emptying and cleaning, it may be allowable to temporarily hold rinsate or other pesticide-related materials in the container. Contact your state regulatory agency to determine allowable practices in your state.]

Triple rinse this container promptly after emptying.

Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container ¼ full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times.

Then offer this container for recycling, if available. If recycling is not available, dispose of in accordance with federal, state and local regulations and procedures, which may include puncturing the properly rinsed container and disposing in a sanitary landfill.

[*Alternate container disposal statement:* Once properly rinsed, some agricultural plastic pesticide containers can be taken to a container collection site or picked up for recycling. To find the nearest site, contact your chemical dealer or Monsanto at 1-800-ROUNDUP (1-800-768-6387). If recycling is not available, dispose of in accordance with federal, state and local regulations and procedures, which may include puncturing the properly rinsed container and disposing in a sanitary landfill.]

[*CONTAINER HANDLING AND DISPOSAL STATEMENT AND REFILLING LIMITATION FOR NONREFILLABLE RIGID PLASTIC 2.5-GALLON CONTAINERS AND OTHER NONREFILLABLE CONTAINERS OF GREATER THAN 1-GALLON BUT EQUAL TO OR LESS THAN 5-GALLON CAPACITY*]

Nonrefillable container. Do not reuse this container to hold materials other than pesticides or dilute pesticides (rinsate). After emptying and cleaning, it may be allowable to temporarily hold rinsate or other pesticide-related materials in the container. Contact your state regulatory agency to determine allowable practices in your state.

[*Alternate container statement:* Nonrefillable container. Do not reuse or refill this container.]

Triple rinse or pressure rinse (or equivalent) this container promptly after emptying.

Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container ¼ full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times.

Pressure rinse as follows: Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 PSI for at least 30 seconds. Drain for 10 seconds after the flow begins to drip.

Once properly rinsed, some agricultural plastic pesticide containers can be taken to a container collection site or picked up for recycling. [*Optional container disposal statement:* To find the nearest site, contact your chemical dealer or Monsanto at 1-800-ROUNDUP (1-800-768-6387)]. If recycling is not available, dispose of in accordance with federal, state and local regulations and procedures, which may include puncturing the properly rinsed container and disposing in a sanitary landfill.

[*Alternate container disposal statement:* Then offer this container for recycling, if available. If recycling is not available, dispose of in accordance with federal, state and local regulations and procedures, which may include puncturing the properly rinsed container and disposing in a sanitary landfill.]

[*CONTAINER HANDLING AND DISPOSAL STATEMENT AND REFILLING LIMITATION FOR NONREFILLABLE RIGID PLASTIC 30-GALLON CONTAINERS AND OTHER NONREFILLABLE CONTAINERS OF GREATER THAN 5-GALLON CAPACITY*]

Nonrefillable container. Do not reuse or refill this container.

[*Alternate container statement:* Nonrefillable container. Do not reuse this container to hold materials other than pesticides or dilute pesticides (rinsate). After emptying and cleaning, it may be allowable to temporarily hold rinsate or other pesticide-related materials in the container. Contact your state regulatory agency to determine allowable practices in your state.]

Triple rinse or pressure rinse (or equivalent) this container promptly after emptying.

Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container ¼ full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two more times.

Pressure rinse as follows: Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 PSI for at least 30 seconds. Drain for 10 seconds after the flow begins to drip.

Once properly rinsed, some agricultural plastic pesticide containers can be taken to a container collection site or picked up for recycling. [*Alternate container disposal statement:* To find the nearest site, contact your chemical dealer or Monsanto at 1-800-ROUNDUP (1-800-768-6387)]. If recycling is not available, dispose of in accordance with federal, state and local regulations and procedures, which may include puncturing the properly rinsed container and disposing in a sanitary landfill.

[*Alternate container disposal statement:* Then offer the container for recycling, if available. If recycling is not available, dispose of in accordance with federal, state and local regulations and procedures, which may include puncturing the properly rinsed container and disposing in a sanitary landfill.]

[*Optional container label statement:* Return Properly Rinsed Container to Monsanto for Recycling Contact: 1-800-ROUNDUP (1-800-768-6387)]

[*CONTAINER HANDLING AND DISPOSAL STATEMENT AND REFILLING LIMITATION FOR ALL REFILLABLE CONTAINERS, EXCEPT TRANSPORT VEHICLES*]

Refillable container. Refill this container with pesticide only. Do not reuse this container for any other purpose.

Cleaning this container before refilling is the responsibility of the refiller. Cleaning this container before final disposal is the responsibility of the person disposing of the container.

To clean this container before final disposal, empty the remaining contents from this container into application equipment or a mix tank. Fill the container about 10 percent full with water. Agitate vigorously or recirculate water with the pump for 2 minutes. Pour or pump rinsate into application equipment or rinsate collection system. Repeat this rinsing procedure two more times. Then offer this container for recycling, if available.

[*Optional container disposal statement:* To obtain information about recycling refillable containers, contact Monsanto Company at 1-800-ROUNDUP (1-800-768-6387)]

[*Optional container label statement:* Return Properly Rinsed Container to Monsanto for Recycling, Call 1-800-ROUNDUP (1-800-768-6387)]

[*CONTAINER HANDLING AND DISPOSAL STATEMENT FOR ALL TRANSPORT VEHICLES AS DEFINED IN 40 CFR 156.3]*

THIS LABEL FOR USE WITH TRANSPORT VEHICLES ONLY

Emptied container retains vapor and product residue. Observe all precautions stated on this label until the container is cleaned, reconditioned or destroyed. Prior to refilling, inspect carefully for damage such as cracks, punctures, abrasions, and worn-out threads and closures. Clean thoroughly before reuse for transportation of a material of different composition or before retiring this transport vehicle from service.

[Alternative label statement: NET CONTENTS: See Bill of Lading]

[Alternative label statement: LOT: See Bill of Lading]

[Alternative label statement: For Net Contents and Lot Number, see Bill of Lading]

6.0 PRODUCT INFORMATION

XtendiMax® With VaporGrip® Technology is approved by U.S. EPA for all uses specified on this label in the following states, subject to county restriction as noted: Alabama, Arkansas, Arizona, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin.

Additional state restrictions and requirements may apply. The applicator must comply with any additional state requirements and restrictions.

This product is a water-soluble formulation intended for control and suppression of many annual, biennials, and perennial broadleaf weeds, as well as woody brush and vines listed in the WEEDS CONTROLLED section of this label. This product may be used for control of these weeds in asparagus, corn, cotton, conservation reserve programs, fallow cropland, grass grown for seed, hay, proso millet, pasture, rangeland, general farmstead (noncropland), small grains, sod farms and farmstead turf, sorghum, soybean, sugarcane, Cotton with XtendFlex Technology and Roundup Ready 2 Xtend Soybean.

XtendiMax® With VaporGrip® Technology is a contact, systemic herbicide which can have moderate residual control on small seeded broadleaf weeds, including waterhemp, lambsquarters and Palmer pigweed, depending on rainfall and soil type.

XtendiMax® With VaporGrip® Technology is readily absorbed by plants through shoot and root uptake, translocates throughout the plant's system, and accumulates in areas of active growth. XtendiMax® With VaporGrip® Technology interferes with the plant's growth hormones (auxins) resulting in death of many broadleaf weeds.

Failure to properly clean the entire spray system can result in inadvertent contamination of the spray system. You must ensure that the spray system used to apply this product is clean before using this product.

Rainfast period: Rainfall or irrigation occurring within 4 hours after postemergence applications may reduce the effectiveness of this product.

Refer to the CROP-SPECIFIC INFORMATION and CROPS WITH XTEND TECHNOLOGY sections for application timing and other crop-specific details.

6.1 Restrictions

The applicator must read the entire label, including product labeling and follow all restrictions for XtendiMax® With VaporGrip® Technology. Restrictions included, but are not limited to:

- DO NOT APPLY THIS PRODUCT AERIALLY.
- DO NOT TANK MIX WITH PRODUCTS CONTAINING AMMONIUM SALTS SUCH AS AMMONIUM SULFATE (AMS) AND UREA AMMONIUM NITRATE. Small quantities of AMS can greatly increase the volatility potential of dicamba. Read the TANK MIXING INSTRUCTIONS of this label (Section 8.0) for instructions regarding other tank mix products.
- DO NOT APPLY TO CROPS UNDER STRESS DUE TO LACK OF MOISTURE, HAIL DAMAGE, FLOODING, HERBICIDE INJURY, MECHANICAL INJURY, INSECTS, OR WIDELY FLUCTUATING TEMPERATURES AS INJURY MAY RESULT.
- DO NOT APPLY THROUGH ANY TYPE OF IRRIGATION EQUIPMENT. DO NOT TREAT IRRIGATION DITCHES OR WATER USED FOR CROP IRRIGATION OR DOMESTIC PURPOSES.
- DO NOT MAKE APPLICATION OF THIS PRODUCT IF RAIN IS EXPECTED IN THE NEXT 24 HOURS.

Review the entire label including, specific crop use direction sections for additional restrictions.

7.0 WEED RESISTANCE MANAGEMENT

GROUP	4	HERBICIDE

Dicamba mimics auxin (a plant hormone) resulting in a hormone imbalance in susceptible plants that interferes with normal cell division, cell enlargement, and protein synthesis. Dicamba active ingredient is a Group 4 herbicide based on the mode of action classification system of the Weed Science Society of America. Any weed population can contain plants naturally resistant to Group 4 herbicides. Weed species resistant to Group 4 herbicides can be effectively managed utilizing another herbicide from a different Group, or by using other cultural or mechanical practices.

7.1 Weed Management Practices

Certain agronomic practices can delay or reduce the likelihood that resistant weed populations will develop and can be utilized to manage weed resistance once it occurs.

Do not use less than the labeled rate of this product in a single application. Using the appropriate application rate can minimize the selection for resistant weeds.

Proactively implementing diversified weed control strategies to minimize selection for weed populations resistant to one or more herbicides is a best practice. A diversified weed management program may include the use of multiple herbicides with different sites of action and overlapping weed spectrum with or without tillage operations and/or other cultural practices. Research has demonstrated that using the labeled rate and directions for use is important to delay the selection for resistance.

The continued effectiveness of this product depends on the successful implementation of a weed resistance management program.

To aid in the prevention of developing weeds resistant to this product:

- Scout fields before application to ensure herbicides and rates will be appropriate for the weed species and weed sizes present.
- Start with a clean field, using either a burndown herbicide application or tillage.
- Control weeds early when they are relatively small (less than 4 inches).
- Apply full rates of XtendiMax® With VaporGrip® Technology for the most difficult to control weed in the field at the specified time (correct weed size) to minimize weed escapes.
- Avoid tank mixtures with other herbicides that reduce the efficacy of this product (through antagonism), or with ones that encourage application rates of this product below those specified on this label.
- Scout fields after application to detect weed escapes or shifts in weed species.
- Control weed escapes before they reproduce by seed or proliferate vegetatively.
- Report any incidence of non-performance of this product against a particular weed species to your Monsanto retailer or representative or call 1-844-RRXTEND (1-844-779-8363).
- If resistance is suspected, treat weed escapes with an herbicide having a site of action other than Group 4 and/or use non-chemical methods to remove escapes, as practical, with the goal of preventing further seed production.

Additionally, users should follow as many of the following herbicide resistance management practices as is practical:

- Use a broad spectrum soil-applied herbicide with other sites of action as a foundation in a weed control program.
- Utilize sequential applications of herbicides with alternative sites of action.

- Rotate the use of this product with non-Group 4 herbicides.
- Avoid making more than two applications of dicamba and any other Group 4 herbicides within a single growing season unless mixed with an herbicide with a different mechanism of action with an overlapping spectrum for the difficult to control weeds.
- Incorporate non-chemical weed control practices, such as mechanical cultivation, crop rotation, cover crops and weed-free crop seeds, as part of an integrated weed control program.
- Use good agronomic principles that enhance crop development and crop competitiveness.
- Thoroughly clean plant residues from equipment before leaving fields suspected to contain resistant weeds.
- Manage weeds in and around fields, during and after harvest to reduce weed seed production.

Contact the local agricultural extension service, Monsanto representative, agricultural retailer or crop consultant for further guidance on weed control practices as needed.

7.2 Management of Dicamba-Resistant Biotypes

Appropriate testing is critical in order to determine if a weed is resistant to dicamba. Contact your Monsanto representative to determine if resistance in any particular weed biotype has been confirmed in your area, or visit on the Internet www.weedresistancemanagement.com or www.weedscience.org.

Monsanto Company is not responsible for any losses that result from the failure of this product to control dicamba-resistant weed biotypes.

The following good agronomic practices can reduce the spread of confirmed dicamba-resistant biotypes:

- If a naturally occurring resistant biotype is present in your field, this product may be tank-mixed or applied sequentially with an appropriately labeled herbicide with a different mode of action to achieve control (read Section 8.0 for more information on tank mixing).
- Cultural and mechanical control practices (e.g., crop rotation or tillage) can also be used as appropriate.
- Scout treated fields after herbicide application and control weed escapes, including resistant biotypes, before they set seed.
- Thoroughly clean equipment, as practical, for all weed seeds before leaving fields known to contain resistant biotypes.

8.0 TANK MIXING INSTRUCTIONS

XtendiMax® With VaporGrip® Technology may only be tank-mixed with products that have been tested and found not to adversely affect the offsite movement potential of XtendiMax® With VaporGrip® Technology. A list of those products may be found at www.xtendimaxapplicationrequirements.com.

The applicator must check the list of tested products found not to adversely affect the offsite movement potential of XtendiMax® With VaporGrip® Technology at www.xtendimaxapplicationrequirements.com no more than 7 days before applying XtendiMax® With VaporGrip® Technology.

DO NOT tank mix any product with XtendiMax® With VaporGrip® Technology unless:

1. The intended tank-mix product is identified on the list of tested products;
2. The intended products are not prohibited on either this label or the label of the tank mix product; and
3. All requirements and restrictions on www.xtendimaxapplicationrequirments.com are followed.

TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, MONSANTO MAKES NO RECOMMENDATION OR WARRANTY HEREIN REGARDING THE USE OF ANY PRODUCT THAT

MAY APPEAR ON THE WEBSITE REFERENCED ABOVE, REGARDLESS OF WHETHER SUCH PRODUCT IS USED ALONE OR IN A TANK MIX WITH XTENDIMAX® WITH VAPORGRIP® TECHNOLOGY. BUYER AND ALL USERS ARE SOLELY RESPONSIBLE FOR ANY LACK OF PERFORMANCE, LOSS, OR DAMAGE IN CONNECTION WITH THE USE OR HANDLING OF ANY SUCH PRODUCT ALONE OR IN A TANK MIX WITH XTENDIMAX® WITH VAPORGRIP® TECHNOLOGY. See the section titled "LIMIT OF WARRANTY AND LIABILITY" herein for more information.

8.1 Compatibility Test for Mix Components

Before mixing components, always perform a compatibility jar test.

- For 15 gallons per acre spray volume, use 2.5 cups (591.5 mL) of water. For other spray volumes, adjust rates accordingly. Only use water from the intended source at the source temperature.
- Add components in the sequence indicated in the Mixing Order section below using 2 teaspoons for each pound or 1 teaspoon for each pint of labeled use rate per acre.
- Cap the jar and invert 10 cycles between component additions.
- When the components have all been added to the jar, let the solution stand for 15 minutes.
- Evaluate the solution for uniformity and stability. The spray solution should not have free oil on the surface; fine particles that precipitate to the bottom; or thick (clabbered) texture. If the spray solution is not compatible, repeat the compatibility test with the addition of a suitable compatibility agent. If the solution is then compatible, use the compatibility agent as directed on its label. If the solution is still incompatible, then do not mix the ingredients in the same tank.

8.2 Mixing Order

Only use approved tank mix products as directed on www.xtendimaxapplicationrequirements.com. Always read and follow label directions for all products in the tank mixture. It is the pesticide user's responsibility to ensure that all products in the listed mixtures are registered for the intended use. Users must follow the most restrictive directions for use and precautionary statements of each product in the tank mixture. See section 8.0 for additional restrictions on tank mixing.

1. Ensure application and mixing equipment are clean and in proper working order
2. Water - Begin by agitating a thoroughly **clean sprayer** tank three-quarters full of clean water.
3. Agitation - Maintain constant agitation throughout mixing and application.
4. Drift Reducing Adjuvants (DRA)-(when applicable)
5. Inductor - If an inductor is used, rinse it thoroughly after each component has been added.
6. Products in PVA bags - Place any product contained in water-soluble PVA bags into the mixing tank. Wait until all water-soluble PVA bags have fully dissolved and the product is evenly mixed in the spray tank before continuing.
7. Water-dispersible products (dry flowables, wettable powders, suspension concentrates, or suspo-emulsions)
8. Water-soluble products (such as XtendiMax® With VaporGrip® Technology)
9. Emulsifiable concentrates (such as oil concentrate when applicable)
10. Water-soluble additives (when applicable)
11. Add remaining quantity of water.

Maintain constant agitation during application

8.3 Adjuvants, Drift Reducing Adjuvants, Surfactants, and Other Tank Mixed Products

See Section 8.0 TANK MIXING INSTRUCTIONS for tank mixing instructions for adjuvants, drift reducing adjuvants, surfactants, and other tank mixed products.

9.0 APPLICATION EQUIPMENT AND TECHNIQUES

DO NOT APPLY THIS PRODUCT USING AERIAL SPRAY EQUIPMENT.

XtendiMax® With VaporGrip® Technology can be applied to actively growing weeds as broadcast, band, or spot spray applications using water as a carrier. For best results, treat weeds early when they are relatively small (less than 4 inches). Timely application to small weeds early in the season will improve control and reduce weed competition. Refer to Table 1 for XtendiMax® With VaporGrip® Technology application rates for control or suppression by weed type and growth stage. For crop-specific application timing and other details, refer to the CROP-SPECIFIC INFORMATION section of this label.

APPLY THIS PRODUCT USING PROPERLY MAINTAINED AND CALIBRATED EQUIPMENT CAPABLE OF DELIVERING THE REQUIRED VOLUMES.

Using a hooded sprayer or other drift reduction technology in combination with approved nozzles may further reduce drift potential.

Cultivation: Do not cultivate within 7 days after applying this product.

Table 1. XtendiMax® With VaporGrip® Technology Application Rates for Control or Suppression by Weed Type and Growth Stage
Use rate limitations are given in sections 10 (RESTRICTIONS), 11 (CROP-SPECIFIC INFORMATION), and 12 (CROPS WITH XTEND TECHNOLOGY)

Weed Type and Stage	Rate Per Acre	Weed Type and Stage	Rate Per Acre
Annual[1] Small, actively growing Established weed growth	 11 – 22 fluid ounces 22 – 33 fluid ounces	**Perennial** Top growth suppression Top growth control and root suppression Noted perennials (footnote 1 in Section 13.0). Other perennials (without footnote 1 in Section 13.0)[3]	 11 – 22 fluid ounces 22 – 44 fluid ounces 44 fluid ounces 44 fluid ounces
Biennial Rosette diameter 1 – 3" Rosette diameter 3" or more Bolting	 11 – 22 fluid ounces 22 – 44 fluid ounces 44 fluid ounces	**Woody Brush & Vines** Top growth suppression Top growth control[2,3] Stems and stem suppression[3]	 22 – 44 fluid ounces 44 fluid ounces 44 fluid ounces

[1] Rates below 11 fluid ounces per acre may provide control or suppression but should typically be applied with other herbicides that are effective on the same species and biotype.
[2] Woody Species listed in section 13.0 may require tank mixes for adequate top growth control.
[3] DO NOT broadcast apply more than 44 ounces per acre for a single application and DO NOT exceed broadcast applications of more than 88 ounces per acre within the growing season when a sequential application is needed for control. Use the higher rate when treating dense

vegetation or perennial weeds with established root growth. Perennials and Woody Species are defined as those listed in Section 13.0.

9.1 Spray Drift Management

Do not allow herbicide solution to mist, drip, drift or splash onto desirable vegetation because severe injury or destruction to desirable broadleaf plants could result.

The most effective way to reduce drift potential is to apply large droplets that provide sufficient coverage and control. Applying larger droplets reduces drift potential, but will not prevent drift if the application is made improperly, or under unfavorable environmental conditions (see the **"Temperature and Humidity"** and "**Temperature Inversions"** sections of this label).

9.1.1 Sprayer Setup

The following sprayer setup requirements for drift management must be followed:

- **Nozzle type.** The applicator must use an approved nozzle within a specified pressure range as found at www.xtendimaxapplicationrequirements.com when applying XtendiMax® With VaporGrip® Technology. Do not use any other nozzle and pressure combination not specifically listed on this website.
- **Spray Volume.** The applicator must apply this product in a **minimum of 15 gallons of spray solution per acre**. See Section 8.0 for information on approved tank mix products.
- **Equipment Ground Speed.** Do not exceed a **ground speed of 15 miles per hour**. Select a ground speed that will deliver the desired spray volume while maintaining the desired spray pressure, but slower speeds generally result in better spray coverage and deposition on the target area. Provided the applicator can maintain the required nozzle pressure, it is recommended that tractor speed is reduced to 5 miles per hour at field edges.
- **Spray boom Height.** Do not exceed a **boom height of 24 inches** above target pest or crop canopy. Excessive boom height will increase the drift potential.
- **Wind Speed.** Do not apply when wind speeds are **less than 3 MPH or greater than 10 MPH**. Only apply when wind speed at boom height is between 3 and 10 mph.

9.1.2 Temperature and Humidity

When making applications in low relative humidity or temperatures above 91 degrees Fahrenheit, set up equipment to produce larger droplets to compensate for evaporation (for example: increase orifice size and/or increase spray volume as directed on www.xtendimaxapplicationrequirements.com). Larger droplets have a lower surface to volume ratio and can be impacted less by temperature and humidity. Droplet evaporation is most severe when conditions are both hot and dry.

9.1.3 Temperature Inversions

Do not apply this product during a temperature inversion as the off-target movement potential is high.
Do not apply this product between sunset and sunrise. In general, temperature inversions are more likely during night time hours.

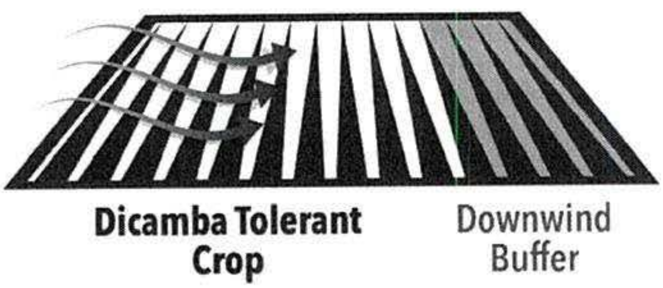
- During a temperature inversion, the atmosphere is very stable and vertical air mixing is restricted, which can cause small, suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light, variable winds common during inversions.
- Temperature inversions can be characterized by increasing temperatures with altitude and can be common on evenings and nights with limited cloud cover and light to no wind. Cooling of air at the earth's surface takes place and warmer air is trapped above it. Temperature inversions can begin to form as the sun sets and often continue into the morning.
- Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing.
- The inversion will typically dissipate with increased winds (above 3 miles per hour) or at sunrise when the surface air begins to warm (generally 3°F from morning low).

9.1.4 Buffer Requirements and Protection of Susceptible Crops

Do not apply under circumstances where drift may occur to food, forage, or other plantings that might be damaged or the crops rendered unfit for sale, use, or consumption.

9.1.4.a. Buffer Requirement

The applicator **must always maintain** a 110 foot downwind buffer (when applying up to 22 fluid ounces of this product per acre) or a 220 foot downwind buffer (when applying greater than 22 up to 44 fluid ounces of this product per acre) between the last treated row and the nearest downwind field edge (in the direction the wind is blowing).



The following areas may be included in the buffer distance calculation when directly adjacent to the treated field edges:

- Roads, paved or gravel surfaces.
- Planted agricultural fields containing: corn, dicamba tolerant cotton, dicamba tolerant soybean, sorghum, proso millet, small grains and sugarcane. If the applicator intends to include such crops as dicamba tolerant cotton and/or dicamba tolerant soybeans in the buffer distance calculation, the applicator must confirm the crops are in fact dicamba tolerant.
- Agricultural fields that have been prepared for planting.
- Areas covered by the footprint of a building, silo, or other man made structure with walls and or roof.

9.1.4.b. **Susceptible Crops**

DO NOT APPLY this product when the wind is blowing toward adjacent non-dicamba tolerant susceptible crops; this includes **NON-DICAMBA TOLERANT SOYBEAN AND COTTON.**

Before making an application, the applicator must survey the application site for adjacent non-target susceptible crops. The applicator must also consult applicable sensitive crop registries to identify any commercial specialty or certified organic crops that may be located near the application site.

Susceptible crops include, but are not limited to non-dicamba tolerant soybeans and cotton, tomatoes and other fruiting vegetables (EPA crop group 8), fruit trees, cucurbits (EPA crop group 9), grapes, beans, flowers, ornamentals, peas, potatoes, sunflower, tobacco, other broadleaf plants, and including plants in a greenhouse. Severe injury or destruction could occur if any contact between this product and these plants occurs.

9.1.5 Application Awareness

AVOIDING SPRAY DRIFT AT THE APPLICATION SITE IS THE RESPONSIBILITY OF THE APPLICATOR.

The interaction of equipment and weather related factors must be monitored to maximize performance and on-target spray deposition. The applicator is responsible for considering all of these factors when making a spray decision. The applicator is responsible for compliance with state and local pesticide regulations, including any state or local pesticide drift regulations.

9.2 Ground Application (Banding)

When applying XtendiMax® With VaporGrip® Technology by banding, determine the amount of herbicide and water volume needed using the following formula:

$$\frac{\text{Bandwidth in inches}}{\text{Row width in inches}} \times \text{Broadcast rate per acre} = \text{Banding herbicide rate per acre}$$

$$\frac{\text{Bandwidth in inches}}{\text{Row width in inches}} \times \text{Broadcast volume per acre} = \text{Banding water volume per acre}$$

9.3 Ground Application (Broadcast)

Water Volume: Use a **minimum of 15 gallons** of spray solution per broadcast acre for optimal performance. Use 20 gallons per acre when treating dense or tall vegetation.

Application Equipment: Select nozzles (refer to section 9.1.1 Nozzle type of this product label) designed to produce minimal amounts of fine spray particles. Spray with nozzles as close to the weeds as practical for good weed coverage.

Using a hooded sprayer or other drift reduction technology in combination with approved nozzles may further reduce drift potential.

9.4 Ground Application (Wipers)

XtendiMax® With VaporGrip® Technology may be applied through wiper application equipment to control or suppress actively growing broadleaf weeds, brush and vines. Use a solution containing 1 part XtendiMax® With VaporGrip® Technology to 1 part water. Do not apply greater than 1 lb dicamba acid equivalent (1 quart of this product) per acre per application. Do not contact desirable vegetation with herbicide solution. Wiper application may be made to crops (including pastures) and non-cropland areas described in this label except for non-dicamba-tolerant cotton, sorghum, and non-dicamba-tolerant soybean.

9.5 Proper Spray System Equipment Cleanout

You must ensure that the spray system used to apply this product is clean before using this product.

Failure to properly clean the entire spray system can result in inadvertent contamination of the spray system.

Small quantities of dicamba may cause injury to non-dicamba tolerant soybeans and other susceptible crops (see Section 9.1.4 of this label for more information).

Clean equipment immediately after using this product, using a triple rinse procedure as follows:

1. After spraying, drain the sprayer (including boom and lines) immediately. Do not allow the spray solution to remain in the spray boom lines overnight prior to flushing.
2. Flush tank, hoses, boom and nozzles with clean water. If equipped, open boom ends and flush.
3. Inspect and clean all strainers, screens and filters.
4. Prepare a cleaning solution with a commercial detergent or sprayer cleaner or ammonia according to the manufacturer's directions.
5. Take care to wash all parts of the tank, including the inside top surface. Start agitation in the sprayer and thoroughly recirculate the cleaning solution for at least 15 minutes. All visible deposits must be removed from the spraying system.
6. Flush hoses, spray lines and nozzles for at least 1 minute with the cleaning solution.
7. Remove nozzles, screens and strainers and clean separately in the cleaning solution after completing the above procedures.
8. Drain pump, filter and lines.
9. Rinse the complete spraying system with clean water.
10. Clean and wash off the outside of the entire sprayer and boom.
11. All rinse water must be disposed of in compliance with local, state, and federal guidelines.

10.0 ADDITIONAL RESTRICTIONS

Maximum Application Rates: The maximum application or use rates stated throughout this label are given in units of volume (fluid ounces or quarts) of this product per acre. However, the maximum allowed application rates apply to this product combined with the use of any and all other herbicides containing the active ingredients dicamba, whether applied separately or as a tank mixture, on a basis of total pounds of dicamba (acid equivalents) per acre. If more than one dicamba-containing product is applied to the same site within the same year, you must ensure that the total use of dicamba (pounds acid equivalents) does not exceed 2 pounds/A per year from all applications. See the INGREDIENTS section of this label for necessary product information.

Maximum seasonal use rate: Refer to Table 2. Crop-Specific Restrictions for crop-specific maximum seasonal use rates. Do not exceed 88 fluid ounces of XtendiMax® With VaporGrip® Technology (2 pounds acid equivalent) per acre, per year.

Preharvest Interval (PHI): Refer to the CROP-SPECIFIC INFORMATION section for preharvest intervals.

Restricted Entry Interval (REI): 24 hours

Crop Rotational Restrictions

No rotational cropping restrictions apply when rotating to Roundup Ready 2 Xtend® Soybeans or cotton seed with XtendFlex® Technology (including Bollgard® 3 XtendFlex® Cotton, Bollgard II® XtendFlex® Cotton, or XtendFlex® Cotton). For other crops the interval between application and planting rotational crop is given below. When counting days from the application of this product, do not count days when the ground is frozen. Planting at intervals less than specified below may result in crop injury. Moisture is essential for the degradation of this herbicide in soil. If dry weather prevails, use cultivation to allow herbicide contact with moist soil.

Planting/replanting restrictions at application rates of 33 fluid ounces of this product per acre per season or less: Follow the planting restrictions in the directions for use for Preplant application in the Crop Specific Information section of this label. For corn, cotton (except cotton seed with XtendFlex® Technology), sorghum, and soybean (except Roundup Ready 2 Xtend® Soybean), follow the planting restrictions in the directions for use for preplant application in **Section 11. Crop-Specific Information** of this label. Do not plant barley, oat, wheat, and other grass seedings for 15 days for every 11 fluid ounces of this product applied per acre east of the Mississippi River and 22 days for every 11 fluid ounces per acre applied west of the Mississippi River. No planting restrictions apply beyond 120 days after application of this product.

Planting/replanting restrictions at application rates of more than 33 fluid ounces and up to 88 fluid ounces of this product per acre per season: Wait a minimum of 120 days after application of this product before planting corn, sorghum and cotton (except cotton seed with XtendFlex® Technology) east of the Rocky Mountains and before planting all other crops (except Roundup Ready 2 Xtend® Soybean) grown in areas receiving 30 inches or more rainfall annually. Wait a minimum of 180 days before planting crops in areas with less than 30 inches of annual rainfall. Wait a minimum of 30 days for every 22 fluid ounces of this product applied per acre before planting barley, oat, wheat, and other grass seedings east of the Mississippi River and 45 days for every 22 fluid ounces of this product applied per acre west of the Mississippi River.

Table 2. Crop-Specific Restrictions[1]

Crop	Maximum Rate Per Acre Per Application	Maximum In-Crop Rate Pre Acre Per Season	Livestock Grazing or Feeding

	(fl oz)	(fl oz)	
Asparagus	22	22	Yes
Barley; Fall Spring	11 11	16.5 15	Yes
Conservation Reserve Program (CRP)	44	88	Yes
Corn	22	33	Yes[2]
Cotton	11	11	Yes
Cotton with XtendFlex Technology	44	88	Yes
Fallow Ground	44	88	Yes
Grass grown for seed	44	88	Yes
Oats	5.5	5.5	Yes
Pastureland	44	44	Yes
Proso Millet	5.5	5.5	Yes
Small grains grown for grass, forage, fodder, hay and/or pasture	22	22	Yes
Sorghum	11	22	Yes
Soybean	44	44	Yes
Roundup Ready 2 Xtend Soybean	44	88	Yes

Sugarcane	44	88	Yes
Triticale	5.5	5.5	Yes
Sod farms and farmstead turf	44	44	Yes
Wheat	11	22	Yes

[1]Refer to section **11. CROP-SPECIFIC INFORMATION** and section **12. CROPS WITH XTEND TECHNOLOGY** for more details.
[2]Once the crop reaches the ensilage (milk) stage or later in maturity

11.0 CROP-SPECIFIC INFORMATION

Read Sections: 8.0 for Tank Mixing Instructions and 9.1.4 for Buffer Requirements and Susceptible Crops for information on tank mixing, buffer requirements, and susceptible crops.

11.1 Asparagus

Apply XtendiMax® With VaporGrip® Technology to emerged and actively growing weeds in 40 - 60 gallons of diluted spray per treated acre immediately after cutting the field, but at least 24 hours before the next cutting. Multiple applications may be made per growing season.

If spray contacts emerged spears, crooking (twisting) of some spears may result. If such crooking occurs, discard affected spears.

Rates: Apply 11-22 fluid ounces of XtendiMax® With VaporGrip® Technology to control annual sowthistle, black mustard, Canada and Russian thistle, and redroot pigweed (carelessweed).

Apply 22 fluid ounces of XtendiMax® With VaporGrip® Technology to control common chickweed, field bindweed, nettleleaf goosefoot, and wild radish. Up to 2 applications may be made per growing season. Do not exceed a total of 22 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre, per crop year.

Do not harvest prior to 24 hours after treatment.

[Optional: Do not use in the Coachella Valley of California]

11.2 Between Crop Applications

Preplant Directions (Postharvest, Fallow, Crop Stubble, Set-Aside) for Broadleaf Weed Control:

XtendiMax® With VaporGrip® Technology can be applied either postharvest in the fall, spring, or summer during the fallow period or to crop stubble/set-aside acres. Apply XtendiMax® With VaporGrip® Technology as a broadcast or spot treatment to emerged and actively growing weeds after crop harvest (postharvest) and before a killing frost or in the fallow cropland or crop stubble the following spring or summer.

See the "Crop Rotational Restrictions" in Section 10 of this label for the recommended interval between application and planting to prevent crop injury.

Rates and Timings:

Apply 5.5 – 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre. Refer to Table 1 to determine use rates for specific targeted weed species. For best performance, apply XtendiMax® With VaporGrip® Technology when annual weeds are less than 4" tall, when biennial weeds are in the rosette stage and to perennial weed regrowth in late summer or fall following a mowing or tillage treatment. The most effective control of upright perennial broadleaf weeds such as Canada thistle and Jerusalem artichoke occurs if XtendiMax® With VaporGrip® Technology is applied when the majority of weeds have at least 4 - 6" of regrowth or for weeds such as field bindweed and hedge bindweed that are in or beyond the full bloom stage.

Avoid disturbing treated areas following application. Treatments may not kill weeds that develop from seed or underground plant parts such as rhizomes or bulblets, after the effective period for XtendiMax® With VaporGrip® Technology. For seedling control, a follow-up program or other cultural practices could be instituted. For small grain in-crop uses of XtendiMax® With VaporGrip® Technology, refer to the small grain section for details.

11.3 Conservation Reserve Program (CRP)

XtendiMax® With VaporGrip® Technology is recommended for use on both newly seeded and established grasses grown in Conservation Reserve or federal Set-Aside Programs. Treatments of XtendiMax® With VaporGrip® Technology will injure or may kill alfalfa, clovers, lespedeza, wild winter peas, vetch, and other legumes.

Newly Seeded Areas

XtendiMax® With VaporGrip® Technology may be applied either preplant or postemergence to newly seeded grasses or small grains such as barley, oats, rye, sudanqrass, wheat, or other grain species grown as a cover crop. Postemergence applications may be made after seedling grasses exceed the 3-leaf stage. Rates of XtendiMax® With VaporGrip® Technology greater than 22 fluid ounces per treated acre may severely injure newly seeded grasses.

Preplant applications may injure new seedlings if the interval between application and grass planting is less than 45 days per 22 fluid ounces of XtendiMax® With VaporGrip® Technology applied per treated acre west of the Mississippi River or 20 days per 22 fluid ounces applied east of the Mississippi River.

Established Grass Stands

Established grass stands are perennial grasses planted one or more seasons prior to treatment. Certain species (bentgrass, carpetgrass, smooth brome, buffalograss, or St. Augustinegrass) may be injured when treated with more than 22 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre.

When applied at recommended rates, XtendiMax® With VaporGrip® Technology will control many annual and biennial weeds and provide control or suppression of many perennial weeds.

Rates and Timings

Apply 5.5 - 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre. Refer to **Table 1** for rates based on target weed species. Retreatments may be made as needed; however, do not exceed a total of 88 fluid ounces (4 pints) of XtendiMax® With VaporGrip® Technology per acre per year.

11.4 Corn (Field, Pop, Seed, And Silage)

Direct contact of XtendiMax® With VaporGrip® Technology with corn seed must be avoided. If corn seeds are less than 1.5" inches below the surface, delay application until corn has emerged.

Applications of XtendiMax® With VaporGrip® Technology to corn during periods of rapid growth may result in temporary leaning. Corn will usually become erect within 3 to 7 days. Cultivation should be delayed until after corn is growing normally to avoid breakage.

Corn may be harvested or grazed for feed once the crop has reached the ensilage (milk) stage or later in maturity.

Up to 2 applications of XtendiMax® With VaporGrip® Technology may be made during a growing season. Sequential applications must be separated by 2 weeks or more.

Do not apply XtendiMax® With VaporGrip® Technology to seed corn or popcorn without first verifying with your local seed corn company (supplier) the selectivity of XtendiMax® With VaporGrip® Technology on your inbred line or variety of popcorn. This precaution will help avoid potential injury of sensitive varieties.

Avoid using crop oil concentrates after crop emergence as crop injury may result. Use crop oil concentrates only in dry conditions when corn is less than 5" tall when applying XtendiMax® With VaporGrip® Technology.

Use of sprayable fluid fertilizer as the carrier is not recommended for applications of XtendiMax® With VaporGrip® Technology made after corn emergence.

XtendiMax® With VaporGrip® Technology is not registered for use on sweet corn.

Preplant and Preemergence Application in No-Tillage Corn:

Rates: Apply 22 fluid ounces of XtendiMax® With VaporGrip® Technology per acre on medium- or fine-textured soils containing 2.5% or greater organic matter. Use 11 fluid ounces per acre on coarse soils (sand, loamy sand, and sandy loam) or medium- and fine-textured soils with less than 2.5% organic matter.

Timing: XtendiMax® With VaporGrip® Technology can be applied to emerging weeds before, during, or after planting a corn crop. When planting into a legume sod (e.g., alfalfa or clover), apply XtendiMax® With VaporGrip® Technology after 4 - 6" of regrowth has occurred

Preemergence Application in Conventional or Reduced Tillage Corn:

Rates: Apply 22 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre on medium- or fine-textured soils containing 2.5% organic matter or more. Do not apply to coarse textured soils (sand, loamy sand, or sandy loam) of any soil with less than 2.5% organic matter until after corn emergence (See Early Postemergence uses below).

Timing: XtendiMax® With VaporGrip® Technology may be applied after planting and prior to corn emergence. Pre-emergence application of XtendiMax® With VaporGrip® Technology does not require mechanical incorporation to become active. A shallow mechanical incorporation is recommended if application is not followed by adequate rainfall or sprinkler irrigation. Avoid tillage equipment (e.g., drags, harrows) which concentrates treated soil over seed furrow as seed damage could result.

Preemergence control of cocklebur, jimsonweed, and velvetleaf may be reduced if conditions such as low temperature or lack of soil moisture cause delayed or deep germination of weeds.

Early Postemergence Application in All Tillage Systems:

Rates: Apply 22 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre. Reduce the rate to 11 fluid ounces per treated acre if corn is growing on coarse textured soils (sand, loamy sand, and sandy loam).

Timing: Apply between corn emergence and the 5-leaf stage or 8" tall, whichever occurs first. Refer to Late Postemergence Applications if the sixth true leaf is emerging from whorl or corn is greater than 8" tall.

Late Postemergence Application:

Rate: Apply 11 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre.

Timing: Apply XtendiMax® With VaporGrip® Technology from 8 - 36" tall corn or 15 days before tassel emergence, whichever comes first. For best performance, apply when weeds are less than 3" tall.

Apply directed spray when corn leaves prevent proper spray.

11.5 Cotton

For directions for use with crops with Xtend Technology see the "CROPS WITH XTEND TECHNOLOGY" section of this label.

Preplant Application:

Apply up to 11 fluid ounces of XtendiMax® With VaporGrip® Technology per acre to control emerged broadleaf weeds prior to planting cotton in conventional or conservation tillage systems.

For best performance, apply XtendiMax® With VaporGrip® Technology when weeds are in the 2 - 4 leaf stage and rosettes are less than 2" across.

Following application of XtendiMax® With VaporGrip® Technology and a minimum accumulation of 1" of rainfall or overhead irrigation, allow a minimum of 21 days between treatment and planting per application of 11 fluid ounces per acre or less. This plant back interval must be observed prior to planting cotton.

Do not apply preplant to cotton west of the Rockies.

Do not make XtendiMax® With VaporGrip® Technology preplant applications to cotton in geographic areas with average annual rainfall less than 25".

If applying a spring preplant treatment following application of a fall preplant (postharvest) treatment, then the combination of both treatments may not exceed 2 pounds acid equivalent per acre.

11.6 Grass Grown For Seed

Apply 11 - 22 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre on seedling grass after the crop reaches the 3 -5 leaf stage. Apply up to 44 fluid ounces of XtendiMax® With VaporGrip® Technology on well-established perennial grass. For best performance, apply XtendiMax® With VaporGrip® Technology when weeds are in the 2 - 4 leaf stage and rosettes are less than 2" across. Use the higher level of listed rate ranges when treating more mature weeds or dense vegetative growth.

To suppress annual grasses such as brome (downy and ripgut), rattail fescue, and windgrass, apply up to 44 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre in the fall or late summer after harvest and burning of established grass seed crops. Applications should be made immediately following the first irrigation when the soil is moist and before weeds have more than 2 leaves.

Do not apply XtendiMax® With VaporGrip® Technology after the grass seed crop begins to joint.

Refer to the Pasture, Hay, Rangeland, and General Farmstead section for grazing and feeding restrictions.

11.7 Proso Millet

For use only within Colorado, Nebraska, North Dakota, South Dakota, [Optional: **and Wyoming].**

XtendiMax® With VaporGrip® Technology combined with an appropriate tank-mix partner will provide control or suppression of the annual broadleaf weeds listed in **Section 13.**

11.8 Pasture, Hay, Rangeland, And General Farmstead (Noncropland)

XtendiMax® With VaporGrip® Technology is recommended for use on pasture, hay, rangeland, and general farmstead (non-cropland) (including fencerows and non-irrigation ditch banks) for control or suppression of broadleaf weed and brush species listed in Section 12.

XtendiMax® With VaporGrip® Technology may also be applied to non-cropland areas to control broadleaf weeds in noxious weed control programs, districts, or areas including broadcast or spot treatment of roadsides and highways, utilities, railroad, and pipeline rights-of-way. Noxious weeds must be recognized at the state level, but programs may be administered at state, county, or other level.

XtendiMax® With VaporGrip® Technology uses described in this section also pertain to grasses and small grains (forage sorghum, rye, sudangrass, or wheat) grown for grass, forage, fodder, hay and/or pasture use only. Grasses and small grains not grown for grass, forage, fodder, hay and/or pasture must comply with crop-specific uses in this label. Some perennial weeds may be controlled with lower rates of XtendiMax® With VaporGrip® Technology (refer to **Table 1**).

Rates and Timings

Refer to **Table 1** for rate selection based on targeted weed or brush species.

Rates above 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre are for spot treatments only. Spot treatment is defined as no more than a total of 1000 square feet of treated area per acre. Do not broadcast apply more than 44 fluid ounces per acre.

Retreatments may be made as needed; however, do not exceed a total of 44 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre during a growing season.

Grass grown for hay requires a minimum of 7-days between treatment and harvest.

Crop-Specific Restrictions

Do not apply more than 22 fluid ounces of XtendiMax® With VaporGrip® Technology per acre to small grains grown for pasture.

Newly seeded areas may be severely injured if more than 22 fluid ounces of XtendiMax® With VaporGrip® Technology is applied per acre.

Established grass crops growing under stress can exhibit various injury symptoms that may be more pronounced if herbicides are applied. Bentgrass, carpetgrass, buffalograss, and St. Augustin grass may be injured if more than 22 fluid ounces of XtendiMax® With VaporGrip® Technology is applied per acre. Usually colonial bent grasses are more tolerant than creeping types. Velvet grasses are most easily injured. Treatments will kill or injure alfalfa, clovers, lespedeza, wild winter peas, vetch, and other legumes.

Table 3 lists the timing restrictions for grazing or harvesting hay from treated fields. There are no grazing restrictions for animals other than lactating dairy animals.

Table 3. Timing Restrictions for Lactating Dairy Animals Following Treatment

XtendiMax® With VaporGrip® Technology Rate per Treated	Days Before Grazing (days)	Days Before Hay Harvest (days)

Acre (fluid ounces)		
Up to 22	7	37
Up to 44	21	51

- **Spot Treatments:** XtendiMax® With VaporGrip® Technology may be applied to individual clumps or small areas of undesirable vegetation using handgun or similar types of application equipment. Apply diluted sprays to allow complete wetting (up to runoff) of foliage and stems.

Cut Surface Treatments:

XtendiMax® With VaporGrip® Technology may be applied as a cut surface treatment for control of unwanted trees and prevention of sprouts of cut trees.

Rate: Mix 1 part XtendiMax® With VaporGrip® Technology with 1 - 3 parts water to create the application solution. Use the lower dilution rate when treating difficult-to-control species.

- **For Frill or Girdle Treatments**: Make a continuous cut or a series of overlapping cuts using an axe to girdle tree trunk. Spray or paint the cut surface with the solution.
- **For Stump Treatments:** Spray or paint freshly cut surface with the water mix. The area adjacent to the bark should be thoroughly wet.

Applications For Control of Dormant Multiflora Rose:

XtendiMax® With VaporGrip® Technology can be applied when plants are dormant as an undiluted spot treatment directly to the soil or as a Lo-Oil basal bark treatment using an oil-water emulsion solution.

- **Spot treatments:** Spot treatment applications of XtendiMax® With VaporGrip® Technology should be applied directly to the soil as close as possible to the root crown but within 6 - 8" of the crown. On sloping terrain, apply XtendiMax® With VaporGrip® Technology to the uphill side of the crown. Do not apply when snow or water prevents applying XtendiMax® With VaporGrip® Technology directly to the soil. The use rate of XtendiMax® With VaporGrip® Technology depends on the canopy diameter of the multiflora rose.

  Examples: Use 0.34, 1.38, or 3.23 fluid ounces of XtendiMax® With VaporGrip® Technology respectively, for 5, 10, or 15 feet canopy diameters.

- **Lo-Oil basal bark treatments:** For Lo-Oil basal bark treatments, apply XtendiMax® With VaporGrip® Technology to the basal stem region from the ground line to a height of 12 - 18". Spray until runoff, with special emphasis on covering the root crown. For best results, apply XtendiMax® With VaporGrip® Technology when plants are dormant. Do not apply after bud break or when plants are showing signs of active growth. Do not apply when snow or water prevents applying XtendiMax® With VaporGrip® Technology to the ground line.

  To prepare approximately 2 gallons of a Lo-Oil spray solution:

  1) Combine 1.5 gallons of water, 1 ounce of emulsifier, 22 fluid ounces of XtendiMax® With VaporGrip® Technology, and 2.5 pints of No. 2 diesel fuel.
  2) Adjust the amounts of materials used proportionately to the amount of final spray solution desired.

  Do not exceed 8 gallons of spray solution mix applied per acre, per year.

11.9 SMALL GRAINS

11.9.1 Small Grains Not Underseeded To Legumes (fall- and spring-seeded barley, oat, triticale and wheat)

Refer to the specific crop sections below for use rates. When treating difficult to control weeds such as kochia, wild buckwheat, cow cockle, prostrate knotweed, Russian thistle, and prickly lettuce or when dense vegetative growth occurs, use the 4.12 – 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology per acre.

Timings: Apply XtendiMax® With VaporGrip® Technology before, during, or after planting small grains. See specific small grain crop uses below for maximum crop stage. For best performance, apply XtendiMax® With VaporGrip® Technology when weeds are in the 2 - 3 leaf stage and rosettes are less than 2" across. Applying XtendiMax® With VaporGrip® Technology to small grains during periods of rapid growth may result in crop leaning. This condition is temporary and will not reduce crop yields.

Restrictions for small grain areas that are grazed or cut for hay are indicated in **Table 3** in Pasture, Hay, Rangeland, and General Farmstead section of this label.

11.9.2 Small Grains: Barley (fall- and spring-seeded)

Early season applications:

Apply 2.75 – 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology to fall-seeded barley prior to the jointing stage. Apply 2.75 – 4.12 fluid ounces of XtendiMax® With VaporGrip® Technology before spring-seeded barley exceeds the 4-leaf stage.

Note: For spring barley varieties that are seeded during the winter months or later, follow the rates and timings given for spring-seeded barley.

Preharvest applications:

XtendiMax® With VaporGrip® Technology can be used to control weeds that may interfere with harvest of fall and spring-seeded barley. Apply 11 fluid ounces of XtendiMax® With VaporGrip® Technology per acre as a broadcast or spot treatment to annual broadleaf weeds when barley is in the hard dough stage and the green color is gone from the nodes (joints) of the stern. Best results will be obtained if application can be made when weeds are actively growing, but before weeds canopy.

Allow a minimum of 7 days between treatment and harvest. Do not use preharvest-treated barley for seed unless a germination test is performed on the seed with an acceptable result of 95% germination or better.

[Optional: Do not make preharvest applications in California.]

11.9.3 Small Grains: Oats (fall- and spring-seeded)

Early season applications:

Apply 2.75 – 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology per acre to fall-seeded oat prior to the jointing stage. Apply 2.75 – 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology before spring-seeded oat exceed the 5-leaf stage.

Do not tank mix XtendiMax® With VaporGrip® Technology with 2,4-D in oat.

Allow a minimum of 7 days between treatment and harvest.

11.9.4 Small Grains: Triticale (fall- and spring-seeded)

Early season applications:

Apply 2.75 – 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology to triticale.

Early season applications to fall-seeded triticale must be made prior to the jointing stage.

Early season applications to spring-seeded triticale must be made before triticale reaches the 6-leaf stage.

11.9.5 Small Grains: Wheat (fall- and spring-seeded)

Early Season Applications:

Apply 2.75 – 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology to wheat unless using one of the fall-seeded wheat specific programs below.

Early season applications to fall-seeded wheat must be made prior to the jointing stage.

Early season applications to spring-seeded wheat must be made before wheat exceeds the 6-leaf stage.

Early developing wheat varieties such as TAM 107, Madison, or Wakefield must receive application between early tillering and the jointing stage. Care should be taken in staging these varieties to be certain that the application occurs prior to the jointing stage.

Specific use programs for fall-seeded wheat only:

[Optional: XtendiMax® With VaporGrip® Technology may be used at 8.25 fluid ounces on fall-seeded wheat in Western Oregon as a spring application only.] In Colorado, Kansas, New Mexico, Oklahoma, and Texas, up to 11 fluid ounces of XtendiMax® With VaporGrip® Technology may be applied on fall-seeded wheat after it exceeds the 3-leaf stage for suppression of perennial weeds, such as field bindweed. Applications may be made in the fall following a frost but before a killing freeze.

Preharvest applications:

XtendiMax® With VaporGrip® Technology can be used to control weeds that may interfere with harvest of wheat. Apply 11 fluid ounces XtendiMax® With VaporGrip® Technology per acre as a broadcast or spot treatment to annual broadleaf weeds when wheat is in the hard dough stage and the green color is gone from the nodes (joints) of the stem. Best results will be obtained if application can be made when weeds are actively growing but before weeds canopy.

Allow a minimum of 7 days between treatment and harvest. Do not use preharvest-treated wheat for seed unless a germination test is performed on the seed with an acceptable result of 95% germination or better.

[Optional: Do not make preharvest applications in California.]

11.10 Sorghum

XtendiMax® With VaporGrip® Technology may be applied preplant, postemergence, or preharvest in sorghum to control many annual broadleaf weeds and to reduce competition from established perennial broadleaf weeds, as well as control their seedlings.

Do not graze or feed treated sorghum forage or silage prior to mature grain stage. If sorghum is grown for pasture or hay, refer to Pasture, Hay, Rangeland, and General Farmstead section of this label for specific grazing and feeding restrictions.

Do not apply XtendiMax® With VaporGrip® Technology to sorghum grown for seed production.

Preplant Application:

Up to 11 fluid ounces of XtendiMax® With VaporGrip® Technology may be applied per acre if applied at least 15 days before sorghum planting.

Postemergence Application:

Up to 11 fluid ounces of XtendiMax® With VaporGrip® Technology per acre may be applied after sorghum is in the spike stage (all sorghum emerged) but before sorghum is 15" tall. For best performance, apply XtendiMax® With VaporGrip® Technology when the sorghum crop is in the 3 - 5 leaf stage and weeds are small (less than 3" tall). Use drop pipes (drop nozzles) if sorghum is taller than 8". Keep the spray off the sorghum leaves and out of the whorl to reduce the likelihood of crop injury and to improve spray coverage of weed foliage. Applying XtendiMax® With VaporGrip® Technology to sorghum during periods of rapid growth may result in temporary leaning of plants or rolling of leaves. These effects are usually outgrown within 10 - 14 days. Delay harvest until 30 days after a preharvest treatment.

Preharvest uses in Texas and Oklahoma only: Up to 11 fluid ounces of XtendiMax® With VaporGrip® Technology per acre may be applied for weed suppression any time after the sorghum has reached the soft dough stage. An agriculturally approved surfactant may be used to improve performance (read Section 8.0 for tank mixing instructions). Delay harvest until 30 days after a preharvest treatment.

Split Application:

XtendiMax® With VaporGrip® Technology may be applied in split applications: preplant followed by postemergence or preharvest; or postemergence followed by preharvest. Do not exceed 11 fluid ounces per acre, per application or a total of 22 ounces per acre, per season.

11.11 Soybean

For directions for use with crops with Xtend Technology see the "CROPS WITH XTEND TECHNOLOGY" section of this label.

Preplant Applications:

Apply 5.5 -22 fluid ounces of XtendiMax® With VaporGrip® Technology per acre to control emerged broadleaf weeds prior to planting soybeans. Do not exceed 22 fluid ounces of XtendiMax® With VaporGrip® Technology per acre in a spring application prior to planting soybeans.

Following application of XtendiMax® With VaporGrip® Technology and a minimum accumulation of 1" rainfall or overhead irrigation, allow a minimum of 14 days between treatment and planting for applications of 11 fluid ounces per acre or less, and allow a minimum of 28 days between treatment and planting for applications of 22 fluid ounces per acre. These plant back intervals must be observed prior to planting soybeans or crop injury may occur.

Do not make XtendiMax® With VaporGrip® Technology preplant applications to soybeans in geographic areas with average annual rainfall less than 25".

Preharvest Applications:

XtendiMax® With VaporGrip® Technology can be used to control many annual and perennial broadleaf weeds and control or suppress many biennial and perennial broadleaf weeds in soybean prior to harvest (refer to **Section 10**). Apply 11 - 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre as a broadcast or spot treatment to emerged and actively growing weeds after soybean pods have reached mature brown color and at least 75% leaf drop has occurred.

Do not harvest soybeans until 7 days after application.

Treatments may not kill weeds that develop from seed or underground plant parts, such as rhizomes or bulblets, after the effective period for XtendiMax® With VaporGrip® Technology. For seedling control, a follow-up program or other cultural practice could be instituted.

Do not use preharvest-treated soybean for seed unless a germination test is performed on the seed with an acceptable result of 95% germination or better.

Do not feed soybean fodder or hay following a preharvest application of XtendiMax® With VaporGrip® Technology.

[Optional: Do not make preharvest applications in California.]

11.12 Sugarcane

Apply XtendiMax® With VaporGrip® Technology for control of annual, biennial, or perennial broadleaf weeds listed in Section 11. Apply 11 - 33 fluid ounces of XtendiMax® With VaporGrip® Technology per acre for control of annual weeds, 22 - 44 fluid ounces for control of biennial weeds, and 44 fluid ounces for control or suppression of perennial weeds.

Use the higher level of listed rate ranges when treating dense vegetative growth.

A single retreatment may be made as needed, however, do not exceed a total of 88 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre during a growing season.

Timing: XtendiMax® With VaporGrip® Technology may be applied to sugarcane any time after weeds have emerged, but before the close-in stage of sugarcane. Applications of 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre made over the top of actively growing sugarcane may result in crop injury.

When possible, direct the spray beneath the sugarcane canopy to minimize the likelihood of crop injury. Using directed sprays will also help maximize the spray coverage of weed foliage.

Allow a minimum of 87 days between treatment and harvest.

11.13 Farmstead Turf (noncropland) and Sod Farms

Do not use on residential sites.

For use in general farmstead (noncropland) and sod farms, apply 4.12 – 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre to control or suppress growth of many annual, biennial, and some perennial broadleaf weeds commonly found in turf. XtendiMax® With VaporGrip® Technology will also suppress many other listed perennial broadleaf weeds and woody brush and vine species. Refer to Table 1 for rate recommendations based on targeted weed or brush species and growth stage.

Repeat treatments may be made as needed; however, do not exceed 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre, per growing season.

Apply 30 - 200 gallons of diluted spray per treated acre (3 - 17 quarts of water per 1,000 square feet), depending on density or height of weeds treated and on the type of equipment used.

To avoid injury to newly seeded grasses, delay application of XtendiMax® With VaporGrip® Technology until after the second mowing. Furthermore, applying more than 16 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre may cause noticeable stunting or discoloration of sensitive grass species such as bentgrass, carpetgrass, buffalograss, and St. Augustinegrass.

In areas where roots of sensitive plants extend, do not apply more than 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre on coarse-textured (sandy-type) soils, or in excess of 8 fluid ounces per treated acre on fine-textured soils. Do not make repeat applications in these areas for 30 days and until previous applications of XtendiMax® With VaporGrip® Technology have been activated in the soil by rain or irrigation.

12.0 CROPS WITH XTEND® TECHNOLOGY

COTTON WITH XTENDFLEX® TECHNOLOGY (INCLUDING BOLLGARD II® XTENDFLEX® COTTON, BOLLGARD® 3 XTENDFLEX® COTTON, OR XTENDFLEX® COTTON) AND ROUNDUP READY 2 XTEND® SOYBEAN CONTAIN A PATENTED GENE THAT PROVIDES TOLERANCE TO DICAMBA, THE ACTIVE INGREDIENT IN THIS PRODUCT. THIS PRODUCT WILL CAUSE SEVERE CROP

INJURY OR DESTRUCTION AND YIELD LOSS IF APPLIED TO COTTON AND SOYBEAN THAT ARE NOT DICAMBA TOLERANT, INCLUDING COTTON AND SOYBEAN WITH A TRAIT ENGINEERED TO CONFER TOLERANCE TO AUXIN HERBICIDES OTHER THAN DICAMBA. FOLLOW THE REQUIREMENTS SET FORTH HEREIN TO PREVENT SEVERE CROP INJURY OR DESTRUCTION AND YIELD LOSS. CONTACT WITH FOLIAGE, GREEN STEMS, OR FRUIT OF CROPS, OR ANY DESIRABLE PLANTS THAT DO NOT CONTAIN A DICAMBA TOLERANCE GENE OR ARE NOT NATURALLY TOLERANT TO DICAMBA, COULD RESULT IN SEVERE PLANT INJURY OR DESTRUCTION.

Information on cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean can be obtained from your seed supplier or Monsanto representative. Cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean must be purchased from an authorized licensed seed supplier.

Note: Cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean and methods of controlling weeds and applying dicamba in a Cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean crop are protected under U.S. patent law. No license to use Cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean is granted or implied with the purchase of this herbicide product. Cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean are owned by Monsanto and a license must be obtained from Monsanto before using it. Contact your Authorized Monsanto Retailer for information on obtaining a license to Cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean.

12.1 Cotton with XtendFlex® Technology

DO NOT combine these instructions with other instructions in the "COTTON" Section of **this** label for use over crops that do not contain the dicamba tolerance trait.

TYPES OF APPLICATIONS: Burndown/Early Preplant; Preplant; At-Planting; Preemergence; Postemergence (In-crop)

USE INSTRUCTIONS
Apply this product in a minimum of 15 gallons of spray solution per acre as a broadcast application. For best performance, control weeds early when they are less than 4 inches. Timely application will improve control and reduce weed competition. Refer to the following table for maximum application rates of this product with cotton with XtendFlex® Technology.

Maximum Application Rates	
Combined total per year for all applications	88 fluid ounces per acre (2.0 lb. a.e. dicamba per acre)
Total of all Burndown/Early Preplant, Preplant, At-Planting, and Preemergence applications	44 fluid ounces per acre (1.0 lb. a.e. dicamba per acre)
Total of all In-crop applications from emergence up to 7 days pre-harvest	88 fluid ounces per acre (2.0 lb. a.e. dicamba per acre)
Maximum In-crop, single application	22 fluid ounces per acre (0.5 lb. a.e. dicamba per acre)

a.e. – acid equivalent

Refer to Table 1 for application rates for weed type and growth stage controlled by this product. Maximum in-crop application rate should be used when treating tough to control weeds, dense vegetative growth or weeds with a well-established root system.

Preplant, At-Planting, Preemergence
USE INSTRUCTIONS: This product may be used to control broadleaf weeds and may be applied before, during or immediately after planting cotton with XtendFlex® Technology. Refer to the "WEEDS CONTROLLED" section of this label for XtendiMax® With VaporGrip® Technology for specific weeds controlled.

RESTRICTIONS:

- The maximum combined quantity of this product that may be applied for all burndown/early preplant, preplant, at-planting, and preemergence applications is 44 fluid ounces (1.0 lb a.e. dicamba) per acre per season.
- The maximum application rate for a single, burndown/early preplant, preplant, at-planting, or preemergence application must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre.
- Do not apply less than 22 fluid ounces (0.5 lb a.e. dicamba) per acre.

Postemergence (In-crop)
USE INSTRUCTIONS: This product may be used to control broadleaf weeds in cotton with XtendFlex® Technology. In-crop applications of this product can be made from emergence up to 7 days prior to harvest. The maximum and minimum rate for any single, in-crop application is 22 fluid ounces (0.5 lb a.e. dicamba) per acre. Using the appropriate application rate may reduce the selection for resistant weeds. For best performance, control weeds early when they are less than 4 inches. To the extent permitted by applicable law, Monsanto Company does not warrant product performance of applications to labeled weeds greater than 4 inches in height. Sequential applications of this product may be necessary to control new flushes of weeds or on tough-to-control weeds. Allow at least 7 days between applications. A pre-harvest application of this product may be made up to 7 days before harvest.

Postemergence applications of this product mixed with adjuvants may cause a leaf response to cotton with XtendFlex® Technology. The symptoms usually appear as necrotic spots on fully expanded leaves. EC-based products that are tank mixed with products containing dicamba may increase the severity of the leaf damage.

RESTRICTIONS:

- The combined total applied from crop emergence up to 7 days prior to harvest must not exceed 88 fluid ounces (2.0 lb a.e. dicamba) per acre.

- The maximum single, in-crop application rate must not exceed 22 fluid ounces (0.5 lb a.e. dicamba).
- The combined total per year for all applications must not exceed 88 fluid ounces (2.0 lb a.e. dicamba) per acre. For example, if a preplant application of 44 fluid ounces (1.0 lb a.e. dicamba) per acre was made, then the combined total in-crop applications must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre.
- Allow at least 7 days between applications and allow at least 7 days between final application and harvest or feeding of cottonseed and cotton gin by-products.

12.2 Roundup Ready 2 Xtend® Soybean

DO NOT combine these instructions with other instructions in the "SOYBEAN" Section of **this** label for use over crops that do not contain the dicamba tolerance trait.

TYPES OF APPLICATIONS: Burndown/Early Preplant; Preplant; At-Planting; Preemergence; Postemergence (In-crop)

USE INSTRUCTIONS
Apply this product in a minimum of 15 gallons of spray solution per acre as a broadcast application. For best performance, control weeds early when they are less than 4 inches. Timely application will improve control and reduce weed competition. Refer to the following table for maximum application rates of this product with Roundup Ready 2 Xtend® Soybean.

Maximum Application Rates	
Combined total per year for all applications	88 fluid ounces per acre (2.0 lb. a.e. dicamba per acre)
Total of all Burndown/Early Preplant, Preplant, At-Planting, and Preemergence applications	44 fluid ounces per acre (1.0 lb. a.e. dicamba per acre)
Total of all In-crop applications from emergence up to and including beginning bloom (R1 stage soybeans)	44 fluid ounces per acre (1.0 lb. a.e. dicamba per acre)
Maximum In-crop, single application	22 fluid ounces per acre (0.5 lb. a.e. dicamba per acre)

a.e. – acid equivalent

Refer to Table 1 for application rates for weed type and growth stage controlled by this product. Maximum in-crop application rate should be used when treating tough to control weeds, dense vegetative growth or weeds with a well-established root system.

Preplant, At-Planting, Preemergence
USE INSTRUCTIONS: This product may be used to control broadleaf weeds and may be applied before, during or immediately after planting Roundup Ready 2 Xtend® Soybean. Refer to the "WEEDS CONTROLLED" section of this label for specific weeds controlled.

RESTRICTIONS:
- The maximum combined quantity of this product that may be applied for all burndown/early preplant, preplant, at-planting, and preemergence applications is 44 fluid ounces (1.0 lb a.e. dicamba) per acre per season.
- The maximum application rate for a single, burndown/early preplant, preplant, at-planting, or preemergence application must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre.
- Do not apply less than 22 fluid ounces (0.5 lb a.e. dicamba) per acre.

Postemergence (In-crop)
USE INSTRUCTIONS: This product may be used to control broadleaf weeds in Roundup Ready 2 Xtend® Soybean. In-crop applications of this product can be made from emergence (cracking) up to and including beginning bloom (R1 growth stage of soybeans). Do not make in-crop applications of this product after beginning bloom (R1 growth stage of soybeans). The maximum and minimum rate for any single, in-crop application is 22 fluid ounces (0.5 lb a.e. dicamba) per acre. Using the appropriate application rate may reduce the selection for resistant weeds. For best performance, control weeds early when they are less than 4 inches. To the extent permitted by applicable law, Monsanto Company does not warrant product performance of applications to labeled weeds greater than 4 inches in height.

A second application of this product up to the R1 crop growth stage may be necessary to control new flushes of weeds. Allow at least 7 days between applications. For best results, apply XtendiMax® With VaporGrip® Technology after some weed re-growth has occurred.

Application of this product postemergence and under stressful environments may cause temporary loss of turgor, a response commonly described as leaf droop in Roundup Ready 2 Xtend® Soybean. Typically, affected plants recover in 1-3 days depending on the level of droop and environmental conditions.

RESTRICTIONS:
- The combined total application rate from crop emergence up to and including R1 must not exceed 44 fluid ounces (1.0 lb. a.e. dicamba) per acre.
- Do not make in-crop applications of this product after beginning bloom (R1 growth stage of soybeans).
- The maximum single, in-crop application rate must not exceed 22 fluid ounces (0.5 lb. a.e. dicamba) per acre.The combined total per year for all applications must not exceed 88 fluid ounces (2.0 lb. a.e. dicamba) per acre.
- Allow at least 7 days between final application and harvest or feeding of soybean forage.
- Allow at least 14 days between final application and harvest or feeding of soybean hay.

13.0 WEEDS CONTROLLED

General Weed List, Including ALS-, Glyphosate, and Triazine-Resistant Biotypes

Annuals

Alkanet
Amaranth, Palmer, Powell, Spiny
Aster, Slender
Bedstraw, Catchweed
Beggarweed, Florida
Broomweed, Common
Buckwheat, Tartary, Wild
Buffalobur
Burclover, California
Burcucumber
Buttercup, Corn, Creeping, Roughseed, Western Field
Carpetweed
Catchfly, Nightflowering
Chamomile, Corn
Chevil, Bur
Chickweed, Common
Clovers
Cockle, Corn, Cow, White
Cocklebur, Common
Copperleaf, Hophornbeam
Cornflower (Bachelor Button)
Croton, Tropic, Woolly
Daisy, English
Dragonhead, American
Eveningprimrose, Cutleaf
Falseflax, Smallseed
Fleabane, Annual
Flixweed
Fumitory
Goosefoot, Nettleleaf
Hempnettle
Henbit
Jacobs-Ladder
Jimsonweed
Knawel (German Moss)
Knotweed, Prostrate
Kochia
Ladysthumb
Lambsquarters Common
Lettuce, Miners, Prickly
Mallow, Common, Venice
Marestail (Horseweed)
Mayweed
Morningglory, Ivyleaf, Tall
Mustard, Black, Blue, Tansy, Treacle, Tumble, Wild, Yellowtops
Nightshade, Black, Cutleaf
Pennycress, Field (Fanweed, Frenchweed, Stinkweed)
Pepperweed, Virginia (Peppergrass)

Pigweed, Prostrate, Redroot (Carelessweed), Rough, Smooth, Tumble
Pineappleweed
Poorjoe
Poppy, Red-horned
Puncturevine
Purslane, Common
Pusley, Florida
Radish, Wild
Ragweed, Common, Giant (Buffaloweed), Lance-Leaf
Rocket, London, Yellow
Rubberweed, Bitter (Bitterweed)
Salsify
Senna, Coffee
Sesbania, Hemp
Shepherdpurse
Sicklepod
Sida, Prickly (Teaweed)
Smartweed, Green, Pennsylvania
Sneezeweed, Bitter
Sowthistle, Annual, Spiny
Spanish Needles
Spikeweed, Common
Spurge, Prostrate, Leafy
Spurry, Corn
Starbur, Bristly
Starwort, Little
Sumpweed, Rough
Sunflower, Common (Wild), Volunteer
Thistle, Russian
Velvetleaf
Waterhemp, Common, Tall
Waterprimrose, Winged
Wormwood

Biennials

Burdock, Common
Carrot, Wild (Queen Anne's Lace)
Cockle, White
Eveningprimrose, Common
Geranium, Carolina
Gromwell
Knapweed, Diffuse, Spotted
Mallow, Dwarf
Plantain, Bracted
Ragwort, Tansy
Starthistle, Yellow
Sweetclover
Teasel
Thistle, Bull, Milk, Musk, Plumeless

Perennials

Alfalfa[1]
Artichoke, Jerusalem
Aster, Spiny, Whiteheath
Bedstraw, Smooth
Bindweed, Field, Hedge
Blueweed, Texas
Bursage, Woollyleaf[1] (Bur Ragweed, Povertyweed)
Buttercup, Tall
Campion, Bladder
Chickweed, Field, Mouseear
Chicory[1]
Clover[1], Hop
Dandelion[1], Common
Dock[1] Broadleaf (Bitterdock), Curly
Dogbane, Hemp
Dogfennel[1] (Cypressweed)
Fern, Bracken
Garlic, Wild
Goldenrod, Canada, Missouri
Goldenweed, Common
Hawkweed
Henbane, Black[1]
Horsenettle, Carolina
Ironweed
Knapweed, Black, Diffuse, Russian[1], Spotted
Milkweed, Climbing, Common, Honeyvine, Western Whorled
Nettle, Stinging
Nightshade, Silverleaf (White Horsenettle)
Onion, Wild
Plaintain, Broadleaf, Buckhorn
Pokeweed
Ragweed, Western
Redvine
Sericia Lespedeza
Smartweed, Swamp
Snakeweed, Broom
Sorrel[1], Red (Sheep Sorrel)
Sowthistle[1], Perennial
Spurge, Leafy
Sundrops
Thistle, Canada, Scotch
Toadflex, Dalmatian
Tropical Soda Apple
Trumpetcreeper (Buckvine)
Vetch
Waterhemlock, Spotted
Waterprimrose, Creeping
Woodsorrel[1], Creeping, Yellow
Wormwood, Absinth, Louisiana
Yankeeweed
Yarrow, Common[1]

[1] Noted perennials may be controlled using lower rates of **XtendiMax® With VaporGrip® Technology** than those recommended for other listed perennial weeds.

Woody Species

Alder
Ash
Aspen
Basswood
Beech
Birch
Blackberry[2]
Blackgum[2]
Cedar[2]
Cherry
Chinquapin
Cottonwood
Creosotebush[2]
Cucumbertree
Dewberry[2]
Dogwood[2]
Elm
Grape

Hawthorn (Thornapple)[2]	Mesquite	Sassafras
Hemlock	Oak	Serviceberry
Hickory	Oak, Poison	Spicebush
Honeylocust	Olive, Russian	Spruce
Honeysuckle	Persimmon, Eastern	Sumac
Hornbeam	Pine	Sweetgum[2]
Huckleberry	Plum, Sand (Wild Plum)[2]	Sycamore
Huisache	Poplar	Tarbush
Ivy, Poison	Rabbitbrush	Willow
Kudzu	Redcedar, Eastern[2]	Witchhazel
Locust, Black	Rose[2], McCartney, Multiflora	Yaupon[2]
Maple	Sagebrush, Fringed[2]	Yucca[2]

[2]Growth suppression only

14.0 LIMIT OF WARRANTY AND LIABILITY

Monsanto Company warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes set forth in the Complete Directions for Use label booklet ("Directions") when used in accordance with those Directions under the conditions described therein. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, NO OTHER EXPRESS WARRANTY OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE. This warranty is also subject to the conditions and limitations stated herein. Specifically, and without limiting the foregoing, MONSANTO MAKES NO RECOMMENDATION OR WARRANTY HEREIN REGARDING THE USE OF ANY PRODUCTS THAT MAY APPEAR ON THE WEBSITE REFERENCED IN THE TANK-MIXING INSTRUCTIONS HEREIN, REGARDLESS OF WHETHER SUCH PRODUCT IS USED ALONE OR IN A TANK MIX WITH XTENDIMAX® WITH VAPORGRIP® TECHNOLOGY. BUYER AND ALL USERS ARE SOLELY RESPONSIBLE FOR ANY LACK OF PERFORMANCE, LOSS, OR DAMAGE IN CONNECTION WITH THE USE OR HANDLING OF ANY SUCH PRODUCT ALONE OR IN A TANK MIX WITH XTENDIMAX® WITH VAPORGRIP® TECHNOLOGY.

Buyer and all users shall promptly notify this Company of any claims whether based in contract, negligence, strict liability, other tort or otherwise.

To the extent consistent with applicable law, buyer and all users are responsible for all loss or damage from use or handling which results from conditions beyond the control of this Company, including, but not limited to, incompatibility with products other than those set forth in the Directions, application to or contact with desirable vegetation, failure of this product to control weed biotypes which develop resistance to dicamba, unusual weather, weather conditions which are outside the range considered normal at the application site and for the time period when the product is applied, as well as weather conditions which are outside the application ranges set forth in the Directions, application in any manner not explicitly set forth in the Directions, moisture conditions outside the moisture range specified in the Directions, or the presence of products other than those set forth in the Directions in or on the soil, crop or treated vegetation.

This Company does not warrant any product reformulated or repackaged from this product except in accordance with this Company's stewardship requirements and with express written permission from this Company.

For in-crop (over-the-top) uses on crops with Xtend® Technology, crop safety and weed control performance are not warranted by Monsanto when this product is used in conjunction with "brown bag" or "bin run" seed saved from previous year's production and replanted.

TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE LIMIT OF THE LIABILITY OF THIS COMPANY OR ANY OTHER SELLER FOR ANY AND ALL LOSSES, INJURIES OR DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT (INCLUDING CLAIMS BASED IN CONTRACT, NEGLIGENCE, STRICT LIABILITY,

OTHER TORT OR OTHERWISE) SHALL BE THE PURCHASE PRICE PAID BY THE USER OR BUYER FOR THE QUANTITY OF THIS PRODUCT INVOLVED, OR, AT THE ELECTION OF THIS COMPANY OR ANY OTHER SELLER, THE REPLACEMENT OF SUCH QUANTITY, OR, IF NOT ACQUIRED BY PURCHASE, REPLACEMENT OF SUCH QUANTITY. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, IN NO EVENT SHALL THIS COMPANY OR ANY OTHER SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES.

Upon opening and using this product, buyer and all users are deemed to have accepted the terms of this LIMIT OF WARRANTY AND LIABILITY which may not be varied by any verbal or written agreement. If terms are not acceptable, return at once unopened.

Bollgard II®, Bollgard®, Degree Xtra®, Field Master®, Harness®, Roundup Ready®, Roundup Ready 2 Xtend®, Roundup PowerMAX®, RT 3®, Roundup WeatherMAX®, XtendiMax®, XtendFlex® and VaporGrip® are registered trademarks of Monsanto Technology LLC. All other trademarks are the property of their respective owners.

EPA Reg. No. 524-617

EPA Establishment No. [insert appropriate est. no.]

Lot number [insert appropriate lot number]

Net contents [insert net contents]

Packed for:
MONSANTO COMPANY
800 N. Lindbergh Blvd.
ST. LOUIS, MISSOURI, 63167 U.S.A.

MONSANTO

MONSANTO COMPANY
1300 I (Eye) Street, NW
Suite 450 East
Washington, D.C. 20005
http://www.monsanto.com

October 4, 2017

Jerry W. Cubbage, Ph.D.
Regulatory Affairs Manager
314-694-7350

Document Processing Desk (AMEND)
Office of Pesticide Programs (7504P)
U.S. Environmental Protection Agency
One Potomac Yard
2777 South Crystal Drive, Room S4900
Arlington, VA 22202-4501

Attention: Kathryn Montague
PM Team 23

Subject: **Amendment to Master Label For M1768 Herbicide / XtendiMax® With VaporGrip® Technology EPA Reg. 524-617.**

Dear Ms. Montague:

Monsanto is herein submitting the attached voluntary amendment to Master Labeling for **M1768 Herbicide**, EPA Reg. No. 524-617. This new version supersedes the version previously approved on August 30, 2016.

Monsanto is voluntarily amending the Master Label by incorporating the dicamba tolerant soy and cotton uses from the prior M1768 Herbicide supplemental labeling and incorporating certain additional training and recordkeeping requirements and certain other amplifications. EPA has not made a finding that M1768 Herbicide can be involuntarily reclassified as a Restricted Use Pesticide, and Monsanto does not believe that any such finding could be justified. However, to facilitate compliance with appropriate training and recordkeeping practices, Monsanto is voluntarily requesting this product be classified as a Restricted Use Pesticide.

Included in this submission are the following documents:

- Cover letter
- 8570-1 Application form
- Revised Master Labeling

Should you require any additional information or have any questions regarding this submission, please contact me by direct telephone (636)737-9574 or electronic mail at jerry.w.cubbage@monsanto.com, or contact Tom Marvin from our Washington DC office by direct telephone at (202) 383-2851.

Sincerely,

Jerry W Cubbage

Jerry W. Cubbage, Ph.D.
Regulatory Affairs Manager

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

October 11, 2017

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

MR. JAMES M. NYANGULU
MONSANTO COMPANY
MONSANTO COMPANY
1300 I (EYE) STREET, NW, SUITE 450 E.
WASHINGTON, DC 20005-7211

PRODUCT NAME: M1768 HERBICIDE
COMPANY NAME: MONSANTO COMPANY
OPP IDENTIFICATION NUMBER:
EPA FILE SYMBOL: 524-617
EPA RECEIPT DATE: 10/04/17

SUBJECT: RECEIPT OF AMENDMENT

DEAR REGISTRANT:

The Office of Pesticide Programs has received your application for an amendment and it has passed an administrative screen for completeness.

During the initial screen we determined that the application appears to qualify for fast track review. The package will now be forwarded to the Product Manager for review to determine its acceptability for fast track status.

If you have any questions, please contact Registration Division, Risk Management Team 23, at (703) 305-1243.

Sincerely,

Front End Processing Staff
Information Services Branch
Information Technology & Resources Management Division

Please read instructions on reverse before completing form. Form Approved. OMB No. 2070-0060.

EPA

United States
Environmental Protection Agency
Washington, DC 20460

☐ **Registration**
☒ **Amendment**
☐ **Other**

OPP Identifier Number

Application for Pesticide – Section I

1. Company/Product Number Monsanto Company / 524-617	2. EPA Product Manager Kay Montague	3. Proposed Classification
4. Company/Product (Name) Monsanto Company / M1768 Herbicide (XtendiMax™ with VaporGrip™ Technology)	PM # 23	☐ None ☐ Restricted
5. Name and Address of Applicant *(Include ZIP Code)* Monsanto Company 1300 I (Eye) Street, NW – Suite 450 East Washington, DC 20005 ☐ Check if this is a new address	6. **Expedited Review.** In accordance with FIFRA Section 3(c)(3) (b)(i), my product is similar or identical in composition and labeling to: EPA Reg. No. ______ Product Name ______	

Section – II

☒ Amendment – Explain below.
☐ Resubmission in response to Agency letter dated
☐ Notification – Explain below.
☐ Final printed labels in response to Agency letter dated
☐ "Me Too" Application.
☐ Other – Explain below.

Explanation: Use additional page(s) if necessary. (For section I and Section II.)

Amendment rolling the dicamba tolerant soy and cotton uses from supplemental labeling into the Master label and language clarifications for M1768 Herbicide / XtendiMax™ With VaporGrip™ Technology EPA Reg. 524-617

Secton – III

1. Material This Product Will Be Packaged In:

Child-Resistant Packaging	Unit Packaging	Water Soluble Packaging	2. Type of Container
☐ Yes* ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Metal ☐ Plastic ☐ Glass ☐ Paper ☐ Other (Specify)
**** Certification must be submitted***	If "Yes" Unit Packaging wgt. / No. per Container	If "Yes" Package wgt. / No. per Container	

3. Location of Net Contents Information ☐ Label ☐ Container	4. Size(s) Retail Container	5. Location of Label Directions ☐ On Label ☐ On Labeling accompanying product

6. Manner in Which Label is Affixed to Product ☐ Lithograph ☐ Paper glued ☐ Stenciled ☐ Other ______

Section – IV

1. Contact Point *(Complete items directly below for identification of individual to be contacted, if necessary, to process this application.)*

Name	Title	Telephone No. *(Include Area Code)*
Tom Marvin	Director, U.S. Regulatory Affairs	202-383-2851

Certification

I certify that the statements I have made on this form and all attachments thereto are true, accurate and complete. I acknowledge that any knowingly false or misleading statement may be punishable by fine or imprisonment or both under applicable law.

2. Signature Jerry W Cubbage	3. Title Regulatory Affairs Manager	6. Date Application Received **(Stamped)**
4. Typed Name Jerry W. Cubbage	5. Date **October 4, 2017**	

EPA Form 8570-1 (Rev. 8-94) Previous editions are obsolete.

No. 17-70196

UNITED STATES COURT OF APPEALS
FOR THE NINTH CIRCUIT

NATIONAL FAMILY FARM COALITION, *et al*.,

Petitioners,

v.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, *et al*.,

Respondents,

and

MONSANTO COMPANY,

Intervenor-Respondent.

ON PETITION FOR REVIEW FROM THE UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

PETITIONERS' EXCERPTS OF RECORD VOLUME II

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T: (808) 559-2436 / F: (808) 521-6841

Counsel for Petitioners

INDEX TO PETITIONERS' EXCERPTS OF RECORD

VOLUME I			
Date	**Admin. R. Doc. No.**[1]	**Document Description**	**ER Page No.**
11/9/2016	A.493[2]	Final Registration of Dicamba on Dicamba-Tolerant Cotton and Soybean	ER 001
11/9/2016	A.924	Final Product Label for XtendiMax™ with VaporGrip™ Technology - EPA Reg. No. 524-617 (For Use on Dicamba-Tolerant Soybeans)	ER 037
11/9/2016	A.895	Final Product Label for XtendiMax™ with VaporGrip™ Technology - EPA Reg. No. 524-617 (For Use on Dicamba-Tolerant Cotton)	ER 049
11/9/2016	A.750	PRIA label Amendment: Adding New Uses on Dicamba-Tolerant Cotton and Soybeans	ER 060
10/12/2017	K.99	Amended Registration of Dicamba on Dicamba-Resistant Cotton and Soybean	ER 072

[1] Unless otherwise specified, the document identifier numbers record to their document numbers as listed in the Certified Amended Index, ECF No. 63-3.

[2] Respondent United States Environmental Protection Agency (EPA) did not produce, but only provided hyperlinks to, publicly available documents. *See* ECF No. 63-3. For the Court's convenience, Petitioners have produced those hyperlinked documents in their entirety in the Excerpts of Record.

VOLUME II			
Date	**Admin. R. Doc. No.**	**Document Description**	**ER Page No.**
10/10/2017	K.36	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: FW: New Dicamba non-crop complaints	ER 122
10/10/2017	K.53	E-mail from Reuben Baris (EPA) to Thomas Marvin (Monsanto) re: Label comments	ER 123
10/10/2017	K.90	E-mail from Philip Perry (Monsanto) to Michele Knorr (EPA), others, re: Response to Terms and conditions Page 1 - EPA comments	ER 165
10/10/2017	K.94	E-mail from Reuben Baris (EPA) to Tom Marvin (Monsanto) with markup of EPA's response to terms and conditions	ER 167
10/9/2017	K.52	E-mail from Phil Perry (Monsanto) to Michele Knorr (EPA) re: Implementation Terms and Conditions	ER 170
10/5/2017	K.16	E-mail from R. Baris (EPA) to T. Marvin (Monsanto) re: dicamba proposed registration conditions	ER 172
9/27/2017	K.11	E-mail from Jamie Green (EPA) to Anne Overstreet (EPA) re: correspondence received from seed company owner regarding Dicamba Control	ER 175
9/27/2017	K.42	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: article on Dicamba from Delta Farm Press[3]	ER 182

[3] This e-mail contains a hyperlink to an online article. *See* David Bennett, *Might Dicamba be Affecting Pollinators*?, Delta Farm Press, Sept. 26, 2017. For the Court's convenience, Petitioners have produced this and other similarly hyperlinked articles in the Excerpts of Record.

9/27/2017	K.32	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: FW: Many U.S. Scientists to skip Monsanto summit on dicamba	ER 188
9/27/2017	K.93	E-mail from Nicholas Sorokin (EPA) to EPA recipients of Office of Public Affairs media clips re: Reuters: Exclusive: U.S. scientists to skip Monsanto summit on controversial weed killer	ER 189
9/26/2017	K.46	E-mail from Reuben Baris (EPA) to Jonathan Becker (EPA) re: FW: yield data forwarded 10 journal articles on yield impact resulting from dicamba exposure	ER 192
9/21/2017	K.19	E-mail from Pesticide Action Network to Rick Keigwin (EPA) re: EPA: Pull Monsanto's crop-killing dicamba now	ER 278
9/21/2017	K.80	E-mail from Caleb Hawkins (EPA) to Jonathan Becker and others at EPA forwarding Reuters article on dicamba[4]	ER 280
9/13/2017	K.39	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Record number of pesticide misuse claims by Iowa farmers due to dicamba drift problems[5]	ER 285
9/12/2017	K.35	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: More Dicamba = Monsanto Petition to Arkansas State Plant Board	ER 291

[4] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* Tom Polansek, *U.S. Regulator Aiming to Allow Controversial Herbicide Use with Safeguards*, Reuters, Sept. 20, 2017.

[5] This e-mail contains a hyperlink to an online article that Petitioners have reproduced in its entirety. *See* Donnelle Eller, *Iowa Farmer Makes Record Number of Pesticide Misuse Claims*, The Des Moines Register, Sept. 12, 2017.

[6] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* David Bennett, *Dicamba Tests Showing Similar Results from Scattered Locations*, Delta Farm Press, Sept. 6, 2017.

8/29/2017	K.51	Ten articles on Dicamba send as a Google Alert to Reuben Baris (EPA)[7]	ER 364
8/23/2017	K.101 (Second Am. Certified Index, ECF No. 69-3)	Notes from 8/23/2017 EPA meeting with various state officials	ER 369
8/22/2017	K.31	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Letter to Topeka paper	ER 372
8/22/2017	K.38	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Off-target Movement of Dicamba in Missouri. Where Do We Go From Here?[8]	ER 374
8/21/2017	K.92	E-mail from Nicholas Sorokin (EPA) to EPA recipients of Office of Public Affairs media clips re: Reuters: Exclusive: U.S. farmers confused by Monsanto's weed killer's complex instructions	ER 379
8/20/2017	K.27	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Dicamba update	ER 382
8/18/2017	K.88	E-mail from Kevin Bradley (University of Missouri) to R. Baris (EPA) regarding WSSA committee	ER 390

[7] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See EPA Responds to Dicamba Complaints*, Ag. Professional, Aug. 29, 2017.

[8] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* Kevin Bradley, *Off-target Movement of Dicamba in Missouri: Where Do We Go from Here?*, Integrated Pest Mgmt., Univ. Mo., Aug. 21, 2017.

8/17/2017	K.12	E-mail from Reuben Baris (EPA) to Dicamba registrants regarding next steps on dicamba	ER 394
8/10/2017	K.21	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: FW Article from Arkansas times[9]	ER 395
8/3/2017	K.49	E-mail from Reuben Baris (EPA) to Mark Corbin (EPA) re: Fwd: TN data Effect of adding Roundup PowerMax to Engenia on vapor losses under field conditions	ER 406
8/2/2017	K.20	E-mail-calendar invite from Emily Ryan (EPA) to Reuben Baris (EPA) and other internal and external parties re: follow-up on Dicamba with AAPCO/SFIREG and agenda for 8/2/17	ER 417
8/2/2017	K.100 (Second Am. Certified Index, ECF No. 69-3)	Notes from 8/2/2017 EPA meeting with various state officials	ER 420
8/1/2017	K.37	E-mail from Sarah Meadows (EPA) to Grant Rowland (EPA) re: FW: Notes from Friday's meeting on Dicamba call (7/28/17) with state reps	ER 428
8/1/2017	K.14	E-mail from Shanta Adeeb (EPA) to Dan Kenny (EPA) re: Dicamba Notes from July 28th meeting with states on dicamba incidents	ER 435
7/28/2017	K.66	E-mail from Reuben Baris (EPA) to Dan Rosenblatt (RPA) re: EPA notes taken during dicamba teleconference with state extension representatives on 7/28/17	ER 441

[9] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* David Koon, *Farmer vs. Farmer*, Ark. Times, Aug. 10, 2017.

7/25/2017	K.22	E-mail from Dan Kenny (EPA) to Reuben Baris (EPA) re: FW Conference Call with EPA on Dicamba 7/25/17 (conference call information will be redacted)	ER 445
7/25/2017	K.59	E-mail from Sarah Meadows (EPA) to Dan Kenny (EPA) re: Notes from Dicamba meeting with states on 7/13/17	ER 447
7/12/2017	K.5	E-mail from Dan Kenny (EPA) to state representatives regarding EPA Dicamba Meeting with States	ER 453
11/7/2016	A.765	Excerpt of Response to Public Comments Received Regarding the New Use of Dicamba on Dicamba-Tolerant Cotton and Soybeans	ER 456
11/3/2016	A.170	M-1691 Herbicide, EPA Reg. No. 524-582 (Active Ingredient: Dicamba Diglycolamine Salt) and M-1768 herbicide, EPA Reg. No. 524-617 (AI: Diglycolamine Salt with VaporGrip™) – Review of EFED Actions and Recent Data Submissions Associated with Spray and Vapor Drift of the Proposed Section 3 New Uses on Dicamba-Tolerant Soybean and Cotton	ER 459
6/20/2016	A.863	Comment submitted by National Family Farm Coalition	ER 473
6/15/2016	A.57	Mortensen *et al.*, *Navigating a Critical Juncture for Sustainable Weed Management*, BioScience, Jan. 2012, at 75-84 (submitted as an attachment to comment submitted by Sylvia Wu, Center for Food Safety)	ER 474
6/15/2016	A.473	Comments submitted by The Center for Food Safety, including Excerpts from Exhibits A and F.	ER 485
6/10/2016	A.304	Comment submitted by J. R. Paarlberg	ER 554

6/10/2016	A.526	Anonymous Public Comment	ER 556
5/31/2016	A.581	Comment submitted by Steve Smith, Chairman, Save Our Crops Coalition (SOCC)	ER 558
5/31/2016	A.703	Comment submitted by Marcia Ishii-Eiteman, PhD, Senior Scientist, Pesticide Action Network	ER 572
5/31/2016	A.528	Comment submitted by Nathan Donley, PhD, Staff Scientist and Stephanie M. Parent, Senior Attorney, Center for Biological Diversity (Center)	ER 576
5/27/2016	A.34	Comment submitted by P. Douglas Williams, Director, Regulatory Affairs and Donald R. Berdahl, Executive Vice President/ CTO, Kalsec, Inc.	ER 603
5/25/2016	A.159	Anonymous Public Comment	ER 610
5/25/2016	A.840	Anonymous Public Comment	ER 612
5/25/2016	A.538	Anonymous Public Comment	ER 613
5/23/2016	A.668	Comment submitted by Dennis M.Dixon, Field Representative, Hartung Brothers Incorporated	ER 616
5/19/2016	A.555	Comment submitted by T. Kreuger	ER 618
5/19/2016	A.743	Anonymous Public Comment	ER 619
5/10/2016	A.255	Anonymous Public Comment	ER 621
5/9/2016	A.617	Comment submitted by Scott E. Rice, Rice Farms Tomatoes, LLC	ER 622
5/9/2016	A.405	Comment submitted by Curt Utterback, Secretary, Utterback Farms, Inc.	ER 624
4/28/2016	A.838	Comment submitted by D. Dolliver	ER 625
4/21/2016	A.696	Comment submitted by Randall Woolsey, Woolsey Bros. Farm Supply	ER 626
3/31/2016	A.628	Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean	ER 627
3/31/2016	A.565	Excerpt of Proposed Registration of Dicamba on Dicamba-Tolerant Cotton and Soybean	ER 629

3/24/2016	A.285	Excerpt of Addendum to Dicamba Diglycolamine Salt (DOA) and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in in 11 U.S. States: (Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia). Phases 3 and 4	ER 702
3/24/2016	A.611	Excerpt of Ecological Risk Assessment for Dicamba DGA Salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA), for the Proposed Post-Emergence New Use on Dicamba-Tolerant Cotton (MON 8770 I)	ER 713
3/24/2016	A.45	Excerpt of Dicamba DGA: Second Addendum to the Environmental Fate and Ecological Risk Assessment for Dicamba DGA salt and its Degradate	ER 716
2014	I.28	Egan, J. F., Barlow, K. M., and Mortensen, D. A. 2014. A meta-analysis on the effects of 2,4-D and dicamba drift on soybean and cotton. Weed Science 62:193-206.	ER 724
3/8/2011	A.91	Excerpt of Ecological Risk Assessment for Dicamba and its Degradate	ER 740
9/17/2010	B.12	Comment submitted by Bill Freese, The Center for Food Safety	ER 774
6/4/2010	B.0024	Scott Kilman, *Superweed Outbreak Triggers Arms Race*, Wall St. J. (submitted as an attachment to the comment submitted by Ryan Crumley, The Center for Food Safety)	ER 782

8/31/2005	C.7	EFED Reregistration Chapter For Dicamba/Dicamba Salts	ER 788
1/23/2004	I.1	Excerpts from Office of Pesticide Programs, EPA, *Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs: Listed and Threatened Species Effects Determinations* (2004).	ER 804
12/1/1993	I.3	Excerpts from Office of Research and Development, EPA, *Wildlife Exposure Factors Handbook* (1993).	ER 813

VOLUME V (UNDER SEAL)			
Date	**Admin. R. Doc. No.**	**Document Description**	**ER Page No.**
10/9/2017	K.10	E-mail from Philip Perry (Monsanto) to Reuben Baris (EPA) re: Current master label and sticker Xtendimax	ER 825
9/25/2017	K.7	E-mail from T. Marvin (Monsanto) to R. Baris (EPA) re: Confidential working Draft Master Label	ER 867
9/22/2017	K.15	E-mail from T. Marvin (Monsanto) to R. Baris (EPA) re: Confidential working Draft Master Label	ER 905
9/13/2017	K.6	E-mail from T. Marvin (Monsanto) to R. Baris (EPA) re: confidential discussion points for label changes	ER 909
6/7/2016	J.240	Monsanto Confidential Document re: Expected Monsanto Submissions to support M1691, Xtendimax & Roundup Xtend Herbicides	ER 912
4/12/2016	E.406	Gavlick, W. (2016) Determination of the Relative Volatility of Dicamba Herbicide Formulations. Project Number: MSL0026648. Unpublished study prepared by Monsanto Agricultural Co. 15p.	ER 917

From: Green, Jamie
To: Baris, Reuben; Kenny, Daniel; Lott, Don; Trivedi, Adrienne; Wormell, Lance
Subject: FW: New dicamba non-crop complaints
Date: Tuesday, October 10, 2017 9:57:41 AM

FYI – likely info you have previously received but passing along.

From: Shields, Amy
Sent: Tuesday, October 10, 2017 8:48 AM
To: Hackett, Shawn <hackett.shawn@epa.gov>; Cook, Charles <Cook.Charles@epa.gov>; Frizzell, Damon <Frizzell.Damon@epa.gov>; Green, Jamie <Green.Jamie@epa.gov>
Subject: FW: New dicamba non-crop complaints

FYI

Amy Shields, Ph.D. | U.S. Environmental Protection Agency Region 7 | 11201 Renner Boulevard, Lenexa, KS 66219 | ☎ (913) 551-7396 | ✉ shields.amy@epa.gov

From: Cybulski, Walter
Sent: Tuesday, October 10, 2017 8:46 AM
To: Shields, Amy <Shields.Amy@epa.gov>
Subject: New dicamba non-crop complaints

Passing this along. Not sure if you are hearing any of these new complaints about dicamba. See there is one Iowa bullet in there.

Complaints surge about weed killer dicamba's damage to oak trees – As soybean and cotton farmers across the Midwest and South continue to see their crops ravaged from the weed killer dicamba, new complaints have pointed to the herbicide as a factor in widespread damage to oak trees.

"• In Iowa, the Department of Natural Resources has received more than 1,000 complaints about oak tree damage from unknown pesticides, some of which cited dicamba as a cause."

From:	Baris, Reuben
To:	"MARVIN, THOMAS [AG/1920]"
Subject:	Label comments
Date:	Tuesday, October 10, 2017 6:43:00 PM
Attachments:	MASTER LABEL 524-617_ADDDTuses_Oct102017_EPAreview- EPA comments.pdf 35008R1-39 Xtendimax VPG Tech Restricted Use Pesticide Sticker2 - EPA comments.pdf

Please share with your team. Like I said, no surprises.

Reuben Baris | Acting Chief | Herbicide Branch
U.S. Environmental Protection Agency, Office of Pesticide Programs | (703) 305-7356

RESTRICTED USE PESTICIDE

Xtendimax® with VaporGrip® Technology

EPA REG. No. 524-617

Product cannot be used if user does not possess new (substitute) label(ing) which can be found at www.xtendimaxapplicationrequirements.com

User must comply in all respects with new (substitute) label(ing) [regardless of any contrary language on existing label]

QR Code

35008R1-39

MASTER LABEL FOR EPA REG. NO. 524-617

RESTRICTED USE PESTICIDE

For retail sale to and use only by Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification

Primary Brand Name:

M1768 Herbicide

Alternate Brand Name:

Xtendimax® With VaporGrip® Technology

RESTRICTED USE PESTICIDE

For retail sale to and use only by Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification

XtendiMax® With VaporGrip® Technology

Complete Directions for Use

This labeling expires on 11/09/2018, unless the U.S. EPA determines before that date that off-site incidents are not occurring at unacceptable frequencies or levels. Do not use or distribute this product after 11/09/2018, unless you visit www.xtendimaxapplicationrequirements.com and can verify that EPA has amended this expiration date

EPA Reg. Number: 524-617

For weed control in asparagus, conservation reserve programs, corn, cotton, fallow croplands, general farmstead (noncropland), sorghum, grass grown for seed, hay, proso millet, pasture, rangeland, small grains, sod farms and farmstead turf, soybean, sugarcane, cotton with XtendFlex Technology, and Roundup Ready 2 Xtend Soybean.

This label supersedes any previously issued labeling for this product.

XtendiMax® With VaporGrip® Technology is approved by U.S. EPA for all uses specified on this label in the following states, subject to county restriction as noted: Alabama, Arkansas, Arizona, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin.

Check the registration status of each product in each state before using.

READ THE ENTIRE LABEL FOR **XTENDIMAX® WITH VAPORGRIP® TECHNOLOGY** BEFORE PROCEEDING WITH THE USE DIRECTIONS CONTAINED IN THIS LABEL

READ AND FOLLOW ALL APPLICABLE DIRECTIONS, RESTRICTIONS, AND PRECAUTIONS ON THE CONTAINER LABEL AND BOOKLET AND WWW.XTENDIMAXAPPLICATIONREQUIREMENTS.COM.

Read the "LIMIT OF WARRANTY AND LIABILITY" statement at the end of the label before buying or using. If terms are not acceptable, return at once unopened.

Net contents:

EPA Establishment No.:

CONTENTS

1.0 INGREDIENTS

ACTIVE INGREDIENT:

Diglycolamine salt of dicamba (3,6-dichloro-*o*-anisic acid)* 42.8%
OTHER INGREDIENTS: 57.2%

TOTAL: 100.0%
* contains 29.0%, 3,6-dichloro-*o*-anisic acid (2.9 pounds acid equivalent per U.S. gallon or 350 grams per liter).

2.0 IMPORTANT PHONE NUMBERS

1. FOR PRODUCT INFORMATION OR ASSISTANCE IN USING THIS PRODUCT, CALL TOLL-FREE, 1-800-332-3111.
2. IN CASE OF AN EMERGENCY INVOLVING THIS HERBICIDE PRODUCT, OR FOR MEDICAL ASSISTANCE, CALL COLLECT, DAY OR NIGHT, (314)-694-4000.

IN CASE OF SPILL:

Steps to be taken in case material is released or spilled:

Dike and contain the spill with inert material (sand, earth, etc.) and transfer liquid and solid diking material to separate containers for disposal. Remove contaminated clothing, and wash affected skin areas with soap and water. Wash clothing before re-use. Keep the spill out of all sewers and open bodies of water.

3.0 PRECAUTIONARY STATEMENTS

3.1 Hazards to Humans and Domestic Animals

Keep out of reach of children.

CAUTION!

Causes moderate eye irritation. Avoid contact with eyes or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet.

FIRST AID	
IF IN EYES	• Hold eye open and rinse slowly and gently with water for 15 to 20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
IF SWALLOWED:	• Call a poison control center or doctor immediately for treatment advice. • Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by a poison control center or doctor. • Do not give anything by mouth to an unconscious person.
IF ON SKIN OR CLOTHING:	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15 to 20 minutes. • Call a poison control center or doctor for treatment advice.
• Have the product container or label with you when calling a poison control center or doctor, or going	

for treatment.

- You can call **(314) 694-4000**, collect day or night, for emergency medical treatment information.
- This product is identified as **XtendiMax® With VaporGrip® Technology, EPA Registration No. 524-617.**

PERSONAL PROTECTIVE EQUIPMENT (PPE)

All mixers, loaders, applicators and other handlers must wear:

- Long-sleeved shirt and long pants
- Waterproof gloves
- Shoes plus socks

See "Engineering Controls Statement" for additional requirements.
Follow the manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry.

ENGINEERING CONTROLS STATEMENT

When handlers use closed systems, or enclosed cabs in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240 (d) (4-6)], the handler PPE requirements may be reduced or modified as specified in the WPS.

IMPORTANT: When reduced PPE is worn because a closed system is being used, handlers must be provided all PPE specified above for "all mixers, loaders, applicators and other handlers" and have such PPE immediately available for use in an emergency, such as a spill or equipment breakdown.

USER SAFETY RECOMMENDATIONS

Users should:

- Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.
- Remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

3.2 Environmental Hazards

Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters or rinsate. Apply this product only as directed on the label.

This chemical is known to leach through soil into ground water under certain conditions as a result of agricultural use. Use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in ground water contamination.

Ground and Surface Water Protection

Point source contamination - To prevent point source contamination, do not mix or load this pesticide product within 50 feet of wells (including abandoned wells and drainage wells), sink holes, perennial or intermittent streams and rivers, and natural or impounded lakes and reservoirs. Do not apply pesticide product within 50 feet of wells. This setback does not apply to properly capped or plugged abandoned wells and does not apply to impervious pad or properly diked mixing/loading areas as described below.

Mixing, loading, rinsing, or washing operations performed within 50 feet of a well are allowed only when conducted on an impervious pad constructed to withstand the weight of the heaviest load that may be on or move across the pad. The pad must be self-contained to prevent surface water flow over or from the pad. The pad capacity must be maintained at 110% that of the largest pesticide container or application equipment used on the pad and have sufficient capacity to contain all product spills, equipment or container leaks, equipment wash waters, and rainwater that may fall on the pad. The containment capacity does not apply to vehicles delivering pesticide shipments to the mixing/loading site. States may have in effect additional requirements regarding wellhead setbacks and operational containment.

Care must be taken when using this product to prevent: a) back siphoning into wells, b) spills or c) improper disposal of excess pesticide, spray mixtures or rinsates. Check valves or anti-siphoning devices must be used on all mixing equipment.

Movement by surface runoff or through soil - Do not apply under conditions which favor runoff. Do not apply to impervious substrates such as paved or highly compacted surfaces in areas with high potential for ground water contamination. Ground water contamination may occur in areas where soils are permeable or coarse and ground water is near the surface. Do not apply to soils classified as sand with less than 3% organic matter and where ground water depth is shallow. To minimize the possibility of ground water contamination, carefully follow application rate recommendations as affected by soil type in the Crop Specific Information section of this label.

Movement by water erosion of treated soil - Do not apply or incorporate this product through any type of irrigation equipment nor by flood or furrow irrigation. Ensure treated areas have received at least one-half inch rainfall (or irrigation) before using tailwater for subsequent irrigation of other fields.

Endangered Species Concerns
The use of any pesticide in a manner that may kill or otherwise harm an endangered species or adversely modify their habitat is a violation of federal law.

3.3 Physical or Chemical Hazards

Do not store or heat near oxidizing agents, hazardous chemical reaction may occur.

4.0 DIRECTIONS FOR USE

It is a violation of Federal law to use this product in any manner inconsistent with its labeling. This product can only be used in accordance with the Directions for Use on this label. This labeling must be in the user’s possession during application.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulations.

This is a restricted use pesticide.

4.1 Training

Prior to applying this product in the 2018 growing season and each growing season thereafter, applicator(s) must complete dicamba or auxin-specific training. If training is available and required by the state where the applicator intends to apply this product, the applicator must complete that training. If the state where the application is intended does not require auxin or dicamba-specific training, then the applicator must complete dicamba or auxin-specific training provided by one of the following sources: a) a registrant of a dicamba product approved for in-crop use with dicamba-tolerant crops, or b) a state or state-authorized provider.

4.2 Record Keeping

Record keeping is required for applications of this product. **The certified applicator must keep the following records for a period of two years**; records must be generated as soon as practical but no later than 14 days after application and a record must be kept for each application. Records must be made available to State Pesticide Control Official(s), USDA, and EPA upon request. An example form summarizing record keeping requirements can be found on www.xtendimaxapplicationrequirements.com.

1. All Items required by 7 CFR Part 110 (RECORDKEEPING ON RESTRICTED USE PESTICIDES BY CERTIFIED APPLICATORS) including:
    a. The brand or product name
    b. The EPA registration number
    c. The total amount applied
    d. The month, day, and year
    e. The location of the application
    f. The crop, commodity, stored product, or site
    g. The size of treated area
    h. The name of the certified applicator
    i. The certification number of the certified applicator
2. Training: Date and provider of required training completed and proof of completion.
3. Receipts of Purchase: Receipts for the purchase of this product.
4. Product Label: A copy of this product label, and any state special local needs label that supplements this label.
5. Buffer Requirement: Record of the buffer distance calculation and any areas included within the buffer distance calculations as allowed in Section 9.1.4.a.
6. Susceptible Crops Awareness: Record that a sensitive crop registry was consulted; or document surveying neighboring fields for any susceptible crops prior to application. At a minimum, records must include the name of the sensitive crop registry and the date it was consulted or the survey of neighboring fields and the date conducted (read Section 9.1.4.b for additional information).
7. Start and Finish Times of Each Application: Record of the time at which the application was initiated and the time when the application was completed.
8. Application Timing: Record of the type of application (for example: pre-emergence, post-emergence) and number of days after planting if post-emergence.
9. Air Temperature: Record of the air temperature in degrees Fahrenheit at the start and completion of each application.
10. Wind Speed and Direction: Record of the wind speed and direction (the direction from which the wind is blowing) at boom height at the start and completion of each application of this product (Read Section 9.1.1 for information on wind speed).
11. Nozzle and Pressure: Record of the spray nozzle manufacturer/brand, type, orifice size, and operating pressure used during each application of this product (Read Section 9.1.1 for information on nozzles and pressures.)
12. Tank Mix Products: Record of the brand names and EPA registration numbers (if available) for all products (pesticides, adjuvants, and other products) that were tank mixed with this product for each application (Read Section 8.0 for more information on tank mixing.)
13. Spray System Cleanout: Record of compliance with the section of this label titled Section 9.5: Proper Spray System Equipment Cleanout. At a minimum, records must include the confirmation that the spray system was clean before using this product and that the post-application cleanout was completed in accordance with Section 9.5.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about Personal Protective Equipment (PPE), and restricted-entry intervals. The requirements in this box only apply to uses of this product that are covered by the WPS.

Do not enter or allow worker entry into treated areas during the restricted-entry interval (REI) of 24 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as, plants, soil, or water is:

- Coveralls worn over short-sleeved shirt and short pants
- Chemical-resistant footwear plus socks
- Waterproof gloves
- Chemical-resistant headgear for overhead exposure
- Protective eyewear

NON-AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses.

Do not enter or allow people (or pets) to enter the treated area until sprays have dried. Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Do not enter or allow other people or pets to enter until sprays have dried.

5.0 STORAGE AND DISPOSAL

Proper pesticide storage and disposal are essential to protect against exposure to people and the environment due to leaks and spills, excess product or waste, and vandalism. Do not allow this product to contaminate water, foodstuffs, feed or seed by storage and disposal. Open dumping is prohibited. This product may not be mixed, loaded, or used within 50 feet of all wells including abandoned wells, drainage wells, and sinkholes. This setback does not apply to properly capped or plugged abandoned wells and does not apply to impervious pad or properly diked mixing/loading areas as described above

5.1 Pesticide Storage

Groundwater contamination may be reduced by diking and flooring of permanent liquid bulk storage sites with an impermeable material. Spillage or leakage should be contained and absorbed with clay granules, sawdust, or equivalent material for disposal.
Store in original container in a well-ventilated and away from food, pet food, feed, seed, fertilizers, and veterinary supplies. Avoid cross-contamination with other pesticides. Keep container closed to prevent spills and contamination.

5.2 Pesticide Disposal

To avoid wastes, use all material in this container, including rinsate, by application according to label directions. If wastes cannot be avoided, offer remaining product to a waste disposal facility or pesticide

disposal program. Such programs are often run by state or local governments or by industry. All disposal must be in accordance with applicable federal, state and local regulations and procedures.
[*Alternate PESTICIDE DISPOSAL statement for transport vehicles only:* To avoid wastes, empty as much product from this transport vehicle as possible for repackaging or use in accordance with label directions. If wastes cannot be avoided, offer remaining product or rinsate to a waste disposal facility or pesticide disposal program. All disposal must be in accordance with applicable federal, state and local regulations and procedures.]

5.3 Container Handling and Disposal

[*Optional label statement if applicable*: See container label for container handling and disposal instructions and refilling limitations.]

[*CONTAINER HANDLING AND DISPOSAL STATEMENTS AND REFILLING LIMITATIONS FOR CONTAINER LABELS*]

[*CONTAINER HANDLING AND DISPOSAL STATEMENT AND REFILLING LIMITATION FOR NONREFILLABLE RIGID CONTAINERS OF LESS THAN 1-GALLON CAPACITY*]

Nonrefillable container. Do not reuse or refill this container.

[*Alternate container statement:* Nonrefillable container. Do not reuse this container to hold materials other than pesticides or dilute pesticides (rinsate). After emptying and cleaning, it may be allowable to temporarily hold rinsate or other pesticide-related materials in the container. Contact your state regulatory agency to determine allowable practices in your state.]

Triple rinse this container promptly after emptying.

Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container ¼ full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times.

Then offer this container for recycling, if available. If recycling is not available, dispose of in accordance with federal, state and local regulations and procedures, which may include puncturing the properly rinsed container and disposing in a sanitary landfill.

[*Alternate container disposal statement:* Once properly rinsed, some agricultural plastic pesticide containers can be taken to a container collection site or picked up for recycling. To find the nearest site, contact your chemical dealer or Monsanto at 1-800-ROUNDUP (1-800-768-6387). If recycling is not available, dispose of in accordance with federal, state and local regulations and procedures, which may include puncturing the properly rinsed container and disposing in a sanitary landfill.]

[*CONTAINER HANDLING AND DISPOSAL STATEMENT AND REFILLING LIMITATION FOR NONREFILLABLE RIGID PLASTIC 2.5-GALLON CONTAINERS AND OTHER NONREFILLABLE CONTAINERS OF GREATER THAN 1-GALLON BUT EQUAL TO OR LESS THAN 5-GALLON CAPACITY*]

Nonrefillable container. Do not reuse this container to hold materials other than pesticides or dilute pesticides (rinsate). After emptying and cleaning, it may be allowable to temporarily hold rinsate or other pesticide-related materials in the container. Contact your state regulatory agency to determine allowable practices in your state.

[*Alternate container statement:* Nonrefillable container. Do not reuse or refill this container.]

Triple rinse or pressure rinse (or equivalent) this container promptly after emptying.

Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container ¼ full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times.

Pressure rinse as follows: Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 PSI for at least 30 seconds. Drain for 10 seconds after the flow begins to drip.

Once properly rinsed, some agricultural plastic pesticide containers can be taken to a container collection site or picked up for recycling. [*Optional container disposal statement:* To find the nearest site, contact your chemical dealer or Monsanto at 1-800-ROUNDUP (1-800-768-6387)]. If recycling is not available, dispose of in accordance with federal, state and local regulations and procedures, which may include puncturing the properly rinsed container and disposing in a sanitary landfill.

[*Alternate container disposal statement:* Then offer this container for recycling, if available. If recycling is not available, dispose of in accordance with federal, state and local regulations and procedures, which may include puncturing the properly rinsed container and disposing in a sanitary landfill.]

[*CONTAINER HANDLING AND DISPOSAL STATEMENT AND REFILLING LIMITATION FOR NONREFILLABLE RIGID PLASTIC 30-GALLON CONTAINERS AND OTHER NONREFILLABLE CONTAINERS OF GREATER THAN 5-GALLON CAPACITY*]

Nonrefillable container. Do not reuse or refill this container.

[*Alternate container statement:* Nonrefillable container. Do not reuse this container to hold materials other than pesticides or dilute pesticides (rinsate). After emptying and cleaning, it may be allowable to temporarily hold rinsate or other pesticide-related materials in the container. Contact your state regulatory agency to determine allowable practices in your state.]

Triple rinse or pressure rinse (or equivalent) this container promptly after emptying.

Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container ¼ full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two more times.

Pressure rinse as follows: Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 PSI for at least 30 seconds. Drain for 10 seconds after the flow begins to drip.

Once properly rinsed, some agricultural plastic pesticide containers can be taken to a container collection site or picked up for recycling. [*Alternate container disposal statement:* To find the nearest site, contact your chemical dealer or Monsanto at 1-800-ROUNDUP (1-800-768-6387)]. If recycling is not available, dispose of in accordance with federal, state and local regulations and procedures, which may include puncturing the properly rinsed container and disposing in a sanitary landfill.

[*Alternate container disposal statement:* Then offer the container for recycling, if available. If recycling is not available, dispose of in accordance with federal, state and local regulations and procedures, which may include puncturing the properly rinsed container and disposing in a sanitary landfill.]

[*Optional container label statement:* Return Properly Rinsed Container to Monsanto for Recycling Contact: 1-800-ROUNDUP (1-800-768-6387)]

[*CONTAINER HANDLING AND DISPOSAL STATEMENT AND REFILLING LIMITATION FOR ALL REFILLABLE CONTAINERS, EXCEPT TRANSPORT VEHICLES*]

Refillable container. Refill this container with pesticide only. Do not reuse this container for any other purpose.

Cleaning this container before refilling is the responsibility of the refiller. Cleaning this container before final disposal is the responsibility of the person disposing of the container.

To clean this container before final disposal, empty the remaining contents from this container into application equipment or a mix tank. Fill the container about 10 percent full with water. Agitate vigorously or recirculate water with the pump for 2 minutes. Pour or pump rinsate into application equipment or rinsate collection system. Repeat this rinsing procedure two more times. Then offer this container for recycling, if available.

[*Optional container disposal statement:* To obtain information about recycling refillable containers, contact Monsanto Company at 1-800-ROUNDUP (1-800-768-6387)]

[*Optional container label statement:* Return Properly Rinsed Container to Monsanto for Recycling, Call 1-800-ROUNDUP (1-800-768-6387)]

[*CONTAINER HANDLING AND DISPOSAL STATEMENT FOR ALL TRANSPORT VEHICLES AS DEFINED IN 40 CFR 156.3]*

THIS LABEL FOR USE WITH TRANSPORT VEHICLES ONLY

Emptied container retains vapor and product residue. Observe all precautions stated on this label until the container is cleaned, reconditioned or destroyed. Prior to refilling, inspect carefully for damage such as cracks, punctures, abrasions, and worn-out threads and closures. Clean thoroughly before reuse for transportation of a material of different composition or before retiring this transport vehicle from service.

[Alternative label statement: NET CONTENTS: See Bill of Lading]

[Alternative label statement: LOT: See Bill of Lading]

[Alternative label statement: For Net Contents and Lot Number, see Bill of Lading]

6.0 PRODUCT INFORMATION

XtendiMax® With VaporGrip® Technology is approved by U.S. EPA for all uses specified on this label in the following states, subject to county restriction as noted: Alabama, Arkansas, Arizona, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin.

Additional state restrictions and requirements may apply. The applicator must comply with any additional state requirements and restrictions.

This product is a water-soluble formulation intended for control and suppression of many annual, biennials, and perennial broadleaf weeds, as well as woody brush and vines listed in the WEEDS CONTROLLED section of this label. This product may be used for control of these weeds in asparagus, corn, cotton, conservation reserve programs, fallow cropland, grass grown for seed, hay, proso millet, pasture, rangeland, general farmstead (noncropland), small grains, sod farms and farmstead turf, sorghum, soybean, sugarcane, Cotton with XtendFlex Technology and Roundup Ready 2 Xtend Soybean.

XtendiMax® With VaporGrip® Technology is a contact, systemic herbicide which can have moderate residual control on small seeded broadleaf weeds, including waterhemp, lambsquarters and Palmer pigweed, depending on rainfall and soil type.

XtendiMax® With VaporGrip® Technology is readily absorbed by plants through shoot and root uptake, translocates throughout the plant's system, and accumulates in areas of active growth. XtendiMax® With VaporGrip® Technology interferes with the plant's growth hormones (auxins) resulting in death of many broadleaf weeds.

Failure to properly clean the entire spray system can result in inadvertent contamination of the spray system. You must ensure that the spray system used to apply this product is clean before using this product.

Rainfast period: Rainfall or irrigation occurring within 4 hours after postemergence applications may reduce the effectiveness of this product.

Refer to the CROP-SPECIFIC INFORMATION and CROPS WITH XTEND TECHNOLOGY sections for application timing and other crop-specific details.

6.1 Restrictions

The applicator must read the entire label, including product labeling and follow all restrictions for XtendiMax® With VaporGrip® Technology**.** Restrictions included, but are not limited to:

- DO NOT APPLY THIS PRODUCT AERIALLY.
- DO NOT TANK MIX WITH PRODUCTS CONTAINING AMMONIUM SALTS SUCH AS AMMONIUM SULFATE (AMS) AND UREA AMMONIUM NITRATE. Small quantities of AMS can greatly increase the volatility potential of dicamba. Read the TANK MIXING INSTRUCTIONS of this label (Section 8.0) for instructions regarding other tank mix products.
- DO NOT APPLY TO CROPS UNDER STRESS DUE TO LACK OF MOISTURE, HAIL DAMAGE, FLOODING, HERBICIDE INJURY, MECHANICAL INJURY, INSECTS, OR WIDELY FLUCTUATING TEMPERATURES AS INJURY MAY RESULT.
- DO NOT APPLY THROUGH ANY TYPE OF IRRIGATION EQUIPMENT. DO NOT TREAT IRRIGATION DITCHES OR WATER USED FOR CROP IRRIGATION OR DOMESTIC PURPOSES.
- DO NOT MAKE APPLICATION OF THIS PRODUCT IF RAIN IS EXPECTED IN THE NEXT 24 HOURS THAT COULD RESULT IN WATER RUNOFF FROM AREA OF APPLICATION.

Review the entire label including, specific crop use direction sections for additional restrictions.

7.0 WEED RESISTANCE MANAGEMENT

GROUP	4	HERBICIDE

Dicamba mimics auxin (a plant hormone) resulting in a hormone imbalance in susceptible plants that interferes with normal cell division, cell enlargement, and protein synthesis. Dicamba active ingredient is a Group 4 herbicide based on the mode of action classification system of the Weed Science Society of America. Any weed population can contain plants naturally resistant to Group 4 herbicides. Weed species resistant to Group 4 herbicides can be effectively managed utilizing another herbicide from a different Group, or by using other cultural or mechanical practices.

7.1 Weed Management Practices

Certain agronomic practices can delay or reduce the likelihood that resistant weed populations will develop and can be utilized to manage weed resistance once it occurs.

Do not use less than the labeled rate of this product in a single application. Using the appropriate application rate can minimize the selection for resistant weeds.

Proactively implementing diversified weed control strategies to minimize selection for weed populations resistant to one or more herbicides is a best practice. A diversified weed management program may include the use of multiple herbicides with different sites of action and overlapping weed spectrum with or without tillage operations and/or other cultural practices. Research has demonstrated that using the labeled rate and directions for use is important to delay the selection for resistance.

The continued effectiveness of this product depends on the successful implementation of a weed resistance management program.

To aid in the prevention of developing weeds resistant to this product:

- Scout fields before application to ensure herbicides and rates will be appropriate for the weed species and weed sizes present.
- Start with a clean field, using either a burndown herbicide application or tillage.
- Control weeds early when they are relatively small (less than 4 inches).
- Apply full rates of XtendiMax® With VaporGrip® Technology for the most difficult to control weed in the field at the specified time (correct weed size) to minimize weed escapes.
- Avoid tank mixtures with other herbicides that reduce the efficacy of this product (through antagonism), or with ones that encourage application rates of this product below those specified on this label.
- Scout fields after application to detect weed escapes or shifts in weed species.
- Control weed escapes before they reproduce by seed or proliferate vegetatively.
- Report any incidence of non-performance of this product against a particular weed species to your Monsanto retailer or representative or call 1-844-RRXTEND (1-844-779-8363).
- If resistance is suspected, treat weed escapes with an herbicide having a site of action other than Group 4 and/or use non-chemical methods to remove escapes, as practical, with the goal of preventing further seed production.

Additionally, users should follow as many of the following herbicide resistance management practices as is practical:

- Use a broad spectrum soil-applied herbicide with other sites of action as a foundation in a weed control program.
- Utilize sequential applications of herbicides with alternative sites of action.

- Rotate the use of this product with non-Group 4 herbicides.
- Avoid making more than two applications of dicamba and any other Group 4 herbicides within a single growing season unless mixed with an herbicide with a different mechanism of action with an overlapping spectrum for the difficult to control weeds.
- Incorporate non-chemical weed control practices, such as mechanical cultivation, crop rotation, cover crops and weed-free crop seeds, as part of an integrated weed control program.
- Use good agronomic principles that enhance crop development and crop competitiveness.
- Thoroughly clean plant residues from equipment before leaving fields suspected to contain resistant weeds.
- Manage weeds in and around fields, during and after harvest to reduce weed seed production.

Contact the local agricultural extension service, Monsanto representative, agricultural retailer or crop consultant for further guidance on weed control practices as needed.

7.2 Management of Dicamba-Resistant Biotypes

Appropriate testing is critical in order to determine if a weed is resistant to dicamba. Contact your Monsanto representative to determine if resistance in any particular weed biotype has been confirmed in your area, or visit on the Internet www.weedresistancemanagement.com or www.weedscience.org.

Monsanto Company is not responsible for any losses that result from the failure of this product to control dicamba-resistant weed biotypes.

The following good agronomic practices can reduce the spread of confirmed dicamba-resistant biotypes:

- If a naturally occurring resistant biotype is present in your field, this product may be tank-mixed or applied sequentially with an appropriately labeled herbicide with a different mode of action to achieve control (read Section 8.0 for more information on tank mixing).
- Cultural and mechanical control practices (e.g., crop rotation or tillage) can also be used as appropriate.
- Scout treated fields after herbicide application and control weed escapes, including resistant biotypes, before they set seed.
- Thoroughly clean equipment, as practical, for all weed seeds before leaving fields known to contain resistant biotypes.

8.0 TANK MIXING INSTRUCTIONS

XtendiMax® With VaporGrip® Technology may only be tank-mixed with products that have been tested and found not to adversely affect the offsite movement potential of XtendiMax® With VaporGrip® Technology. A list of those products may be found at www.xtendimaxapplicationrequirements.com.

The applicator must check the list of tested products found not to adversely affect the offsite movement potential of XtendiMax® With VaporGrip® Technology at www.xtendimaxapplicationrequirements.com no more than 7 days before applying XtendiMax® With VaporGrip® Technology.

DO NOT tank mix any product with XtendiMax® With VaporGrip® Technology unless:

1. The intended tank-mix product is identified on the list of tested products;
2. The intended products are not prohibited on either this label or the label of the tank mix product; and
3. All requirements and restrictions on www.xtendimaxapplicationrequirments.com are followed.

TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, MONSANTO MAKES NO RECOMMENDATION OR WARRANTY HEREIN REGARDING THE USE OF ANY PRODUCT THAT

MAY APPEAR ON THE WEBSITE REFERENCED ABOVE, REGARDLESS OF WHETHER SUCH PRODUCT IS USED ALONE OR IN A TANK MIX WITH XTENDIMAX® WITH VAPORGRIP® TECHNOLOGY. BUYER AND ALL USERS ARE SOLELY RESPONSIBLE FOR ANY LACK OF PERFORMANCE, LOSS, OR DAMAGE IN CONNECTION WITH THE USE OR HANDLING OF ANY SUCH PRODUCT ALONE OR IN A TANK MIX WITH XTENDIMAX® WITH VAPORGRIP® TECHNOLOGY. See the section titled "LIMIT OF WARRANTY AND LIABILITY" herein for more information.

8.1 Compatibility Test for Mix Components

Before mixing components, always perform a compatibility jar test.

- For 20 gallons per acre spray volume, use 3.3 cups (800 mL) of water. For other spray volumes, adjust rates accordingly. Only use water from the intended source at the source temperature.
- Add components in the sequence indicated in the Mixing Order section below using 2 teaspoons for each pound or 1 teaspoon for each pint of labeled use rate per acre.
- Cap the jar and invert 10 cycles between component additions.
- When the components have all been added to the jar, let the solution stand for 15 minutes.
- Evaluate the solution for uniformity and stability. The spray solution should not have free oil on the surface; fine particles that precipitate to the bottom; or thick (clabbered) texture. If the spray solution is not compatible, repeat the compatibility test with the addition of a suitable compatibility agent. If the solution is then compatible, use the compatibility agent as directed on its label. If the solution is still incompatible, then do not mix the ingredients in the same tank.

8.2 Mixing Order

Only use approved tank mix products as directed on www.xtendimaxapplicationrequirements.com. Always read and follow label directions for all products in the tank mixture.

1. Ensure application and mixing equipment are clean and in proper working order
2. Water - Begin by agitating a thoroughly **clean sprayer** tank three-quarters full of clean water.
3. Agitation - Maintain constant agitation throughout mixing and application.
4. Drift Reducing Adjuvants (DRA)-(when applicable)
5. Inductor - If an inductor is used, rinse it thoroughly after each component has been added.
6. Products in PVA bags - Place any product contained in water-soluble PVA bags into the mixing tank. Wait until all water-soluble PVA bags have fully dissolved and the product is evenly mixed in the spray tank before continuing.
7. Water-dispersible products (dry flowables, wettable powders, suspension concentrates, or suspo-emulsions)
8. Water-soluble products (such as XtendiMax® With VaporGrip® Technology)
9. Emulsifiable concentrates (such as oil concentrate when applicable)
10. Water-soluble additives (when applicable)
11. Add remaining quantity of water.

Maintain constant agitation during application

8.3 Adjuvants, Drift Reducing Adjuvants, Surfactants, and Other Tank Mixed Products

See Section 8.0 TANK MIXING INSTRUCTIONS for tank mixing instructions for adjuvants, drift reducing adjuvants, surfactants, and other tank mixed products.

9.0 APPLICATION EQUIPMENT AND TECHNIQUES

DO NOT APPLY THIS PRODUCT USING AERIAL SPRAY EQUIPMENT.

XtendiMax® With VaporGrip® Technology can be applied to actively growing weeds as broadcast, band, or spot spray applications using water as a carrier. For best results, treat weeds early when they are relatively small (less than 4 inches). Timely application to small weeds early in the season will improve control and reduce weed competition. Refer to Table 1 for XtendiMax® With VaporGrip® Technology application rates for control or suppression by weed type and growth stage. For crop-specific application timing and other details, refer to the CROP-SPECIFIC INFORMATION section of this label.

APPLY THIS PRODUCT USING PROPERLY MAINTAINED AND CALIBRATED EQUIPMENT CAPABLE OF DELIVERING THE REQUIRED VOLUMES.

Using a hooded sprayer or other drift reduction technology in combination with approved nozzles may further reduce drift potential.

Cultivation: Do not cultivate within 7 days after applying this product.

Table 1. XtendiMax® With VaporGrip® Technology Application Rates for Control or Suppression by Weed Type and Growth Stage
Use rate limitations are given in sections 9 (RESTRICTIONS) and 10 (CROP-SPECIFIC INFORMATION)

Weed Type and Stage	Rate Per Acre	Weed Type and Stage	Rate Per Acre
Annual[1] Small, actively growing Established weed growth	 11 – 22 fluid ounces 22 – 33 fluid ounces	**Perennial** Top growth suppression Top growth control and root suppression Noted perennials (footnote 1 in Section 10.0). Other perennials[3]	 11 – 22 fluid ounces 22 – 44 fluid ounces 44 fluid ounces 44 fluid ounces
Biennial Rosette diameter 1 – 3” Rosette diameter 3” or more Bolting	 11 – 22 fluid ounces 22 – 44 fluid ounces 44 fluid ounces	**Woody Brush & Vines** Top growth suppression Top growth control[2,3] Stems and stem suppression[3]	 22 – 44 fluid ounces 44 fluid ounces 44 fluid ounces

[1] Rates below 11 fluid ounces per acre may provide control or suppression but should typically be applied with other herbicides that are effective on the same species and biotype.
[2] Species noted will require tank mixes for adequate control.
[3] For species noted do not broadcast apply more than 44 fluid ounces per acre in any single application. One sequential application of up to 44 fluid ounces may be required for adequate control. Use the higher level listed rate ranges when treating dense vegetative growth or perennial weeds with well established root growth.

9.1 Spray Drift Management

Do not allow herbicide solution to mist, drip, drift or splash onto desirable vegetation because severe injury or destruction to desirable broadleaf plants could result.

The most effective way to reduce drift potential is to apply large droplets that provide sufficient coverage and control. Applying larger droplets reduces drift potential, but will not prevent drift if the application is made improperly, or under unfavorable environmental conditions (see the **"Temperature and Humidity"** and "**Temperature Inversions"** sections of this label).

9.1.1 Sprayer Setup

The following sprayer setup requirements for drift management must be followed:

- **Nozzle type.** The applicator must use an approved nozzle within a specified pressure range as found at www.xtendimaxapplicationrequirements.com when applying XtendiMax® With VaporGrip® Technology. Do not use any other nozzle and pressure combination not specifically listed on this website.

- **Spray Volume.** The applicator must apply this product in a **minimum of 15 gallons of spray solution per acre**. See Section 8.0 for information on approved tank mix products.

- **Equipment Ground Speed.** Do not exceed a **ground speed of 15 miles per hour**. Select a ground speed that will deliver the desired spray volume while maintaining the desired spray pressure, but slower speeds generally result in better spray coverage and deposition on the target area. Provided the applicator can maintain the required nozzle pressure, it is recommended that tractor speed is reduced to 5 miles per hour at field edges.

- **Spray boom Height.** Do not exceed a **boom height of 24 inches** above target pest or crop canopy. Excessive boom height will increase the drift potential.

- **Wind Speed.** Do not apply when wind speeds are **less than 3 MPH or greater than 10 MPH**. Only apply when wind speed at boom height is between 3 and 10 mph.

9.1.2 Temperature and Humidity

When making applications in low relative humidity or temperatures above 91 degrees Fahrenheit, set up equipment to produce larger droplets to compensate for evaporation (for example: increase orifice size and/or increase spray volume as directed on www.xtendimaxapplicationrequirements.com). Larger droplets have a lower surface to volume ratio and can be impacted less by temperature and humidity. Droplet evaporation is most severe when conditions are both hot and dry.

9.1.3 Temperature Inversions

Do not apply this product during a temperature inversion as the off-target movement potential is high.
Do not apply this product between sunset and sunrise. In general, temperature inversions are more likely during night time hours.

- During a temperature inversion, the atmosphere is very stable and vertical air mixing is restricted, which can cause small, suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light, variable winds common during inversions.
- Temperature inversions can be characterized by increasing temperatures with altitude and can be common on evenings and nights with limited cloud cover and light to no wind. Cooling of air at the earth's surface takes place and warmer air is trapped above it. Temperature inversions can begin to form as the sun sets and often continue into the morning.

- Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing.
- The inversion will typically dissipate with increased winds (above 3 miles per hour) or at sunrise when the surface air begins to warm (generally 3°F from morning low).

9.1.4 Buffer Requirements and Protection of Susceptible Crops

Do not apply under circumstances where drift may occur to food, forage, or other plantings that might be damaged or the crops rendered unfit for sale, use, or consumption.

9.1.4.a. Buffer Requirement

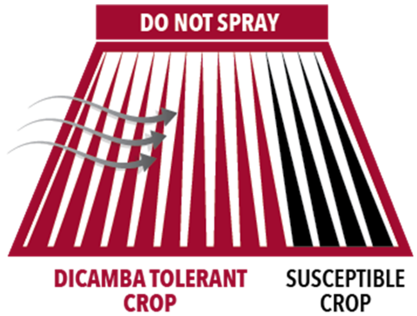
The applicator **must always maintain** a 110 foot downwind buffer (when applying up to 22 fluid ounces of this product per acre) or a 220 foot downwind buffer (when applying greater than 22 up to 44 fluid ounces of this product per acre) between the last treated row and the nearest downwind field edge (in the direction the wind is blowing).

The following areas may be included in the buffer distance calculation when directly adjacent to the treated field edges:

- Roads, paved or gravel surfaces.
- Planted agricultural fields containing: corn, dicamba tolerant cotton, dicamba tolerant soybean, sorghum, proso millet, small grains and sugarcane. If the applicator intends to include such crops as dicamba tolerant cotton and/or dicamba tolerant soybeans in the buffer distance calculation, the applicator must confirm the crops are in fact dicamba tolerant.
- Agricultural fields that have been prepared for planting.
- Areas covered by the footprint of a building, silo, or other man made structure with walls and or roof.

9.1.4.b. Susceptible Crops

DO NOT APPLY this product when the wind is blowing toward adjacent non-dicamba tolerant susceptible crops; this includes **NON-DICAMBA TOLERANT SOYBEAN AND COTTON.**



Before making an application, the applicator must survey the application site for adjacent non-target susceptible crops. The applicator must also consult applicable sensitive crop registries to identify any commercial specialty or certified organic crops that may be located near the application site.

Susceptible crops include, but are not limited to non-dicamba tolerant soybeans and cotton, tomatoes and other fruiting vegetables (EPA crop group 8), fruit trees, cucurbits (EPA crop group 9), grapes, beans, flowers, ornamentals, peas, potatoes, sunflower, tobacco, other broadleaf plants, and including plants in a greenhouse. Severe injury or destruction could occur if any contact between this product and these plants occurs.

9.1.5 Application Awareness

AVOIDING SPRAY DRIFT AT THE APPLICATION SITE IS THE RESPONSIBILITY OF THE APPLICATOR.

The interaction of equipment and weather related factors must be monitored to maximize performance and on-target spray deposition. The applicator is responsible for considering all of these factors when making a spray decision. The applicator is responsible for compliance with state and local pesticide regulations, including any state or local pesticide drift regulations.

9.2 Ground Application (Banding)

When applying XtendiMax® With VaporGrip® Technology by banding, determine the amount of herbicide and water volume needed using the following formula:

$$\frac{\text{Bandwidth in inches}}{\text{Row width in inches}} \times \text{Broadcast rate per acre} = \text{Banding herbicide rate per acre}$$

$$\frac{\text{Bandwidth in inches}}{\text{Row width in inches}} \times \text{Broadcast volume per acre} = \text{Banding water volume per acre}$$

9.3 Ground Application (Broadcast)

Water Volume: Use a **minimum of 15 gallons** of spray solution per broadcast acre for optimal performance. Use 20 gallons per acre when treating dense or tall vegetation.

Application Equipment: Select nozzles (refer to section 9.1.1 Nozzle type of this product label) designed to produce minimal amounts of fine spray particles. Spray with nozzles as close to the weeds as practical for good weed coverage.

Using a hooded sprayer or other drift reduction technology in combination with approved nozzles may further reduce drift potential.

9.4 Ground Application (Wipers)

XtendiMax® With VaporGrip® Technology may be applied through wiper application equipment to control or suppress actively growing broadleaf weeds, brush and vines. Use a solution containing 1 part XtendiMax® With VaporGrip® Technology to 1 part water. Do not apply greater than 1 lb dicamba acid equivalent (1 quart of this product) per acre per application. Do not contact desirable vegetation with herbicide solution. Wiper application may be made to crops (including pastures) and non-cropland areas described in this label except for non-dicamba-tolerant cotton, sorghum, and non-dicamba-tolerant soybean.

9.5 Proper Spray System Equipment Cleanout

You must ensure that the spray system used to apply this product is clean before using this product.

Failure to properly clean the entire spray system can result in inadvertent contamination of the spray system.

Small quantities of dicamba may cause injury to non-dicamba tolerant soybeans and other susceptible crops (see Section 9.1.4 of this label for more information).

Clean equipment immediately after using this product, using a triple rinse procedure as follows:

1. After spraying, drain the sprayer (including boom and lines) immediately. Do not allow the spray solution to remain in the spray boom lines overnight prior to flushing.
2. Flush tank, hoses, boom and nozzles with clean water. If equipped, open boom ends and flush.
3. Inspect and clean all strainers, screens and filters.
4. Prepare a cleaning solution with a commercial detergent or sprayer cleaner or ammonia according to the manufacturer’s directions.
5. Take care to wash all parts of the tank, including the inside top surface. Start agitation in the sprayer and thoroughly recirculate the cleaning solution for at least 15 minutes. All visible deposits must be removed from the spraying system.
6. Flush hoses, spray lines and nozzles for at least 1 minute with the cleaning solution.
7. Remove nozzles, screens and strainers and clean separately in the cleaning solution after completing the above procedures.
8. Drain pump, filter and lines.
9. Rinse the complete spraying system with clean water.
10. Clean and wash off the outside of the entire sprayer and boom.
11. All rinse water must be disposed of in compliance with local, state, and federal guidelines.

10.0 ADDITIONAL RESTRICTIONS

Maximum Application Rates: The maximum application or use rates stated throughout this label are given in units of volume (fluid ounces or quarts) of this product per acre. However, the maximum allowed application rates apply to this product combined with the use of any and all other herbicides containing the active ingredients dicamba, whether applied separately or as a tank mixture, on a basis of total pounds of dicamba (acid equivalents) per acre. If more than one dicamba-containing product is applied to the same site within the same year, you must ensure that the total use of dicamba (pounds acid equivalents) does not exceed 2 pounds/A per year from all applications. See the INGREDIENTS section of this label for necessary product information.

Maximum seasonal use rate: Refer to Table 2. Crop-Specific Restrictions for crop-specific maximum seasonal use rates. Do not exceed 88 fluid ounces of XtendiMax® With VaporGrip® Technology (2 pounds acid equivalent) per acre, per year.

Preharvest Interval (PHI): Refer to the CROP-SPECIFIC INFORMATION section for preharvest intervals.

Restricted Entry Interval (REI): 24 hours

Crop Rotational Restrictions

No rotational cropping restrictions apply when rotating to Roundup Ready 2 Xtend® Soybeans or cotton seed with XtendFlex® Technology (including Bollgard® 3 XtendFlex® Cotton, Bollgard II® XtendFlex® Cotton, or XtendFlex® Cotton). For other crops the interval between application and planting rotational crop is given below. When counting days from the application of this product, do not count days when the ground is frozen. Planting at intervals less than specified below may result in crop injury. Moisture is essential for the degradation of this herbicide in soil. If dry weather prevails, use cultivation to allow herbicide contact with moist soil.

Planting/replanting restrictions at application rates of 33 fluid ounces of this product per acre per season or less: Follow the planting restrictions in the directions for use for Preplant application in the Crop Specific Information section of this label. For corn, cotton (except cotton seed with XtendFlex® Technology), sorghum, and soybean (except Roundup Ready 2 Xtend® Soybean), follow the planting restrictions in the directions for use for preplant application in **Section 11. Crop-Specific Information** of this label. Do not plant barley, oat, wheat, and other grass seedings for 15 days for every 11 fluid ounces of this product applied per acre east of the Mississippi River and 22 days for every 11 fluid ounces per acre applied west of the Mississippi River. No planting restrictions apply beyond 120 days after application of this product.

Planting/replanting restrictions at application rates of more than 33 fluid ounces and up to 88 fluid ounces of this product per acre per season: Wait a minimum of 120 days after application of this product before planting corn, sorghum and cotton (except cotton seed with XtendFlex® Technology) east of the Rocky Mountains and before planting all other crops (except Roundup Ready 2 Xtend® Soybean) grown in areas receiving 30 inches or more rainfall annually. Wait a minimum of 180 days before planting crops in areas with less than 30 inches of annual rainfall. Wait a minimum of 30 days for every 22 fluid ounces of this product applied per acre before planting barley, oat, wheat, and other grass seedings east of the Mississippi River and 45 days for every 22 fluid ounces of this product applied per acre west of the Mississippi River.

Table 2. Crop-Specific Restrictions[1]

Crop	Maximum Rate Per Acre Per Application (fl oz)	Maximum In-Crop Rate Pre Acre Per Season (fl oz)	Livestock Grazing or Feeding
Asparagus	22	22	Yes

Barley; Fall Spring	11 11	16.5 15	Yes
Conservation Reserve Program (CRP)	44	88	Yes
Corn	22	33	Yes[2]
Cotton	11	11	Yes
Cotton with XtendFlex Technology	44	88	Yes
Fallow Ground	44	88	Yes
Grass grown for seed	44	88	Yes
Oats	5.5	5.5	Yes
Pastureland	44	44	Yes
Proso Millet	5.5	5.5	Yes
Small grains grown for grass, forage, fodder, hay and/or pasture	22	22	Yes
Sorghum	11	22	Yes
Soybean	44	44	Yes
Roundup Ready 2 Xtend Soybean	44	88	Yes
Sugarcane	44	88	Yes

Triticale	5.5	5.5	Yes
Sod farms and farmstead turf	44	44	Yes
Wheat	11	22	Yes
[1]Refer to section **11. CROP-SPECIFIC INFORMATION** and section **12. CROPS WITH XTEND TECHNOLOGY** for more details. [2]Once the crop reaches the ensilage (milk) stage or later in maturity			

11.0 CROP-SPECIFIC INFORMATION

Read Sections: 8.0 for Tank Mixing Instructions and 9.1.4 for Buffer Requirements and Susceptible Crops for information on tank mixing, buffer requirements, and susceptible crops.

11.1 Asparagus

Apply XtendiMax® With VaporGrip® Technology to emerged and actively growing weeds in 40 - 60 gallons of diluted spray per treated acre immediately after cutting the field, but at least 24 hours before the next cutting. Multiple applications may be made per growing season.

If spray contacts emerged spears, crooking (twisting) of some spears may result. If such crooking occurs, discard affected spears.

Rates: Apply 11-22 fluid ounces of XtendiMax® With VaporGrip® Technology to control annual sowthistle, black mustard, Canada and Russian thistle, and redroot pigweed (carelessweed).

Apply 22 fluid ounces of XtendiMax® With VaporGrip® Technology to control common chickweed, field bindweed, nettleleaf goosefoot, and wild radish. Up to 2 applications may be made per growing season. Do not exceed a total of 22 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre, per crop year.

Do not harvest prior to 24 hours after treatment.

[Optional: Do not use in the Coachella Valley of California]

11.2 Between Crop Applications

Preplant Directions (Postharvest, Fallow, Crop Stubble, Set-Aside) for Broadleaf Weed Control:

XtendiMax® With VaporGrip® Technology can be applied either postharvest in the fall, spring, or summer during the fallow period or to crop stubble/set-aside acres. Apply XtendiMax® With VaporGrip® Technology as a broadcast or spot treatment to emerged and actively growing weeds after crop harvest (postharvest) and before a killing frost or in the fallow cropland or crop stubble the following spring or summer.

See the "Crop Rotational Restrictions" in Section 10 of this label for the recommended interval between application and planting to prevent crop injury.

Rates and Timings:

Apply 5.5 – 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre. Refer to Table 1 to determine use rates for specific targeted weed species. For best performance, apply XtendiMax® With

VaporGrip® Technology when annual weeds are less than 4" tall, when biennial weeds are in the rosette stage and to perennial weed regrowth in late summer or fall following a mowing or tillage treatment. The most effective control of upright perennial broadleaf weeds such as Canada thistle and Jerusalem artichoke occurs if XtendiMax® With VaporGrip® Technology is applied when the majority of weeds have at least 4 - 6" of regrowth or for weeds such as field bindweed and hedge bindweed that are in or beyond the full bloom stage.

Avoid disturbing treated areas following application. Treatments may not kill weeds that develop from seed or underground plant parts such as rhizomes or bulblets, after the effective period for XtendiMax® With VaporGrip® Technology. For seedling control, a follow-up program or other cultural practices could be instituted. For small grain in-crop uses of XtendiMax® With VaporGrip® Technology, refer to the small grain section for details.

11.3 Conservation Reserve Program (CRP)

XtendiMax® With VaporGrip® Technology is recommended for use on both newly seeded and established grasses grown in Conservation Reserve or federal Set-Aside Programs. Treatments of XtendiMax® With VaporGrip® Technology will injure or may kill alfalfa, clovers, lespedeza, wild winter peas, vetch, and other legumes.

Newly Seeded Areas

XtendiMax® With VaporGrip® Technology may be applied either preplant or postemergence to newly seeded grasses or small grains such as barley, oats, rye, sudanqrass, wheat, or other grain species grown as a cover crop. Postemergence applications may be made after seedling grasses exceed the 3-leaf stage. Rates of XtendiMax® With VaporGrip® Technology greater than 22 fluid ounces per treated acre may severely injure newly seeded grasses.

Preplant applications may injure new seedlings if the interval between application and grass planting is less than 45 days per 22 fluid ounces of XtendiMax® With VaporGrip® Technology applied per treated acre west of the Mississippi River or 20 days per 22 fluid ounces applied east of the Mississippi River.

Established Grass Stands

Established grass stands are perennial grasses planted one or more seasons prior to treatment. Certain species (bentgrass, carpetgrass, smooth brome, buffalograss, or St. Augustinegrass) may be injured when treated with more than 22 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre.

When applied at recommended rates, XtendiMax® With VaporGrip® Technology will control many annual and biennial weeds and provide control or suppression of many perennial weeds.

Rates and Timings

Apply 5.5 - 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre. Refer to **Table 1** for rates based on target weed species. Retreatments may be made as needed; however, do not exceed a total of 88 fluid ounces (4 pints) of XtendiMax® With VaporGrip® Technology per acre per year.

11.4 Corn (Field, Pop, Seed, And Silage)

Direct contact of XtendiMax® With VaporGrip® Technology with corn seed must be avoided. If corn seeds are less than 1.5" inches below the surface, delay application until corn has emerged.

Applications of XtendiMax® With VaporGrip® Technology to corn during periods of rapid growth may result in temporary leaning. Corn will usually become erect within 3 to 7 days. Cultivation should be delayed until after corn is growing normally to avoid breakage.

Corn may be harvested or grazed for feed once the crop has reached the ensilage (milk) stage or later in maturity.

Up to 2 applications of XtendiMax® With VaporGrip® Technology may be made during a growing season. Sequential applications must be separated by 2 weeks or more.

Do not apply XtendiMax® With VaporGrip® Technology to seed corn or popcorn without first verifying with your local seed corn company (supplier) the selectivity of XtendiMax® With VaporGrip® Technology on your inbred line or variety of popcorn. This precaution will help avoid potential injury of sensitive varieties.

Avoid using crop oil concentrates after crop emergence as crop injury may result. Use crop oil concentrates only in dry conditions when corn is less than 5" tall when applying XtendiMax® With VaporGrip® Technology.

Use of sprayable fluid fertilizer as the carrier is not recommended for applications of XtendiMax® With VaporGrip® Technology made after corn emergence.

XtendiMax® With VaporGrip® Technology is not registered for use on sweet corn.

Preplant and Preemergence Application in No-Tillage Corn:

Rates: Apply 22 fluid ounces of XtendiMax® With VaporGrip® Technology per acre on medium- or fine-textured soils containing 2.5% or greater organic matter. Use 11 fluid ounces per acre on coarse soils (sand, loamy sand, and sandy loam) or medium- and fine-textured soils with less than 2.5% organic matter.

Timing: XtendiMax® With VaporGrip® Technology can be applied to emerging weeds before, during, or after planting a corn crop. When planting into a legume sod (e.g., alfalfa or clover), apply XtendiMax® With VaporGrip® Technology after 4 - 6" of regrowth has occurred

Preemergence Application in Conventional or Reduced Tillage Corn:

Rates: Apply 22 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre on medium- or fine-textured soils containing 2.5% organic matter or more. Do not apply to coarse textured soils (sand, loamy sand, or sandy loam) of any soil with less than 2.5% organic matter until after corn emergence (See Early Postemergence uses below).

Timing: XtendiMax® With VaporGrip® Technology may be applied after planting and prior to corn emergence. Pre-emergence application of XtendiMax® With VaporGrip® Technology does not require mechanical incorporation to become active. A shallow mechanical incorporation is recommended if application is not followed by adequate rainfall or sprinkler irrigation. Avoid tillage equipment (e.g., drags, harrows) which concentrates treated soil over seed furrow as seed damage could result.

Preemergence control of cocklebur, jimsonweed, and velvetleaf may be reduced if conditions such as low temperature or lack of soil moisture cause delayed or deep germination of weeds.

Early Postemergence Application in All Tillage Systems:

Rates: Apply 22 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre. Reduce the rate to 11 fluid ounces per treated acre if corn is growing on coarse textured soils (sand, loamy sand, and sandy loam).

Timing: Apply between corn emergence and the 5-leaf stage or 8" tall, whichever occurs first. Refer to Late Postemergence Applications if the sixth true leaf is emerging from whorl or corn is greater than 8" tall.

Late Postemergence Application:

Rate: Apply 11 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre.

Timing: Apply XtendiMax® With VaporGrip® Technology from 8 - 36" tall corn or 15 days before tassel emergence, whichever comes first. For best performance, apply when weeds are less than 3" tall.

Apply directed spray when corn leaves prevent proper spray.

11.5 Cotton

For directions for use with crops with Xtend Technology see the "CROPS WITH XTEND TECHNOLOGY" section of this label.

Preplant Application:

Apply up to 11 fluid ounces of XtendiMax® With VaporGrip® Technology per acre to control emerged broadleaf weeds prior to planting cotton in conventional or conservation tillage systems.

For best performance, apply XtendiMax® With VaporGrip® Technology when weeds are in the 2 - 4 leaf stage and rosettes are less than 2" across.

Following application of XtendiMax® With VaporGrip® Technology and a minimum accumulation of 1" of rainfall or overhead irrigation, allow a minimum of 21 days between treatment and planting per application of 11 fluid ounces per acre or less. This plant back interval must be observed prior to planting cotton.

Do not apply preplant to cotton west of the Rockies.

Do not make XtendiMax® With VaporGrip® Technology preplant applications to cotton in geographic areas with average annual rainfall less than 25".

If applying a spring preplant treatment following application of a fall preplant (postharvest) treatment, then the combination of both treatments may not exceed 2 pounds acid equivalent per acre.

11.6 Grass Grown For Seed

Apply 11 - 22 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre on seedling grass after the crop reaches the 3 -5 leaf stage. Apply up to 44 fluid ounces of XtendiMax® With VaporGrip® Technology on well-established perennial grass. For best performance, apply XtendiMax® With VaporGrip® Technology when weeds are in the 2 - 4 leaf stage and rosettes are less than 2" across. Use the higher level of listed rate ranges when treating more mature weeds or dense vegetative growth.

To suppress annual grasses such as brome (downy and ripgut), rattail fescue, and windgrass, apply up to 44 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre in the fall or late summer after harvest and burning of established grass seed crops. Applications should be made immediately following the first irrigation when the soil is moist and before weeds have more than 2 leaves.

Do not apply XtendiMax® With VaporGrip® Technology after the grass seed crop begins to joint.

Refer to the Pasture, Hay, Rangeland, and General Farmstead section for grazing and feeding restrictions.

11.7 Proso Millet

For use only within Colorado, Nebraska, North Dakota, South Dakota, [Optional: **and Wyoming].**

XtendiMax® With VaporGrip® Technology combined with an appropriate tank-mix partner will provide control or suppression of the annual broadleaf weeds listed in **Section 13.**

11.8 Pasture, Hay, Rangeland, And General Farmstead (Noncropland)

XtendiMax® With VaporGrip® Technology is recommended for use on pasture, hay, rangeland, and general farmstead (non-cropland) (including fencerows and non-irrigation ditch banks) for control or suppression of broadleaf weed and brush species listed in Section 12.

XtendiMax® With VaporGrip® Technology may also be applied to non-cropland areas to control broadleaf weeds in noxious weed control programs, districts, or areas including broadcast or spot treatment of roadsides and highways, utilities, railroad, and pipeline rights-of-way. Noxious weeds must be recognized at the state level, but programs may be administered at state, county, or other level.

XtendiMax® With VaporGrip® Technology uses described in this section also pertain to grasses and small grains (forage sorghum, rye, sudangrass, or wheat) grown for grass, forage, fodder, hay and/or pasture use only. Grasses and small grains not grown for grass, forage, fodder, hay and/or pasture must comply with crop-specific uses in this label. Some perennial weeds may be controlled with lower rates of XtendiMax® With VaporGrip® Technology (refer to **Table 1**).

Rates and Timings

Refer to **Table 1** for rate selection based on targeted weed or brush species.

Rates above 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre are for spot treatments only. Spot treatment is defined as no more than a total of 1000 square feet of treated area per acre. Do not broadcast apply more than 44 fluid ounces per acre.

Retreatments may be made as needed; however, do not exceed a total of 44 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre during a growing season.

Grass grown for hay requires a minimum of 7-days between treatment and harvest.

Crop-Specific Restrictions

Do not apply more than 22 fluid ounces of XtendiMax® With VaporGrip® Technology per acre to small grains grown for pasture.

Newly seeded areas may be severely injured if more than 22 fluid ounces of XtendiMax® With VaporGrip® Technology is applied per acre.

Established grass crops growing under stress can exhibit various injury symptoms that may be more pronounced if herbicides are applied. Bentgrass, carpetgrass, buffalograss, and St. Augustin grass may be injured if more than 22 fluid ounces of XtendiMax® With VaporGrip® Technology is applied per acre. Usually colonial bent grasses are more tolerant than creeping types. Velvet grasses are most easily injured. Treatments will kill or injure alfalfa, clovers, lespedeza, wild winter peas, vetch, and other legumes.

Table 3 lists the timing restrictions for grazing or harvesting hay from treated fields. There are no grazing restrictions for animals other than lactating dairy animals.

Table 3. Timing Restrictions for Lactating Dairy Animals Following Treatment

XtendiMax® With VaporGrip® Technology Rate per Treated Acre (fluid ounces)	Days Before Grazing (days)	Days Before Hay Harvest (days)
Up to 22	7	37
Up to 44	21	51

- **Spot Treatments:** XtendiMax® With VaporGrip® Technology may be applied to individual clumps or small areas of undesirable vegetation using handgun or similar types of application equipment. Apply diluted sprays to allow complete wetting (up to runoff) of foliage and stems.

Cut Surface Treatments:

XtendiMax® With VaporGrip® Technology may be applied as a cut surface treatment for control of unwanted trees and prevention of sprouts of cut trees.

Rate: Mix 1 part XtendiMax® With VaporGrip® Technology with 1 - 3 parts water to create the application solution. Use the lower dilution rate when treating difficult-to-control species.

- **For Frill or Girdle Treatments**: Make a continuous cut or a series of overlapping cuts using an axe to girdle tree trunk. Spray or paint the cut surface with the solution.
- **For Stump Treatments:** Spray or paint freshly cut surface with the water mix. The area adjacent to the bark should be thoroughly wet.

Applications For Control of Dormant Multiflora Rose:

XtendiMax® With VaporGrip® Technology can be applied when plants are dormant as an undiluted spot treatment directly to the soil or as a Lo-Oil basal bark treatment using an oil-water emulsion solution.

- **Spot treatments:** Spot treatment applications of XtendiMax® With VaporGrip® Technology should be applied directly to the soil as close as possible to the root crown but within 6 - 8" of the crown. On sloping terrain, apply XtendiMax® With VaporGrip® Technology to the uphill side of the crown. Do not apply when snow or water prevents applying XtendiMax® With VaporGrip® Technology directly to the soil. The use rate of XtendiMax® With VaporGrip® Technology depends on the canopy diameter of the multiflora rose.

  Examples: Use 0.34, 1.38, or 3.23 fluid ounces of XtendiMax® With VaporGrip® Technology respectively, for 5, 10, or 15 feet canopy diameters.

- **Lo-Oil basal bark treatments:** For Lo-Oil basal bark treatments, apply XtendiMax® With VaporGrip® Technology to the basal stem region from the ground line to a height of 12 - 18". Spray until runoff, with special emphasis on covering the root crown. For best results, apply XtendiMax® With VaporGrip® Technology when plants are dormant. Do not apply after bud break or when plants are showing signs of active growth. Do not apply when snow or water prevents applying XtendiMax® With VaporGrip® Technology to the ground line.

  To prepare approximately 2 gallons of a Lo-Oil spray solution:

  1) Combine 1.5 gallons of water, 1 ounce of emulsifier, 22 fluid ounces of XtendiMax® With VaporGrip® Technology, and 2.5 pints of No. 2 diesel fuel.
  2) Adjust the amounts of materials used proportionately to the amount of final spray solution desired.

  Do not exceed 8 gallons of spray solution mix applied per acre, per year.

11.9 SMALL GRAINS

11.9.1 Small Grains Not Underseeded To Legumes (fall- and spring-seeded barley, oat, triticale and wheat)

Refer to the specific crop sections below for use rates. When treating difficult to control weeds such as kochia, wild buckwheat, cow cockle, prostrate knotweed, Russian thistle, and prickly lettuce or when dense vegetative growth occurs, use the 4.12 – 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology per acre.

Timings: Apply XtendiMax® With VaporGrip® Technology before, during, or after planting small grains. See specific small grain crop uses below for maximum crop stage. For best performance, apply

XtendiMax® With VaporGrip® Technology when weeds are in the 2 - 3 leaf stage and rosettes are less than 2" across. Applying XtendiMax® With VaporGrip® Technology to small grains during periods of rapid growth may result in crop leaning. This condition is temporary and will not reduce crop yields.

Restrictions for small grain areas that are grazed or cut for hay are indicated in **Table 3** in Pasture, Hay, Rangeland, and General Farmstead section of this label.

11.9.2 Small Grains: Barley (fall- and spring-seeded)

Early season applications:

Apply 2.75 – 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology to fall-seeded barley prior to the jointing stage. Apply 2.75 – 4.12 fluid ounces of XtendiMax® With VaporGrip® Technology before spring-seeded barley exceeds the 4-leaf stage.

Note: For spring barley varieties that are seeded during the winter months or later, follow the rates and timings given for spring-seeded barley.

Preharvest applications:

XtendiMax® With VaporGrip® Technology can be used to control weeds that may interfere with harvest of fall and spring-seeded barley. Apply 11 fluid ounces of XtendiMax® With VaporGrip® Technology per acre as a broadcast or spot treatment to annual broadleaf weeds when barley is in the hard dough stage and the green color is gone from the nodes (joints) of the stern. Best results will be obtained if application can be made when weeds are actively growing, but before weeds canopy.

Allow a minimum of 7 days between treatment and harvest. Do not use preharvest-treated barley for seed unless a germination test is performed on the seed with an acceptable result of 95% germination or better.

[Optional: Do not make preharvest applications in California.]

11.9.3 Small Grains: Oats (fall- and spring-seeded)

Early season applications:

Apply 2.75 – 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology per acre to fall-seeded oat prior to the jointing stage. Apply 2.75 – 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology before spring-seeded oat exceed the 5-leaf stage.

Do not tank mix XtendiMax® With VaporGrip® Technology with 2,4-D in oat.

Allow a minimum of 7 days between treatment and harvest.

11.9.4 Small Grains: Triticale (fall- and spring-seeded)

Early season applications:

Apply 2.75 – 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology to triticale.

Early season applications to fall-seeded triticale must be made prior to the jointing stage.

Early season applications to spring-seeded triticale must be made before triticale reaches the 6-leaf stage.

11.9.5 Small Grains: Wheat (fall- and spring-seeded)

Early Season Applications:

Apply 2.75 – 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology to wheat unless using one of the fall-seeded wheat specific programs below.

Early season applications to fall-seeded wheat must be made prior to the jointing stage.

Early season applications to spring-seeded wheat must be made before wheat exceeds the 6-leaf stage.

Early developing wheat varieties such as TAM 107, Madison, or Wakefield must receive application between early tillering and the jointing stage. Care should be taken in staging these varieties to be certain that the application occurs prior to the jointing stage.

Specific use programs for fall-seeded wheat only:

[Optional: XtendiMax® With VaporGrip® Technology may be used at 8.25 fluid ounces on fall-seeded wheat in Western Oregon as a spring application only.] In Colorado, Kansas, New Mexico, Oklahoma, and Texas, up to 11 fluid ounces of XtendiMax® With VaporGrip® Technology may be applied on fall-seeded wheat after it exceeds the 3-leaf stage for suppression of perennial weeds, such as field bindweed. Applications may be made in the fall following a frost but before a killing freeze.

Preharvest applications:

XtendiMax® With VaporGrip® Technology can be used to control weeds that may interfere with harvest of wheat. Apply 11 fluid ounces XtendiMax® With VaporGrip® Technology per acre as a broadcast or spot treatment to annual broadleaf weeds when wheat is in the hard dough stage and the green color is gone from the nodes (joints) of the stem. Best results will be obtained if application can be made when weeds are actively growing but before weeds canopy.

Allow a minimum of 7 days between treatment and harvest. Do not use preharvest-treated wheat for seed unless a germination test is performed on the seed with an acceptable result of 95% germination or better.

[Optional: Do not make preharvest applications in California.]

11.10 Sorghum

XtendiMax® With VaporGrip® Technology may be applied preplant, postemergence, or preharvest in sorghum to control many annual broadleaf weeds and to reduce competition from established perennial broadleaf weeds, as well as control their seedlings.

Do not graze or feed treated sorghum forage or silage prior to mature grain stage. If sorghum is grown for pasture or hay, refer to Pasture, Hay, Rangeland, and General Farmstead section of this label for specific grazing and feeding restrictions.

Do not apply XtendiMax® With VaporGrip® Technology to sorghum grown for seed production.

Preplant Application:

Up to 11 fluid ounces of XtendiMax® With VaporGrip® Technology may be applied per acre if applied at least 15 days before sorghum planting.

Postemergence Application:

Up to 11 fluid ounces of XtendiMax® With VaporGrip® Technology per acre may be applied after sorghum is in the spike stage (all sorghum emerged) but before sorghum is 15" tall. For best performance, apply XtendiMax® With VaporGrip® Technology when the sorghum crop is in the 3 - 5 leaf stage and weeds are small (less than 3" tall). Use drop pipes (drop nozzles) if sorghum is taller than 8".

Keep the spray off the sorghum leaves and out of the whorl to reduce the likelihood of crop injury and to improve spray coverage of weed foliage. Applying XtendiMax® With VaporGrip® Technology to sorghum during periods of rapid growth may result in temporary leaning of plants or rolling of leaves. These effects are usually outgrown within 10 - 14 days. Delay harvest until 30 days after a preharvest treatment.

Preharvest uses in Texas and Oklahoma only: Up to 11 fluid ounces of XtendiMax® With VaporGrip® Technology per acre may be applied for weed suppression any time after the sorghum has reached the soft dough stage. An agriculturally approved surfactant may be used to improve performance (read Section 8.0 for tank mixing instructions). Delay harvest until 30 days after a preharvest treatment.

Split Application:

XtendiMax® With VaporGrip® Technology may be applied in split applications: preplant followed by postemergence or preharvest; or postemergence followed by preharvest. Do not exceed 11 fluid ounces per acre, per application or a total of 22 ounces per acre, per season.

11.11 Soybean

For directions for use with crops with Xtend Technology see the "CROPS WITH XTEND TECHNOLOGY" section of this label.

Preplant Applications:

Apply 5.5 -22 fluid ounces of XtendiMax® With VaporGrip® Technology per acre to control emerged broadleaf weeds prior to planting soybeans. Do not exceed 22 fluid ounces of XtendiMax® With VaporGrip® Technology per acre in a spring application prior to planting soybeans.

Following application of XtendiMax® With VaporGrip® Technology and a minimum accumulation of 1" rainfall or overhead irrigation, allow a minimum of 14 days between treatment and planting for applications of 11 fluid ounces per acre or less, and allow a minimum of 28 days between treatment and planting for applications of 22 fluid ounces per acre. These plant back intervals must be observed prior to planting soybeans or crop injury may occur.

Do not make XtendiMax® With VaporGrip® Technology preplant applications to soybeans in geographic areas with average annual rainfall less than 25".

Preharvest Applications:

XtendiMax® With VaporGrip® Technology can be used to control many annual and perennial broadleaf weeds and control or suppress many biennial and perennial broadleaf weeds in soybean prior to harvest (refer to **Section 10**). Apply 11 - 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre as a broadcast or spot treatment to emerged and actively growing weeds after soybean pods have reached mature brown color and at least 75% leaf drop has occurred.

Do not harvest soybeans until 7 days after application.

Treatments may not kill weeds that develop from seed or underground plant parts, such as rhizomes or bulblets, after the effective period for XtendiMax® With VaporGrip® Technology. For seedling control, a follow-up program or other cultural practice could be instituted.

Do not use preharvest-treated soybean for seed unless a germination test is performed on the seed with an acceptable result of 95% germination or better.

Do not feed soybean fodder or hay following a preharvest application of XtendiMax® With VaporGrip® Technology.

[Optional: Do not make preharvest applications in California.]

11.12 Sugarcane

Apply XtendiMax® With VaporGrip® Technology for control of annual, biennial, or perennial broadleaf weeds listed in Section 11. Apply 11 - 33 fluid ounces of XtendiMax® With VaporGrip® Technology per acre for control of annual weeds, 22 - 44 fluid ounces for control of biennial weeds, and 44 fluid ounces for control or suppression of perennial weeds.

Use the higher level of listed rate ranges when treating dense vegetative growth.

A single retreatment may be made as needed, however, do not exceed a total of 88 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre during a growing season.

Timing: XtendiMax® With VaporGrip® Technology may be applied to sugarcane any time after weeds have emerged, but before the close-in stage of sugarcane. Applications of 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre made over the top of actively growing sugarcane may result in crop injury.

When possible, direct the spray beneath the sugarcane canopy to minimize the likelihood of crop injury. Using directed sprays will also help maximize the spray coverage of weed foliage.

Allow a minimum of 87 days between treatment and harvest.

11.13 Farmstead Turf (noncropland) and Sod Farms

Do not use on residential sites.

For use in general farmstead (noncropland) and sod farms, apply 4.12 – 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre to control or suppress growth of many annual, biennial, and some perennial broadleaf weeds commonly found in turf. XtendiMax® With VaporGrip® Technology will also suppress many other listed perennial broadleaf weeds and woody brush and vine species. Refer to Table 1 for rate recommendations based on targeted weed or brush species and growth stage.

Repeat treatments may be made as needed; however, do not exceed 44 fluid ounces of XtendiMax® With VaporGrip® Technology per acre, per growing season.

Apply 30 - 200 gallons of diluted spray per treated acre (3 - 17 quarts of water per 1,000 square feet), depending on density or height of weeds treated and on the type of equipment used.

To avoid injury to newly seeded grasses, delay application of XtendiMax® With VaporGrip® Technology until after the second mowing. Furthermore, applying more than 16 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre may cause noticeable stunting or discoloration of sensitive grass species such as bentgrass, carpetgrass, buffalograss, and St. Augustinegrass.

In areas where roots of sensitive plants extend, do not apply more than 5.5 fluid ounces of XtendiMax® With VaporGrip® Technology per treated acre on coarse-textured (sandy-type) soils, or in excess of 8 fluid ounces per treated acre on fine-textured soils. Do not make repeat applications in these areas for 30 days and until previous applications of XtendiMax® With VaporGrip® Technology have been activated in the soil by rain or irrigation.

12.0 CROPS WITH XTEND® TECHNOLOGY

COTTON WITH XTENDFLEX® TECHNOLOGY (INCLUDING BOLLGARD II® XTENDFLEX® COTTON, BOLLGARD® 3 XTENDFLEX® COTTON, OR XTENDFLEX® COTTON) AND ROUNDUP READY 2 XTEND® SOYBEAN CONTAIN A PATENTED GENE THAT PROVIDES TOLERANCE TO DICAMBA, THE ACTIVE INGREDIENT IN THIS PRODUCT. THIS PRODUCT WILL CAUSE SEVERE CROP INJURY OR DESTRUCTION AND YIELD LOSS IF APPLIED TO COTTON AND SOYBEAN THAT ARE NOT DICAMBA TOLERANT, INCLUDING COTTON AND SOYBEAN WITH A TRAIT ENGINEERED TO CONFER TOLERANCE TO AUXIN HERBICIDES OTHER THAN DICAMBA. FOLLOW THE REQUIREMENTS SET FORTH HEREIN TO PREVENT SEVERE CROP INJURY OR DESTRUCTION AND YIELD LOSS. CONTACT WITH FOLIAGE, GREEN STEMS, OR FRUIT OF CROPS, OR ANY

DESIRABLE PLANTS THAT DO NOT CONTAIN A DICAMBA TOLERANCE GENE OR ARE NOT NATURALLY TOLERANT TO DICAMBA, COULD RESULT IN SEVERE PLANT INJURY OR DESTRUCTION.

Information on cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean can be obtained from your seed supplier or Monsanto representative. Cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean must be purchased from an authorized licensed seed supplier.

Note: Cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean and methods of controlling weeds and applying dicamba in a Cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean crop are protected under U.S. patent law. No license to use Cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean is granted or implied with the purchase of this herbicide product. Cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean are owned by Monsanto and a license must be obtained from Monsanto before using it. Contact your Authorized Monsanto Retailer for information on obtaining a license to Cotton with XtendFlex® Technology and Roundup Ready 2 Xtend® Soybean.

12.1 Cotton with XtendFlex® Technology

DO NOT combine these instructions with other instructions in the “COTTON” Section of **this** label for use over crops that do not contain the dicamba tolerance trait.

TYPES OF APPLICATIONS: Burndown/Early Preplant; Preplant; At-Planting; Preemergence; Postemergence (In-crop)

USE INSTRUCTIONS
Apply this product in a minimum of 15 gallons of spray solution per acre as a broadcast application. For best performance, control weeds early when they are less than 4 inches. Timely application will improve control and reduce weed competition. Refer to the following table for maximum application rates of this product with cotton with XtendFlex® Technology.

Maximum Application Rates	
Combined total per year for all applications	88 fluid ounces per acre (2.0 lb. a.e. dicamba per acre)
Total of all Burndown/Early Preplant, Preplant, At-Planting, and Preemergence applications	44 fluid ounces per acre (1.0 lb. a.e. dicamba per acre)
Total of all In-crop applications from emergence up to 7 days pre-harvest	88 fluid ounces per acre (2.0 lb. a.e. dicamba per acre)
Maximum In-crop, single application	22 fluid ounces per acre (0.5 lb. a.e. dicamba per acre)

a.e. – acid equivalent

Refer to Table 1 for application rates for weed type and growth stage controlled by this product. Maximum in-crop application rate should be used when treating tough to control weeds, dense vegetative growth or weeds with a well-established root system.

Preplant, At-Planting, Preemergence
USE INSTRUCTIONS: This product may be used to control broadleaf weeds and may be applied before, during or immediately after planting cotton with XtendFlex® Technology. Refer to the "WEEDS CONTROLLED" section of this label for XtendiMax® With VaporGrip® Technology for specific weeds controlled.

RESTRICTIONS:

- The maximum combined quantity of this product that may be applied for all burndown/early preplant, preplant, at-planting, and preemergence applications is 44 fluid ounces (1.0 lb a.e. dicamba) per acre per season.
- The maximum application rate for a single, burndown/early preplant, preplant, at-planting, or preemergence application must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre.
- Do not apply less than 22 fluid ounces (0.5 lb a.e. dicamba) per acre.

Postemergence (In-crop)
USE INSTRUCTIONS: This product may be used to control broadleaf weeds in cotton with XtendFlex® Technology. In-crop applications of this product can be made from emergence up to 7 days prior to harvest. The maximum and minimum rate for any single, in-crop application is 22 fluid ounces (0.5 lb a.e. dicamba) per acre. Using the appropriate application rate may reduce the selection for resistant weeds. For best performance, control weeds early when they are less than 4 inches. To the extent permitted by applicable law, Monsanto Company does not warrant product performance of applications to labeled weeds greater than 4 inches in height. Sequential applications of this product may be necessary to control new flushes of weeds or on tough-to-control weeds. Allow at least 7 days between applications. A pre-harvest application of this product may be made up to 7 days before harvest.

Postemergence applications of this product mixed with adjuvants may cause a leaf response to cotton with XtendFlex® Technology. The symptoms usually appear as necrotic spots on fully expanded leaves. EC-based products that are tank mixed with products containing dicamba may increase the severity of the leaf damage.

RESTRICTIONS:

- The combined total applied from crop emergence up to 7 days prior to harvest must not exceed 88 fluid ounces (2.0 lb a.e. dicamba) per acre.

- The maximum single, in-crop application rate must not exceed 22 fluid ounces (0.5 lb a.e. dicamba).
- The combined total per year for all applications must not exceed 88 fluid ounces (2.0 lb a.e. dicamba) per acre. For example, if a preplant application of 44 fluid ounces (1.0 lb a.e. dicamba) per acre was made, then the combined total in-crop applications must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre.
- Allow at least 7 days between applications and allow at least 7 days between final application and harvest or feeding of cottonseed and cotton gin by-products.

12.2 Roundup Ready 2 Xtend® Soybean

DO NOT combine these instructions with other instructions in the "SOYBEAN" Section of **this** label for use over crops that do not contain the dicamba tolerance trait.

TYPES OF APPLICATIONS: Burndown/Early Preplant; Preplant; At-Planting; Preemergence; Postemergence (In-crop)

USE INSTRUCTIONS
Apply this product in a minimum of 15 gallons of spray solution per acre as a broadcast application. For best performance, control weeds early when they are less than 4 inches. Timely application will improve control and reduce weed competition. Refer to the following table for maximum application rates of this product with Roundup Ready 2 Xtend® Soybean.

Maximum Application Rates	
Combined total per year for all applications	88 fluid ounces per acre (2.0 lb. a.e. dicamba per acre)
Total of all Burndown/Early Preplant, Preplant, At-Planting, and Preemergence applications	44 fluid ounces per acre (1.0 lb. a.e. dicamba per acre)
Total of all In-crop applications from emergence up to and including beginning bloom (R1 stage soybeans)	44 fluid ounces per acre (1.0 lb. a.e. dicamba per acre)
Maximum In-crop, single application	22 fluid ounces per acre (0.5 lb. a.e. dicamba per acre)

a.e. – acid equivalent

Refer to Table 1 for application rates for weed type and growth stage controlled by this product. Maximum in-crop application rate should be used when treating tough to control weeds, dense vegetative growth or weeds with a well-established root system.

Preplant, At-Planting, Preemergence
USE INSTRUCTIONS: This product may be used to control broadleaf weeds and may be applied before, during or immediately after planting Roundup Ready 2 Xtend® Soybean. Refer to the "WEEDS CONTROLLED" section of this label for specific weeds controlled.

RESTRICTIONS:
- The maximum combined quantity of this product that may be applied for all burndown/early preplant, preplant, at-planting, and preemergence applications is 44 fluid ounces (1.0 lb a.e. dicamba) per acre per season.
- The maximum application rate for a single, burndown/early preplant, preplant, at-planting, or preemergence application must not exceed 44 fluid ounces (1.0 lb a.e. dicamba) per acre.
- Do not apply less than 22 fluid ounces (0.5 lb a.e. dicamba) per acre.

Postemergence (In-crop)
USE INSTRUCTIONS: This product may be used to control broadleaf weeds in Roundup Ready 2 Xtend® Soybean. In-crop applications of this product can be made from emergence (cracking) up to and including beginning bloom (R1 growth stage of soybeans). Do not make in-crop applications of this product after beginning bloom (R1 growth stage of soybeans). The maximum and minimum rate for any single, in-crop application is 22 fluid ounces (0.5 lb a.e. dicamba) per acre. Using the appropriate application rate may reduce the selection for resistant weeds. For best performance, control weeds early when they are less than 4 inches. To the extent permitted by applicable law, Monsanto Company does not warrant product performance of applications to labeled weeds greater than 4 inches in height.

A second application of this product up to the R1 crop growth stage may be necessary to control new flushes of weeds. Allow at least 7 days between applications. For best results, apply XtendiMax® With VaporGrip® Technology after some weed re-growth has occurred.

Application of this product postemergence and under stressful environments may cause temporary loss of turgor, a response commonly described as leaf droop in Roundup Ready 2 Xtend® Soybean. Typically, affected plants recover in 1-3 days depending on the level of droop and environmental conditions.

RESTRICTIONS:
- The combined total application rate from crop emergence up to and including R1 must not exceed 44 fluid ounces (1.0 lb. a.e. dicamba) per acre.
- Do not make in-crop applications of this product after beginning bloom (R1 growth stage of soybeans).
- The maximum single, in-crop application rate must not exceed 22 fluid ounces (0.5 lb. a.e. dicamba) per acre.The combined total per year for all applications must not exceed 88 fluid ounces (2.0 lb. a.e. dicamba) per acre.
- Allow at least 7 days between final application and harvest or feeding of soybean forage.
- Allow at least 14 days between final application and harvest or feeding of soybean hay.

13.0 WEEDS CONTROLLED

General Weed List, Including ALS-, Glyphosate, and Triazine-Resistant Biotypes

Annuals

Alkanet
Amaranth, Palmer, Powell, Spiny
Aster, Slender
Bedstraw, Catchweed
Beggarweed, Florida
Broomweed, Common
Buckwheat, Tartary, Wild
Buffalobur
Burclover, California
Burcucumber
Buttercup, Corn, Creeping, Roughseed, Western Field
Carpetweed
Catchfly, Nightflowering
Chamomile, Corn
Chevil, Bur
Chickweed, Common
Clovers
Cockle, Corn, Cow, White
Cocklebur, Common
Copperleaf, Hophornbeam
Cornflower (Bachelor Button)
Croton, Tropic, Woolly
Daisy, English
Dragonhead, American
Eveningprimrose, Cutleaf
Falseflax, Smallseed
Fleabane, Annual
Flixweed
Fumitory
Goosefoot, Nettleleaf
Hempnettle
Henbit
Jacobs-Ladder
Jimsonweed
Knawel (German Moss)
Knotweed, Prostrate
Kochia
Ladysthumb
Lambsquarters Common
Lettuce, Miners, Prickly
Mallow, Common, Venice
Marestail (Horseweed)
Mayweed
Morningglory, Ivyleaf, Tall
Mustard, Black, Blue, Tansy, Treacle, Tumble, Wild, Yellowtops
Nightshade, Black, Cutleaf
Pennycress, Field (Fanweed, Frenchweed, Stinkweed)
Pepperweed, Virginia (Peppergrass)

Pigweed, Prostrate, Redroot (Carelessweed), Rough, Smooth, Tumble
Pineappleweed
Poorjoe
Poppy, Red-horned
Puncturevine
Purslane, Common
Pusley, Florida
Radish, Wild
Ragweed, Common, Giant (Buffaloweed), Lance-Leaf
Rocket, London, Yellow
Rubberweed, Bitter (Bitterweed)
Salsify
Senna, Coffee
Sesbania, Hemp
Shepherdpurse
Sicklepod
Sida, Prickly (Teaweed)
Smartweed, Green, Pennsylvania
Sneezeweed, Bitter
Sowthistle, Annual, Spiny
Spanish Needles
Spikeweed, Common
Spurge, Prostrate, Leafy
Spurry, Corn
Starbur, Bristly
Starwort, Little
Sumpweed, Rough
Sunflower, Common (Wild), Volunteer
Thistle, Russian
Velvetleaf
Waterhemp, Common, Tall
Waterprimrose, Winged
Wormwood

Biennials

Burdock, Common
Carrot, Wild (Queen Anne's Lace)
Cockle, White
Eveningprimrose, Common
Geranium, Carolina
Gromwell
Knapweed, Diffuse, Spotted
Mallow, Dwarf
Plantain, Bracted
Ragwort, Tansy
Starthistle, Yellow
Sweetclover
Teasel
Thistle, Bull, Milk, Musk, Plumeless

Perennials

Alfalfa[1]
Artichoke, Jerusalem
Aster, Spiny, Whiteheath
Bedstraw, Smooth
Bindweed, Field, Hedge
Blueweed, Texas
Bursage, Woollyleaf[1] (Bur Ragweed, Povertyweed)
Buttercup, Tall
Campion, Bladder
Chickweed, Field, Mouseear
Chicory[1]
Clover[1], Hop
Dandelion[1], Common
Dock[1] Broadleaf (Bitterdock), Curly
Dogbane, Hemp
Dogfennel[1] (Cypressweed)
Fern, Bracken
Garlic, Wild
Goldenrod, Canada, Missouri
Goldenweed, Common
Hawkweed
Henbane, Black[1]
Horsenettle, Carolina
Ironweed
Knapweed, Black, Diffuse, Russian[1], Spotted
Milkweed, Climbing, Common, Honeyvine, Western Whorled
Nettle, Stinging
Nightshade, Silverleaf (White Horsenettle)
Onion, Wild
Plaintain, Broadleaf, Buckhorn
Pokeweed
Ragweed, Western
Redvine
Sericia Lespedeza
Smartweed, Swamp
Snakeweed, Broom
Sorrel[1], Red (Sheep Sorrel)
Sowthistle[1], Perennial
Spurge, Leafy
Sundrops
Thistle, Canada, Scotch
Toadflex, Dalmatian
Tropical Soda Apple
Trumpetcreeper (Buckvine)
Vetch
Waterhemlock, Spotted
Waterprimrose, Creeping
Woodsorrel[1], Creeping, Yellow
Wormwood, Absinth, Louisiana
Yankeeweed
Yarrow, Common[1]

[1] Noted perennials may be controlled using lower rates of **XtendiMax® With VaporGrip® Technology** than those recommended for other listed perennial weeds.

Woody Species

Alder
Ash
Aspen
Basswood
Beech
Birch
Blackberry[2]
Blackgum[2]
Cedar[2]
Cherry
Chinquapin
Cottonwood
Creosotebush[2]
Cucumbertree
Dewberry[2]
Dogwood[2]
Elm
Grape

Hawthorn (Thornapple)[2]	Mesquite	Sassafras
Hemlock	Oak	Serviceberry
Hickory	Oak, Poison	Spicebush
Honeylocust	Olive, Russian	Spruce
Honeysuckle	Persimmon, Eastern	Sumac
Hornbeam	Pine	Sweetgum[2]
Huckleberry	Plum, Sand (Wild Plum)[2]	Sycamore
Huisache	Poplar	Tarbush
Ivy, Poison	Rabbitbrush	Willow
Kudzu	Redcedar, Eastern[2]	Witchhazel
Locust, Black	Rose[2], McCartney, Multiflora	Yaupon[2]
Maple	Sagebrush, Fringed[2]	Yucca[2]

[2]Growth suppression only

14.0 LIMIT OF WARRANTY AND LIABILITY

Monsanto Company warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes set forth in the Complete Directions for Use label booklet ("Directions") when used in accordance with those Directions under the conditions described therein. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, NO OTHER EXPRESS WARRANTY OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE. This warranty is also subject to the conditions and limitations stated herein. Specifically, and without limiting the foregoing, MONSANTO MAKES NO RECOMMENDATION OR WARRANTY HEREIN REGARDING THE USE OF ANY PRODUCTS THAT MAY APPEAR ON THE WEBSITE REFERENCED IN THE TANK-MIXING INSTRUCTIONS HEREIN, REGARDLESS OF WHETHER SUCH PRODUCT IS USED ALONE OR IN A TANK MIX WITH XTENDIMAX® WITH VAPORGRIP® TECHNOLOGY. BUYER AND ALL USERS ARE SOLELY RESPONSIBLE FOR ANY LACK OF PERFORMANCE, LOSS, OR DAMAGE IN CONNECTION WITH THE USE OR HANDLING OF ANY SUCH PRODUCT ALONE OR IN A TANK MIX WITH XTENDIMAX® WITH VAPORGRIP® TECHNOLOGY.

Buyer and all users shall promptly notify this Company of any claims whether based in contract, negligence, strict liability, other tort or otherwise.

To the extent consistent with applicable law, buyer and all users are responsible for all loss or damage from use or handling which results from conditions beyond the control of this Company, including, but not limited to, incompatibility with products other than those set forth in the Directions, application to or contact with desirable vegetation, failure of this product to control weed biotypes which develop resistance to dicamba, unusual weather, weather conditions which are outside the range considered normal at the application site and for the time period when the product is applied, as well as weather conditions which are outside the application ranges set forth in the Directions, application in any manner not explicitly set forth in the Directions, moisture conditions outside the moisture range specified in the Directions, or the presence of products other than those set forth in the Directions in or on the soil, crop or treated vegetation.

This Company does not warrant any product reformulated or repackaged from this product except in accordance with this Company's stewardship requirements and with express written permission from this Company.

For in-crop (over-the-top) uses on crops with Xtend® Technology, crop safety and weed control performance are not warranted by Monsanto when this product is used in conjunction with "brown bag" or "bin run" seed saved from previous year's production and replanted.

TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE LIMIT OF THE LIABILITY OF THIS COMPANY OR ANY OTHER SELLER FOR ANY AND ALL LOSSES, INJURIES OR DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT (INCLUDING CLAIMS BASED IN CONTRACT, NEGLIGENCE, STRICT LIABILITY,

OTHER TORT OR OTHERWISE) SHALL BE THE PURCHASE PRICE PAID BY THE USER OR BUYER FOR THE QUANTITY OF THIS PRODUCT INVOLVED, OR, AT THE ELECTION OF THIS COMPANY OR ANY OTHER SELLER, THE REPLACEMENT OF SUCH QUANTITY, OR, IF NOT ACQUIRED BY PURCHASE, REPLACEMENT OF SUCH QUANTITY. TO THE EXTENT CONSISTENT WITH APPLICABLE LAW, IN NO EVENT SHALL THIS COMPANY OR ANY OTHER SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES.

Upon opening and using this product, buyer and all users are deemed to have accepted the terms of this LIMIT OF WARRANTY AND LIABILITY which may not be varied by any verbal or written agreement. If terms are not acceptable, return at once unopened.

Bollgard II®, Bollgard®, Degree Xtra®, Field Master®, Harness®, Roundup Ready®, Roundup Ready 2 Xtend®, Roundup PowerMAX®, RT 3®, Roundup WeatherMAX®, XtendiMax®, XtendFlex® and VaporGrip® are registered trademarks of Monsanto Technology LLC. All other trademarks are the property of their respective owners.

EPA Reg. No. 524-617

EPA Establishment No. [insert appropriate est. no.]

Lot number [insert appropriate lot number]

Net contents [insert net contents]

Packed for:
MONSANTO COMPANY
800 N. Lindbergh Blvd.
ST. LOUIS, MISSOURI, 63167 U.S.A.

From:	Philip.Perry@lw.com
To:	Knorr, Michele; Baris, Reuben; thomas.marvin@monsanto.com
Subject:	Response to Terms and Conditions Page1 - EPA comments (3).docx
Date:	Tuesday, October 10, 2017 4:59:36 PM
Attachments:	Response to Terms and Conditions Page1 - EPA comments (3).docx

Michele and Reuben:

Attached please find our response on the terms and conditions. We are providing a clean copy because the redline was difficult to follow. We accepted a number of the proposed changes, but did not incorporate all the iterative communications with retailers proposed in the last draft. In particular, we are concerned that those iterative communications might require a potentially significant period of time to complete. Instead, we believe the better course is to move quickly, with a clear letter explaining the fundamental points of the plan to retailers – specifically including instructions that unregistered retailers cannot sticker the products, and must either register with EPA or contact Monsanto immediately (so that Monsanto can reclaim the product). This should mitigate concerns that unregistered establishments might engage in unauthorized stickering themselves. We are currently working on that letter and hope to supply it to you soon.

Latham & Watkins LLP

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1. Stickering, new paper label (*i.e.* supplemental labeling to accompany the product):

    - Sticker – Sticker that was submitted to EPA for approval contains the following information:
        - "Restricted Use Pesticide" ;
        - "Product cannot be used if user does not possess new label(ing) that can be found at www.xtendimaxapplicationrequirements.com; and
        - "User must comply in all respects with new label(ing), regardless of any contrary language on existing label."
    - In addition to the new label being available on the website listed above, paper labels will be provided to accompany stickered products.

2. Registrant will take all reasonable steps to:

    - As soon as new glossy labeling (booklets) become available, affix the new label to XtendiMax products at the time of manufacture in registered facilities;
    - Notify EPA, within one week of the booklet becoming available, of the date the booklet became available. All product manufactured after the booklet is available must contain the new glossy label;
    - For other XtendiMax products – whether in retail inventories, in the distribution chain, or for which manufacturing will occur before new glossy label booklets become available – produce and distribute sufficient quantities of stickers and new paper labels to update product;
    - Inform retailers of the need to sticker and supply new paper labels for products currently in inventory and products received with the former label;
    - Provide specific instructions to the retailers that are registered establishments on how to affix the sticker on the label as well as that the supplemental label be provided at time of purchase;
    - Inform retailers that are not yet EPA registered establishments that stickering can only occur in an EPA registered establishment; inform retailers of the process for establishment registration and reporting;
    - Inform retailers who do not intend to become registered establishments to contact Monsanto immediately, so that Monsanto can reclaim the retailer inventory and provide replacement product with labeling updated in a registered establishment. Communicate that retailers should not sell product until stickering is appropriately conducted;
    - Provide a copy to EPA of the communications used to inform retailers and others as described above.
    - Provide access to new label through an internet webpage located at www.xtendimaxapplicationrequirements.com.

From:	Baris, Reuben
To:	"MARVIN, THOMAS [AG/1920]"
Subject:	terms and conditions (comments)
Date:	Tuesday, October 10, 2017 6:45:00 PM
Attachments:	Response to Terms and Conditions Page1 - Monsanto revisions - EPA comments 10-11-17.docx

As promised. Please share with Phil.

REUBEN BARIS | ACTING CHIEF | HERBICIDE BRANCH
U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF PESTICIDE PROGRAMS | (703) 305-7356

1. Stickering, new paper label (*i.e.* supplemental labeling to accompany the product):

- Sticker – Sticker that was submitted to EPA for approval contains the following information:
  - "Restricted Use Pesticide"-;
  - "Product cannot be used if user does not possess new label(ing) that can be found at www.xtendimaxapplicationrequirements.com; and
  - "User must comply in all respects with new label(ing), regardless of any contrary language on existing label."
- In addition to the new label being available on the website listed above, paper labels will be provided to accompany stickered products.

2. Registrant will take all reasonable steps to:

- As soon as new glossy labeling (booklets) become available, affix the new label to XtendiMax products at the time of manufacture in registered facilities;
- Notify EPA, within one week of the booklet becoming available, of the date the booklet became available. All product manufactured after the booklet is available must contain the new glossy label;
- For other XtendiMax products – whether in retail inventories, in the distribution chain, or for which manufacturing will occur before new glossy label booklets become available – produce and distribute sufficient quantities of stickers and new paper labels to update product (recognizing that stickering must occur in a registered establishment);
- ~~Inform retailers of the need to sticker and supply new paper labels for products currently in inventory and products received with the former label;~~
- Inform retailers of the need to sticker and supply new labels for products currently in inventory and products received with the former label as well as ~~…Provide~~ provide specific instructions to the retailers that are registered establishments on how to affix the sticker on the label and provide the ~~as well as that the~~ supplemental label ~~be provided~~ at time of purchase;
- Inform retailers that are not yet EPA registered establishments about the importance of stickering the products currently in their inventory and products received with the former label ~~in their possession and~~ and that stickering and providing the new labels can only occur in an EPA registered establishments; inform retailers of the process for establishment registration and reporting; communicate that retailers should not sell product until stickering is appropriately conducted.
- Inform retailers who do not intend to become registered establishments the importance of -the new labeling and ~~stickering product in their possession and~~ to contact Monsanto immediately, so that Monsanto can reclaim the retailer inventory and provide replacement product with labeling updated in a registered

Commented [A1]: Deleted this bullet and incorporated it into the following bullets

Commented [A2]: Copied the language from the next bullet to help address the issue of not wanting unregistered establishments to sell older labeled products establishment. Communicate that retailers should not sell product until stickering is appropriately conducted;

- Provide a copy to EPA of the communications used to inform retailers and others as described above.
- Provide access to new label through an internet webpage located at www xtendimaxapplicationrequirements.com.

From:	Philip.Perry@lw.com
To:	Knorr, Michele; Baris, Reuben
Cc:	thomas.marvin@monsanto.com
Subject:	Implementation Terms and Conditions
Date:	Monday, October 09, 2017 4:01:07 PM
Attachments:	Response to Terms and Conditions Page1.docx

Michele:

Attached are our thoughts regarding the implementation terms and conditions. You can reach me in the office today at 202-637-2244, and tonight on my cell. Thanks again.

---

1. What will be done for product currently in retail inventories, in the distribution chain (package released for shipment), and product that will be manufactured before new glossy label booklets are available:
    - Sticker – Sticker will contain the following information:
        - Restricted Use requirements;
        - "Product cannot be used if user does not possess new (substitute) label(ing)";
        - How/where to get new (substitute) label(ing); and
        - "User must comply in all respects with new (substitute) label(ing), regardless of any contrary language on existing label."
    - New paper label will be provided to accompany each stickered product.

2. Registrant will:
    - As soon as new glossy label booklets become available, apply the new label to XtendiMax products at the time of manufacture in Monsanto registered facilities;
    - For other XtendiMax products – whether in retail inventories, in the distribution chain, or for which manufacturing will occur before new glossy label booklets become available – produce and distribute sufficient quantities of stickers and new paper labels to update product;
    - Inform retailers of the need to sticker and supply new paper labels for products currently in inventory and products received with the former label;
    - For those retail establishments who are not yet EPA registered establishments, inform those retailers that stickering can only occur in an EPA registered facility and inform retailers of the process for registration and reporting;
    - Inform retailers that in the event that any retailer is not registered and does not intend to register before stickering would occur, Monsanto will reclaim the retailer inventory and appropriately update labeling in a registered establishment; and
    - Provide access to new label through an internet webpage.

3. Consequences of noncompliance with Paragraph 2

    If Registrant does not fulfill any of its obligations under paragraph 2, Registrant will be subject to the procedures set forth at 7 U.S.C. § 136d and 40 C.F.R. Part 164.

From: Baris, Reuben
To: "MARVIN, THOMAS [AG/1920]"
Cc: Kenny, Daniel
Subject: draft
Date: Thursday, October 05, 2017 6:33:00 PM
Attachments: dicamba proposed registration conditions - deliberative.docx

1. What will be done
    - Sticker or label - will the existing label be totally covered by a sticker or a new label, or is the old label going to be visible when product is sold?
    - If sticker but no complete new label – what will sticker say? We recommend the following:
        - Restricted Use requirements;
        - "Product cannot be used if user does not possess new (substitute) label(ing)";
        - How/where to get new (substitute) label(ing); and
        - "User must comply in all respects with new (substitute) label(ing), [regardless of any contrary language on existing label]."

2. Registrant will:
    - Produce and distribute sufficient quantities of stickers;
    - Assure that stickering takes place in a registered establishment and complies with any other relevant requirements under FIFRA and its implementing regulations;
    - If retailers are handing out new (substitute) label(ing), assure that retailers have sufficient quantities of new (substitute) label(ing) and that retailers hand it out to purchasers;
    - If retailers are handing out new (substitute) label(ing), the retailers must be registered establishments.
    - Assure that users can get new (substitute) label(ing) through an internet webpage; and
    - Assure that users have products (purchased after a certain date) that are appropriately stickered and that users have the new substitute labeling in their possession.

3. Consequences of noncompliance with Paragraph 2
    - If Registrant does not fulfill any of its obligations under paragraph 2, EPA may cancel the registration by order without a formal hearing subject to procedures in paragraph 4.

4. Procedure for cancellation because of noncompliance with Paragraph 2
    a. Intent to Cancel - If EPA determines that Registrant has failed to comply in any respect with an obligation under Paragraph 2, EPA may notify Registrant in writing (which can be done via email) of EPA's determination that Registrant has failed to comply with a requirement of Paragraph 2 and that EPA intends to cancel the registration by order without hearing under this Paragraph. The notice to Registrant will include a description of the noncompliance warranting cancellation.
    b. Right to be heard – Registrant may respond to any notice under subparagraph (a) in writing (which can be done via email) no later than [10][14][21] days after first receipt of the notice and challenge the factual determination of noncompliance

and/or the appropriate consequence of the noncompliance. If Registrant does not respond in the required time frame, EPA may issue a cancellation order as described in subparagraph e.

c. EPA will respond to Registrant's response under subparagraph (b) in writing (which can be done via email) and determine whether Registrant failed to comply in any respect with an obligation under Paragraph 2 and, if so, whether cancellation is appropriate.

d. If Registrant is dissatisfied with EPA's response under subparagraph (c), Registrant may request a meeting with the Director of OPP to appeal the decision to cancel the registration under this Paragraph. Any such request for a meeting must be in writing (which can be done via email) and must be received by the Director of OPP no later than [7][10][14] days after the Registrant receives EPA's response under subparagraph (c). The Director will agree to be available for a meeting which must occur at a mutually agreeable time and date, but no later than [14][21] days after the Director receives the request for a meeting. If Registrant does not request a meeting with the Director of OPP within the time period set forth in subparagraph (d), EPA may issue a cancellation order as described in subparagraph e.

e. After any meeting under subparagraph (d), or if Registrant does not agree to a meeting within [14][21] days after the Director receives the request for a meeting, the Director may issue a final written determination of whether Registrant has failed to comply with a requirement of Paragraph 2 and if so, if the Director determines that cancellation is appropriate. If the Director determines cancellation is appropriate, he may cancel the registration by order without hearing. Any such cancellation shall be in writing and shall include a cancellation order, which shall include an explanation of the basis for cancellation, the effective date of cancellation, and provisions governing the sale, distribution, and use of existing stocks. The Director's determination and cancellation order shall be provided to the Registrant both electronically and by mail, and shall be deemed a final agency action for purpose of judicial review.

From:	Green, Jamie
To:	Overstreet, Anne; Baris, Reuben
Cc:	Frizzell, Damon
Subject:	Dicamba Control
Date:	Wednesday, September 27, 2017 8:19:24 AM
Attachments:	Scanned from a Xerox multifunction device.pdf

Hello Anne and Reuben -

I wanted to touch base with you regarding the attached control we received yesterday. We received it yesterday and it has a due date of Monday. It is from a gentleman in NE concerned because all of his seed customers are telling him they will no longer buy seed beans from him because of this year's damage from dicamba. In his letter to the administrator, he includes a couple of recommendations.

I am guessing you guys have gotten a number of these. Do you have any responses you have prepared previously that we could use? I also wasn't sure if we should be responding or if the response should come from OPP.

assigned to TOPE
due 10/2/17

Bowman, Janet

From: cmsadmin@epa.gov
Sent: Tuesday, September 26, 2017 12:00 PM
To: Robichaud, Jeffery; Bowman, Janet
Subject: CMS New Assignment - Dana Peters - AX-17-001-3181

Control AX-17-001-3181 has been assigned to your office on 9/26/17 12:59 PM by Dana Peters. Please go to the CMS webpage to view the details of the control.

Summary Information -
Control Number: AX-17-001-3181
Control Subject: Concern- Roundup Ready Xtend soybean Offering two solutions
From: Rob Robinson, Rob Robinson

Note: This Email was automatically generated. Please do not attempt to respond to it. You can access this control at https://cms.epa.gov/cms. Questions or comments concerning CMS should be directed to CMS Support at 202-564-4985 or CMS Information@epa.gov.

9/26/2017 - Jamie G. contacting OPP

ROB-SEE-CO

PO Box 129 | Waterloo, NE 68069 | toll free: 855-450-1822 | www.robseeco.com

September 14, 2017

Environmental Protection Agency
Scott Pruitt, Administrator
1101A
1200 Pennsylvania AVE N.W.
Washington, DC 20460

Dear Scott Pruitt,

My name is Edward Robinson and I am the CEO of a family owned seed company called Rob-See-Co. My company sells soybean seed throughout the Midwest. I am writing you to express my deep concern over Roundup Ready Xtend soybeans. My concern is twofold. First, the amount of damage I am hearing about from my soybean seed customers and sales force is alarming. Even more alarming is the number of my customers who have told me they will plant all Xtend varieties, instead of my seed, as a defensive measure against damage from neighbors who will use Xtend varieties and spray the approved dicamba products.

I do not sell Xtend varieties and do not plan to sell them. While I understand the necessity for better weed control options, I believe the unavoidable collateral damage from on-label use of Engenia and Xtendimax is unacceptable. As a result of not selling Xtend varieties, I will lose substantial sales, not due to the fact that my varieties aren't preferred by my customers, but due to the fact that my customers do not want to sue their neighbors over dicamba drift or volatility damage to their soybean fields. I find this issue incredibly anticompetitive, and something that should be considered when reviewing continued Xtendimax and Engenia label approval. As more growers use the Xtend system to control weeds, more growers with adjacent land will be forced to plant Xtend varieties to avoid injury in their fields. This will create a barrier for other weed control options to enter the market and limit grower choice.

I see two potential solutions. First is a dramatic increase in the field borders that cannot be sprayed with the approved dicamba products. I have no research to gauge the size of the borders and wonder if this approach will be effective in avoiding drift or volatility damage in neighboring fields, as damage this year seemed to spread beyond what a practical border would prevent. The other alternative is to restrict the use of the approved dicamba products to preplant only. This will ensure no damage will occur.

Thank you for your consideration of my deep concerns. I have listed my contact information below should you have any questions of me.

Sincerely,

Rob Robinson

Rob Robinson
CEO and Owner, Rob-See-Co
rrobinson@robseeco.com
402-206-6546

RE
2017 SEP 21 AM 10: 23
OFFICE OF THE
EXECUTIVE SECRETARIAT

Innotech seed is distributed by Rob-See-Co

ROB-SEE-CO

PO Box 129 | Waterloo, NE 68069 | toll free 855-450-1822

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SEP 21 2017

FCL 2077828

Environmental Protection Agency
Scott Pruitt, Administrator
1101A
1200 Pennsylvania AVE N.W.
Washington, DC 20460

Correspondence Management System
Control Number: AX-17-001-3181
Printing Date: September 26, 2017 01:21:32

CMS

Citizen Information

Citizen/Originator: **Robinson, Rob**
Organization: Rob-See-Company
Address: PO 6ox 129, Waterloo, NE 68069

Constituent: N/A
Committee: N/A **Sub-Committee:** N/A

Control Information

Control Number:	AX-17-001-3181	**Alternate Number:**	N/A
Status:	Pending	**Closed Date:**	N/A
Due Date:	Oct 5, 2017	**# of Extensions:**	0
Letter Date:	Sep 14, 2017	**Received Date:**	Sep 21, 2017
Addressee:	AD-Administrator	**Addressee Org:**	EPA
Contact Type:	LTR (Letter)	**Priority Code:**	Normal
Signature:	DX-Direct Reply	**Signature Date:**	N/A

File Code: 403_255_04_0572_a(2) General awards correspondence for awards from other federal agencies or non-federal organizations
Subject: Concern- Roundup Ready Xtend soybean Offering two solutions
Instructions: DX-Respond directly to this citizen's questions, statements, or concerns
Instruction Note: N/A
General Notes: N/A
CC: OCSPP - OCSPP - Immediate Office
ORD - Office of Research and Development -- Immediate Office

Lead Information

Lead Author: N/A

Lead Assignments:

Assigner	Office	Assignee	Assigned Date	Due Date	Complete Date
Brenda Salvador	OEX	R7	Sep 21, 2017	Oct 5, 2017	N/A
	Instruction: DX-Respond directly to this citizen's questions, statements, or concerns				
Dana Peters	R7	R7-WWPD	Sep 26, 2017	Oct 3, 2017	N/A
	Instruction: DX-Respond directly to this citizen's questions, statements, or concerns				

Supporting Information

Supporting Author: N/A

Supporting Assignments:

Assigner	Office	Assignee	Assigned Date
No Record Found.			

History

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Control Number: AX-17-001-3181
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Action By	Office	Action	Date
Brenda Salvador	OEX	Control Created	Sep 21, 2017
Brenda Salvador	OEX	Assign R7 as lead office	Sep 21, 2017
Dana Peters	R7	Accepted the group assignment	Sep 26, 2017
Dana Peters	R7	Assign R7-WWPD as lead office	Sep 26, 2017

Comments

Commentator	Comment	Date
	No Record Found.	

From: Green, Jamie
To: Baris, Reuben; Kenny, Daniel; Lott, Don; Vizard, Elizabeth; Wormell, Lance
Subject: FW: Shared with you: Paul.Bailey@mda.mo.gov
Date: Wednesday, September 27, 2017 11:32:49 AM

MDA requested I pass this information along.

From: webmaster [mailto:webmaster@deltafarmpress.com]
Sent: Wednesday, September 27, 2017 8:39 AM
To: Green, Jamie <Green.Jamie@epa.gov>
Subject: Shared with you: Paul.Bailey@mda.mo.gov

Shared with you by MO Dept of Ag - Pesticide Control.

Jamie:

Might dicamba be affecting pollinators?

Beekeepers among those claiming problems with dicamba-tolerant crops

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Might dicamba be affecting pollinators?

Beekeepers among those claiming problems with dicamba-tolerant crops

David Bennett | Sep 26, 2017

Since Xtend crops have been planted in the Mid-South, the focus of off-target damage from dicamba has largely been on soybeans. But what about some of the damage to more peripheral, but no less vital, players in the agricultural chain?

Before getting to that, it's important to know that Richard Coy isn't a man afraid to take a stand for his farming partners. Coy, Vice President of Coy's Honey Farm, manages some 13,000 bee hives scattered throughout Arkansas, Mississippi, Missouri, and California. The family honey business is the largest in Arkansas.

"I know what it means to operate a 'family business' and I know the pressures of operating a large-scale farm," Coy recently testified before the Arkansas Dicamba Task Force. "During my 26 years as a commercial beekeeper, I have developed and maintained good relationships with many of the agriculture industry leaders in Arkansas and throughout the nation. Within the past two years, I have written letters on behalf of cotton, and grain sorghum producers requesting Section 18's for Transform. I recently met with EPA officials in Memphis, Tenn., and voiced my support for neonics as a seed treatment. Also, I have worked closely with the University of Arkansas Division of Agriculture Research and Extension along with various aspects of the USDA."

Dicamba and bees

Coy says he first began noticing issues with increased dicamba use and its relationship with his hives in 2016.

"I was finally able to pinpoint it this year. But I began noticing the problem last year when my production was off in the area around (northeast Arkansas') Monette and Leachville. That's where the major controversy and shooting over dicamba took place in 2016."

He didn't know what the problem was and assumed it was weather-related or maybe involved an insecticide.

In 2017, "just like the past 10 years, we placed bees on our locations in Mississippi and Crittenden Counties. Production in these counties this year has been dramatically reduced.

"We began noticing lower than normal bee population the last week of June. The hives stopped building population and we could not understand what the problem might be. We looked at all of our management practices and found nothing out of the ordinary."

In retrospect, Coy says what happened was pollen had stopped coming into the beehives. "Pollen is the protein source for the hive. Without it, the queen will not lay eggs because there's no protein to feed the larvae. That has a tipping effect that negatively impacts honey production."

It takes 21 days for eggs to mature into adult bees. Therefore, "you don't really notice what's going on for a few weeks. There's a lag time and so it was deep into July before we knew there was a major problem. Another reason it took so long to get a grip on this is we have about 13,000 hives and we run them about every three weeks."

So, from middle to late July the Coys knew there was "a major problem. The hive-check rotation takes about three weeks since the hives are scattered all over the Delta. My younger brother, David, and I began going to different areas and really looking closely at the hives. We determined in areas without dicamba drift our honey production had not decreased. We dug deep into the hives and found we had a lot of pollen available in non-dicamba use areas and very little, to no, pollen stored where there were dicamba-tolerant crops."

Research

Even without dicamba-tolerant crops, how would Coy describe this year for making honey?

"This year, the weather has been conducive for an average crop. We had too much rain in August to have an above-average crop.

"However, there are hives set up where apparently little dicamba was used because there are pigweeds in the fields and the vines also show no damage. The hives in those areas have average to above average production.

“When you’re trying to put together the pieces of a puzzle together it can take a while.”

Around the last week of July, Richard and his brother “went to check our bee locations around Webb and Tutwiler, Miss. We run about 1,600 (hives) in that area. Chris said ‘We have some locations that have filled every box full. But, I have found an area where they haven’t made any honey since the first of July.’ He checked into it, and sure enough, where the honey production had stopped was also where the farmers had planted (dicamba-tolerant) soybeans.”

That spurred Richard to do some more research to “see if I was reading too much into the situation. Well, I found a study from Penn State University that shows where there is widespread dicamba use in an area there would be enough visible drift and volatility to damage all the vegetation. The study found it would decrease pollinator habitat by 50 percent and pollinator visits by 50 percent.”

At that point, in late July, Coy called the Arkansas Plant Board and explained what he’d found and had been seeing. “They sent out some inspectors a couple of weeks later and they took some pictures of the vegetation. They verified what I was seeing.”

Symptomology

What was Coy observing?

“In fencerows and ditches, vegetation like wild grape, red vine and even ragweed were damaged. All that unwanted vegetation for farming is something that bees use to make honey. Those plants had curled leaves and had stopped growing prior to the blooming process.

“I went south of I-40 to an area I know there hadn’t been a lot of dicamba sprayed. There was a bunch of the (aforementioned) plants that were growing and blooming and the bees had produced a tremendous honey crop.”

What are other beekeepers saying?

"I've spoken with others in this region and they'd been seeing the same symptoms in their hives where there are dicamba-tolerant crops and drift complaints are the highest. Healthy hives had stopped collecting nectar and pollen and the population hadn't grown enough to produce a good honey crop."

Cut-off date

What about the April 15 dicamba-spraying cutoff date urged by the task force?

"I think it's a good idea. If you look at all the data put out by university weed scientists it looks like there isn't an issue with dicamba and volatility until temperatures get hotter. Most of the vegetation our bees rely on isn't really up and going by mid-April. For example, red vine doesn't start putting on leaves until sometime in May.

"I think beekeepers would be happy to live with an April 15 cut-off."

Source URL: http://www.deltafarmpress.com/soybeans/might-dicamba-be-affecting-pollinators

From: Green, Jamie
To: Baris, Reuben; Kenny, Daniel; Lott, Don; Vizard, Elizabeth; Wormell, Lance
Subject: FW: Many U.S. scientists to skip Monsanto summit on dicamba | Business | stltoday.com
Date: Wednesday, September 27, 2017 11:37:43 AM

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-----Original Message-----
From: Bailey, Paul [mailto:Paul.Bailey@mda.mo.gov]
Sent: Wednesday, September 27, 2017 8:54 AM
To: Green, Jamie <Green.Jamie@epa.gov>
Subject: FW: Many U.S. scientists to skip Monsanto summit on dicamba | Business | stltoday.com

FYI

Paul Bailey
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-----Original Message-----
From: Klenklen, Chris
Sent: Wednesday, September 27, 2017 6:59 AM
To: Chinn, Chris - Director <directorcc@mda.mo.gov>; Hawkins, Garrett <Garrett.Hawkins@mda.mo.gov>; Bailey, Paul <Paul.Bailey@mda mo.gov>; Alsager, Sarah <Sarah.Alsager@mda.mo.gov>
Subject: Many U.S. scientists to skip Monsanto summit on dicamba | Business | stltoday.com

http://www.stltoday.com/business/local/many-u-s-scientists-to-skip-monsanto-summit-on-dicamba/article_1551d53e-57b6-5d90-904e-80153fd7e6dc.html

Sent from Chris Klenklen's mobile

From: Sorokin, Nicholas
To: AO OPA OMR CLIPS
Subject: Reuters: U.S. scientists to skip Monsanto summit on controversial weed killer, 9/27/17
Date: Wednesday, September 27, 2017 9:46:22 AM

Reuters
http://www.reuters.com/article/us-usa-pesticides-monsanto/u-s-scientists-to-skip-monsanto-summit-on-controversial-weed-killer-idUSKCN1C13CK
U.S. scientists to skip Monsanto summit on controversial weed killer
By Tom Polansek, 9/26/17

CHICAGO (Reuters) - Monsanto Co invited dozens of weed scientists to a summit this week to win backing for a controversial herbicide but many have declined, threatening the company's efforts to convince regulators the product is safe to use.

Monsanto faces a barrage of lawsuits over its dicamba herbicide and risks of tighter restrictions on its use, after the chemical drifted away from where it was sprayed this summer and damaged nearby crops unable to tolerate it.

Arkansas and Missouri suffered the most complaints of U.S. states with damage linked to dicamba. Weed scientists from the two states declined to attend the summit on concerns about Monsanto's response to the incident.

The company plans to present data at the summit that it says show user error was behind the damage, contrary to academics' findings that dicamba products can vaporize and move off target under certain conditions in a process known as volatilization.

Missing will be Kevin Bradley, a University of Missouri plant sciences professor who has tracked the number of crop acres nationwide that have been hurt by dicamba sprayings. Bradley said he believed Monsanto was not willing to discuss volatilization.

"I think it's best for me to stay away from that," he said.

To prevent damage next year, states and the U.S. Environmental Protection Agency (EPA) are considering new rules for usage, decisions to be based partly on advice from university weed scientists invited to the meeting, whether they attend or not.

Tighter restrictions could hurt sales of the herbicide or of Monsanto soybean seeds engineered to resist the chemical, the company's biggest ever biotech seed launch.

Arkansas on Thursday moved just one step away from barring sprayings of dicamba next summer, setting the stage for a potential legal showdown with Monsanto.

Time is now of the essence as farmers start to make planting decisions for next spring.

The EPA has held calls with university weed experts to discuss potential regulations.

BASF SE, which also sells a dicamba-based weed killer, has invited scientists to its own meeting on the herbicide. The American Soybean Association, which represents farmers, is convening a meeting, too.

Monsanto's summit, to be held near the company's headquarters in St. Louis, will be the largest meeting so far on dicamba, said Scott Partridge, the company's vice president of global strategy. At least half of about 60 invitees will attend and hear presentations from Monsanto and outside experts, he said.

Reuters contacted 10 scientists who were invited. Of these, three said they would attend and seven said they would not, for reasons including scheduling conflicts.

"We want them to challenge us and we intend to challenge those who are presenting data," Partridge said.

INTEGRITY QUESTIONED

Monsanto recently upset U.S. weed scientists by questioning the objectivity of two Arkansas experts, Jason Norsworthy and Ford Baldwin, who said dicamba had problems with volatilization. The specialists could be biased against the chemical because they were affiliated with Bayer AG, which sells a competing system to control weeds in soybeans, according to Monsanto.

Norsworthy, a University of Arkansas professor, has declined an invitation to speak about volatilization at Monsanto's meeting, according to the university. Last year, the EPA cited his research on the best way to use dicamba when the agency approved the use of the chemical on crops that can resist it.

Two other University of Arkansas experts, Tom Barber and Bob Scott, will also not attend.

"With Monsanto questioning of the integrity of our science, we felt it was best not to participate," university spokeswoman Mary Hightower said.

Monsanto highlighted connections Norsworthy and Baldwin had to Bayer to ensure that Arkansas fairly reviewed dicamba, Partridge said.

In July, Arkansas banned dicamba use for 120 days.

MONSANTO MONOLOGUE?

Monsanto's critiques of experts follows past accusations by farmers and activists that the company improperly influenced science.

In March, farmers and others suing Monsanto claimed in court filings that Monsanto employees ghostwrote scientific reports that U.S. regulators relied on to determine that glyphosate, a chemical in its Roundup weed killer, did not cause cancer.

In 2015, the New York Times reported U.S. academics who received grants from Monsanto were used in lobbying and corporate public relations campaigns to defend the safety of genetically engineered food.

Monsanto will cover travel costs for academics who attend this week's meeting, as is customary for the company, spokeswoman Charla Lord said.

Among those attending will be University of Tennessee weed scientist Tom Mueller, who told Reuters he planned to pay his own way and was skeptical Monsanto would engage in discussions.

"I think it's just going to be a monologue," he said.

Mueller said U.S. weed scientists had discussed skipping the meeting because they were upset Monsanto had criticized the Arkansas scientists.

"There's some pretty strong sentiment that some states won't send anybody," he said. Reuters did not confirm that any states would have no representatives at the meeting.

___
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From:	Baris, Reuben
To:	Becker, Jonathan; Chism, William
Subject:	FW: yield data
Date:	Tuesday, September 26, 2017 10:01:00 AM
Attachments:	solomon and bradley - auxins on soy.pdf soybean response to growth regulators u of Ill.pdf meta analysis of 2,4-D and dicamba drift.pdf Farrell Poster WSSA 2017.pdf Brown 2009 Crop-Protection.pdf Dicamba on soybean.pdf dicambainjurytosoybean1989agronomy journal.pdf quantification of volatility texas aandm.pdf quantifying injury texas a and m.pdf soybean yield and dicamba.pdf

REUBEN BARIS | ACTING CHIEF | HERBICIDE BRANCH
U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF PESTICIDE PROGRAMS | (703) 305-7356

From: Baris, Reuben
Sent: Thursday, September 14, 2017 9:31 AM
To: Chism, William <Chism.Bill@epa.gov>; Becker, Jonathan <becker.jonathan@epa.gov>
Cc: Kenny, Daniel <Kenny.Dan@epa.gov>; Rosenblatt, Daniel <Rosenblatt.Dan@epa.gov>; Rowland, Grant <Rowland.Grant@epa.gov>; Meadows, Sarah <Meadows.Sarah@epa.gov>; Montague, Kathryn V. <Montague.Kathryn@epa.gov>; Keigwin, Richard <Keigwin.Richard@epa.gov>; Goodis, Michael <Goodis.Michael@epa.gov>; Pease, Anita <Pease.Anita@epa.gov>
Subject: FW: yield data

Some Journal articles on yield impact resulting from dicamba exposures. A few distilled slides from Kevin Bradley that he "uses to share with his growers" and is not meant to be an expert view.

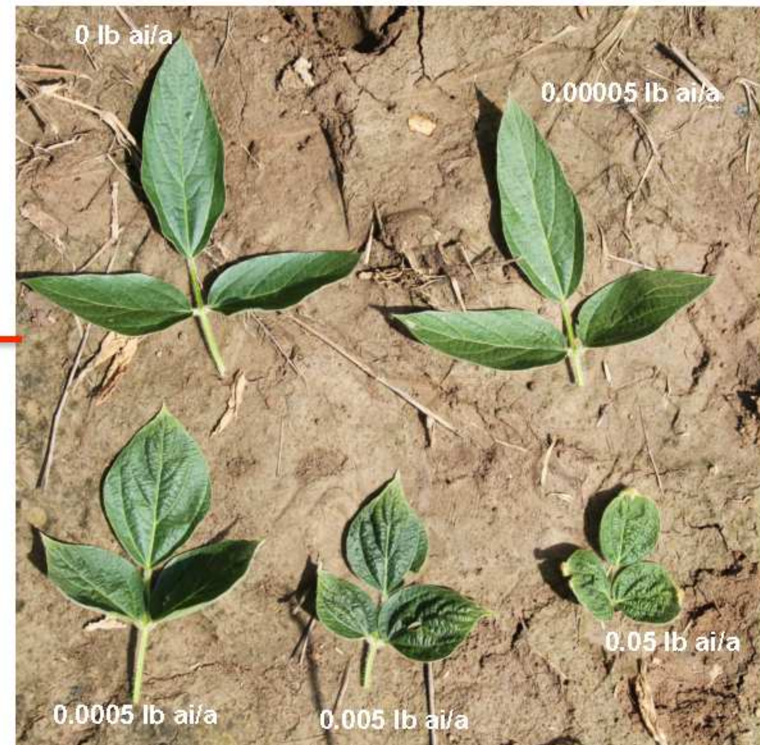
REUBEN BARIS | ACTING CHIEF | HERBICIDE BRANCH
U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF PESTICIDE PROGRAMS | (703) 305-7356

Studying the relationship between dicamba injury and yield loss

Table 1: Soybean Injury and subsequent yield
Columbia, MO 2016

Soybean stage	Herbicide Rate: dicamba rate*	Herbicide Rate: Amount compared to labeled rate	% Injury: 14 Days After Treatment	Yield: Bushel/acre
V3	0.05 lb/a	1/10th	80	32
V3	0.005 lb/a	1/100th	70	54
V3	0.0005 lb/a	1/1000th	50	54
V3	0.00005 lb/a	1/10,000th	45	52
V3	Glyphosate only	------------	0	56
R1	0.05 lb/a	1/10th	80	6
R1	0.005 lb/a	1/100th	60	40
R1	0.0005 lb/a	1/1000th	50	49
R1	0.00005 lb/a	1/10,000th	20	55
R1	Glyphosate only	------------	0	59

*Each treatment included 28 oz/a Roundup



Trifoliates selected from upper canopy of Roundup Ready soybean; 28 days after dicamba applications on R1 plants.

The Impact of Driftable Fractions of Dicamba on Non-Resistant Soybean

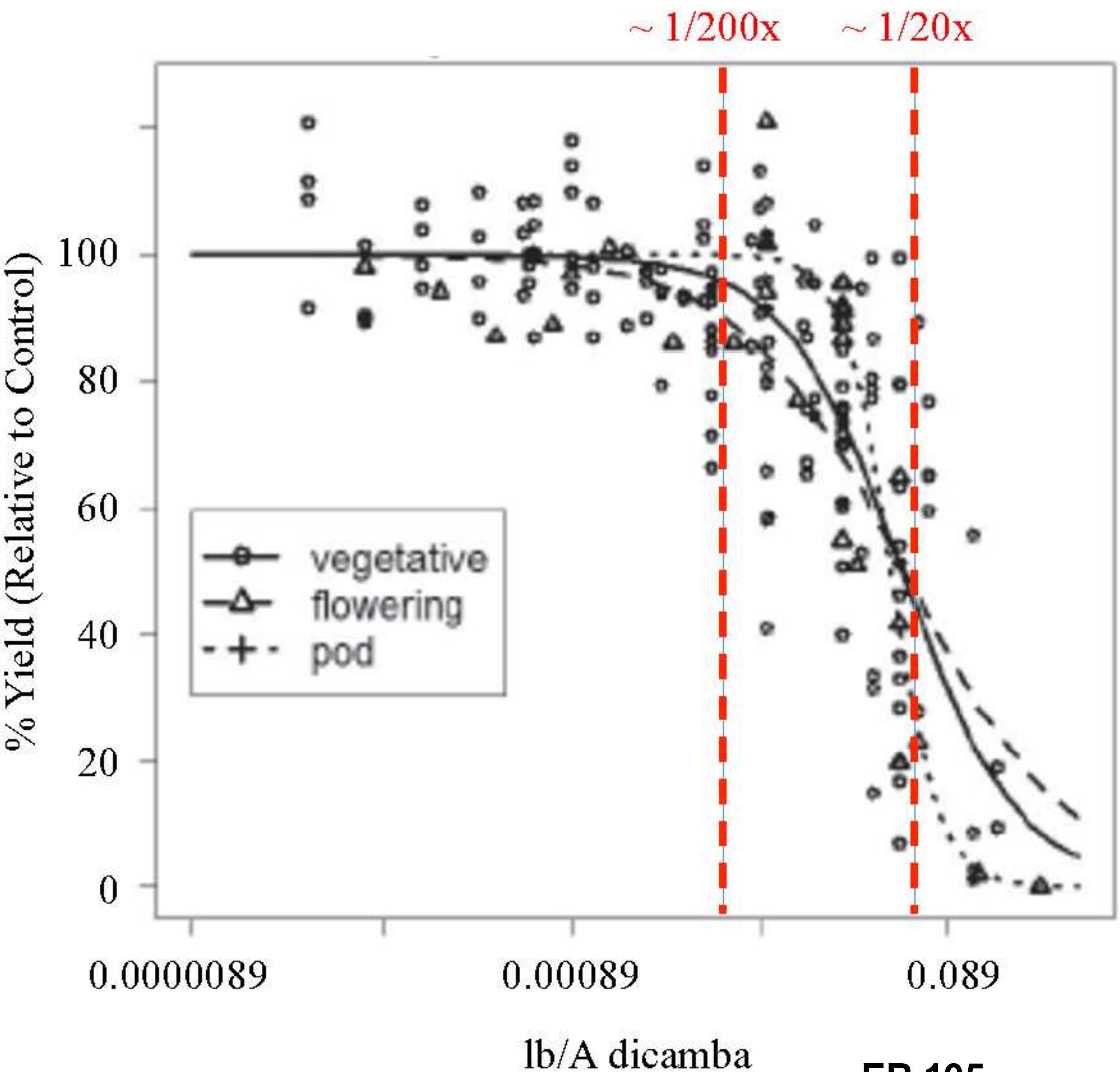
Herbicide	Fraction of 1x Use Rate*	V3 Drift Event: 2 Weeks After	V3 Drift Event: 4 Weeks After	R2 Drift Event: 2 Weeks After	R2 Drift Event: 4 Weeks After	Pods per Plant: V3 Drift Event	Pods per Plant: R2 Drift Event	Soybean Yield: V3 Drift Event	Soybean Yield: R2 Drift Event
		--% Visual Injury--		--% Visual Injury--		---------#---------		------Bu/A------	
Dicamba	1/20,000	21	10	15	17	45	42	62	63
	1/2000	28	9	17	16	50	43	64	61
	1/200	32	9	14	15	45	39	63	56
	1/20	44	12	18	14	50	13	62	21
Control	----	1	0	0	0	48	48	65	65

*1x use rate = 0.5 lb dicamba/A; for reference, 1/20x = 0.025 lb dicamba/A or 0.8 oz Clarity/A.
**Numbers in red indicate significant differences from the non-treated control.

*The same rates of 2,4-D were sprayed in this experiment and no yield reduction ever occurred.

Solomon and Bradley (2014) *Weed Technology* 28(3): 454-464.

Yield Response of Soybean to Dicamba Across Different Growth Stages : Results from A Meta-Analysis



Franklin et al. (2014) *Weed Science* 62: 193-206.

Some General Conclusions about Dicamba Injury on Soybean

- Early-season injury **does not correlate** with yield loss but late-season injury **generally does**
- Soybean injured with typical driftable fractions of dicamba during vegetative stages will generally experience **only very slight or no yield loss**
- Results from the meta-analysis (12 studies) indicate:
  - flowering soybean exposed to dicamba vapor drift (~1/1000x use rate) will experience an **approximate 1% yield loss**
  - flowering soybean exposed to dicamba particle drift (~1/100x use rate) will experience an **approximate 9% yield loss**

Franklin et al. (2014) *Weed Science* 62: 193-206.

Another Consideration: Seed

Dicamba injury this year can aff

- Soybean seed emergence
reduced by 50% when soy
plants were exposed to a
use rate of dicamba (0.025
at flowering or pod filling

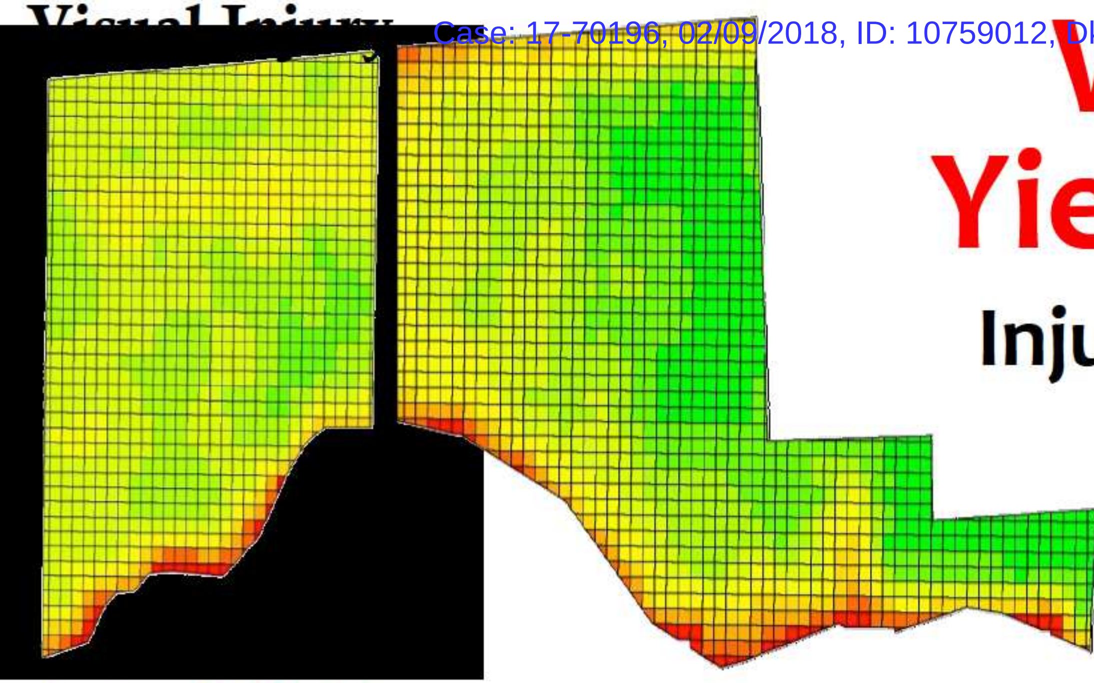
- Progeny from plants treat
R1-R6 growth stages exhi
significant dicamba sympt
14 days after planting

Thompson and Egli. (1973) *Weed Science* 21: 141-144; Barber et al.

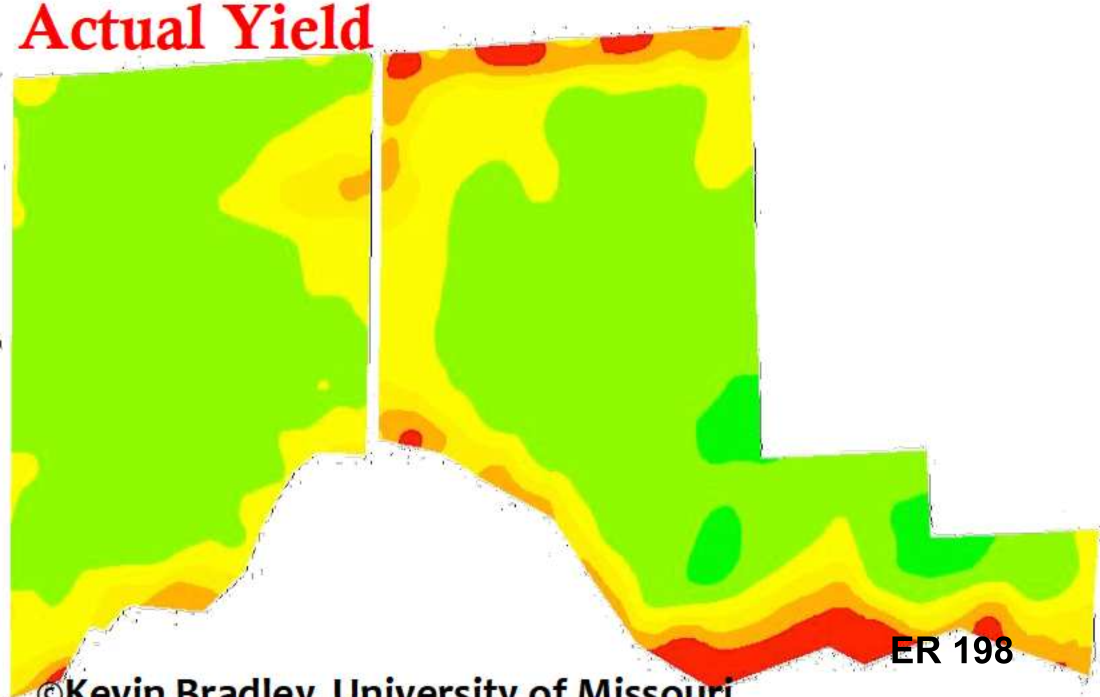
What about Yield Impacts ?

Injured Field Example

Visual Injury



Actual Yield



	Soybean Yield	
% Visual Injury	% of Historical Average	Bushels per Acre
0-20	115%	55
21-40	104%	49
41-60	68%	32
61-80	35%	17
81-100	2%	1

Entire field yielded 3 Bu/A < than historical average in a year when all other fields were above average

What about Yield impacts from off-target moment of dicamba in 2016?

A phone survey of ~40 Missouri soybean producers injured by dicamba in 2016 revealed an average yield loss of ~ 35%

Weed Technology. 2004. Volume 18:1125–1134

Education/Extension

Determining Exposure to Auxin-Like Herbicides. I. Quantifying Injury to Cotton and Soybean[1]

AUDIE S. SCIUMBATO, JAMES M. CHANDLER, SCOTT A. SENSEMAN, RODNEY W. BOVEY, and KEN L. SMITH[2]

Abstract: Crop injury caused by drift of auxin-like herbicides has been a concern since their development. Research was conducted to describe a method of quantifying injury from auxin-like herbicides as a first step in determining crop damage. Reduced rates of 2,4-D, dicamba, and triclopyr were applied to cotton and soybean plants in the three- to six-leaf stage in field and greenhouse studies. Injury to leaves and stems were evaluated separately, and the values were combined so that one injury estimate was obtained for each individual plant rated. Injury symptoms were typical for auxin-type herbicides and ranged from slight bending of stems or petioles and wrinkled leaves to necrosis. Specific descriptions of leaf and stem injury levels were used to describe plant injury consistently. These descriptions were very detailed for the lower injury levels, but the characterizations became more general as the injury increased because of the prominence of factors such as necrosis. The injury evaluation method provided repeatable results for each herbicide and herbicide rate used. This injury evaluation method has many possible uses in auxin-like herbicide research and lays the foundation for forecasting the impact of early-season injury to cotton and soybean yield.
Nomenclature: 2,4-D; dicamba; triclopyr; cotton, *Gossypium hirsutum* L. 'Delta Pine 50' #[3] GOSHI; soybean, *Glycine max* (L.) 'Delta Pine 415' Merr. # GLYMA.
Additional index words: Epinasty, method, plant injury, rating scale.
Abbreviation: DAT, days after treatment.

INTRODUCTION

Auxin-like herbicides have been well received by producers since their introduction in the 1940s. The first auxin-like herbicide, 2,4-D, was introduced commercially in 1945 (Peterson 1967). In 1996, 2,4-D alone was used on more than 40 crops (Burnside et al. 1996). Although agricultural diversion programs and reduced rate recommendations have decreased herbicide use in the United States since the early 1980s (Burnside 1993), auxin-like herbicides still accounted for approximately 10% of all herbicides used (Burnside 1996). These herbicides are popular for many reasons, including their relatively low cost when compared with newer herbicides (Mississippi Cooperative Extension Service 1997). In addition to being inexpensive, the auxin-like herbicides pose minimal health hazards when applied properly (Bovey and Young 1980; Council for Agricultural Science and Technology 1975; Fletcher and Kirkwood 1982).

Although popular, auxin-like herbicides have long been scrutinized because of injury to susceptible off-target plants caused by drift (Arle 1954; Bovey and Meyer 1981; Miller et al. 1963). Drift concerns have led some states to enact numerous safeguards such as the use of low-volatility formulations, restrictions on application times, or banning auxin-like herbicide use (Texas Agriculture Code 1984). Despite these efforts, crop injury from auxin-like herbicides still occurs.

Although the auxin-like herbicides represent the oldest organic herbicide mode of action in use today, a numerical system has not been devised to describe the symptoms that occur with plant injury. The objective of this study was to devise a method of quantifying plant injury from auxin-like herbicide exposure. Such a system must be specific to these herbicides because of the unique in-

[1] Received for publication April 9, 2003, and in revised form July 24, 2003.
[2] Research Associate, Professor, and Associate Professor, respectively, Texas Agricultural Experiment Station, Department of Soil and Crop Sciences, College Station, TX 77843-2474; Professor, Texas Agricultural Experiment Station, Department of Rangeland Ecology and Management, College Station, TX 77843-2126; Extension Weed Specialist, University of Arkansas-Monticello, Monticello, AR 71656. Corresponding author's E-mail: audie@tamu.edu.
[3] Letters following this symbol are WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

Table 1. Reduced rates of 2,4-D, dicamba, and triclopyr applied to cotton and soybean plants at the four- to six-leaf stage.

Rate	2,4-D		Dicamba		Triclopyr	
	Concentration	Use rate	Concentration	Use rate	Concentration	Use rate
	μg/mL	kg/ha	μg/mL	kg/ha	μg/mL	kg/ha
Standard	2,850	0.53	3,000	0.56	6,000	1.12
4×10^{-1} [a]	1,140	2.1×10^{-1}	1,200	2.2×10^{-1}	2,400	4.5×10^{-1}
2×10^{-1} [a]	570	1.1×10^{-1}	600	1.1×10^{-1}	1,200	2.2×10^{-1}
1×10^{-1}	285	5.3×10^{-2}	300	5.6×10^{-2}	600	1.1×10^{-1}
5×10^{-2}	142	2.7×10^{-2}	150	2.8×10^{-2}	300	5.6×10^{-2}
1×10^{-2}	28	5.3×10^{-3}	30	5.6×10^{-3}	60	1.1×10^{-2}
5×10^{-3}	14	2.7×10^{-3}	15	2.8×10^{-3}	30	5.6×10^{-3}
1×10^{-3}	2.8	5.3×10^{-4}	3	5.6×10^{-4}	6	1.1×10^{-3}
5×10^{-4}	1.4	2.7×10^{-4}	1.5	2.8×10^{-4}	3	5.6×10^{-4}
1×10^{-4}	0.2	5.3×10^{-5}	0.3	5.6×10^{-5}	0.6	1.1×10^{-4}
5×10^{-5} [b]	0.14	2.7×10^{-5}	0.15	2.8×10^{-5}	0.3	5.6×10^{-5}
1×10^{-5} [b]	0.02	5.3×10^{-6}	0.03	5.6×10^{-6}	0.06	1.1×10^{-5}

[a] Applied to cotton only.
[b] Applied to soybean only.

jury symptoms associated. In addition, it could be an important first step in determining crop damage severity and forecasting potential yield losses. To be useful, this scale must be clearly defined with well-described injury features along with being user friendly so that a variety of users could use it.

MATERIALS AND METHODS

The rating scale was constructed by observing and categorizing injury to test plants that had been exposed to reduced rates of auxin-like herbicides. The procedure was derived from both greenhouse and field experiments using cotton and soybean with four to six leaves. Auxin-like herbicides used included the dimethylamine salt of 2,4-D,[4] the diglycolamine salt of dicamba,[5] and the butoxyethyl ester of triclopyr.[6] Visual estimates of plant injury were recorded at 1, 5, 9, and 14 d after treatment (DAT) in all experiments, although only data from the 14 DAT observations will be presented.

Greenhouse Injury Evaluation Procedure. The greenhouse procedure was performed at the Norman E. Borlaug Center for Southern Crop Improvement on the campus of Texas A&M University during the fall of 1996 and spring of 1997. Each repetition consisted of six replications for each herbicide treatment for both cotton and soybean. The experimental design was completely randomized and was performed twice.

'Delta Pine 50'[7] cotton and 'Delta Pine 415'[7] soybean seeds were planted in standard 15-cm-diam by 15-cm-deep plastic pots at populations of three plants per pot. Seeds were planted at a depth of 4 cm into growth medium composed of a 3:1 (v/v) mixture of Pro-Mix[8] and Redi-Earth[9] potting soils. Greenhouse conditions were 10 h of darkness at 23 C (±3 C) and 14 h of light at 29 C (±3 C). One application of $N–P_2O_5–K_2O$ (20:20:20) fertilizer was made to the young plants 1 wk after emergence at a rate equivalent to 23 kg/ha for N, P, and K.

Nine different rates of 2,4-D, dicamba, and triclopyr were applied to the cotton and soybean plants at the four- to six-leaf stage, approximately 21 d after planting (Table 1). The herbicides were applied without surfactant in a 187 L/ha spray volume using a research track sprayer.[10] The track sprayer was washed thoroughly with water before treatments of each herbicide were applied.

The nine rates that were applied ranged from 4×10^{-1} to 1×10^{-5} times the recommended use rates of 2,4-D, dicamba, and triclopyr. The respective use rates for these herbicides were 0.53 kg ai/ha, 0.56 kg/ha, and 1.12 kg/ha. These use rates represented concentrations of 2,850 μg/ml, 3,000 μg/ml, and 6,000 μg/ml for 2,4-D, dicamba, and triclopyr, respectively. Herbicide rates were similar for both plant species, but the two highest doses (4×10^{-1} and 2×10^{-1} times the field rates) were only used on cotton. In addition, the two lowest doses (5×10^{-5} and 1×10^{-5} times the field rates) were only applied to soybean. The low soybean rates were included after the highest rates of dicamba and triclopyr quickly killed the soybean test plants during preliminary trials.

[4] Weedar 64® herbicide, Nufarm Limited, 103 Pipe Road, Laverton, North Victoria 3026, Australia.
[5] Clarity® herbicide, BASF Corporation, Agricultural Products Group, Research Triangle Park, NC 27709.
[6] Remedy® herbicide, Dow AgroSciences, Indianapolis, IN 46268-1189.
[7] Delta and Pine Land Company, P.O. Box 157, Scott, MS 38772.
[8] Potting soil, Premier Horticulture Inc., Red Hill, PA 18076.
[9] Potting soil, Scotts-Sierra Horticultural Products Company, 14111 Scottslawn Road, Marysville, OH 43041.
[10] Spray chamber, De Vries Manufacturing, Hollandale, MN 56045.

Table 2. Leaf injury scale for injury evaluation on a 0–100 basis.

Rating[a]	Observed symptomology
1–3	Slight ripples in leaf margin creating "drawstring" effect. Isolated wart-like growths may also be observed on the upper epidermis of the leaf.
4–6	Ripples are more pronounced and present on at least 50% of leaf margin. Wart-like growths on leaf are common.
7–10	Leaves appear stiff and brittle. Stiff areas may also display chlorosis. Necrosis begins to appear around leaf margin which is uneven and gnarled throughout its perimeter.
11–15	Chlorosis is more obvious. Necrosis becomes more prominent and has affected no more than 10% of the total new leaf area.
16–20	Necrosis is the dominant factor affecting up to 20% of the young leaves. Epinasty is severe around the entire leaf margin.
21–30	Up to 30% of the leaf tissue is necrotic, with chlorosis apparent through much of the leaf perimeter.
31–40	The leaf is very disfigured and chlorotic. Necrosis is evident on up to 40% of the leaf.
41–100	Necrosis becomes the primary indicator of plant injury. Although epinasty is extreme throughout the leaves, chlorosis and necrosis coverage is dominant.

[a] The higher the value, the more severe the injury.

Figure 1. Cotton leaf injury value of 5.

The plants were returned to an adequately ventilated greenhouse after the herbicides were applied, and injury symptoms were recorded using the rating scale.

Field Injury Evaluation Procedure. The field procedure was carried out at the Texas A&M Agronomy Field Laboratory near College Station during June, July, and August of 1997. The experimental design was a strip-split plot and was conducted four times during the 3-mo period. Replication in time was done to evaluate potential environmental impact on symptomology. Varieties used were Delta Pine 50 cotton and Delta Pine 415 soybean. Soil at the test site was a Belk clay (Entic Hapluderts). Four-row strips of the cotton and soybean varieties were planted 4 cm deep on 102-cm centers for each repetition using a four-row John Deere planter equipped with insecticide application boxes. Each experiment consisted of a four-row strip of cotton and a four-row strip of soybean.

The first replication was planted on June 16, 1997, the second on June 30, 1997, the third on July 11, 1997, and the fourth on July 17, 1997. The fungicide metalaxyl[11] [*N*-(2,6-dimethylphenyl)-*N*-(methoxyacetyl) alanine methyl ester] and the insecticide phorate[12] {*O,O*-diethyl *S*-[(ethylthio) methyl] phosphorodithioate} were applied

[11] Ridomil® fungicide, Syngenta Crop Protection, Inc. P.O. Box 18300, Greensboro, NC 27409.

[12] Thimet® insecticide, BASF Corporation, Agricultural Products Group, Research Triangle Park, NC 27709.

Table 3. Stem injury scale for categorical injury evaluation on a 0–100 basis.

Rating[a]	Observed symptomology
1–3	Slight swelling of the stem or vascular tissues with no observed twisting or abnormal bending.
4–6	Twisting and abnormal bending becoming apparent near the apical meristem, with stem bending less than 6°. Leaf petioles may be slightly languid but are not horizontal.
7–10	Twisting and bending in the main stem and branches range from 5 to 45°. Stem discoloration may also become apparent. Petioles have dropped no farther than horizontal.
11–15	Stems or branches are bent in angles between 45 and 90°. Stem may appear red and swollen. Petioles appear weak and have fallen beyond horizontal.
16–20	Epinastic symptoms are intense with necrosis in the meristematic regions. Malformation angles range from 90 to 120°. Petioles have fallen as much as 90° beyond horizontal.
21–30	Stems or petioles are twisted at angles of 120–150°, with up to 30% dead tissue.
31–40	Stem or petioles twisted in excess of 150°. Up to 40% of the plant tissue is necrotic.
41–100	Necrosis is now the primary indicator of injury to the stem, with over 40% of the tissue being necrotic.

[a] The higher the value, the more severe the injury.

Figure 2. Cotton leaf injury value of 10.

Figure 3. Cotton leaf injury value of 15.

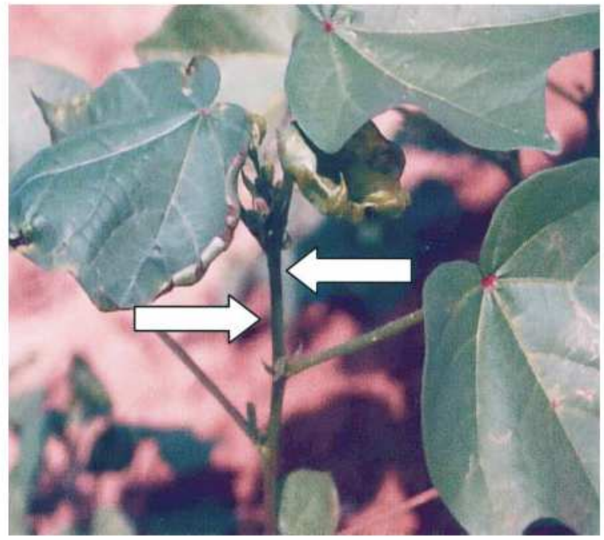


Figure 5. Cotton stem injury value of 5.

during planting to protect the seeds and emerging seedlings. A preemergence application of pendimethalin[13] was also applied at 0.47 kg ai/ha to control grasses. The studies were furrow irrigated as needed, and tillage or hand hoeing was done to provide postemergence weed control.

Plots were arranged in strips to minimize the risk of spray droplet or vapor drift from one plot to another. Using this configuration, contamination could only be spread from plot to plot by being moved lengthwise along the species strips. The two center rows of each four-row strip were used to comprise the actual test plots, whereas the outer two rows were used as buffer rows. In addition, four rows separated the cotton and soybean strips. The cotton and soybean rows were divided lengthwise into three equal parts, one part for each of the three herbicides to be used. Thirty 1.5-m-long test plots, 10 plots for each of the three herbicides used, were marked and separated by 1.2-m alleys in each species strip.

The plants were treated with 2,4-D, triclopyr, and dicamba using a CO_2-pressurized backpack sprayer and handheld spray boom when each replication reached the four- to six-leaf stage. All herbicides were delivered in a 187 L/ha spray solution, and the herbicide rates used in the field were the same as those used in the greenhouse injury evaluation process (Table 1). Surfactants were not included in the spray solutions.

[13] Prowl® herbicide, BASF Corporation, Agricultural Products Group, Research Triangle Park, NC 27709.

Figure 4. Cotton leaf injury value of 20.

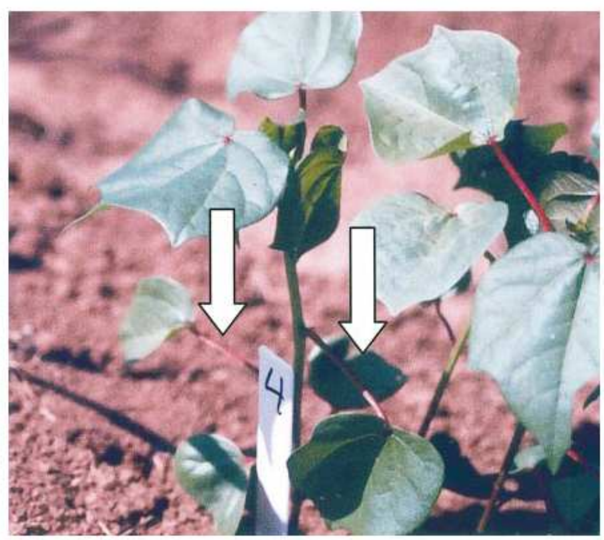


Figure 6. Cotton stem injury value of 10.

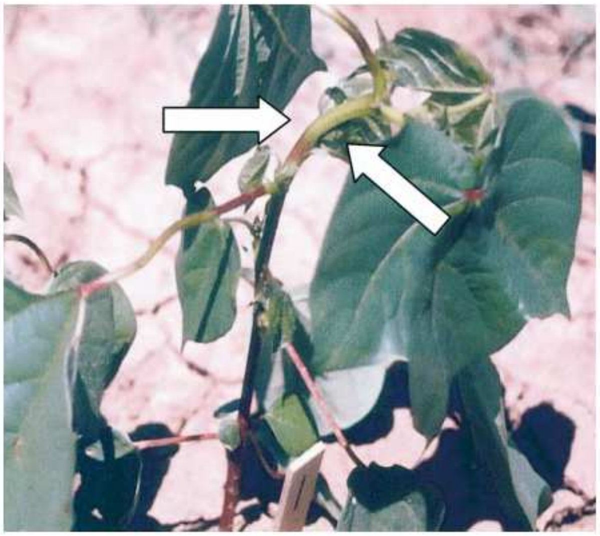


Figure 7. Cotton stem injury value of 15.

Figure 9. Soybean leaf injury value of 5.

The herbicides were applied to the first, second, third, and fourth replications on July 7, July 24, August 4, and August 11, respectively. During the spray applications, 1.8- by 2.4-m plastic tarps were held around the plot being treated to reduce the risk of spray drift particles contaminating other plots. After the herbicides were applied, five random test plants in each plot were chosen and rated at 1, 5, 9, and 14 DAT using the leaf and stem injury scale described later. The selected plants were marked with plastic garden stakes so that the same plants were rated each time.

Evaluation. The scale used to quantify the injury associated with these herbicides was based on a 0 to 100 scale, with 100 representing plant death (Tables 2 and 3). During the evaluation process, leaves and stems were monitored separately on each plant for the effects of auxin-like herbicides. Petioles and branches were combined with the main stem and considered together as stem injury, whereas the leaves comprised leaf injury data. Injury that was observed on leaves was documented using the scale summarized in Table 2. Symptomology and values used for stem injury evaluations are located in Table 3. Figures 1–4 and 5–8 depict typical cotton leaf and stem injury, respectively. Soybean leaf and stem injury is shown in Figures 9–12 and 13–16, respectively.

The categorical ranges were used to provide general injury values from which the final evaluation would be determined. During the evaluation procedure, broad generalizations of a plant's leaves or stem appearance were

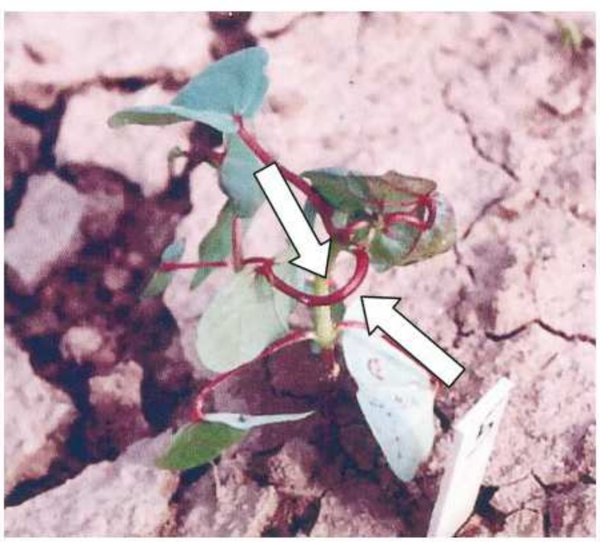


Figure 8. Cotton stem injury value of 20.

Figure 10. Soybean leaf injury value of 10.

Figure 11. Soybean leaf injury value of 15.

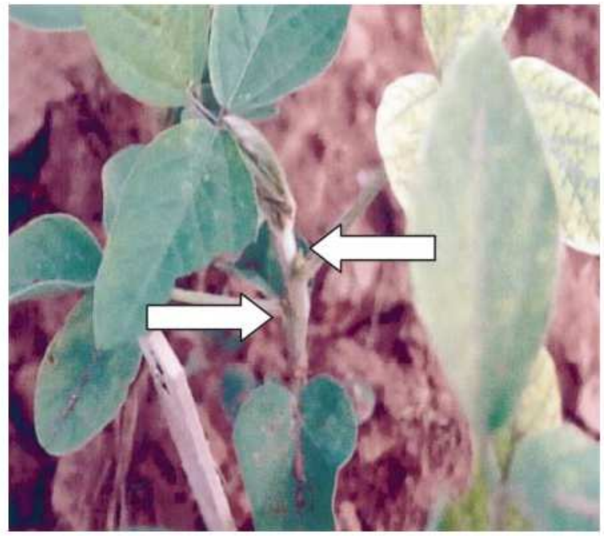


Figure 13. Soybean stem injury value of 5.

considered so that a basic range of injury could be determined. The final injury value was assigned after this approximation had been made based on the level of injury within that range. The leaf and stem injury evaluations were then averaged so that one injury value described the combined leaf and stem injury of the plant. Mean standard errors were calculated for each treatment to determine variability within the evaluations.

RESULTS AND DISCUSSION

Evaluation Scale. The majority of the injury recorded from cotton was observed on leaves in both the field and greenhouse. This variability between leaf and stem injury within plants did little to affect the results of the rating scale because leaf and stem injury from each plant was averaged together. Soybean injury appeared more consistent across leaves and stems, particularly in the field. However, severe stem injury was observed on soybean exposed to the highest triclopyr rates in the greenhouse. In addition, epinasty was easier to quantify on cotton plants because of the larger leaf size and longer, more prominent stems. The largest standard error recorded for the evaluations throughout the experiment was 1.62, indicating good precision.

Greenhouse. Average injury values and their standard errors are shown in Tables 4–7. The overall injury evaluations of 2,4-D varied from 10.3 to 1.9 for cotton (Table 4) and 3.8 to 2.4 for soybean (Table 5). The average

Figure 12. Soybean leaf injury value of 20.

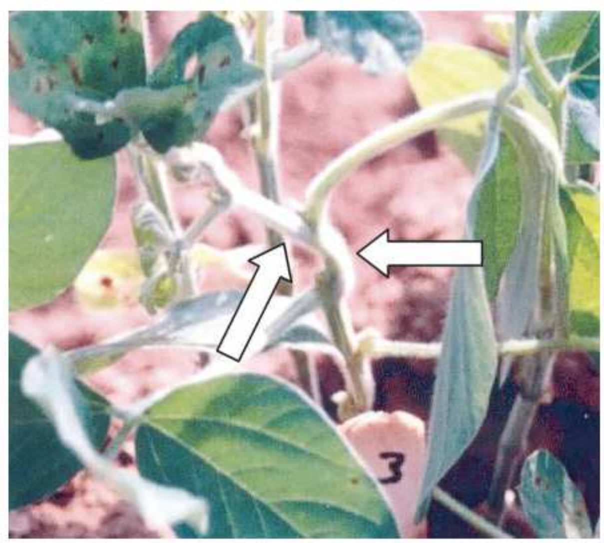


Figure 14. Soybean stem injury value of 10.

Figure 15. Soybean stem injury value of 15.

standard error for 2,4-D injury was 0.48 and 0.36 for cotton leaf and stem injury, respectively. The standard errors of soybean leaf values were similar with an average of 0.36, but soybean stem evaluations were more variable, averaging 0.96. Injury caused by dicamba was generally higher than that of 2,4-D and had greater variability, with soybean stem being the most variable of the greenhouse dicamba evaluations. Overall greenhouse triclopyr injury ranged from 25.3 to 1.9 on cotton and 18.5 to 2.3 on soybean. Variability in the greenhouse values was the greatest with triclopyr, with the mean standard error for cotton leaves being 1.62 and 1.10 for soybean stem. Standard error values indicate that the most consistent evaluations from the greenhouse were

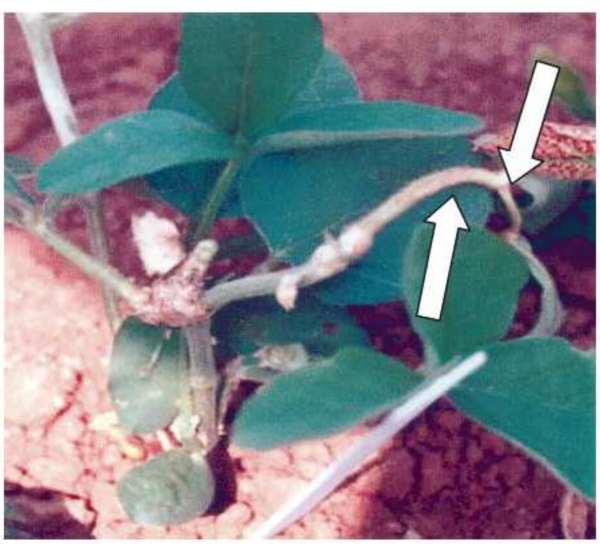


Figure 16. Soybean stem injury value of 20.

Table 4. Greenhouse cotton injury evaluations made 14 d after treatments with 2,4-D, dicamba, or triclopyr.

Injury category	Herbicide	Herbicide rate (×)[a]									Average standard error
		4×10^{-1}	2×10^{-1}	1×10^{-1}	5×10^{-2}	1×10^{-2}	5×10^{-3}	1×10^{-3}	5×10^{-4}	1×10^{-4}	
		average % injury									
Leaf rating	2,4-D	11.3 (0.59)[b]	11.1 (0.57)	9.8 (0.46)	10.4 (0.83)	8.7 (0.59)	4.9 (0.29)	3.7 (0.26)	2.6 (0.34)	1.8 (0.37)	0.48
	Dicamba	23.1 (0.58)	20.4 (0.70)	18.3 (0.87)	14.6 (0.43)	8.3 (0.36)	5.2 (0.37)	5.1 (0.92)	3.7 (0.47)	1.8 (0.21)	0.55
	Triclopyr	26.7 (1.13)	31.8 (6.63)	15.8 (0.75)	13.8 (1.93)	14.0 (1.76)	10.5 (1.88)	2.2 (0.18)	2.1 (0.15)	1.4 (0.15)	1.62
Stem rating	2,4-D	9.3 (0.59)	8.8 (0.68)	5.2 (0.39)	5.0 (0.39)	3.8 (0.27)	2.8 (0.28)	2.8 (0.24)	2.4 (0.19)	2.0 (0.21)	0.36
	Dicamba	15.8 (0.37)	9.8 (1.05)	9.2 (0.99)	4.1 (0.25)	3.6 (0.23)	3.2 (0.30)	2.6 (0.31)	3.2 (0.22)	2.1 (0.26)	0.44
	Triclopyr	23.8 (0.67)	18.1 (0.87)	15.2 (1.27)	7.2 (0.62)	5.2 (0.48)	3.6 (0.19)	2.6 (0.19)	2.0 (0.21)	2.3 (0.19)	0.52
Overall rating	2,4-D	10.3	9.9	7.5	7.7	6.2	3.8	3.2	2.5	1.9	
	Dicamba	19.5	15.1	13.8	9.3	6.0	4.2	3.8	3.5	2.0	
	Triclopyr	25.3	25.0	15.5	10.5	9.6	7.0	2.4	2.0	1.9	

[a] Rate is calculated from general use rates of 0.53 kg/ha of 2,4-D, 0.56 kg/ha of dicamba, and 1.12 kg/ha of triclopyr.
[b] Standard error of average percent injury.

Table 5. Greenhouse soybean injury evaluations made 14 d after treatments with 2,4-D, dicamba, or triclopyr.

Injury category	Herbicide	Herbicide rate (×)[a]									Average standard error
		1×10^{-1}	5×10^{-2}	1×10^{-2}	5×10^{-3}	1×10^{-3}	5×10^{-4}	1×10^{-4}	5×10^{-5}	1×10^{-5}	
		average % injury									
Leaf rating	2,4-D	3.4 (0.26)[b]	3.0 (0.17)	2.9 (0.21)	3.6 (0.21)	3.5 (0.40)	2.8 (0.22)	3.0 (0.37)	3.6 (0.62)	5.4 (0.78)	0.36
	Dicamba	16.3 (0.51)	16.3 (0.79)	14.3 (0.76)	10.8 (0.61)	8.7 (0.99)	6.5 (1.13)	3.1 (0.23)	3.2 (0.30)	3.4 (0.29)	0.62
	Triclopyr	14.9 (0.91)	13.2 (0.98)	9.4 (1.09)	5.3 (0.54)	3.8 (0.38)	3.0 (0.12)	3.2 (0.22)	4.1 (0.75)	3.5 (0.47)	0.61
Stem rating	2,4-D	3.6 (0.84)	3.8 (0.87)	4.4 (1.39)	1.2 (0.37)	3.4 (1.14)	4.1 (1.25)	3.2 (1.04)	3.3 (1.02)	2.1 (0.72)	0.96
	Dicamba	6.6 (0.93)	5.4 (0.90)	4.7 (1.04)	5.2 (1.24)	4.7 (1.46)	3.5 (1.09)	2.2 (0.72)	1.8 (0.61)	1.5 (0.48)	0.94
	Triclopyr	22.2 (0.86)	18.9 (0.92)	5.2 (1.30)	3.4 (0.86)	4.4 (1.34)	4.7 (1.48)	3.9 (1.28)	4.1 (1.33)	1.2 (0.51)	1.10
Overall rating	2,4-D	3.5	3.4	3.7	2.4	3.5	3.4	3.1	3.5	3.8	
	Dicamba	11.5	10.9	9.5	8.1	6.7	5.0	2.7	2.5	2.5	
	Triclopyr	18.5	16.0	7.3	4.4	4.1	3.8	3.6	4.1	2.3	

[a] Rate is calculated from general use rates of 0.53 kg/ha of 2,4-D, 0.56 kg/ha of dicamba, and 1.12 kg/ha of triclopyr.
[b] Standard error of average percent injury.

Table 6. Field cotton injury evaluations made 14 d after treatments with 2,4-D, dicamba, or triclopyr.

Injury category	Herbicide	Herbicide rate (×)[a]									Average standard error
		4×10^{-1}	2×10^{-1}	1×10^{-1}	5×10^{-2}	1×10^{-2}	5×10^{-3}	1×10^{-3}	5×10^{-4}	1×10^{-4}	
		average % injury									
Leaf rating	2,4-D	10.5 (0.46)[b]	10.1 (0.33)	5.4 (1.33)	10.9 (0.78)	9.0 (1.12)	3.7 (0.75)	2.2 (0.40)	1.6 (0.35)	1.4 (0.30)	0.65
	Dicamba	22.9 (1.10)	18.9 (0.57)	15.9 (0.67)	13.5 (0.32)	9.3 (0.79)	5.5 (0.97)	2.9 (0.41)	1.5 (0.36)	1.4 (0.32)	0.61
	Triclopyr	12.5 (2.97)	5.4 (1.66)	4.8 (1.38)	2.9 (0.69)	2.1 (0.46)	2.1 (0.44)	2.0 (0.40)	1.7 (0.41)	1.5 (0.34)	0.97
Stem rating	2,4-D	7.2 (1.27)	5.5 (0.72)	3.9 (0.77)	3.3 (0.60)	2.3 (0.42)	2.2 (0.28)	2.0 (0.34)	1.1 (0.37)	1.5 (0.41)	0.58
	Dicamba	6.0 (0.91)	4.0 (0.48)	4.4 (0.54)	3.2 (0.48)	2.7 (0.47)	3.1 (0.59)	2.4 (0.42)	1.9 (0.36)	0.7 (0.33)	0.51
	Triclopyr	2.1 (0.38)	2.0 (0.40)	2.0 (0.44)	2.5 (0.44)	1.8 (0.44)	1.3 (1.40)	1.5 (0.43)	1.2 (0.43)	1.1 (0.32)	0.41
Overall rating	2,4-D	8.9	7.8	6.1	7.1	5.6	2.9	2.1	1.3	1.4	
	Dicamba	14.5	11.5	10.1	8.4	6.0	4.3	2.7	1.7	1.1	
	Triclopyr	7.3	3.7	3.4	2.7	1.9	1.7	1.8	1.5	1.3	

[a] Rate is calculated from general use rates of 0.53 kg/ha of 2,4-D, 0.56 kg/ha of dicamba, and 1.12 kg/ha of triclopyr.
[b] Standard error of average percent injury.

Table 7. Field soybean injury evaluations made 14 d after treatments with 2,4-D, dicamba, or triclopyr.

Injury category	Herbicide	Herbicide rate (X)[a] 1 × 10⁻¹	5 × 10⁻²	1 × 10⁻²	5 × 10⁻³	1 × 10⁻³	5 × 10⁻⁴	1 × 10⁻⁴	5 × 10⁻⁵	1 × 10⁻⁵	Average standard error
		average % injury									
Leaf rating	2,4-D	2.7 (0.35)[b]	2.0 (0.26)	1.8 (0.26)	1.6 (0.21)	1.7 (0.27)	1.9 (0.25)	1.8 (0.24)	1.5 (0.27)	2.1 (0.43)	0.28
	Dicamba	9.0 (1.0)	7.7 (0.80)	7.5 (0.72)	5.4 (0.63)	3.5 (0.54)	2.7 (0.50)	1.4 (0.27)	1.9 (0.28)	1.5 (0.36)	0.56
	Triclopyr	4.6 (0.94)	4.1 (0.85)	2.3 (0.30)	1.9 (0.33)	2.1 (0.29)	1.9 (0.22)	1.7 (0.15)	1.7 (0.19)	2.7 (0.35)	0.40
Stem rating	2,4-D	4.5 (0.52)	1.9 (0.31)	1.9 (0.34)	1.4 (0.25)	2.5 (0.53)	1.8 (0.26)	1.3 (0.41)	1.2 (0.31)	1.0 (0.32)	0.36
	Dicamba	9.7 (1.72)	8.2 (1.24)	1.9 (0.44)	3.1 (0.31)	2.1 (0.34)	1.4 (0.25)	1.0 (0.20)	1.1 (0.33)	1.3 (0.30)	0.57
	Triclopyr	1.7 (1.26)	4.0 (0.77)	2.3 (0.40)	0.7 (0.23)	1.3 (0.27)	1.1 (0.18)	0.9 (0.16)	0.7 (0.27)	1.7 (0.35)	0.43
Overall rating	2,4-D	3.6	1.9	1.9	1.5	2.1	1.9	1.5	1.41	1.6	
	Dicamba	9.3	8.0	6.2	4.3	2.8	2.0	1.2	1.5	1.4	
	Triclopyr	5.9	4.1	2.3	1.3	1.7	1.5	1.3	1.2	2.2	

[a] Rate is calculated from general use rates of 0.53 kg/ha of 2,4-D, 0.56 kg/ha of dicamba, and 1.12 kg/ha of triclopyr.
[b] Standard error of average percent injury.

obtained with 2,4-D on cotton in both leaf and stem categories.

Field. Average evaluations and standard error values for field injury are displayed in Tables 6 and 7. The overall evaluations for 2,4-D ranged from 8.9 to 1.3 for cotton (Table 6) and 3.6 to 1.4 for soybean (Table 7). The average standard errors of 2,4-D evaluations were 0.65 and 0.58 for cotton leaf and stem injury, respectively. Those of soybean leaf and stem evaluations were 0.28 and 0.36, respectively. Injury evaluations for dicamba were again larger than those of 2,4-D, but the variability was not increased. The average standard errors for dicamba injury to cotton leaf and stem were 0.61 and 0.51, and 0.56 and 0.57 for soybean leaf and stem evaluations, respectively. The overall triclopyr injury ranged from 7.3 to 1.3 on cotton and 5.9 to 1.2 on soybean. Mean standard errors for triclopyr evaluations in the field were less than those observed in the greenhouse, although the largest mean standard error value from the field data was that of triclopyr on cotton leaf.

This rating system provided consistent, repeatable results when evaluating injury on cotton and soybean, although cotton was the easier species to evaluate because of the petiole size and leaf characteristics. The system was effective in determining injury severity across both species and for all three of the auxin-like herbicides used. Injury recorded for minute levels of different herbicides were similar yet showed increased injury values with increased herbicide rates.

The evaluation procedure seemed particularly effective in describing injury caused by extremely small amounts of auxin-like herbicides. The injury features outlined in this scale make it possible to quantify epinasty without the presence of necrosis or even chlorosis by determining severity of injury based on physical malformations displayed by the injured plant. This property is valuable because it is these low injury levels that are not only the most difficult to quantify but also those that are commonly encountered in cases of drift damage to cash crops. To be useful to producers, additional research featuring the use of this scale to evaluate early-season injury and its relation to plant yield is necessary.

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Determining Exposure to Auxin-Like Herbicides. II. Practical Application to Quantify Volatility[1]

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Abstract: Volatility and drift are problems commonly associated with auxin-like herbicides. Field and greenhouse studies were conducted at Texas A & M University to develop a method of quantifying volatility and subsequent off-target movement of 2,4-D, dicamba, and triclopyr. Rate–response curves were established by applying reduced rates ranging from 4×10^{-1} to 1×10^{-5} times the normal use rates of the herbicides to cotton and soybean and recording injury for 14 d after treatment (DAT) using a rating scale designed to quantify auxin-like herbicide injury. Injury from herbicide volatility was then produced on additional cotton and soybean plants through exposure to vapors of the dimethylamine salt of 2,4-D, diglycolamine salt of dicamba, and butoxyethyl ester of triclopyr using air chambers inside a greenhouse and volatility plots in the field. Injury resulting from this exposure was evaluated for 14 d using the same injury-evaluation scale that was used to produce the rate–response curves. Volatility-injury data were then applied to the rate–response curves so that herbicide rates corresponding with observed injury could be calculated. Using this method, herbicide volatility rates estimated from greenhouse-cotton injury were determined to be 3.0×10^{-3}, 1.0×10^{-3}, and 4.9×10^{-2} times the use rates of 2,4-D, dicamba, and triclopyr, respectively. Greenhouse-grown soybean developed injury consistent with 1.4×10^{-2}, 1.0×10^{-3}, and 2.5×10^{-2} times the normal use rate of 2,4-D, dicamba, and triclopyr, respectively. Under field conditions, cotton developed injury symptoms that were consistent with 4.0×10^{-3}, 2.0×10^{-3}, and 1.25×10^{-1} times the recommended use rates of 2,4-D, dicamba, and triclopyr, respectively. Field soybean displayed injury symptomology concordant with 1.6×10^{-1}, 1.0×10^{-2}, and 1.1×10^{-1} times the normal use rates of 2,4-D, dicamba, and triclopyr, respectively. This procedure provided herbicide volatility rate estimates that were consistent with rates and injury from the rate–response injury curves. Additional research is needed to ascertain its usefulness in determining long-term effects of drift injury on crop variables such as yield.

Nomenclature: 2,4-D, dicamba, triclopyr, cotton, *Gossypium hirsutum* L. 'Delta Pine 50', #[3] GOSHI, soybean, *Glycine max* (L.) Merr. 'Delta Pine 415', # GLYMA.

Additional index words: Injury modeling, plant injury, rate of exposure.

Abbreviations: BEE, butoxyethyl ester; DAT, days after treatment; DGA, diglycolamine; DMA, dimethylamine; WAE, weeks after emergence.

INTRODUCTION

Volatilization, a major cause of herbicide loss, has been associated with the removal of as much as 90% of an applied herbicide (Taylor and Spencer 1990). It is not uncommon for volatilization and subsequent vapor drift of auxin-like herbicides to injure susceptible crops near areas of application (Anonymous 1975; Arle 1954; Behrens and Lueschen 1979). The effect of auxin-like herbicides on crops such as cotton is both destructive and well documented (Bovey and Meyer 1981), therefore the use of most auxin-like herbicides has been restricted in areas of broadleaf crop production. These restrictions vary by location, but stipulations on time and method of application, permit requirements, or chemical formulation may apply (Texas Agriculture Code 1984).

Producers must determine the extent of crop damage

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[3] Letters following this symbol are WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

Table 1. Reduced rates of 2,4-D, dicamba, and triclopyr applied to cotton and soybean plants at the four- to six-leaf stage.

Rate	Herbicide					
	2,4-D		Dicamba		Triclopyr	
	μg/mL	kg/ha	μg/mL	kg/ha	μg/mL	kg/ha
Standard	2,850	0.53	3,000	0.56	6,000	1.12
4×10^{-1}[a]	1,140	2.1×10^{-1}	1,200	2.2×10^{-1}	2,400	4.5×10^{-1}
2×10^{-1}[a]	570	1.1×10^{-1}	600	1.1×10^{-1}	1,200	2.2×10^{-1}
1×10^{-1}	285	5.3×10^{-2}	300	5.6×10^{-2}	600	1.1×10^{-1}
5×10^{-2}	142	2.7×10^{-2}	150	2.8×10^{-2}	300	5.6×10^{-2}
1×10^{-2}	28	5.3×10^{-3}	30	5.6×10^{-3}	60	1.1×10^{-2}
5×10^{-3}	14	2.7×10^{-3}	15	2.8×10^{-3}	30	5.6×10^{-3}
1×10^{-3}	2.8	5.3×10^{-4}	3	5.6×10^{-4}	6	1.1×10^{-3}
5×10^{-4}	1.4	2.7×10^{-4}	1.5	2.8×10^{-4}	3	5.6×10^{-4}
1×10^{-4}	0.2	5.3×10^{-5}	0.3	5.6×10^{-5}	0.6	1.1×10^{-4}
5×10^{-5}[b]	0.14	2.7×10^{-5}	0.15	2.8×10^{-5}	0.3	5.6×10^{-5}
1×10^{-5}[b]	0.02	5.3×10^{-6}	0.03	5.6×10^{-6}	0.06	1.1×10^{-5}

[a] Applied to cotton only.
[b] Applied to soybean only.

on the basis of injury symptoms alone and decide whether drastic action such as replanting is necessary after crops have been injured. The uncertainty of the long-term effects of these herbicides makes decisions based on early-season injury difficult (Miller et al. 1963). A method that uses early injury symptoms to determine the amount of auxin-like herbicide that a broadleaf plant has been exposed to would be helpful in forecasting the effect of drift on crop growth and yield.

One approach to quantifying herbicide exposure is through modeling procedures that rely on data from plant injury. Such a system would be well suited for practical agronomic use because it could be applied as soon as crop injury is discovered during the growing season. Upon determining drift rates, producers could forecast probable crop damage and modify management strategies immediately where exposure is found to be at unacceptable rates. The objective of this research was to describe a method for estimating auxin-like herbicide exposure rates for different herbicides and plant species.

MATERIALS AND METHODS

This research was carried out in a three-step process that included (1) establishment of rate–response injury curves, (2) production of equations describing those curves, and (3) insertion of volatility-injury data into model equations to estimate exposure rates. Each process was performed on cotton and soybean under both field and greenhouse conditions. All 2,4-D used was the dimethylamine (DMA) salt,[4] all dicamba was the diglycolamine (DGA) salt,[5] and all triclopyr was the butoxyethyl ester (BEE).[6]

Rate–Response Injury Curve Establishment. *Greenhouse.* Greenhouse-injury curves were produced by applying nine reduced rates of 2,4-D, dicamba, and triclopyr to cotton and soybean plants. 'Delta Pine 50' cotton and 'Delta Pine 415' soybean plants[7] were grown at the seeding rate of three plants per pot in a greenhouse using standard 15-cm plastic pots. The growth medium was a 3:1 (v/v) mixture of Pro-Mix[8] and Redi-Earth[9] potting soils. Environmental conditions were 10 h of darkness at 23 C (±3 C) and 14 h of light at 29 C (±3 C). One fertilizer application of $N:P_2O_5:K_2O$ 20:20:20 was made 1 wk after emergence (WAE) at a rate equivalent to 23 kg of N, P, and K/ha, and irrigation water was provided as needed.

Herbicide treatments were applied to the cotton and soybean plants when they reached the four- to six-leaf stage. Herbicide rates are listed in Table 1. The normal use rates of 0.53 kg ai/ha, 0.56 kg/ha, and 1.12 kg/ha for 2,4-D, dicamba, and triclopyr, respectively, were considered full doses when calculating the reduced rates. Each of the treatments was applied to cotton and soybean plants without surfactant in 187 L of spray solution/ha using a spray chamber.[10] Each treatment was applied to six pots of each species, and each pot was considered a replication. The two highest rates, 4×10^{-1} and $2 \times$

[4] Weedar 64® herbicide, Rhone-Poulenc Ag Company, Research Triangle Park, NC 27709.

[5] Clarity® herbicide, BASF Corporation, Agricultural Products Group, Research Triangle Park, NC 27709.

[6] Remedy® herbicide, Dow AgroSciences, Indianapolis, IN 46268-1189.

[7] Delta and Pine Land Company, P.O. Box 157, Scott, MS 38772.

[8] Potting soil, Premier Horticulture Inc., Red Hill, PA 18076.

[9] Potting soil, Scotts-Sierra Horticultural Products Company, 14111 Scottslawn Road, Marysville, OH 43041.

[10] Spray chamber, De Vries Manufacturing, Hollandale, MN 56045.

10^{-1}, were only applied to the cotton plants. Similarly, the two lowest rates, 5×10^{-5} and 1×10^{-5}, were only applied to the soybean plants. These occlusions were based on plant responses recorded during preliminary trials. The plants were evaluated 1, 5, 9, and 14 d after treatment (DAT) using the scale outlined by Sciumbato et al. (2004) with one-leaf and one-stem evaluation being recorded for each pot. The greenhouse rate–response experiment was performed twice, and the test plants were destroyed after the 14-d evaluation periods.

Field. Data for the field-injury curve were collected at the Texas A & M Agronomy Field Laboratory near College Station, TX. Delta Pine 50 cotton and Delta Pine 415 soybean were planted in four-row plots on a Belk clay (Entic Hapluderts). The fungicide metalaxyl[11] [*N*-(2,6-dimethylphenyl)-*N*-(methoxyacetyl) alanine methyl ester] and the insecticide phorate[12] {*O*,*O*-diethyl *S*-[(ethylthio) methyl] phosphorodithioate} were applied at planting followed by a preemergence application of pendimethalin[13] at 0.47 kg/ha for weed control. The plots were furrow irrigated as needed, and postemergence weed control was performed through tillage or hand hoeing.

All herbicide treatments were applied in 187 L/ha carrier volume using a CO_2 backpack sprayer when the test plants reached the four- to six-leaf stage. Herbicide rates were identical to those used to produce the greenhouse-injury curves and are listed in Table 1. Plastic tarps were held around each plot receiving the herbicide application to reduce the risk of spray particles moving off target and contaminating other plots. Five test plants were then selected randomly in each plot and evaluated 1, 5, 9, and 14 DAT using the evaluation method outlined by Sciumbato et al. (2004). One-leaf and one-stem evaluation was made for each of the five plants. The field rate–response experiment was carried out four times, and the plots were destroyed after each 14-d evaluation period.

Equation Estimation. Injury curve establishment was done identically for greenhouse and field data. First, rate–response data were transformed using Equation 1 and graphed in scatter plots with the natural log of the rates on the *x* axis. The natural log transformation was used on the *x* axis because differences between herbicide rates were often an order of magnitude. The arcsine transformation was used for injury data because most scatter plots were sigmoid after this transformation.

$$\text{DAT injury} = \text{ARCSINE}\left(\sqrt{\frac{\frac{\text{leaf injury} + \text{stem injury}}{2}}{100}}\right) \qquad [1]$$

Next, parameters of Equation 2 (Seefeldt et al. 1995) were estimated using the SAS secant method (DUD method) of nonlinear regression modeling (SAS 1985) until the best possible fit of equation line to injury data was obtained for each treatment at each DAT.

$$Y = C + \frac{D - C}{1 + (X/I_{50})^{b}} \qquad [2]$$

In Equation 2, D represents the response of the plants at low herbicide rates, C denotes the response of the plants at high herbicide rates, b is the slope, and I_{50} is the herbicide rate that caused 50% of the total plant response. Because this was a nonlinear regression procedure, the fit of the model to the data was determined using residual plot analysis.

Quantitation of Volatility. *Greenhouse.* Herbicide volatilization and drift were produced in the greenhouse using volatility chambers (Figure 1). These chambers directed air at a constant speed first over bermudagrass (*Cynodon dactylon* L. Pers. CYNDA) sod that had been treated with 2,4-D, dicamba, or triclopyr, then through the canopies of cotton and soybean indicator plants placed downwind, and finally out of the greenhouse. The wind speed was maintained at 3.2 km/h and monitored using hot-wire anemometers.

Delta Pine 50 cotton and Delta Pine 415 soybean to be used as indicator plants were grown in a greenhouse at the seeding rate of three plants per pot using 15-cm plastic pots. The growth medium was a 3:1 (v/v) mixture of Pro-Mix and Redi-Earth. Greenhouse conditions were 10 h of darkness at 23 C (±3 C) and 14 h of light at 29 C (±3 C). One fertilizer application of $N:P_2O_5:K_2O$ 20:20:20 was made 1 WAE at a rate equivalent to 23 kg of N, P, and K/ha, and irrigation was performed as needed.

The flats of bermudagrass sod used in the chambers were 42 by 23 cm and were maintained in the greenhouse for 2 mo before the experiment. The grass was cut to 7 cm before treatment. Each herbicide and water alone as a control was applied to two bermudagrass flats when the cotton and soybean indicator plants reached the four- to six-leaf stage. The herbicides were applied in carrier volumes of 187 L/ha using the same spray cham-

[11] Ridomil® fungicide, Syngenta Crop Protection, Inc. P.O. Box 18300, Greensboro, NC 27409.
[12] Thimet® insecticide, BASF Corporation, Agricultural Products Group, Research Triangle Park, NC 27709.
[13] Prowl® herbicide, BASF Corporation, Agricultural Products Group, Research Triangle Park, NC 27709.

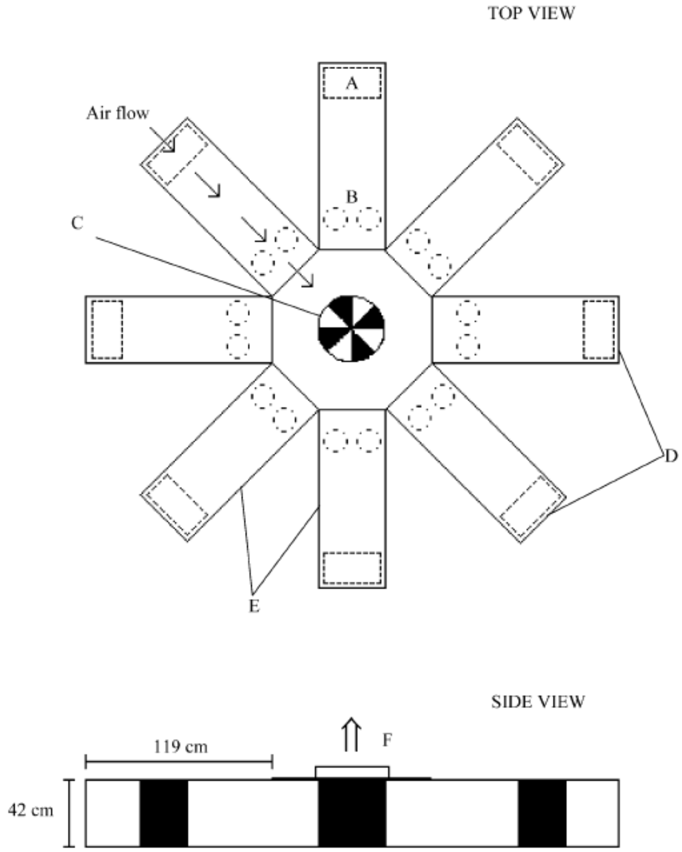

Figure 1. A diagram of the volatility chambers used in the greenhouse-volatility experiment. Air enters the assembly through the outermost openings of the air ducts and exits through the fan near the top. Flexible ducting was used to route exhaust outside the greenhouse. Legend: A = treated bermudagrass, B = indicator plants, C = exhaust fan, D = air intake, E = air ducts (chambers), and F = exhaust to outside.

ber that was used to create the rate–response curves. Herbicide rates were 2 times the normal use rates, or 1.06, 1.12, and 2.24 kg/ha of 2,4-D, dicamba, and triclopyr, respectively.

One hour was allowed to pass after the herbicide applications were made and before the flats were placed in the drift chambers so that spray droplets would disperse and all herbicide movement could be attributed to volatilization. As soon as the hour had elapsed, one bermudagrass flat was placed at the intake end of each volatility-chamber duct. In addition, one cotton and one soybean pot were inserted 40 cm downwind in each chamber (Figure 1). This configuration provided a total of two cotton and two soybean replications for each herbicide treatment. The cotton and soybean were left in the airflow of the chambers for 48 h, whereupon they were removed and evaluated 1, 5, 9, and 14 d after exposure. One-leaf and one-stem evaluation was given for each pot at each DAT. This experiment was carried out four times, and the test plants were destroyed at the end of each 14-d evaluation period.

Field. Herbicide volatility was assessed in the field by placing cotton and soybean indicator plants onto 15 by 15 m range plots that had been sprayed with 2,4-D, dicamba or triclopyr. The plots were populated primarily with bermudagrass and Johnsongrass (*Sorghum halepense* L. Pers. SORHA). Delta Pine 50 cotton and Delta Pine 415 soybean plants were grown in 15-cm plastic pots at populations of three plants per pot. The growth medium was composed of a 3:1 (v/v) mixture of the Belk clay from the field rate–response experiment location and Redi-Earth potting soil. Indicator plants to be used in the field-volatility experiment were maintained in outdoor conditions, and water was supplied as needed. One application of N:P_2O_5:K_2O 20:20:20 was applied 1 WAE at the NPK rate of 23 kg/ha.

Volatility plots were mowed to a uniform height of 8 cm when the indicator plants reached the four- to six-leaf stage. A tractor-mounted spray boom was used to apply 1.06, 1.12, or 2.24 kg/ha of 2,4-D, dicamba, or triclopyr, respectively. One hour was allowed to elapse between the herbicide application and test plant placement so that spray particles could disperse. Five pots of each indicator species were then placed inside the treated plots. Eight cotton plants were also placed in 3.5-m buffer zones around each plot to monitor movement of herbicides outside the plots. The plants were left inside the plots for 48 h and then collected for evaluation. Plant injury was recorded 1, 5, 9, and 14 d after collection with one-leaf and one-stem injury value being assigned per pot. The experiment was carried out four times, and the plants were destroyed at the end of each 14-d evaluation period.

Equation Application. Plant injury values resulting from herbicide volatilization during the field and greenhouse-volatility experiments were applied to the rate–response curves to calculate herbicide exposure rates. Injury values from the

$$\mathrm{Log}(X) = \frac{\ln\left(\frac{D - C}{Y - C} - 1\right) + \log(I_{50})}{b} \qquad [3]$$

greenhouse-volatility experiment were applied to the greenhouse rate–response curves. Similarly, injury from indicator plants used in the field-volatility experiment was applied to field rate–response curves.

Volatility data were transformed as before using Equation 1 and inserted into Equation 3 as Y along with the

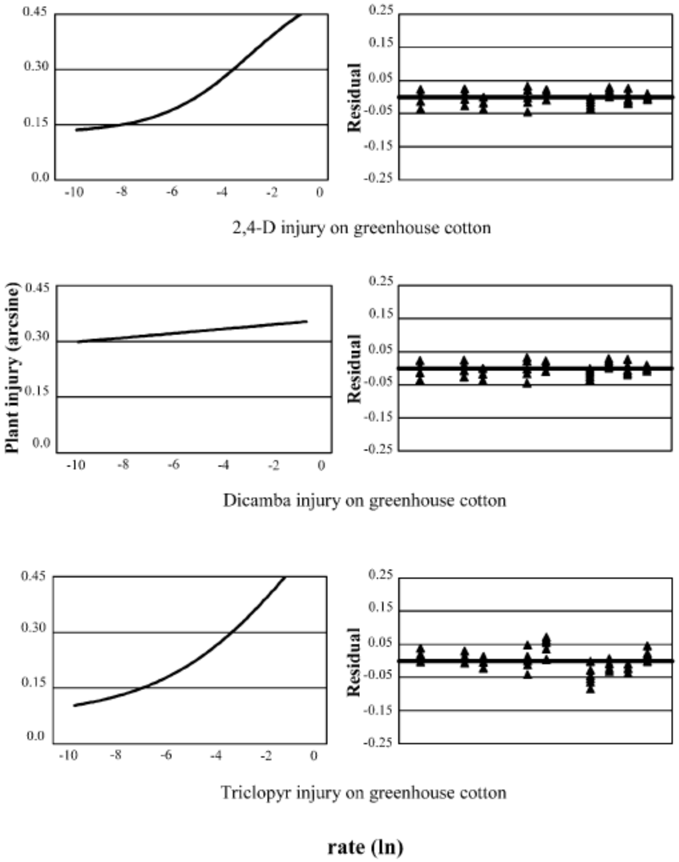

Figure 2. Model lines and residual graphs for 2,4-D, dicamba, and triclopyr injury on cotton recorded 14 d after treatment. The cotton plants were grown and maintained in a greenhouse and treated with reduced rates of the herbicides during the four- to six-leaf stage of growth.

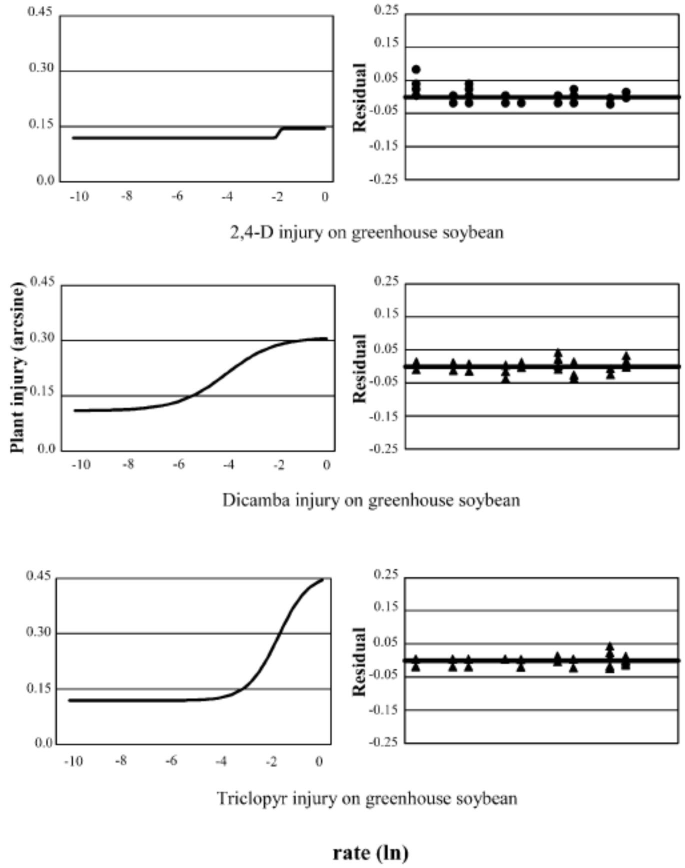

Figure 3. Model lines and residual graphs for 2,4-D, dicamba, and triclopyr injury on soybean recorded 14 d after treatment. The soybean plants were grown and maintained in a greenhouse and treated with reduced rates of the herbicides during the four- to six-leaf stage of growth.

parameters that were obtained through SAS from the rate–response curves. The equations were then solved, providing herbicide-rate estimations that corresponded with recorded visual injury. Results were analyzed using SAS with mean separations performed using Fisher's LSD at $P = 0.05$.

RESULTS AND DISCUSSION

Rate–Response Curves. Extreme variability in plant responses to the herbicides in both environments before 14 DAT made the modeling of early data difficult. Therefore, only the modeling results for 14-DAT data are presented in this study. The model lines and residual graphs for each herbicide on greenhouse cotton and soybean are shown in Figures 2 and 3, respectively. Model lines and residual graphs for each herbicide on field cotton and soybean are listed in Figures 4 and 5, respectively. Injury observed in the greenhouse was generally less variable than that from the field. This difference is obvious when the residual graphs from greenhouse and field injury are compared (Figures 2–5). Equation parameters for these models are listed in Table 2.

Volatility. Tables 3 and 4 contain herbicide rates estimated using the modeling procedure. Mean separations were performed among herbicide exposure rates (expressed as multiples of the normal use rates) within each species and location. In addition, equivalent rates expressed in kilogram per hectare and volatilization values as percentages of the total herbicide applied were calculated for each treatment. Significant differences were detected among the volatility rates of the herbicides in each environment.

Greenhouse. The greenhouse-volatility results for cotton indicate no difference in herbicide volatilization among the three herbicides (Table 3). Soybean injury results suggest that the herbicide exposure rate of dicamba was lower than that of the other two herbicides (Table 3). The DMA salt of 2,4-D was more volatile than the DGA salt of dicamba but less volatile than BEE triclopyr. The triclopyr ester tended to produce high herbicide exposure

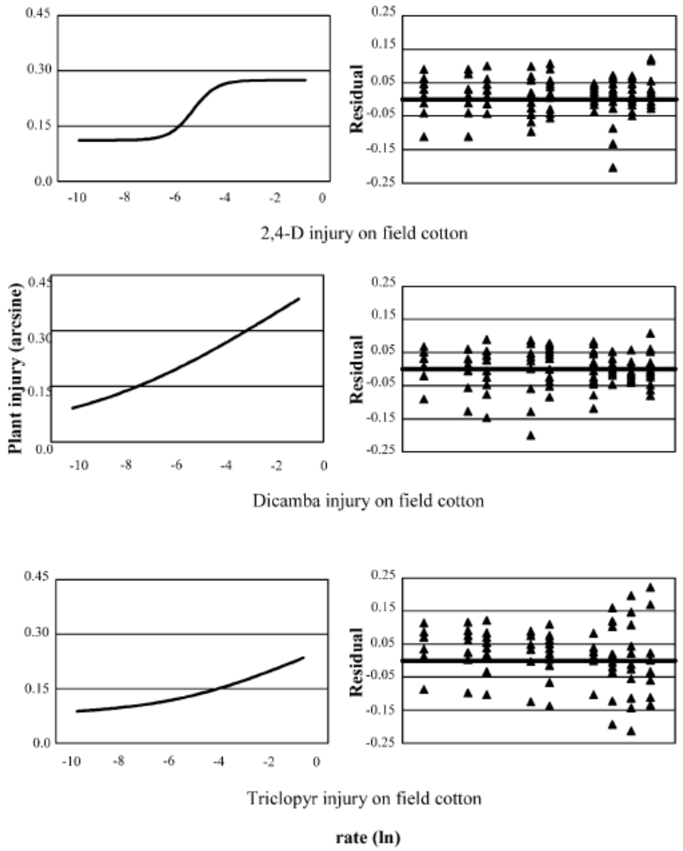

Figure 4. Model lines and residual graphs for 2,4-D, dicamba, and triclopyr injury on cotton plants 14 d after treatment. The cotton plants were grown and maintained under field conditions and treated with reduced rates of the herbicides during the four- to six-leaf stage of growth.

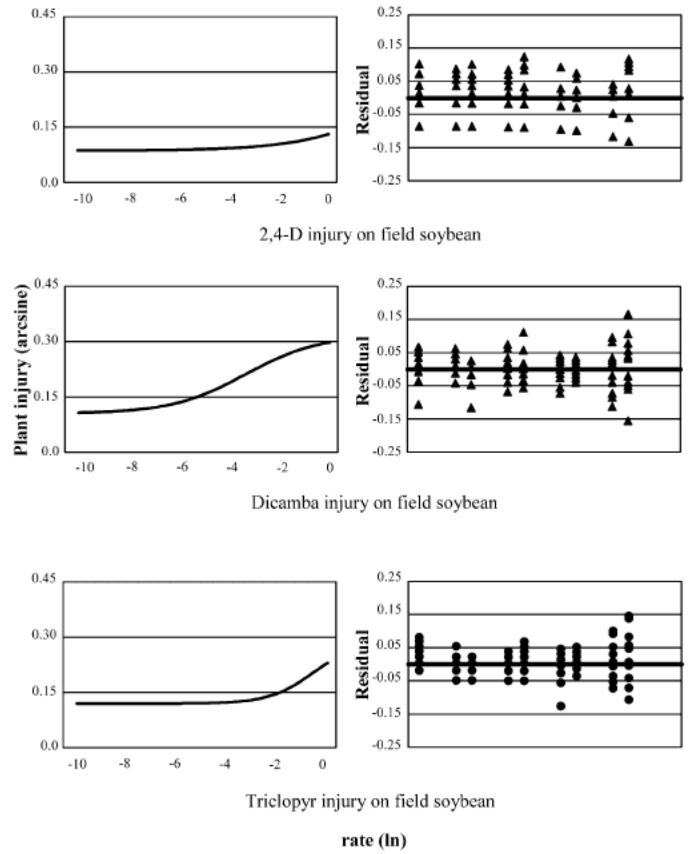

Figure 5. Model lines and residual graphs for 2,4-D, dicamba, and triclopyr injury on soybean plants 14 d after treatment. The soybean plants were grown and maintained under field conditions and treated with reduced rates of the herbicides during the four- to six-leaf stage of growth.

Table 2. Equation parameters used to produce rate–response curves for 2,4-D, dicamba, and triclopyr on cotton and soybean.

			Equation parameter			
Herbicide	Species	Location	D[a]	I_{50}[b]	C[c]	b[d]
2,4-D	Cotton	Greenhouse	0.127451804	0.058282629	0.553188598	0.615002368
		Field	0.111256753	0.006530843	0.274637140	2.346593855
	Soybean	Greenhouse	0.14471091	0.01884355	0.11889786	−27.7838911
		Field	0.085808708	2.650930326	0.412926810	0.560964401
Dicamba	Cotton	Greenhouse	0.127456222	0.058289464	0.553197713	0.615006164
		Field	0.000000036	0.204063510	0.710261595	0.252187506
	Soybean	Greenhouse	0.109684117	0.002548099	0.309249972	1.113252520
		Field	0.105134999	0.004593443	0.316954681	0.746412742
Triclopyr	Cotton	Greenhouse	0.071783946	0.503525162	0.971210467	0.388578618
		Field	0.074766650	0.328585818	0.382724099	0.388538078
	Soybean	Greenhouse	0.118560852	0.019842014	0.463636067	1.788452643
		Field	0.119530719	0.060349614	0.290065472	1.223556518

[a] D, plant response at low rates.
[b] I_{50}, herbicide rate causing 50% of the total plant response.
[c] C, plant response at high rates.
[d] b, slope.

Table 3. Greenhouse herbicide exposure rates estimated for cotton and soybean 14 d after exposure.

Crop	Herbicide	Estimation[a]	Equivalent rate[b]	Volatilization[c]
		×	kg/ha	%
Cotton	2,4-D	0.003 a[d]	0.0016	0.1500
	dicamba	0.001 a	0.0006	0.0500
	triclopyr	0.049 a	0.0549	2.4500
Soybean	2,4-D	0.014 b	0.0074	0.7000
	dicamba	0.001 c	0.0006	0.0500
	triclopyr	0.025 a	0.0280	1.2500

[a] Concentation of herbicide exposure rate expressed as a multiple of the normal use rates of 0.53 kg/ha of 2,4-D, 0.56 kg/ha of dicamba, and 1.12 kg/ha of triclopyr.

[b] Exposure rate expressed in kilograms per hectare.

[c] Volatilization percentage calculated by dividing the equivalent rate by the total amount of the herbicide applied.

[d] Values with the same letter are not significantly different from one another at the 5% level of significance.

Table 4. Field herbicide exposure rates estimated for cotton and soybean 14 d after exposure.

Crop	Herbicide	Estimation[a]	Equivalent rate[b]	Volatilization[c]
		×	kg/ha	%
Cotton	2,4-D	0.004 a[d]	0.0021	0.2000
	dicamba	0.002 a	0.0011	0.1000
	triclopyr	0.125 b	0.1400	6.2500
Soybean	2,4-D	0.160 a	0.0848	8.0000
	dicamba	0.010 c	0.0056	0.5000
	triclopyr	0.110 b	0.1232	5.5000

[a] Concentation of herbicide exposure rate expressed as a multiple of the normal use rates of 0.53 kg/ha of 2,4-D, 0.56 kg/ha of dicamba, and 1.12 kg/ha of triclopyr.

[b] Exposure rate expressed in kilograms per hectare.

[c] Volatilization percentage calculated by dividing the equivalent rate by the total amount of the herbicide applied.

[d] Values with the same letter are not significantly different from one another at the 5% level of significance.

rates in the greenhouse, although this value was only significant with soybean.

Field. No injury was found on cotton plants placed in the buffer zones of the field-volatility plots, therefore all injury observed on test plants placed inside the plots was considered to be the result of volatility from that plot. The most obvious difference in herbicide-volatilization injury to field cotton was between the 2,4-D and dicamba salts and the triclopyr ester (Table 4). The exposure rates of the DGA salt of dicamba and the DMA salt of 2,4-D did not differ significantly with field cotton. However, both herbicides were less volatile than BEE triclopyr.

Volatility injury on field soybean was different from that of field cotton (Table 4). There were significant differences among the volatility rates of all three herbicides, with the DGA salt of dicamba producing significantly lower exposure rates than the other herbicides in field soybean. However, unlike what was observed in the greenhouse, the DMA salt of 2,4-D appeared to be the most volatile of the three compounds in field soybean.

This is difficult to explain because all field cotton and soybean plants received the same herbicide exposure rate during each replication. A difference in herbicide uptake because of leaf surface area is not likely. If soybean plants absorbed more of the herbicides because of surface area, all three herbicides would have increased activity proportional to that observed in cotton. This was not the case because the DGA salt of dicamba caused less injury than the DMA salt of 2,4-D. The contrast could be explained by the relative difficulty in evaluating soybean injury when compared with cotton (Sciumbato et al. 2004). The more prominent petioles and larger leaf margins of cotton make injury to that species easier to record. That difference between species could translate to different evaluations of injury brought about by identical herbicide exposure, therefore different volatilization estimates.

Volatility estimations from field data tended to be greater than those obtained from greenhouse data. This difference can be explained by the contrast between greenhouse and field conditions. High temperatures have been shown to promote herbicide volatility (Behrens and Lueschen 1979), and temperatures recorded during the field study were sometimes greater than 38 C whereas greenhouse temperatures never exceeded 29 C.

The position of the test plants relative to the herbicide source may also explain some of the difference between field and greenhouse injury. Herbicide fumes may have risen from the treated surface up through the plant canopies in the field experiment, exposing the numerous stomata found on lower leaf surfaces to an upward movement of herbicide vapor. In contrast, test plants that were placed in volatility chambers were exposed to herbicide vapors moving horizontally, which may have limited the amount of herbicide retained and absorbed on plant surfaces resulting in less injury.

Modeling Procedure Evaluation. The modeling procedure used in this study was effective for calculating herbicide rates that corresponded to injury from rate–response curves. Herbicide-rate estimates produced by the models were reasonable for the observed injury. However, the discrepancies between rates calculated from cotton and soybean suggest that difficulties in species evaluations can have significant effects on volatilization estimates.

The volatility chambers provided a reliable and effective method of simulating field volatility and off-target movement of herbicides. The use of the volatility chambers can easily be expanded to include other herbicides and treated surfaces. In addition, the drift chambers could be effective tools for particle-drift research after modification. Estimates of greenhouse volatility tended to be less than that from the field. The most likely explanation for this is the difference between greenhouse and field temperatures. Future research gathering yield data from plants treated with these herbicides will be necessary before it will be possible to predict the effect of drift on crop yield.

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Dicamba Injury to Soybean

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ABSTRACT

Dicamba (3,6-dichloro-2-methoxybenzoic acid) effectively controls many dicotyledonous weeds, but nontarget species such as soybean [*Glycine max* (L.) Merrill] are susceptible to spray or vapor drift. Field studies were conducted on a Canfield silt loam (fine-loamy, mixed, mesic Aquic Fragiudalf) soil to determine the response of 'Elf' and 'Williams' soybean to dicamba over a wide range of applied rates, and to evaluate the use of dicamba injury symptoms to predict yield reductions. Soybean yield in response to increasing rates of dicamba was described by equations of the form $y = A\exp(-bx)$, where y = yield, A = maximum yield (rate = 0 g ha^{-1}), b is a constant, and x = rate of dicamba applied. Height reduction, seed number ha^{-1}, and morphological symptoms of dicamba injury were useful in assessing yield reduction. Except for Elf soybean treated at the midbloom stage, there was no yield reduction without height reduction, regardless of foliar symptoms. Seed number ha^{-1} decreased with increasing rates of dicamba and was closely correlated with yield. Yield reductions greater than 10% were indicated by severe morphological symptoms of injury, such as terminal bud kill, splitting of the stem, swollen petioles, and curled, malformed pods. Other foliar symptoms, such as distinctive crinkling and cupping of the terminal leaves, occurred at rates much lower than those required to cause yield reductions.

DICAMBA effectively controls many dicotyledonous weeds in corn (*Zea mays* L.) and other crops. However, its use may be limited by drift and injury to nontarget species. Soybean is especially sensitive to dicamba, and foliar symptoms can occur at rates as low as 1.0 g ha^{-1} (1). Such symptoms, while highly visible, may not indicate yield loss (1) and rates considerably higher may be required before a decrease in production occurs. Data on the correlation of dicamba drift injury symptoms with actual yield reductions is needed to settle claims when drift does occur.

Behrens and Lueschen (2) devised a scale (0 to 100) to evaluate dicamba drift injury to soybean at the first trifoliate leaf stage. Leaf crinkling, cupping, and malformation, as well as growth suppression and terminal bud injury, were among the symptoms observed. Yield reductions were associated with injury ratings of 60 to 70 or more.

Soybean cultivar and the growth stage at time of dicamba application influence soybean response to dicamba (1,2,9). Soybean appears to be most sensitive to injury while in the flowering stage, where 9 to 11 g ha^{-1} dicamba has reduced yields, compared with prebloom applications that require rates of 56 to 70 g ha^{-1} to reduce yields (1,9). Contrary to studies with dicamba, Smith (8) found greater sensitivity before flowering when 'Lee' soybean was treated with other chlorophenoxy herbicides. Wax et al. (9) noted that this cultivar is determinate and suggested that soybean yield response to dicamba at different stages of growth may depend on whether cultivars are determinate or indeterminate.

Among soybean cultivars that are similarly susceptible to yield losses from dicamba, other differences in response have been observed. Yield reductions of 'Jacques 109' and 'Corsoy' soybean were approximately equal for equivalent rates of dicamba applied at the early bloom stage, but height reductions at specific rates differed markedly (1).

The objectives of this research were (i) to determine the response of Elf and Williams soybean to dicamba over a wide range of applied rates; and (ii) to evaluate the use of dicamba injury symptoms to predict resulting losses in yield.

MATERIALS AND METHODS

Three field studies were conducted in 1980 and 1981 on a Canfield silt loam soil at the Ohio Agricultural Research and Development Center, Wooster, OH. Table 1 summarizes the treatment variables (cultivar, row width, dicamba formulation, growth stages at time of application, and rates) examined for each study.

Fertilizer (40 kg ha^{-1} P and 70 kg ha^{-1} K) was applied to all sites before spring plowing, disking, and seed innoculation and planting of Elf or Williams soybean. Main plots were 3 × 27.5 m (17 rows spaced 0.18 m apart or four rows spaced 0.76 m apart), with a 1-m unplanted border between plots. Seeding rates were 13 seed m^{-1} (0.18 m row spacing) and 33 to 39 seed m^{-1} (0.76 m row spacing) for Elf soybean, and 11.5 seeds m^{-1} (0.18 m row spacing) and 26 to 33 seed m^{-1} (0.76 m row spacing) for Williams soybean. Following planting, 0.45 kg ha^{-1} metribuzin [4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4*H*)-one] and 3.4 kg ha^{-1} alachlor [2-chloro-*N*-(2,6-diethylphenyl)-*N*-(methoxymethyl)acetamide] were applied. Weeds not controlled by preemergence herbicides were removed by hand.

Because dicamba causes morphological changes and yield reductions in soybean over a wide range of rates, a belt-carried CO_2 logarithmic rate sprayer was chosen to simplify experimental operations. The logarithmic sprayer was first described by Pfeiffer et al. (6) in 1955 and is particularly useful for herbicide screening studies (4,7). Dedolph (3) has discussed questions of statistical analysis and validity of data, and described procedures for data analysis from experiments using logarithmic spraying techniques.

Logarithmic applications of dicamba were made using a volume of solution necessary to deliver 12 dilutions, after which the sprayer ceased operation. The dilution rate decreased the concentration of dicamba by 50% (one half-rate) every 1.8 to 2.2 m in the 27.5 m main plots. Proper dilution was verified by applying a KCl solution, and analyzing paper strips placed at 1.8 m intervals for potassium content. The average rate of dicamba applied to each half-rate subplot was calculated to facilitate data analysis. These rates are shown in Table 2 and 3.

All logarithmic treatments were applied in the same direction, instead of being randomized as recommended by

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Dedolph (3), because of concern that slight spray and/or vapor drift might occur between plots. If spraying direction were randomized, drift from subplots receiving the highest rates of over 100 g ha^{-1} dicamba might be greater than the actual amount (< 0.1 g ha^{-1}) applied to a neighboring low-rate subplot. The low rate might not produce foliar symptoms, while the low rate plus drift from the neighboring high-rate subplot might show these symptoms, confounding the results. Control plots of both cultivars were present in each replication. These were divided into 12 subplots similar to the treated plots for observation and harvest. No significant variation occurred across these main nonsprayed plots for either plant height or yield. This indicates that soil and growing conditions were similar across the blocks.

Precautions were taken to prevent drift. Dicamba was applied under calm conditions during moderate temperatures. As a result, little drift actually occurred. As estimated by the severity of foliar symptoms on untreated plants 0.5 m from plants receiving the highest applied rates of dicamba, drift was less than 0.25 of 1% of the amount applied. Given the 0.5 m unsprayed border on each main plot, and the 1 m unplanted border between main plots, drift between main plots was insignificant, and within main plots, drift of this magnitude would not significantly change the applied rates.

Soybean injury was assessed by measurement of height (average of three randomly selected plants per subplot), percentage stand reduction, and the presence or absence of several distinct morphological symptoms of herbicide injury; foliar aberrations, terminal bud injury, pod malformation, petiole enlargement, twisting of plant tops, splitting of the stem, canopy closure, and delayed maturity. For each symptom there was a threshold rate below which it did not occur, a small range of rates where some plants were slightly affected, and a rate above which all plants were affected. Evaluations were based on this latter rate.

The center 1.4 m (eight rows spaced 0.18 m apart) or 1.5 m (two rows spaced 0.76 m apart) of each subplot was machine harvested. Seed weight was determined for 100 randomly selected seed per sample. The number of seed produced per hectare was calculated from yield and 100 seed weight. All yields and 100 seed weights were adjusted to 135 g kg^{-1} moisture content.

Logarithmic Rate Study

The initial study was conducted to correlate yield reductions from dicamba injury with morphological symptoms, over a wide range of applied rates. Elf (a semi-drawf determinate cultivar) and Williams soybean (an indeterminate cultivar) were treated at the late prebloom (41 DAP, days after planting) and midbloom (78 DAP) stages of growth. Rates were chosen to produce the complete range of dicamba injury to soybean, from complete kill to no effect. The experiment was arranged in a randomized complete-block design with three replications. The experimental site was planted 7 May 1980.

Observations were made at 1.8 m intervals along the main plots. Effects of prebloom treatments were evaluated approximately 5 and 10 wk after application. Effects of midbloom treatments were observed approximately 10 wk after application. The times chosen for evaluation allowed for full development of injury symptoms. Significant recovery from injury occurred following prebloom applications, and this was assessed in the 10 wk evaluation.

The subplots receiving the two highest rates of dicamba were hand harvested because of reduced plant height.

Discrete Rate Study

A discrete rate study was conducted to verify the results obtained in the logarithmic rate study. In addition, row width was incorporated as a treatment variable along with cultivar and stage of growth at application. Main treatments consisted of all combinations of cultivars, growth stage at application, and row widths. They were arranged as a randomized complete block in three replications. Subplots received six rates of dicamba including a control. Rates ranged above and below the minimum rate required for yield reduction in 1980, with the median rate being the highest rate that did not reduce yields in 1980. Because of differences in 1980 for cultivars and times of application, four sets of rates were chosen. These are listed in Table 1.

Dicamba was applied to the subplots in strips 4.0 m long, leaving 0.6 m borders. Discrete rates were applied by filling both the concentrate chamber and the diluent tank of the sprayer with the same herbicide solution. Late prebloom treatments were applied 52 DAP, immediately before flowering. Midbloom treatments were applied 70 DAP, when plants were blooming and the first pod was up to 20 mm long. The harvested subplot length was 3.4 m.

Prebloom treatments were evaluated 1, 2, and 6 wk after application, and midbloom treatments 2 and 6 to 7 wk after application. The 1 and 2 wk evaluations were included to better quantify the development of injury symptoms with time. A later (10 wk) evaluation of prebloom treatments was unnecessary because droughty conditions reduced growth and recovery from injury did not occur as in 1980.

Formulation Study

This study was conducted to determine whether there was any difference in the effects of dicamba dimethylamine (DMA) and Na salts on soybean at a specific stage of growth.

Table 1. Summary of treatment variables and herbicide rates examined.

Experiment	Cultivars	Row width (m)	Dicamba formulation	Time of application	Type of application	Rates, g active ingredient ha^{-1}	Evaluation of injury
Logarithmic rate study (1980)	Elf, Williams	0.18	DMA†	Pre- and midbloom	Logarithmic	0.028–115	5 WAT‡ (Pre-, midbloom) 10 WAT (Prebloom)
Discrete rate study (1981)	Elf, Williams	0.18, 0.76	DMA	Pre- and midbloom	Discrete	0, 0.32, 5.0, 11, 40, 81 (Elf prebloom) 0, 0.32, 5.0, 22, 71, 110 (Elf midbloom) 0, 0.64, 10, 20, 40, 81 (Williams prebloom) 0, 0.32, 2.5, 9.5, 20, 81 (Williams midbloom)	1, 2, 6 WAT (Prebloom) 2, 6-7 WAT (Midbloom)
Formulation study (1981)	Williams	0.18	DMA, Na§	Midbloom	Logarithmic	0.056–460	2, 6–7 WAT

† DMA = Dimethylamine salt.
‡ WAT = Weeks after treatment.
§ Na = Sodium salt.

The initial rate was increased to 460 g ha⁻¹ because complete kill had not been obtained in the Logarithmic Rate Study at 115 g ha⁻¹. The experimental design was a randomized complete block with three replications. Three main treatments consisted of each herbicide plus an untreated control. Williams soybean was planted on 22 May and flowering began 14 to 16 July 1981. Treatments were applied on 24 July 63 DAP, during the midbloom growth stage. Detailed ob-

Table 2. Effect of dicamba treatment at the prebloom and midbloom stages of growth on yield and morphology of two soybean cultivars (Elf and Williams) planted in 0.18 m rows (Logarithmic study, 1980).

Average dicamba rate (g ha⁻¹)	Yield† (Mg ha⁻¹)		Height (% of control)		Terminal leaf morphology‡																		Plant morphology			
					CRK		CUP		LS<		LS>		LM<		LM>		DST		TT		TBK		POD		SR	
Elf soybean																										
	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid
0.04	4.07	3.76	111	107	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
0.08	3.42	3.01	107	104	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
0.16	3.32	3.64	102	101	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
0.32	3.22	3.70	100	102	+	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−
0.63	3.38	3.66	98	109	+	−	+	−	+	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−
1.3	3.31	2.93	95	110	+	+	+	−	+	−	−	−	+	−	−	−	+	−	−	−	−	−	−	−	−	−
2.5	3.29	3.22	80	109	+	+	+	+	+	+	−	−	+	+	−	−	+	−	−	−	−	−	−	−	−	−
5.0	3.45	3.84	71	106	+	+	+	+	+	+	−	−	+	+	−	−	+	−	−	−	−	−	−	−	−	−
10	3.62	3.81	63	102	+	+	+	+	+	−	−	+	+	+	−	−	+	−	−	−	−	−	−	−	−	−
20	2.61	3.53	61	94	+	−	+	−	+	−	−	−	+	−	−	−	+	−	−	−	+	+	−	−	−	−
40	2.61	3.35	47	88	+	−	+	−	−	−	+	−	−	−	+	−	+	−	−	−	+	+	−	−	+	−
80	2.20	2.19	38	82	+	−	+	−	−	−	+	−	−	−	+	−	+	−	−	−	+	+	−	+	+	−
Control§	3.37		0.56m	0.82m																						
R^2¶	0.55	0.23	0.86	0.92																						
Williams soybean																										
	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid	Pre	Mid
0.04	3.29	3.90	92	98	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
0.08	3.23	3.25	95	100	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
0.16	3.39	3.73	97	106	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
0.32	3.69	3.23	92	104	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
0.63	3.76	3.12	83	102	+	−	+	−	+	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−
1.3	3.35	3.88	84	100	+	−	+	−	+	−	−	−	+	−	−	−	+	−	−	−	−	−	−	−	−	−
2.5	3.48	3.23	78	96	+	−	+	−	+	−	−	−	+	+	−	−	+	−	−	−	−	−	−	−	−	−
5.0	3.33	3.76	66	92	+	−	+	−	+	−	−	+	+	+	−	−	+	−	−	+	−	−	−	−	−	−
10	3.42	3.26	66	92	+	−	+	−	+	−	−	−	−	−	+	−	+	−	−	+	+	+	−	−	−	−
20	3.42	2.68	63	79	+	−	+	−	+	−	−	−	−	−	+	−	+	−	−	+	+	+	−	+	−	−
40	2.84	2.89	50	74	+	−	+	−	+	−	−	−	−	−	+	−	−	−	−	+	+	+	−	+	−	−
80	2.14	2.76	38	68	+	−	+	−	+	−	−	−	−	−	+	−	−	−	−	+	+	+	−	+	−	−
Control§	3.59		0.57m	1.0m																						
R^2*	0.46	0.39	0.80	0.82																						

* All R^2 values are significant at the 0.05 level.
† Due to loss of yield data from one replicate of both Elf and Williams controls, statistically valid comparisons to control cannot be made.
‡ + = symptom present, − = symptom absent, CRK = crinkling, and CUP = cuppimg of terminal leaves; LS< or LS> = size of terminal leaves reduced < or > 40%; LM< = minor leaf margin damage (<25% of margin); LM> = severe leaf margin damage; DST = gross distortion of leaf venation patterns; TT = twisted tops; TBK = terminal bud kill; POD = curled, malformed pods; SR = stand reduced > 10%. When the terminal bud was killed, any foliar symptoms (CRK, CUP, etc.) occurred on developing lateral shoots. Treatments were evaluated 5 wk after treatment.
§ Control plots received no dicamba application.

Table 3. Effect of dicamba DMA treatment at the midbloom stage of growth on yield and morphology of Williams soybeans planted in 0.18 m rows (Formulation study, 1981).

Average dicamba rate (g ha⁻¹)	Yield (% of control)	Height (% of control)	Maturity delay	Terminal leaf morphology†											Plant morphology				
				CRK	CUP	LS<	LS>	LM<	LM>	DST	TT	TBS	TBK	TBK+	SS	PET	POD	CAN	SR
0.08	98	96	−	+	+	+	−	+	−	−	−	−	−	−	−	−	−	−	−
0.2	94	94	−	+	+	+	−	+	−	−	−	−	−	−	−	−	−	−	−
0.4	87	95	−	+	+	+	−	+	−	−	−	−	−	−	−	−	−	−	−
0.8	89	95	−	+	+	−	+	+	−	−	−	−	−	−	−	−	−	−	−
1.6	101	94	−	+	+	−	+	+	−	−	−	−	−	−	−	−	−	−	−
3.5	86	84	−	+	+	−	+	−	+	−	−	−	−	−	−	−	−	−	−
7.4	86	85	−	+	+	−	+	−	+	−	−	−	−	−	−	−	+	−	−
16	77	75	+	−	−	−	−	−	−	−	−	−	+	−	−	−	+	−	−
33	51	70	+	−	−	−	−	−	−	−	+	−	+	−	−	−	+	−	−
70	23	64	+	−	−	−	−	−	−	−	+	−	+	−	−	−	+	−	−
149	2	54	+	−	−	−	−	−	−	−	+	−	+	+	+	−	+	+	+
316	0	42	+	−	−	−	−	−	−	−	+	−	+	+	+	−	+	+	+
Control‡	2.49 Mg ha⁻¹	0.83 m																	
R^2*	0.93	0.90																	

* All R^2 values are significant at the 0.05 level.
† TBS = terminal bud stunted, TBK+ = more than terminal bud killed, SS = split stems, PET = abnormal enlargement of petioles, CAN = loss of canopy closure. For other symptoms, see Table 2. Data for the dicamba Na treatment showed no differences from the dicamba DMA treatment and are not presented.
‡ Control plots received no dicamba application. Treatments were evaluated 7 wk after treatment.

servations of soybean injury were made at approximately 2 and 7 wk after spraying.

Statistical Analysis

All data were subjected to standard analysis of variance and regression procedures. The Gauss-Newton method of iteration was used for nonlinear regression. All comparisons made are significant at the 5% probability level, unless noted otherwise.

RESULTS AND DISCUSSION

Yield

Soybean yield response to increasing rates of dicamba is described by equations of the form $y = A\exp(-bx)$, where y = yield, A = maximum yield (rate = 0 g ha^{-1}), b is a constant, and x = rate of dicamba applied (Fig. 1).

Equations were fitted by the modified Gauss-Newton method of iteration because normal probability plots of residuals indicated that the appropriate model is $y = A\exp(-bx) + \xi$, rather than $y = A\exp(-bx) \times \xi$, where ξ represents sampling error. Were the latter model correct, the data could be analyzed more simply by taking the natural logarithm of both sides of the equation, which gives the equation for a straight line.

Data from other studies also suggest an exponential decrease in soybean yield with increasing rates of dicamba (1,9). However, data in those studies were evaluated not by determining yield-response curves, which is more appropriate when treatments vary levels of a quantitative factor (5), but by multiple comparison procedures.

For the variables studied, differences between dicamba treatments in their effect on yield were minor (see Table 2). Differences in yield reductions caused by prebloom and midbloom applications were less than previous reports (1,9). This may have been due to later application of the prebloom treatments in our studies. No difference in yield reductions was seen between the dicamba DMA and Na formulations ($F = 0.21$, $Pr > F$ = NS).

Row width had a small but significant effect on yield reductions caused by dicamba treatment. At rates above 1 g ha^{-1}, yields of soybean in 0.18 m rows were as much as 10% lower than yields of soybean in 0.76 m rows (Because of length, most data from the discrete rate study are not presented, but are available from the senior author on request). At the time of spraying, soybean planted in 0.18 m rows had formed a complete canopy, while those planted in 0.76 m rows had not. Thus a higher percentage of the dicamba spray was probably intercepted by foliage in 0.18 m rows than in 0.76 m rows. At the rates used, dicamba that did not contact the foliage was considered to have a negligible effect.

Yield reductions were not as great in 1980 as in 1981 for equivalent rates of dicamba. In 1980, at least 15 g ha^{-1} dicamba were required for a 10% reduction from maximum observed yields (Table 2). In 1981 rates as low as 1.3 g ha^{-1} dicamba caused a 10% yield reduction (Table 3). This difference is attributed to droughty conditions in 1981 (240 mm less rainfall during June through August) when soybean were less able to recover from dicamba injury. Auch and Arnold (1) also observed that dry conditions following dicamba applications resulted in greater yield reductions.

Components of Yield

Soybean yield is a function of plant population, the number of seed produced per plant and seed weight. Treatment with dicamba affected each of these components of yield.

In both 1980 and 1981 stand reductions occurred at rates of 40 to 80 g ha^{-1} dicamba and above for prebloom applications, and above 150 g ha^{-1} for midbloom applications (Table 2 and 3). In 1980 stand reductions of approximately 30% were associated with yields reduced 20 to 40% of maximum observed yields. Under droughty conditions in 1981, stand reductions were associated with yields already greatly reduced by other factors.

Seed number was closely correlated with yield in both 1980 and 1981. The number of seed produced per hectare (a function of plant population and the number of seed produced per plant) decreased as much as 95 to 100% with increasing rates of dicamba. Figure 2 summarizes the regression analysis of mean values of seed number ha^{-1} and yield for all treatments in the

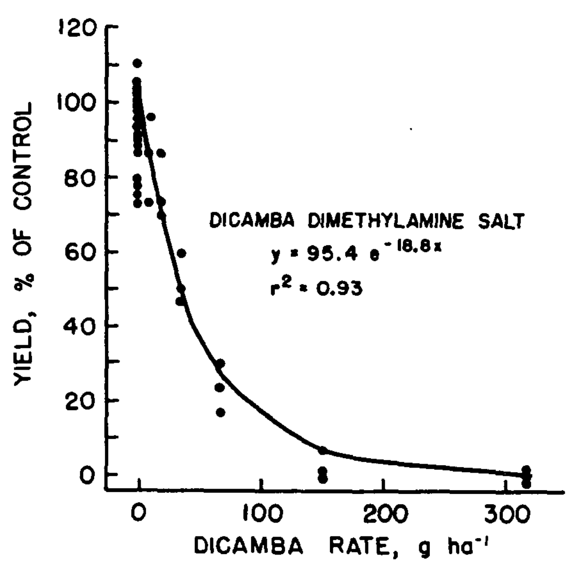

Fig. 1. Yield-rate response curve for midbloom applications of dicamba dimethylamine salt in the formulation study.

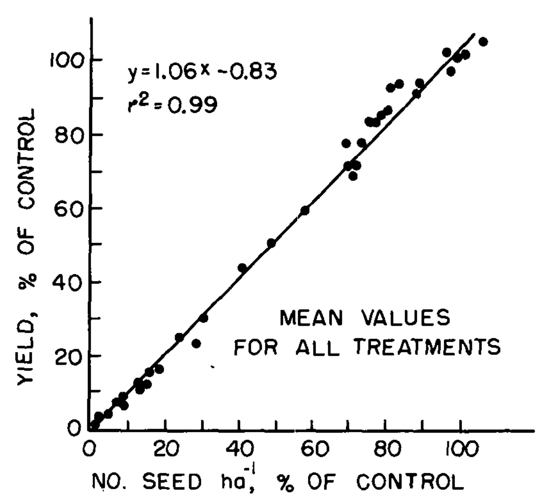

Fig. 2. Relationship of yield and number seed ha^{-1} for all treatments in the discrete rate study.

discrete rate study. The slope was approximately 1.0. Similar results were observed in the logarithmic rate study ($y = 0.912x + 9.84$, $R^2 = 0.93$) for all treatments except Elf soybean treated prebloom, which did not show any decrease in seed number at the highest applied rates. Thus, the primary component of soybean yield affected by dicamba applied shortly before or during flowering appears to be seed number.

At higher rates, dicamba affected seed weight (Fig. 3a and 3b). Midbloom applications of dicamba above 30 g ha^{-1} increased seed weight approximately 2 g 100 seed^{-1} in 1980 (Fig. 3a). This increase in seed size is probably due to the reduction in the number of seed produced. Prebloom treatment with dicamba reduced Elf soybean seed size (Fig. 2b). This was the primary component of yield affected for this treatment. Seed number was not reduced because the plants produced many lateral shoots and set the same number of seed as untreated plants.

Height

Low rates of dicamba did not reduce soybean height. Height was reduced as much as 62% by higher rates of dicamba (Table 2 and 3). Quadratic equations described the relationship of height and log rate of dicamba applied (Fig. 4). For midbloom treatments, the effect of dicamba on height was similar in both 1980 and 1981. Because little growth occurred following midbloom treatments, there was little change in this relationship from 2 wk after treatment until harvest. With prebloom treatments, however, significant changes in the magnitude of height reductions at a given dicamba rate did occur with time as the plants grew. Also, height reductions from prebloom applications were greater in 1981 than in 1980, when higher rainfall levels facilitated recovery from dicamba injury (Fig. 4).

The correlation of height with yield was typically high for individual treatments (Fig. 5). Use of height reductions to predict reductions in yield was expected to be a valuable tool in evaluating actual drift injury where the amount of drift in unknown. However, the quantitative relationship of yield and height varied widely between years for both cultivars and times of application (Fig. 4b). Height reduction are, therefore, only a qualitative indicator of dicamba injury.

Plant Morphology

Injury increased with dicamba rate, and at higher rates (> 15 g ha^{-1} in 1980 and 1.3 g ha^{-1} in 1981) dicamba greatly affected the growth and development of soybean plants (Table 2 and 3). Symptoms of severe injury included stand reductions, death of the terminal bud, curled malformed pods, split stems, swollen petioles, and twisting of plant tops.

Foliar aberrations included distinctive crinkling and cupping of the terminal leaves, leaf margin injury, and size reduction. These symptoms, which are understandably worrisome to growers, occurred at rates as low as 0.2 g ha^{-1} in 1980 and 0.06 g ha^{-1} in 1981, much lower than rates required for yield reduction (Table 2 and 3). Foliar injury developed sooner and continued to develop on new growth longer at higher rates of dicamba (data not shown). In the formulation study, symptoms appeared 1 to 2 d after treatment at rates above 100 g ha^{-1}, and after 13 d, foliar symptoms were present at all rates.

Soybean response to dicamba varied depending on growth stage at the time of application. Foliar symptoms were most pronounced and occurred at lower

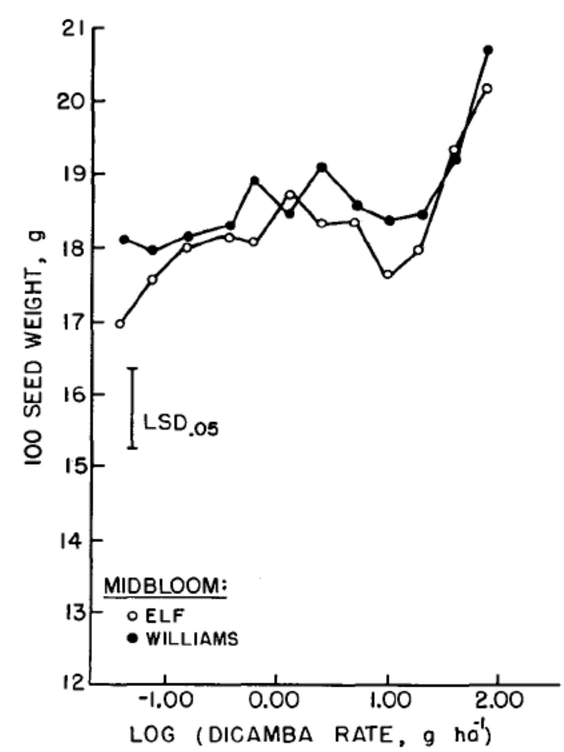

Fig. 3a. Relationship of 100-seed weight and log rate dicamba applied for midbloom treatments in the logarithmic rate study.

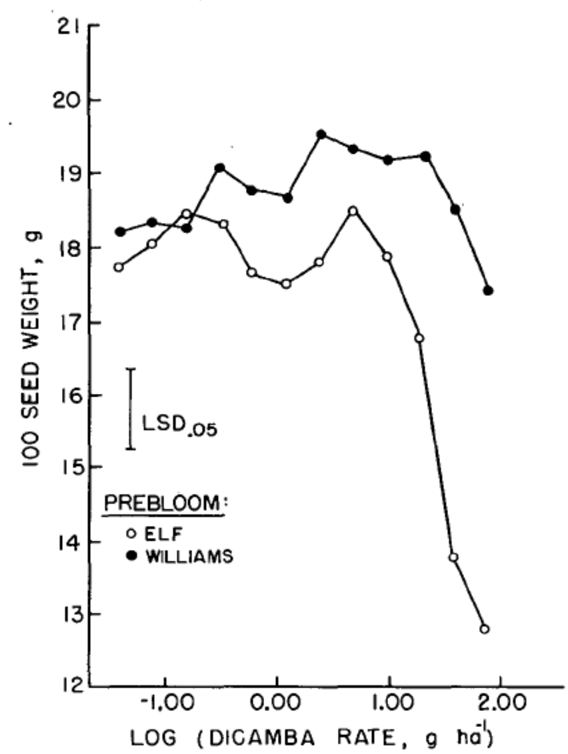

Fig. 3b. Relationship of 100-seed weight and log rate dicamba applied for prebloom treatments in the logarithmic rate study.

Table 4. Tentative criteria for evaluation of drift injury; symptoms associated with yield reductions of less than and greater than 10% of control.

	Symptoms that may be present with yield reductions < 10%†							
Cultivar—Time of treatment	CRK	CUP	LS<	LM<	DST	TT	TBK	NHR§
Williams—Prebloom	+	+	+	+	+			+
Williams—Midbloom	+	+	+		+	+		+
Elf—Prebloom	+	+	+	+	+		+	+
Elf—Midbloom	+	+	+	+		+		

	Symptoms that indicate yield reductions > 10%‡										
	TBS	TBK	TT	SS	PET	POD	CAN	MAT	SR	SDN	HT
Williams—Prebloom	+	+	+	+	+	+	+§		+	+	>15%(0.18m) > 5%(0.76m)
Williams—Midbloom		+		+	+	+		+	+	+	> 5%(0.18m) >10%(0.76m)
Elf—Prebloom		+	+	+	+	+	+	+	+		>10%(0.76m)
Elf—Midbloom				+	+	+	+			+	

† NHR = yields not reduced if there was no height reduction. For definitions of other symptoms, see footnotes of Tables 2 and 3.
‡ HT = height reduction 5 to 10 wk after treatment, and SDN = reduction in seed number ha^{-1} > 10%.
§ 0.18 m rows only.

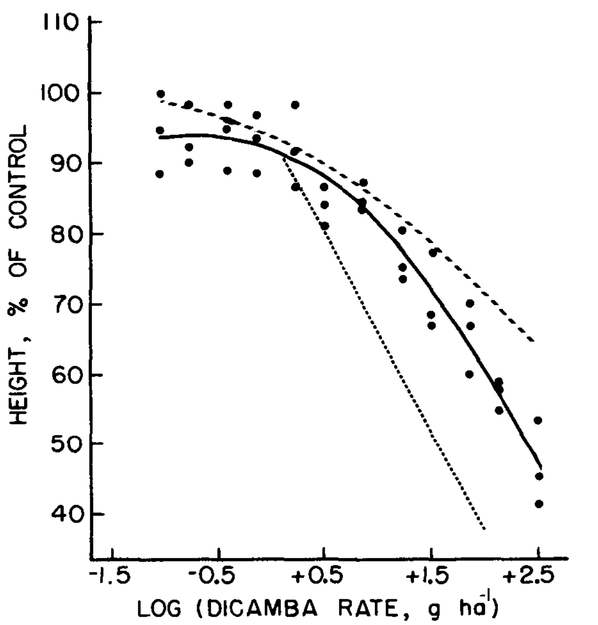

Fig. 4. Relationship of height 7 wk after treatment and log rate dicamba applied for the midbloom dicamba DMA treatment in the formulation study (data points and ——, $y = -4.67x^2 - 6.18x + 91.4$, $R^2 = 0.90$). Height of untreated controls was 0.8 m. Dashed lines indicate height-log rate relationships for Williams soybean in 0.18 m rows treated prebloom in 1980 (10 wk after treatment, ----) and 1981 (6 wk after treatment, · · · ·).

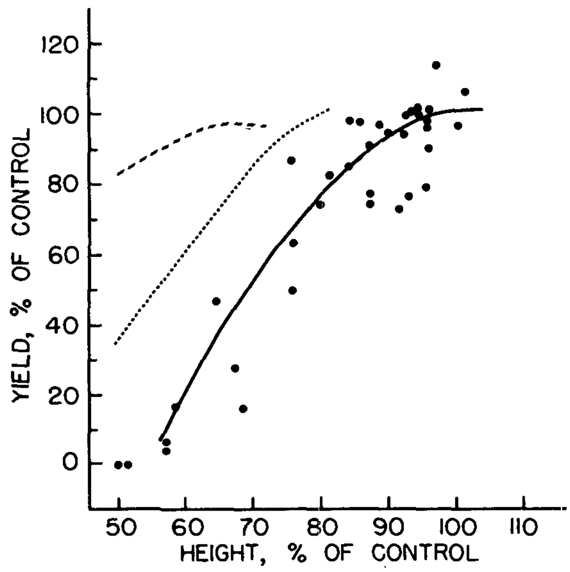

Fig. 5. Relationship of yield and height 7 wk after treatment for midbloom dicamba DMA treatments in the formulation study (data points and ——, $y = -0.0406x^2 + 8.48x - 342$, $r^2 = 0.84$). Yield and height of untreated controls were 2490 kg ha^{-1} and 0.8 m respectively. Dashed lines indicate yield-height relationships for Williams soybean in 0.18 m rows treated prebloom in 1980 (5 wk after treatment, ----) and 1981 (6 wk after treatment, · · · ·).

rates on growing plants treated at the prebloom stage. The fewest symptoms were observed on Elf soybean treated midbloom (Table 2). Elf is a determinate cultivar that ceases vegetative growth after flowering. Following midbloom treatment with dicamba, there was little or no vegetative growth evident on severely injured plants, such as lateral branch formation, and foliar symptoms were largely absent. With prebloom treatments, severe injury and death of the terminal bud occurred at high rates, but these plants formed numerous lateral shoots. These lateral shoots typically showed symptoms of dicamba injury.

The effect of row width on plant morphology was similar to that noted for yield. Morphological aberrations and height reductions were greater in 0.18 m than in 0.76 m rows (data not shown).

Field Evaluation of Drift Injury

The data demonstrate that, for a given treatment in a given year, height reduction and plant morphology are good predictors of yield reductions from dicamba injury. Results of all three studies were compared to develop tentative criteria for the evaluation of drift injury (Table 4). Most foliar symptoms (i.e., crinkling and cupping of the terminal leaves, leaf margin injury and size reduction, and distorted venation patterns) were not indicative of reductions in yield. With the exception of Elf soybean treated at the midbloom stage, there was no yield reduction without height reduction, regardless of any foliar symptoms present. Since Elf is a determinate cultivar, growth in height is essentially complete at the midbloom stage. For all treatments, severe injury symptoms (i.e., terminal bud kill, splitting of the stem, swelling of the petioles, and curled, malformed pods) were associated with substantial reductions in yield.

We feel this approach is useful for evaluating dicamba drift injury to soybeans. Further experiments should be undertaken to validate it under a wider range of environmental conditions.

ACKNOWLEDGMENTS

Statistician Bert Bishop of the Ohio Agricultural Research and Development Center provided helpful suggestions and advice on data analysis.

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Soybean Foliage Residues of Dicamba and 2,4-D and Correlation to Application Rates and Yield

Shane M. Andersen, S. A. Clay,* L. J. Wrage, and D. Matthees

ABSTRACT

Plant growth regulator (PGR) herbicides dicamba (3,6-dichloro-2-methyloxybenzoic acid) and 2,4-D [(2,4-dichlorophenoxy)acetic acid] can severely injure soybean [*Glycine max* (L.) Merr.] by drift or tank contamination and reduce yield. Often in regulatory disputes, tissue is analyzed for PGR residue. However, relationships between grain yield reduction and foliar residue concentrations at various times after exposure are not well documented. This 2-yr study quantified the amount of dicamba and 2,4-D in soybean foliage 0, 6, 12, 24, and 48 d after treatment (DAT) when treated with 1 to 20% of 0.56 kg a.e. ha^{-1} [labeled rate for corn (*Zea mays* L.)] at the three-leaf (V3) stage of growth and determined if these concentrations were correlated to initial application rate or grain yield. Herbicide concentrations were determined using gas chromatography/mass spectrometry techniques with selective ion monitoring. Visual symptoms were slight (<10%) to severe (90%) and included leaf cupping, epinasty and, in some cases, death of the apical bud. Grain yields from dicamba-treated plants were reduced from 14 to 93% compared with untreated plant yield, whereas only 2,4-D at the highest rate reduced yield. In both years, foliar residue concentrations were correlated with initial application rates and yield reduction up to 24 DAT for dicamba and 12 DAT for 2,4-D, with all treatments having residue amounts similar to untreated plants after these intervals. The data suggest that plant samples should be collected as soon as possible after suspected PGR exposure for accurate detection and quantification of PGR residue.

Plant growth regulator herbicides dicamba and 2,4-D are widely used for broadleaf weed control in corn, sorghum [*Sorghum bicolor* (L.) Moench], small grains, and pasture. These two herbicides consistently rank among the top 25 herbicides in annual usage in the United States (USEPA Office of Pestic. Progr., 2002). For example, dicamba was among the five most applied herbicides to corn in the USA during 2001, with 15% of all corn treated with an average of 0.17 kg a.e. ha^{-1} dicamba (USDA National Agricultural Statistics Service, 2002). The active ingredient 2,4-D was applied to about 8% of corn in 2000 at a rate of 0.42 kg a.e. ha^{-1} whereas in spring and winter wheat (*Triticum* spp.), 2,4-D was applied to 45 and 13% of these crops in 2000, respectively.

Soybean is often placed in a rotation with corn and wheat and is highly sensitive to PGR herbicides. The close proximity of soybean fields to areas treated with PGR herbicides increases the risk for soybean exposure by off-target movement from field applications due to particle drift or volatilization (Behrens and Lueschen, 1979; Weidenhamer et al., 1989; Kelley et al., 2002). Small amounts of PGR herbicides left in spray tanks after treating labeled crops also can result in soybean injury. Injury symptoms include leaf cupping, stunting, death of the apical bud, and malformations of the stem (Fribourg and Johnson, 1955; Auch, 1977; Behrens and Lueschen, 1979; Al-Khatib and Peterson, 1999). In addition, yield loss due to PGR exposure can be substantial under some conditions.

Low detection levels are needed to document PGR herbicide contamination due to the low concentrations that can cause soybean injury. In addition, sampling for residue frequently occurs long after herbicide exposure. Concentrations may be low due to volatilization losses from the plant leaf, dilution due to plant growth, and/or degradation of the herbicide within the growing plant. Extraction of PGR herbicides from plant tissue requires acidification along with alkaline hydrolysis to remove free, bound, and conjugated forms of the herbicide (Yip and Ney, 1966; Chow et al., 1971). Detection and quantification of PGR residue in tissue extract has been problematic due to poor sensitivity and background interference when using gas chromatography (GC) and electron capture (ECD) techniques (Marquardt and Luce, 1961; Yip, 1962; Lorah and Hemphill, 1974), with typical detection levels ranging from 0.05 to 2 μg g^{-1}. Detection limits have been lowered by about 10-fold (to 0.005 μg g^{-1}) when using a GC coupled with mass spectrometry (MS) and selective ion monitoring (SIM) because much of the background interference is eliminated and confirmation ions of each herbicide are monitored.

Documenting soybean injury and yield loss from PGR herbicides typically involves describing plant symptoms and their extent in the field, analyzing vegetative material for residue, and quantifying yield losses in areas of suspected exposure. The advancements in detection and quantification may allow for detection of PGR residues long after exposure to very low levels of these herbicides. However, the relationship between the amount recovered and plant yield is tenuous. The objectives of this study were to quantify the amount of dicamba and 2,4-D in soybean foliage 0, 6, 12, 24, and 48 DAT at the three-leaf (V3) stage of growth and determine if these concentrations were correlated to initial application rate, grain yield, or both.

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Abbreviations: COC, crop oil concentrate; DAT, days after treatment; ECD, electron capture detector; GC, gas chromatography; GDD, growing degree days; MS, mass spectrometry; PGR, plant growth regulator; SIM, selective ion monitoring; VCRR, visual crop response rating.

MATERIALS AND METHODS

Site Description

Field experiments were conducted at the Southeast Research Station (SE farm) near Beresford, SD, in 2001 and at the Brookings Agronomy Farm, Brookings, SD, in 2002. Soil at the SE farm was an Egan silty clay, 0 to 2% slope (fine-silty, mixed, superactive, mesic Udic Haplustoll), with a sand, silt, and clay content of 180, 420, and 400 g kg^{-1}, respectively, and a pH of 6.6. Soil at Brookings was a Vienna clay loam, 2 to 6% slope (fine-loamy, mixed, superactive, frigid Calcic Hapludoll), with a sand, silt, and clay content of 420, 280, and 300 g kg^{-1}, respectively, and a pH of 6.7.

Daily temperature and precipitation data for 1 May through 30 September of 2001 and 2002 were obtained from the South Dakota Cooperative Extension Service weather website and were used to calculate monthly averages. In addition, daily temperatures were used to calculate growing degree days (GDD):

$$\text{GDD} = \Sigma\{[\text{Max. Daily Temp. (°C)} + \text{Min. Daily Temp. (°C)}]/2\} - \text{Base Temp. (°C)}$$

A base temperature of 10°C and a ceiling temperature of 30°C were used in the calculations. The monthly and seasonal averages were compared with the 30-yr averages (1961–1990) obtained from the NRCS National Water and Climate Center website.

Plot Preparation and Maintenance

The seedbed was tilled to a depth of about 10 cm with two passes of a field cultivator. Prairie Brand[1] ('PB1901RR') (Maturity Group 1.9) soybean was planted at the SE farm on 29 May 2001. Asgrow ('AG1301RR') (Maturity Group 1.3) soybean was planted at Brookings on 21 May 2002. Seeding rate was 419 900 seeds ha^{-1}, and planting depth was about 2.5 cm.

Plots were maintained weed-free using a combination of herbicides, cultivation, and hand weeding. At both locations, sulfentrazone {*N*-2,4-dichloro-5[4-(dihydro-3-methyl-5-oxo-1*H*-1,2,4-triazol-1-yl)phenyl]methanesulfonamide} (281 g a.i. ha^{-1}) plus cloransulam-methyl {3-chloro-2-[[(5-ethoxy-7-fluoro[1,2,4]triazolo[1,5-*c*]pyrimidin-2yl)sulfonyl]amino]benzoic acid, methyl ester} (36 g a.i. ha^{-1}) were applied 2 d after planting to control broadleaf weeds. At Brookings, *S*-metolachlor [2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl)acetamide] (2.1 kg a.i. ha^{-1}) also was applied for grass control. All maintenance herbicides were applied with an air-pressurized tractor-mounted sprayer equipped with flat-fan nozzles spaced 51 cm apart that delivered 187 L ha^{-1} at 290 kPa at 4.5 km h^{-1}. Plots at the SE farm were cultivated to a depth of 5 cm 30 d after planting. Hand weeding was used throughout the season as needed.

Treatments and Experimental Design

Treatments were arranged in a randomized complete block design with four replications and included an untreated control and herbicide applications that ranged from 1 to 20% of a labeled rate for corn. The rates of the diglycolamine salt of dicamba were 0.0056, 0.0112, and 0.056 kg a.e. ha^{-1}, which corresponded to 1, 2, and 10% of a 0.56 kg a.e. ha^{-1} label rate, respectively. The highest rate of dicamba was included in two treatments, one with a 1% volume per volume (v/v) rate of crop oil concentrate (COC) and the other without COC. The rates of the dimethylamine salt of 2,4-D were 0.0112, 0.056, and 0.112 kg a.e. ha^{-1}, which corresponded to 2, 10, and 20% of a 0.56 kg a.e. ha^{-1} corn rate, respectively.

Herbicides were applied to soybean at V3 growth stage (Ritchie et al., 1997) (3 July 2001 and 25 June 2002) with an air-pressurized bicycle-type sprayer equipped with six flat-fan nozzles spaced 51 cm apart and 46 cm above the crop. Delivery rate was 187 L ha^{-1} at 290 kPa at 4.5 km h^{-1}.

Plots were 3 m wide (four 76-cm soybean rows) by 12 m long. Four soybean rows were left untreated between each plot as a buffer to limit herbicide drift among treatments. A 6-m untreated buffer also was left between replications.

Plant Evaluation and Sampling

Plant height, phenological development (Ritchie et al., 1997), and visual crop response rating (VCRR) (Behrens and Lueschen, 1979) (Table 1) were recorded just before herbicide application, 4 h after treatment, and 6, 12, 24, and 48 DAT. Plant height from the soil surface to the top node of the main stem was determined on six random plants from the outer two rows of each plot. These plants were clipped at soil level and placed in sealed polyethylene bags on ice. Samples were separated according to application rate and herbicide, transferred to several freezers to prevent possible contamination among treatments, and stored at –20°C until analyzed for herbicide residue.

At phenological maturity of the untreated control, maturity index [days earlier (–) or later (+) than the untreated control] and lodging score (based on average erectness of the main stem of 12 plants within each treatment) were estimated. The center two rows of each plot were combined for grain yield using a plot combine when the seeds were at 15% moisture or less. Yields were calculated on a 13% moisture content basis and expressed as kilograms per hectare.

Herbicide Residue Extraction and Detection

A 25-g subsample (fresh weight) of each soybean sample was cut into 1-cm lengths, blended at high speed for 5 min with 200 mL of 0.1 *M* NaOH, and filtered. The volume of filtrate was measured, transferred to a separatory funnel that contained 25 g of NaCl, acidified to pH 1 using 3 *M* H_2SO_4, and partitioned with CH_2Cl_2. After centrifugation, the aqueous layer was poured off and discarded. The organic layer was filtered through phase-separation filter paper and condensed to about 1 mL using a rotary evaporator. This solution was methylated with diazomethane, transferred to a Florisil column (Alltech Assoc., Deerfield, IL) prewet with 3% acetone in hexane, eluted with 40 mL of the mobile phase, and evaporated under N_2 to about 5 mL, and the volume was increased to 10 mL with hexane. Herbicide residues were quantified using a GC/MS (Model 5890 GC plus a 5971 series mass-selective detector, Hewlett-Packard, Wilmington, DE) using the SIM data acquisition mode monitoring at m/z 234 and 236. Injection volumes were 2 μL. Average recovery of each herbicide from fortified plant tissue was 88%. This method determined bound as well as free forms of both herbicides, with a detection limit of 0.001 μg chemical residue per gram fresh plant material. Residue values were calculated on a microgram chemical residue per gram dry plant material basis by drying the remaining plant sample at 65°C for 48 h, weighing, and correcting fresh weight for plant water content.

Data Analyses

All plant, grain, and residue data were analyzed using Statistical Analysis Systems software (SAS Inst., 1990). Significant

[1] The use of trade names is for the convenience of the reader only and does not imply endorsement by South Dakota State University.

Table 1. Injury levels and corresponding symptoms used to rate plant growth regulator herbicide injury to soybean as developed and reported by Behrens and Lueschen (1979).

Injury level	Symptoms
0%	No effect, plants normal
10%	Slight crinkle of leaflets of terminal leaf
20%	Cupping of terminal leaflets, slight crinkle of leaflets of second leaf, growth rate normal
30%	Leaflets of two terminal leaves cupped, expansion of terminal leaf suppressed slightly
40%	Malformation and growth suppression of two terminal leaves, terminal leaf size less than one-half that of control
50%	No expansion of terminal leaf, second leaf size one-half or less that of control
60%	Slight terminal growth, vigorous, malformed axillary shoot growth developing
70%	Terminal bud dead, substantial, strongly malformed, axillary shoot growth
80%	Limited axillary shoot growth, leaves present at time of treatment chlorotic with slight necrosis
90%	Plants dying, leaves mostly necrotic
100%	Plants dead

differences among treatment means were determined using analysis of variance (ANOVA) with the GLM procedure at a significance level of $P > 0.05$ unless otherwise noted. Treatment differences are reported as a least significant difference (LSD) (Steel et al., 1997).

Regression analysis was used to quantify the relationship between initial application rates and residue concentrations at each sampling date. A correlation procedure (SAS Inst., 1990) was used to determine the Pearson correlation coefficients between residue concentrations at each sampling date and yield.

RESULTS

A third study site was located at the Northeast Research Farm (Watertown, SD) in 2002, and results for injury and yield loss are similar to data reported herein (Andersen, 2003). Due to budget constraints, residue analyses were not done for this site.

Climate Data

In general, the 2001 growing season at the SE farm had average temperatures with total GDD accumulation about 4% above the 30-yr average of 1467 (data not shown). Rainfall over the growing season was 18% below the 30-yr average (42.2 cm). Rainfall in July (just after application) was 33% above and in August was 56% below the 30-yr average. The 2002 growing season at Brookings was warm, with total GDD accumulation about 16% above the 30-yr average of 1220. The season was very dry (23% below the 30-yr average of 40.3 cm). Rainfall in July (just after application) was 93% less than average whereas in August, rainfall was 56% above average.

Plant Injury

Soybean injury was similar each year, and VCRR ranged from 5% (slight leaflet malformations) to 90% (necrosis of all leaves), depending on treatment and sampling date (Tables 1 and 2). Plant injury was less severe with 2,4-D than dicamba (Table 2). Wax et al. (1969) also reported greater soybean injury with dicamba than 2,4-D at equal exposure rates. The addition of COC to dicamba generally resulted in higher injury ratings, especially 6 and 12 DAT.

At 6 DAT, injury symptoms of dicamba-treated plants included shoot and petiole epinasty, cupping, and marginal chlorosis of terminal leaflets and were similar to those reported by others (Wax et al., 1969; Auch and Arnold, 1978; Behrens and Lueschen, 1979). At 12, 24, and 48 DAT, injury was slightly greater than the injury observed 6 DAT (Table 2). However, apical meristems died, and with this loss of apical dominance, lower leaf axillary buds were released, resulting in significant amounts of lateral branching. This response also has been reported in other dicamba studies (Wax et al., 1969; Weidenhamer et al., 1989). Trifoliates of the lateral branches were cupped and distorted with an oblong

Table 2. Visual crop response rating (VCRR) of soybean treated at the V3 stage of soybean growth with several sublethal rates of dicamba and 2,4-D.

		VCRR							
		SE farm (2001)				Brookings (2002)			
		Days after treatment							
Treatment	Rate	6	12	24	48	6	12	24	48
	kg a.e. ha^{-1}	injury rating, %†							
Check	0	0	0	0	0	0	0	0	0
Dicamba‡	0.0056	30	40	40	40	40	45	45	45
Dicamba	0.0112	35	45	50	55	50	50	50	55
Dicamba	0.056	80	85	85	90	80	85	90	90
Dicamba + COC§	0.056 + 1% (v/v)	85	90	90	90	90	90	90	90
2,4-D¶	0.0112	5	5	5	5	5	5	5	5
2,4-D	0.056	20	25	10	10	20	20	10	10
2,4-D	0.112	35	35	30	30	30	30	25	30
	$LSD_{(0.05)}$	3	5	4	5	3	4	4	4

† Plant injury rated according to Behrens and Lueschen (1979).
‡ Dicamba applied as the diglycolamine salt formulation.
§ COC, crop oil concentrate.
¶ 2,4-D applied as the dimethylamine salt formulation.

Table 3. Plant biomass (g plant^{-1}) of soybean treated at the V3 stage of soybean growth with several sublethal rates of dicamba and 2,4-D.

		Plant biomass									
		SE farm (2001)					Brookings (2002)				
		Days after treatment									
Treatment	Rate	0	6	12	24	48	0	6	12	24	48
	kg a.e. ha^{-1}	g plant^{-1}									
Check	0	1.32	2.49	4.31	9.92	22.25	1.11	2.31	3.44	5.02	11.91
Dicamba†	0.0056	1.35	2.04	3.46	5.92	13.98	1.33	1.97	3.12	5.41	8.10
Dicamba	0.0112	1.44	2.39	3.25	5.46	12.76	1.33	2.02	2.64	4.01	7.62
Dicamba	0.056	1.33	1.94	2.68	4.60	8.52	1.22	1.56	1.66	2.56	8.84
Dicamba + COC‡	0.056 + 1% (v/v)	1.30	1.69	2.74	3.63	7.62	1.19	1.56	1.48	2.53	9.43
2,4-D§	0.0112	1.63	2.44	4.22	9.04	17.87	1.28	1.79	2.69	5.68	11.55
2,4-D	0.056	1.49	2.10	3.81	6.86	17.13	1.13	1.54	2.56	4.08	7.71
2,4-D	0.112	1.44	1.89	3.01	6.78	15.60	1.14	1.30	2.51	4.94	7.87
	$LSD_{(0.05)}$	NS	0.53	0.69	1.47	4.56	NS	0.50	0.45	0.81	3.67

† Dicamba applied as the diglycolamine salt formulation.
‡ COC, crop oil concentrate.
§ 2,4-D applied as the dimethylamine salt formulation.

shape and chlorotic tips, similar to the symptoms of the terminal growth at 6 DAT. At higher rates, the point of petiole attachment to the main stem was weak and easily broken. Plants treated with higher rates of dicamba had small, curled, and malformed pods 48 DAT.

Soybean biomass (Table 3) and plant height (Andersen, 2003) were reduced by dicamba compared with the check at 12, 24, and 48 DAT. Reductions in both parameters generally were greater as the dicamba rate increased, with maximum reductions of 70 and 66% for height and biomass, respectively.

Visual injury symptoms caused by 2,4-D were similar to those reported by others (Slife, 1956; Rojas-Garciduenas and Kommedahl, 1958; Smith, 1965; Kelley et al., 2002). Unlike dicamba symptoms that were not noted until 6 DAT, 2,4-D injury was noticeable as leaf epinasty 4 h after treatment. At 6 DAT, shoot and petiole epinasty near the apical meristem had increased to greater than a 90-degree angle from the main stem. New trifoliate growth appeared strapped with parallel venation. At 12 DAT, main stems and petioles had upright growth. About 20% of plants treated with the lowest 2,4-D rate had growth from the unifoliate axil, indicating apical meristem release, but branching was less than that of plants treated with an identical rate of dicamba. A bend in the lower portion of the main stem developed in plants treated with the two highest 2,4-D rates and was attributed to epinasty that occurred immediately after treatment. The bend persisted throughout the remainder of the growing season. Callusing and cracking of the lower 12 cm of the main stem also were observed at the highest 2,4-D rate.

Maximum height reduction from 2,4-D occurred at 6 and 12 DAT whereas maximum dicamba height reduction occurred at 24 and 48 DAT (Andersen, 2003). Plants treated with 2,4-D were better able to recover from early-season stunting than those treated with dicamba. Maximum biomass reduction (32%) occurred at 24 DAT with the 0.112 kg a.e. ha^{-1} 2,4-D treatment at the SE farm (Table 3).

All treatments of dicamba and 2,4-D delayed vegetative plant development and maturity (data not shown), with dicamba-treated plants being more affected. Soybean planted at SE farm was from Maturity Group 1.9 whereas Group 1.3 was planted at Brookings. However, maturity delay was similar at both locations. The high rate of dicamba + COC virtually stopped vegetative development of soybean plants up to 24 DAT. Treated plants, except those treated with 0.056 kg a.e. ha^{-1} dicamba, reached the reproductive stages at similar times as the untreated plants although maturity was delayed about 7 d in dicamba treatments and about 1 d in 2,4-D treatments. Auch and Arnold (1978) noted a maturity delay of 12 d when 0.056 kg a.e. ha^{-1} dicamba was applied to soybean in the early-bloom stage. Wax et al. (1969) applied simulated drift-type rates of 2,4-D and dicamba at prebloom (V3) and also reported that dicamba delayed maturity more than 2,4-D. Plant lodging was not prevalent with any treatment (Andersen, 2003).

Soybean Grain Yield

All rates of dicamba reduced yield (Table 4), with reductions ranging from 14 to 93%. Maximum reductions occurred with the 0.056 kg a.e. ha^{-1} + COC treatment. Yield and initial dicamba rate were highly negatively correlated [r = –0.98 (2001) and –0.94 (2002); p = 0.01]. Only the 0.112 kg a.e. ha^{-1} rate of 2,4-D reduced yield.

Weidenhamer et al. (1989) stated that soybean generally is able to tolerate considerable early-season foliar injury without reducing yield. Al-Khatib and Peterson (1999) noted that visual injury ratings of dicamba-treated soybean were always greater than yield loss. The loss of apical dominance and release of axillary buds that produce new branches and, eventually, flowers and seed pods (Moore, 1979) can compensate for a portion of the expected yield loss when soybean is exposed to PGR herbicides.

Plant Growth Regulator Herbicide Residue

Before application and throughout the sampling period each season, plants from the untreated check had low concentrations of PGR residue present in foliage (Table 5). Other studies have reported positive PGR

Table 4. Soybean yield after treatment at the V3 stage of soybean growth with sublethal rates of dicamba and 2,4-D during 2001 and 2002.

		SE farm (2001)		Brookings (2002)	
Treatment	Rate	Grain yield	Yield reduction	Grain yield	Yield reduction
	kg a.e. ha^{-1}	kg ha^{-1}	%	kg ha^{-1}	%
Check	0	3097	0	2567	0
Dicamba†	0.0056	2663	14.0	1708	33.5
Dicamba	0.0112	2670	13.8	1505	41.4
Dicamba	0.056	884	71.5	426	83.4
Dicamba + COC‡	0.056 + 1% (v/v)	605	80.5	175	93.2
2,4-D§	0.0112	3109	0	2510	2.2
2,4-D	0.056	2874	7.2	2381	7.2
2,4-D	0.112	2114	31.7	1933	24.7
	$LSD_{(0.05)}$	313		283	

† Dicamba applied as the diglycolamine salt formulation.
‡ COC, crop oil concentrate.
§ 2,4-D applied as the dimethylamine salt formulation.

residue detection on control samples (Cessna, 1980; Hemphill and Montgomery, 1981; Smith, 1984). In addition, 10 random soybean samples taken in 2000 from fields that had no visual PGR injury symptoms had 2,4-D detections ranging from 0.009 to 0.036 μg g^{-1} and three had positive dicamba detections (unpublished data, 2000). The herbicide source is unknown but was not due to laboratory contamination because samples having no PGR herbicide detections were obtained. Contamination before application may have been due to drift or volatilized chemical deposition from areas outside of the treatment sites (Behrens and Lueschen, 1979).

Herbicide residue concentrations of both dicamba and 2,4-D were greater throughout most of 2002 compared with concentrations measured in 2001 (Table 5). Herbicide treatments in both years were applied at V3; however, plant biomass was greater (2–32%) in 2001 than in 2002 (Table 3) due to the dry conditions in 2002. If the amount of residue per whole plant is compared, residue levels for the 2 yr are similar.

Foliar residue concentration of PGRs dropped quickly over time (Table 5). It is unclear if the decrease was due to metabolism, dilution as the plant grew, or both. In an extensive literature search, the rate of dicamba metabolism in soybean was not found. Dicamba metabolism in tartary buckwheat [*Fagopyrum tataricum* (L.) Gaertn.] was slow, with only 10% of the herbicide detoxified 20 DAT whereas 50% of the dicamba was detoxified 1 DAT in wheat (Chang and Vanden Born, 1971). Metabolism of 2,4-D in tomato (*Lycopersicon* spp.) was very slow, with characteristic injury symptoms to transplanted buds still evident 60 DAT when grafted onto treated plants (Muzik and Whitworth, 1960). These data from other sensitive plants would suggest that the decrease in soybean was due to dilution of the herbicide during plant growth and not metabolism. The decrease in foliar residues of both dicamba and 2,4-D agrees with results reported by Auch and Arnold (1978) although they reported no detection of dicamba residue after 7 d, most likely due to the less sensitive detection limit of the GC/ECD system.

Correlations of application rate to residue level and residue level to yield reduction were similar each year. Only 2001 data are presented here although data for 2002 parameters are reported in Andersen (2003). Dicamba foliar concentrations were correlated with application rate up to 24 DAT, whereas 2,4-D residue amounts were correlated with application rate up to 12 DAT (Fig. 1 and 2). The addition of COC to the high

Table 5. Foliar residue concentrations of soybean treated at the V3 stage of growth with several sublethal rates of dicamba and 2,4-D at the SE farm (2001) and Brookings (2002).

		Foliar herbicide residue									
		SE farm (2001)					Brookings (2002)				
		Days after treatment									
Treatment	Rate	0	6	12	24	48	0	6	12	24	48
	kg a.e. ha^{-1}	μg dicamba/g dry plant material									
Check		0.142	0.249	0.153	0.041	0.047	0.068	0.093	0.049	0.091	0.075
Dicamba†	0.0056	2.951	0.583	0.187	0.034	0.030	2.882	0.646	0.393	0.129	0.030
Dicamba	0.0112	4.831	0.969	0.301	0.057	0.017	5.259	1.099	0.733	0.216	0.020
Dicamba	0.056	21.401	7.207	2.230	0.120	0.031	26.08	18.59	7.342	2.536	0.053
Dicamba + COC‡	0.056 + 1% (v/v)	25.463	9.709	4.358	0.173	0.033	30.20	15.64	12.17	4.337	0.062
	$LSD_{(0.05)}$	5.01	1.43	1.14	0.09	0.03	7.94	4.56	5.21	0.76	0.04
		μg 2,4-D/g dry plant material									
Check		0.592	0.620	0.304	0.134	0.150	0.211	0.550	0.325	0.514	0.393
2,4-D§	0.0112	5.438	0.628	0.444	0.076	0.073	4.806	1.010	0.592	0.261	0.080
2,4-D	0.056	16.069	1.455	0.405	0.100	0.082	23.78	4.761	1.437	0.223	0.069
2,4-D	0.112	39.519	4.923	1.703	0.159	0.084	59.86	18.507	3.446	0.424	0.071
	$LSD_{(0.05)}$	4.10	1.66	0.48	0.08	0.11	18.46	4.12	0.92	0.23	0.16

† Dicamba applied as the diglycolamine salt formulation.
‡ COC, crop oil concentrate.
§ 2,4-D applied as the dimethylamine salt formulation.

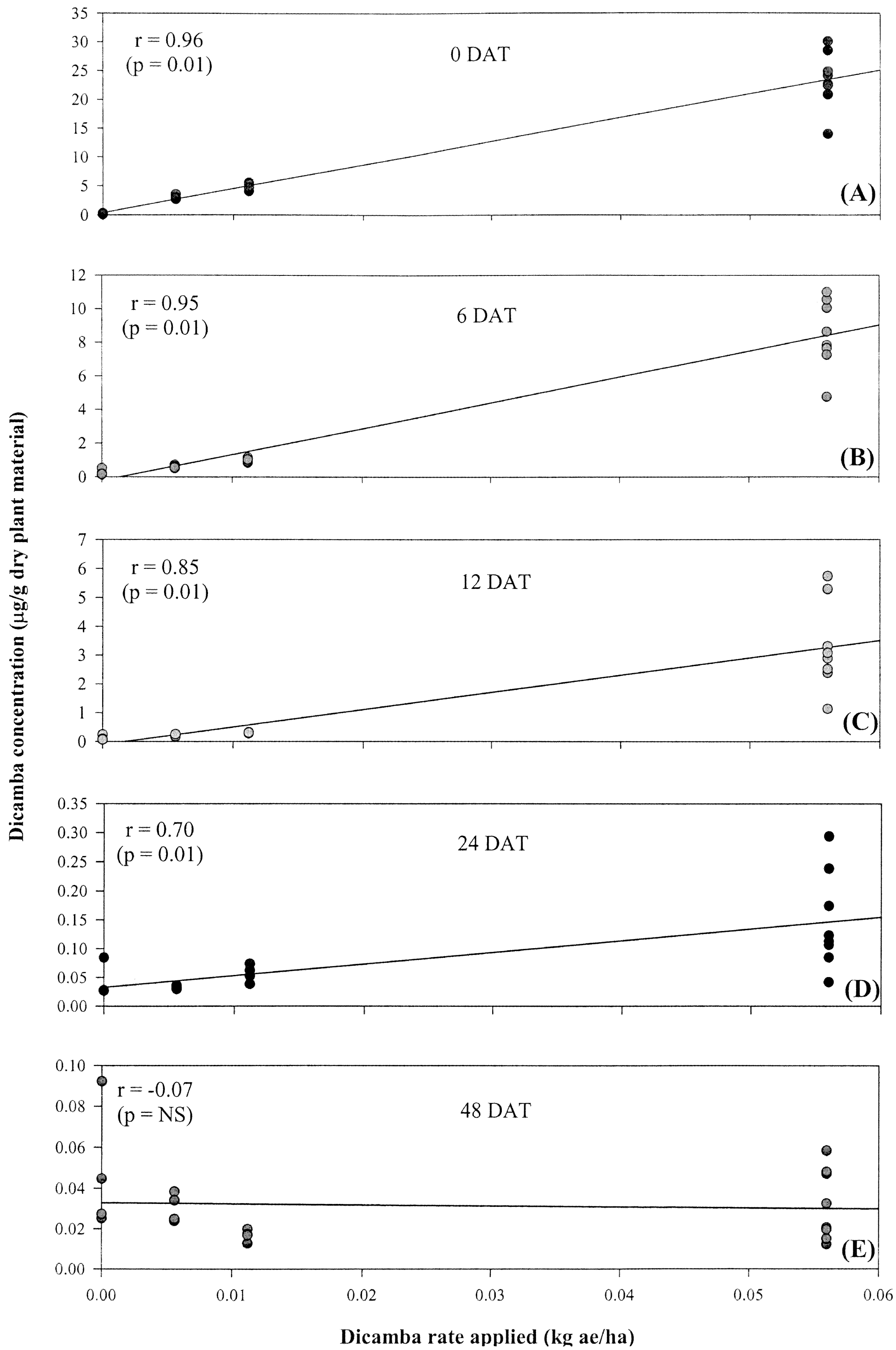

Fig. 1. Correlation of dicamba residue with original dicamba application rate at (A) application [0 d after treatment (DAT)] and (B) 6, (C) 12, (D) 24, and (E) 48 DAT. Data collected at the SE farm, Beresford, SD, in 2001.

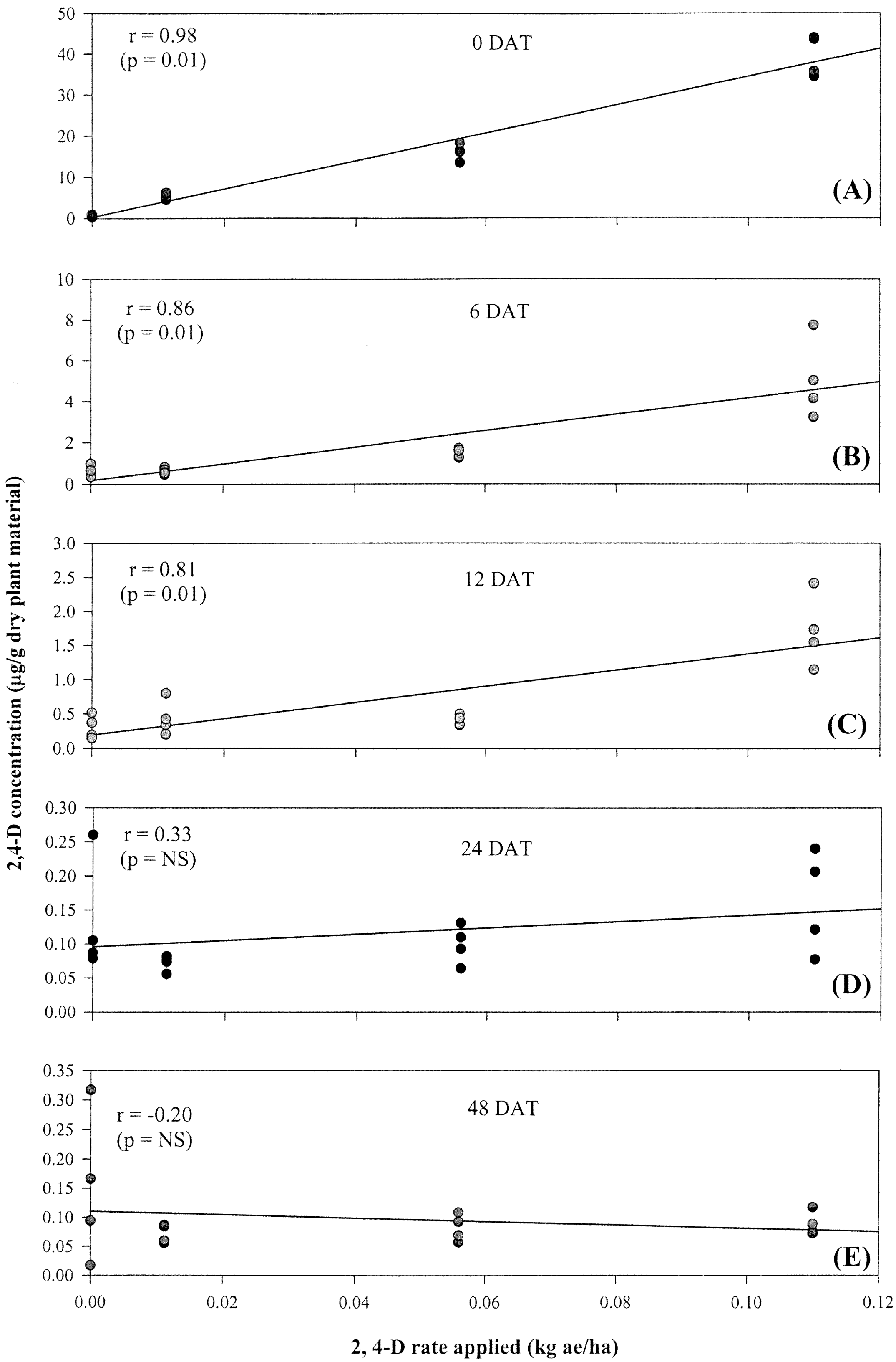

Fig. 2. Correlation of 2,4-D residue with original 2,4-D application rate at (A) application [0 d after treatment (DAT)] and (B) 6, (C) 12, (D) 24, and (E) 48 DAT. Data collected at the SE farm, Beresford, SD, in 2001.

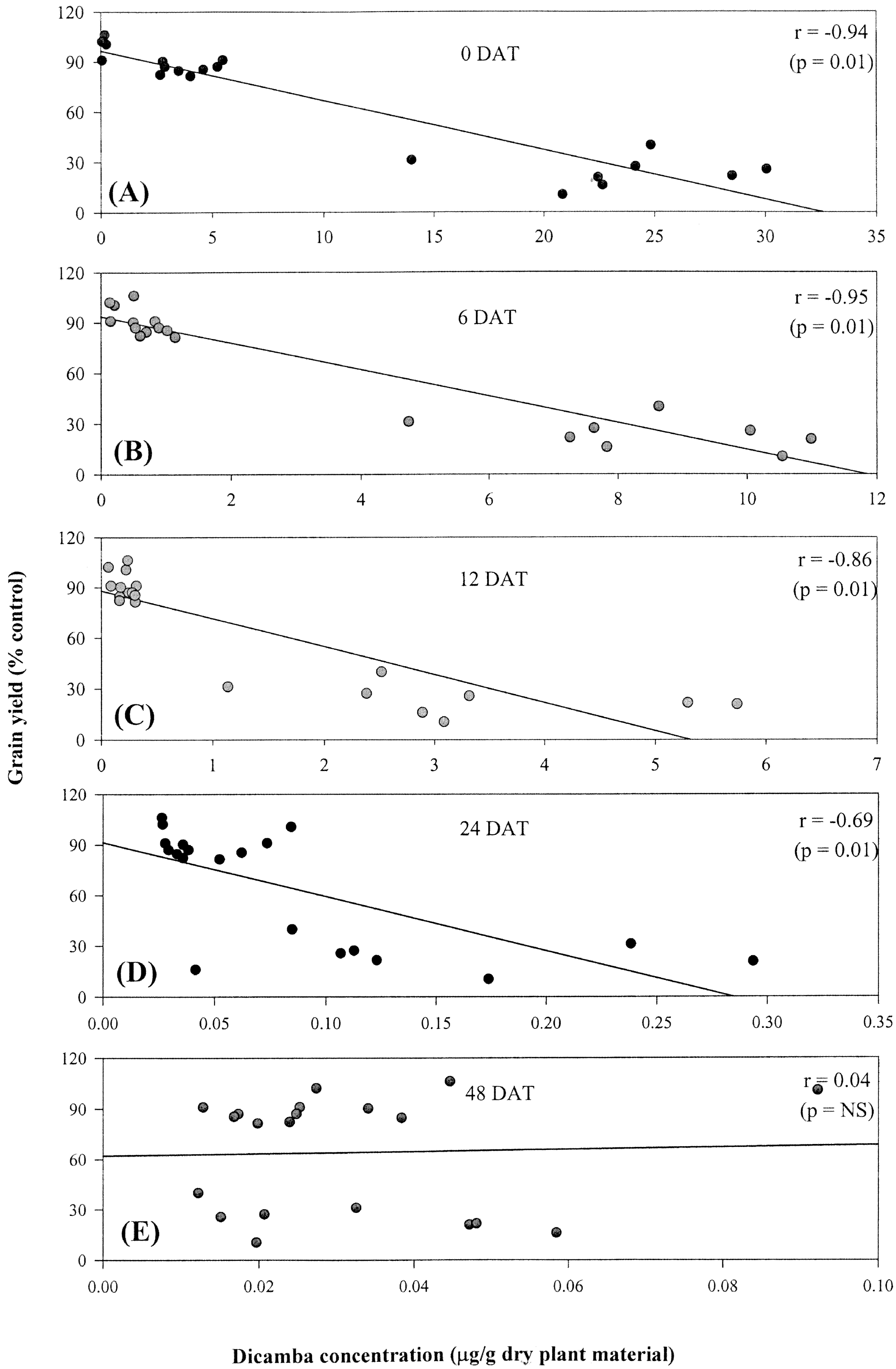

Fig. 3. Correlation of yield with dicamba residue in plant at (A) 0, (B) 6, (C) 12, (D) 24, and (E) 48 d after treatment (DAT). Data collected at the SE farm, Beresford, SD, in 2001.

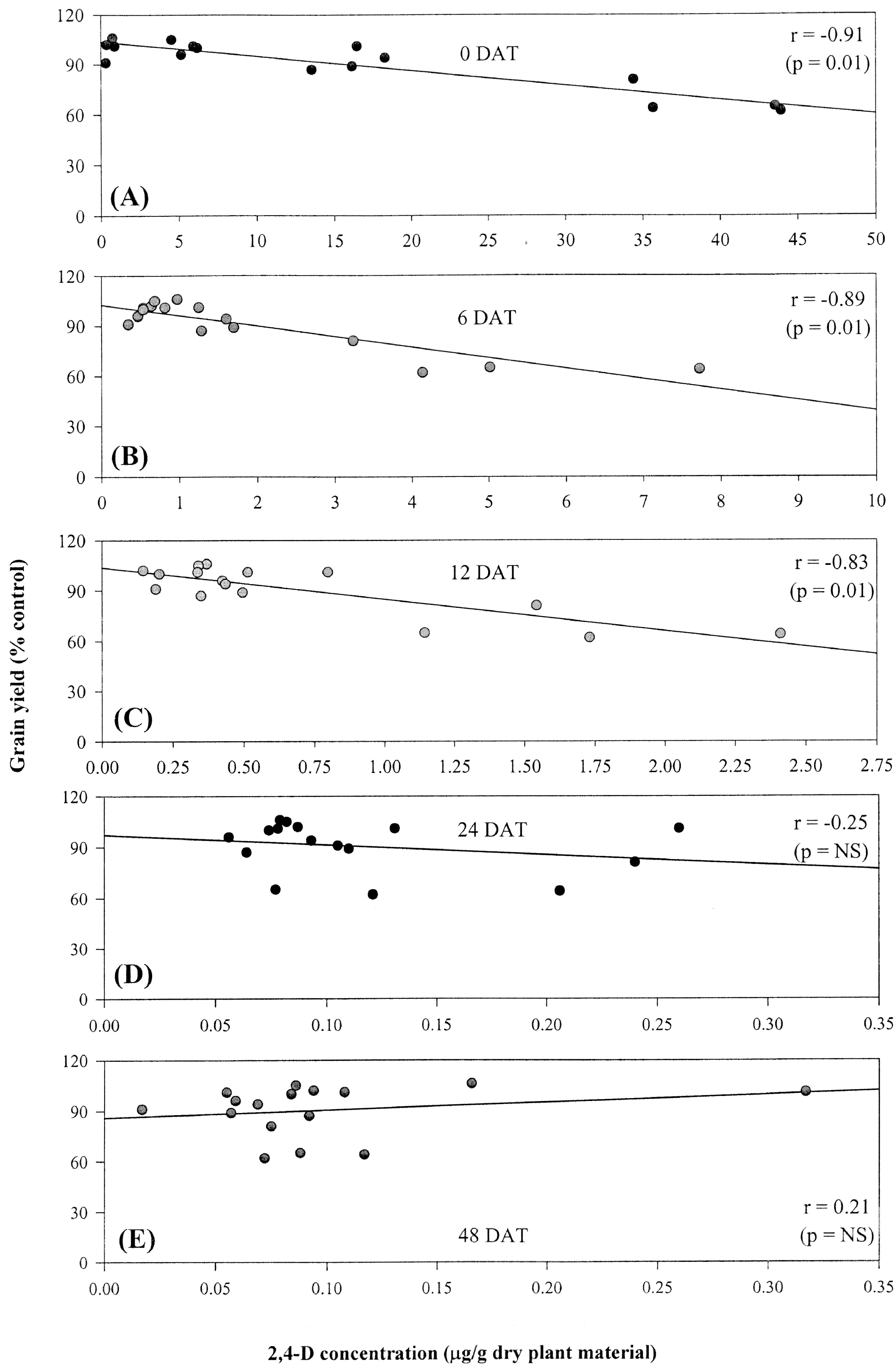

Fig. 4. Correlation of yield with 2,4-D residue in plant at (A) 0, (B) 6, (C) 12, (D) 24, and (E) 48 d after treatment (DAT). Data collected at the SE farm, Beresford, SD, in 2001.

rate of dicamba increased residue amounts at 0 DAT and resulted in higher residue levels up to 24 DAT (Table 5). Crop oil concentrate generally enhances the absorption of herbicides by increasing movement through leaf cuticles and may reduce herbicide losses due to volatilization and photodecomposition (Jansen et al., 1961). Volatilization losses of dicamba can be considerable (Behrens and Lueschen, 1979) although the diglycolamine salt formulation is less volatile than the amine formulation.

Yield loss was correlated with dicamba foliar concentrations from 0 to 24 DAT ($r \geq -0.69$; $p = 0.01$) (Fig. 3). Although yield reductions were not reported to be statistically significant for most 2,4-D treatments, the measured reductions were correlated to foliar 2,4-D concentrations up to 12 DAT ($r \geq -0.83$; $p = 0.01$) (Fig. 4).

CONCLUSIONS

Residue analysis of soybean plants exhibiting PGR herbicide symptomology is requested frequently in regulatory investigations as a means of substantiating the cause of injury and possible source. Yet there is little information on the relationship between the amount of residue detected in soybean tissue at various sampling dates and soybean injury or yield reduction. This lack of information is most likely due to quantification techniques that lacked sensitivity to very low levels of PGR in plant tissues. However, now care must be taken to accurately interpret very low residue amounts. For example, before application, plants from the untreated control had some PGR residue present, and at 24 and 48 DAT, residue concentrations were similar among all treatments.

In this study, PGR exposure occurred at V3 stage of soybean growth, when a large percentage of PGR herbicides are applied to labeled crops. Results suggest that to document PGR injury, suspected exposure areas should be scouted, noting the plant symptomology and severity of the injury. The most severe dicamba injury was noted between 12 to 48 DAT whereas the most severe 2,4-D injury occurred 6 DAT. Other studies have reported more severe soybean injury and yield reduction when PGR herbicides are applied at V5 or later growth stages (Slife, 1956; Wax et al., 1969; Auch and Arnold, 1978); however, the possibility of PGR exposure in this study area would be greatly reduced due to the earlier timing of these applications. Environmental conditions also affected plant injury and ultimately grain yield. Both parameters were more severe during 2002, a very dry year, than during 2001 when water was not limiting. Auch and Arnold (1978) also reported increased injury and yield reduction due to PGR exposure during dry years.

All leaflets and petioles of the plant were taken for residue analysis in this study. This system was clear-cut and less ambiguous than collecting the top one-third of growth or only affected leaflets (a method that could not be used for asymptomatic plants). Different sampling methods may lead to different data interpretation. However, when all leaflets and petioles were collected for residue analysis, samples had to be collected as soon as possible after suspected exposure to accurately assess the amount of chemical exposure. If possible, healthy soybean plants from the area also should be collected at the same time for residue analysis for comparison. Differences among soybean residue PGR concentrations from the lowest exposure rates and untreated material were indistinguishable 6 DAT; however, plants treated with low dicamba rates suffered yield loss whereas plants treated with 2,4-D did not. At higher exposure rates, differences between treated and background residue levels could be distinguished up to 24 DAT. Collecting samples after 24 DAT may be of little or no value since the analysis is costly and there is no correlation between residue levels and yield.

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Soybean response to simulated dicamba/diflufenzopyr drift followed by postemergence herbicides

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Five field experiments were conducted in 2007 to determine the effect of simulated dicamba/diflufenzopyr drift followed by postemergence applications of chlorimuron ethyl, imazethapyr or bentazon on soybean (*Glycine max* Merr.) crop injury, dry weight, height and yield. In the absence of a postemergence herbicide, as the dose of simulated dicamba/diflufenzopyr increased there was an increase in soybean injury and a decrease in dry weight, height and yield. The application of registered postemergence herbicides following simulated dicamba/diflufenzopyr drift resulted in a synergistic increase in crop injury in some environments. There was no synergistic response in respect to dry weight and height when simulated drift was followed by postemergence herbicides. A synergistic yield response was observed with yield being decreased 4 7% more than expected due to simulated dicamba/diflufenzopyr drift followed by the application of chlorimuron ethyl. No synergistic yield response was observed for dicamba/diflufenzopyr drift followed by either imazethapyr or bentazon.

1. Introduction

Maize (*Zea mays*) and soybean (*Glycine max* Merr.) are frequently planted in fields that are adjacent to one another. When these two crops are grown in close proximity, there is the potential for soybean injury due to herbicide drift from an adjacent maize field. Previous research conducted by Maybank et al. (1978) and Wolf et al. (1992) has determined that herbicide drift from unshielded sprayers can range from 1 to 16% depending on nozzle type, spray additives, boom height and wind velocity. Possible synergistic responses in respect to crop injury and yield from herbicide drift followed by the application of a registered postemergence herbicide have been postulated.

The interaction of herbicides when applied either simultaneously or sequentially, may result in responses that are not predictable based on their response when applied alone. The interaction of herbicides in combination is synergistic if the actual effect is greater than the sum of the effects from the two herbicides applied individually (Gressel, 1990; Lich et al., 1997). These herbicide combinations can cause a synergistic response that increases crop damage. An example of this was documented by Simpson and Stoller (1996) who reported that individual applications of thifensulfuron (4.4 g a.i. ha^{-1}) and imazethapyr (70 g a.i. ha^{-1}) caused 0 and 28% injury, respectively in soybean, but the combination of both herbicides caused 50% injury.

Dicamba/diflufenzopyr is a postemergence herbicide registered for broadleaf weed control in maize in Canada. Diflufenzopyr is an auxin transport inhibitor and dicamba causes irregular accumulation of indoleacetic acid (Vencill, 2002) and stimulates ethylene production. Soybean injury symptoms due to dicamba/diflufenzopyr drift appear as cupping and puckering of the leaves, twisted stems, shortened internodes, and a triangular shaped canopy.

Chlorimuron ethyl and imazethapyr are registered for postemergence broadleaf weed control in soybean. They are acetolactate synthase (ALS) inhibitors (Vencill, 2002) and are widely used due to their low mammalian toxicity, broad spectrum weed control, and flexibility of use on a wide variety of crops. Both chlorimuron ethyl and imazethapyr have the potential to cause some initial soybean injuries. Bentazon is a photosystem II inhibitor (Vencill, 2002) that provides annual broadleaf weed control in soybean.

The objective of this research was to determine if simulated dicamba/diflufenzopyr drift followed by postemergence applications of chlorimuron ethyl, imazethapyr or bentazon has a synergistic effect on soybean crop injury, dry weight, height and yield.

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2. Materials and methods

Five field experiments were established in 2007 at the Univer sity of Guelph, Elora, Ontario, at the Agriculture and Agri Food Canada Research Centre, Harrow, Ontario and at the University of Guelph Ridgetown Campus, Ridgetown, Ontario. At Elora and Ridgetown, trial areas were moldboard plowed in the fall and worked twice with a cultivator with rolling basket harrows in the spring to prepare the seedbed. At Harrow the seedbed was prepared by cultivation in the spring.

At each location, the experiments were established as a randomized complete block design with four replications. Glyphosate resistant soybean were planted in 60 76 cm rows at a seeding rate of 400,000 480,000 seeds ha^{-1} at Elora (DK27 02) on May 24, 2007, Harrow (DK31 52) on June 11, 2007, and Ridge town (DK30 07) on May 23 and May 24, 2007, into plots that were 2 by 7 m, 1.8 by 8 m, and 2 by 8 m, respectively. The soil at Elora was a silt loam with 31% sand, 50% silt, 19% clay, 4.2% organic matter, and a pH of 7.4. The soil at Harrow was sandy loam with 83% sand, 5% silt, 12% clay, 2.6% organic matter, and a pH of 6.0. The soil at two of the Ridgetown locations was a sandy clay loam with 52% sand, 26% silt, 21% clay, 5.3% organic matter, and a pH of 6.8. The soil at the third Ridgetown location was a sandy loam with 54% sand, 27% silt, 19% clay, 5.6% organic matter, and a pH of 6.4. The two herbicide treatments (simulated drift followed by the registered post emergence herbicide) at the Ridgetown sites were applied on June 15 and 18, June 22 and 25 and June 25 and 28. At Elora, the treat ments were made on June 23 and 25 and at Harrow, the treatments were applied on July 3 and 7. Plots were maintained weed free with s metolachlor/benoxacor plus glyphosate applied preemergence, glyphosate applied postemergence and hand hoeing as required.

The sodium salt of dicamba in combination with diflufenzopyr (5:2 ratio) was applied to soybean at the two to three trifoliate stages at 0, 2, 10, 20 and 40 g a.i. ha^{-1}, representing 0, 1, 5, 10, and 20% of the recommended labeled dose, respectively, to simulate herbicide drift. Chlorimuron ethyl (9 g a.i. ha^{-1}), ammonium salt of imazethapyr (100 g a.i. ha^{-1}) or sodium salt of bentazon (1080 g a.i. ha^{-1}) was applied 2 4 days after the simulated dicamba/ diflufenzopyr drift application. Chlorimuron ethyl, imazethapyr and bentazon treatments included urea ammonium nitrate (UAN) at 2.0% v/v. A nonionic surfactant was added at 0.10% v/v to the chlorimuron ethyl treatments and at 0.25% v/v to the imazethapyr treatments. Herbicides were applied with a CO_2 pressurized backpack sprayer equipped with 120 02 ultra low drift nozzles calibrated to deliver 200 L ha^{-1} at 207 kPa at the Elora and Ridge town locations, and using flat fan 11004XR (Teejet Spraying Systems Co. Wheaton, IL) nozzles at Harrow.

Crop injury was rated 7, 14, 28, and 56 days after application (DAA) with 0% indicating no crop injury and a rating of 100% indicating complete plant death. Average soybean height was determined by measuring the height of 10 plants from the soil surface to the top trifoliate leaf 28 DAA. Soybean dry weight was determined at 42 DAA by destructively harvesting 10 plants per plot at ground level and placing them into a paper bag. The plants were then dried at 60 °C to a constant moisture, and the weight was recorded. Soybean grain yield was determined by harvesting the middle two rows of each plot with a small plot combine. Yields were adjusted to 13.0% moisture.

All data were subjected to analysis of variance, and analyzed using the PROC MIXED procedure of SAS (Ver. 9.1, SAS Inst., Cary NC). To meet the assumptions of variance analyses, means of injury ratings 7 DAA (Ridgetown and Harrow) were transformed using log and square root transformations. Injury ratings 14 DAA (Ridge town) and 56 DAA were transformed using an arcsine square root transformation. Dry weight was transformed using a square root transformation. Means were back transformed to the original scale for presentation of results. Injury at 28 DAA, height and yield data met the assumptions of normality, therefore no transformations were necessary. The random effect of location and its interaction with herbicide treatments was significant for several of the vari ables analyzed. As a result, data for some parameters were reported by location. Means were separated using Fisher's protected LSD at $P < 0.05$. Colby (1967) Equation (1) was used to determine the expected combination means by using the observed means for dicamba/diflufenzopyr (A) alone and the postemergence herbicide (B) alone.

$$\text{expected} \quad A + B \quad A \times B/100 \tag{1}$$

Yield, dry weight and height were calculated as a percent of the untreated check and Colby's modified Equation (2) for percent of control values was used to determine the expected combination means.

$$\text{expected} \quad A \times B/100 \tag{2}$$

Following the calculation of the expected means, observed versus expected means were compared at the 0.05 level of significance using a paired *t* test in order to determine synergistic or antago nistic responses.

3. Results and discussion

3.1. Crop injury

Generally, as dicamba/diflufenzopyr dose increased, soybean foliar injury increased at 7 (data not shown), 14, 28, and 56 DAA (Tables 1 3). Dicamba/diflufenzopyr injury included cupping and crinkling of newly emerged leaves and twisting of the fully expanded leaves. Similar dicamba injury symptoms have been reported by Andersen et al. (2004), Kelley et al. (2005) and Wei denhamer et al. (1989). Chlorimuron ethyl, imazethapyr and ben tazon applied postemergence caused little injury to soybean. Combinations of the simulated dicamba/diflufenzopyr drift fol lowed by the postemergence herbicides resulted in synergistic responses in some environments.

When dicamba/diflufenzopyr drift was simulated without the postemergence herbicide, there was an increase in soybean injury with increasing dose at all three locations 7 DAA (data not shown). Generally, there was no synergistic response from simulated dicamba/diflufenzopyr drift followed by the postemergence herbicides (chlorimuron ethyl, imazethapyr or bentazon) at the Harrow and Elora locations. In contrast, synergistic responses were observed at Ridgetown with all three postemergence herbicides. The application of dicamba/diflufenzopyr at 2, 10, 20 and 40 g a.i. ha^{-1} followed by chlorimuron ethyl or imazethapyr resulted in a synergistic response. In addition, the simulated drift of dicamba/ diflufenzopyr at 10 and 20 g a.i. ha^{-1} followed by bentazon appli cation showed a synergistic response. For example, the observed crop injury from the dicamba/diflufenzopyr drift at 2, 10, 20 and 40 g a.i. ha^{-1} followed by chlorimuron ethyl was 6, 31, 27 and 11% greater than the expected values indicating a synergistic response. Similar increases in crop injury were observed with the application of imazethapyr and bentazon.

At 14 DAA, there was an increase in crop injury in soybean with increasing doses of dicamba/diflufenzopyr (Table 1). Kelley et al. (2005) also reported observing more injury with increasing doses of dicamba/diflufenzopyr. When dicamba/diflufenzopyr was applied at 0.2 g a.i. ha^{-1} plus 0.08 g a.i. ha^{-1} and 2.0 g a.i. ha^{-1} plus 0.8 g a.i. ha^{-1}, soybean injury two weeks after application was 22 and 42%, respectively (Kelley et al., 2005). Generally, there was no

Table 1
Percent soybean injury 14 DAA with simulated dicamba/diflufenzopyr drift alone or followed by the application of a postemergence herbicide at Elora, Harrow and the three sites at Ridgetown in 2007.[a]

Dicamba/diflufenzopyr drift (dose) (g a.i. ha $^{-1}$)	Injury (14 DAA)[b] (%)			
	Dicamba/ diflufenzopyr	Drift fb chlorimuron-ethyl	Drift fb imazethapyr	Drift fb bentazon
Elora				
Untreated check	0 a	0 a	0 a	0 a
0	0 a	5 a (5)[c]	10 b (10)	0 a (0)
2	11 b	16 b (15)	13 b (19)	13 b (11)
10	11 b	21 bc (15)+	24 c (20)	13 b (11)
20	18 c	24 c (22)	26 c (26)	21 c (18)
40	28 d	36 d (31)	28 c (35)	27 d (28)
SE	2.1	2.6	2.3	2.1
Harrow				
Untreated check	0 a	0 a	0 a	0 a
0	0 a	0 a (0)	0 a (0)	6 b (6)
2	16 b	16 b (16)	16 b (16)	16 c (22)−
10	30 c	20 b (30)	29 c (30)	25 d (35)
20	34 c	39 c (34)	34 c (34)	28 d (38)
40	55 d	58 d (55)	46 d (55)	53 e (58)
SE	4.4	4.4	3.8	3.6
Ridgetown				
Untreated check	0 a	0 a	0 a	0 a
0	0 a	0 a (0)	0 a (0)	0 a (0)
2	16 b	33 b (16)+	38 b (16)+	27 b (16)+
10	36 c	55 c (36)+	54 c (36)+	45 c (36)+
20	51 d	66 d (51)+	63 d (51)+	61 d (51)+
40	70 e	76 e (70)+	72 e (70)	71 d (70)
SE	3.3	3.6	3.4	3.3

[a] Abbreviations: DAA, days after application; fb, followed by.
[b] Ridgetown means have been back-transformed to original scale. Means followed by the same letter in each column are not significantly different according to Fisher's protected LSD test ($P < 0.05$).
[c] Expected responses, based on Colby's equation ($E \; A + B - A \times B/100$), for combinations are shown in parentheses following each observed response. Significant differences based on a paired t-test between observed and expected values are shown by a "+" sign to indicate synergism and a "−" sign to indicate antagonism.

synergistic response from simulated dicamba/diflufenzopyr drift followed by the three postemergence herbicides at the Harrow and Elora locations. At Harrow, there was an antagonistic response with the simulated drift (2 g a.i. ha^{-1}) followed by bentazon. However, this was an isolated response that was not observed in any of the other data. At Ridgetown, there were synergistic responses with all three postemergence herbicides. The application of dicamba/diflufenzopyr at 2, 10, 20 and 40 g a.i. ha^{-1} followed by chlorimuron ethyl had 17, 20, 15 and 6% more injury, respectively than what was expected indicating a synergistic response. Similarly, synergistic responses were also observed with dicamba/diflufenzopyr at 2, 10 and 20 g a.i. ha^{-1} followed by imazethapyr and bentazon.

Soybean injury at 28 DAA increased with increasing doses of dicamba/diflufenzopyr (Table 2). The application of dicamba/diflufenzopyr at 10 and 20 g a.i. ha^{-1} followed by chlorimuron ethyl and imazethapyr resulted in 6 11% more injury than expected indicating a synergistic response. Similarly, the application of dicamba/diflufenzopyr at 2, 10 and 20 g a.i. ha^{-1} followed by imazethapyr resulted in a synergistic response. There was no synergistic response from simulated dicamba/diflufenzopyr drift followed by bentazon.

At 56 DAA, there was an increase in crop injury in soybean with increasing doses of dicamba/diflufenzopyr (Table 3). The application of dicamba/diflufenzopyr at 2 and 10 g a.i. ha^{-1} followed by either imazethapyr or bentazon resulted in a synergistic response. In addition, the simulated drift of dicamba/diflufenzopyr at 20 g a.i. ha^{-1} followed by either chlorimuron ethyl, imazethapyr or bentazon, resulted in injury that was 6, 5 and 4% greater than the expected values, respectively. Similarly, synergistic responses were also observed with the application of dicamba/diflufenzopyr at 40 g a.i. ha^{-1} followed by either chlorimuron ethyl or bentazon.

Table 2
Percent soybean injury 28 DAA with simulated dicamba/diflufenzopyr drift alone or followed by the application of a postemergence herbicide at Elora, Harrow and Ridgetown in 2007.[a]

Dicamba/diflufenzopyr drift (dose) (g a.i. ha $^{-1}$)	Injury (28 DAA)[b] (%)			
	Dicamba/ diflufenzopyr	Drift fb chlorimuron-ethyl	Drift fb imazethapyr	Drift fb bentazon
Untreated check	0 a	0 a	0 a	0 a
0	0 a	0 a (0)[c]	0 a (0)	1 a (1)
2	18 b	21 b (18)	28 b (18)+	24 b (18)
10	31 c	42 c (31)+	42 c (31)+	36 c (32)
20	43 d	49 c (43)+	50 c (43)+	48 d (43)
40	60 e	64 d (60)	63 d (60)	62 e (61)
SE	2.6	2.8	2.7	2.6

[a] Abbreviations: DAA, days after application; fb, followed by.
[b] Means followed by the same letter in each column are not significantly different according to Fisher's protected LSD test ($P < 0.05$).
[c] Expected responses, based on Colby's equation ($E \; A + B - A \times B/100$), for combinations are shown in parentheses following each observed response. Significant differences based on a paired t-test between observed and expected values are shown by a "+" sign to indicate synergism.

Table 3
Percent soybean injury 56 DAA with simulated dicamba/diflufenzopyr drift alone or followed by the application of a postemergence herbicide at Elora, Harrow and Ridgetown in 2007.[a]

Dicamba/diflufenzopyr drift (dose) (g a.i. ha $^{-1}$)	Injury (56 DAA)[b] (%)			
	Dicamba/ diflufenzopyr	Drift fb chlorimuron-ethyl	Drift fb imazethapyr	Drift fb bentazon
Untreated check	0 a	0 a	0 a	0 a
0	0 a	0 a (0)[c]	0 a (0)	0 a (0)
2	11 b	13 b (11)	17 b (11)+	16 b (11)+
10	23 c	25 c (23)	27 c (23)+	27 c (23)+
20	28 c	34 d (28)+	33 c (28)+	32 c (28)+
40	42 d	47 e (42)+	45 d (42)	47 d (42)+
SE	2.1	2.2	2.0	2.1

[a] Abbreviations: DAA, days after application; fb, followed by.
[b] Means have been back-transformed to original scale. Means followed by the same letter in each column are not significantly different according to Fisher's protected LSD test ($P < 0.05$).
[c] Expected responses, based on Colby's equation ($E \; A + B - A \times B/100$), for combinations are shown in parentheses following each observed response. Significant differences based on a paired t-test between observed and expected values are shown by a "+" sign to indicate synergism.

3.2. Crop height

Height decreased with increasing doses of dicamba/diflufenzopyr (data not shown). Height decreased by 13, 29, 37 and 47% when dicamba/diflufenzopyr was applied at 2, 10, 20 and 40 g a.i. ha^{-1}, respectively. Similarly, Kelley et al. (2005) also reported a 12 24% height reduction, despite the development of lateral branches on the more severely injured plants. There were no synergistic responses from simulated dicamba/diflufenzopyr drift followed by any postemergence herbicides.

3.3. Crop dry weight

Percent dry weight reflected the amount of injury observed. Dry weight decreased by 19, 26, 36 and 50%, respectively, with increasing doses of dicamba/diflufenzopyr (data not shown). There were no synergistic responses from simulated dicamba/diflufenzopyr drift followed by the postemergence herbicides.

Table 4
Percent soybean yield in comparison to an untreated check when dicamba/diflufenzopyr drift was simulated alone or followed by the application of a postemergence herbicide at all three locations in 2007.[a]

Dicamba/diflufenzopyr drift (dose) (g a.i. ha $^{-1}$)	Yield[b] (%)			
	Dicamba/ diflufenzopyr	Drift fb chlorimuron-ethyl	Drift fb imazethapyr	Drift fb bentazon
Untreated check	100 a	100 a	100 a	100 a
0	100 a	102 a (102)[c]	95 ab (95)	98 a (98)
2	94 ab	98 a (96)	94 abc (90)	96 a (92)
10	94 ab	90 ab (97)	86 bc (90)	90 ab (92)
20	87 b	81 b (89)+	82 c (83)	83 b (85)
40	69 c	62 c (70)+	63 d (65)	64 c (67)
SE	1.7	1.8	1.6	1.6

[a] Abbreviations: DAA, days after application; fb, followed by.
[b] Means followed by the same letter in each column are not significantly different according to Fisher's protected LSD test ($P < 0.05$).
[c] Expected responses, based on Colby's equation ($E = A \times B/100$), for combinations are shown in parentheses following each observed response. Significant differences based on a paired *t*-test between observed and expected values are shown by a "+" sign to indicate synergism.

3.4. Crop yield

Soybean yield decreased with increasing doses of dicamba/diflufenzopyr (Table 4). Synergistic responses were observed with the simulated drift of dicamba/diflufenzopyr at 10, 20 and 40 g a.i. ha^{-1} followed by the chlorimuron ethyl application which resulted in a 7–8% greater yield reduction than expected. The application of dicamba/diflufenzopyr at 2, 10, 20 and 40 g a.i. ha^{-1} followed by imazethapyr or bentazon did not result in a synergistic yield response. Similarly, dicamba/diflufenzopyr (2 g a.i. ha^{-1}) followed by chlorimuron ethyl also did not result in a synergistic response in yield.

This study confirms that injury in soybean is accentuated when dicamba/diflufenzopyr drift is followed by some registered post-emergence herbicides. A synergistic response for crop injury 7, 14, 28 and 56 DAA and soybean yield was documented when soybean was stressed due to herbicide drift followed by the postemergence herbicide. Weed management practitioners and crop consultants must be aware that herbicides with an acceptable margin of crop safety can cause injury if the crop was stressed due to a previous herbicide drift event.

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Uti izing Geospat al echnology to Assess Off target Dicamba Injury and Yield Loss in Missouri Soybean F elds

Shea a ell* D Kent Shannon E c Ose and Mandy Bish and Kevin B ad ey Un ve s ty o Missou i Columb a

IN RODUC ION

n 20 6 he ma o ty o the cot on c ea e in the m d South we e p an ed w th d camba- o e ant D) va e i s and a im ted numbe o D oybean va e i s we e a so p an ed Du ng the 20 6 g owi g eason he e we e no app o ed dic mba he b c de o mu at ons o pos - me gence app i at on o hese c ops yet a subset o g owe s made i egal app ca io s an w y Ove 40 000 ac es o non-D soyb an we e n u ed by o ta get movement o d camba caus ng u known amoun s o yi ld lo s ev ous esea ch as s own soy ean y e d oss is depe dent on g owth tage nd exposu e dosa e Howe e in eld s t in s p a t tone s n ve know he peci c dose o ic mba hat co tac ed the non D oybean

OB EC IVES

o de e m ne i ate seas n v sual val at ons o d camba n u y c n p ed ct y e d oss on a eld sca e le el

MA ERIALS AND ME HODS

n 20 6 4 s pa a e on-D soybean e ds that we e n u ed by o ta get movement o d camba we e isu l y a ed u ing he Beh ens and ue chen sca e (979)

e d bounda es we e mapp d to SMS Mobi e Ag eade so wa e o am le g d c e t on (g Bounda y)

Samp e oca ons we e sta l shed us ng a ce te g id o mat at 5 me e spac ngs (g Sampl ng G ds)

V sual so bean n u y a i gs we e e o ded once oybean eached the R6 R7 s age o g ow h Handhe d G S un ts we e u ed o n vi ate to t e p ede e mi ed g id oca ions so at ngs cou d be geo e e enced (g Vi ual I ju y R t ngs)

n u y eva ua ions we e g ouped y se e ty and i te po ated n GIS so a a a soc at d w th e ch ange c uld be c lc la ed (g In e ola ed In u y Ra i gs)

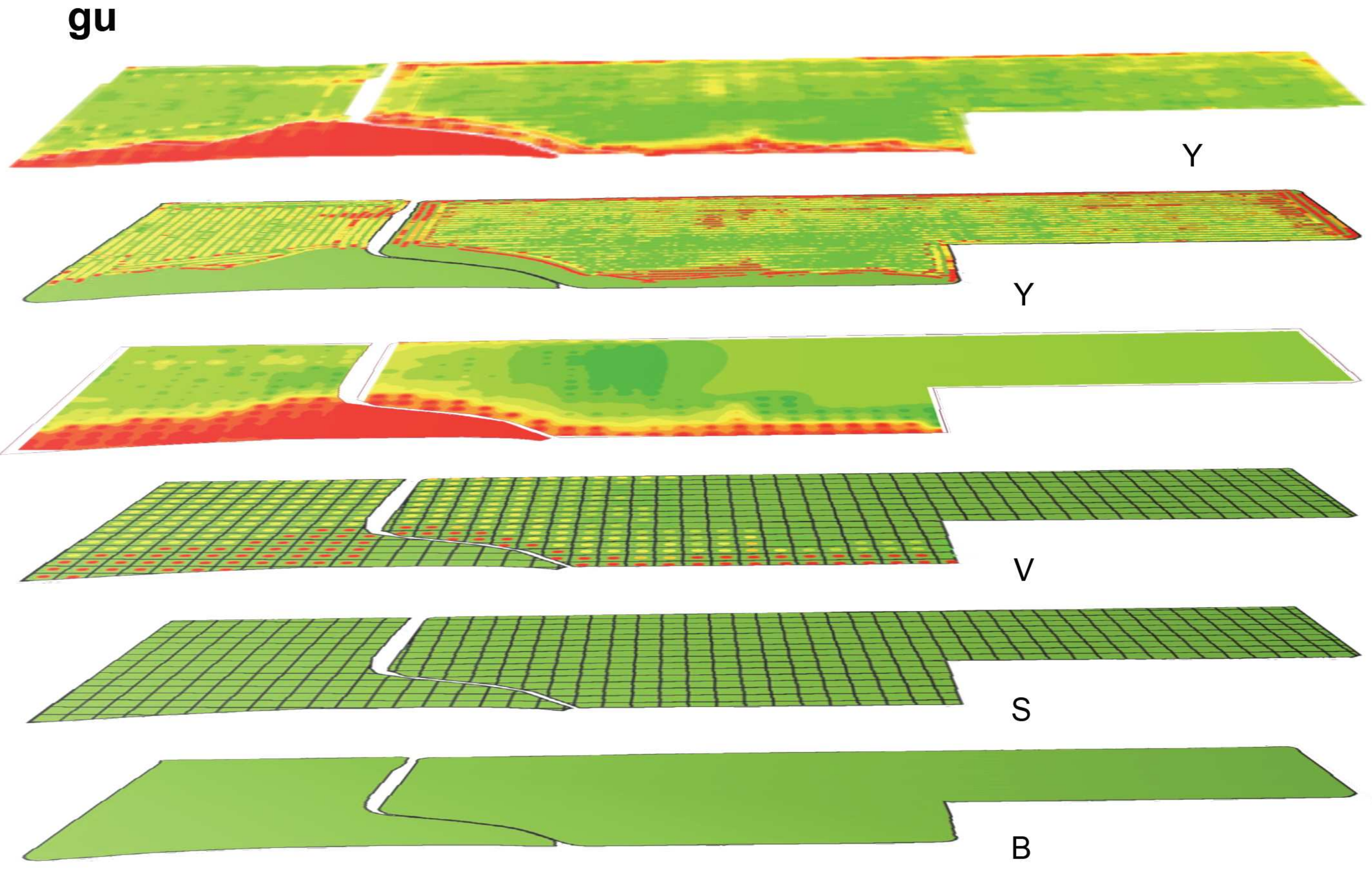
S t -spe i ic y e d n o mat on o ea h samp ed oca on was ob a ned th ough comb ne y e d mon o s (g ie d Map)

e ds we e g ouped n o anges ep esen i g ow i e- s eci c y e d va ues compa ed o the e d ave age then n e po a ed o ca cu ate a a (ig nte po a ed e d Map)

So bean ie d and vi ual nju y a ngs t each p e ete m ned s mpe oca on we e compa ed in SAS us ng he MEANS p ocedu e at the 0 05 le el o s gni can e

n u y a ngs we e g ou ed o p ed ct y e d oss anges based on he MEANS p ocedu e and om a ed to he ctua y elds

gu

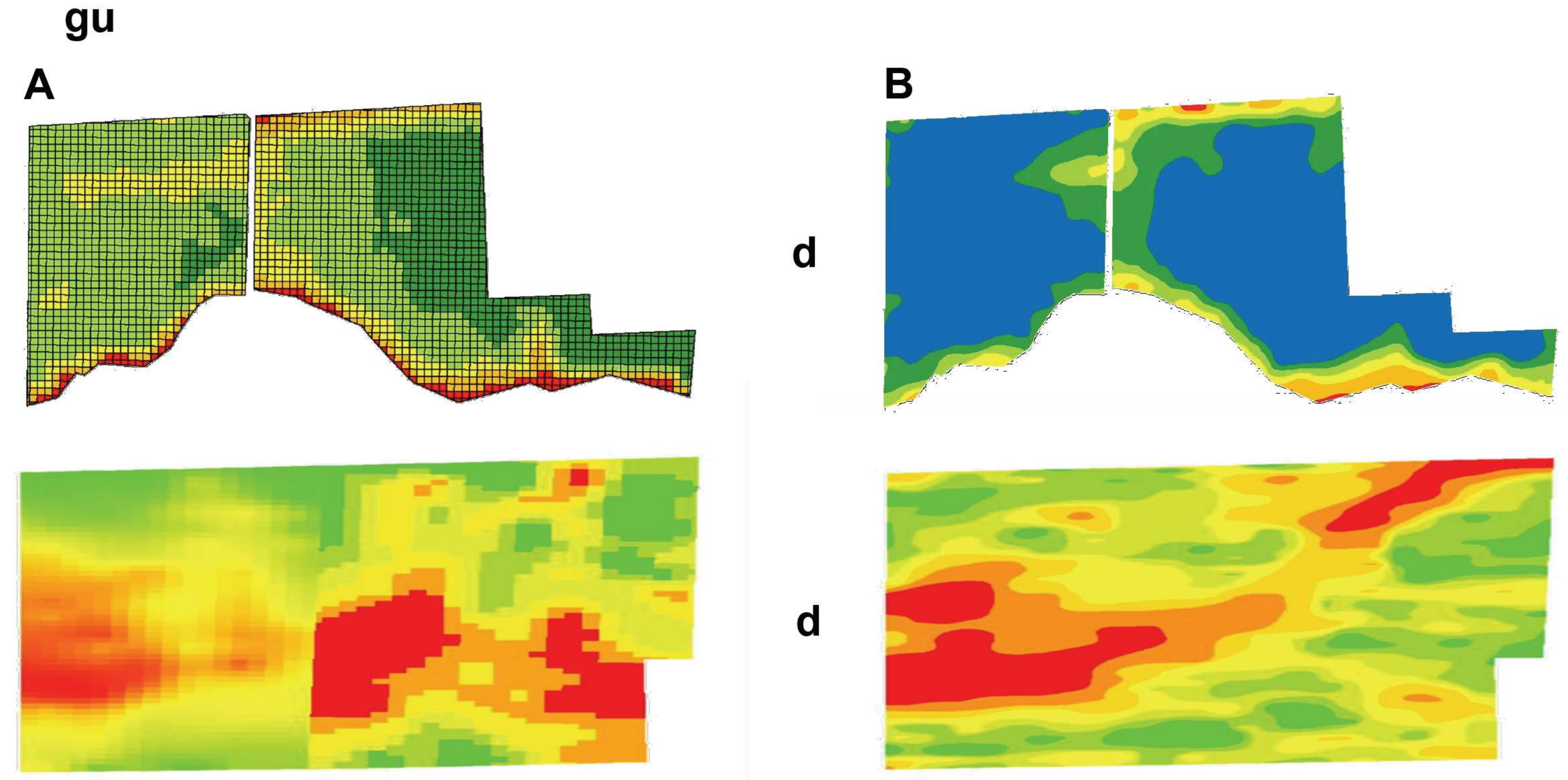


RESUL S

n e po a ed v sual nju y eva ua ons (gu es 2A a d 2C) we e a s gned and g o ped by in u y nte si y n o nc men s o 20% he ota a ea o ea h n u y ange was ca cu a ed (ab es and)

n e po a ed y e d m ps (gu es 2B a d 2D) we e c assi ed by ompa ng 20 6 y e ds o he c mb ned ave age y e d o he h e p ev ous oybean o at ons ie d a ea ep e ent ng e ch y e d ange was cal ul ted (ables and 2)

gu



Y	%		Y B % Y
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Ha ves ed yi ld da a was o gan zed in o ones de in ng how a eas o elds y e ded in 20 6 compa d o he hi to i al ave age he mean ie d o e ch one was us d o al ula e to al y e d (ab es and 2)

#		d		Y			
%	%Y					Y	
	0 00 0 0 0 0 0 0 0 0	**9**	9 99 0	**9**	 0 0 0		9 0 9 90 9
							9

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RESUL S

he est mat d ve a e yie d o each nju y a ge w s mu t p ed by ts ep ese ta i e a ea hen added to de e m ne to al y e d e t m ton (ab es and)

A e age y e d o ea h n u y ange ac o s all el s col ec ve y was compu ed o u he nal ze i amount o yie d l ss an e a soc ated w th v sual n u y (ab e 3)

	% Y					
%						
0 0	0%	%	%		9	9
0	9%	%	**9 %**	00	0	0
0	%	%	**%**		9	
0	%	%	**%**			9
00	%	0%	**%**	0		9

R su ts om a meta ana ys s ndi ate owe ng soyb an exposed o 000X a e o dic mba equal % yi ld l ss nd exposu e to 00X ate equ ls a 9% y eld oss

e im na y da a i dic tes yi ld oss d d not occu un il at le st 0% vi ual in u y was bse ed and >25% y eld lo s occu ed when at east 40% n u y was p sent (ab e 3)

#			
	0 0	9 0 99	9 999 9

In 20 6 y eld es ima io s us ng th s p oce u e ang d om -5 2% to 8% o he act al 20 6 y eld (ab e 4)

CONCLUSIONS & FU URE WORK

On ve a e in 20 6 es ima ed y e d l sses ased on in- eason n u y a ngs we e wi h n 2 5% o he ac ual y e d c o s al ou ie ds he s udy w l be epea ed in 20 7

n g ne al v sual nju y nd y e d oss was mo e p eva ent nd eve e as p oxim ty o he sou e nc eased

Ad i i nal y a elep one u vey s eing cond cted o ob a n p odu e s inp t on ie d lo ses due to d camba n u y

u he ana ys s w ll be onduc ed o de e m ne i yie d lo s p t e ns wi h n a e d an e ve as bet e ind ca o s o expe ted y e d lo s aused by o - a et mo eme t o d camba

Re ul s om t is s udy w l he p a me s and p o es iona s n he ag i ul u e ind st y be te i ual ze and un e s and he e ec s hat o ta get movement o d camba (i u e 3) has on oybean y e d

gu

S B 0
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Weed Science 2014 62:193 206

A Meta-Analysis on the Effects of 2,4-D and Dicamba Drift on Soybean and Cotton

J. Franklin Egan, Kathryn M. Barlow, and David A. Mortensen*

Commercial introduction of cultivars of soybean and cotton genetically modified with resistance to the synthetic auxin herbicides dicamba and 2,4-D will allow these compounds to be used with greater flexibility but may expose susceptible soybean and cotton cultivars to nontarget herbicide drift. From past experience, it is well known that soybean and cotton are both highly sensitive to low-dose exposures of dicamba and 2,4-D. In this study, a meta-analysis approach was used to synthesize data from over seven decades of simulated drift experiments in which investigators treated soybean and cotton with low doses of dicamba and 2,4-D and measured the resulting yields. These data were used to produce global dose–response curves for each crop and herbicide, with crop yield plotted against herbicide dose. The meta-analysis showed that soybean is more susceptible to dicamba in the flowering stage and relatively tolerant to 2,4-D at all growth stages. Conversely, cotton is tolerant to dicamba but extremely sensitive to 2,4-D, especially in the vegetative and preflowering squaring stages. Both crops are highly variable in their responses to synthetic auxin herbicide exposure, with soil moisture and air temperature at the time of exposure identified as key factors. Visual injury symptoms, especially during vegetative stages, are not predictive of final yield loss. Global dose–response curves generated by this meta-analysis can inform guidelines for herbicide applications and provide producers and agricultural professionals with a benchmark of the mean and range of crop yield loss that can be expected from drift or other nontarget exposures to 2,4-D or dicamba.

Nomenclature: 2,4-D (2,4-dichlorophenoxyacetic acid); dicamba (3,6-dichloro-2-methoxy benzoic acid); glyphosate; soybean, *Glycine max* (L.) Merr.; cotton, *Gossypium hirsutum* L.
Key words: Dose–response curves, *Glycine max*, *Gossypium hirsutum*, herbicide drift, herbicide-resistant crops, meta-analysis.

Biotechnology companies are currently developing cultivars of corn, soybean, and cotton engineered with transgenic resistance to the synthetic-auxin herbicides 2,4-D and dicamba (Behrens et al. 2007; Waltz 2010; Wright et al. 2010). Dow AgroSciences is currently developing corn (*Zea mays* L.), soybean, and cotton cultivars resistant to 2,4-D, and the Monsanto Company in collaboration with BASF is developing cultivars of soybean and cotton resistant to dicamba. Dicamba and 2,4-D have been widely used for decades for selective weed control of broadleaf plants in grass and cereal crops (Monaco et al. 2002). However, the new resistant cultivars will enable these compounds to be applied in new crops, at new times during the growing season (including more POST applications), and over greatly expanded areas, potentially leading to increased problems with nontarget drift onto susceptible crops, including non-transgenic soybean and cotton (Mortensen et al. 2012).

Soon after the commercialization of 2,4-D in the 1940s and dicamba in the 1960s, recurrent problems of nontarget exposures to susceptible crops began to occur (Staten 1946; Wax et al. 1969). Continuing to the present, the Association of American Pesticide Control Officers (AAPCO) consistently ranks 2,4-D and dicamba at or near the top of herbicide active ingredients implicated in crop injury complaints (AAPCO 2005), and several states and municipalities have special restrictions on the use of these compounds to help prevent crop injury problems (Louisiana Department of Agriculture and Forestry 2011; Texas Department of Agriculture 2012). This high frequency of crop injury complaints relative to other herbicides is likely due to several factors specific to 2,4-D and dicamba. First, synthetic auxin herbicides can cause distinctive injury symptoms on many broadleaf crops, including twisting or epinasty of stems and cupping of leaves, such that even slight injury can be readily recognized by growers and land owners.

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Secondly, several broadleaf crops, including soybean and cotton, are very sensitive to these compounds, creating the potential for noticeable injury and potential yield loss following very low-dose exposures. Finally, several commercially available 2,4-D and dicamba products include moderately volatile herbicide formulations that can travel away from treated fields as vapor drift (Behrens and Lueschen 1979; Egan and Mortensen 2012; Grover et al. 1972).

In regions where synthetic auxin–resistant cultivars of cotton and soybean will be widely adopted, the use of 2,4-D and dicamba is likely to increase substantially over the next 5 to 10 years (Mortensen et al. 2012). These trends could increase the risk of injury and yield loss to susceptible crops, including non-transgenic soybean and cotton through a variety of mechanisms. First, as with all herbicides, 2,4-D and dicamba can move as particle drift from ground or aerial application equipment, especially when herbicides are applied under windy conditions or when spray equipment not designed to reduce particle drift is used (Wang and Rautman 2008). Secondly, as previously mentioned, if volatile formulations are used under high temperature conditions, 2,4-D and dicamba can move from treated fields onto susceptible fields. Third, 2,4-D and dicamba residues are known to be difficult to clean from equipment, and small amounts of these compounds could be inadvertently applied to susceptible crops if the same equipment was recently used to treat dicamba or 2,4-D resistant or tolerant crops (Boerboom 2004). Finally, in regions where 2,4-D or dicamba are used frequently and over large areas, such as the wheat (*Triticum aestivum* L.) cropping systems of the Canadian prairie provinces, herbicide residues can accumulate in the atmosphere and return to fields as precipitation at concentrations high enough to cause injury to susceptible crops (Hill et al. 2002; Tuduri et al. 2006).

Anticipating potential problems, Dow AgroSciences, BASF, and Monsanto Company have been working with growers, agricultural service providers, and university extension to develop stewardship practices for these technologies. These practices will include the development of extremely low volatility formulations of 2,4-D and dicamba, adjuvants and herbicide premixes that reduce particle drift, and advanced spray nozzle designs that limit fine spray droplets (Dow AgroSciences 2011a, 2011b; Thomas et al. 2012). However, due to the combination of exposure routes, it remains likely that nontarget drift to susceptible crops will be a significant concern for growers, especially during the early phase of commercialization of these technologies. Because soybean and cotton are among the crop species most susceptible to these compounds, the risk of crop injury and potential yield loss will perhaps be greatest to soybean and cotton growers who choose not to use resistant cultivars in regions where the transgenic cultivars and associated herbicide programs are widely adopted by neighboring farmers. Importantly, because 2,4-D resistant crops will be susceptible to dicamba (and vice versa), crop injury risk could extend to growers that choose 2,4-D resistant cultivars in regions where dicamba resistant cultivars are more popular (and vice versa). In order to prepare for crop injury incidents and potential yield loss, growers and agricultural professionals may find it helpful to be equipped with a detailed understanding of the likely responses of cotton and soybean to low-dose exposures of 2,4-D and dicamba.

Fortunately, the dose–response patterns of crop injury and yield loss in cotton and soybean to 2,4-D and dicamba have already been extensively researched. Beginning in the 1950s with cotton, weed scientists in the United States and internationally began conducting simulated drift bioassay experiments to determine the herbicide doses that are likely to cause noticeable injury symptoms and the doses that are likely to cause significant yield loss. In this paper, a meta-analysis approach was used to review and synthesize the results from many of these previously published simulated drift experiments. After conducting an exhaustive search of the literature, an extensive dataset on the response of cotton and soybean to simulated drift was used to answer four key interrelated questions. First, what is the dose–response pattern of herbicide exposure dose (in g ha^{-1}) and crop yield? Second, how is the dose–response pattern affected by crop phenology at the time of exposure? Third, what other environmental and agronomic factors may influence crop dose–response? Finally, how do visual injury symptoms in soybean and cotton from 2,4-D and dicamba exposure correlate with yield loss?

Material and Methods

Literature Search. Literature searches were performed using the CAB Direct database in October and November of 2011 (Centre for Agriculture and Biosciences International 2012). CAB Direct spe-cializes in agricultural research and indexes many materials that would be missed by more general literature search engines such as Web of Science or Google Scholar, including conference proceedings and research reports from state agricultural experiment stations. The search was defined using the terms (cotton or soy*) and (2,4-D or dicamba) and (drift or injury or sensitiv* or toleran*). Several pilot searches using broader search terms such as "yield" were also conducted, but it was found that the more specific search terms captured all of the relevant material. Studies were classified as relevant based on the following criteria:

1. The study must have employed a replicated field experiment in which cotton or soybean was exposed to at least one dose of dicamba or 2,4-D and a water or untreated control. Studies in which dicamba or 2,4-D was applied in mixtures with other herbicidal compounds were not included. Herbicide treatment doses must have been applied as a foliar spray and presented in grams per hectare or in units that could be converted into grams per hectare doses.
2. Because 2,4-D or dicamba applications could affect crop performance by influencing weed–crop competition in addition to having direct phytotoxic effects, studies were selected that eliminated background weed communities with appropriate herbicides or cultivation. In some instances, studies selected as relevant did not specifically describe background weed control practices, but based on their methodologies and stated objectives, it could be safely inferred that weeds were effectively managed.
3. Studies must have collected and reported data on grain yield for soybean and seed cotton or lint yield for cotton. Data on visual injury ratings from studies that reported yield were also included.

CAB Direct indexes international publications and proceedings, but it reports all abstracts in English. For studies not published in English, the abstract, tables, and figures were reviewed to determine if the paper was likely to fit the criteria defined above. For these likely papers, international colleagues at The Pennsylvania State University were recruited to assist with interpretation. One study originally published in Portuguese (Constantin et al. 2007) was fully translated.

For each study that was selected as relevant, the bibliography was also reviewed and a backward search was then performed using the same criteria.

Data Coding. For each relevant study, information was gathered from tables and figures, and the available data on the dose of dicamba or 2,4-D exposure in each treatment and the resulting yield and visual injury (most commonly reported on a 0 to 100 scale) was coded. Yield response and injury data were coded as the mean value for a given dose as presented in each study's tables or figures. All yield data were normalized as the proportion of the respective control dose. Data presented in figures were extracted using the software program EnGauge (M. Mitchell 2007, Engauge Digitizing Software).

The crop growth stage at the time of exposure was coded by grouping the phenology described by the authors into either vegetative, flowering, or pod formation stages for soybean and into vegetative, preflower squaring (flower buds are first forming), early flowering, or mature flowering/boll formation stages for cotton. Several studies did not clearly describe the crop's growth stage, but instead listed the crop's height or number of leaves or nodes at the time of herbicide treatment. In these cases, the crop's phenology was inferred based on other studies in the dataset that reported height, leaf number, and phenology from similar locations and using similar cultivars or using information presented in Barker et al. (1985), Oosterhuis and Jernstedt (1999), and Pedersen (2004).

Many studies quantified yield response under several unique experimental conditions, for instance crop response may have been measured to both dicamba and 2,4-D or to different 2,4-D doses at multiple phenological timings of herbicide exposure. Within a study, a unique set of experimental conditions was classified as a unique "sequence." For instance Kelley et al. (2005) present data from an experiment in which soybean were exposed to dicamba at the V3, V7, and R2 growth stages, providing three unique dose–response sequences. They also report on a separate experiment in which soybean were exposed to dicamba at the V3 and V7 stages in two different years, with each year reported separately. In total, this reference therefore contributed seven different dicamba dose–response sequences to the dataset. Because each sequence contained either one or two different doses of dicamba exposure, Kelley et al. (2005) contributed 10 data points to this meta-analysis for dicamba and soybean.

Statistical Analysis. The dose–response patterns of dicamba or 2,4-D simulated drift on soybean and cotton yield were analyzed by fitting log-logistic curves to the data using the nls package in R (R Core Team 2011; Ritz and Streibig 2008). Because the untreated control yields were defined as 1.0, and because label rates of dicamba and 2,4-D are obviously fatal to both cotton and soybean, a two-parameter log-logistic function with the upper asymptote set to 1 and the lower asymptote set to zero was used (Equation 1).

$$\mathrm{Yield}_i = 1/(1+\exp\{b\times[\log(\mathrm{Dose}_i)\quad\log(e)]\}) + e_i,\ e_i \sim N\left(0,\sigma^2\right) \qquad [1]$$

where e is the dose that causes a 50% yield loss and b is the slope of the curve at the e-parameter dose (Ritz and Streibig 2005). Because all yields were normalized as a proportion of the control, the untreated control yields were removed from the data set before fitting the models to avoid heteroscedasticity and nonnormality of residuals. To quantify the influence of crop phenology at the time of exposure, separate models were fitted for each combination of crop growth stage and herbicide active ingredient (dicamba or 2,4-D).

For cotton, a fraction of studies reported yield in terms of both raw seed cotton yield and ginned lint yield. To test for any potential interaction of herbicide dose and lint yield as a percentage of seed cotton yield (ginning percentage), the correlation between normalized seed cotton and lint yield was assessed for this subset of studies. Linear regression results indicated a near perfect correlation (0.999) with a slope nearly equal to one (0.993), implying no influence of either herbicide on ginning percentage. Studies that reported seed cotton or lint cotton yields were therefore pooled into the same dose–response curves.

In this meta-analysis, the effect size or response statistic is the ratio of treatment yield to control yield. Meta-analysis requires estimating the within-study variation in effect size as a measure of the precision with which the authors of a given study were able to estimate an effect or response in their experiments (Cooper et al. 2009). Within-study variation statistics can then be used to weight more precise studies more heavily than less precise studies in the meta-analysis. For response ratio data, Hedges et al. (1999) suggested that the variance of response ratios provides a good estimate of within-study variation. Hedges et al. (1999) further suggested that the natural logarithm of response ratios and its associated variance are better effect size statistics because they weight changes in control and treatment response equally and tend to be more normally distributed than the untransformed response ratio statistic. But, for log-logistic models, log-transforming the y-axis and using log response ratios would lose the biological meaning of the model's asymptotes, because log(1) equals zero and log(0) equals negative infinity. Therefore the more interpretable untransformed response ratio statistic and its associated variance were used in this analysis, as defined in Equation 2 and in Appendix A of Hedges et al. (1999).

$$\text{Variance of Response Ratio} = (X_\mathrm{T}/X_\mathrm{C})^2\times\left[\left(\mathrm{SE}_\mathrm{T}^2/n_\mathrm{T}X_\mathrm{T}^2\right)+\left(\mathrm{SE}_\mathrm{C}^2/n_\mathrm{C}X_\mathrm{C}^2\right)\right] \qquad [2]$$

where, X_T is the mean from a treatment group, SE_T is the standard error of that mean, n_T is the sample size of the treatment group, and X_C, SE_C, and n_C are the analogous quantities for the control group.

For several studies in this meta-analysis, the values for the standard error of the mean that were needed to calculate Equation 2 were either reported directly or could be back-calculated using summary statistics reported by the authors, such as the Fisher's Least Significant Difference (Kuehl 2000; Zar 1998). Using reported values or back-calculations, Equation 2 could be calculated for four studies and 35 sequences for soybean and eight studies and 57 sequences for cotton. Unfortunately, in many cases authors did not report sufficient information to calculate standard errors of the means but instead only reported sample size or the number of replications. Rather than simply exclude studies that did not report variance statistics from this meta-analysis, the subset of studies for which Equation 2 could be calculated was used to exploit a correlation between within-study variance and sample size. The pattern evident in this correlation was then applied to the entire dataset using the following bootstrap procedure.

For the subset of studies for which Equation 2 could be calculated, the variance of the response ratio statistics were binned into three replicate size classes (three, four or five, and more than six replicates). Figure 1 indicates a clear pattern of decreasing variation with increasing sample size, as is expected from basic statistical theory (Crawley 2005). Next, the subset for which Equation 2 could be calculated was separated by crop and the variance statistics were then randomly sampled with replacement from each replicate size class. These randomly sampled values were then assigned to data points with corresponding sampling sizes in the full dataset. A two-parameter log-logistic model was then fit using the randomly

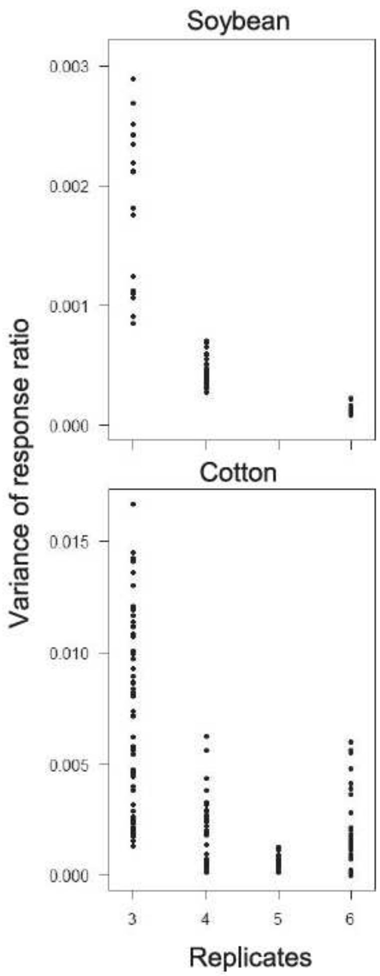

Figure 1. Relationship between the number of replications and the variance of the response ratio of yields in treated to untreated control plots. Data are compiled from previously published experiments that measured the effect of simulated dicamba and 2,4 D drift on yields of soybean and cotton.

assigned variance statistics as weights (Equation 3; Ritz and Streibig 2008).

$$\text{Yield}_i = 1/(1 + \exp\{b \times [\log(\text{Dose}_i) \quad \log(e)]\}) + e_i/\sqrt{w_i},\ e_i \sim N(0,\sigma^2) \qquad [3]$$

where w_i is the variance of response ratio randomly assigned based on sample size. For each combination of crop growth stage and herbicide, this procedure was repeated 100 times, and results are reported as the median from this bootstrapped distribution of fitted models. R code for this procedure is available from the authors upon request.

Synthetic auxin herbicides are widely reported to cause stimulatory effects to crops at low doses, also known as hormesis. To test for the possibility of hormesis, the log-logistic model was compared to the Cedergreen hormesis model (Cedergreen et al. 2005) using Akaike's Information Criterion (Burnham and Anderson 2002) and *t*-tests of the Cedergreen f parameter (Cedergreen et al. 2005). For all combinations of crop growth stage and herbicide, the log-logistic model showed a substantially better fit to the data, indicating no evidence for a hormesis effect (data not presented).

To assess potential yield loss from herbicide drift, the predicted yield loss for each crop growth stage and herbicide combination was calculated at doses of 0.56, 5.6, and 56 g ha^{-1}. Assuming a field application rate of 560 g ha^{-1}, these doses roughly correspond to a vapor drift exposure in an adjacent field (Egan and Mortensen 2012; Grover et al. 1972), a particle drift exposure in an adjacent field (Brown et al. 2004; Carlsen et al. 2006; de Jong et al. 2008; United States Environmental Protection Agency 2006; Wang and Rautman 2008), or a serious application error, respectively. For each bootstrapped model fit, 95% confidence intervals were calculated around these yield loss estimates using the delta method in the R package car (Fox and Weiseberg 2010). The median intervals from the bootstrapped distribution of 100 models are reported.

For the subset of studies that reported data on both yield and visual injury for the same treatments, simple linear models of the relationship between yield and injury rating were calculated. Multiple linear (including a quadratic term for injury) and logistic regression models for the relationship between yield and injury were also calculated. For soybean, logistic models provided a better fit, but for cotton, linear, multiple linear, and logistic models all produced similar fits. However, for both soybean and cotton, all models led to a similar interpretation of the results, therefore results will only be presented for the simple linear models. Injury ratings 12 to 16 d after treatment (DAT) were used because this was the most commonly reported injury rating interval. For one cotton 2,4-D study (Goodman et al. 1955), injury 3 DAT was used, since this was the closest reported interval.

Mitigating Environmental and Agronomic Factors. Many authors conducted experiments over multiple years and sites or crossed herbicide dose with another potentially important factor such as herbicide formulation or crop genetics. Because data on these potentially important factors was not collected or reported consistently across the family of studies in the dataset, their significance could not be statistically assessed. Instead each author's explanation and discussion of potentially important factors that could influence dose–response patterns was carefully examined, and these findings are presented here as a narrative review.

Table 1. Summary of the number of studies, dose response sequences, and unique mean data points excluding controls (*n*). collected from a literature search of studies that measured the yield response of soybean and cotton to simulated dicamba and 2,4 D drift at different crop growth stages.

Crop, herbicide	Growth stage	Studies	Sequences	*n*	Citations
Soybean, dicamba	Vegetative	6	20	61	Al Khatib and Peterson 1999; Andersen et al. 2004; Auch and Arnold 1978; Johnson et al. 2012; Kelley et al. 2005; Wax et al. 1969
	Flowering	4	22	80	Auch and Arnold 1978; Kelley et al. 2005; Wax et al. 1969; Weidenhamer et al. 1989
	Pod	2	9	26	Auch and Arnold 1978; Weidenhamer et al. 1989
Soybean, 2,4 D	Vegetative	9	25	81	Andersen et al. 2004; Johnson et al. 2012; Kelley et al. 2005; Merotto et al. 1999; Robinson et al. 2013; Slife 1956; Smith 1965; Wax et al. 1969; Wiese and Martin 1963
	Flowering	5	13	35	Kelley et al. 2005; Slife 1956; Smith 1965; Wax et al. 1969; Wiese and Martin 1963
Cotton, dicamba	Vegetative	6	11	42	Everitt and Keeling 2009; Johnson et al. 2012; Lanini 1999; Marple et al. 2007, 2008; Smith and Wiese 1972
	Squaring	4	6	18	Everitt and Keeling 2009; Hamilton and Arle 1979; Marple et al. 2008; Smith 1972
	Flowering	5	7	19	Everitt and Keeling 2009; Hamilton and Arle 1979; Lanini 1999; Marple et al. 2008; Smith 1972
Cotton, 2,4 D	Vegetative	15	44	117	Behrens et al. 1955; Carns and Goodman 1956; Charles et al. 2007; Epps 1953; Everitt and Keeling 2009; Goodman et al. 1955; Goodman 1953; Johnson et al. 2012; Lanini 2000; Marple et al. 2007, 2008; Miller et al. 1963; Smith 1972; Watson 1955; Wiese and Martin 1963
	Squaring	11	28	76	Arle 1954; Banks and Schroeder 2002; Behrens et al. 1955; Carns and Goodman 1956; Charles et al. 2007; Everitt and Keeling 2009; Goodman et al. 1955; Marple et al. 2008; Miller et al. 1963; Smith 1972; Wiese and Martin 1963
	Flowering	12	34	75	Arle 1954; Behrens et al. 1955; Carns and Goodman 1956; Charles et al. 2007; Constantin et al. 2007; Everitt and Keeling 2009; Goodman et al. 1955; Lanini 1999; Marple et al. 2008; Miller et al. 1963; Smith 1972; Watson et al. 1955
	Boll	10	33	64	Arle 1954; Behrens et al. 1955; Carns and Goodman 1956; Charles et al. 2007; Constantin et al. 2007; Epps 1953; Goodman et al. 1955; Kittock and Arle 1977; Kittock et al. 1973; Miller et al. 1963

Results and Discussion

Search Results. The literature searches retrieved 512 unique studies, of which 23 were classified as relevant. Backward searches produced an additional five relevant studies. Two recent papers (Johnson et al. 2012; Robinson et al. 2013) that were published after the conclusion of the literature review were added. In total, the dataset includes 30 studies and a total number of 252 sequences. The number of studies, sequences, and unique dose-response data points (excluding control points) for each crop growth stage and herbicide combination is summarized in Table 1.

Dose–Response Curves. *Soybean*. Soybean was far more sensitive to dicamba than to 2,4-D and was more sensitive to both herbicides in the flowering growth stage than in other stages (Tables 2 and 3, Figure 2). During the flowering stage, the dose–response curves indicate a mean yield loss of ~1.0% from dicamba vapor drift exposures (0.56 g ha^{-1}) and 8.7% from dicamba particle drift exposures (5.6 g ha^{-1}). Yield losses were basically zero for 0.56 g ha^{-1} exposures during vegetative and pod formation stages, and slight (3.7%) for 5.6 g ha^{-1} exposures during vegetative stages. For serious misapplication exposures (56.1 g ha^{-1}), all soybean growth stages showed drastic yield losses of 48% or greater.

The dose–response curves suggest that soybean has surprisingly high tolerance to 2,4-D. During both vegetative and flowering stages, soybean showed essentially no yield loss to vapor or particle drift level exposures and only slight yield losses (1.5 to 3.0%) to even serious misapplication exposures. There were no data available for pod formation stage exposures to 2,4-D.

These data suggest that yield loss from synthetic auxin drift to soybean is more likely to be an issue when soybean is exposed to dicamba during the flowering stage. Because soybean may be planted

Table 2. Summary of log logistic dose response models for the effects of dicamba and 2,4 D exposure on yields of soybean and cotton at different crop growth stages. Values reflect the median parameter estimates across 100 bootstrapped model fits.[a]

Crop, herbicide	Growth stage	e^{b}	b^{c}	r^{2d}
Soybean, dicamba	Vegetative	58	1.40	0.60
	Flowering	60	0.99	0.58
	Pod	51	3.41	0.84
Soybean, 2,4 D	Vegetative	651	1.42	0.47
	Flowering	461	2.00	0.63
Cotton, dicamba	Vegetative	6730	0.46	0.22
	Squaring	109	1.46	0.63
	Flowering	92	1.15	0.60
Cotton, 2,4 D	Vegetative	61	0.33	0.28
	Squaring	15	0.70	0.48
	Flowering	72	0.63	0.44
	Boll	328	0.66	0.38

[a] Yield = 1/(1 + exp{b × [log(Dose) log(e)]}), with yield normalized as proportion of untreated control.
[b] The *e* parameter is the herbicide dose causing a 50% loss in yield (in units of g ha^{1}).
[c] The *b* parameter describes the slope of the curve at the *e* parameter dose.
[d] The r^2 statistic is the squared Pearson correlation of predicted and observed values for each curve.

over a long period (6 wk or longer, particularly in the southern United States), such a scenario is more likely to occur if POST applications of dicamba herbicides become more common in soybean production areas. The new resistant traits will make later POST applications of dicamba in soybean and corn a weed control option that may be very attractive to growers where glyphosate-resistant and tolerant weeds are a serious problem. Thus, it will remain important to use appropriate application techniques and stewardship practices when using dicamba near susceptible soybean and other crops.

Cotton. Cotton was far more sensitive to 2,4-D than dicamba (Tables 2 and 3, Figure 2), and for 2,4-D, cotton showed the most sensitivity relative to all of the other three crop–herbicide combinations. Cotton was most sensitive to dicamba during early flowering, with slight losses (1.3%) predicted from vapor drift exposures and slightly more substantial (3.9%) losses predicted from particle drift exposures. During vegetative and squaring stages, basically no yield loss is predicted from vapor drift exposures of dicamba, but more substantial yield losses are possible from particle drift exposures. Serious misapplication doses (56.1 g ha^{-1}) indicated yield losses of 10% or more from all growth stages (no data were available for dicamba exposures in the boll stage).

As has been widely appreciated nearly since the discovery of 2,4-D, cotton is extremely sensitive to this herbicide, especially during vegetative and preflowering squaring stages. During vegetative stages, average yield losses of more than 19% are predicted just from vapor drift exposures, and 32% and 49% yield losses are possible from particle drift or misapplication exposures. During preflowering squaring stages, cotton showed less sensitivity to vapor drift exposures (9% yield loss), but greater sensitivity to particle drift (33% loss) and misapplication (71% loss) doses. Cotton sensitivity declines somewhat as plants mature and begin

Table 3. Predicted yield of soybean or cotton exposed to three doses of dicamba or 2,4 D at different crop growth stages. Yield is presented as the proportion of untreated or control yield, and doses represent probable exposures to vapor drift, particle drift, or herbicide misapplication onto a sensitive crop adjacent to a field treated at 560 g ha^{1} with either herbicide. Predictions are derived from log logistic dose response[a] curves fit to data from previously published simulated drift experiments. Values reflect the median estimates across 100 bootstrapped model fits with 95% confidence intervals displayed in parentheses.

		Yield		
Crop, herbicide	Growth stage	0.56 g ha^{1} vapor drift	5.6 g ha^{1} particle drift	56 g ha^{1} misapplication
Soybean, dicamba	Vegetative	0.998 (0.995, 1.002)	0.963 (0.920, 1.006)	0.511 (0.414, 0.607)
	Flowering	0.990 (0.979, 1.002)	0.913 (0.873, 0.953)	0.515 (0.455, 0.576)
	Pod	1.000 (1.000, 1.000)	0.999 (0.998, 1.001)	0.414 (0.278, 0.550)
Soybean, 2,4 D	Vegetative	1.000 (1.000, 1.000)	0.999 (0.997, 1.001)	0.970 (0.945, 0.996)
	Flowering	1.000 (1.000, 1.000)	1.000 (0.999, 1.000)	0.985 (0.965, 1.006)
Cotton, dicamba	Vegetative	0.989 (0.966, 1.015)	0.969 (0.923, 1.008)	0.904 (0.858, 0.955)
	Squaring	1.000 (0.998, 1.001)	0.986 (0.959, 1.012)	0.727 (0.624, 0.823)
	Flowering	0.997 (0.989, 1.005)	0.961 (0.903, 1.017)	0.642 (0.520, 0.751)
Cotton, 2,4 D	Vegetative	0.805 (0.712, 0.900)	0.680 (0.601, 0.756)	0.509 (0.412, 0.605)
	Squaring	0.912 (0.844, 0.978)	0.670 (0.577, 0.763)	0.293 (0.223, 0.361)
	Flowering	0.956 (0.906, 1.001)	0.835 (0.747, 0.914)	0.545 (0.456, 0.626)
	Boll	0.985 (0.963, 1.005)	0.937 (0.890, 0.983)	0.761 (0.704, 0.817)

[a] Yield = 1/(1 + exp{b × [log(Dose) log(e)]}).

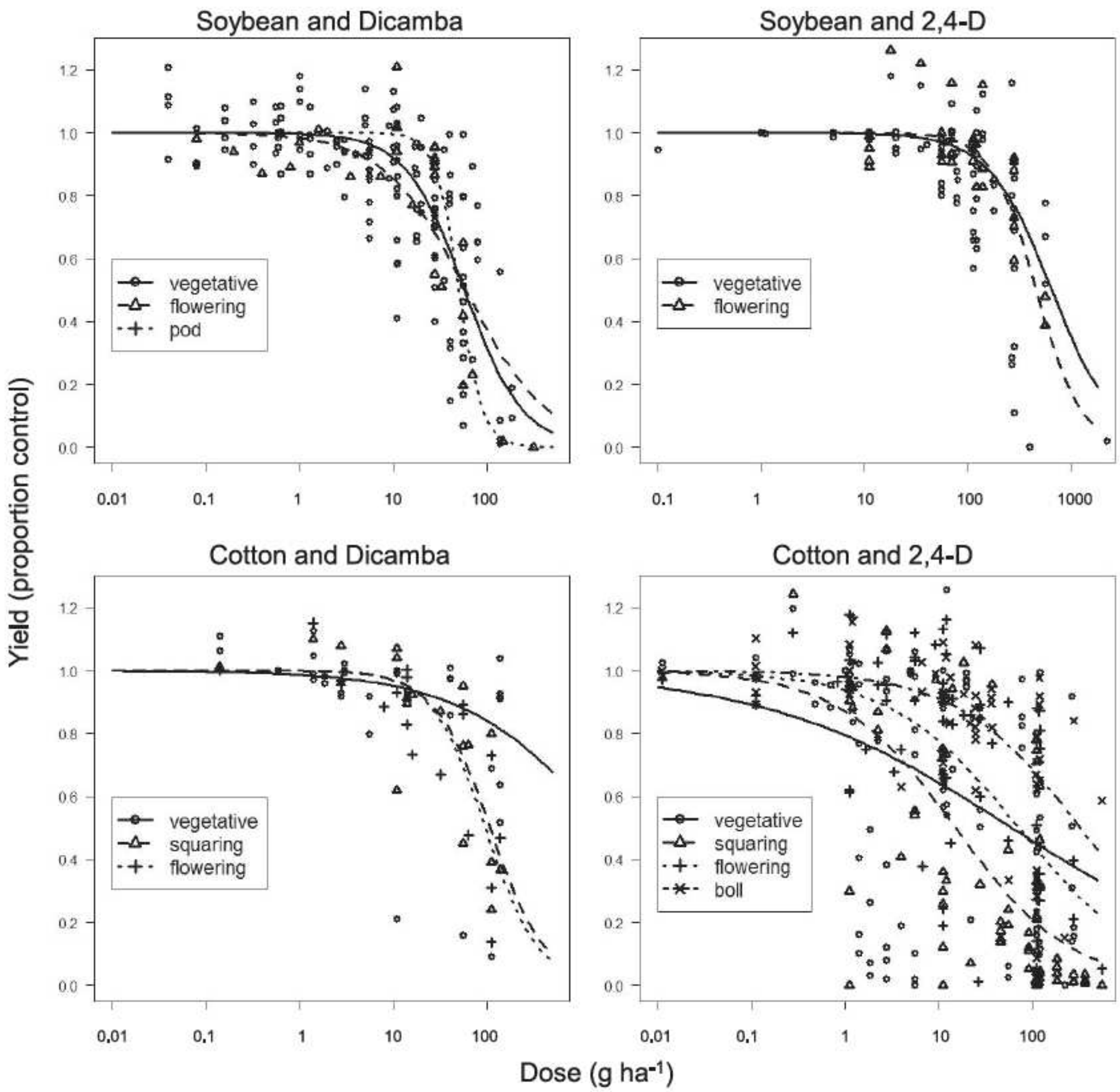

Figure 2. Yield response of soybean and cotton to dicamba or 2,4 D exposure across different crop growth stages. Data are compiled from previously published simulated drift experiments. Dose response curve lines reflect the log logistic models defined in Table 2.

developing bolls, but small yield losses are still possible from vapor drift (1.5%) or particle drift exposures (6.3%) during boll stages. Interestingly, cotton was also far more variable in its response to 2,4-D as compared with soybean's response to either herbicide (Table 3, Figure 2). This variability may reflect inherent variation in the uptake and biochemical response of cotton to 2,4-D, or it may reflect the fact that this dataset contains a greater number of studies, locations, and environmental conditions for cotton and 2,4-D as compared with the other herbicide–crop combinations in this meta-analysis (Table 1).

These data suggest that yield losses from 2,4-D drift to cotton may be a substantial problem if new resistant crops make postemergence 2,4-D applications common when susceptible cotton is growing nearby. Such a scenario is probable, because in much of the southern United States cotton is planted before soybean. The observed variability in response indicates it will be very difficult to anticipate yield loss following crop injury, but that yield losses could potentially be high. It will be critically important to use low volatility formulations, state-of-the-art application equipment, and perform applications under appropriate environmental conditions. Dicamba may be a safer option than 2,4-D if susceptible cotton is nearby, and it may be more appropriate to avoid synthetic auxins all together and integrate alternative weed management practices instead.

Mitigating Environmental and Agronomic Factors. The studies in this dataset reflect broad heterogeneity with regard to many factors that are well known to influence crop response to herbicides,

Table 4. Summary of environmental and agronomic factors found to influence soybean and cotton sensitivity to yield loss and injury from simulated dicamba or 2,4 D drift.

Crop	Herbicide	Factor	Effect on sensitivity	Citations
Soybean	Dicamba	Crop oil adjuvants in spray solution	Increased	Andersen et al. 2004
	Dicamba, 2,4 D	Dry conditions around exposure	Increased	Andersen et al. 2004; Auch and Arnold 1978; Kelley et al. 2005; Weidenhamer et al. 1989
	Dicamba	Higher temperatures around exposure	Increased	Al Khatib and Peterson 1999
	Dicamba, 2,4 D	Crop cultivar	Variable	Auch and Arnold 1978; Wax et al 1969; Weidenhamer et al. 1989
	2,4 D	Formulation (ester vs. amine)	Increased	Smith 1965; Weise and Martin 1963
	Dicamba, 2,4 D	"Thickening agent" (Norbak) added to spray solution	No effect	Wax et al. 1969
	Dicamba	Narrower row spacing	Increased	Weidenhamer et al. 1989
	Dicamba	Formulation (DMA vs. Na)	No effect	Weidenhamer et al. 1989
Cotton	2,4 D	Favorable fall weather facilitates recovery	Decreased	Arle 1954; Behrens 1955; Carns and Goodman 1956; Miller et al. 1963
	2,4 D	Higher carrier volume in simulated drift studies	Decreased	Banks and Schroeder 2002
	Dicamba, 2,4 D	Dry conditions around exposure	Increased	Behrens 1955; Carns and Goodman 1956; Marple et al. 2007; Marple et al. 2008
	Dicamba, 2,4 D	Moist conditions around exposure	Increased	Carns and Goodman 1956; Goodman 1953; Marple et al. 2007
	2,4 D	Higher temperatures around exposure	Increased	Kittock and Arle 1953
	2,4 D	Formulation (ester vs. amine)	Increased	Marple et al. 2007; Wiese and Martin 1963
	2,4 D	Soil quality facilitates recovery	Decreased	Miller et al. 1963

including meteorological and edaphic conditions at the time of spraying, crop cultivar and genetics, herbicide formulation, and herbicide carrier volume. Because these factors were generally not balanced in this dataset in a way that permitted a rigorous statistical analysis, the dose–response curves reflect the mean or expected yield loss across this broad heterogeneity. The often substantial variability around these mean curves (Table 3, Figure 2) reflects the combined contributions of these mitigating factors. Nevertheless, many authors explored crop herbicide response over multiple site years or over different experimental conditions and offered some explanations for the variation they observed in crop response. These factors are summarized in Table 4, and a few consistent themes emerge.

First, environmental conditions before, during, and following herbicide exposure play a very important role determining crop sensitivity to herbicide drift. Soil moisture level and air temperature were identified by several authors as key factors. For soybean, dry conditions were consistently associated with increased dicamba and 2,4-D sensitivity relative to conditions with less water stress. For cotton, the effect of soil moisture was more nuanced. For vegetative and squaring stage exposures, several authors noted that sufficient soil moisture and humid conditions led to plants that were actively growing and therefore absorbed and translocated more herbicide, leading to greater sensitivity. However, for late flowering or boll stage exposures, dry conditions were found to affect the floral abscission and boll development process negatively, such that sensitivity to 2,4-D was increased. For vegetative growth stages, Marple et al. (2007) found that dry conditions increased sensitivity, especially with ester formulations of 2,4-D. Marple et al. (2007) suggested this occurred because esters are less polar molecules relative to amine formulations and therefore may be more likely to cross the waxy cuticle of cotton leaves under dry conditions. Several authors also concluded that higher air temperatures increased herbicide uptake and resulted in greater injury and yield loss in both cotton and soybean.

As an indeterminate species, cotton produces squares and flowers continuously until arrested by low night temperatures (~5 C) or by "cut-out," a physiological end of a flowering cycle that depends on latitude, night temperatures, cultivar, and fruit load (Bednarz and Nichols 2005). Consequently, cotton plants injured by 2,4-D or dicamba early in development can often resume flowering and compensate with later fruit set. However, depending on latitude, climate, and weather patterns during a particular season, injured plants may hit the end of the growing season before they are able to fully recover. Several authors (Arle 1954; Behrens 1955; Carns and Goodman 1956; Miller et al. 1963) documented that in seasons with delayed frosts and extended growing seasons, yield losses from 2,4-D exposures during vegetative, preflowering squaring, and flowering stages were substantially reduced from losses observed during shorter growing seasons.

Cultivars and crop genetics are also likely key factors, but the effect of crop cultivar on sensitivity was only well explored for soybean. Weidenhamer et al. (1989) found that for flowering stage exposures to dicamba, a determinate soybean cultivar that ceases vegetative growth at the onset of flowering was less sensitive than an indeterminate cultivar. Wax et al. (1969) also commented that indeterminate cultivars were likely to be more sensitive to dicamba during flowering stages than determinate cultivars, but that determinate cultivars may be more sensitive during vegetative stages. Auch and Arnold (1978) observed variation for dicamba sensitivity across cultivars, but did not find that any cultivars were especially tolerant. Several authors working with cotton discussed the possibility of selecting cotton cultivars with increased tolerance to 2,4-D (Charles et al. 2007; Marple et al. 2008), but none compared different cultivars statistically.

Particularly with 2,4-D, the specific active ingredient and formulation of the herbicide was also identified as an important factor. Both cotton and soybean were consistently shown to be more sensitive to esters vs. amine simulated drift of 2,4-D. As part of their resistant crop cultivar technology packages, Dow AgroSciences and Monsanto/BASF are both promoting new low volatility formulations (Dow AgroSciences 2011a; Thomas et al. 2012). Dow is promoting Cholex-D, a quaternary choline salt of 2,4-D, and BASF (the primary manufacturer of dicamba and business partner of Monsanto) has developed EnGenia, an aminopropyl methylamine salt of dicamba. However, there are currently no published data on how susceptible crops will respond to these formulations. Only one study in this dataset systematically compared dicamba formulations (Weidenhamer et al. 1989) and found no difference in soybean susceptibility to dimethlylamine vs. sodium salt dicamba treatments. Depending on the nature of the adjuvant, incorporating adjuvants were observed to either increase or have no effect on the sensitivity of soybean to simulated dicamba or 2,4-D drift (Table 4).

Herbicide carrier volume was addressed in one study as an important factor influencing crop sensitivity (Banks and Schroeder 2002) and has also been highlighted by authors conducting simulated drift studies on other crop–herbicide combinations (Ellis et al. 2002; Roider et al. 2008). In simulated drift studies, experimenters typically hold the carrier volume constant while reducing the grams per hectare dose, thus effectively also reducing the grams per liter herbicide concentration of the treatment. When carrier volume is reduced across a dose gradient, such that grams per liter concentrations are kept constant, the crop response is often more severe. Most of the studies in this dataset used field application rate carrier volumes (~187 L ha^{-1}). Thus, the dose–response curves presented here may in fact underestimate the real yield losses that can occur from particle or vapor drift exposures.

Considering the range of factors affecting crop sensitivity to herbicide drift, it is important to consider that these dose–response curves are not meant to predict yield loss in any specific field event. Instead, global dose–response curves can provide a statistically valid estimate of the mean and variation of potential yield loss and also highlight the important differences between crops, herbicides, and growth stages at the time of exposure.

Visual Injury and Yield Loss. From the subset of studies that measured both yield loss and visual injury symptoms ~14 DAT, linear models with visual injury symptoms generally overestimated yield loss (Figure 3). For both cotton and soybean, data was mainly available only for vegetative growth stages, so it remains unclear how well the patterns documented in Figure 3 translate across growth stages, or to other circumstances beyond this sample of studies.

For soybean, injury seemed to correlate fairly closely with yield loss for both dicamba (r^2 0.62) and 2,4-D (r^2 0.61). However, for both herbicides the slope was somewhat above unity, indicating that a linear model for injury will overestimate yield loss and that plants exposed in vegetative stages can generally grow out of low to moderate injury symptoms. For cotton and dicamba, injury appeared to greatly overestimate yield loss, indicating that plants may sometimes express severe synthetic auxin injury symptoms but will generally grow out of the injury without suffering

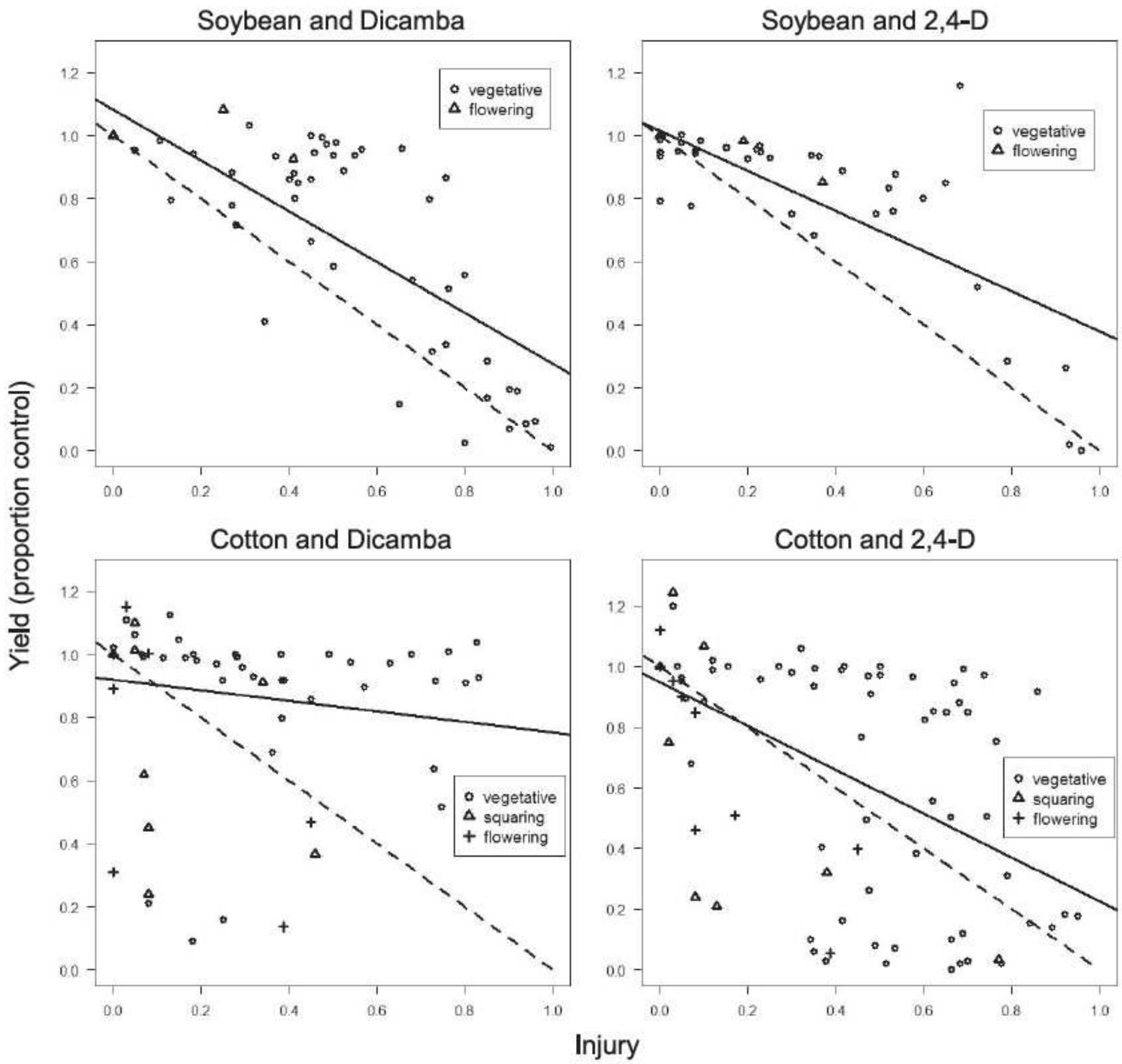

Figure 3. Correlations between yields of soybean and cotton and visual ratings of dicamba or 2,4 D 14 d after treatment. Data are compiled from previously published experiments evaluating the response of soybean or cotton to simulated dicamba and 2,4 D drift. Solid lines reflect the fit of linear regression models and dashed lines reflect an idealized 1:1 exact correlation. Symbols reflect different crop growth stages, but regressions for each crop and herbicide were calculated with all growth stages combined. Regression equations for each panel are as follows: soybean and dicamba, Yield = 1.08 0.81 × Injury (r^2 = 0.62); soybean and 2,4 D, Yield = 1.02 0.64 × Injury (r^2 = 0.61); cotton and dicamba, Yield = 0.92 0.17 × Injury (r^2 = 0.01); cotton and 2,4 D, Yield = 0.95 0.72 × Injury (r^2 = 0.32).

substantial yield loss. For cotton and 2,4-D the slope of the trend line was close to unity, indicating broad agreement between injury symptoms and yield loss. However, there was large variation around the trend line indicating that in specific circumstances, injury can only serve as a rough predictor of final yield loss.

Utility of Meta-Analysis. Meta-analysis has long been a standard research tool in the biomedical sciences (Cooper et al. 2009) but has been seldom applied in weed science research. For instance, a recent Web of Science search on the topic "meta-analysis" in the journals *Weed Science* and *Weed Technology* retrieved only three publications (Rinella and Sheley 2005; Schutte et al. 2010; Wagner et al. 2007). Statistical approaches for the meta-analysis of dose–response curves continue to be developed (Bagnardi et al. 2004; Paul et al. 2006; Ritz and Streibig 2008; Thompson and Higgins 2002). As has been demonstrated in this paper, these approaches can readily be adapted to the synthesis of data on dose–response patterns of crops and weeds to herbicides. As weed science continues to address changes in weed communities across cropping systems, the evolution of new resistant weed species, and the commercialization of new herbicide-resistance traits, carefully synthesized information describing the sensitivity of crops to herbicide active ingredients will continue to be useful. During the time work was progressing on this meta-analysis, other research groups interested in synthetic auxin drift from herbicide-resistant cropping systems published results from new field experiments assessing the response of cotton and soybean to simulated dicamba and 2,4-D drift (Johnson et al. 2012; Robinson et al. 2013). While these studies added several valuable data points to this meta-analysis, the multiple site-year experiments described in these papers were no doubt very costly and time-consuming to conduct, and on their own, they provide an understanding of cotton and soybean sensitivity to herbicide drift that is limited to their site and experimental conditions. When an opportunity arises to use existing chemistries in new contexts, meta-analysis approaches can provide a supplement to new experiments and can be a powerful and cost-effective approach towards understanding the dose–response patterns of weeds and crops.

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Soybean response to plant growth regulator herbicides is affected by other postemergence herbicides

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Two studies investigated off-target exposure of soybean to plant growth regulator (PGR) herbicides and determined if simultaneous exposure to PGR herbicides and labeled soybean herbicides increase PGR injury. The PGR herbicides, 2,4-D, clopyralid, and dicamba, as well as dicamba plus the auxin transport inhibitor diflufenzopyr, were applied to glyphosate-resistant soybean at the V3, V7, and R2 soybean growth stages. Two rates were chosen from previous and preliminary research to approximate threshold rates that would cause a yield reduction so as to distinguish differences in sensitivity between growth stages. All four PGR herbicides caused significant soybean injury, height reduction, and yield loss at one or more application rates and growth stages. Relative to other PGR herbicides, dicamba reduced soybean yield at the lowest rate (a potential rate from residues remaining in improperly cleaned application equipment), followed by clopyralid, with 2,4-D requiring the highest rate to reduce soybean yield (a potential rate from a high level of spray drift). Dicamba and dicamba plus diflufenzopyr were applied at equal fractions of labeled use rates for corn to compare them directly at equivalent levels of off-target movement. Dicamba plus diflufenzopyr caused less injury and yield loss than dicamba applied alone. In a second study, the highest labeled soybean use rates of glyphosate, imazethapyr, imazamox, and fomesafen were applied alone and in combination with the highest rate of dicamba used in the first study (1% of a labeled use rate for corn) at the V3 and V7 stages. Dicamba demonstrated synergistic interactions with imazamox, imazethapyr, and fomesafen (but not with glyphosate) to further reduce yield under some circumstances, especially when applied at the V7 stage. Several treatments that included dicamba reduced soybean seed weight when applied at either the V3 or V7 stage and reduced the number of seeds per pod at the V7 stage.

Nomenclature: clopyralid; 2,4-D; dicamba; diflufenzopyr; fomesafen; glyphosate; imazamox; imazethapyr; corn, *Zea mays* L.; soybean, *Glycine max* (L.) Merr. 'Pioneer 94B01RR'.

Key words: Auxinic herbicides, crop injury, herbicide interaction, spray drift, spray tank contamination, synergy.

Plant growth regulator (PGR) herbicides have been widely used in monocotyledonous crops for many years and effectively control a broad spectrum of dicotyledonous weeds. Compared with herbicides with other modes of action, weed resistance to PGR herbicides has been slow to develop (Sterling and Hall 1997), which also increases their appeal. However, soybean is frequently grown in close proximity and often in rotation with monocot crops and is very sensitive to PGR herbicides (Al-Khatib and Peterson 1999; Wax et al. 1969). Reports of soybean injury with symptoms resembling off-target exposure to PGR herbicides have been widespread and recurring (Boerboom 2004; Hager and Nordby 2004), although the cause of injury is not often readily identifiable.

PGR herbicide injury to soybean can result in yield loss, but abnormal foliar symptoms and other developmental abnormalities can occur at rates lower than those required to reduce yield (Auch and Arnold 1978; Wax et al. 1969; Weidenhamer et al. 1989). The PGR herbicides most commonly used in close proximity to soybean fields include 2,4-D, clopyralid, and dicamba. Also, the auxin transport inhibitor diflufenzopyr is used in combination with dicamba and synergizes its activity on dicot weeds (Grossman et al. 2002), although there is no information available on the effect that the addition of diflufenzopyr to dicamba has on potential soybean injury. Soybean differ in sensitivity between dicamba and 2,4-D. When directly applied at the V3 soybean growth stage, 5.6 g ha^{-1} of dicamba (1% of a labeled use rate for corn) reduced soybean yield 14 to 34%, whereas 112 g ha^{-1} of 2,4-D (20% of a labeled use rate for corn) was required to cause a similar reduction (25 to 32%) (Andersen et al. 2004). In addition, off-target movement of dicamba has been reported to result in more soybean injury than 2,4-D. In 1974 in Minnesota, postemergence (POST) use of dicamba and 2,4-D in corn resulted in 68 reports of dicamba injury to soybean and 7 reports of 2,4-D injury to soybean, although 2,4-D was applied to over three times as many hectares of corn as was dicamba (Behrens and Lueschen 1979). Clopyralid also has been shown to cause soybean injury (Bovey and Meyer 1981). A 50% soybean yield reduction was caused by nearly equal rates of clopyralid and dicamba (Smith and Geronimo 1977), although the rates were not reported.

Soybean sensitivity to PGR herbicides varies at different growth stages. Dicamba caused greater yield reductions when exposure occurred at a late vegetative or early reproductive stage, relative to an early vegetative stage (Auch and Arnold 1978; Wax et al. 1969). Reports of soybean sensitivity to 2,4-D are somewhat conflicting, however, with 2,4-D causing the greatest yield response when applied at early vegetative stages (Smith 1965), whereas others report little difference in sensitivity between growth stages (Wax et al. 1969), and yet others report that soybean is more sensitive to 2,4-D as it grows taller (Slife 1956). Little has been reported about soybean sensitivity to clopyralid at different growth stages.

PGR herbicides can unintentionally come in contact with soybean and cause injury through several routes of exposure. Spray particles or volatile active ingredients can drift from neighboring fields. Spray particles can drift in air currents with injury often showing a pattern that follows wind direction (Bode 1987), and many herbicide labels have statements regarding wind speed and drift. Risk of vapor drift depends on the volatility of the herbicide formulation used and can be influenced by environmental factors. Short-chain esters of 2,4-D are very volatile, whereas volatility is lower with long-chain esters and is almost eliminated by amine salts of 2,4-D (Que Hee and Sutherland 1974). Dicamba can volatilize as the free acid and injure soybean even when applied as the dimethylamine salt formulation (Behrens and Lueschen 1979). However, dicamba volatility is reduced by lower temperatures and higher relative humidity. PGR herbicide residues remaining in application equipment after previous applications to a corn crop can also be dislodged when the spray equipment is used in soybean. Labels of products containing dicamba provide information describing how to clean equipment to remove these residues. However, even after following recommended cleaning procedures, dicamba residues can remain in application equipment and be detected in a subsequent spray solution at levels as high as 0.63% of a field use rate in corn (Boerboom 2004).

Previous research has described the effects of PGR herbicides on soybean growth and yield when these herbicides are applied alone. However, it is not currently known if there is an interaction between PGR herbicides and herbicides labeled for POST use in soybean that may increase injury. Data from the National Agricultural Statistics Service (NASS 2002) indicate there has been an increase in the use of POST herbicides in soybean with a concomitant decrease in the use of soil-applied herbicides. The increase in POST herbicide use in soybean increases the potential for herbicides labeled for use in soybean to be present when off-target soybean exposure to PGR herbicides occurs. Dicamba and clopyralid interacted with diclofop to increase yield loss in sunflower (*Helianthus annuus* L.) and lentils (*Lens culinaris* L.), respectively (Derksen 1989). PGR herbicides could also potentially interact with soybean herbicides to increase soybean injury. An interaction is possible if PGR herbicide residues are not cleaned from application equipment or if a PGR herbicide drifts from neighboring fields at or near the time of a herbicide application to soybean. The increased dependence on POST herbicides in soybean increases the necessity to understand how herbicides labeled for use in soybean affect soybean exposed to PGR herbicides.

In this study, PGR herbicides commonly used near soybean fields were applied directly to soybean at reduced rates at different growth stages to determine the effect of off-target PGR herbicide exposure on growth, development, and yield. Soybean herbicides with different modes of action were included for comparison and to obtain tissue samples for lab analysis (Kelley et al. 2004). In addition, dicamba and several soybean herbicides were applied alone and in combination at two vegetative growth stages to determine whether the presence of POST herbicides labeled for use in soybean would increase the injury caused by dicamba. Dicamba was chosen because of its widespread use in corn and the high number of soybean injury reports attributed to dicamba.

Materials and Methods

Two soybean field experiments were conducted at the Crop Sciences Research and Education Center in Urbana, IL. Fields were planted to corn in previous years and had been chisel plowed each fall after corn harvest. In the spring, fields were tilled with a field cultivator. Glyphosate-resistant soybean variety 'Pioneer 94B01RR' was planted in 0.76-m rows at a rate of 400,000 seeds ha^{-1} in 2001 and 2002 and 420,000 seeds ha^{-1} in 2003. Plots were kept weed free with a preemergence application of 2.14 kg ha^{-1} metolachlor, 44 g ha^{-1} chlorimuron-ethyl, and 0.27 kg ha^{-1} metribuzin. All treatments were applied with a CO_2-pressurized backpack sprayer equipped with a 2.3-m-wide handheld boom and five 8003 flat-fan nozzles[1] spaced 46 cm apart that delivered 187 L ha^{-1} at 221 kPa. The spray boom, narrower than the plot width (3.0 m), was centered over each four-row plot so that the two outside rows were not completely within the spray pattern and acted as a buffer to reduce movement between adjacent plots. Applications were made under mostly calm conditions (wind speed was 4 m s^{-1} or less) to further reduce drift.

PGR Herbicide Study

To evaluate the effects of current PGR herbicides on soybean development, reduced rates of PGR herbicides were applied in 2001, 2002, and 2003. The soil was a Flanagan silt loam (fine, smectitic, mesic Aquic Argiudolls) in 2001 and 2003 and a Catlin silt loam (fine-silty, mixed, superactive, mesic Oxyaquic Argiudolls) in 2002. The soil organic matter was 4.8, 4.0, and 4.8%, and the soil pH was 6.6, 6.5, and 6.6, respectively. Soybean was planted on May 30, 2001, June 1, 2002, and May 21, 2003.

Treatments included the diglycolamine salt of dicamba, the sodium salt of dicamba plus the sodium salt of diflufenzopyr, the monoethanolamine salt of clopyralid, the isooctylester formulation of 2,4-D, imazethapyr as a free acid, the isopropylamine salt of glyphosate, and the sodium salt of fomesafen, each applied at the soybean growth stages and rates presented in Table 1. Imazethapyr, fomesafen, and glyphosate are three of the most commonly used POST herbicides labeled for use in soybean and were included in the experiment so that PGR herbicide injury could be compared with the effects of herbicides labeled for use in soybean. The rates chosen for the PGR herbicides were based on preliminary research (data not shown) to bracket the threshold rate that would cause a yield reduction so as to distinguish any differences in soybean sensitivity to these herbicides at the different growth stages. Less dicamba was included with diflufenzopyr than dicamba applied alone, although these are equal fractions of corn field use rates because diflufenzopyr allows for less dicamba to provide similar weed control

TABLE 1. Soybean injury caused by reduced rates of PGR herbicides applied at the V3, V7, and R2 stages of soybean growth combined across 2001, 2002, and 2003.[a,b]

		Early soybean injury[c]			Late soybean injury		
		2 WAT			6 WAT	6–7 WAT	4–5 WAT
Herbicide	Rate	V3	V7	R2	V3	V7	R2
	g ae/ha	%					
Dicamba	0.56	37 d	31 e	25 e	16 c	23 cd	26 b
	5.6	50 b	41 c	41 b	29 ab	36 b	38 a
Dicamba + diflufenzopyr	0.2 + 0.08	22 e	17 f	18 f	9 d	12 e	18 c
	2.0 + 0.8	42 cd	38 cd	34 cd	21 bc	28 c	28 b
2,4-D	56	8 f	22 f	19 f	3 e	4 f	7 d
	180	49 bc	52 b	37 bc	30 ab	20 d	25 bc
Clopyralid	2.1	41 cd	32 de	29 de	17 c	26 cd	28 b
	6.6	65 a	64 a	47 a	33 a	61 a	45 a
Imazethapyr	71	4 g	6 g	1 i	0 e	0 g	0 f
Glyphosate	840	1 h	1 h	5 h	0 e	0 g	0 f
Fomesafen	330	8 f	8 g	12 g	0 e	0 g	2 e
Untreated control		0 h	0 h	0 i	0 e	0 g	0 f

[a] Abbreviations: PGR, plant growth regulator; WAT, weeks after treatment.
[b] Means within a column (treatments applied at the same growth stage) followed by the same letter(s) are not significantly different according to Fisher's Protected LSD (0.05).
[c] Visual injury ratings on a scale of 0 to 100% with 0% = no injury and 100% = complete death.

(Grossman et al. 2002). This allows a direct comparison of the effect that the addition of diflufenzopyr to dicamba has on the potential for soybean injury caused by off-target exposure. The fractions of a field use rate in corn represented in this study are 0.1 and 1% for dicamba or dicamba plus diflufenzopyr, 10 and 32% for 2,4-D, and 1 and 3.2% for clopyralid. The higher rates of 2,4-D and clopyralid were not included in 2001 but were added in 2002 and 2003. Because application equipment cleaned using recommended procedures may contain dicamba residues as high as 0.63% of a field use rate (Boerboom 2004), equipment that was not properly cleaned could contain PGR herbicide levels similar to the rates applied in this study of dicamba, dicamba plus diflufenzopyr, or even possibly clopyralid. Also, if a PGR herbicide is applied adjacent to a soybean field at a high spray pressure and with high wind speeds, it is feasible for a PGR herbicide to drift onto soybean at rates as high as the rates of 2,4-D applied in this study. All PGR herbicides were applied with 0.25% (v/v) of a nonionic surfactant.[2] Glyphosate was applied with ammonium sulfate at 1.9 kg ha^{-1}. Methylated seed oil (MSO)[3] and 28% urea ammonium nitrogen (UAN) were each included with imazethapyr at 1.25% (v/v) and with fomesafen at 1.0 and 2.5% (v/v), respectively. Soybean growth stages for PGR herbicide applications were chosen to include a vegetative stage when many herbicides are commonly applied to corn (soybean V3 stage), a growth stage when later rescue treatments for weed escapes in corn are often applied (soybean V7 stage), and a reproductive stage when drift from other sources, such as noncrop and pasture areas, may occur.

The experiment was established as a randomized complete block design with three replications and a factorial arrangement of treatments. Herbicide treatments and growth stages were separate factors. Plots measured 3.0 m wide by 9.1 m in length. All herbicide treatments were applied to soybean in the V3 stage 30 to 37 d after planting (DAP), the V7 stage 43 to 51 DAP, and the R2 stage 61 to 66 DAP. At the V3 application, soybean were 9 cm tall in 2001, 16 cm tall in 2002, and 22 cm tall in 2003. At the V7 application, soybean were 31 cm tall in 2001, 38 cm tall in 2002, and 44 cm tall in 2003. At the R2 application, soybean were 65 cm tall in 2001, 70 cm tall in 2002, and 72 cm tall in 2003.

Soybean injury and height were recorded 2 wk after treatment (WAT) and again 4 to 7 WAT, depending on the time of application. Visual soybean injury ratings were made on a scale of 0 to 100%, where 0 equals no crop injury and 100 equals complete crop death. Final height was measured when plants reached full height before leaf senescence. Delayed maturity was measured by recording the day on which 95% of the soybean pods in each plot reached a mature color and then comparing that with the day when the untreated control plots matured. Yield was measured by machine harvesting the center two rows from each plot and adjusting the moisture to 13%.

Soybean Herbicide Interaction Study

In 2002 and 2003, four herbicides labeled for use in soybean and a reduced rate of dicamba were applied alone and in combination to evaluate an interaction of soybean herbicides and injury caused by dicamba. The soil was a Flanagan silt loam in 2002, and a Drummer silty clay loam (fine-silty, mixed, superactive, mesic Typic Endoaquolls) in 2003. The soil organic matter was 4.8 and 5.4% and the soil pH was 6.3 and 6.6, respectively. Soybean was planted on June 3, 2002, and May 21, 2003.

The isopropylamine salt of glyphosate, imazethapyr as a free acid, the ammonium salt of imazamox, and the sodium salt of fomesafen were applied with and without the diglycolamine salt of dicamba, as well as dicamba applied alone, at the growth stages and rates listed in Table 3. The adjuvants and rates included with each herbicide were the same as in the PGR herbicide study. Imazamox was applied with

MSO and 28% UAN, both at 1.25% (v/v). Soybean growth stages for soybean herbicide interaction applications were chosen to include an early vegetative stage (V3) when soybean herbicides are commonly applied and a late vegetative stage (V7) before flowering when rescue treatments for weed escapes are often applied. Drift of a PGR herbicide from outside the soybean field could injure soybean at any stage. However, soybean exposure to a PGR herbicide can occur in the presence of a herbicide labeled for use in soybean only when herbicides are applied to soybean (most commonly during vegetative growth stages). The rate of dicamba chosen to be sufficient to cause a yield reduction but not plant death is equivalent to the highest rate used in the PGR herbicide study and represents a potential rate from improperly cleaned application equipment (Boerboom 2004). The rates of the soybean herbicides were the maximum labeled rates at the time of application. With the highest labeled use rates for soybean herbicides and a rate of dicamba expected to cause a yield reduction, these treatments represent a worst-case scenario to determine whether there is potential for dicamba to interact with soybean herbicides and cause a greater yield loss in their presence than if soybean were exposed to dicamba alone.

The experimental design and number of replications were the same as the PGR herbicide study. Plot size was 3.0 m wide by 11.6 m long in 2002, and 3.0 m wide by 9.1 m long in 2003. Treatments were applied to soybean in the V3 stage 30 to 37 DAP and the V7 stage 45 to 51 DAP. At the V3 application, soybean were 20 cm tall in 2002 and 22 cm tall in 2003. At the V7 application, soybean were 40 cm tall in 2002 and 50 cm tall in 2003. Soybean injury and height were recorded 2 and 6 WAT. Final soybean height, delayed maturity, and grain yield were measured in the same fashion as the PGR herbicide study. Before harvest, 10 plants in a row from the center of each plot were collected and used for yield component analysis.

All data were analyzed with a mixed linear model with Statistical Analysis Systems (SAS 1999). In the PGR herbicide study, data from the 3 yr were combined and years were treated as random effects. In the soybean herbicide interaction study, each year was analyzed separately assuming that 2 yr are not a sufficient random sample to represent the larger population (Carmer et al. 1989). Visual injury data were transformed by arcsine square root before statistical analysis to stabilize variances. Untransformed data are presented with statistical interpretation based on transformed data. Visual injury data for applications at each growth stage were analyzed separately because of the data being collected at different times and under different conditions. Within each factor (herbicide treatment and growth stage), means were separated using Fisher's Protected LSD at the 0.05 level of significance.

Synergistic and antagonistic responses between dicamba and soybean herbicides were determined using the method described by Colby (1967) to calculate expected response of herbicide tank mixtures. Expected response values were calculated by expressing values as a percent of the untreated control, and taking the product of values for each herbicide applied alone included in the combination and dividing by 100. Synergistic or antagonistic responses were determined by significant differences between the expected and observed responses using Fisher's protected LSD at the 0.05 level of significance. When expected and observed responses are not significantly different, interactions between herbicides in a combination are considered additive.

Results and Discussion

PGR Herbicide Study

By 2 wk after all applications (V3, V7, and R2), soybean had significant foliar injury in response to all PGR herbicides, with more injury as rates increased (Table 1). Dicamba and dicamba plus diflufenzopyr resulted in new trifoliolate leaves that were cupped and crinkled, with the higher rates resulting in smaller leaves and reduced overall growth compared with the lower rates (Figures 1A and 1B). Symptoms caused by 2,4-D included epinasty of leaves and stems and swollen, cracked stems. Clopyralid injury resembled dicamba injury, but there were more thin, strapped leaves with parallel venation and less cupping injury (Figures 1C and 1D). Similar symptoms have been described previously (Al-Khatib and Peterson 1999; Andersen et al. 2004; Auch and Arnold 1978; Wax et al. 1969; Weidenhamer et al. 1989). Fomesafen caused temporary necrosis of leaf tissue but had no effect on subsequent growth, whereas imazethapyr temporarily stunted plant growth. Glyphosate caused no visible plant injury, except that the youngest leaves temporarily exhibited chlorosis after the R2 application. The terminal growing point was killed by the higher rate of dicamba or clopyralid at all application timings, by the higher rate of dicamba plus diflufenzopyr at V3 and V7, and by the lower rate of clopyralid at the V7 application. Two WAT at all growth stages, soybean plants treated with the higher rates of PGR herbicides were 10 to 50% shorter than the untreated control (data not shown). Soybean treated with the higher rates of 2,4-D or clopyralid at all growth stages showed little to no increase in height during the 2 wk after treatment.

By 4 to 7 WAT, soybean had recovered from injury caused by fomesafen, imazethapyr, and glyphosate, and injury caused by most PGR herbicides had decreased (Table 1). Soybean treated with the lower rate of dicamba at V3 and the lower rates of dicamba plus diflufenzopyr and 2,4-D at both V3 and V7 showed signs of recovery (emerging trifoliolate leaves lacked injury symptoms). Injury symptoms from both rates of clopyralid and the higher rates of the other PGR herbicides remained more persistent, with the most severe injury from the high rate of clopyralid applied at V7.

All PGR herbicides resulted in a significant reduction in final soybean height, except for the lower rate of dicamba applied at R2 and the lower rate of dicamba plus diflufenzopyr at V7 and R2. Treatments that resulted in the death of the terminal growing point (as mentioned previously) stimulated development of lateral branches for subsequent growth, yet resulted in a 16 to 42% reduction in final height (Table 2). Although the higher rate of 2,4-D did not kill the terminal growing point, it resulted in soybean with severe stem epinasty and an 18 to 25% reduction in final height. The greatest height reductions resulted from the higher rates of all four PGR herbicide treatments at V7, with the higher rate of clopyralid reducing height the most.

Several PGR herbicide treatments caused significant delays in soybean maturity (Table 2). Except for the R2 ap-

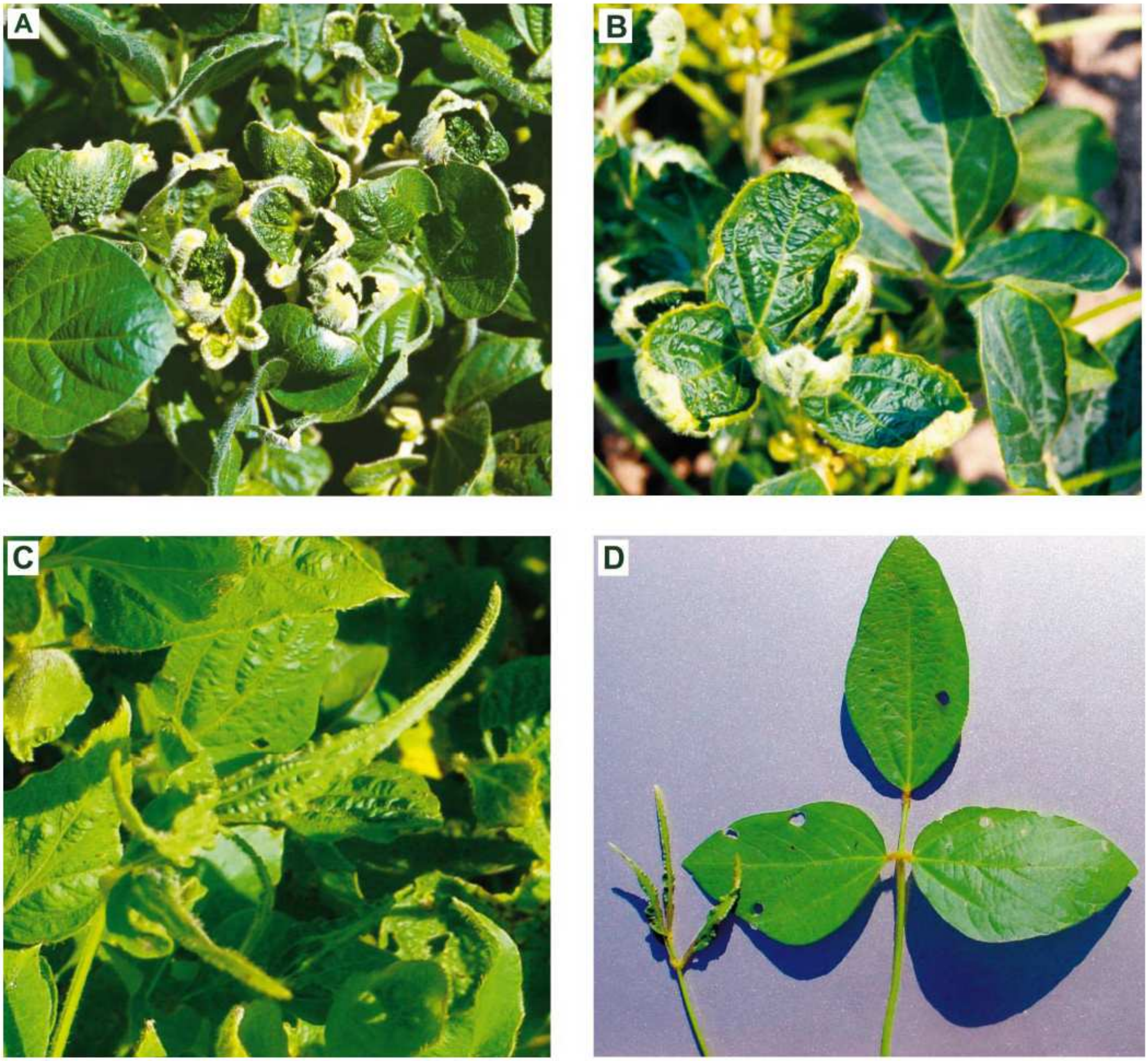

Figure 1. Foliar leaf abnormalities caused by plant growth regulator (PGR) herbicides in soybean. (A) and (B) treated with dicamba at 5.6 g ha^{-1}, (C) and (D) treated with clopyralid at 2.1 g ha^{-1}. (D) Clopyralid injured trifoliolate on the left and untreated trifoliolate on the right.

plication at the lower rates, all dicamba and clopyralid treatments resulted in delayed maturity, whereas only the V3 and V7 applications of the higher rate of dicamba plus diflufenzopyr caused a delay. Maturity was delayed by 2,4-D at both rates applied at R2 and the higher rate applied at V7. Injury from higher rates of dicamba, 2,4-D, and clopyralid applied during flowering development (R2) caused the greatest delay in maturity.

Notwithstanding significant injury and reduced height, many PGR herbicide treatments did not result in yield reductions (Table 2). Dicamba plus diflufenzopyr reduced yield by 8% when the higher rate was applied at V3, whereas dicamba reduced yield from 6 to 12% after application of the higher rate at all growth stages and the lower rate at V3. Yield was reduced by 15 to 25% from the higher rates of 2,4-D applied at all growth stages, and clopyralid reduced yield by 9 to 48% from the higher rate applied at all stages and the lower rate applied at V3. The higher rate of clopyralid applied at V7 resulted in the lowest yield (Table 2). Imazethapyr applied at V7 also reduced yield by 7%.

The growth stages at which soybean were most sensitive to height or yield reductions (or both) varied among the herbicides (Table 2). The highest rate of clopyralid applied at V7 reduced height and yield more than the same rate applied at the other growth stages. The highest rate of dicamba applied at V7 also reduced height more than the same rate applied at the other growth stages, but dicamba did not have a similar effect on yield. Previous research (Auch and Arnold 1978; Wax et al. 1969) showed that dicamba caused greater injury and yield reduction when ap-

TABLE 2. Soybean yield, rate of maturity, and height in response to application of reduced rates of PGR herbicides applied at the V3, V7 and R2 stages of soybean growth combined across 2001, 2002, and 2003.[a,b]

Herbicide	Rate	Soybean yield[c]			Maturity delay[d]			Height[e]		
		V3	V7	R2	V3	V7	R2	V3	V7	R2
	g ae/ha		kg ha^{-1}			d			% untreated control	
Dicamba	0.56	2,820 bc	3,120 a	3,270 a	4 bc	3 abc	0 d	88 c	87 c	97 a
	5.6	2,830 bc	2,660 de	2,800 de	7 a	4 ab	9 a	77 e	65 f	81 c
Dicamba + diflufenzopyr	0.2 + 0.08	2,970 ab	3,080 ab	3,040 bc	1 d	0 d	1 cd	95 b	98 ab	97 a
	2.0 + 0.8	2,790 bc	3,000 abc	3,150 ab	5 ab	4 ab	1 cd	84 cd	76 e	88 b
2,4-D	56	2,850 ab	2,890 bc	2,970 bcd	2 cd	2 bcd	4 b	95 b	88 c	87 b
	180	2,270 d	2,520 e	2,570 e	1 d	3 abc	8 a	82 de	75 e	79 c
Clopyralid	2.1	2,740 bc	2,940 abc	3,180 ab	6 ab	5 a	0 d	86 cd	81 d	92 b
	6.6	2,580 c	1,560 f	2,670 e	6 ab	2 bcd	8 a	71 f	58 g	72 d
Imazethapyr	71	2,890 ab	2,820 cd	2,980 bcd	1 d	2 bcd	1 cd	98 ab	96 b	99 a
Glyphosate	840	3,040 a	2,900 abc	3,110 abc	1 d	1 cd	3 cd	98 ab	99 ab	99 a
Fomesafen	330	2,920 ab	2,960 abc	2,930 cd	2 cd	2 bcd	0 d	98 ab	98 ab	98 a
Untreated control		3,020 a	3,020 ab	3,020 bc	0 d	0 d	0 d	100 a	100 a	100 a
LSD (0.05)[f]			270			3			6	
LSD (0.05)[g]			220			3			4	

[a] Abbreviation: PGR, plant growth regulator.
[b] Means within a column (treatments applied at the same growth stage) followed by the same letter(s) are not significantly different according to Fisher's Protected LSD (0.05).
[c] Measured by harvesting the center two rows from each plot and adjusting moisture to 13%.
[d] Measured by recording the day when 95% of the pods reached a mature color and comparing with the untreated control.
[e] Measured when plants reached full height before leaf senescence. Final height of untreated plants was 102 cm.
[f] Between growth stages for the same herbicide treatment (only the higher rates of 2,4-D and clopyralid—applied only in 2002 and 2003).
[g] Between growth stages for the same herbicide treatment (only those treatments applied in all years).

TABLE 3. Soybean injury caused by combinations of dicamba and herbicides labeled for use in soybean applied at the V3 and V7 stages of soybean growth.[a]

Growth stage	Herbicide	Rate	Early-season injury[b] 2 WAT[c] 2002	Early-season injury[b] 2 WAT[c] 2003	Late-season injury 6 WAT 2002	Late-season injury 6 WAT 2003
		g ae/ha	%			
V3	Glyphosate	1,270	0 d	0 e	0 c	0 d
	Imazethapyr	71	2 d	3 d	0 c	0 d
	Imazamox	44	3 cd	5 d	1 c	0 d
	Fomesafen	330	5 c	5 d	0 c	0 d
	Dicamba	5.6	42 b	32 c	27 b	23 c
	Glyphosate + dicamba	1,270 + 5.6	47 b	33 bc	30 b	25 bc
	Imazethapyr + dicamba	71 + 5.6	50 ab*[d]	42 ab*	29 b	28 ab*
	Imazamox + dicamba	44 + 5.6	53 ab*	43 a*	32 ab	30 a*
	Fomesafen + dicamba	330 + 5.6	60 a*	48 a*	37 a*	30 a*
	Untreated control		0 d	0 e	0 c	0 d
V7	Glyphosate	1,270	0 c	2 e	0 e	0 c
	Imazethapyr	71	0 c	5 d	0 e	0 c
	Imazamox	44	2 c	5 d	0 e	0 c
	Fomesafen	330	5 b	7 d	0 e	0 c
	Dicamba	5.6	27 a	28 c	30 d	37 b
	Glyphosate + dicamba	1,270 + 5.6	30 a	35 bc*	33 c	43 b*
	Imazethapyr + dicamba	71 + 5.6	37 a*	40 ab*	40 a*	50 a*
	Imazamox + dicamba	44 + 5.6	33 a*	40 ab*	42 a*	52 a*
	Fomesafen + dicamba	330 + 5.6	37 a*	48 a*	38 b*	57 a*
	Untreated control		0 c	0 e	0 e	0 c

[a] Means of treatments applied in the same year at the same growth stage followed by the same letter(s) are not significantly different according to Fisher's Protected LSD (0.05).
[b] Visual injury ratings on a scale of 0 to 100% with 0% = no injury and 100% = complete death.
[c] Abbreviation: WAT, weeks after treatment.
[d] * Indicates significant synergistic interaction at the 0.05 level.

plied near the R2 or V7 stage, relative to the V3 stage. The higher rate of 2,4-D resulted in the lowest yield from the V3 application, significantly lower than the R2 application at $P < 0.05$, and the V7 application at $P < 0.1$. Smith (1965) also reported lower yields after 2,4-D was applied to soybean at an early vegetative stage compared with at a reproductive stage. Many of the applications of dicamba plus diflufenzopyr resulted in reduced crop injury (Table 1) and greater height and yield (Table 2) compared with an equal fraction of a field use rate of dicamba in corn. The addition of diflufenzopyr to dicamba, which allows a reduction in the amount of dicamba necessary to achieve adequate weed control, may reduce injury caused by off-target exposure to dicamba-containing products.

Soybean Herbicide Interaction Study

By 2 wk after the V3 and V7 applications, treatments that included dicamba caused a considerable amount of injury (Table 3), including death of the terminal growing point and leaf cupping symptoms (Figures 1A and 1B). When applied alone, fomesafen caused temporary leaf necrosis but had no effect on subsequent growth, imazethapyr and imazamox temporarily stunted plant growth, and glyphosate caused no significant plant injury. Imazethapyr, imazamox, and fomesafen all demonstrated synergistic interactions with dicamba, increasing soybean injury at 2 wk after both application timings in both years, and glyphosate had a similar interaction with dicamba after the V7 application in 2003 (Table 3).

By 6 wk after both application timings, dicamba-treated soybean were still showing foliar leaf cupping symptoms and were reduced in height (Table 3). When applied at V3, there were synergistic interactions between the following soybean herbicides and dicamba to increase soybean injury 6 WAT: fomesafen in both years and imazethapyr and imazamox in 2003. When applied at V7, there were synergistic interactions between the following herbicides and dicamba to increase injury 6 WAT: imazethapyr, imazamox, and fomesafen in both years, and glyphosate in 2003. Dicamba-treated plants (alone or with another herbicide) failed to achieve canopy closure and all leaves that emerged after application exhibited cupping injury symptoms, with leaves that were smaller than leaves from plants not treated with dicamba (data not shown).

All treatments that included dicamba caused a significant reduction in final soybean height, whereas herbicides labeled for use in soybean did not reduce final height in the absence of dicamba (Table 4). Dicamba applied alone at V3 reduced final soybean height by 21 to 22%, and when applied at V7, dicamba applied alone reduced height by 25 to 28%. When applied at the V7 application both years, there were synergistic interactions between dicamba and imazamox or fomesafen to further reduce final soybean height, whereas similar interactions occurred with dicamba plus imazethapyr in 2002 and dicamba plus glyphosate in 2003.

Dicamba treatments had a significant effect on the rate of soybean maturity, but the effect varied between 2002 and 2003 (Table 4). Most treatments containing dicamba re-

TABLE 4. Soybean yield, rate of maturity, and height in response to combinations of dicamba and herbicides labeled for use in soybean applied at the V3 and V7 stages of soybean growth.[a]

			Soybean yield[b]		Delayed maturity[c]		Final height[d]	
Growth stage	Herbicide	Rate	2002	2003	2002	2003	2002	2003
		g ae/ha	kg ha^{-1}		days delayed		% untreated control	
V3	Glyphosate	1,270	3,280 a	3,370 abc	0 b	0 b	104 a	98 a
	Imazethapyr	71	3,320 a	3,130 bcd	0 b	0 b	104 a	95 a
	Imazamox	44	2,870 bcd	3,390 ab	0 b	0 b	96 a	94 a
	Fomesafen	330	3,190 ab	3,470 ab	0 b	1 b	103 a	94 a
	Dicamba	5.6	2,690 cde	2,720 ef	5 a	6 a	78 b	79 b
	Glyphosate + dicamba	1,270 + 5.6	2,730 cd	3,010 cde	4 a	7 a	80 b	79 b
	Imazethapyr + dicamba	71 + 5.6	2,950 abc	2,440 f	3 a	6 a	76 b	73 b
	Imazamox + dicamba	44 + 5.6	2,540 de	2,930 de	4 a	7 a	73 b	77 b
	Fomesafen + dicamba	330 + 5.6	2,340 e	2,440 f	2 ab	7 a	71 b	74 b
	Untreated		3,160 ab	3,490 a	0 b	0 b	100 a	100 a
V7	Glyphosate	1,270	3,200 a	3,270 a	1 a	0 b	99 a	98 a
	Imazethapyr	71	3,160 ab	3,340 a	1 a	0 b	102 a	99 a
	Imazamox	44	3,010 abc	3,400 a	0 a	0 b	102 a	94 a
	Fomesafen	330	3,280 a	3,330 a	1 a	1 b	100 a	96 a
	Dicamba	5.6	2,790 c	2,500 b	−4 b	5 a	75 b	72 b
	Glyphosate + dicamba	1,270 + 5.6	2,580 d	2,300 bc	−4 b	6 a	73 bc	63 c*[e]
	Imazethapyr + dicamba	71 + 5.6	2,060 e*	2,200 bc	−4 b	5 a	64 cd*	65 bc
	Imazamox + dicamba	44 + 5.6	1,970 e*	2,110 bc	−4 b	6 a	63 d*	61 c*
	Fomesafen + dicamba	330 + 5.6	2,070 e*	2,060 c*	−4 b	6 a	63 d*	60 c*
	Untreated		3,160 ab	3,490 a	0 a	0 b	100 a	100 a
	LSD (0.05)[f]		390	410	3	NS	8	8

[a] Means of treatments applied in the same year at the same growth stage followed by the same letter(s) are not significantly different according to Fisher's Protected LSD (0.05).
[b] Measured by harvesting the center two rows from each plot and adjusting moisture to 13%.
[c] Measured by recording the day when 95% of the pods reached a mature color and comparing with the untreated control. NS, not significant.
[d] Measured when plants reached full height before leaf senescence. Final heights of untreated plants were 81 cm in 2002 and 111 cm in 2003.
[e] * Indicates significant synergistic interaction at the 0.05 level.
[f] Between growth stages for the same herbicide treatment.

Table 5. Rainfall before and after treatments of the soybean herbicide interaction study.[a]

	2002		2003	
	V3	V7	V3	V7
	mm			
1 MBT[b]	59	1	64	151
1 WAT	0	35	6	0
2 WAT	0.3	24	106	52
3 WAT	35	0	0	5

[a] Illinois Climate Network Data, Illinois State Water Survey for Champaign, IL.
[b] Abbreviations: MBT, month before treatment, WAT, week after treatment.

sulted in delayed maturity. However, applications at V7 in 2002 resulted in earlier maturity. The late-season injury (Table 3) and final height data (Table 4) indicate that dicamba applied at V7 was potentially more damaging to soybean than at V3. Precipitation received before and after the V7 application in 2002 was less favorable than in 2003, as illustrated by the rainfall data in Table 5. These plants in 2002 had received only 1 mm of rainfall during the entire month before treatment, resulting in drought-stressed plants that were further stressed by dicamba. Soybean received rainfall after herbicide treatment (Table 5), but it is likely that the addition of dicamba injury and drought stress at application caused enough damage to result in premature senescence (Table 4), although this did not appreciably alter the response of soybean height or yield to dicamba injury between the 2 yr. Notably, the addition of another herbicide to dicamba did not affect maturity.

Yield results also show a significant impact of the presence of herbicides labeled for use in soybean on dicamba injury. Less favorable rainfall in 2002 resulted in lower yields, with the untreated control yielding 3,160 kg ha^{-1} in 2002 compared with 3,490 kg ha^{-1} in 2003. Soybean yield after applications containing dicamba ranged from 7 to 38% less than the untreated control in 2002 and 14 to 41% less in 2003 (Table 4). Herbicide treatments applied at V7 that resulted in significantly lower yield ($P < 0.05$) than the same treatment applied at V3 included imazamox plus dicamba in both years, imazethapyr plus dicamba in 2002, and glyphosate plus dicamba in 2003. After the V7 application in 2002, there were synergistic interactions between dicamba and imazethapyr, imazamox, or fomesafen to further decrease yield (Table 4), and when applied at V7 in 2003, fomesafen had a similar interaction with dicamba. If the significance level is set at $P < 0.1$, then imazamox applied at V7 in 2002 and fomesafen applied at V3 in 2002 also demonstrated synergistic interactions with dicamba to further decrease yield. Fomesafen plus dicamba resulted in the highest soybean injury rating (Table 3) and the greatest height reduction (Table 4) of all V3 applications in 2002. These results demonstrate that dicamba can cause a greater yield loss in the presence of a herbicide labeled for use in soybean than if there is no other herbicide present, and that among the soybean herbicides included in this study, fomesafen exacerbated yield losses caused by dicamba more than other herbicides.

To determine which growth process was affected to reduce yield, plant samples were collected before harvest for yield component analysis (Table 6). Seeds per pod were significantly reduced by all applications at V7 that included dicamba in both years. The stress from dicamba may have affected seed development during flowering, which began shortly after the V7 stage. Other treatments that reduced seeds per pod included dicamba applied alone at V3 in 2002, glyphosate plus dicamba at V3 in 2003, and imazethapyr or imazamox applied alone at V7 in 2002. Pods per plant were not significantly affected by dicamba applications (Table 6). Pods per node were reduced in response to dicamba, but nodes per plant were increased (data not shown). Although plants were shorter, they were able to produce sufficient nodes on lateral branches from which pods could develop to offset any reduction in pod set during flowering. The degree of seed and pod development vs. floral abortion is influenced by auxin (Cho et al. 2002). Also, exogenous auxin enhances the growth of different tissues (roots, buds, stems), but only at specific concentrations, with higher concentrations inhibiting growth (Gardner et al. 1985). Therefore, it would be anticipated that PGR herbicides, which overstimulate auxin receptors (Sterling and Hall 1997), would inhibit floral development at a sublethal dose if applied near flowering. Seed weight was significantly reduced by several treatments that included dicamba at both the V3 and V7 stages (Table 6). This appears unusual because seed fill does not begin until late in development, several weeks after the V3 stage. However, decreased seed weight may be due to diminished photosynthetic capacity caused by reduced leaf area, given that dicamba prevented canopy closure and resulted in smaller, malformed leaves (data not shown).

All the herbicides labeled for use in soybean that exacerbated yield losses caused by dicamba are not phytotoxic to soybean due to rapid metabolism of the herbicide (Skipsey et al. 1997; Tecle et al. 1993). However, glyphosate, which did not significantly increase dicamba injury, is not phytotoxic due to an insensitive target site in soybean (Padgette et al. 1995). It may therefore be possible that dicamba injury prevented soybean from metabolizing these herbicides at a sufficient rate to prevent phytotoxicity.

Because the presence of herbicides labeled for use in soybean may affect the level of soybean injury and yield loss caused by dicamba, there is added significance in identifying the route of exposure to a PGR herbicide in a reported case of injury. However, with some reports of soybean symptoms resembling PGR herbicide injury, there is not a readily determined source of PGR herbicide exposure. It could be possible for other sources of stress, such as herbicides with a different mode of action, aphid feeding, or infection by certain soybean viruses, to cause symptoms that are mistaken for PGR herbicide injury (Proost et al. 2004). This makes it difficult to accurately assess the cause of soybean injury, especially because no diagnostic tools are available to conclusively verify that a PGR herbicide is the cause of injury. Another study performed in conjunction with this one explores the development of a diagnostic assay for PGR herbicide injury in soybean based on the expression of auxin-responsive genes (Kelley et al. 2004).

The results of this study reveal differences in the way that soybean responds to PGR herbicides and may influence decisions on their use. Clopyralid caused much greater yield losses at 6.6 g ha^{-1} when applied at a late-vegetative stage

TABLE 6. Components of soybean yield in response to combinations of dicamba and herbicides labeled for use in soybean applied at the V3 and V7 stages of soybean growth.[a]

Growth stage	Herbicide	Rate	Seeds per pod 2002	Seeds per pod 2003	Pods per plant 2002	Pods per plant 2003	Seed weight 2002	Seed weight 2003
		g ae ha^{-1}					g per 100 seeds	g per 100 seeds
V3	Glyphosate	1,270	2.38 ab	2.47 ab	28 a	28 a	17.03 a	13.84 ab
	Imazethapyr	71	2.42 a	2.52 ab	26 a	31 a	16.27 ab	13.66 ab
	Imazamox	44	2.27 ab	2.51 ab	28 a	37 a	16.79 a	13.75 ab
	Fomesafen	330	2.29 ab	2.53 a	26 a	30 a	16.64 a	13.28 ab
	Dicamba	5.6	2.20 b	2.48 ab	23 a	30 a	14.54 cd	12.69 b
	Glyphosate + dicamba	1,270 + 5.6	2.29 ab	2.35 b	21 a	32 a	13.96 d	13.08 ab
	Imazethapyr + dicamba	71 + 5.6	2.26 ab	2.51 ab	22 a	25 a	14.88 bcd	12.28 b
	Imazamox + dicamba	44 + 5.6	2.29 ab	2.43 ab	25 a	28 a	15.75 abc	13.05 ab
	Fomesafen + dicamba	330 + 5.6	2.27 ab	2.44 ab	25 a	30 a	14.29 cd	14.15 a
	Untreated control		2.41 a	2.53 a	25 a	35 a	16.52 a	14.34 a
V7	Glyphosate	1,270	2.31 ab	2.48 a	31 a	34 a	16.47 abc	13.56 ab
	Imazethapyr	71	2.23 bc	2.43 a	29 a	30 a	16.54 ab	13.88 ab
	Imazamox	44	1.97 d	2.42 a	28 a	31 a	17.12 a	14.44 a
	Fomesafen	330	2.43 a	2.52 a	25 a	28 a	16.17 abc	14.12 ab
	Dicamba	5.6	2.15 bcd	1.90 b	26 a	33 a	14.76 c	12.66 b
	Glyphosate + dicamba	1,270 + 5.6	2.10 cd	2.00 b	26 a	30 a	15.54 bc	12.83 b
	Imazethapyr + dicamba	71 + 5.6	2.05 cd	1.86 b	26 a	29 a	15.23 c	13.41 ab
	Imazamox + dicamba	44 + 5.6	2.00 d	1.86 b	26 a	28 a	15.42 bc	13.41 ab
	Fomesafen + dicamba	330 + 5.6	2.00 d	1.87 b	26 a	26 a	15.37 bc	13.18 ab
	Untreated control		2.41 a	2.53 a	25 a	35 a	16.52 ab	14.34 a
	LSD (0.05)[b]		0.20	0.19	NS[c]	NS	1.47	NS

[a] Measured from a sample of 10 plants taken from the center of each plot before harvest. Means of treatments applied in the same year at the same growth stage followed by the same letter(s) are not significantly different according to Fisher's Protected LSD (0.05). Treatments that include more than one herbicide were tested for synergistic interactions using the method described by Colby (1967), but no treatments were significant at the 0.05 level.

[b] Between growth stages for the same herbicide treatment.

[c] Abbreviation: NS, nonsignificant.

approaching flowering than at an early-vegetative stage or during flowering, whereas dicamba and 2,4-D showed less of a difference among growth stages. Dicamba caused yield losses at the lowest rate, with 2,4-D requiring the highest rate to reduce yield and clopyralid causing yield losses at a rate in between dicamba and 2,4-D. The addition of diflufenzopyr to dicamba, which allows for less dicamba to be applied to maintain adequate weed control, resulted in less of a yield effect than dicamba applied alone at an equal fraction of a field use rate in corn. This indicates that the use of diflufenzopyr may reduce the risk for unintended soybean injury due to dicamba. Results show that soybean responds differently to the various PGR herbicides examined in our study, and an understanding of these differences will allow growers to select a PGR herbicide based on an assessment of their weed management needs and the potential for soybean injury due to off-target movement.

Previous research on the effects of PGR herbicides in soybean has not addressed the impact of the presence of herbicides labeled for use in soybean. However, our results clearly show that the presence of a POST soybean herbicide can significantly exacerbate yield losses caused by off-target dicamba exposure. Dicamba can interact with a soybean herbicide when dicamba herbicide residues are present in application equipment used for soybean. The rate used in this study would not likely be present in application equipment that was cleaned properly, which emphasizes the need to clean application equipment thoroughly after use of a PGR herbicide. Dicamba may also interact in the plant with soybean herbicides when dicamba drifts onto soybean from a neighboring corn field at or near the time of a POST application to soybean, although this type of interaction was not evaluated in this study and may have different consequences than those reported here. Results showed a difference between herbicides that are selective in soybean due to metabolism (imidazolinones and fomesafen) vs. an insensitive target site (glyphosate), which indicates that a reduction in the ability of soybean to metabolize either herbicide may play a role in the interaction between the soybean herbicide and dicamba. Regardless of the mechanism, it is clear that under certain circumstances, the presence of some soybean herbicides can aggravate injury and yield losses caused by dicamba. It would also be of interest to determine if dicamba injury to soybean is affected by other POST herbicides in soybean where selectivity is due to engineered metabolism (e.g., glufosinate-resistant soybean).

Sources of Materials

[1] TeeJet standard flat spray tips, Spraying Systems Co., P.O. Box 7900, Wheaton, IL 60189-7900.

[2] Activator-90, nonionic surfactant, a mixture of alkylphenyl hydroxypolyoxyethylene and fatty acids, Loveland Industries Inc., P.O. Box 1289, Greeley, CO 80632-1289.

[3] MSO, methylated seed oil and emulsifying surfactants 100%, Loveland Industries Inc., P.O. Box 1289, Greeley, CO 80632-1289.

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Influence of Application Timings and Sublethal Rates of Synthetic Auxin Herbicides on Soybean

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Synthetic auxin herbicides have long been utilized for the selective control of broadleaf weeds in a variety of crop and noncrop environments. Recently, two agrochemical companies have begun to develop soybean with resistance to 2,4-D and dicamba which might lead to an increase in the application of these herbicides in soybean production areas in the near future. Additionally, little research has been published pertaining to the effects of a newly-discovered synthetic auxin herbicide, aminocyclopyrachlor, on soybean phytotoxicity. Two field trials were conducted in 2011 and 2012 to evaluate the effects of sublethal rates of 2,4-D amine, aminocyclopyrachlor, aminopyralid, clopyralid, dicamba, fluroxypyr, picloram, and triclopyr on visible estimates of soybean injury, height reduction, maturity, yield, and yield components. Each of these herbicides was applied to soybean at the V3 and R2 stages of growth at 0.028, 0.28, 2.8, and 28 g ae ha ^{1}. Greater height reductions occurred with all herbicides, except 2,4-D amine and triclopyr when applied at the V3 compared to the R2 stage of growth. Greater soybean yield loss occurred with all herbicides except 2,4-D amine when applied at the R2 compared to the V3 stage of growth. The only herbicide applied that resulted in no yield loss at either stage was 2,4-D amine. When applied at 28 g ae ha ^{1} at the V3 stage of growth, the general order of herbicide-induced yield reductions to soybean from greatest to least was aminopyralid > aminocyclopyrachlor clopyralid picloram > fluroxypyr > triclopyr > dicamba > 2,4-D amine. At the R2 stage of growth, the general order of herbicide-induced yield reductions from greatest to least was aminopyralid > aminocyclopyrachlor picloram > clopyralid > dicamba > fluroxypyr triclopyr > 2,4-D amine. Yield reductions appeared to be more correlated with seeds per pod than to pods per plant and seed weight. An 18- to 26-d delay in soybean maturity also occurred with R2 applications of all synthetic auxin herbicides at 28 g ae ha ^{1} except 2,4-D. Results from this research indicate that there are vast differences in the relative phytotoxicity of these synthetic auxin herbicides to soybean, and that the timing of the synthetic auxin herbicide exposure will have a significant impact on the severity of soybean height and/or yield reductions.

Nomenclature: Aminocyclopyrachlor; aminopyralid; clopyralid; dicamba; fluroxypyr; picloram; triclopyr; 2,4-D; soybean, *Glycine max* (L.) Merr.

Key words: Growth regulator herbicides, herbicide-resistant crops, off-target spray, spray drift, tank contamination.

Los herbicidas auxinas sintéticas han sido utilizados por un largo tiempo para el control selectivo de malezas de hoja ancha en una variedad de situaciones con y sin cultivos. Recientemente, dos compañías de agroquímicos iniciaron el desarrollo de soya con resistencia a 2,4 D y dicamba, lo que podría llevar a un incremento en la aplicación de estos herbicidas en zonas productoras de soya en un futuro cercano. Adicionalmente, pocas investigaciones han sido publicadas en relación a los efectos de aminocyclopyrachlor, un herbicida auxina sintética recientemente descubierto, sobre la fitotoxicidad en soya. Se realizaron dos experimentos de campo en 2011 y 2012 para evaluar los efectos de dosis subletales de 2,4 D amine, aminocyclopyrachlor, aminopyralid, clopyralid, dicamba, fluroxypyr, picloram, y triclopyr sobre los estimados visuales de daño en soya, la reducción en la altura, la madurez, el rendimiento, y los componentes de rendimiento. Cada uno de estos herbicidas fue aplicado a soya en los estadios de desarrollo V3 y R2 a 0.028, 0.28, 2.8, y 28 g ae ha^{-1}. Las mayores reducciones en altura ocurrieron con todos los herbicidas, excepto 2,4 D amine y triclopyr cuando se aplicó en el estadio de desarrollo V3 en comparación con R2. Las mayores pérdidas en el rendimiento de la soya ocurrieron con todos los herbicidas excepto 2,4 D amine cuando se aplicó en el estadio R2 en comparación con V3. El único herbicida aplicado que no resultó en pérdidas de rendimiento en ninguno de los estadios de desarrollo fue 2,4 D amine. Cuando se aplicó a 28 g ae ha^{-1} en el estadio V3, el orden general de mayor a menor, de reducciones en el rendimiento de la soya inducidas por el herbicida fue: aminopyralid > aminocyclopyrachlor = clopyralid = picloram > fluroxypyr > triclopyr > dicamba > 2,4

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D amine. En el estadio de desarrollo R2, el orden general, de mayor a menor, de reducciones en el rendimiento de la soya inducidas por el herbicida fue: aminopyralid > aminocyclopyrachlor = picloram > clopyralid > dicamba > fluroxypyr = triclopyr > 2,4 D amine. Las reducciones en el rendimiento parecieron estar más correlacionadas con el número de semillas por vaina que el número de vainas por planta o el peso de la semilla. Un retraso de 18 a 26 d en la madurez de la soya también ocurrió con aplicaciones en R2 de todos los herbicidas auxinas sintéticas a 28 g ae ha^{-1} excepto 2,4 D. Los resultados de esta investigación indican que existen amplias diferencias en la fitotoxicidad relativa de esos herbicidas auxinas sintéticas en soya, y que el momento de exposición a estos herbicidas tendrá un impacto significativo en la severidad de las reducciones en altura y/o rendimiento de la soya.

As of 2012, 93% of soybean hectares planted in the United States were genetically engineered, herbicide-resistant varieties (USDA 2012). Due to the increase in the occurrence of glyphosate-, protoporphyrinogen oxidase- (PPO) and acetolactate synthase/acetohydroxyacid synthase- (ALS/AHAS) resistant weed populations, several new herbicide-resistant crop offerings are expected to be introduced onto the marketplace in the near future. Among these are soybean that have been genetically modified to withstand applications of either 2,4-D (Wright et al. 2010) or dicamba (Behrens et al. 2007). Although 2,4-D was first introduced in 1945 (Troyer 2001) and dicamba in 1967 (CCME 1999), weeds with resistance to these herbicides have been relatively slow to evolve. To date, only 30 weed species in the world have been characterized with resistance to at least one of the members of the synthetic auxin herbicide family (Heap 2013). Specifically, there have been 18 species characterized with resistance to 2,4-D, and six with resistance to dicamba (Heap 2013). In these instances, resistance to synthetic auxin herbicides was associated with continuous applications of a single active ingredient over many years (Cranston et al. 2001; Heap and Morrison 1992; Holt and LeBaron 1990).

Common symptoms of off-target movement of synthetic auxin herbicides include leaf cupping, stem and leaf epinasty, and cracked and swollen stems, as well as chlorosis and necrosis (Al-Khatib and Peterson 1999; Andersen et al. 2004; Auch and Arnold 1978; Kelley et al. 2005; Sciumbato et al. 2004; Wax et al. 1969). Kelley et al. (2005) described that dicamba applications to soybean resulted in new trifoliate leaves being cupped and crinkled, with higher rates resulting in smaller leaves and reduced overall growth compared to lower rates. Symptoms associated with 2,4-D include leaf and stem epinasty, leaf elongation (often known as "strapping"), as well as swollen and cracked stems (Kelley et al. 2005; Wax et al. 1969). Clopyralid injury has been described as similar to dicamba, but with more thin, elongated leaves with parallel venation and less leaf cupping (Kelley et al. 2005). Due to the diversity of cropping systems in the United States, it is not uncommon for crops that are tolerant of synthetic auxin herbicides to be grown in close proximity to crops that are more susceptible to these herbicides, and often in rotation with one another (Wax et al. 1969). Thus, off-target movement can become a major concern due to the widespread use of 2,4-D, dicamba, picloram, triclopyr, and clopyralid in controlling emerged broadleaf weeds in corn (*Zea mays* L.), sorghum (*Sorghum bicolor* L. Moench), small grains, fallow land, turfgrasses, pastures, and rangelands. Injury to susceptible plants from off-target movement of synthetic auxins has been well documented in many crops, including cotton (*Gossypium hirsutum* L.) (Everitt and Keeling 2009; Johnson et al. 2012; Marple et al. 2007), alfalfa (*Medicago sativa* L.) (Al-Khatib et al. 1992), common sunflower (*Helianthus annuus* L.) (Derksen 1989; Lanini 2000), peanut (*Arachis hypogaea* L.) (Johnson et al. 2012), wine grape (*Vitis vinifera* L.) (Al-Khatib et al. 1993), and many other crops (Derksen 1989; Hemphill and Montgomery 1981; Lanini 2000). As a result, certain states have laws that dictate which synthetic auxin herbicides may be applied, the chemical formulation, and at what time of year the herbicide may be applied (ASPB 2012; Texas Agriculture Code 1984).

Soybean are especially at risk of injury from off-target movement of synthetic auxin herbicides due to their similar geographic vicinity and rotation with monocot crops (Wax et al. 1969). Al-Khatib and Peterson (1999) evaluated the response of soybean to reduced rates of dicamba and other herbicides when applied at the V2 to V3 stage of growth. In their research, they found that 187 g ae ha^{-1} of dicamba (33% of the labeled use rate in corn) resulted in yield reductions of 92 and 80%, respectively. In the same study, 56 g ae ha^{1} of dicamba (10% of the labeled use rate in corn) resulted in yields 45% lower than the control (Al-Khatib and Peterson 1999). Andersen et al. (2004) found that when 5.6 g ae ha^{1} of dicamba (1% of the labeled use rate in corn) was applied to soybean at the V3 stage of growth, yield reductions of 14 to 34% occurred. The same study reported that it took applications of 112 g ae ha^{1} of 2,4-D (20% of the labeled use rate in corn) to provide similar yield reductions (Andersen et al. 2004). In a similar study, Kelley et al. (2005) observed that applications of 5.6 g ae ha^{1} dicamba to V3 soybean resulted in yield reductions of 6%, whereas applications of 2,4-D at 180 g ae ha^{1} resulted in a 25% yield reduction. Dicamba applications of 0.56 and 5.6 g ae ha^{1} to soybean in the R2 stage of growth resulted in yield reductions of 0 and 7%, respectively, and 2 and 15% for 56 and 180 g ae ha^{1} of 2,4-D, respectively (Kelley et al. 2005). In the same study, clopyralid was applied at 2.1 and 6.6 g ae ha^{1} to both V3 and R2 soybean, respectively, resulting in yield reductions of 9 and 15%, respectively, for the V3 applications, and 0 and 12%, respectively, for the R2 applications (Kelley et al. 2005). With the exception of 5.6 g ae ha^{1} dicamba, all treatments resulted in lower yields when applied at the V3 compared to the R2 stage of growth (Kelley et al. 2005). This is in contrast to previous research, which reported greater injury and yield reductions when dicamba was applied at later soybean growth stages (Auch and Arnold 1978; Slife 1956; Wax et al. 1969). Wax et al. (1969) determined that approximately 16.7 g ae ha^{1} of dicamba applied to soybean at the prebloom and bloom growth stages resulted in yield reductions of 11 and 49%, respectively, with 2,4-D applications at these stages resulting in no yield losses. In the same study, 8.75 g ae ha^{1} of picloram resulted in soybean yield reductions of 18 and 98% when applied at the prebloom and bloom stages, respectively (Wax et al. 1969).

Delayed maturity of soybean following exposure to synthetic auxin herbicides has also been documented in a number of previous experiments (Auch and Arnold 1978; Kelley et al. 2005; Wax et al. 1969). Wax et al. (1969) observed greater maturity delay when dicamba and picloram were applied during the reproductive stages compared to earlier vegetative stages. When picloram was applied at 8.75 g ae ha^{1} to soybean in the prebloom and bloom growth stages, soybean maturity was delayed 2 and 27 d, respectively (Wax et al. 1969). Dicamba applied at 16.7 g ae ha^{1} to soybean in the prebloom and bloom growth stages resulted in delays in maturity of 4 and 14 d, respectively (Wax et al. 1969). Auch and Arnold (1978) also observed a delay in soybean maturity from foliar applications of dicamba throughout the reproductive growth stages. When comparing early-bloom, midbloom, early-pod, and late-pod dicamba applications, most rates and applications resulted in additional delays in maturity as soybean further developed (Auch and Arnold 1978).

A variety of research has been conducted to determine the effects of synthetic auxin herbicides on soybean phytotoxicity and yield loss. However, few of these studies have provided results pertaining to aminocyclopyrachlor and aminopyralid, which are two of the newest synthetic auxin herbicides introduced onto the marketplace. Some authors have evaluated the response of soybean to different rates of synthetic auxin herbicides and the rates selected were based on fractions of the recommended use rate of these herbicides in other cropping systems (Andersen et al. 2004; Sciumbato et al. 2004; Weidenhamer et al. 1989), whereas other authors (Everitt and Keeling 2009; Marple et al. 2007; Thompson et al. 2007) have conducted this research with equivalent rates of the synthetic auxin herbicides to determine the relative response of all synthetic auxin herbicides to each other. The objective of this research was to determine the relative effects of sublethal rates of 2,4-D amine, aminocyclopyrachlor, aminopyralid, clopyralid, dicamba, fluroxypyr, picloram, and triclopyr on visible soybean injury, height reduction, yield, and yield components when applied to plants in the V3 and R2 stages of growth.

Materials and Methods

General Trial Information. Duplicate field trials were conducted during 2011 and 2012 in Boone County, Missouri at the University of Missouri Bradford Research Center (38.9089°N, 92.20°W). The soil was a Mexico silt loam (fine, smectic, mesic Aeric Vertic Epiaqualfs) with 2.3% organic matter and pH of 6.0 in 2011 and a pH of 6.3 and organic matter content of 2.4% in 2012. On June 6, 2011

Table 1. Sources of materials used in the experiment.

Common name[a]	Trade name	Formulation[b]	Manufacturer
2,4 D amine	Weedar 64	456 g L ^{1} EC	Nufarm, Inc., Burr Ridge, IL (www.nufarm.com/US)
Dicamba	Clarity	480 g L ^{1} EC	BASF Crop Research Triangle Park, NC (www.agro.basf.com)
Clopyralid	Transline	360 g L ^{1} EC	Dow Agrosciences, Indianapolis, IN (www.dowagro.com)
Picloram	Tordon 22K	240 g L ^{1} EC	Dow Agrosciences
Triclopyr	Remedy Ultra	480 g L ^{1} EC	Dow Agrosciences
Aminopyralid	Milestone	240 g L ^{1} EC	Dow Agrosciences
Aminocyclopyrachlor	MAT28	0.50 g g ^{1} SG	DuPont Corporation, Wilmington, DE (www.dupont.com)
Fluroxypyr	Starane	180 g L ^{1} EC	Dow Agrosciences

[a] InterLock® at 0.208% v/v was added to each herbicide solution.

[b] Abbreviations: EC, emulsifiable concentrate; SG, soluble granule.

and May 22, 2012, Asgrow 3803 glyphosate-resistant soybean were planted into a conventionally-tilled seedbed in rows spaced 76 cm apart at a rate of 432,000 seeds ha ^{1}. All treatments were arranged in a randomized complete block (RCB) design with six replications. Individual plots were 2 by 8 m in size. In both years, the entire trial was maintained weed-free with a PRE application of sulfentrazone plus cloransulam plus pendimethalin (139 + 18 + 780 g ae ha ^{1}) followed by POST applications of glyphosate (1,121 g ae ha ^{1}). Treatments included the eight synthetic auxin herbicides listed in Table 1. Each of these herbicides was applied at the V3 and R2 stages of soybean growth at 0.028, 0.28, 2.8, and 28 g ae or ai ha ^{1}. In 2011, V3 and R2 applications were made on July 1 and August 3, respectively, whereas in 2012, V3 and R2 applications were made on June 18 and July 13, respectively. All treatments were applied with a CO_2-pressurized backpack sprayer equipped with 80025 air induction nozzles that delivered coarse to extremely coarse droplets at 140 L ha ^{1} and 117 kPa. In an effort to minimize spray drift and/or contamination between plots: (1) drift shields were established on three sides of the spray boom during treatment; (2) all treatments included a drift reduction agent (InterLock®, 0.2% v/v; Winfield Solutions LLC, P.O. Box 64589, St. Paul, MN 55164); and (3) each herbicide was applied using a specific boom that had never been used before and was designated for that active ingredient only. Monthly rainfall totals and average monthly temperatures for each year are presented in Table 2.

Table 2. Monthly rainfall (mm) and average monthly temperatures (C) from April through October in 2011 and 2012 in comparison to the 30 yr average in Boone County, Missouri.

	Rainfall			Temperature		
Month	2011	2012	30 yr average[a]	2011	2012	30 yr average[a]
		mm			C	
April	72	171	121	13.6	13.9	13.6
May	130	25	127	16.5	21.0	18.9
June	77	39	94	24.0	24.1	23.8
July	59	18	101	27.6	28.5	25.7
August	61	5	75	24.6	24.7	24.8
September	46	46	78	17.4	18.6	20.4
October	26	68	99	13.8	11.7	14.0
Total	471	372	695			

[a] 30 yr averages (1981 2010) obtained from National Climatic Data Center (2011).

Treatment Evaluation and Data Collection. Visible herbicide injury and soybean height were evaluated at 2 and 4 wk after treatment (WAT). Visible estimates of injury were evaluated on a scale from 0 to 100%, where 0 equals no injury and 100 was equivalent to complete crop death. Soybean height was evaluated by measuring six random soybean plants per plot (three from each row) from the soil surface to the top of the central stem. Delayed maturity was measured by recording the day on which 95% of the soybean pods in each plot reached a mature color and then comparing that with the day when the nontreated control plots reached maturity. Before harvest, a sample of six random soybean plants from the center of each plot were collected and used for yield component analysis. Each sample was evaluated by counting the number of seeds per pod and pods per plant to determine an average value for each respective treatment. Soybean were harvested from the center two rows of each plot with a small plot combine, and seed yields were adjusted to 13% moisture content. A 100-count seed subsample was collected from each plot to determine seed weight.

Statistical Analysis. All data were checked for normality to meet basic assumptions prior to statistical analysis. Visible estimates of injury, soybean height, yield component analyses, and soybean yield were subjected to ANOVA using the PROC MIXED procedure in SAS (SAS 9.2, SAS® Institute Inc.) and tested for appropriate interactions. Year–location combinations were considered an environment sampled at random, as suggested by Carmer et al. (1989) and Blouin et al. (2011). Herbicide, herbicide rate, and application timing were considered fixed effects in the model, whereas environment, replications, subsamples, and interactions within environment were considered random effects. Analyses were performed on the means and least squares means and detected using Fisher's protected LSD at $\alpha = 0.05$.

Results and Discussion

Visible Estimates of Injury. At 2 WAT, injury symptoms were dependent on herbicide and rate, regardless of growth stage (Table 3). In general, injury intensity increased with increasing herbicide rates. No significant injury was noted following any application of 2,4-D amine. Soybean injury was greatest in response to aminopyralid, aminocyclopyrachlor, picloram, clopyralid, and dicamba, and least with triclopyr and 2,4-D amine (Table 3).

By 2 WAT, 28 g ha^{1} aminocyclopyrachlor and picloram applied at the V3 stage of growth resulted in terminal clusters of undeveloped buds, moderate epinasty, and chlorosis, with noticeable cupping of leaves. Applications of aminopyralid and clopyralid at the same rate resulted in more necrotic buds and bleached tissues, but less cupping than many of the other synthetic auxin herbicides. Although there were varying degrees of symptomology observed, by 2 WAT of the V3 application timing, 28 g ha^{1} aminopyralid, aminocyclopyrachlor, picloram, clopyralid, and fluroxypyr resulted in 56 to 73% visible soybean injury, which was the highest observed in these trials (Table 3). Dicamba and triclopyr at 28 g ha^{1} resulted in intermediate levels of soybean injury at 44 and 29%, respectively, with soybean exhibiting fewer necrotic buds and overall leaf cupping in response to these herbicides. Although leaf cupping is more characteristic of dicamba exposure to soybean, at 28 g ha^{1} leaves that developed following herbicide treatment did not expand further than bud clusters; thus, visible leaf cupping was minimal. Similar symptoms have been described previously (Al-Khatib and Peterson 1999; Andersen et al. 2004; Auch and Arnold 1978; Kelley et al. 2005; Wax et al. 1969; Weidenhamer et al. 1989). When applied at the V3 stage of growth, 28 g ha^{1} 2,4-D amine resulted in only 3% soybean injury, which was the lowest level of injury observed in these experiments. There were no leaf or stem epinastic symptoms observed following treatment with triclopyr or 2,4-D amine at any rate.

Applications of aminopyralid, picloram, clopyralid, aminocyclopyrachlor, and dicamba at 2.8 and 0.28 g ha^{1} to soybean in the V3 stage of growth caused noticeable leaf cupping and leaf mottling/puckering, as well as chlorotic, undeveloped bud clusters 2 WAT. Due to fewer necrotic buds and stems, visible injury values were overall lower compared to the 28 g ha^{1} rate of these same herbicides. In response to V3 applications of 0.028 g ha^{1} aminopyralid and dicamba, soybean exhibited a moderate degree of leaf cupping and chlorosis of leaf edges, with dicamba displaying more cupped bud clusters than the other synthetic auxin herbicides. No significant soybean injury was noted 2 WAT of the V3 applications of 0.028 g ha^{1} aminocyclopyrachlor and 0.028, 0.28, and 2.8 g ha^{1} 2,4-D, triclopyr, and fluroxypyr (Table 3).

Aminopyralid, clopyralid, picloram, and aminocyclopyrachlor applied at 28 g ha^{1} to R2 soybean resulted in the greatest injury (30 to 39%) 2 WAT (Table 3). These treatments resulted in terminal bud death, loss of apical dominance/expansion, and severe stem chlorosis and epinasty. Soybean stems had splits, callouses, and angles of 45 to 120 degrees. These symptoms predominantly occurred on newer plant tissues, and therefore visible injury ratings were overall much lower than V3 applications. Equivalent applications of dicamba and triclopyr to R2 soybean resulted in similar bud necrosis/death, but less epinasty and chlorosis. Overall injury was 15 and 18% in response to 28 g ha^{1} triclopyr and dicamba, respectively (Table 3). R2 applications of 0.028, 0.28, and 2.8 g ha^{1} dicamba all resulted in similar levels of leaf cupping/mottling. At the same timing, 0.028, 0.28, and 2.8 g ae ha^{1} of aminopyralid and clopyralid resulted in terminal leaf cupping/chlorosis and bud abortions,

Table 3. Soybean injury, rate of maturity, and height in response to eight synthetic auxin herbicides applied at the V3 and R2 stages of soybean growth combined across 2011 and 2012.

		Injury[a]				Soybean height				Maturity delay[b]	
		2 WAT		4 WAT		2 WAT		4 WAT			
Herbicide	Rate	V3	R2	V3	R2	V3	R2	V3	R2	V3	R2
	g ae ha ^{1}	%[cd]				% of nontreated control[cd]				No. days[cd]	
2,4 D amine	0.028	2	0	1	0	96	102	103	103	0	0
	0.28	1	0	1	1	102	100	101	100	0	0
	2.8	1	0	0	0	99	101	101	101	0	0
	28	3	0	0	0	94	95	99	98	0	0
Aminocyclopyrachlor	0.028	5	3	2	3	103	100	104	101	0	0
	0.28	11	9	4	8	95	97	99	99	0	0
	2.8	32*	13	11	14	78	85*	83*	76	4	10*
	28	70*	33	63*	29	52	68*	47	59*	8	23*
Aminopyralid	0.028	31*	12	7	9	87	91	92*	86	1	1
	0.28	41*	11	14	11	84	91*	88	84	1	1
	2.8	48*	14	43*	13	74	80*	66	71	3	16*
	28	73*	39	65*	34	44	59*	26	53*	21	23*
Clopyralid	0.028	7	10	1	7*	93	102*	97	101	0	0
	0.28	11	12	2	8*	92	96	95	93	0	0
	2.8	41*	14	7	14*	83	86	83	80	2	1
	28	60*	30	68*	21	52	56	35	57*	8	26*
Dicamba	0.028	21	15	10	17*	89	94	94	89	0	0
	0.28	28	17	9	16*	85	93*	90	85	3	0
	2.8	32*	14	9	15*	79	86*	75	77	3	1
	28	44*	18	12	14	80*	74	74*	62	5	24*
Fluroxypyr	0.028	1	0	0	1	102	102	101	102	0	0
	0.28	1	1	0	2	101	99	101	100	0	0
	2.8	4	1	1	2	93	97	96	99	0	0
	28	56*	15	36*	8	58	74*	59	72*	4	18*
Picloram	0.028	10	5	2	4	98	98	99	101	0	0
	0.28	11	7	2	6	98	96	99	98	0	0
	2.8	30*	10	5	12*	85	85	90	84*	1	10*
	28	69*	32	66*	25	52	64*	46	56*	8	26*
Triclopyr	0.028	1	0	0	0	97	99	100	101	0	0
	0.28	3	1	1	1	98	98	98	100	0	0
	2.8	2	0	0	1	98*	92	99	96	0	0
	28	29	15	7	10	71	76	78*	62	0	18*
Nontreated		1	0	0	0	100	100	100	100	0	0
LSD (0.05)[d]		18	9	5	3	6	4	6	4	1	1

[a] Injury ratings on a scale of 0 (no injury) to 100% (complete kill).
[b] Measured by recording the day when 95% of the soybean pods in each plot reached maturity compared to the nontreated control.
[c] Values followed by an asterisk indicate a significantly higher level of visible injury, soybean height reduction, and maturity delay between the V3 and R2 applications of a given active ingredient and rate, LSD (0.05).
[d] LSD (0.05) within a column between herbicide treatments applied at the same soybean growth stage.

with 0.28 and 2.8 g ha ^{1} of aminopyralid displaying unexpanded/undeveloped bud clusters and stem epinasty. Aminocyclopyrachlor at 2.8 g ha ^{1} exhibited chlorotic terminal leaf cupping and mottling, as well as undeveloped bud clusters similar to aminopyralid. The 0.028, 0.28, and 2.8 g ha ^{1} rates of picloram applied at R2 resulted in slight cupping of the newest trifoliates. This differential response to the eight synthetic auxin herbicides was not surprising because plants absorb, translocate, and metabolize herbicides at different rates.

By 4 WAT, all soybean exposed to synthetic auxin herbicides at the V3 growth stage, except for

28 g ha^{1} clopyralid, picloram, aminocyclopyrachlor, and 2.8 and 28 g ha^{1} of aminopyralid, had recovered from 2 wk prior (Table 3). Conversely, soybean treated with synthetic auxin herbicides at the R2 stage of growth did not recover as well, and in many instances exhibited similar levels of injury as 2 WAT.

Soybean Height. Previous research has correlated soybean yield loss with reductions in plant height following an application of dicamba (Weidenhamer et al. 1989). In this research, reductions in plant height were generally correlated with, but less severe than, visible injury estimates. Greater height reductions occurred with all herbicides except for 2,4-D amine and triclopyr when applied at the V3 compared to the R2 stage of growth (Table 3). Auch and Arnold (1978) observed that the greatest soybean height reductions from dicamba applications were made at the early-bloom stage, as compared to applications made at vegetative growth stages or from midbloom through late-pod. At 2 WAT, soybean height was not reduced following V3 or R2 applications of 2,4-D and triclopyr at 0.028, 0.28, and 2.8 g ha^{1}, and for aminocyclopyrachlor, fluroxypyr, and picloram at 0.028 and 0.28 g ha^{1}, but was reduced for all rates of aminopyralid, clopyralid, and dicamba (Table 3). At 2 WAT when herbicides were applied at 28 g ae ha^{1}, soybean height expressed as a percent of the nontreated was equal for V3 and R2 applications of 2,4-D (94 and 95% of the nontreated) and clopyralid (52 and 56%), but height reduction for 28 g ha^{1} was greater for R2 compared to V3 applications for aminocyclopyrachlor (52 and 68%), aminopyralid (44 and 59%), dicamba (80 and 74%), fluroxypyr (58 and 74%), picloram (52 and 64%), and triclopyr (71 and 76%). At 4 WAT soybean height compared with the nontreated control was reduced with V3 and R2 applications of aminocyclopyrachlor, aminopyralid, clopyralid, dicamba, and picloram at 2.8 and 28 g ha^{1} and with fluroxypyr and triclopyr at 28 g ha^{1}.

Soybean Maturity. The specific herbicide, herbicide rate, and timing of herbicide application had significant effects on the delay in soybean maturity (Table 3). In general, applications made to soybean in the R2 stage of growth resulted in greater delays in soybean maturity compared to V3 herbicide applications. Wax et al. (1969) also observed greater maturity delays following dicamba and picloram applications to soybean in the reproductive stages of growth compared to the prebloom stages of growth. Applications of aminocyclopyrachlor, clopyralid, dicamba, and picloram at 28 g ha^{1} delayed maturity 5 to 8 d when applied at the V3 stage of growth and 23 to 26 d when applied at the R2 stage of growth (Table 3). V3 and R2 applications of 28 g ha^{1} aminopyralid delayed maturity 21 and 23 d, respectively. Applications of aminocyclopyrachlor, aminopyralid, dicamba, and picloram at 2.8 g ha^{1} delayed soybean maturity 1 to 4 d when applied at the V3 stage of growth and 1 to 16 d when applied at the R2 stage of growth. Soybean maturity was not delayed for 2,4-D regardless of application timing or for triclopyr at all rates at V3. Wax et al. (1969) also reported that dicamba delayed soybean maturity more than 2,4-D. Triclopyr applied at R2 delayed maturity 18 d for only the 28 g ha^{1} rate.

Soybean Yield. In general, herbicide treatments and rates resulting in less than 10% injury 2 WAT did not reduce yield (Tables 3 and 4). Except for either application timing of 2,4-D amine and V3 applications of dicamba, all herbicides resulted in greater soybean yield loss with increasing herbicide rates (Table 4). Additionally, greater soybean yield loss occurred with applications made to R2 compared to V3 soybean, except for 2,4-D amine, which did not reduce soybean yield compared to the nontreated control at either application timing. This result is consistent with previous research; Slife (1956) and Wax et al. (1969) reported less yield reduction from early compared to later 2,4-D treatments, and Robinson et al. (2013) reported soybean yield losses of 5% with V2 or R2 applications of 2,4-D at rates up to 116 g ha^{1}. Soybean yield after R2 applications of dicamba ranged from 2 to 67% less than the nontreated control, but V3 applications of dicamba did not result in any soybean yield loss. This result is in agreement with previous research, where 9 to 11 g ha^{1} dicamba reduced yields in the flowering stage, compared with prebloom applications that required rates of 56 to 70 g ha^{1} to reduce yields (Auch and Arnold 1978; Wax et al. 1969). In relation to the significant injury following early-season dicamba applications, Behrens and Leuschen (1979) determined yield reductions following dicamba drift injury to soybean at the first trifoliate stage were associated with injury ratings of 60 to 70 or more.

Table 4. Soybean yield and yield components in response to eight synthetic auxin herbicides applied at the V3 and R2 stages of soybean growth combined across 2011 and 2012.

Herbicide	Rate	Soybean yield[ab]		Seeds per pod[ab]		Pods per plant[ab]		Seed weight[ab]	
		V3	R2	V3	R2	V3	R2	V3	R2
	g ae ha ^{1}	—kg ha ^{1}—		—No.—				—g 100 seeds ^{1}—	
2,4 D amine	0.028	4,345	4,340	2.22	2.33	45	55*	16.77	16.62
	0.28	4,306	4,395	2.27	2.22	45	53*	16.68	16.83
	2.8	4,462	4,354	2.26	2.20	49	48	16.63	16.66
	28	4,306	4,373	2.23	2.20	51	45	16.88	17.25
Aminocyclopyrachlor	0.028	4,513	4,466	2.28	2.24	46	48	16.72	17.11
	0.28	4,440	4,594	2.20	2.18	46	45	16.40	17.18
	2.8	4,222*	3,823	2.27*	2.02	48*	37	16.24	19.37*
	28	1,927*	435	2.23	0.19*	45*	7	16.42	17.16*
Aminopyralid	0.028	4,141	4,016	2.27	2.17	45	40	16.37	17.99*
	0.28	4,086	3,898	2.26*	2.07	49*	40	16.25	17.54*
	2.8	3,329*	2,752	2.10*	1.93	44	41	16.24	18.79*
	28	423*	135	0.76*	0.01	16*	1	16.61	15.87
Clopyralid	0.028	4,369	4,640*	2.25	2.20	44	48	16.52	17.50
	0.28	4,015	4,073	2.19	2.15	47	46	16.08	17.27*
	2.8	3,944	3,795	2.24	2.00*	48*	40	16.14	18.01*
	28	1,838*	622	2.28*	0.08	49*	9	16.33	17.87*
Dicamba	0.028	4,147	4,222	2.17	2.06	45	42	16.23	18.11*
	0.28	4,260	4,052	2.17	2.07	50	43	16.35	18.35*
	2.8	4,178*	3,730	2.16*	2.00	45	39	16.44	17.73*
	28	4,128*	1,427	2.20*	0.64	50*	13	16.35	18.99*
Fluroxypyr	0.028	4,463	4,671	2.29	2.17	50	46	16.47	17.02
	0.28	4,447	4,425	2.23	2.22	45	48	16.60	16.99
	2.8	4,289	4,530	2.28	2.30	49*	40	16.80	17.35
	28	3,079*	2,306	2.30*	1.07	50*	15	16.45	18.98*
Picloram	0.028	4,464	4,511	2.27	2.27	47	44	16.79	17.11
	0.28	4,401	4,242	2.22	2.18	45	44	16.53	17.10
	2.8	4,088*	3,653	2.28	2.15	44	42	16.39	18.38*
	28	2,070*	480	2.29*	0.12	53*	10	16.34	16.67
Triclopyr	0.028	4,446	4,464	2.13	2.20	51	53	16.78	16.67
	0.28	4,360	4,550	2.25	2.23	50	49	16.67	17.07
	2.8	4,543	4,513	2.35	2.33	47	45	16.87	17.69*
	28	3,832*	2,468	2.31*	1.07	49*	11	16.45	20.41*
Nontreated		4327	4,327	2.27	2.27	48	48	16.70	16.70
LSD (0.05)[b]		267	234	0.12	0.14	8	6	0.37	0.89

[a] Values followed by an asterisk indicate a significantly higher level of soybean yield, seeds per pod, pods per plant, and seed weight between the V3 and R2 applications of a given active ingredient and rate, LSD (0.05).

[b] LSD (0.05) within a column between herbicide treatments applied at the same soybean growth stage.

Other authors (Auch and Arnold 1978; Slife 1956; Wax et al. 1969) have also noted greater yield reductions following dicamba applications to soybean in the reproductive rather than vegetative stages of growth. Conversely, Kelley et al. (2005) reported equivalent or greater yield reductions from V3 applications of dicamba, 2,4-D, and clopyralid, compared to R2 applications of these same herbicides.

Regardless of growth stage, yields were significantly reduced following 0.28, 2.8, and 28 g ha ^{1} clopyralid and 2.8 and 28 g ha ^{1} picloram. Only 2.8 and 28 g ha ^{1} aminopyralid applied to V3 soybean reduced yield, while all aminopyralid rates applied to R2 soybean resulted in yields 7 to 97% less than the nontreated control. Similarly, only 28 g ha ^{1} aminocyclopyrachlor applied to V3 soybean reduced yield, while the 2.8 and 28 g ha ^{1} rates applied at the R2 stage reduced yield 12 and 90%, respectively. Lastly, only 28 g ha ^{1} of triclopyr and fluroxypyr applied at either growth stage resulted in yields less than the nontreated control. When applied at 28 g ha ^{1} at the V3 stage of growth, the general order of herbicide-induced yield reductions to soybean from greatest to least was aminopyralid > aminocyclopyrachlor = clopyralid = picloram > fluroxypyr > triclopyr > dicamba - 2,4-D amine. At the R2 stage of growth, the general order of herbicide-induced yield reductions from greatest to least was aminopyralid > aminocyclopyrachlor = picloram > clopyralid > dicamba > fluroxypyr = triclopyr > 2,4-D amine.

Interestingly, certain synthetic auxin treatments resulted in yields higher than the nontreated control (Table 4). When applied at the R2 stage of growth, 0.028 g ha ^{1} clopyralid and fluroxypyr resulted in yields 313 and 344 kg ha ^{1} greater than the nontreated control. This response can be explained by a phenomenon known as herbicide hormesis (Southman and Ehrlich 1943), or the Arndt-Schultz law (Thimann 1956), which states that every toxicant is a stimulant at low levels (Schabenberger et al. 1999). Several other authors have reported stimulatory effects on field crops from low concentrations of 2,4-D and other synthetic auxin herbicides (Miller et al. 1962; Taylor 1946; Wiedman and Appleby 1972).

Soybean Yield Components. Generally, all synthetic auxin herbicides other than 2,4-D amine reduced soybean seeds per pod in response to increasing herbicide rates. All rates of 2,4-D amine resulted in seeds per pod equivalent to the nontreated control. In general, R2 applications of synthetic auxin herbicides influenced seeds per pod more than V3 applications, but the response varied by herbicide and rate (Table 4). Kelley et al. (2005) found that 5.6 g ha ^{1} dicamba reduced seeds per pod more when applied to soybean at V7 compared to V3 in 1 of 2 yr. Dicamba was the only herbicide where all rates applied to R2 soybean resulted in fewer seeds per pod than the nontreated control (Table 4). Following V3 applications, all herbicides except triclopyr and aminopyralid resulted in similar numbers of seeds per pod, regardless of herbicide rate. When compared to the nontreated control, 2.8 and 28 g ha ^{1} aminopyralid and 0.028 g ae ha ^{1} triclopyr were the only herbicides applied at the V3 timing that reduced soybean seeds per pod. Overall, seeds per pod were most affected by aminopyralid and least by 2,4-D amine; therefore, the number of soybean seeds per pod were strongly correlated with the soybean yield losses observed.

Following V3 applications, the number of pods per plant was only reduced in response to the highest rate of aminopyralid; all other synthetic auxin herbicides and rates resulted in a similar number of pods per plant as the nontreated control (Table 4). Kelley et al. (2005) reported that soybean treated at the V3 and V7 stages with 5.6 g ha ^{1} dicamba resulted in a similar number of pods per plant as the nontreated control. In contrast, following R2 applications, the number of pods per plant was highly influenced by herbicide rate. All synthetic auxin herbicides applied at the R2 stage of soybean growth resulted in significant differences in pods per plant in response to rate, with higher rates reducing pods per plant more than lower rates (Table 4). The lowest rate of 2,4-D applied to R2 soybean was the only treatment that resulted in more pods per plant than the nontreated control. All rates of aminopyralid, 2.8 and 28 g ha ^{1} dicamba, clopyralid, aminocyclopyrachlor, and fluroxypyr, and 28 g ha ^{1}picloram and triclopyr applied to R2 soybean reduced pods per plant in comparison to the nontreated control. As with seeds per pod, the differences in pods per plant was greatest with aminopyralid and least with 2,4-D.

Soybean seed weight was variable, with no consistent trend in response to either application timing. When applied at the V3 growth stage, there were no treatments that resulted in soybean seed weight greater than the nontreated control, whereas the same treatments applied to the R2 growth stage resulted in no seed weights less than the nontreated control (Table 4). Applications of 2,4-D at either soybean growth stage resulted in similar soybean seed weight as the nontreated control. Robinson et al. (2013) observed similar seed weight as the nontreated control with doses ≤ 560 g ha ^{1} 2,4-D. Only 0.028 g ha ^{1} dicamba, 2.8 g ha ^{1} aminocyclopyrachlor, and 0.28 and 2.8 g ha ^{1} clopyralid and aminopyralid applied to V3 soybean resulted in seed weight less than the nontreated control. Wax et al. (1969) reported > 1 g reductions in seed weight per 100 seeds following prebloom applications of 1 to 33 g ha ^{1} dicamba. Following R2 applications, all rates of dicamba, and several rates of all other synthetic auxin herbicides other than 2,4-D resulted in seed weight greater than the nontreated control (Table 4). Weidenhamer et al. (1989) also observed increases in seed weight following later applications of dicamba, whereas earlier dicamba applications reduced seed weight. Wax et al. (1969) also reported greater soybean seed weight from late- compared to early-season treatments of dicamba and picloram, noting that the increased seed size did not counteract the reduction in seed number and thus resulted in lower yields. The increase in seed weight was likely due to the reduction in the number of seeds produced.

The results from this research indicate that the risk to soybean from herbicide drift and/or tank contamination is dependent on herbicide, herbicide rate, and maturity of soybean following exposure. Overall, soybean are more likely to recover from misapplications of synthetic auxin herbicides made earlier, rather than later in the growing season. In this research, soybean exposed to synthetic auxin herbicides in early vegetative stages were able to maintain seed and pod set more efficiently than equivalent exposure to these herbicides at reproductive stages. In general, herbicide-induced injury increased with increasing herbicide rate, with aminopyralid, clopyralid, aminocyclopyrachlor, and dicamba resulting in more phytotoxicity to soybean than 2,4-D amine, triclopyr, and fluroxypyr. In this study, yield reductions were correlated with seeds per pod and pods per plant more so than seed weight.

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Received September 23, 2013, and approved February 21, 2014.

From: Pesticide Action Network Pesticide Action Network
To: Keigwin, Richard
Subject: EPA: Pull Monsanto's crop-killing dicamba, now.
Date: Thursday, September 21, 2017 12:26:51 PM

Dicamba helps Monsanto, hurts farmers

Dear Rick,

Thanks to Monsanto's latest genetically engineered (GE) seeds, use of the herbicide dicamba has skyrocketed this year — and so has damage to crops growing nearby.

Farmers in 20 states have reported more than 2,200 incidents of crop damage from dicamba drift on more than 3.1 million acres of land. This has to stop.

Tell the Environmental Protection Agency (EPA) to do its job and halt use of this harmful product, now.

Dicamba is not a new chemical, and it has a reputation of drifting from where it's applied in the field. Scientists and farmers also know that it's particularly harmful to broadleaf plants like fruits, nuts, vegetables and non-GE soy.

And now, after being rushed to market in 2015, Monsanto's Xtend soy seeds are driving up use of this drift-prone herbicide — and ushering in a new wave of serious problems for farmers.

Speak up to protect farmers! Urge EPA to halt the use of dicamba on soy and put an end

to this devastating crop damage.

Monsanto's Xtend seeds have been advertised as a necessary tool for farmers to combat the "superweed" epidemic. Interestingly, the corporation fails to mention two key points in its product marketing:

1. Glyphosate-resistant superweeds are the direct result of Monsanto's own RoundUp Ready crops; and
2. Scientists say weeds will also develop resistance to herbicides used on new GE seed lines, like dicamba and 2,4-D.

Put simply, engineering seeds to withstand repeated applications of herbicides just doesn't work. While the model may keep profits flowing for Monsanto, it's wreaking havoc in farmers' fields across the country.

Thank you for speaking up for farmers!

Pesticide Action Network North America
Berkeley, CA | Minneapolis, MN
510.788.9020 | community@panna.org | www.panna.org
Facebook | Twitter

From: Hawkins, Caleb
To: Becker, Jonathan; Chism, William; Jones, Arnet; Baris, Reuben; Kenny, Daniel; Rowland, Grant; Montague, Kathryn V.; Meadows, Sarah
Subject: RE: FYI -- PANNA email on dicamba
Date: Thursday, September 21, 2017 11:40:57 AM

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https://www.reuters.com/article/legal-us-usa-pesticides-epa/u-s-regulator-aiming-to-allow-controversial-herbicide-use-with-safeguards-idUSKCN1BU30R

From: Becker, Jonathan
Sent: Thursday, September 21, 2017 9:38 AM
To: Chism, William <Chism.Bill@epa.gov>; Hawkins, Caleb <Hawkins.Caleb@epa.gov>; Jones, Arnet <Jones.Arnet@epa.gov>; Baris, Reuben <Baris.Reuben@epa.gov>; Kenny, Daniel <Kenny.Dan@epa.gov>; Rowland, Grant <Rowland.Grant@epa.gov>; Montague, Kathryn V. <Montague.Kathryn@epa.gov>; Meadows, Sarah <Meadows.Sarah@epa.gov>
Subject: FYI -- PANNA email on dicamba

From: Pesticide Action Network Pesticide Action Network [mailto:subscribe@panna.org]
Sent: Wednesday, September 20, 2017 3:55 PM
To: Becker, Jonathan <Becker.Jonathan@epa.gov>
Subject: EPA: Pull Monsanto’s crop-killing herbicide, now.

Dicamba helps Monsanto, hurts farmers

Dear Friend,

Thanks to Monsanto's latest genetically engineered (GE) seeds, use of the herbicide dicamba has skyrocketed this year — and so has damage to crops growing nearby.

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#U.S. LEGAL NEWS

SEPTEMBER 20, 2017 / 6:40 PM / 5 MONTHS AGO

U.S. regulator aiming to allow controversial herbicide use with safeguards

Tom Polansek

WASHINGTON (Reuters) - The U.S. Environmental Protection Agency is aiming to allow farmers to spray the controversial weed-killer dicamba next year, but with additional rules for its use, an official with the agency said on Tuesday.

Reuben Baris, acting chief of the herbicide branch of the Environmental Protection Agency's (EPA) Office of Pesticide Programs, said the agency had not yet determined what steps it would take to mitigate problems associated with dicamba. The herbicide, which fights weeds resistant to another herbicide called glyphosate, was linked to widespread crop damage this summer.

The EPA has been discussing with state regulators ways to prevent such crop damage.

Use of dicamba, which is produced by BASF SE and Monsanto Co, spiked after U.S. regulators last year approved a new formulation that allowed farmers to apply it to soybean plants that were engineered to resist the chemical while it killed weeds. Previously it had been sprayed on fields prior to planting.

Farmers say the chemical caused damage by drifting away from where it was sprayed to fields of soybeans and other plants that could not tolerate it.

Baris told a meeting of state regulatory officials in Washington, D.C., that the agency was "very concerned with what has occurred and transpired in 2017."

"We're committed to taking appropriate action for the 2018 growing season with an eye towards ensuring that the technology is available, number one, to growers but that it is used responsibly," he said.

The EPA is in negotiations with Monsanto and BASF, which sell dicamba herbicides under different brands, to make changes regarding how they are used, Baris said.

State regulators previously told Reuters the EPA was considering establishing a set date after which the spraying of dicamba weed killers on growing crops would not be allowed.

Arkansas is independently weighing an April 15, 2018, deadline.

But Tony Cofer of the Alabama Department of Agriculture, who attended the meeting, said such a cut-off date would not match Baris' goal of maintaining dicamba's usefulness.

"That type of restriction would not be something they're probably considering, in all practicality, if they wanted to continue use of the product," said Cofer, director of the Pesticide Management Division at the state's agriculture department.

Monsanto has said the April 15, 2018, date would amount to a ban in Arkansas because the chemical was designed to be sprayed over the genetically engineered crops during the summer growing season.

Arkansas previously blocked sales of Monsanto's dicamba herbicide in the state.

Our Standards: *The Thomson Reuters Trust Principles.*

From: Green, Jamie
To: Kenny, Daniel; Baris, Reuben
Subject: FW: Record number of pesticide misuse claims by Iowa farmers due to dicamba drift problems
Date: Wednesday, September 13, 2017 10:30:06 AM

FYI

From: Ridnour, Lacey
Sent: Wednesday, September 13, 2017 9:25 AM
To: Green, Jamie <Green.Jamie@epa.gov>
Subject: Record number of pesticide misuse claims by Iowa farmers due to dicamba drift problems

https://geneticliteracyproject.org/2017/09/13/record-number-pesticide-misuse-claims-iowa-farmers-due-dicamba-drift-problems/

Lacey Ridnour
Iowa & Tribal Circuit Rider Project Officer
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Record number of pesticide misuse claims by Iowa farmers due to dicamba drift problems

geneticliteracyproject.org/2017/09/13/record-number-pesticide-misuse-claims-iowa-farmers-due-dicamba-drift-problems/

Nationally, 2,242 farmers say dicamba has damaged an estimated 3.1 million acres, a University of Missouri report shows.

Iowa ag leaders are investigating a record 258 crop damage reports from pesticide misuse this year. About 100 complaints on 150,000 acres are tied to dicamba.

Monsanto and other ag giants like DuPont and BASF have developed seeds that are genetically modified so they can be sprayed with dicamba, killing weeds but leaving the crop unharmed.

At issue is whether the new dicamba products stay where they're sprayed — or move to neighboring fields, where they can damage non-resistant crops, fruits and vegetables, trees and flowers.

Monsanto claims the problems primarily come from farm application errors.

...

Some university weed scientists disagree.

"The big debate is whether or not the stuff is volatilizing," or turning from liquid to vapor, enabling it to easily move, potentially over a few days, said Robert Hartzler, an Iowa State University weed scientist.

...

The U.S. Environmental Protection Agency is talking with academic researchers, state farm regulators, and Monsanto and other manufacturers to determine whether new restrictions should be placed on the chemical's use.

The GLP aggregated and excerpted this article to reflect the diversity of news, opinion, and analysis. Read full, original post: Iowa farmers make record number of pesticide misuse claims

Iowa farmers make record number of pesticide misuse claims

Donnelle Eller, deller@dmreg.com Published 6:39 p.m. CT Sept. 11, 2017 | **Updated 11:24 a.m. CT Sept. 12, 2017**

(Photo: Zach Boyden-Holmes/The Register)

About three-fourths of Shane Susie's 80-acre soybean field was damaged after getting hit with dicamba that drifted over his crops from neighboring fields.

The herbicide also savaged his family's trees, flowers and vegetable patch.

"We're not eating anything out of it this year," said the 30-year-old who farms near Kingsley in northwest Iowa.

He estimates his soybean damage losses at $15,000. With drought worries and low corn and soybean prices, "it will be a tough year." he said. "It makes a challenging year more challenging."

Susie and other Midwest farmers have been drawn into a national debate swirling around whether new dicamba versions are safe for growers to use.

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Volatility vs. applicator error

Fullscreen

Photos: Controversial herbicide is damaging Iowa crops

Monsanto claims the problems primarily come from farm application errors.

"We did 1,200-some odd tests in connection with registration of our product with EPA," said Scott Partridge, Monsanto's vice president of global strategy. "They confirmed to us what the label says — if it's followed ... there will be no off-target movement of dicamba by wind or volatization."

Some university weed scientists disagree.

"The big debate is whether or not the stuff is volatilizing," or turning from liquid to vapor, enabling it to easily move, potentially over a few days, said Robert Hartzler, an Iowa State University weed scientist.

"New formulations were supposed to have taken care of the volatility problem," he said, "but all the research suggests that they've reduced the volatility, but not to a level that's safe" after plants have emerged from the ground.

The U.S. Environmental Protection Agency is talking with academic researchers, state farm regulators, and Monsanto and other manufacturers to determine whether new restrictions should be placed on the chemical's use.

"The underlying causes of the various damage incidents are not yet clear, as ongoing investigations have yet to be concluded," the EPA told the Register.

Monsanto said it's cooperating with the EPA's review and expects a decision soon.

Last week, the company challenged an Arkansas task force recommendation to ban the use of dicamba-related products after April 15 next year.

In July, the state issued a four-month prohibition on dicamba use. Arkansas farmers have logged 963 dicamba-related complaints this year.

Buy Photo

Bob Hartzler, a weed specialist at Iowa State University, stands in a soybean field near ISU on Monday, Sept. 11, 2017. *(Photo: Zach Boyden-Holmes/The Register)*

Hartzler said he and other weed scientists support EPA restrictions on dicamba product-use after plants have emerged from the ground, a time that can vary depending on the state.

"If it is volatilizing, it's nearly impossible to use, in my opinion, post-emergence," he said.

Hartzler said Monsanto and BASF are fighting restrictions because they would "greatly reduce the value" of their chemical and seed systems, which required "a huge investment" to develop over several years.

"The seed is where they make the majority of their money," Hartzler said. "So if the chemical is restricted and it no longer controls waterhemp or Palmer amaranth, farmers would not see the need to pay additional money" for that technology.

Iowa and U.S. farmers want more weapons in their battle against weeds that can't be killed with glyphosate, the active ingredient in Monsanto's popular Roundup Ready products.

Several Southern states are struggling with glyphosate-resistant Palmer amaranth, a rapidly growing, fast-adapting "super weed" that can quickly overrun cotton and soybean fields.

Palmer amaranth is creeping across Iowa, moving into about half of its counties. So far, the weed can be killed with glyphosate, but weed scientists say it's only a matter of time until it adapts to the the widely used chemical.

The Iowa Department of Agriculture has asked farmers in the state to check fields this harvest for Palmer amaranth, which can grow more than 7 feet tall.

Buy Photo

Bob Hartzler, a weed specialist at Iowa State University, hold a soybean plant that has been affected by dicamba near ISU on Monday, Sept. 11, 2017. *(Photo: Zach Boyden-Holmes/The Register)*

Who will cover damage?

Partridge said about 75 percent of the 1,000 U.S. crop damage reports Monsanto has investigated are due to "failure to follow the label."

Monsanto continues to look into the other 25 percent to determine what role weather might have played, he said.

Partridge believes better education can reduce complaints and points to Georgia as an example. It required that chemical applicators become certified and has experienced no reports of drift damage.

With Monsanto expecting customer demand to double, he warned that Arkansas growers could see twice the damage if the state continues its ban in 2018. That could result in farmers using an older, more volatile version of the herbicide, he said.

Clark Porter, who farms near Waterloo, said he anticipates more farmers will look at using dicamba-tolerant seeds to reduce their damage risk.

Porter said two of his fields received dicamba damage — one when he sprayed using a tank contaminated with a dicamba product and another he believes was vapor drift. One field should see little reduction in yields; the other — just a few acres — will have losses, he said.

Depending on when it occurs, dicamba damage may have no impact or climb up to 40 percent in yield reduction, Hartzler said, based on damage reported in Iowa.

Pat Swanson, who farms near Ottumwa, said her family experienced no problems when they had a contractor spray 220 acres of soybeans.

"We were happy with the results," said Swanson, a Pioneer seed dealer. "We had no problems with drift."

The Iowa Soybean Association said it's working with farmers, researchers, manufacturers and others to find answers, so growers "can continue to have access to these important products and they can be assured that their own and their neighbors' crops won't be affected."

Susie, a Beck's Hybrids seed dealer, worries that his losses won't get covered, given the ongoing debate about whether the responsibility for the damage lies with dicamba makers or those applying their products.

Insurance adjusters have determined their clients followed label instructions when spraying the dicamba that damaged his fields. His only other option is to file a lawsuit against the applicators or join a class action suit against dicamba makers.

"I think it's a great product, but I'm not sure there was enough research done" to ensure it remains stable once it's applied, he said.

He agrees with Porter that farmers might feel forced to buy dicamba-tolerant seeds next year "to protect themselves."

"It's not what we should have to do. We shouldn't be fearful about getting damaged," Susie said.

Read or Share this story: http://dmreg.co/2w2NaKf

From: Green, Jamie
To: Kenny, Daniel; Baris, Reuben; Lott, Don; Dyer, Brian; Trivedi, Adrienne
Cc: Weekley, Erin; Hackett, Shawn; Frizzell, Damon
Subject: FW: More Dicamba = Monsanto Petition to Arkansas State Plant Board
Date: Tuesday, September 12, 2017 5:07:58 PM
Attachments: image002.png

FYI

From: Baumgartner, Donald
Sent: Tuesday, September 12, 2017 4:00 PM
To: Andrew Martin <martinag@purdue.edu>; Brad Beaver <Brad.Beaver@illinois.gov>; Brian Verhougstraete <verhougstraeteb@michigan.gov>; Chris Difonzo <difonzo@msu.edu>; cindy flock <folck.2@osu.edu>; curt colwell <curt.colwell@illinois.gov>; scottde@purdue.edu; dean herzfeld <deanh@tc.umn.edu>; Dustin Roy <dustin.roy@whiteearth-nsn.gov>; fred whitford <fwhitford@purdue.edu>; Gary Edwards <gary.edwards@state.mn.us>; glenn nice <gnice@wisc.edu>; Greg Minor <gregory.minor@agri.ohio.gov>; heidi fischer <heidi.fischer@state.mn.us>; jim belt <jbelt@agri.ohio.gov>; joe spitzmueller <joseph.spitzmueller@state.mn.us>; john stone <stonejo2@msu.edu>; Kari Leach <leach13@purdue.edu>; Ken Runkle <ken.runkle@illinois.gov>; Kim Middendorf <kimberly.middendorf@state.mn.us>; leo reed <reedla@purdue.edu>; Lori Bowman <Lori.Bowman@Wisconsin.gov>; mark mccloskey <mark.mccloskey@wisconsin.gov>; mary ann rose <rose.155@osu.edu>; Matt Beal <matthew.beal@agri.ohio.gov>; Michael Stoliecki <stolieckim1@michigan.gov>; Molly Mott-Oosting <mottm@michigan.gov>; robby personette <robby.personette@wisconsin.gov>; Ryan King <ryan.king@agri.ohio.gov>; scott frank <scott.frank@illinois.gov>; tim hoffman <thoffman@agri.ohio.gov>; Travis Cleveland <tclevela@illinois.edu>; warren goetsch <warren.goetsch@illinois.gov>
Cc: Green, Jamie <Green.Jamie@epa.gov>; Carroll, Craig <Carroll.Craig@epa.gov>; Teter, Royan <Teter.Royan@epa.gov>
Subject: More Dicamba = Monsanto Petition to Arkansas State Plant Board

See link below

http://www.agriculture.com/crops/soybeans/monsanto-levels-criticism-at-arkansas-weed-scientists?did=169450

Thanks to Margaret Jones of our office for bringing this to our attention.

Donald

Donald Baumgartner, B.S., M.S. Medical Entomologist
R5 WPS Coordinator, Bed Bug Specialist, Zika/Mosq Control, Urban Pests
Pesticides Section (LC-17J), Chemicals Mgt. Branch
U.S. Environmental Protection Agency Region 5
77 West Jackson Blvd.
Chicago, Illinois 60604
ph. 312/886-7835

fax 312/697-2531
baumgartner.donald@epa.gov
For pesticide information visit http://www.epa.gov/pesticides/ or http://npic.orst.edu/
R5 Bed Bug Hotline at 888/644-2200 or bedbugs@umn.edu
To report environmental violations visit https://www.epa.gov/pesticide-incidents
Life Lesson: We do not stop playing because we grow old; we grow old because we stop playing.
Have a Bed Bug Free Day!!

EPA United States Environmental Protection Agency

From: Bradley, Kevin
To: Baris, Reuben
Subject: Re: call this week?
Date: Monday, September 11, 2017 10:15:58 PM
Attachments: A68295E2-4431-4EF5-944A-3488169A97FC[70].png
5939E0CA-ECB1-4FAB-9D4D-0C2C4E8C81AE[70].png
image002.png
Volatility Data for EPA Review.pdf

Reuben, attached is a pdf of slides from several university weed scientists that have done some independent volatility testing of the new dicamba formulations this summer; Jason Norsworthy, Larry Steckel, Tom Mueller, and myself. I realize you pretty much already have the slides from Mueller's presentation. If you have any questions on any of this please let me know. In case the file is too large to go through email, you can download it here instead:
https://www.dropbox.com/s/xlfpzo8i8qbtdmd/Volatility%20Data%20for%20EPA%20Review.pdf?dl=0

Kevin Bradley, PhD
Professor, Division of Plant Sciences
State Extension Weed Scientist
University of Missouri

Weed Science Website: http://weedscience.missouri.edu
Weed ID Website: http://weedid.missouri.edu

Follow us on:

From: "Baris, Reuben" <Baris.Reuben@epa.gov>
Date: Friday, September 1, 2017 at 7:30 PM
To: Kevin Bradley <bradleyke@missouri.edu>
Subject: Re: call this week?

Hi Kevin,
It was been a crazy week for both of us. I'm sorry we kept missing each other. We are interested in the volatility data. While GLP would be ideal we are interested in any data that you or your colleagues are willing/able to share. The other pieces of information we are trying to nail down are non-target damage estimates that includes both non-DY soy and any other sensitive crop, plant etc. I can explain the rationale more for that when we are able to chat on the phone. And then what other investigations are going on in the field that you are hearing. Are Monsanto and BASF out in the field still? How are the various CheckOff groups involved in the issues at hand? There are still a lot of things to discuss. I

hope we can find some time next week to chat.
Hope you are able to enjoy the long weekend.
Reuben

Sent from my iPhone

On Sep 1, 2017, at 4:35 PM, Bradley, Kevin <bradleyke@missouri.edu> wrote:

Reuben, doesn't seem like we can catch each other on the phone. I just wanted to let you know our committee can get you some data and at least for my own part, there aren't any restrictions on what we can and can't show you….we can share everything we have. I assume we are talking about volatility but not even sure what kind of data you were asking for on the phone voice message. You are free to call me anytime on my cell, 573-999-1278.

Kevin Bradley, PhD
Professor, Division of Plant Sciences
State Extension Weed Scientist
University of Missouri

Weed Science Website: http://weedscience.missouri.edu
Weed ID Website: http://weedid.missouri.edu

Follow us on:

<A68295E2-4431-4EF5-944A-3488169A97FC[57].png> <5939E0CA-ECB1-4FAB-9D4D-0C2C4E8C81AE[57].png>

From: "Baris, Reuben" <Baris.Reuben@epa.gov>
Date: Friday, August 25, 2017 at 8:29 AM
To: Kevin Bradley <bradleyke@missouri.edu>
Subject: RE: call this week?

Hi Kevin,
There was a call with the State Lead Agencies (SLAs) who have primacy with the enforcement for pesticide use. The intent of the call was to discuss labeling and work together to find some solutions for the 2018 season. The invite for the call went out through AAPCO/SFIREG, and was extended to the EPA regional points of contact as well as HQ OECA. It ended up going out to a much broader audience and I apologize that it didn't make it to you. We had some discussion about volatility which I think would have benefited from your perspective and research. I think Dr. Norsworthy represented the current state of research fairly well. If you're available today, I'd like to discuss the

outcome and next steps with you more. I have a few sporadic meetings throughout the day, but for the most part I am available. Please give me a call at your convenience.

REUBEN BARIS | ACTING CHIEF | HERBICIDE BRANCH
U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF PESTICIDE PROGRAMS | (703) 305-7356

From: Bradley, Kevin [mailto:bradleyke@missouri.edu]
Sent: Friday, August 25, 2017 8:30 AM
To: Baris, Reuben <Baris.Reuben@epa.gov>
Subject: call this week?

Reuben, was there some kind of EPA call this week, like on Tuesday or Wednesday? If it is none of my business no problem but apparently other university weed scientists were on it and they are asking me how come I wasn't on it/didn't know about it if I am the contact person for this WSSA committee that is to interact with you all. People are asking me questions and I don't know anything about it.

Kevin Bradley

From: "Baris, Reuben" <Baris.Reuben@epa.gov>
Date: Friday, August 18, 2017 at 3:18 PM
To: Kevin Bradley <bradleyke@missouri.edu>
Subject: RE: WSSA committee

Hi Kevin,
Thanks for pulling this together. I think this is along the lines of what some are talking about. Do you (or your colleagues) have a sense of how this correlates with the incidents that are being reported?

REUBEN BARIS | ACTING CHIEF | HERBICIDE BRANCH
U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF PESTICIDE PROGRAMS | (703) 305-7356

From: Bradley, Kevin [mailto:bradleyke@missouri.edu]
Sent: Friday, August 18, 2017 12:01 PM
To: Baris, Reuben <Baris.Reuben@epa.gov>
Subject: Re: WSSA committee

Reuben, this is what we have come up with at this point in time. Is this what you had in mind?

The following species sensitivity rankings are based on published literature

and/or studies:

Extremely Sensitive:
Grapes
Lima Bean
Southern Pea
Snap Bean
Soybean
Tobacco
Peach
Elderberry
Dogwood
Oaks
Viburnum

Very Sensitive:
Cotton
Pepper
Pumpkin
Tomato
Watermelon

Moderately Sensitive:
Cantaloupe
Cucumber
Squash
Apple
Maple
Elm
Redbud
Rose
Dogwoods

Low Sensitivity:
Peanut
Broccoli
Cabbage
Kale
Mustard
Turnip
Walnut

Pecan
Raspberry
Strawberry
Sweetgum
Crabapple
Hydrangea

Species which appear to be sensitive based on observations from the field but no published data:
Ginkgo
Paulinao
Frindge
Sycamores
Cypress
Boxelder
Birch
Catalpa
Honeylocus
Spruce
Poplar

Kevin Bradley, PhD
Associate Professor,
Division of Plant Sciences
University of Missouri

Weed Science Website: http://weedscience.missouri.edu
Weed ID Website: http://weedid.missouri.edu

Follow us on:

<image001.png> <image003.png>

From: "Baris, Reuben" <Baris.Reuben@epa.gov>
Date: Tuesday, August 15, 2017 at 12:36 PM
To: Kevin Bradley <bradleyke@missouri.edu>
Subject: RE: WSSA committee

Hi Kevin,
Thanks for the quick response. If you don't mind holding off on scheduling the call, I think that will allow us to better formulate and organize our thoughts around a larger teleconference. In the meantime, there is one item that I think the committee would

be able to provide quick feedback on, and that is a list of sensitive plants. Either stemming what has been formally/informally reported in terms of complaint or incidents or your observations from the field. We have been so focused on soybeans that we have not discussed (in as granular a focus) all the other sensitive crops, fruits, vegetables, ornamentals, and trees (etc.). The idea being that this would potentially feed into training and stewardship.
Thank you again for your continued engagement. It certainly is extremely helpful to know we have a wealth of knowledge and experience just a short call away.
Sincerely,
Reuben

Reuben Baris | Acting Chief | Herbicide Branch
U.S. Environmental Protection Agency, Office of Pesticide Programs | (703) 305-7356

From: Bradley, Kevin [mailto:bradleyke@missouri.edu]
Sent: Tuesday, August 15, 2017 1:21 PM
To: Baris, Reuben <Baris.Reuben@epa.gov>
Subject: Re: WSSA committee

Can you propose a time, or several times, that you are available next week and we can schedule a call then? Or do you just want to wait until you know for sure you need something?

Kevin

From: "Baris, Reuben" <Baris.Reuben@epa.gov>
Date: Tuesday, August 15, 2017 at 10:04 AM
To: Kevin Bradley <bradleyke@missouri.edu>
Subject: RE: WSSA committee

Hi Kevin,
Sorry for the delay in getting back to you regarding the WSSA committee. We are still in negotiations with the Registrants on label changes. So I'm not exactly sure what's needed in terms of help at this very moment. But in the next few days or early next week we will certainly need feedback from you and your colleagues on the registration structure. That is to say once we have a better handle on how these products will be structured for the 2018 growing season. I think a conference call in the next week would be helpful to provide WSSA's feedback to the agency.

Thank you.
Reuben

Reuben Baris | Acting Chief | Herbicide Branch
U.S. Environmental Protection Agency, Office of Pesticide Programs | (703) 305-7356

From: Bradley, Kevin [mailto:bradleyke@missouri.edu]
Sent: Thursday, August 10, 2017 7:56 PM
To: Baris, Reuben <Baris.Reuben@epa.gov>
Cc: McFarland Janis USGR <janis.mcfarland@syngenta.com>; Mike Barrett <mbarrett@uky.edu>
Subject: WSSA committee

Reuben,

As per our phone conversation the other day, I wanted to let you know that the WSSA has formed a special committee to be used as a resource by you (EPA) pertaining to off target movement of dicamba. This committee is comprised of 9 university academics as well as two individuals from ag co-operatives that are closely associated with spraying these products across large acreages in the Midwest and mid-south. Now that we have the committee formed, I wanted to reach out to you directly and ask how we might be able to help? What information can we provide? Would you like for me to arrange a conference call between you and the committee? If you tell me what information you are looking to obtain, I can work with the committee to get that to you. If you are looking for opinions and thoughts about a variety of topics related to all this, a call might be better at least initially. Thanks.

Kevin Bradley

<image001.png>

<image002.png>

<image003.png>

Some Preliminary Results with Dicamba Volatility Testing in 2017

Kevin Bradley
University of Missouri

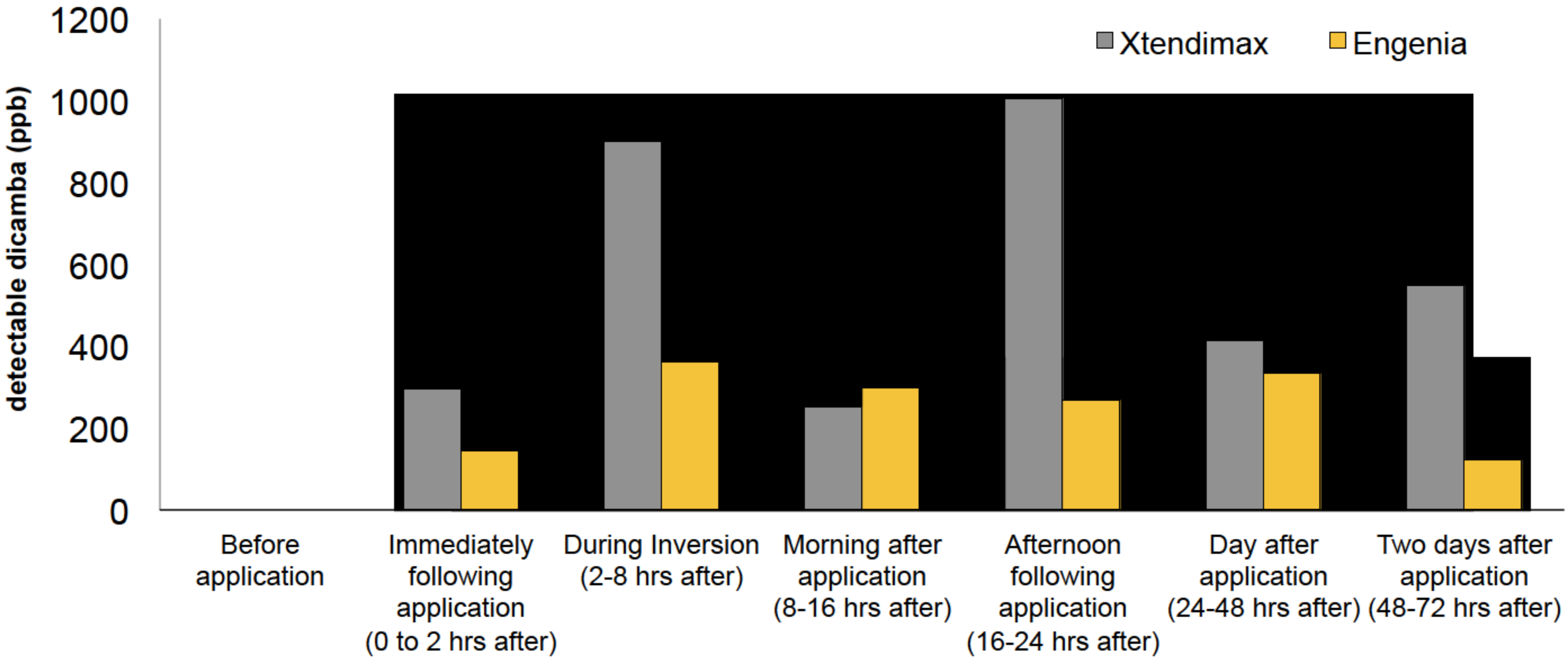
Our Efforts to Understand the Role of Formulations & Temperature Inversions in the Off-site Movement of Dicamba

2 separate experiments running in June, July, August of 2017:

- **Experiment 1 (3 runs):** Engenia, and Xtendimax (+Roundup PwrMax) sprayed in 20 x 100 ft plots in geographically separate areas of Bradford research center. Air samples taken and indicator plants placed at regular intervals after treatment

- **Experiment 2 (6 runs):** Xtendimax sprayed in 20 x 100 ft plot in mid-afternoon, and then in a geographically separate 20 x 100 ft plot into an inversion during the evening/night. Air samples taken and indicator plants placed at regular intervals after treatment.

Some Preliminary Air Sampling Results with Engenia and XtendiMax



*combined results from 2 experiments

Soybean "Indicator Plant" Response following Application of Xtendimax

*Photos taken 21 days after application

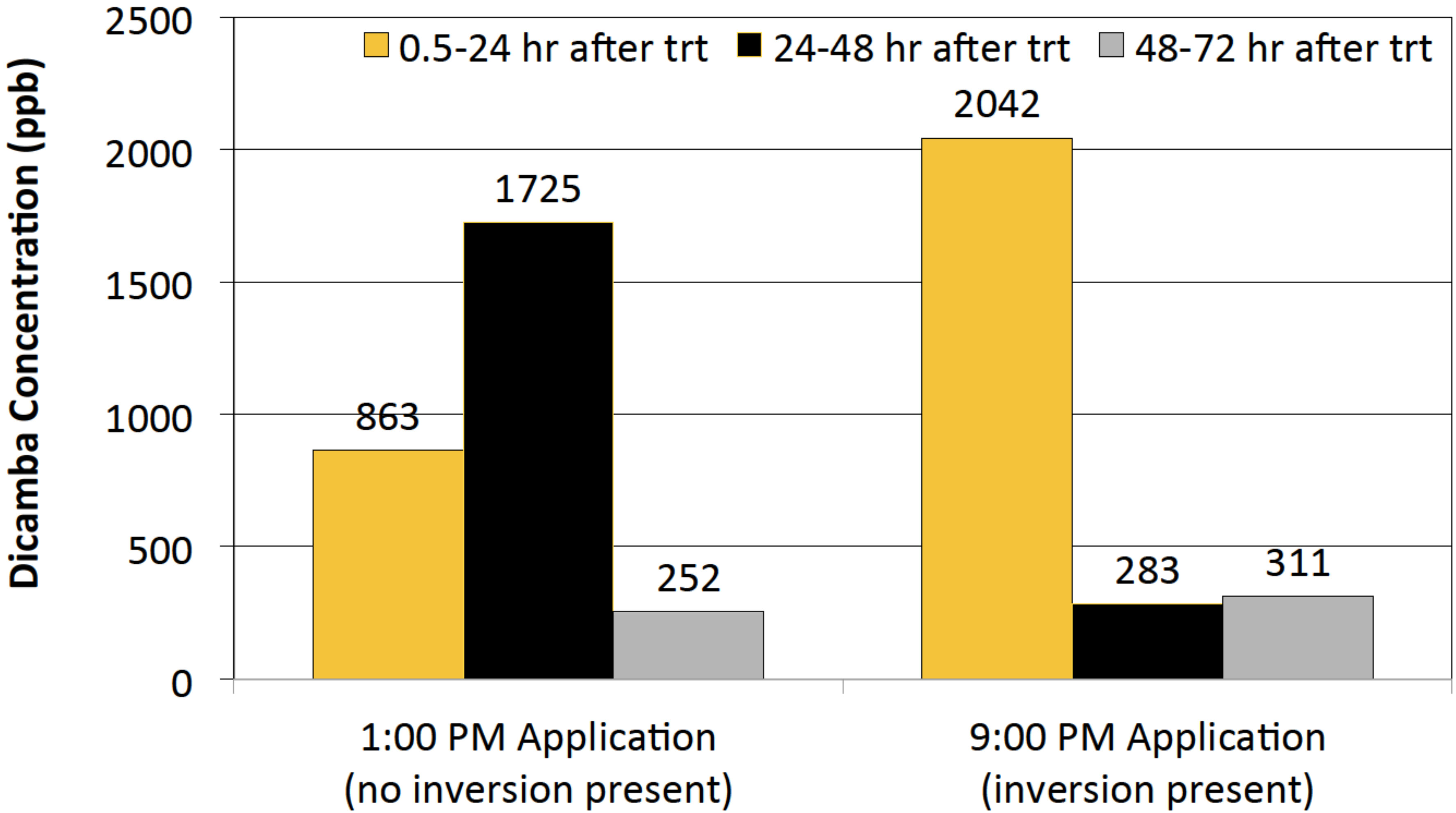
ER 303

Soybean "Indicator Plant" Response following Application of Engenia

*Photos taken 21 days after application

ER 304

Influence of Application Time of Day and Inversion Presence on Dicamba Air Concentrations following an XtendiMax Treatment

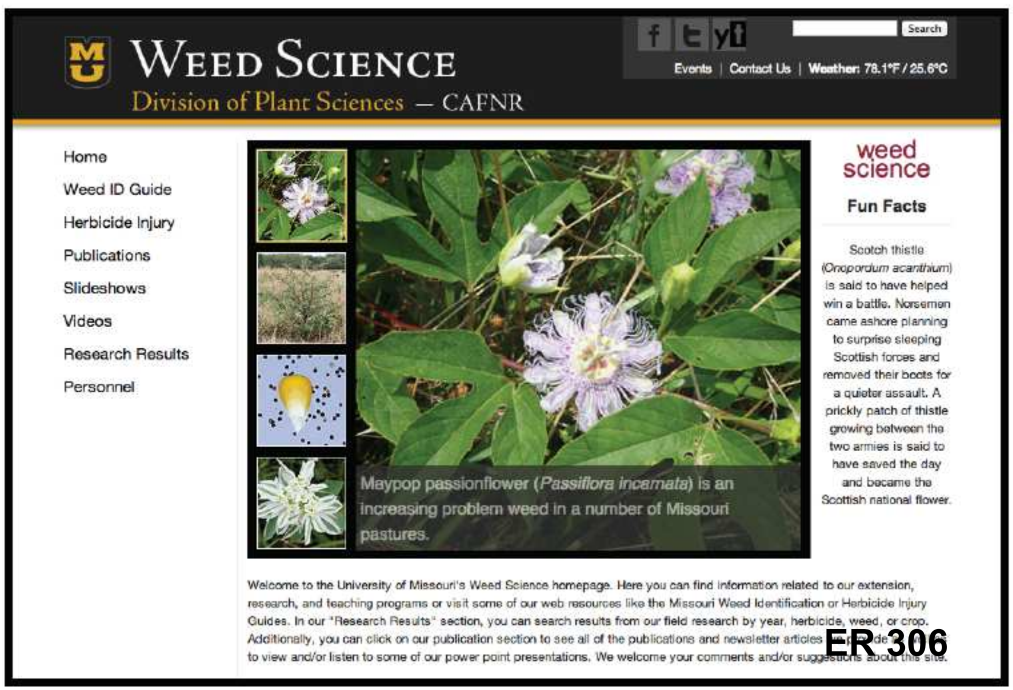


*results from 1 experiment conducted 7/11-7/15

Mizzou® weed science

Email: bradleyke@missouri.edu

Website: weedscience.missouri.edu



App: ID Weeds (free download)

id weeds

Facebook: Mizzou Weed Science

facebook

Twitter: @ShowMeWeeds

twitter

Effect of adding Roundup PowerMax to Engenia on vapor losses under field conditions

Thomas C Mueller
University of Tennessee

July, 2017

Methods

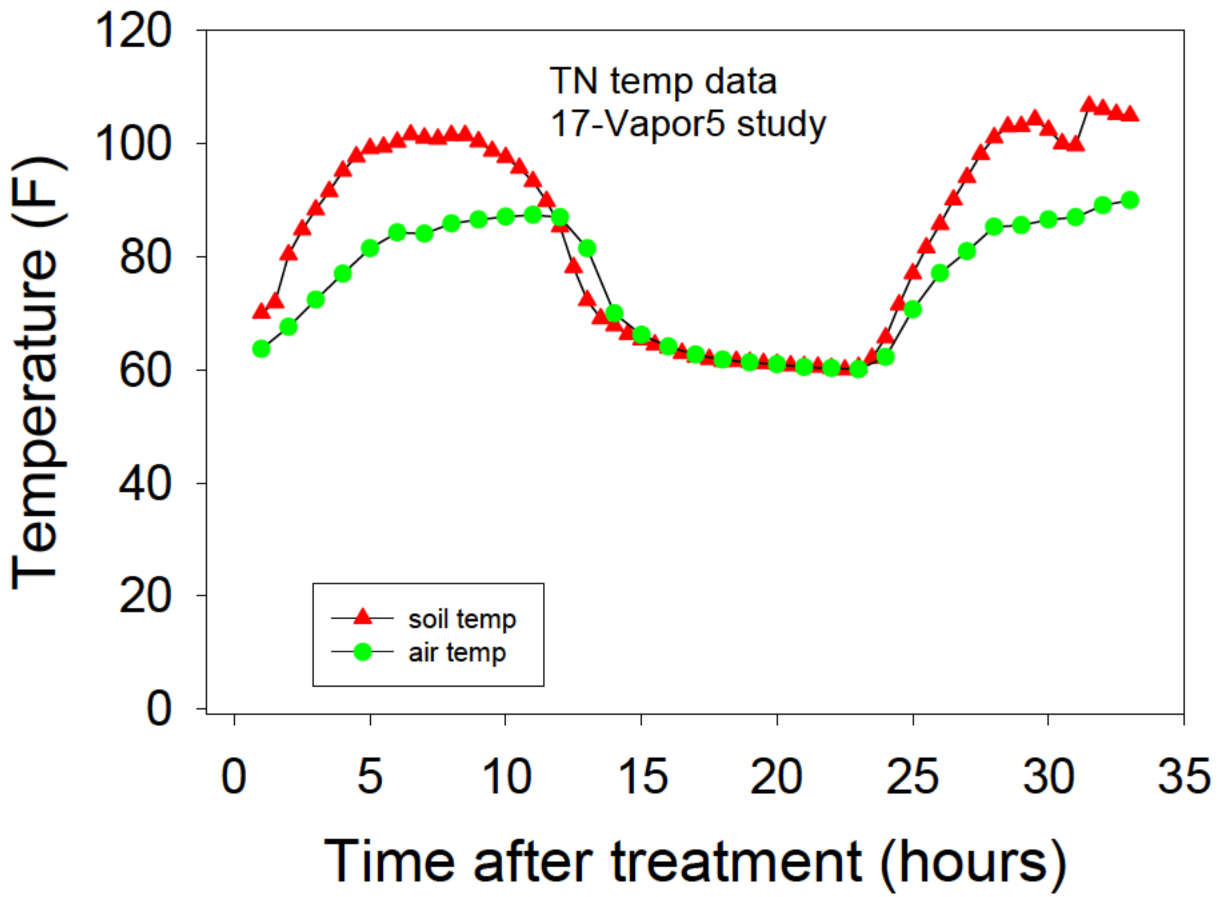
- Field plots established using farmer-scale equipment (30 foot boom, TTI nozzles) following label rates and instructions (late June 2017)
- Plot size = 200*200 ft (~ 1 acre per each treatment)
- High Volume air samplers used to collect dicamba vapors from within the treated area
- Samples collected at 4 different intervals at various hours after treatment (HAT), with 4 samplers in each treated plot
- 0-6 HAT (morning of application)
- 6-12 HAT (afternoon of application)
- 12-24 HAT (overnight)
- 24-36 (day after initial application)

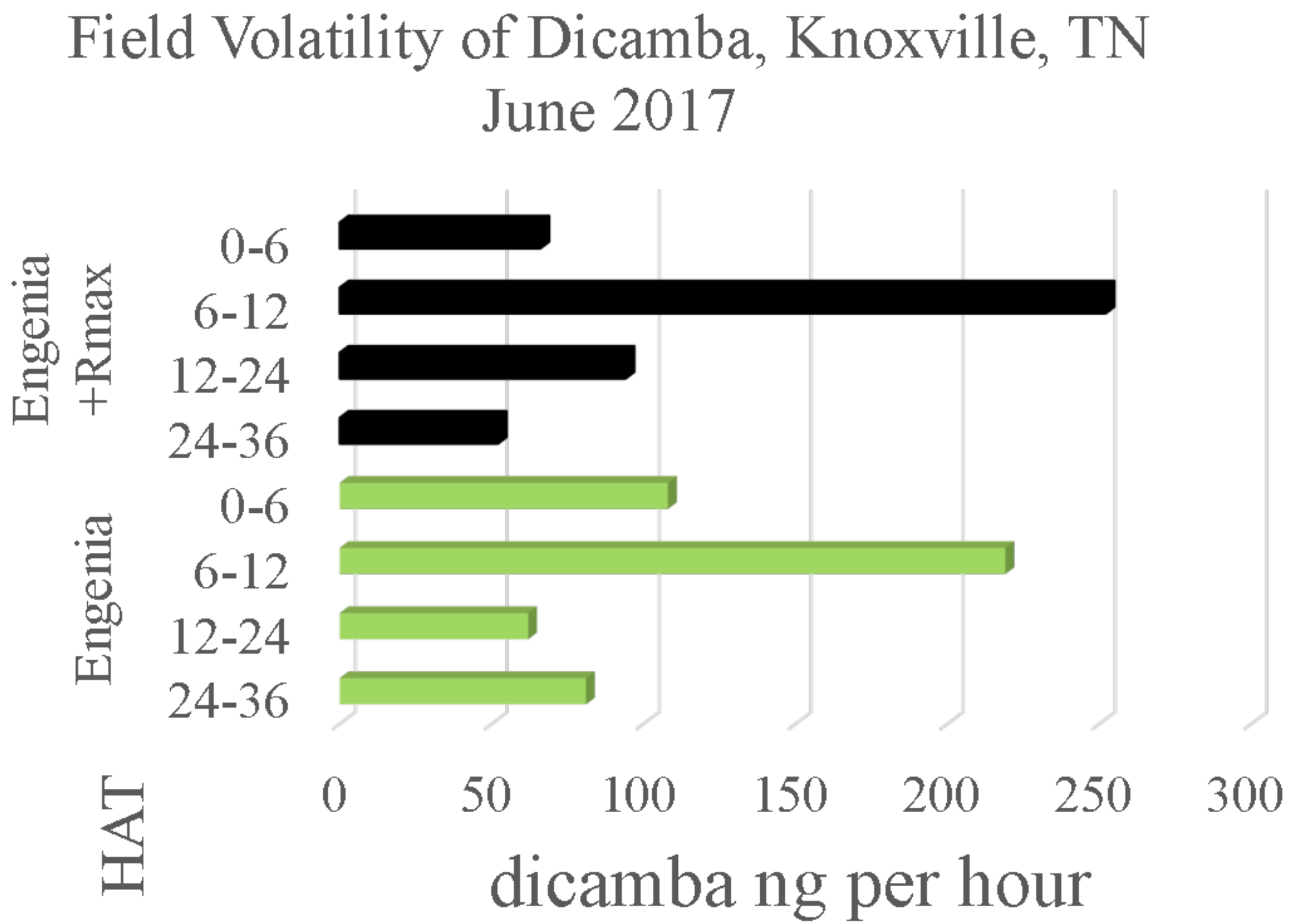
Methods

- Herbicide treatments included:
- Engenia alone at 12.8 fl oz/acre
- Engenia at same rate + Rmax at 32 fl oz/acre
- Untreated control

- Applications were made early in the AM of first day (0 HAT)
- Surface condition of plots was small soybeans (V2-3) planted in a high residue, long-term no-till environment
- Soil was a medium textured silt loam (pH 6.2, OM = 1.3)
- No rainfall occurred during the sampling period

temperature




Field Volatility of Dicamba, Knoxville, TN
June 2017
Engenia +Rmax
0-6
6-12
12-24
24-36
Engenia
0-6
6-12
12-24
24-36
HAT
0
50
100
150
200
250
300
dicamba ng per hour

Observations

- All samples had detected concentrations of dicamba
- No apparent effect of adding Rmax on dicamba volatility from Engenia
- Greatest dicamba concentrations at 6-12 and 12-24 HAT sampling intervals
- Most dicamba loss to atmosphere per hour was in the first afternoon after spraying (6-12 HAT)

TENNESSEE SOYBEAN PROMOTION BOARD

Field Drift Evaluation of Xtendimax and Engenia

Larry Steckel
University of Tennessee
August, 2017

Initial Setup

- Trial was conducted in a 40 acre field of dicamba-sensitive soybeans in Sharon, Tennessee.
  - Soybean row spacing was 7.5"
  - Soybeans were at the V5-V6 growth stage at the time of application.
  - Both treatments tested on 2 acres within the 40 acre field.

- Treatments included:
  1. 22 fl. oz. Xtendimax + 32 fl. oz. Roundup Powermax + 0.5% Intact
  2. 12.8 fl. oz. Engenia + 32 fl. oz. Roundup Powermax

UTIA INSTITUTE OF AGRICULTURE THE UNIVERSITY OF TENNESSEE

XTENDIMAX™ With VaporGrip® Technology

Engenia™ Herbicide

Application

- Treatments were put out ***simultaneously*** with two Bowman Mudmasters
  - 25 foot boom, 20 inch nozzle spacing
  - Boom Height: 24" above the canopy
  - 9 mph ground speed
  - 15 GPA using the TeeJet 844E Sprayer Control system on both sprayers
  - TTI 04 nozzles

Date	Time at Application	Temperature	Relative Humidity	Wind Speed	Prevailing Wind Direction
July 27, 2017	10:45 am	84.2 °F	84%	6 mph	SW

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Initial Setup

22 fl. oz.
Xtendimax
+ 32 fl. oz.
Roundup
Powermax
+ 0.5%
Intact

12.8 fl. oz.
Engenia
+ 32 fl. oz.
Roundup
Powermax

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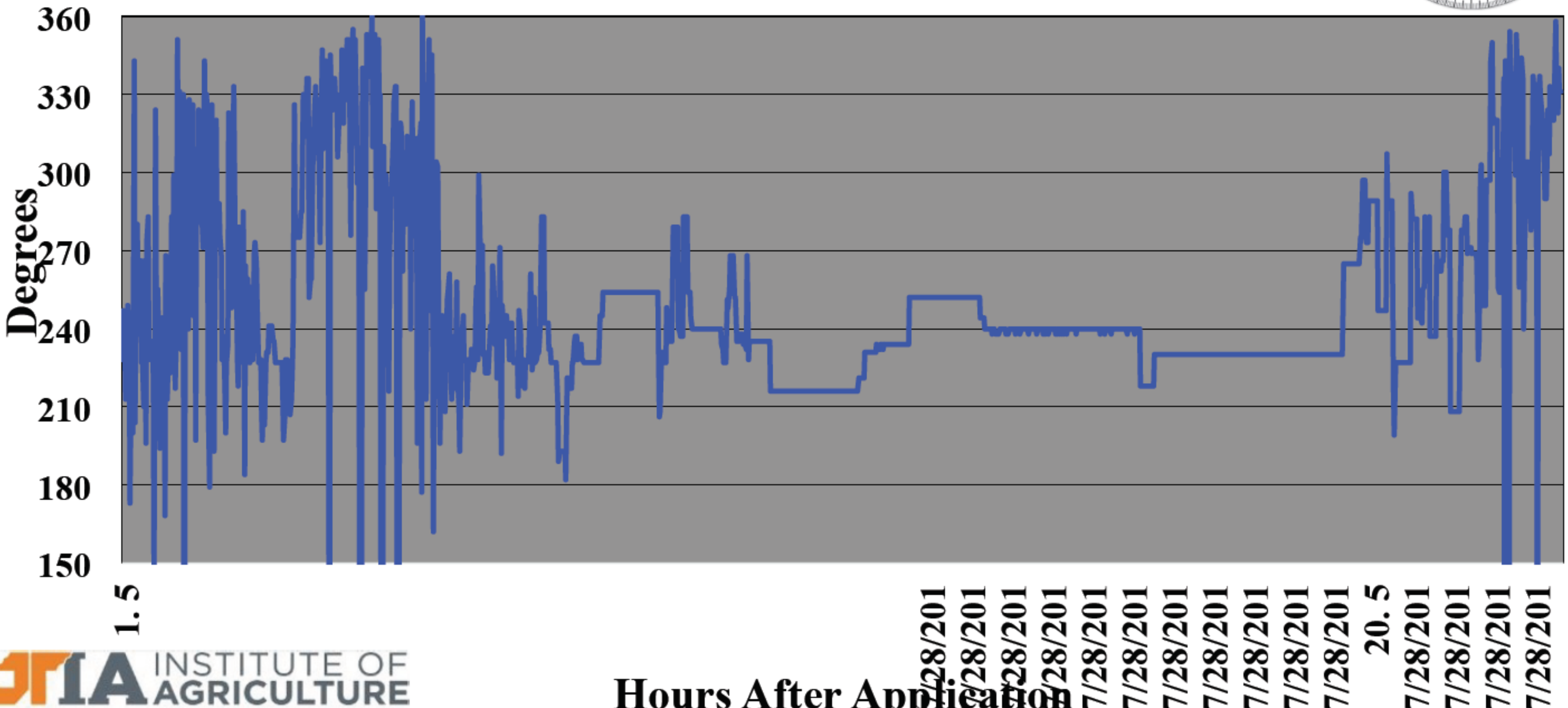
THE UNIVERSITY OF TENNESSEE

Wind Direction After Applicati



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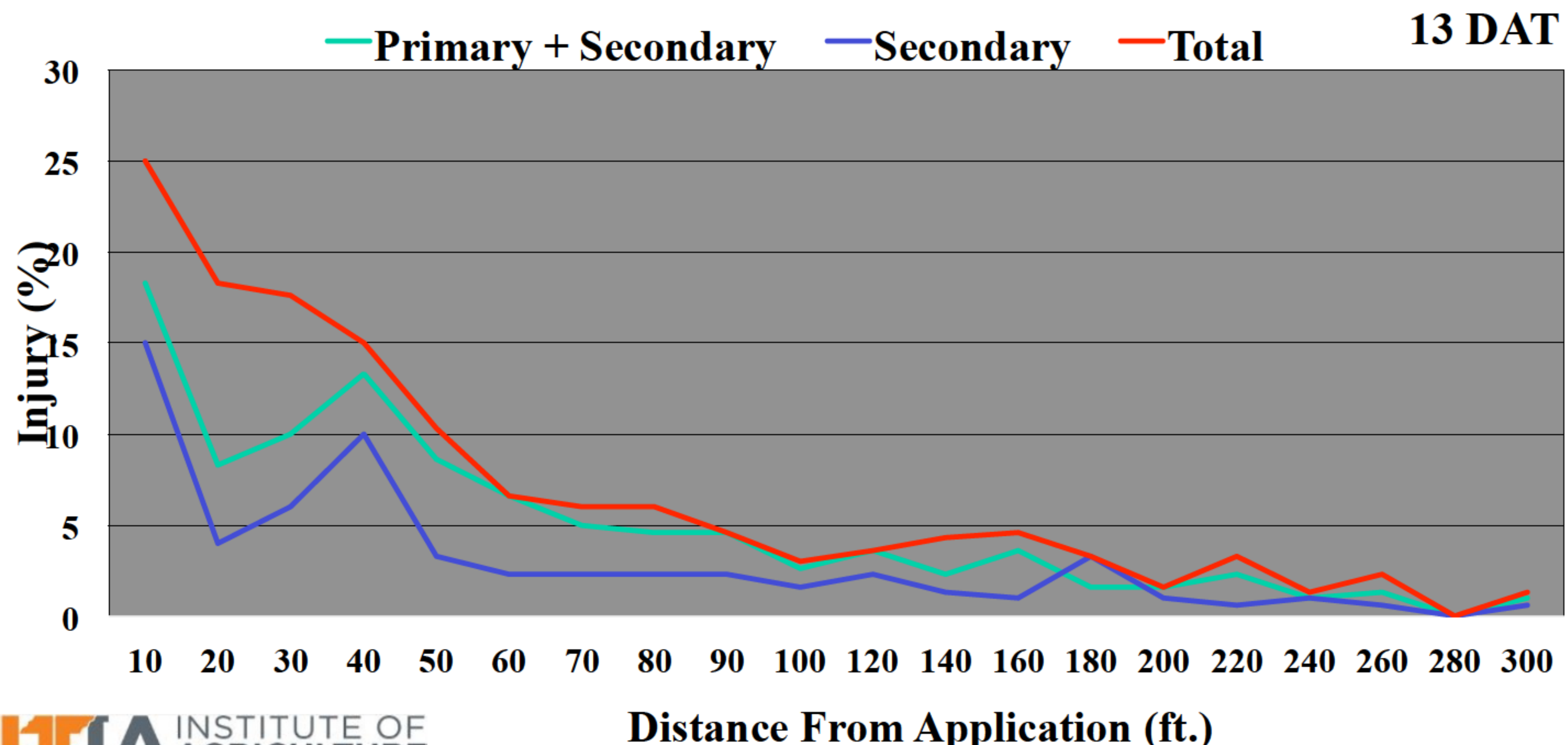
22 fl. oz. Xtendimax + 32 fl. oz. Roundup Injury + 0.5 % Intact



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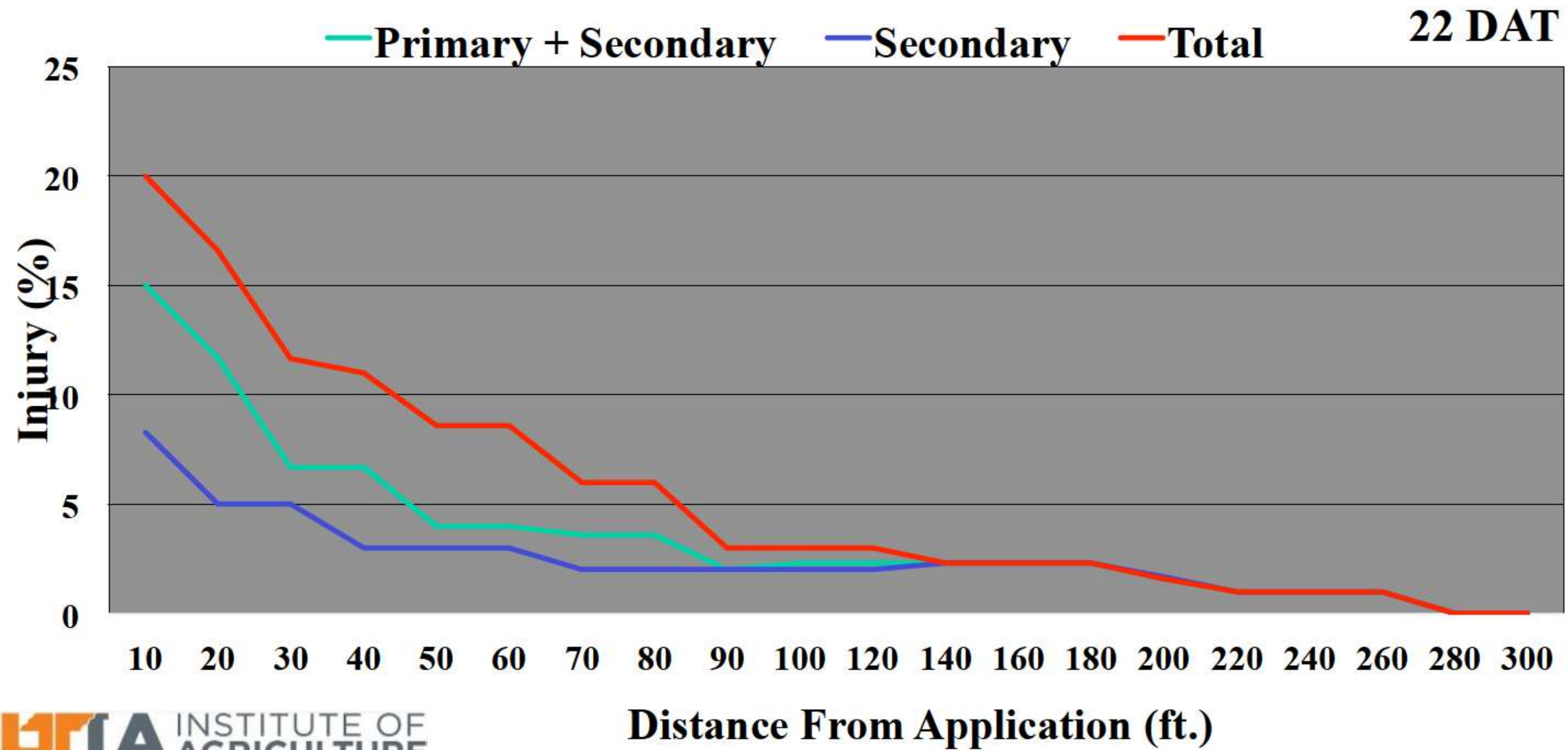
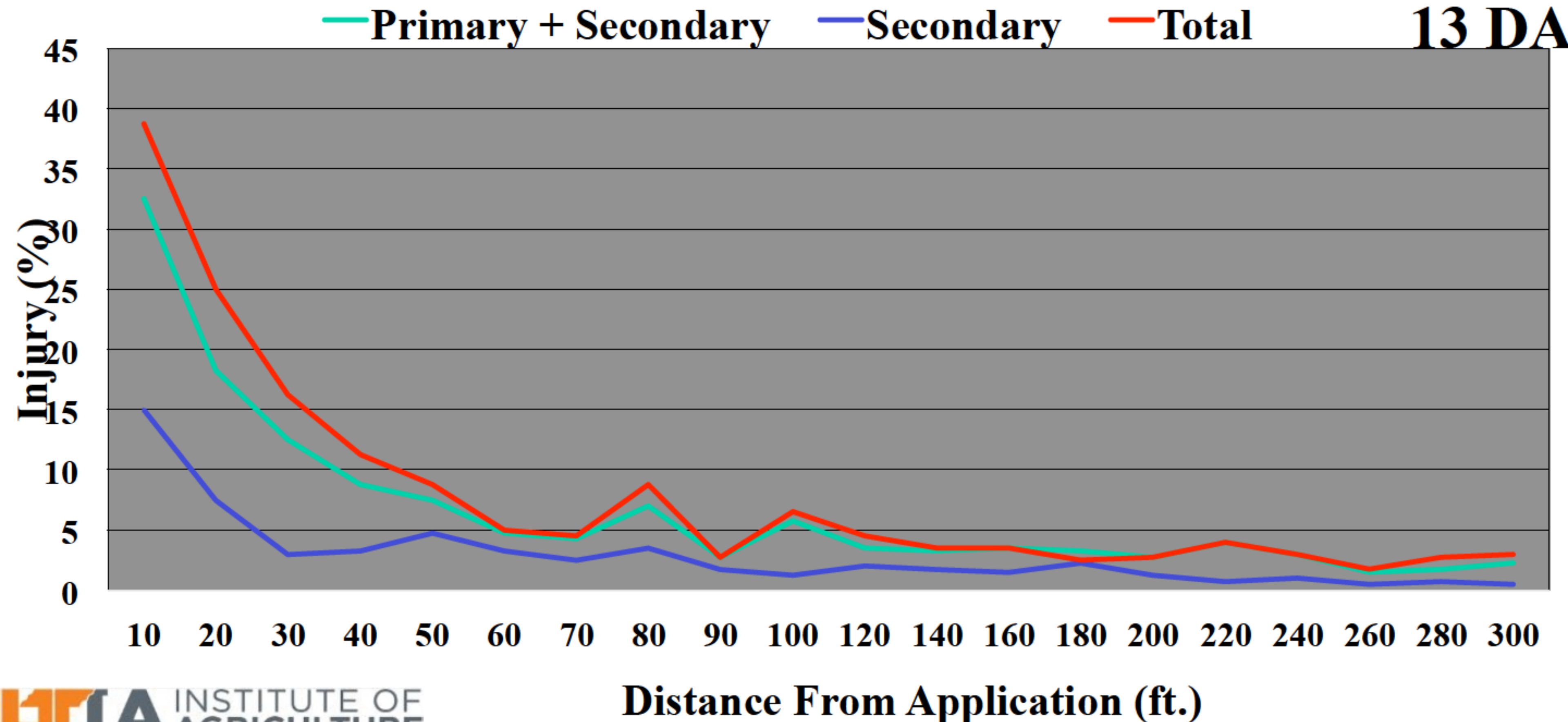
THE UNIVERSITY OF TENNESSEE

22 fl. oz. Xtendimax + 32 fl. oz. Roundup Injury + 0.5 % Intact



INSTITUTE OF AGRICULTURE
THE UNIVERSITY OF TENNESSEE

12.8 fl. oz. Engenia + 32 fl. oz. Roundup Injury



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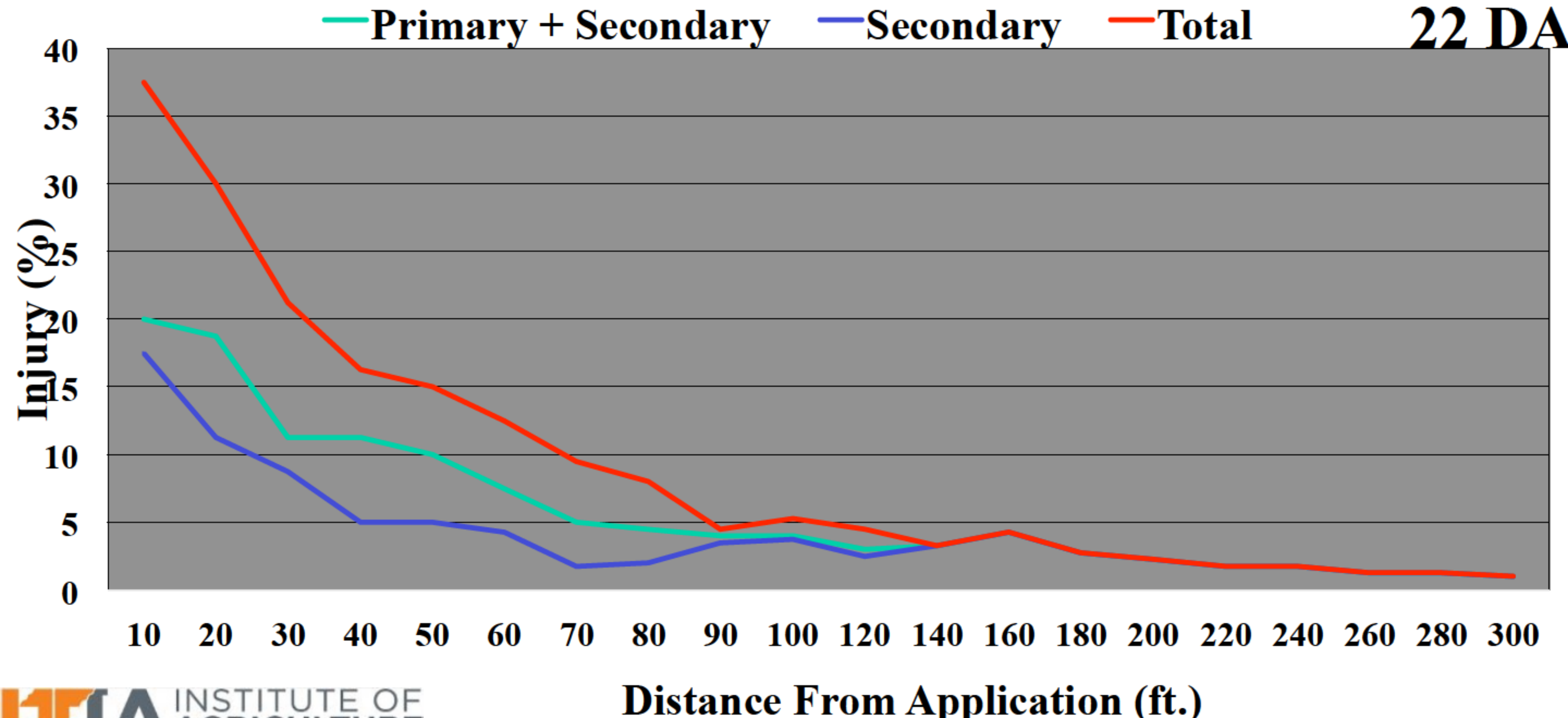
12.8 fl. oz. Engenia + 32 fl. oz. Roundup Injury



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THE UNIVERSITY OF TENNESSEE

Drift Symptomology showed up in a Direction wind was not blowing at Application Time

22 fl. oz.
Xtendimax
+ 32 fl. oz.
Roundup
Powermax
+ 0.5%
Intact

12.8 fl. oz.
Engenia
+ 32 fl. oz.
Roundup
Powermax

INSTITUTE OF AGRICULTURE
THE UNIVERSITY OF TENNESSEE

Wind changed from the SW at application time to W about 2 hours after application and symptomology could be seen to E

Observations

- Xtendimax caused at least 5% visual soybean injury 160’ and Engenia 120’ down wind at application time
- Wind shifted about 2 hours after application from SW at application to W
- Engenia moved E 2 hours after application about 120’ *Xtendimax was buffered by thick brush line on east side of its’ treated area and little eastward movement was notable

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TENNESSEE SOYBEAN PROMOTION BOARD

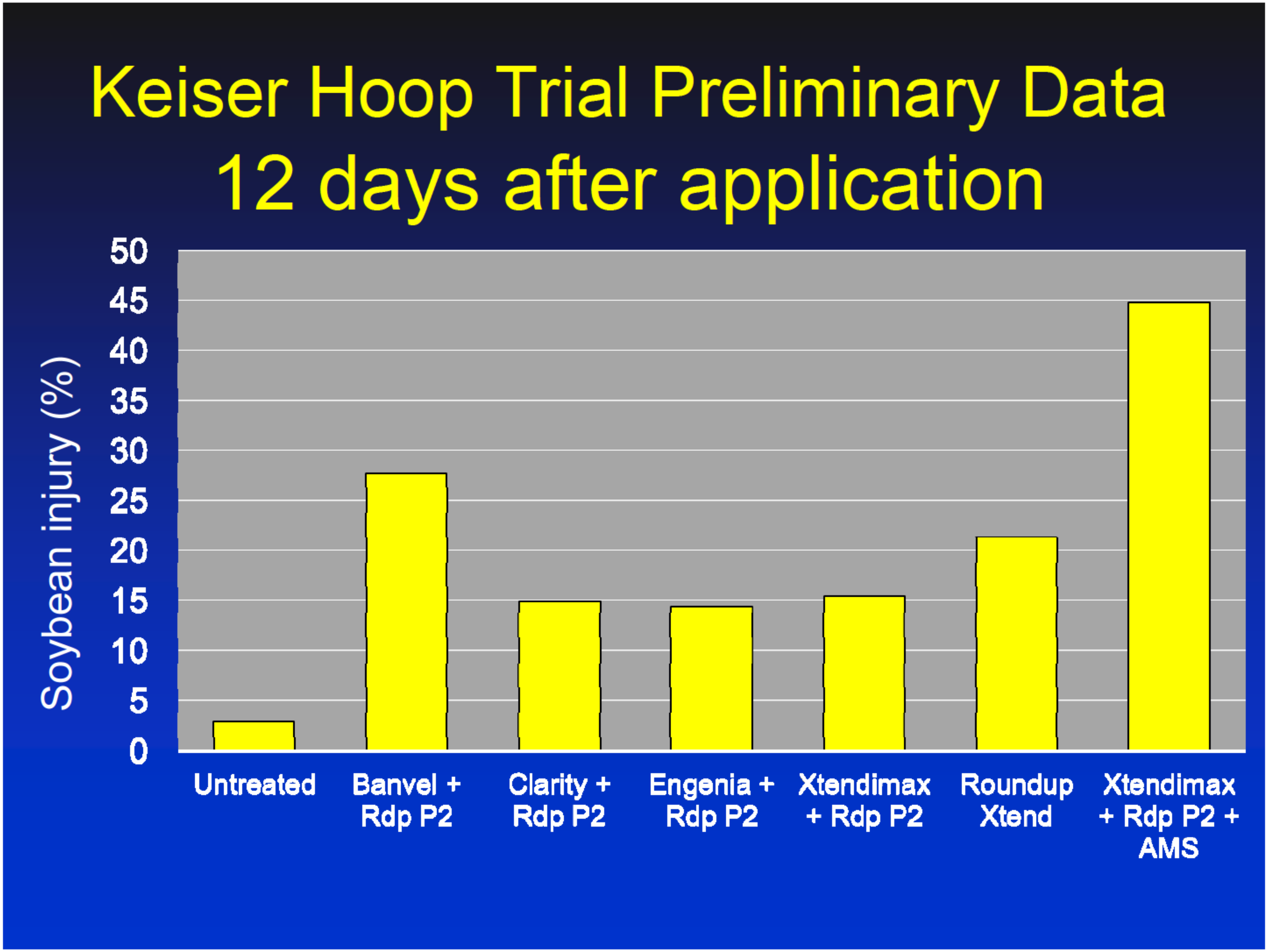
Dicamba Volatility

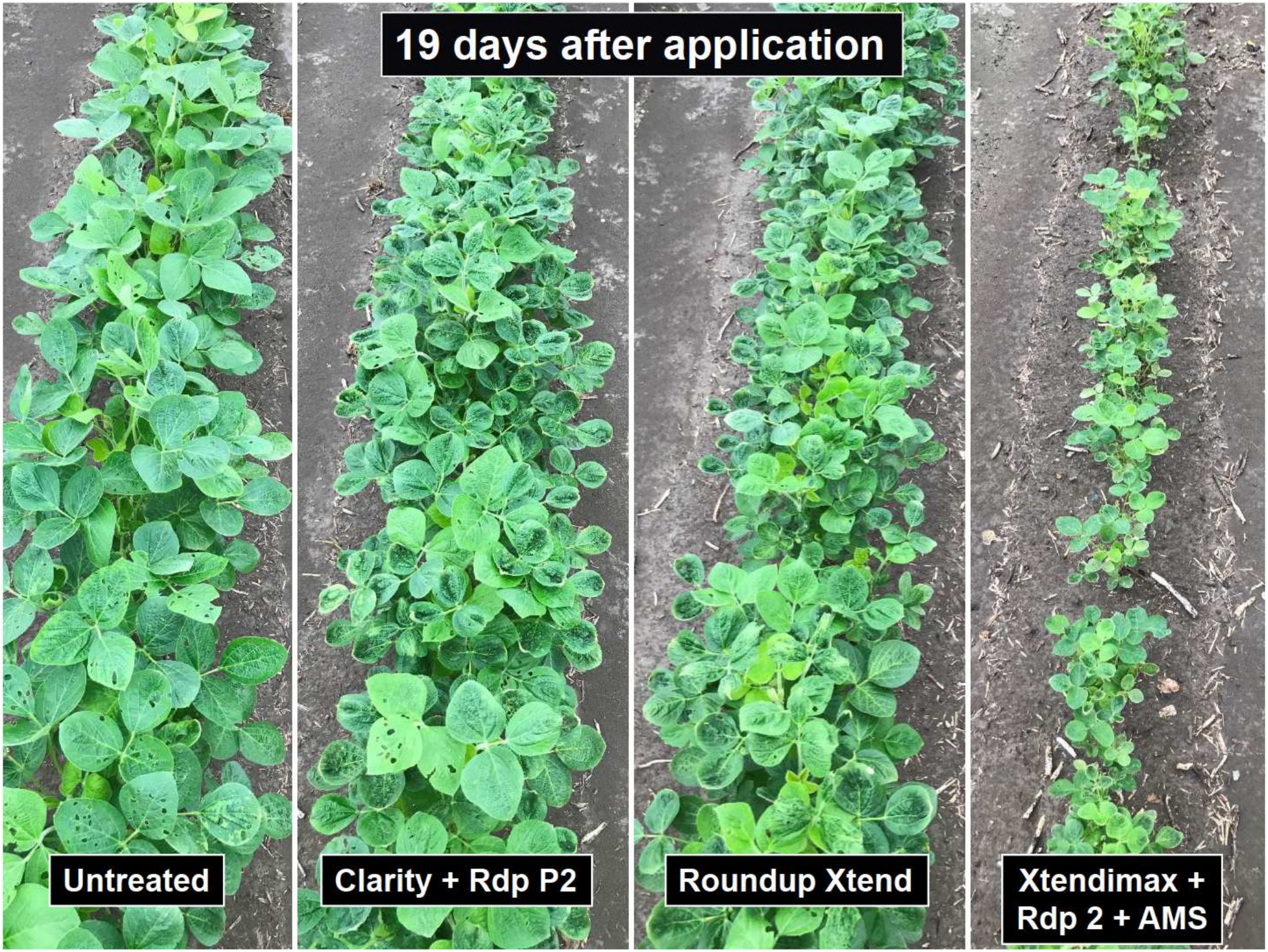
Jason K. Norsworthy

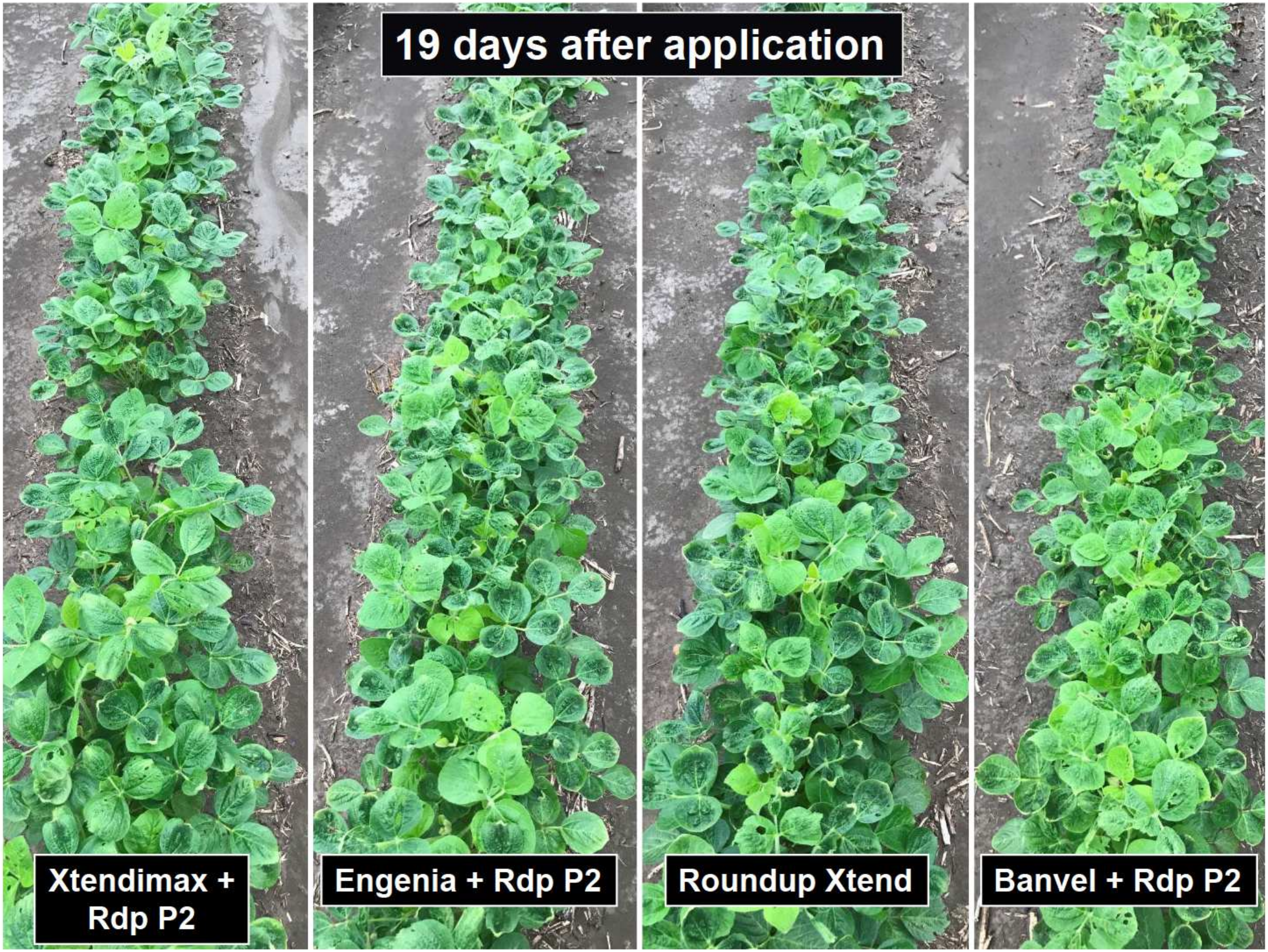
Professor and Endowed Chair of Weed Science

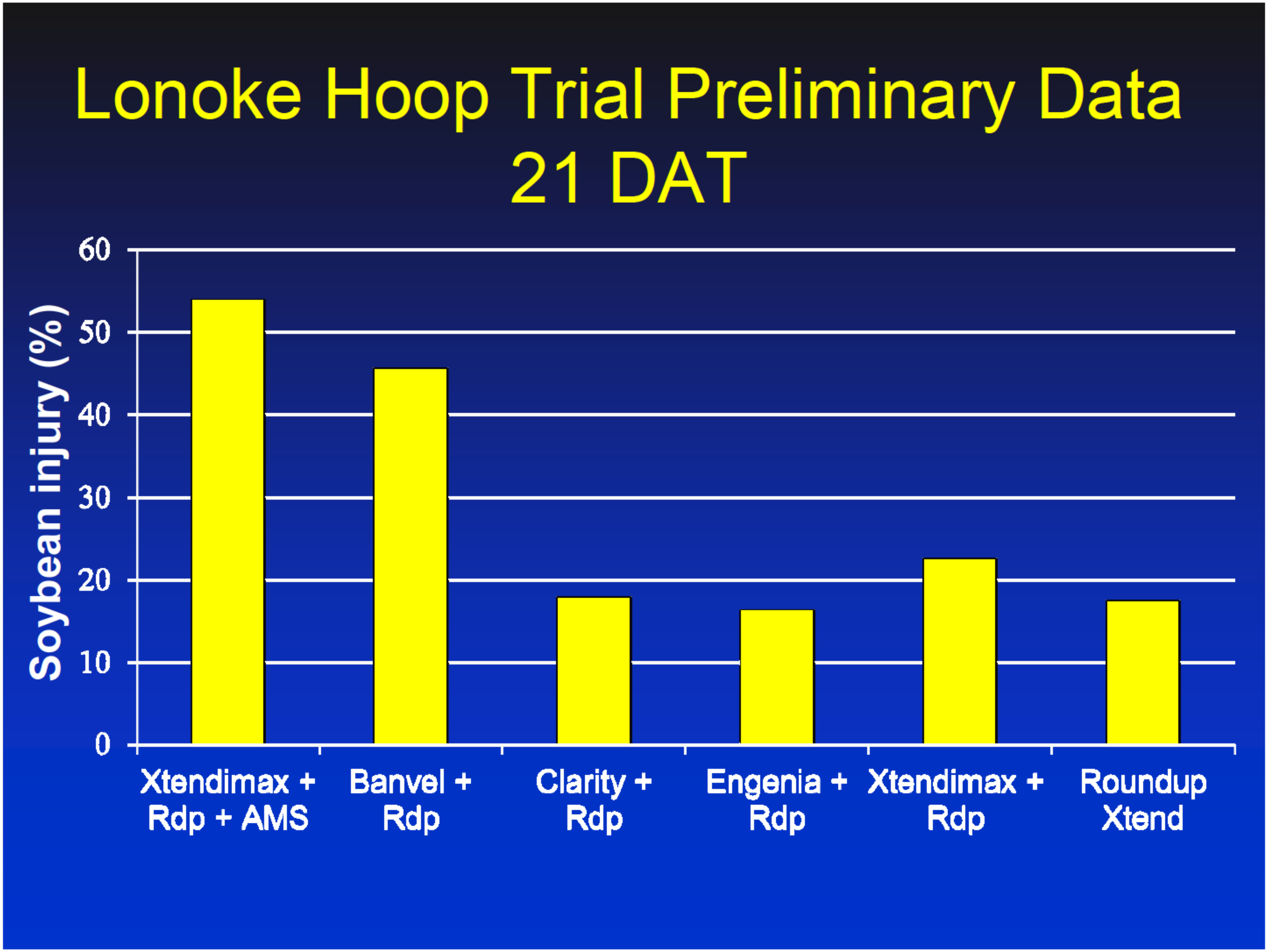
UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE

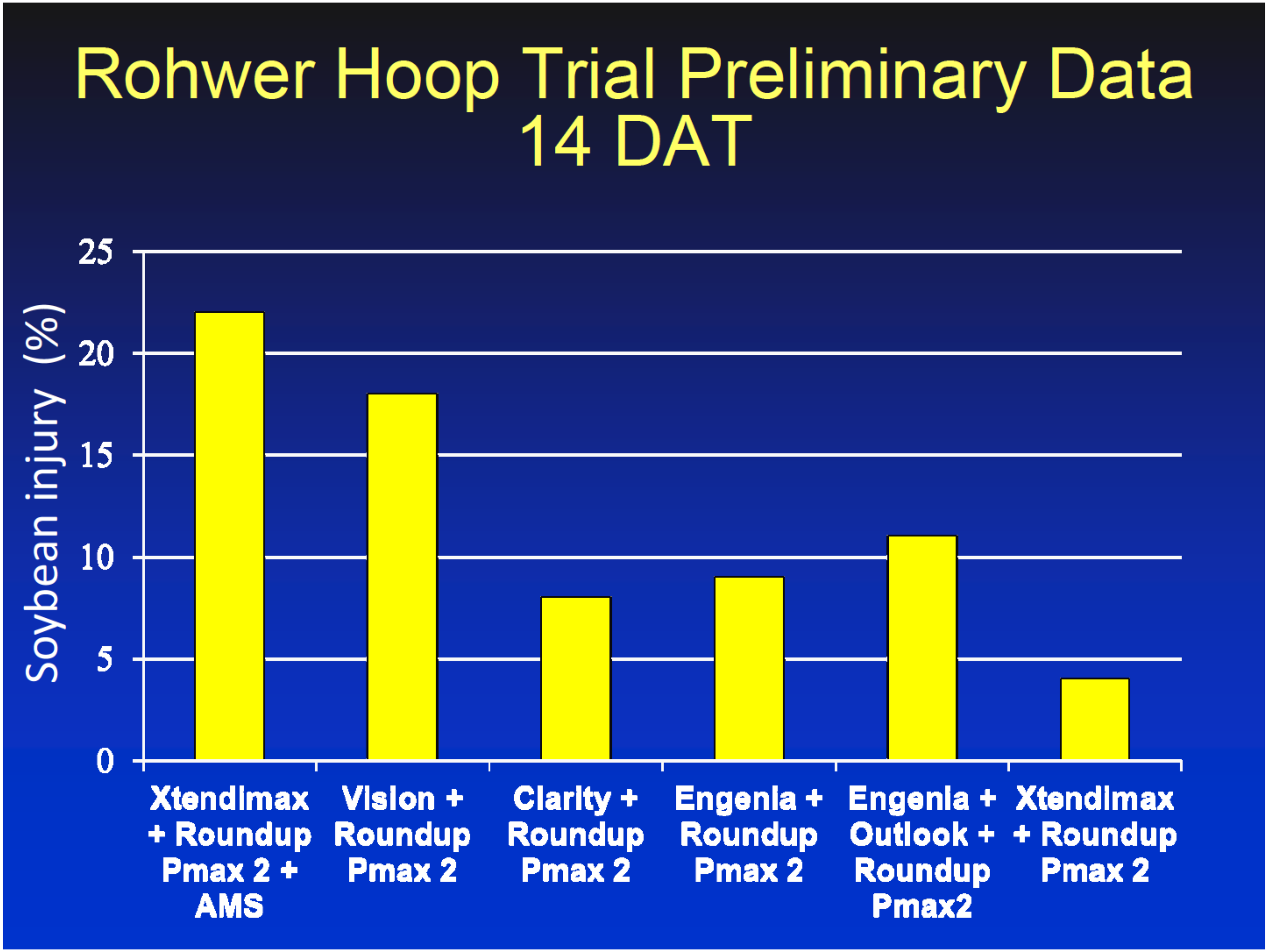
UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE


Keiser Hoop Trial Preliminary Data
12 days after application
Soybean injury (%)
50
45
40
35
30
25
20
15
10
5
0
Untreated
Banvel + Rdp P2
Clarity + Rdp P2
Engenia + Rdp P2
Xtendimax + Rdp P2
Roundup Xtend
Xtendimax + Rdp P2 + AMS

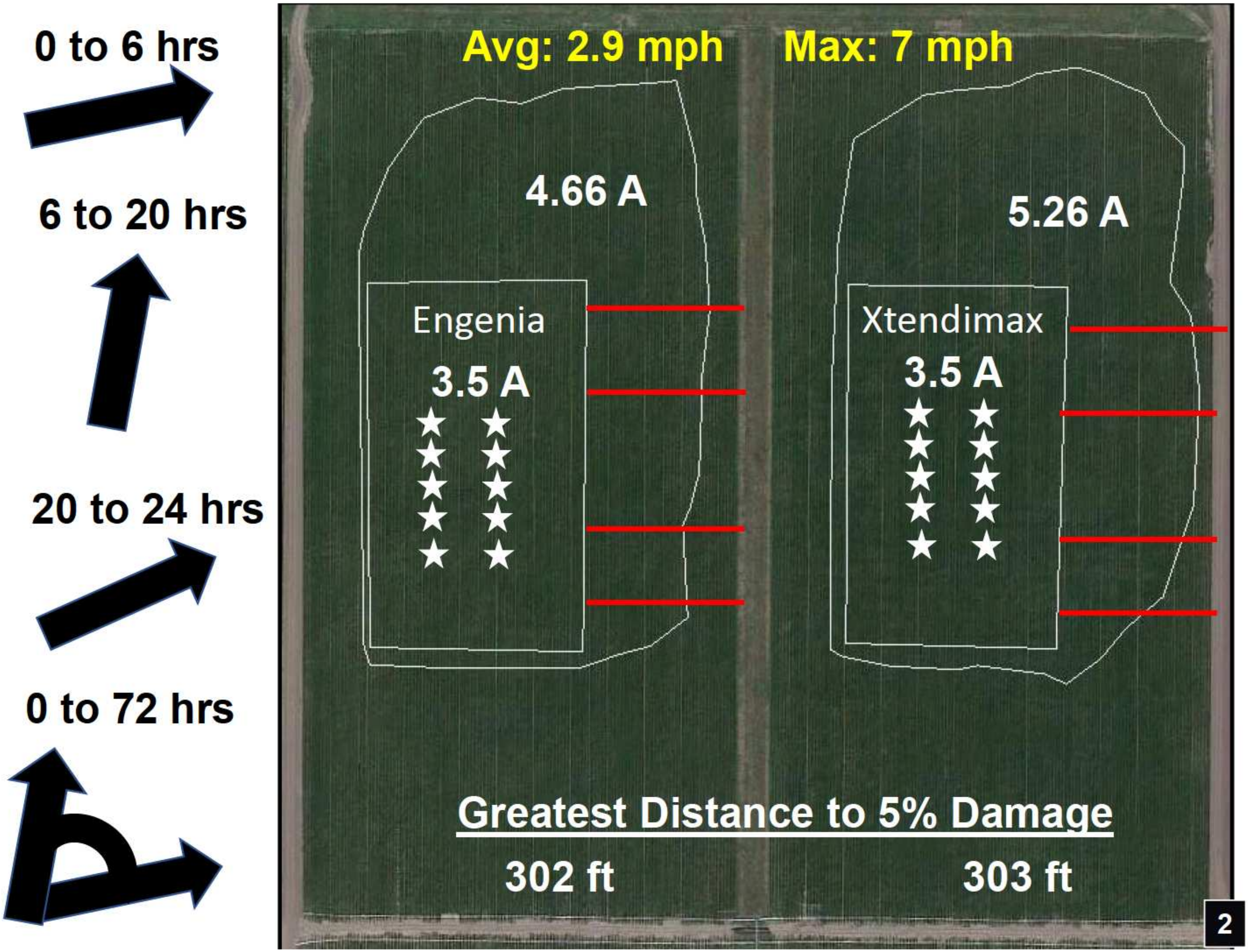

19 days after application
Untreated
Clarity + Rdp P2
Roundup Xtend
Xtendimax +
Rdp 2 + AMS

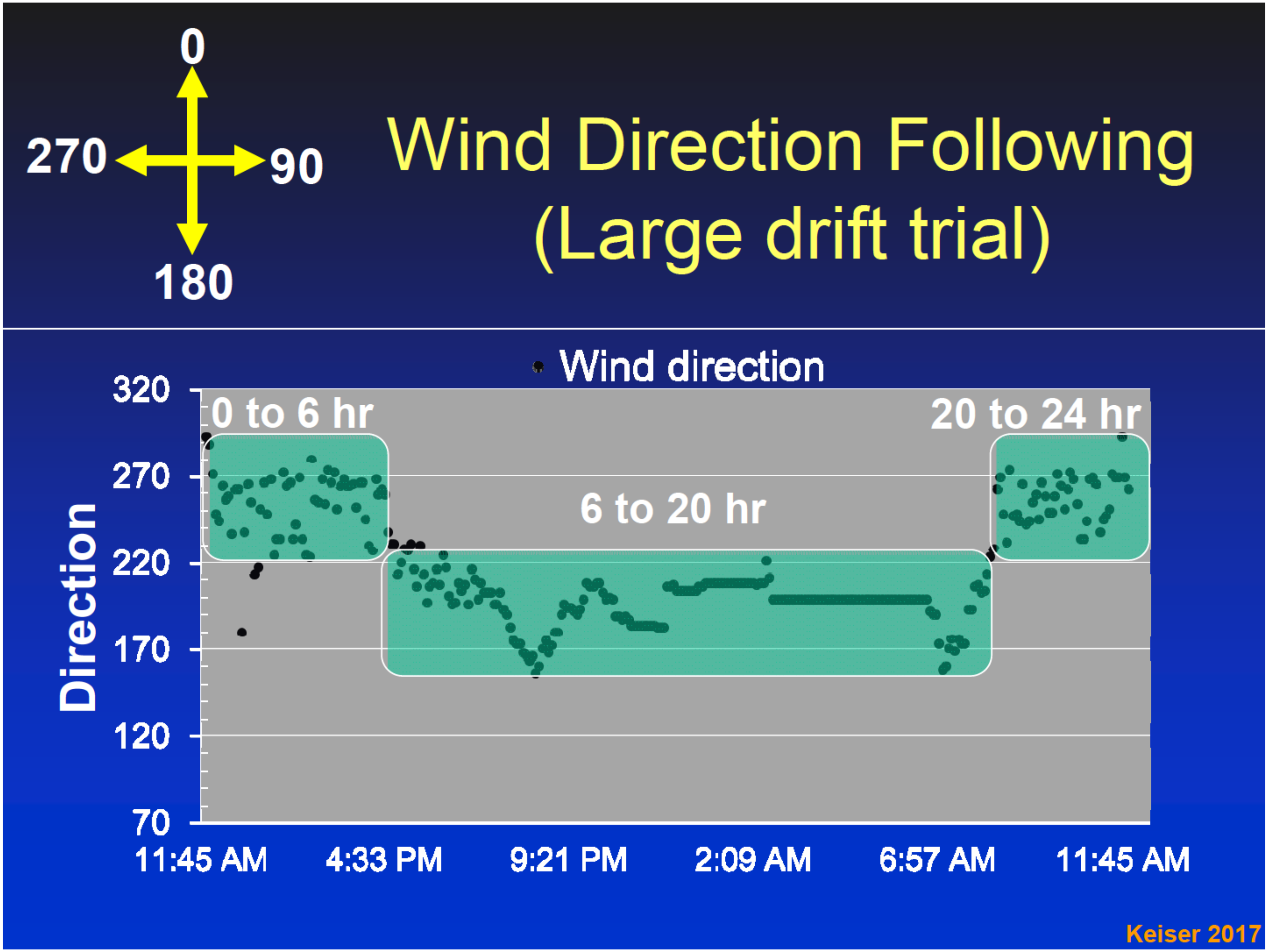

19 days after application
Xtendimax + Rdp P2
Engenia + Rdp P2
Roundup Xtend
Banvel + Rdp P2

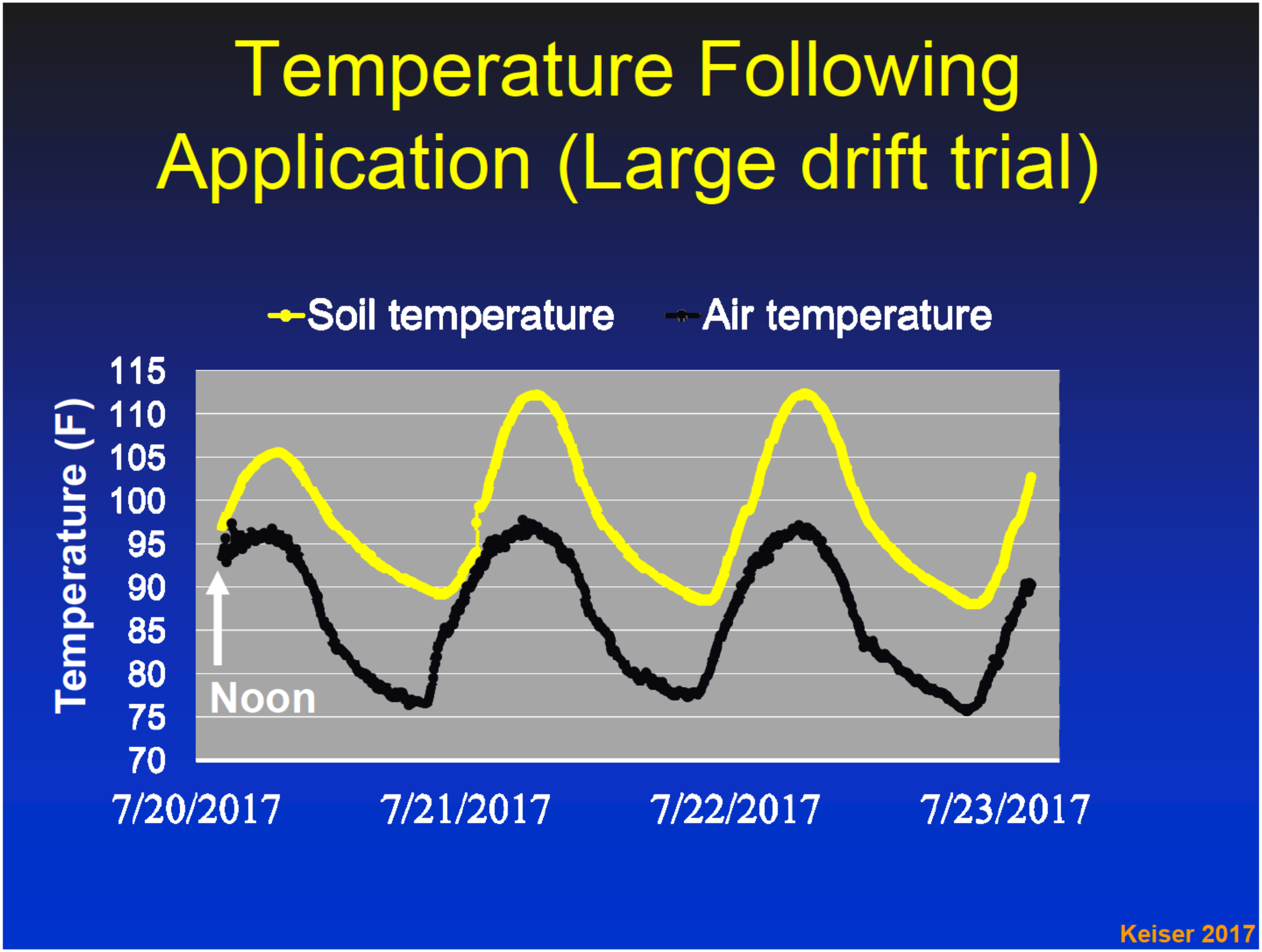

Lonoke Hoop Trial Preliminary Data
21 DAT
Soybean injury (%)
60
50
40
30
20
10
0
Xtendimax + Rdp + AMS
Banvel + Rdp
Clarity + Rdp
Engenia + Rdp
Xtendimax + Rdp
Roundup Xtend


Rohwer Hoop Trial Preliminary Data
14 DAT
Soybean injury (%)
25
20
15
10
5
0
Xtendimax + Roundup Pmax 2 + AMS
Vision + Roundup Pmax 2
Clarity + Roundup Pmax 2
Engenia + Roundup Pmax 2
Engenia + Outlook + Roundup Pmax2
Xtendimax + Roundup Pmax 2

Application Parameters


0 to 6 hrs
6 to 20 hrs
20 to 24 hrs
0 to 72 hrs
Avg: 2.9 mph
Max: 7 mph
4.66 A
5.26 A
Engenia
3.5 A
Xtendimax
3.5 A
Greatest Distance to 5% Damage
302 ft
303 ft
2


0
270
90
180
Wind Direction Following
(Large drift trial)
Wind direction
320
270
220
170
120
70
Direction
0 to 6 hr
6 to 20 hr
20 to 24 hr
11:45 AM
4:33 PM
9:21 PM
2:09 AM
6:57 AM
11:45 AM
Keiser 2017


Temperature Following Application (Large drift trial)
Soil temperature
Air temperature
Temperature (F)
115
110
105
100
95
90
85
80
75
70
Noon
7/20/2017
7/21/2017
7/22/2017
7/23/2017
Keiser 2017

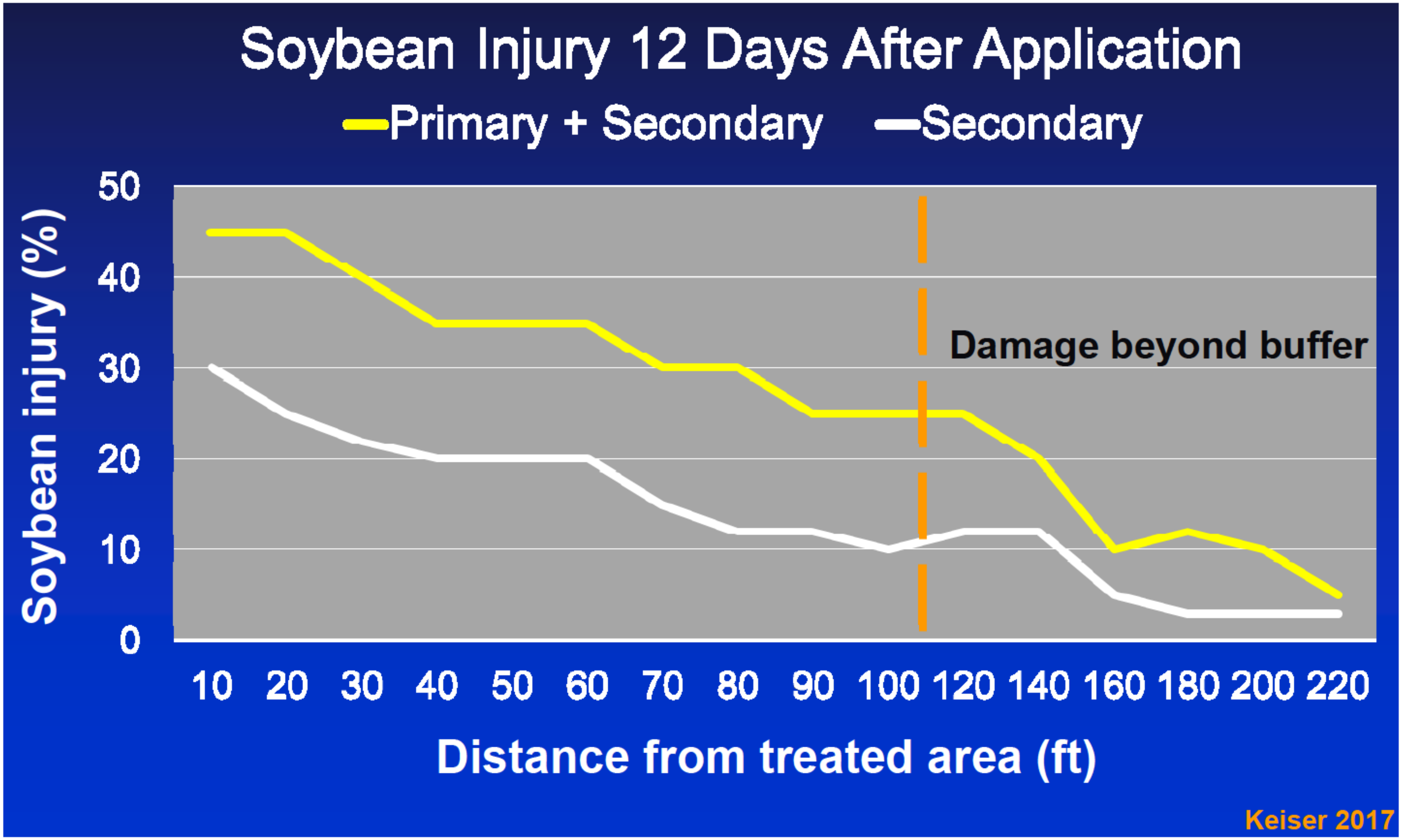

Soybean from greenhouse

Xtendimax

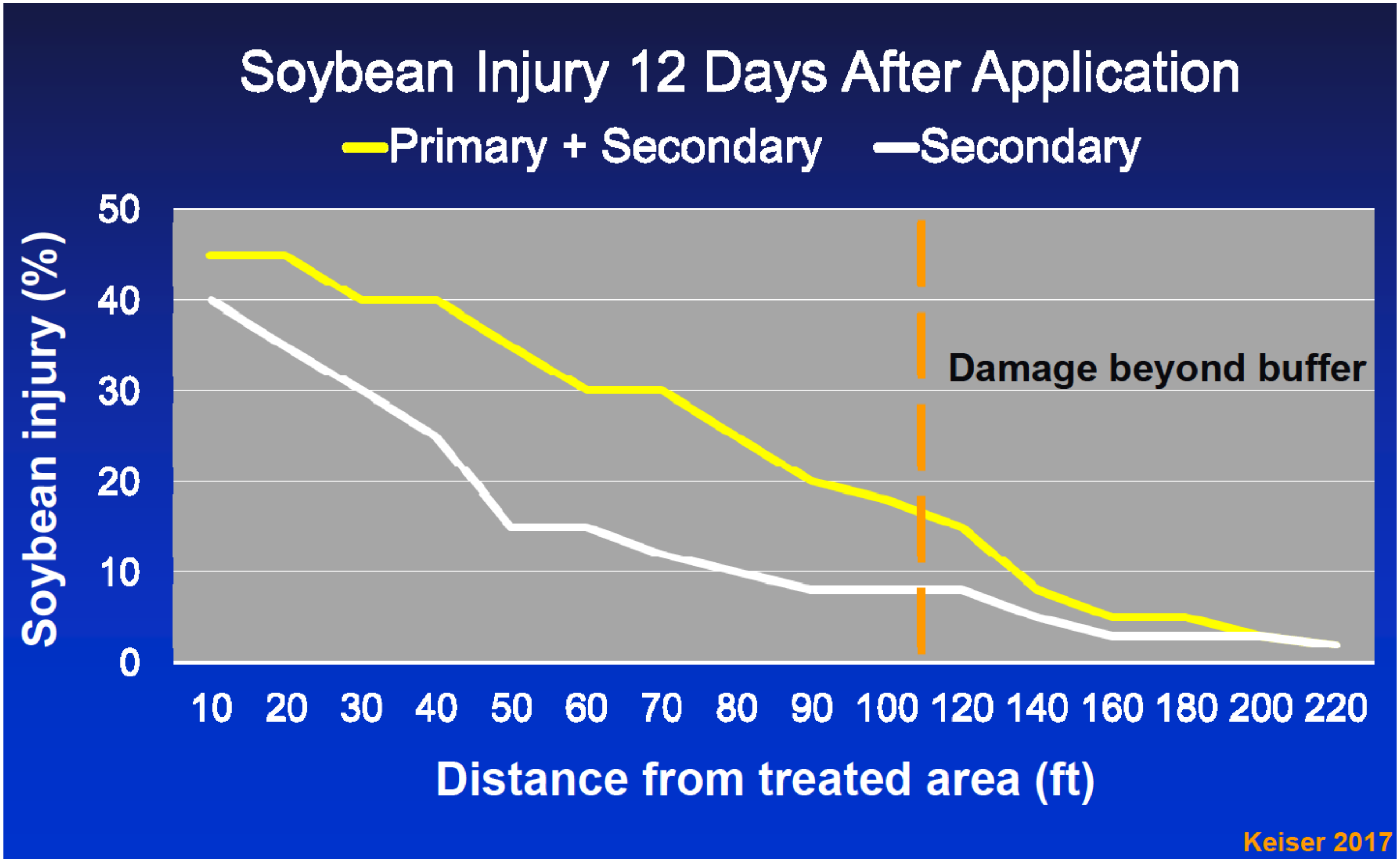
0.5 to 36 hours

24 to 36 hours

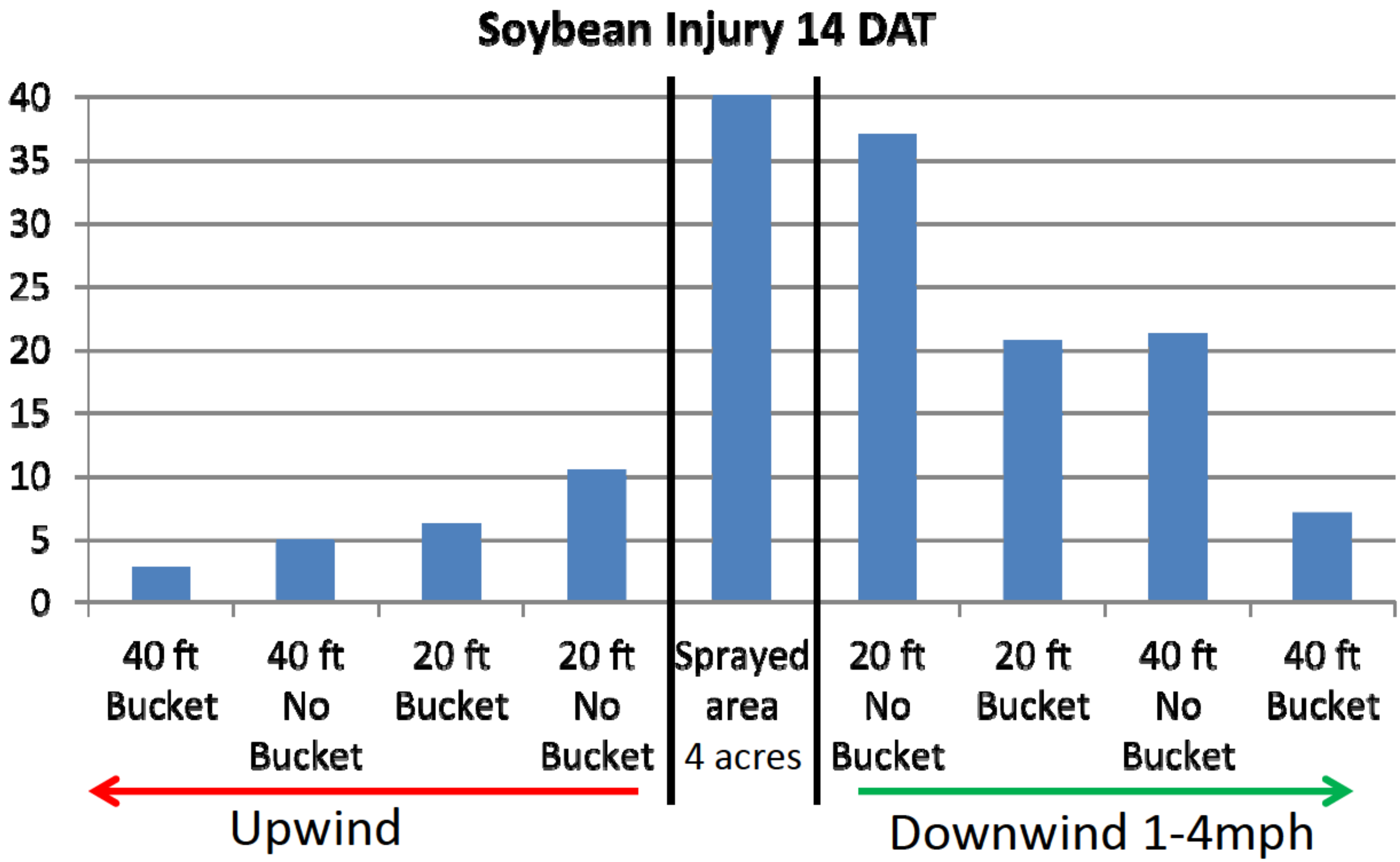
Xtendimax Movement – North Transect



Engenia Movement – North Transect



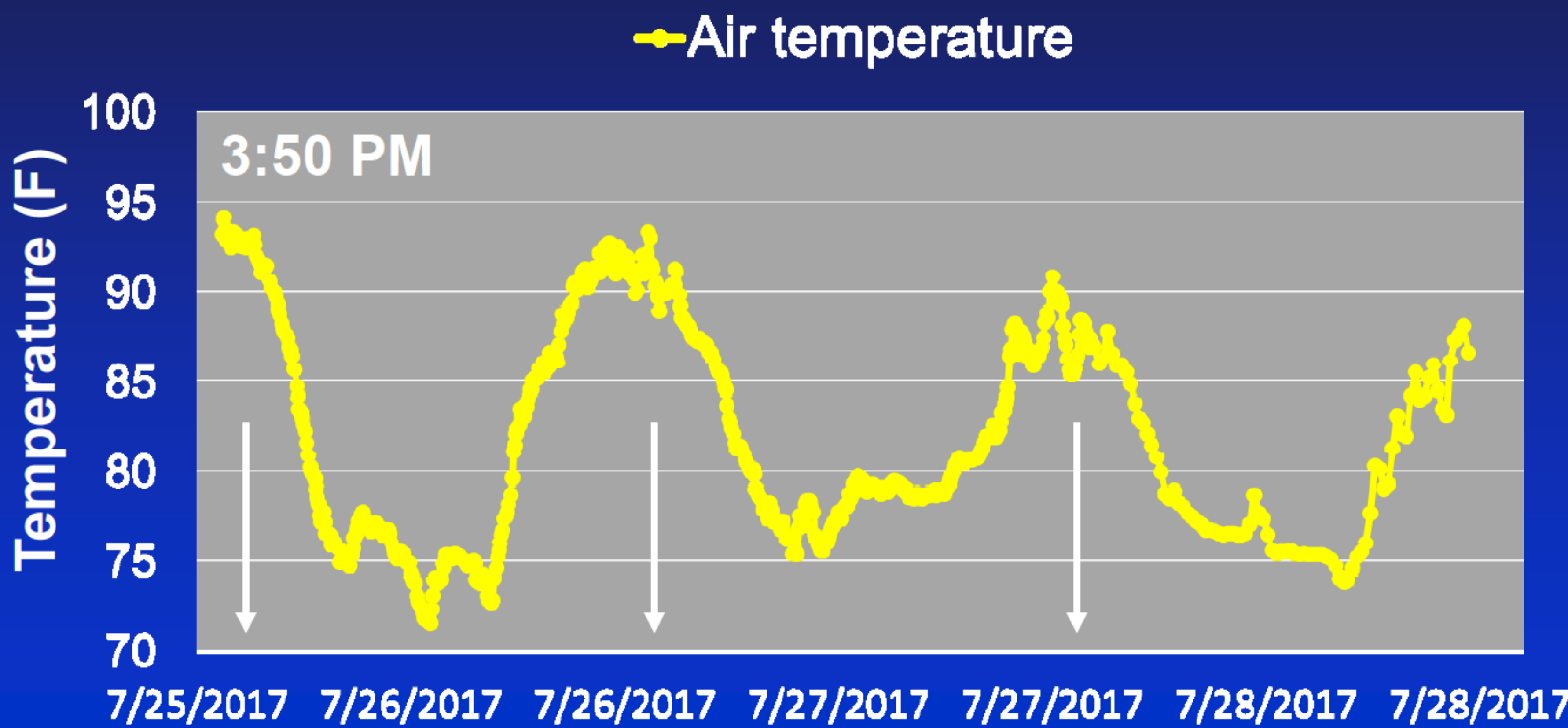
20 Acre Drift Study Rohwer Xtendimax 22 oz



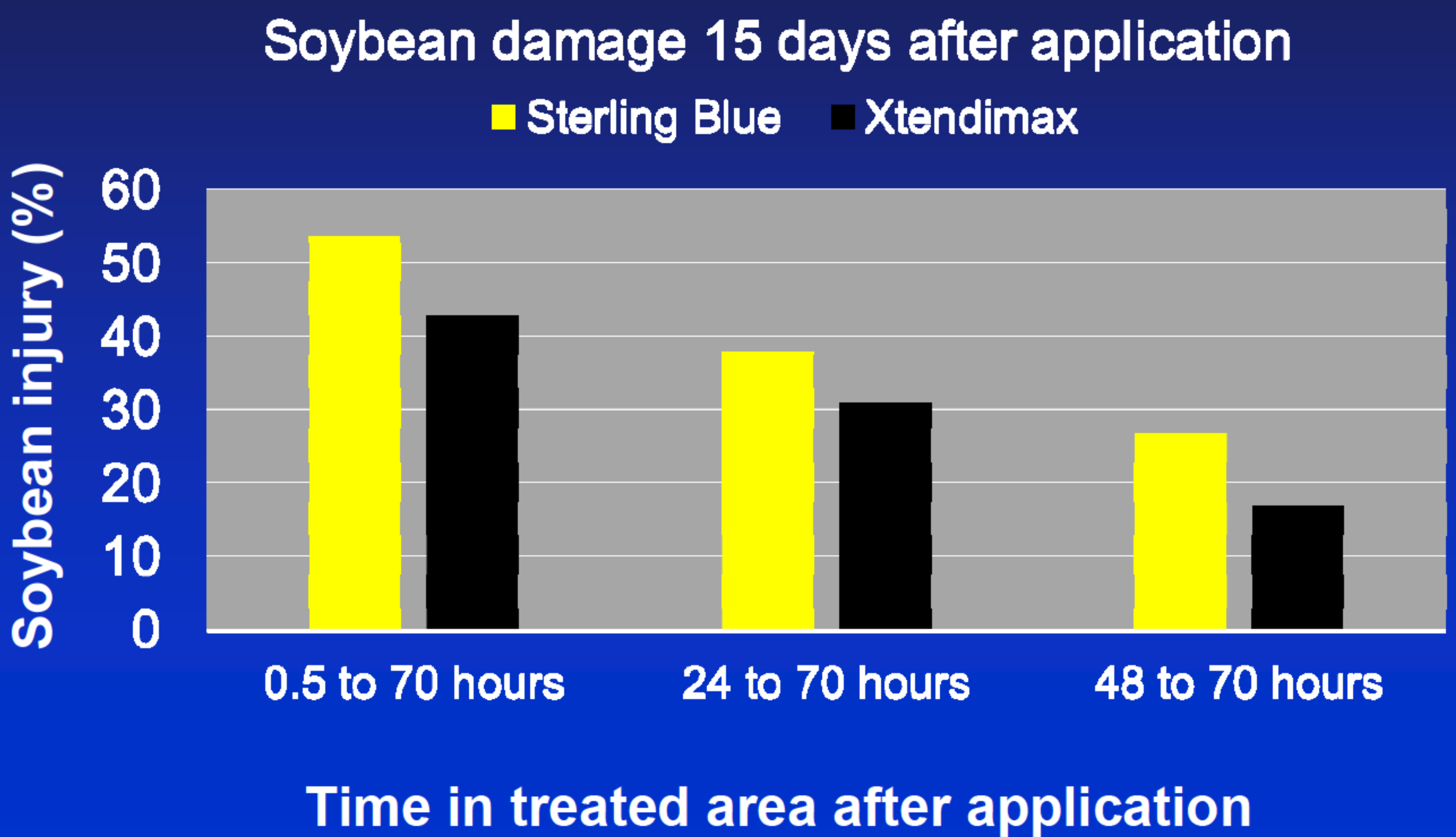
3

Farmington Volatility Trial #1

Temperature Following Application (Farmington – Trial #1)



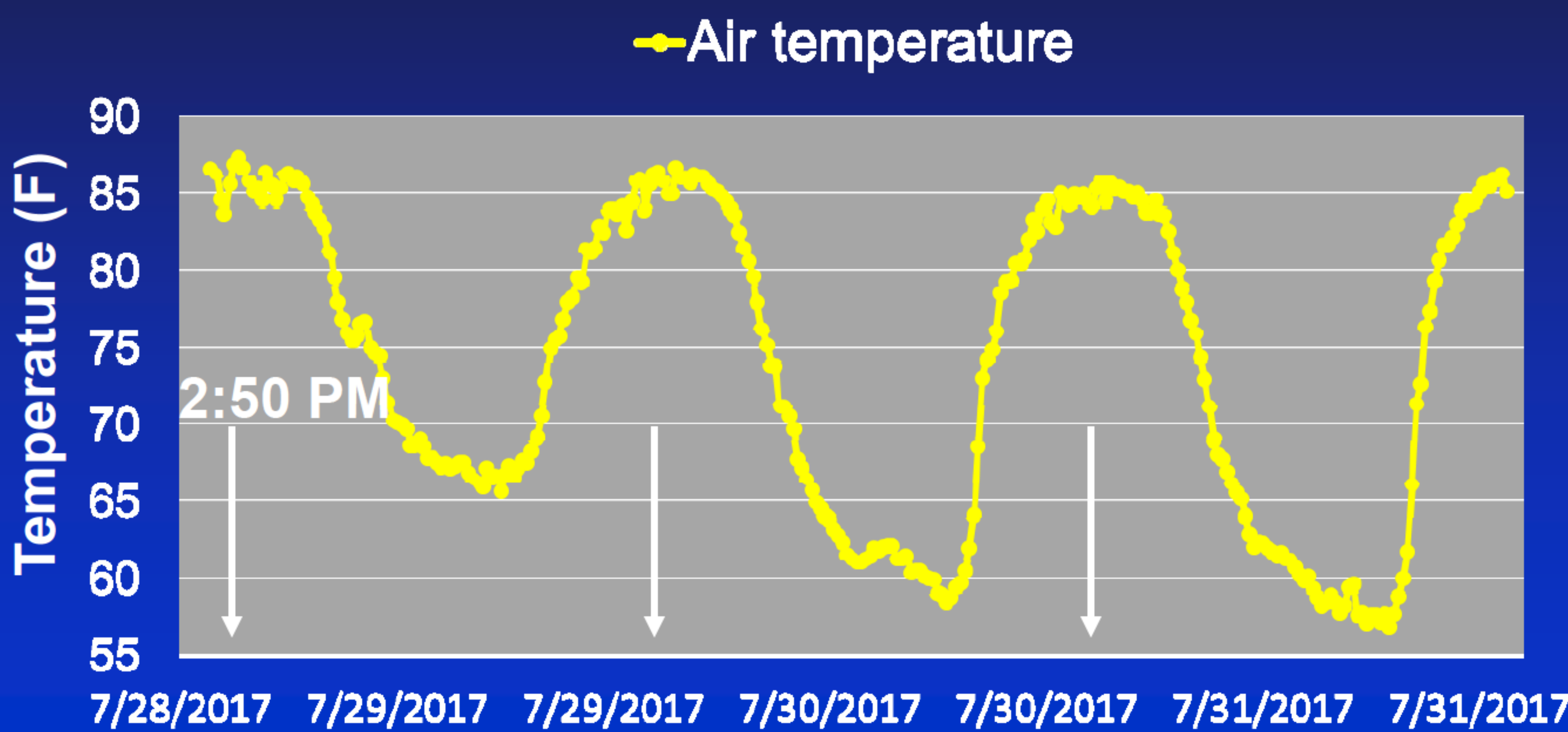
Secondary Damage to Soybean (Farmington Trial #1)



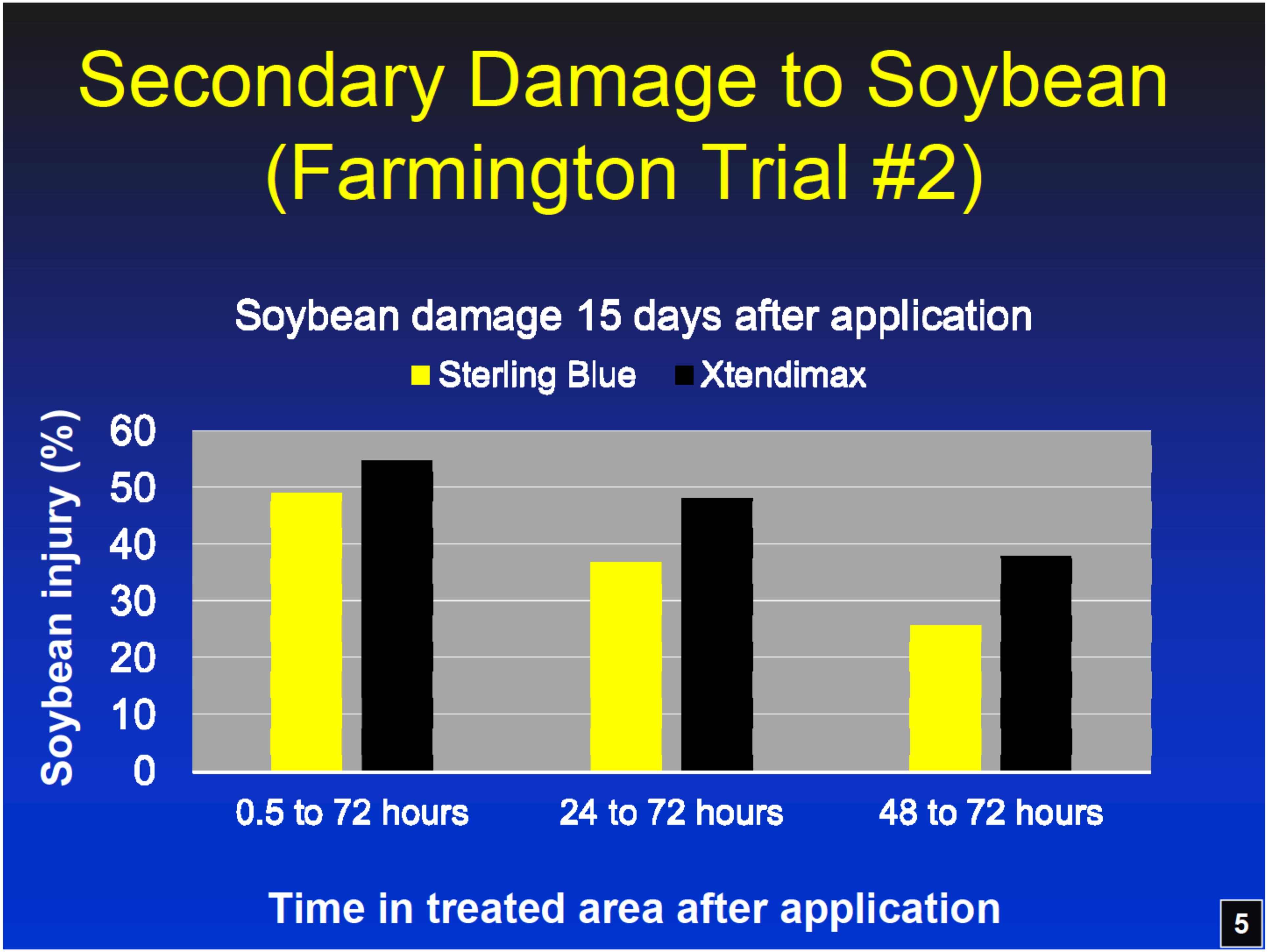
4

Farmington Volatility Trial #2

Temperature Following Application (Farmington – Trial #2)



Farmington 2017, Trial #2


Secondary Damage to Soybean
(Farmington Trial #2)
Soybean damage 15 days after application
Sterling Blue
Xtendimax
Soybean injury (%)
60
50
40
30
20
10
0
0.5 to 72 hours
24 to 72 hours
48 to 72 hours
Time in treated area after application
5

From: Green, Jamie
To: Baris, Reuben; Kenny, Daniel; Lott, Don; Trivedi, Adrienne; Vizard, Elizabeth; Wormell, Lance
Cc: Hackett, Shawn; Frizzell, Damon; Ridnour, Lacey; Taylor, Maren
Subject: FW: Shared with you: Paul.Bailey@mda.mo.gov
Date: Thursday, September 07, 2017 9:28:33 AM

FYI

From: webmaster [mailto:webmaster@deltafarmpress.com]
Sent: Thursday, September 07, 2017 8:22 AM
To: Green, Jamie <Green.Jamie@epa.gov>
Subject: Shared with you: Paul.Bailey@mda.mo.gov

Shared with you by MO Dept of Ag - Pesticide Control.

Interesting article. Might forward to OPP.

Dicamba tests showing similar results from scattered locations

Preliminary data shows agreement on formulations' volatility

Copy and paste this URL into your browser:
http://www.deltafarmpress.com/soybeans/dicamba-tests-showing-similar-res...

DELTA FarmPress

ANSWER PLOTS: The University of Missouri Columbia is conducting research to determine if dicamba drift causes yield loss in soybean fields.

CROPS > SOYBEANS

Dicamba tests showing similar results from scattered locations

Preliminary data shows agreement on formulations' volatility

David Bennett | Sep 06, 2017

As the 2017 spraying season winds down and field days begin to tail off, Mid-South weed scientists are commenting on how similar many of their preliminary dicamba research results appear. These results come from tests well scattered across the northern part of the region.

One word used frequently in their findings regarding new dicamba formulations: volatility.

Related: **What's the latest on dicamba drift in Missouri?**

"We have data that supports volatility being a part of the problem otherwise we wouldn't say it," said Kevin Bradley, University of Missouri weed scientist, in late August . "And surrounding states and research have similar data and support for the volatility bucket. What we're seeing isn't much different than what's being found in Arkansas and Tennessee."

Hoops

Related: **How might new technologies help with dicamba troubles?**

In Arkansas, University of Arkansas weed scientists Bob Scott, Jason Norsworthy and Tom Barber studied "hoop" set-ups in the northeast (Keiser), the central part of the state (Lonoke) and in the southeast (Rohwer).

"The purpose of the hoop studies was to observe if any differences existed between the old and new dicamba formulations in regards to volatility," says Barber. "Although we haven't analyzed all the locations together, it appears the data is going to fit together pretty well."

The trio looked at some of the older dicamba products like Banvel, some of the older DGA products like Clarity and compared those to XtendiMax, Engenia, Roundup Xtend (a pre-mix formulation). They also had an XtendiMax treatment with AMS, or ammonium sulfate.

"We did the tests in 'hoops.' The hoops are about 20-feet long, covering two rows of soybean. In the middle of the hoops, we placed two standard (18 x 26 in) greenhouse trays full of moistened soil from the field the research was conducted. We sprayed the soil in the trays and then set them in the hoop for 48 hours."

To avoid contamination, each individual treatment or herbicide was handled by a separate individual and those individuals were not allowed anywhere in the study except their specific treatment.

The hoops are made out of a PVC frame with visqueen plastic -- a miniature greenhouse out in the field. The ends are open and weather stations were used to take temperatures inside/outside the hoop.

Symptomology

The trays were left in the hoops for 48 hours before they were taken down.

"So, all the data – all the volatility from the hoop studies, anyway – were based on what came off the soil in those trays in those 48 hours.

"We took plant counts, percent injury and height data from the center of the plot in both directions, either side of the center, in increments, on two rows. Usually, with dicamba injury, symptoms begin showing up about 14 days after application. So, we collected data at 14, 21, and 28 days.

"What we were looking for was dicamba symptomology on soybean, the number of plants showing symptoms, and if there was any reduction in height. The biggest thing that stuck out in all the hoop trials was some of the first dicamba formulations like the acids or DMA salts had very high volatility. That led to very high soybean injury to the plants in the hoop as well as reduction in plant height."

One of the highest injury-causing treatments was when AMS was mixed with XtendiMax. "The AMS caused the DGA salt in XtendiMax to disassociate from the parent acid. That allowed the parent acid to readily volatilize, resulting in a lot of injury to the plots."

When it came to Clarity, a DGA salt, "we had less visual injury symptoms than with dicamba acids, with Banvel, or when we added AMS to DGA salts.

Statistical differences?

"At this point, we don't know if there will be any statistical differences between Clarity, Engenia, and XtendiMax in terms of volatility because the data have not been analyzed. What we do know is they all injured soybeans to some extent in the rows where the trays were placed.

"Now, in one location, injury from Clarity may have been higher than Engenia or Xtendimax than in another but, when the data is all brought together from these three locations, I don't expect there will be large differences. I believe the data will show anytime we put AMS with a dicamba formulation we'll significantly increase volatility. If older formulations like Banvel are used, DMA salts or the dicamba acids, you'll also see an increase in volatility and subsequent injury."

Regardless of whether or not researchers are able to statistically separate Engenia and XtendiMax from Clarity, "they all volatilized enough to cause some level of injury and it was, significant enough to notice (3 to 10 percent). Remember the scale; we are talking about injury from only two 18x26 in trays of soil sitting inside the hoops for 48 hours."

Going in, the trio was "just trying to tease out differences between the dicamba formulations," says Barber. "The claims going in said these formulations would show a significant reduction in volatility over older products like Banvel and Clarity.

"Based on these preliminary data we have now, I agree those formulations are less volatile than Banvel, other DMA salts or dicamba acids. But in terms of soybean response, it doesn't appear that the volatility is greatly reduced from Clarity, a standard DGA salt that is widely used. Again, this is preliminary.

However, "even if these new products show reduced volatility, they are still volatile and can cause injury."

In other studies , the Arkansas researchers "sprayed 3 to 4 acres in a sensitive soybean field and either covered plants with buckets or inserted plants from the greenhouse we are observing volatility up to 48 hours after application.

Barber points to a term – "atmospheric loading" -- used frequently during the dicamba spraying controversy. "The research tells us that because these newer formulations remain volatile they can potentially load the atmosphere with dicamba. Is that the only way to load it? Nope. But we know when you spray a dicamba product over large acreage the amount available to volatilize, and the amount that can fill the air, can continue to increase for at least 48 hours."

Source URL: http://www.deltafarmpress.com/soybeans/dicamba-tests-showing-similar-results-scattered-locations

From: Beck, Nancy
To: Richard Keigwin (Keigwin.Richard@epa.gov); Avivah Jakob (Jakob.Avivah@epa.gov)
Subject: FW: Meeting request
Date: Wednesday, September 6, 2017 10:06:00 AM

Rick,
The best window for me to meet with Monsanto is Friday 2pm -3pm or after 3:30.
I know you were planning to meet with them on Friday as well and I don't want this meeting to delay those discussions.
If we set this up for 2-2:30 would that be a problem? And of course if you can join that would be great.

Thanks.

Nancy B. Beck, Ph.D., DABT
Deputy Assistant Administrator, OCSPP
P: 202-564-1273
M: 202-731-9910
beck.nancy@epa.gov

-----Original Message-----
From: KUSCHMIDER, SCOTT [AG/1920] [mailto:scott.kuschmider@monsanto.com]
Sent: Tuesday, September 5, 2017 7:54 PM
To: Beck, Nancy <Beck.Nancy@epa.gov>
Subject: Meeting request

Ms. Beck,

I hope this email finds you well. I wanted to reach out to see if you had time later this week to continue our conversation from last Monday. I was told by the office when i called today to try again in the morning, so i wanted to give you a heads up that our group - mostly the same folks - are going to try and get on your schedule for a half hour. Thanks, and I look forward to speaking with you.

Scott Kuschmider
Monsanto

From: Bowman, Liz
To: Beck, Nancy
Cc: Wilcox, Jahan
Subject: Fwd: Daily Caller: EPA May Curtail The Use Of Chemical Spray That Could Cut Into Monsanto's Bottom Line, 9/6/17
Date: Wednesday, September 6, 2017 12:27:54 PM

[redacted]

Sent from my iPhone

Begin forwarded message:

> **From:** "Sorokin, Nicholas" <sorokin.nicholas@epa.gov>
> **Date:** September 6, 2017 at 10:13:27 AM EDT
> **To:** AO OPA OMR CLIPS <AO_OPA_OMR_CLIPS@epa.gov>
> **Subject: Daily Caller: EPA May Curtail The Use Of Chemical Spray That Could Cut Into Monsanto's Bottom Line, 9/6/17**
>
> **Daily Caller**
> **http://dailycaller.com/2017/09/05/epa-may-curtail-the-use-of-chemical-spray-that-could-cut-into-monsantos-bottom-line/**
> **EPA May Curtail The Use Of Chemical Spray That Could Cut Into Monsanto's Bottom Line**
> By Tim Pearce, 9/5/17
>
> The Environmental Protection Agency (EPA) is considering banning use of the herbicide dicamba after the chemical reportedly damaged other crops by drifting into areas neighboring sprayed fields, Reuters reports.
>
> The ban could be implemented sometime in 2018, and would cut into the profits of Monsanto, which sells agricultural goods internationally, and DuPont, a science and engineering company that operates around the world.
>
> A task force in Arkansas is advising the state to create an April 15 cutoff date for dicamba application. The EPA may consider something similar.
>
> "If the EPA imposed a April 15 cut-off date for dicamba spraying, that would be catastrophic for Xtend – it invalidates the entire point of planting it," Bernstein analyst Jonas Oxgaard told Reuters.
>
> Dicamba resistant soybeans are twice the price of Monsanto's Roundup Ready soybeans, so neutralizing the benefits of planting Xtend soybeans would effectively kill the market. Monsanto would lose between $400 million and $800 million in potential profit off herbicide sales, according to Reuters.

Since farmers began treating the new strains of soybean with the chemical, many have complained about dicamba drifting into other fields during the application process and harming or killing soybeans without the Xtend trait.

Monsanto blames dicamba's damage to other crops on farmers not administering the herbicide properly. Farmers, however, have said the instructions on the label are unreasonably complex, according to Reuters.

___

Nicholas Sorokin
Office of Media Relations Intern
U.S. Environmental Protection Agency
Telephone: (202) 564-5334
sorokin.nicholas@epa.gov

No. 17-70196

UNITED STATES COURT OF APPEALS
FOR THE NINTH CIRCUIT

NATIONAL FAMILY FARM COALITION, *et al*.,

Petitioners,

v.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, *et al*.,

Respondents,

and

MONSANTO COMPANY,

Intervenor-Respondent.

ON PETITION FOR REVIEW FROM THE UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

PETITIONERS' EXCERPTS OF RECORD VOLUME III

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Counsel for Petitioners

INDEX TO PETITIONERS' EXCERPTS OF RECORD

[1] Unless otherwise specified, the document identifier numbers record to their document numbers as listed in the Certified Amended Index, ECF No. 63-3.

[2] Respondent United States Environmental Protection Agency (EPA) did not produce, but only provided hyperlinks to, publicly available documents. *See* ECF No. 63-3. For the Court's convenience, Petitioners have produced those hyperlinked documents in their entirety in the Excerpts of Record.

VOLUME II			
Date	**Admin. R. Doc. No.**	**Document Description**	**ER Page No.**
10/10/2017	K.36	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: FW: New Dicamba non-crop complaints	ER 122
10/10/2017	K.53	E-mail from Reuben Baris (EPA) to Thomas Marvin (Monsanto) re: Label comments	ER 123
10/10/2017	K.90	E-mail from Philip Perry (Monsanto) to Michele Knorr (EPA), others, re: Response to Terms and conditions Page 1 - EPA comments	ER 165
10/10/2017	K.94	E-mail from Reuben Baris (EPA) to Tom Marvin (Monsanto) with markup of EPA's response to terms and conditions	ER 167
10/9/2017	K.52	E-mail from Phil Perry (Monsanto) to Michele Knorr (EPA) re: Implementation Terms and Conditions	ER 170
10/5/2017	K.16	E-mail from R. Baris (EPA) to T. Marvin (Monsanto) re: dicamba proposed registration conditions	ER 172
9/27/2017	K.11	E-mail from Jamie Green (EPA) to Anne Overstreet (EPA) re: correspondence received from seed company owner regarding Dicamba Control	ER 175
9/27/2017	K.42	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: article on Dicamba from Delta Farm Press[3]	ER 182

[3] This e-mail contains a hyperlink to an online article. *See* David Bennett, *Might Dicamba be Affecting Pollinators*?, Delta Farm Press, Sept. 26, 2017. For the Court's convenience, Petitioners have produced this and other similarly hyperlinked articles in the Excerpts of Record.

9/27/2017	K.32	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: FW: Many U.S. Scientists to skip Monsanto summit on dicamba	ER 188
9/27/2017	K.93	E-mail from Nicholas Sorokin (EPA) to EPA recipients of Office of Public Affairs media clips re: Reuters: Exclusive: U.S. scientists to skip Monsanto summit on controversial weed killer	ER 189
9/26/2017	K.46	E-mail from Reuben Baris (EPA) to Jonathan Becker (EPA) re: FW: yield data forwarded 10 journal articles on yield impact resulting from dicamba exposure	ER 192
9/21/2017	K.19	E-mail from Pesticide Action Network to Rick Keigwin (EPA) re: EPA: Pull Monsanto's crop-killing dicamba now	ER 278
9/21/2017	K.80	E-mail from Caleb Hawkins (EPA) to Jonathan Becker and others at EPA forwarding Reuters article on dicamba[4]	ER 280
9/13/2017	K.39	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Record number of pesticide misuse claims by Iowa farmers due to dicamba drift problems[5]	ER 285
9/12/2017	K.35	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: More Dicamba = Monsanto Petition to Arkansas State Plant Board	ER 291

[4] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* Tom Polansek, *U.S. Regulator Aiming to Allow Controversial Herbicide Use with Safeguards*, Reuters, Sept. 20, 2017.

[5] This e-mail contains a hyperlink to an online article that Petitioners have reproduced in its entirety. *See* Donnelle Eller, *Iowa Farmer Makes Record Number of Pesticide Misuse Claims*, The Des Moines Register, Sept. 12, 2017.

9/11/2017	K.63	E-mail from Kevin Bradley (Professor Division of Plant Sciences, University of Missouri) to Reuben Baris (EPA) re:slides from several university weed scientists on volatility testing on new dicamba forumulations	ER 293
9/7/2017	K.41	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: article on Dicamba from Delta Farm Press[6]	ER 346
9/6/2017	K.33	E-mail from Nancy Beck (EPA) to Rick Keigwin (EPA) re: FW: Meeting Request from Monsanto	ER 352
9/6/2017	K.47	E-mail from Liz Bowman (EPA) to Nancy Beck (EPA) re: FW: Daily Caller: EPA May Curtail the Use of Chemical Spray That Could Cut Into Monsanto's Bottom Line	ER 353

VOLUME III			
Date	**Admin. R. Doc. No.**	**Document Description**	**ER Page No.**
9/5/2017	K.91	E-mail from Nicholas Sorokin (EPA) to EPA recipients of Office of Public Affairs media clips re: Reuters: Exclusive: EPA eyes limits for agricultural chemical linked to crop damage.	ER 355
8/31/2017	K.79	E-mail from TJ Wyatt (EPA) to Jonathan Becker (EPA) and to other EPA staff forwarding Washington Post article on Dicamba	ER 358

[6] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* David Bennett, *Dicamba Tests Showing Similar Results from Scattered Locations*, Delta Farm Press, Sept. 6, 2017.

8/29/2017	K.51	Ten articles on Dicamba send as a Google Alert to Reuben Baris (EPA)[7]	ER 364
8/23/2017	K.101 (Second Am. Certified Index, ECF No. 69-3)	Notes from 8/23/2017 EPA meeting with various state officials	ER 369
8/22/2017	K.31	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Letter to Topeka paper	ER 372
8/22/2017	K.38	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Off-target Movement of Dicamba in Missouri. Where Do We Go From Here?[8]	ER 374
8/21/2017	K.92	E-mail from Nicholas Sorokin (EPA) to EPA recipients of Office of Public Affairs media clips re: Reuters: Exclusive: U.S. farmers confused by Monsanto's weed killer's complex instructions	ER 379
8/20/2017	K.27	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Dicamba update	ER 382
8/18/2017	K.88	E-mail from Kevin Bradley (University of Missouri) to R. Baris (EPA) regarding WSSA committee	ER 390

[7] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See EPA Responds to Dicamba Complaints*, Ag. Professional, Aug. 29, 2017.

[8] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* Kevin Bradley, *Off-target Movement of Dicamba in Missouri: Where Do We Go from Here?*, Integrated Pest Mgmt., Univ. Mo., Aug. 21, 2017.

8/17/2017	K.12	E-mail from Reuben Baris (EPA) to Dicamba registrants regarding next steps on dicamba	ER 394
8/10/2017	K.21	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: FW Article from Arkansas times[9]	ER 395
8/3/2017	K.49	E-mail from Reuben Baris (EPA) to Mark Corbin (EPA) re: Fwd: TN data Effect of adding Roundup PowerMax to Engenia on vapor losses under field conditions	ER 406
8/2/2017	K.20	E-mail-calendar invite from Emily Ryan (EPA) to Reuben Baris (EPA) and other internal and external parties re: follow-up on Dicamba with AAPCO/SFIREG and agenda for 8/2/17	ER 417
8/2/2017	K.100 (Second Am. Certified Index, ECF No. 69-3)	Notes from 8/2/2017 EPA meeting with various state officials	ER 420
8/1/2017	K.37	E-mail from Sarah Meadows (EPA) to Grant Rowland (EPA) re: FW: Notes from Friday's meeting on Dicamba call (7/28/17) with state reps	ER 428
8/1/2017	K.14	E-mail from Shanta Adeeb (EPA) to Dan Kenny (EPA) re: Dicamba Notes from July 28th meeting with states on dicamba incidents	ER 435
7/28/2017	K.66	E-mail from Reuben Baris (EPA) to Dan Rosenblatt (RPA) re: EPA notes taken during dicamba teleconference with state extension representatives on 7/28/17	ER 441

[9] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* David Koon, *Farmer vs. Farmer*, Ark. Times, Aug. 10, 2017.

7/25/2017	K.22	E-mail from Dan Kenny (EPA) to Reuben Baris (EPA) re: FW Conference Call with EPA on Dicamba 7/25/17 (conference call information will be redacted)	ER 445
7/25/2017	K.59	E-mail from Sarah Meadows (EPA) to Dan Kenny (EPA) re: Notes from Dicamba meeting with states on 7/13/17	ER 447
7/12/2017	K.5	E-mail from Dan Kenny (EPA) to state representatives regarding EPA Dicamba Meeting with States	ER 453
11/7/2016	A.765	Excerpt of Response to Public Comments Received Regarding the New Use of Dicamba on Dicamba-Tolerant Cotton and Soybeans	ER 456
11/3/2016	A.170	M-1691 Herbicide, EPA Reg. No. 524-582 (Active Ingredient: Dicamba Diglycolamine Salt) and M-1768 herbicide, EPA Reg. No. 524-617 (AI: Diglycolamine Salt with VaporGrip™) – Review of EFED Actions and Recent Data Submissions Associated with Spray and Vapor Drift of the Proposed Section 3 New Uses on Dicamba-Tolerant Soybean and Cotton	ER 459
6/20/2016	A.863	Comment submitted by National Family Farm Coalition	ER 473
6/15/2016	A.57	Mortensen *et al.*, *Navigating a Critical Juncture for Sustainable Weed Management*, BioScience, Jan. 2012, at 75-84 (submitted as an attachment to comment submitted by Sylvia Wu, Center for Food Safety)	ER 474
6/15/2016	A.473	Comments submitted by The Center for Food Safety, including Excerpts from Exhibits A and F.	ER 485
6/10/2016	A.304	Comment submitted by J. R. Paarlberg	ER 554

3/24/2016	A.285	Excerpt of Addendum to Dicamba Diglycolamine Salt (DOA) and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in in 11 U.S. States: (Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia). Phases 3 and 4	ER 702
3/24/2016	A.611	Excerpt of Ecological Risk Assessment for Dicamba DGA Salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA), for the Proposed Post-Emergence New Use on Dicamba-Tolerant Cotton (MON 8770 I)	ER 713
3/24/2016	A.45	Excerpt of Dicamba DGA: Second Addendum to the Environmental Fate and Ecological Risk Assessment for Dicamba DGA salt and its Degradate	ER 716
2014	I.28	Egan, J. F., Barlow, K. M., and Mortensen, D. A. 2014. A meta-analysis on the effects of 2,4-D and dicamba drift on soybean and cotton. Weed Science 62:193-206.	ER 724
3/8/2011	A.91	Excerpt of Ecological Risk Assessment for Dicamba and its Degradate	ER 740
9/17/2010	B.12	Comment submitted by Bill Freese, The Center for Food Safety	ER 774
6/4/2010	B.0024	Scott Kilman, *Superweed Outbreak Triggers Arms Race*, Wall St. J. (submitted as an attachment to the comment submitted by Ryan Crumley, The Center for Food Safety)	ER 782

8/31/2005	C.7	EFED Reregistration Chapter For Dicamba/Dicamba Salts	ER 788
1/23/2004	I.1	Excerpts from Office of Pesticide Programs, EPA, *Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs: Listed and Threatened Species Effects Determinations* (2004).	ER 804
12/1/1993	I.3	Excerpts from Office of Research and Development, EPA, *Wildlife Exposure Factors Handbook* (1993).	ER 813

VOLUME V (UNDER SEAL)			
Date	**Admin. R. Doc. No.**	**Document Description**	**ER Page No.**
10/9/2017	K.10	E-mail from Philip Perry (Monsanto) to Reuben Baris (EPA) re: Current master label and sticker Xtendimax	ER 825
9/25/2017	K.7	E-mail from T. Marvin (Monsanto) to R. Baris (EPA) re: Confidential working Draft Master Label	ER 867
9/22/2017	K.15	E-mail from T. Marvin (Monsanto) to R. Baris (EPA) re: Confidential working Draft Master Label	ER 905
9/13/2017	K.6	E-mail from T. Marvin (Monsanto) to R. Baris (EPA) re: confidential discussion points for label changes	ER 909
6/7/2016	J.240	Monsanto Confidential Document re: Expected Monsanto Submissions to support M1691, Xtendimax & Roundup Xtend Herbicides	ER 912
4/12/2016	E.406	Gavlick, W. (2016) Determination of the Relative Volatility of Dicamba Herbicide Formulations. Project Number: MSL0026648. Unpublished study prepared by Monsanto Agricultural Co. 15p.	ER 917

From: Sorokin, Nicholas
To: AO OPA OMR CLIPS
Subject: Reuters: Exclusive: EPA eyes limits for agricultural chemical linked to crop damage,9/5/17
Date: Tuesday, September 5, 2017 10:40:40 AM

Reuters
http://www.reuters.com/article/us-usa-pesticides-epa-exclusive/exclusive-epa-eyes-limits-for-agricultural-chemical-linked-to-crop-damage-idUSKCN1BG1GT
Exclusive: EPA eyes limits for agricultural chemical linked to crop damage
By Tom Polansek and Emily Flitter, 9/5/17

(Reuters) - The U.S. environmental agency is considering banning sprayings of the agricultural herbicide dicamba after a set deadline next year, according to state officials advising the agency on its response to crop damage linked to the weed killer.

Setting a cut-off date, possibly sometime in the first half of 2018, would aim to protect plants vulnerable to dicamba, after growers across the U.S. farm belt reported the chemical drifted from where it was sprayed this summer, damaging millions of acres of soybeans and other crops.

A ban could hurt sales by Monsanto Co (MON.N) and DuPont which sell dicamba weed killers and soybean seeds with Monsanto's dicamba-tolerant Xtend trait. BASF (BASFn.DE) also sells a dicamba herbicide.

It is not yet known how damage attributed to the herbicides, used on Xtend soybeans and cotton, will affect yields of soybeans unable to withstand dicamba because the crops have not been harvested.

The Environmental Protection Agency (EPA) discussed a deadline for next year's sprayings on a call with state officials last month that addressed steps the agency could take to prevent a repeat of the damage, four participants on the call told Reuters.

It was the latest of at least three conference calls the EPA has held with state regulators and experts since late July dedicated to dicamba-related crop damage and the first to focus on how to respond to the problem, participants said.

A cut-off date for usage in spring or early summer could protect vulnerable plants by only allowing farmers to spray fields before soybeans emerge from the ground, according to weed and pesticide specialists.

Monsanto spokeswoman Christi Dixon told Reuters on Aug. 23, the day of the last EPA call, that the agency had not indicated it planned to prohibit sprayings of dicamba herbicides on soybeans that had emerged. That action "would not be warranted," she said.

The EPA had no immediate comment.

EPA officials on the last call made clear that it would be unacceptable to see the same extent of crop damage again next year, according to Andrew Thostenson, a pesticide specialist for North Dakota State University who participated in the call.

They said "there needed to be some significant changes for the use rules if we're going to maintain it in 2018," he said about dicamba usage.

State regulators and university specialists from Arkansas, Missouri, Illinois, Iowa and North Dakota are pressuring the EPA to decide soon on rules guiding usage because farmers will make planting decisions for next spring over the next several months.

Tighter usage limits could discourage cash-strapped growers from buying Monsanto's more expensive dicamba-resistant Xtend soybean seeds. Dicamba-tolerant soybeans cost about $64 a bag, compared with about $28 a bag for Monsanto's Roundup Ready soybeans and about $50 a bag for soybeans resistant to Bayer's Liberty herbicide.

Already, a task force in Arkansas has advised the state to bar dicamba sprayings after April 15 next year, which would prevent most farmers there from using dicamba on Xtend soybeans after they emerge.

Arkansas previously blocked sales of Monsanto's dicamba herbicide, XtendiMax with VaporGrip, in the state.

"If the EPA imposed a April 15 cut-off date for dicamba spraying, that would be catastrophic for Xtend - it invalidates the entire point of planting it," said Jonas Oxgaard, analyst for investment management firm Bernstein.

Monsanto has projected its Xtend crop system would return a $5 to $10 premium per acre over soybeans with glyphosate resistance alone, creating a $400-$800 million opportunity for the company once the seeds are planted on an expected 80 million acres in the United States, according to Oxgaard.

By 2019, Monsanto predicts U.S. farmers will plant Xtend soybeans on 55 million acres, or more than 60 percent of the total planted this year.

RISKY DRIFT

About 3.1 million acres of soybeans vulnerable to dicamba were hurt by sprayings this summer, accounting for 3.5 percent of U.S. plantings, according to the University of Missouri.

Chemical companies have blamed the crop damage on farmers misusing the herbicides.

Specialists, though, say the weed killers are also risky because they have a tendency to vaporize and drift across fields, referred to as volatility. Summer can be a riskier time for sprayings, they said, because high temperatures can increase volatility.

Monsanto previously denied requests by university researchers to study its XtendiMax herbicide for volatility, as previously reported by Reuters. In the end, the EPA gave dicamba weed killers from Monsanto and BASF abridged two-year registrations, less than the five years experts say is more common.

To address the crop damage, the EPA has also asked state officials about enhanced training for dicamba users; tighter restrictions on when and how the herbicides can be sprayed; and the possibility of reclassifying the products so the general public could not buy them, according to participants on the call.

“Everything is an option,” said Jason Norsworthy, a University of Arkansas professor who was on the call.

Monsanto Chief Technology Officer Robb Fraley said in a statement that the company was communicating with the EPA, which is “evaluating potential actions to facilitate enhanced training and compliance for 2018.”

DuPont, too, is working with the EPA and state regulators on issues involving its dicamba herbicide, FeXapan, spokeswoman Laura Svec said.

Rival BASF “could see some label enhancements” to its dicamba herbicide, Engenia, if the EPA requires changes, spokeswoman Odessa Hines told Reuters. The company “will be as flexible as possible” so farmers can use the product, she said.

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From: Wyatt, TJ
To: Becker, Jonathan; OPP BEAD BAB; OPP BEAD EAB; Jones, Arnet; Rowland, Grant; Kenny, Daniel; Rosenblatt, Daniel; Baris, Reuben; Montague, Kathryn V.; Meadows, Sarah
Subject: RE: FYI - WP article on dicamba
Date: Thursday, August 31, 2017 8:32:06 AM

You all probably saw the Washington Post article yesterday.

https://www.washingtonpost.com/business/economy/this-miracle-weed-killer-was-supposed-to-save-farms-instead-its-devastating-them/2017/08/29/33a21a56-88e3-11e7-961d-2f373b3977ee_story.html?utm_term=.f557dc9ebdd1

From: Becker, Jonathan
Sent: Thursday, August 31, 2017 7:40 AM
To: OPP BEAD BAB <OPP_BEAD_BAB@epa.gov>; OPP BEAD EAB <OPP_BEAD_EAB@epa.gov>; Jones, Arnet <Jones.Arnet@epa.gov>; Rowland, Grant <Rowland.Grant@epa.gov>; Kenny, Daniel <Kenny.Dan@epa.gov>; Rosenblatt, Daniel <Rosenblatt.Dan@epa.gov>; Baris, Reuben <Baris.Reuben@epa.gov>; Montague, Kathryn V. <Montague.Kathryn@epa.gov>; Meadows, Sarah <Meadows.Sarah@epa.gov>
Subject: FYI - BNA article on dicamba

Pesticides
As Dicamba Dust Settles, Scientists and Industry Spar

Snapshot
• Widely used weedkiller sparks debate over damage caused to neighboring farms
• Scientists, industry at odds over causes, impacts, solutions

By Tiffany Stecker
Arkansan soybean farmers are wrapping up a summer of harvesting bumper crops alongside the crippling devastation of their neighbors' fields. The same herbicide is causing both optimism and bitterness in the region, and discussions over its future use is dividing farmers, scientists, and industry.
Dicamba, a weedkiller first registered in 1967, has undergone a makeover to fight weeds immune to most herbicides. BASF Corp., Monsanto Co., and DuPont this year stocked new versions of dicamba, designed for use with Monsanto's soybeans and cotton that are genetically-engineered to withstand the new herbicides. But the herbicide spread easily to neighboring farms, falling on vulnerable crops.
This summer was one the best growing seasons in years for Arkansans in terms of controlling insidious weeds that creep into fields. It also was a year of unusual harm to nearly a third of the state's soybean crops, marked by curled leaves, stunted growth, poor yields, and J-shaped pods that have been tied to new formulations of the herbicide.
What was a blockbuster year for many growers cost others millions of dollars, pitting farmer against farmer and scientists against the herbicide's manufacturers.
State university scientists believe the new formulations can't be managed to control the damage. They easily evaporate, or "volatilize," and can spread potentially thousands of feet over a couple of days into a neighbor's field.

"As a weed scientist, I can't tell you how to fix this problem," Jason Norsworthy, an extension scientist with the University of Arkansas told a group of farmers and industry representatives Aug. 17.

The manufacturers are loathe to blame volatility, saying the herbicides were studied extensively before their launch earlier this year. The damage, they say, could be due to errors in applying the herbicide, poorly written instructions, and generally weak control of physical drift—the travel of liquid droplets of dicamba via wind or weather patterns.

To avoid a repeat of the disaster next year, Arkansas' Plant Board convened a task force of growers and trade association representatives to craft recommendations on the spraying of dicamba.

On Aug. 24, the task force agreed to develop preliminary recommendations for the Plant Board to send to the governor. The panel suggested that the Plant Board impose an April 15 cut-off date for spraying the chemical and thereby prevent spraying in the hot summer months. The cut-off date also effectively would bar use of the herbicide for many farmers, given that most of the soybean planting happens in May.

The task force will incorporate the recommendations in a formal report due in the next three weeks. If implemented by the Arkansas Plant Board, the recommendations will drive hundreds of farmers' decisions next year. A compromise between those who have gained from the new dicamba and those who have suffered won't be easy. Farmers in Arkansas have been clamoring for solutions to their weed problems for years, and are feeling the pressure of declining grain prices that can threaten the viability of their farm operations in just one season.

Grasping for Solutions

"It's something that we desperately need to control the weeds," Justin Blackburn, a 33-year old, eighth generation soybean and corn grower in Northeastern Arkansas, told Bloomberg BNA. "We're grasping for anything that works."

Hundreds of thousands of soybean acres, plus trees, vegetables crops, and flowering plants that feed honeybees, have shriveled this year as the new product for killing weeds came on the market.

Soybeans are particularly sensitive to dicamba. The only crops that are safe are Monsanto Xtend seeds that are genetically engineered to withstand the herbicide. About 35 percent of the soybeans planted this year in the state are Xtend crops.

"We've got some serious issues we've got to address," Wes Ward, the state's Agriculture Secretary, told Bloomberg BNA. "We're hoping that this task force...can try to nail this down a little better."

In preparing its recommendations, the 19-person panel must consider conflicting information from university researchers and the manufacturers of the new herbicide.

Manufacturers hailed new formulations as a cure for stubborn weeds that suffocate crop yields. The aptly-named pigweed—also called palmer amaranth—began to resist applications of the widely-used weedkiller glyphosate after the turn of the 21st century. Weeds also have developed resistance to another class of herbicides called protoporphyrinogen oxidase (PPO) inhibitors. Resistant weeds can cut yields by up to 91 percent in corn and up to 79 percent in soybean, according to Purdue University Extension.

The new products were made to be less prone to evaporate and spread to neighboring fields than the dicamba of the past. But starting in late May, complaints began to mount. Dozens of calls to the Plant Board turned to hundreds. To date, 950 complaints have been filed.

The State Plant Board voted to ban spraying of dicamba in crops on June 23. As of Aug. 10, an estimated 900,000 acres of Arkansas soybean fields have been allegedly damaged by dicamba, according to state extension scientists, about one-third of the total soybean damage for the nation as a whole.

Ground Zero

Dicamba works by mimicking plant hormones that make weeds grow abnormally and eventually die. More than 2,200 reports of dicama injury, affecting more than 3 million acres of soybeans, are being investigated nationwide, according to the University of Missouri's Integrated Pest Management program. Northeastern Arkansas is ground zero for the damage.

In Mississippi County, a sprawling horizon of soybean and cotton fields one hour northwest of Memphis, Tenn., 240 dicamba misuse complaints were filed this year—one quarter of all of the complaints in the state.

David Wildy, a task force member who pushed for an April 15 cutoff date for spraying the chemical, is one of the most vocal critics of the new formulations. A silver-haired grower of soybeans, corn, and other crops from Manila, in the northeastern part of Arkansas, he's earned awards for his high production, management style, and outreach to the agricultural community.

Earlier this season, Wildy estimated his loss from soybean damage to be a little shy of $1 million, injury that is not covered by federal crop insurance or private insurance unless a neighbor admits to spraying dicamba and agrees to cover the loss with liability insurance.

"This technology is driving a wedge between farmers," he told Bloomberg BNA.

Arkansas was the only state of 34 not to approve XtendiMax for use, despite allowing farmers to plant Extend seeds that can withstand applications of dicamba. The Plant Board denied XtendiMax's approval because university scientists were not able to do independent tests, particularly under local conditions, Arkansas Agriculture Department spokeswoman Adriane Barnes told Bloomberg BNA in an email. This dampened their confidence in the product.

In A Pickle

Monsanto's vice president of global strategy Scott Partridge said the refusal to approve the use of Xtendimax drove farmers to use older versions of dicamba not suitable for use with the company's genetically-modified seeds. It's no surprise that Arkansas has fared the worst in the dicamba crisis, Partridge told Bloomberg BNA.

"I can understand why Arkansas is scrambling," he said. "I think they got themselves into a bit of a pickle."

Some states that have seen little to no problems with dicamba, a pattern BASF attributes to more in-person training. Arkansas Agriculture Secretary Ward told Bloomberg BNA that his state relied on the protocol for Mississippi, which did not require face-to-face training.

On a press call Aug. 17, BASF pointed to the in-person training in states like Alabama, North Carolina, and Georgia as a likely reason for fewer complaints in those states.

"We do recognize differences in agriculture around the country, but we shouldn't be quick to discount the value of in-person and face-to-face training," Scott Kay, vice president of U.S. Crops forBASF, said. "We do believe that's an important contributor to their reduced numbers of alleged complaints coming from those states."

But Norsworthy said those differences could be attributed to different agricultural systems, like smaller fields and forests interspersed with farmland.

In that county, a farmer was shot and killed after a dispute with a dicamba-spraying neighbor last year. At the time, Xtend seeds were legal, but the Environmental Protection Agency had not yet approved the new versions of dicamba, leading to widespread "off-label" use. It is illegal to use older versions of dicamba on the genetically-engineered plants.

This year was supposed to be different. The EPA approved the new formulations last November, more than a year after the Agriculture Department allowed for Monsanto's Xtend seeds to go on the market. But this year's calls to the Arkansas Plant Board have far outpaced last year's 33 complaints, 23 of which were confirmed to be dicamba injury.

Record Soybean Crop

The crisis won't lead to a national soybean shortage. On the contrary, the U.S. is set to break its soybean record this year, and Arkansas is expected to produce 400,000 more acres than in 2016, with a slight increase in yields per acre, according to USDA. Monsanto Chief Technology Officer Robb Fraley said Aug. 29 that the company is planning to supply enough Xtend seeds for up to half of the U.S. soybean acreage for next year's growing season.

But that gain comes at a significant cost, Wildy said. Sycamore trees are wilting. Tomato plants are wiped out. Wildy needs and wants the technology. But if this is the price of progress, he says, it's not worth it. Non-agricultural plants—from ornamental trees to flowers that feed honeybees—have been affected too.

"When the general public gets involved, to me that's very serious," he said, referring to the broader number of groups affected.

Wildy planted about 300 of his 3,300 soybean acres with Xtend seeds this year. He said he will plant more next year as a protective measure if the state Plant Board allows continued use. Farmers pay about $8 more per acre for dicamba-resistant beans than for LibertyLink seeds, Bayer AG's technology that matches glufosinate-tolerant crops to a new version of the herbicide glufosinate—another result of farmers' clamor for tools to beat weeds.

Arkansas farmer Blackburn tends to 1,700 acres with his brother in Greene County. Last year, he was hit with a wave of dicamba that damaged his soybeans. This year, he went on the defense. The brothers planted every acre of their soybeans to be dicamba-resistant. It was an extra expense, he said, but worth it. It worked wonderfully until late June, when the state imposed its ban.

That bothers Blackburn. This new technology has brought benefits to farmers, and smearing the formulations with a broad brush means a step backwards.

"We followed all of the regulations, all of the guidelines," he said. "They're sort of making it out to be that everybody who sprays this stuff is an outlaw, is a criminal."

Still, Blackburn thinks the product is "flawed" because it's been so easy for farmers to misuse.

An April 15 cutoff wouldn't work for Blackburn, who spends that month planting corn and begins sowing soybeans in May.

'This Is A Product That Is Broken'

The task force meetings on Aug. 17 and Aug. 24 were held at the Winthrop Rockefeller Institute, atop the fog-covered Petit Jean Mountain north of Little Rock. Named after the state's Republican governor who pushed for civil rights and prison reform in his state, the resort-like stone lodge serves as a neutral outpost to discuss the region's most pressing matters, from rural healthcare to agricultural trade with Cuba.

The dicamba matter may be the most contentious issue addressed there yet. Norsworthy gave an hour-long presentation to the audience of about 50 at the Aug. 17 meeting, summarizing a number of his field studies on the new dicamba formulations.

In one experiment that was replicated by scientists at the University of Tennessee, Norsworthy covered certain soybeans with buckets in a field where he sprayed XtendiMax (Monsanto's dicamba herbicide) and Engenia (BASF's new formulation). He removed the buckets 30 minutes after spraying, and soon after, the plants exhibited the telltale signs of dicamba damage. Had it been drift, the weedkiller would have moved away from the areas in minutes, Norsworthy said.

In another trial, Norsworthy sprayed two 3.5 acre plots with Engenia and XtendiMax each, with wind traveling 2.9 miles per hour. Though applied well below the label instruction limit of 15 miles per hour, the herbicide traveled more than 300 feet. With field sizes in the thousands of acres, a real life situation could see dicamba travel well beyond the state's quarter-mile buffer zone, he said.

His conclusion: When it comes to volatility, there's no buffer big enough, no nozzle spray fine enough, no wait period long enough, to control the movement. Drift can be controlled by the type of nozzle, by the boom height, and by refraining from spraying at times of high wind speed and at certain times of the day.

The distinction between drift and volatility is important. Regulations and label instructions on its use can control physical drift. Volatility is uncontrollable, Norsworthy said.

"This is a product that is broken," he told the task force Aug. 17.

Those findings bristled the handful of manufacturer representatives present, who had just a few minutes to defend their new herbicides. The presentation, they said, would taint farmers' opinions of the product and bring on hasty recommendations to restrict a necessary tool for clearing weeds.

"I wasn't happy with the process," Dan Westburg, a BASF technical services manager with a doctorate in weed science, told Bloomberg BNA at the meeting.

Companies worked hard to suppress this in their new formulations. Monsanto's proprietary VaporGrip technology was developed specifically to reduce volatility by preventing the formation of dicamba acid in a solution.

Perry Galloway, a farmer in Northeastern Arkansas and proponent of the technology, agreed that a presentation from only the extension scientists was "biased."

'Dicamba Is Heavier Than Air'

The companies brought their concerns to the Arkansas Plant Board. A week later at the second task force meeting, Monsanto deployed three scientists to defend their data. BASF had one presentation.

Monsanto has conducted extensive volatility studies since 2009, company scientists said at the Aug. 24 meeting. Those studies, mostly done in closed enclosures called humidomes, show that dicamba concentration in the air drops dramatically in the first day, meaning it can't volatilize and travel far.

"Volatility does occur, it absolutely occurs, but the amount that occurs will happen very quickly in 24 hours," Ty Witten, North America Crop Protection Systems Lead for Monsanto, told the participants. "Dicamba is heavier than air, it's going to fall over time."

Can dicamba drift? Yes, said Witten, maybe by 40 or 100 feet. But not by half a mile or ten miles, as some have suggested.

Tom Mueller, a professor of weed science at the University of Tennessee Institute of Agriculture, challenges this 24-hour claim from Witten in recent trials. He found that dicamba concentrations in the air can shoot back up the day following an application after dipping overnight.

Mueller has repeated this trial several times. "It always follows the same pattern," he told Bloomberg BNA.

Mueller attributes the increase in concentrations to higher temperatures the following day rather than in the evening. Heat drives volatility, and researchers link the dicamba problems to a relatively new phenomenon in its use. Older formulations were applied only on corn in the cooler temperatures of early spring, he said, whereas the new versions are being sprayed in 90-degree June weather.

The EPA ultimately will decide the herbicide's future. The agency gave companies a provisional two-year registration for the herbicides in 2016 and it is investigating the complaints and meeting weekly with Arkansas and other states affected via teleconference.

The underlying causes of the various cases of damage are not yet clear, EPA spokesman Robert Daguillard said, "but EPA is reviewing the available information carefully."

If the EPA revokes the registration, or imposes greater restrictions, on use of the herbicides, they would not go into effect until the 2019 growing season. That leaves another year of rising tensions in the Heartland.

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From: Google Alerts
To: Baris, Reuben
Subject: Google Alert - Dicamba
Date: Tuesday, August 29, 2017 10:03:15 PM

Dicamba

Daily update · August 30, 2017

NEWS

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EPA Responds to Dicamba Complaints

by:- Ag Professional

Since June 2017, the EPA has learned of formal dicamba off-target complaints for this growing season. And as the soybean season progressed, those complaints continued north into Ohio, Nebraska, Minnesota, North Dakota and South Dakota.

"The agency is very concerned by off-field dicamba damage," says Reuben Baris, acting branch chief of EPA's Office of Pesticide Programs, Registration Division herbicide branch. "The underlying causes are not yet entirely clear. We are evaluating all available information."

There have been 2,400 formal dicamba complaints. There are 3.1 million acres of soybeans affected, and that total doesn't include other crops.

"We don't consider this normal growing pains for a new technology," says Dan Kenny, Office of Pesticide Programs, Registration Division Deputy Director (Acting). "We don't feel it's helpful to solve a problem for one grower and create a problem for another."

The agency officials say the issue with dicamba is very dynamic, and as soon as numbers are reported, they are outdated.

The regulatory agency is reacting to potentially make changes for the 2018 growing season. Of note, EPA has regulatory oversight for the pesticides—not the traited seed.

"We are working as fast as we can to make meaningful changes for the 2018 growing season. We are working with the registrants to make meaningful regulatory changes so growers are able to make the most informed decisions for the 2018 season," Baris says.

Additionally, the current follow up is informing the approval process for the dicamba formulations, BASF's Engenia and Monsanto's XtendiMax with Vapor Grip Technology, which is also licensed to DuPont and sold as FeXapan, which were registered with a two-year expiration timeframe.

"The 2-year expiration was put in place because of the concerns about resistance and off-target movement. After our review a few things could happen. The expiration could be removed if everything is working well. In the worst-case the risks outweigh the benefits, and the registration expires," Kenny says.

While the expiration provides a looming deadline, it could be a tool to find resolution.

"Expirations can help get everyone at the table in a short time frame. We hope we can make this a workable program. More tools are important for growers. We have to ensure these products meet the registration standard in order to protect human health and the environment, otherwise, our hands are tied," Kenny says.

Dicamba Call with States 8/23/2017

Reuben Baris, Dan Kenny introduction. We're looking for feedback on what we can/want to do as soon as possible. We want growers to have access to information ASAP so they can make informed choices for 2018 season.

These are elements that we've entered into negotiation with the 3 registrants: Classifying these products as restricted use (record keeping) - Waiting on registrants to voluntarily do that, wind speed restriction, tractor speed restriction, timing of application, required training.

Tony Cofer from Alabama -Didn't have a lot of tools to approach this process appropriately early on. Tried to do what they could do in short turn-around time. Individual states could see this coming – and the SLNs were the states' effort to get some control. Would have preferred as a state restricted use, but didn't have time. They did the 24c with mandated training and wind restriction. Not sure if this had an effect, but record keeping would be essential, and timing of application would be good to look at. Maybe with a date cutoff. Probably growth stage restriction. Don't know how you get enhanced training onto federal label. Not all states are set up to do enhanced training. Training requirement should be put on registrant. We're forcing people into buying into new technology out of fear. Need to differentiate between old and new products. A marker or registrant is required to give up polymer analysis to the labs.

Cary Giguere – Vermont. Make it restricted use, require additional training. Do something about volatilization. Unfortunate that we're still talking theoretical changes at this point. It's a seed technology problem more than herbicide problem.

Reuben Baris - Apologized that we're not farther along in negotiations, but wanted to keep the partnership with the states going. EPA considering options for making the 2018 products – separate registrations. Asking for your feedback on that proposition.

Arkansas – Jason Norsworthy. Weed scientists now have a better understanding of data. Field trials are pointing to volatilization. Many others have the same data. Most of the regulatory suggestions EPA thinking about focus on physical drift – not volatility. If we're going to shift a product from burndown to over the top product, there's nothing we can do for a volatile product as far as label changes. Measuring volatility up to 72 hours after treatment in the field. Not sure what path forward would be. Acreage is going to be much higher in 2018, and these solutions won't address that. Willing to continue to share data.

EPA asked for label language examples that may address the issue based on his data. Jason - working on collecting the data to help with that. Still seeing volatility at 80 degrees (lower than earlier this season.)

Question: Are studies done in other states at lower temperatures? Volatilization is not fully understood, and we don't know the threshold that will result in minimal risk. Not sure what other states are seeing.

? Bradley - University of Arkansas. Supports what Jason said. Cutoff date could make a difference. Not sure what kind of education program they could put together for a volatile product.

Dan K: RUP would help with compliance. Record keeping could help with knowing what happened when. Tractor and wind speed restrictions would help with drift. Temp restrictions, humidity restriction, growth stage restriction, and allowing a single application only are other options. Eliminating double cropping applications or time of year restrictions.

David Wayne – Kentucky. Low number of complaints. Having a RUP would be beneficial. Cutoff dates would be a moving target for each state, and be cumbersome. Training is not the best way to fix the issue.

Tommy Gray - Georgia. Agree with use restrictions, would support these products being federally restricted use with agronomic crops covered under supplemental label. How would it happen? Spending a lot of time looking at purchasing info for generic products. It would help us monitor products and track via dealers

Kerry Richards? - National pesticide safety education center. Possibly package Georgia's training via livestream videos to other states. May be a coordinated message throughout country.

Andrew Thostenson – ND State. Tommy's query about RUP designation - One thing to have an RUP for new formulations, but there's been significant off label use of generics on Xtend beans. Concerned whether RUP would be for generics as well? Dan R. - It's unresolved. Goals for this intervention are focused on cotton and soybeans, and changes to generics would take us longer then would be effective in 2018 use season.

Dan K- Restricted use requires recordkeeping, so would protect against misuse of generics.

Paul Bailey - Missouri Department of Ag. FIFRA doesn't require private applicator to keep records.

In Pennsylvania they require record keeping for private applicator.

Dave Scott - Indiana. Question for Tommy Gray. Any official complaints? No. Presentations this morning showed that with this technology increasing next year, it's going to get so much worse. Homeowners don't know what to look for yet, in terms of damage.

Dan K. - We are looking for something that could help. Anyone on the call have any ideas?

Cary Ann Rose? from Ohio. Like the hard and fast date restriction. Or make it an early post emergence product. R1 is too late. It's definitely volatility.

Andrew Thostenson. ND. The date would be great, but not practical across states. Growth stage wouldn't be a good idea, because planting dates vary greatly. Possible temperature thresholds. Have to make them stick? The label is too complicated now.

Tony from APCO – label is too complicated now, and people are never going to comply if we make it even more complicated.

Andrew says growth stage is dramatically different across the state. Cotton? Double cropped beans?

Jim Reese - Oklahoma. Can't each state register the products as restricted use if they choose? Yes, so why is everyone asking for it to be federal restricted use?

Karen: Did Arkansas ban the use of these products? Yes. What was the grower pushback? The ban offered the crop an opportunity to recover from the damage.

Bob Spencer - Idaho Dept of Ag. Are the applicators already certified? Will making it RUP really solve the problem? If RUP, there are Record keeping requirements for private applicators under USDA.

Dave Scott - If applicators are all using the product correctly, when does it turn into a stop sale and an enforcement case to the companies? Brought up Imprelis example. Dan K– SSURO would be possible

Cofer: we need to make a quick decision. Growers need to know how to approach next year. Also state agencies don't have resources to support this issue. Another year of this isn't possible. If product is beyond salvaging – that call needs to be made. Listen to research scientist. EPA and state agencies can't take another year like this. We don't have the resources.

Cary from Vermont asked about monetary support from EPA for states.

From: Green, Jamie
To: Kenny, Daniel; Baris, Reuben
Cc: Taylor, Maren; Ridnour, Lacey; Hackett, Shawn; Frizzell, Damon
Subject: FW: Letter to Topeka paper
Date: Tuesday, August 22, 2017 9:48:12 AM

In case you had not seen:

Posted August 20, 2017 07:10 pm

Letter: Time for Kansas to outlaw use of Dicamba

Several states have outlawed the use of Dicamba for weed control on soybeans. (2016 file photograph/The Associated Press)

This year has begun the large scale use of Monsanto's Roundup Ready 2 Xtend soybeans, which are genetically modified and tolerant to chemical Dicamba. Dicamba is a broad-spectrum broadleaf (non-grass plants) control chemical. It has been used for years in the spring with Corn.

Until recently, Dicamba use has been limited to use at lower temperatures (85 degrees and below). At higher temperatures, Dicamba tends to volatize (volatization is when a field is sprayed and afterward the chemical travels to an off-target location (sometimes miles away). When a Dicamba-tolerant soybean was developed, Monsanto and BASF both worked on developing a "low-volitatzation" Dicamba. (Xtend Max and Ingenuity) In fact, these two products are the only ones labeled to be used on the Dicamba-tolerant soybeans.

It hasn't worked out well. Off-target damage is rampant all across the country and here in Kansas. I know of several farmers who have non-Xtend soybeans and have had damage on most of their fields from neighbors who used a Dicamba program on their soybeans. I have a neighbor whose garden was "nuked" by off target Dicamba, and I have had soybeans and clover damaged as well.

Several states have outlawed the use of Dicamba in Soybeans, and it's time for Kansas to do so as well. There are many other options for weed control in soybeans. The Xtend systems are by far the most hazardous to neighboring farms, gardens and vineyards. One of the primary roles of our government is the protection of private property. If our government fails to stop this Dicamba disaster by ignoring property rights, then we have started down a slippery slope that ends in anarchy. Where have all the flowers gone? Dicamba.

ROSS WAHL, Riley

From: Green, Jamie
To: Kenny, Daniel; Baris, Reuben; Pease, Anita; Jones, Arnet; Wormell, Lance; Vizard, Elizabeth; Lott, Don; Chism, William
Cc: Ridnour, Lacey; Frizzell, Damon; Hackett, Shawn; Taylor, Maren
Subject: FW: Off-target Movement of Dicamba in Missouri. Where Do We Go From Here?
Date: Tuesday, August 22, 2017 9:54:08 AM

FYI - In the event Dr. Bradley didn't send this along himself

From: Slade, Darryl [mailto:Darryl.Slade@mda.mo.gov]
Sent: Tuesday, August 22, 2017 8:42 AM
To: Hackett, Shawn <hackett.shawn@epa.gov>; Green, Jamie <Green.Jamie@epa.gov>; Frizzell, Damon <Frizzell.Damon@epa.gov>
Subject: Off-target Movement of Dicamba in Missouri. Where Do We Go From Here?

https://ipm.missouri.edu/IPCM/2017/8/Off-target_movement/

Darryl Slade
Enforcement Program Coordinator
Missouri Department of Agriculture
Plant Industries Division
Office: (573) 751-5511
agriculture.mo.gov

Integrated Pest Management
University of Missouri

Off-target Movement of Dicamba in Missouri. Where Do We Go From Here?

Kevin Bradley
University of Missouri
(573) 882-4039
bradleyke@missouri.edu (mailto:bradleyke@missouri.edu)

PUBLISHED: AUGUST 21, 2017

The situation. In 2017, there have been numerous instances of off-target movement of dicamba throughout the state of Missouri and beyond. While the majority of the injury on a per land unit area has definitely occurred in the boot heel of Missouri, there are many problems with off-target movement of dicamba in the rest of the state. The Missouri Department of Agriculture is currently investigating over 280 dicamba-related injury cases (Figure 1), and based on University of Missouri Extension field visits, we estimate 325,000 acres of soybean injured by dicamba across 54 counties in Missouri. On a national scale, there are now more than 2,200 dicamba-related injury investigations being conducted by various state Departments of Agriculture, and more than 3.1 million acres of soybean estimated with dicamba injury (see our recent update here (https://ipm.missouri.edu/IPCM/2017/8/Update-on-Dicamba-related-Injury-Investigations-and-Estimates-of-Injured-Soybean-Acreage/)). In my opinion, we have ***never*** seen anything like this before; this is not like the introduction of Roundup Ready or any other new trait or technology in our agricultural history.

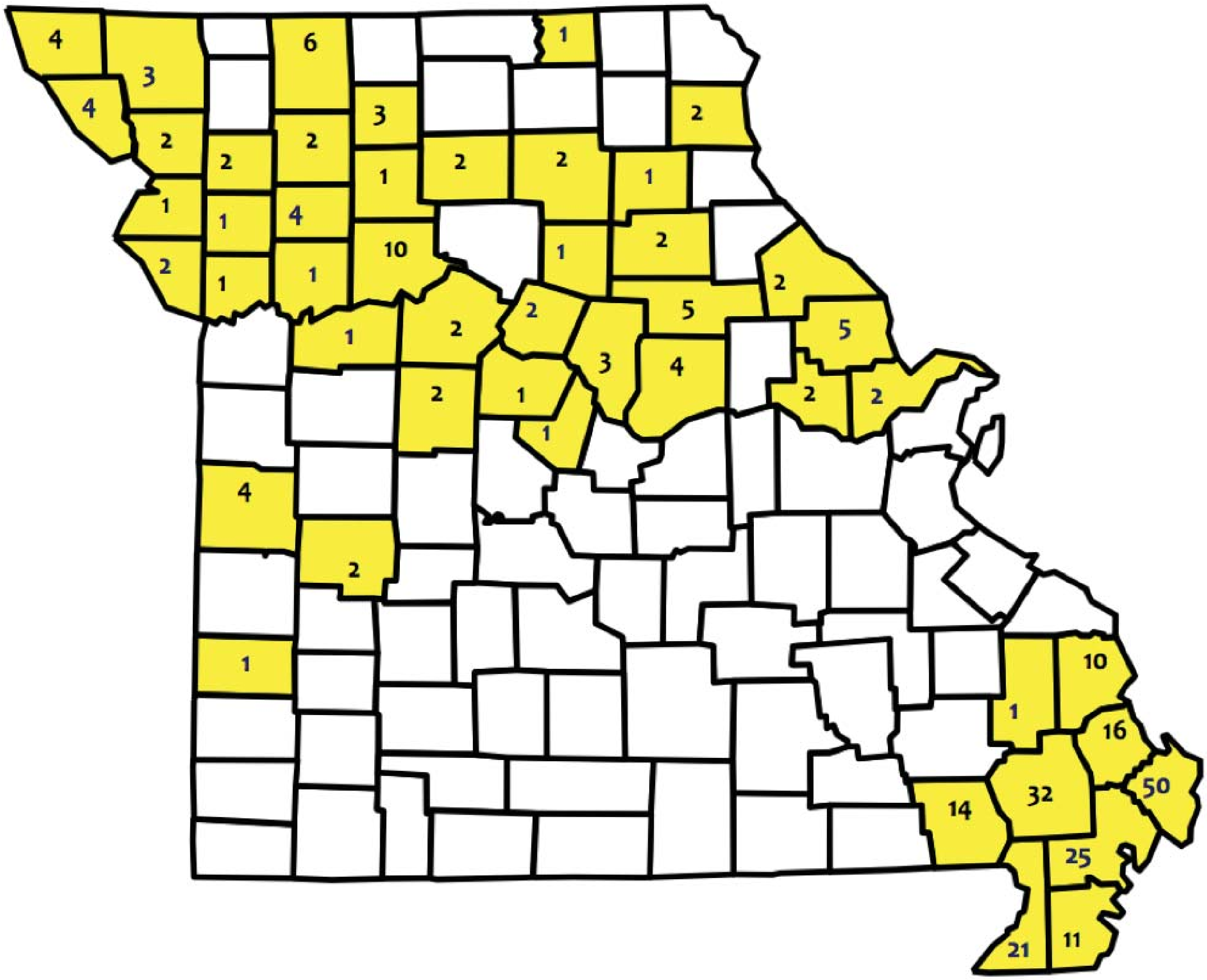


Figure 1. Official dicamba-related injury investigations as reported by the Missouri Department of Agriculture (updated August 17, 2017).

Reasons. In my opinion, there are basically four routes by which dicamba can move away from its intended target, and we have experienced every one of these in 2017. The real debate seems to be about what percent of the total off-target movement should be placed into each one of these categories.

First, dicamba can move off-target by way of physical drift at the time of application. This can occur due to spraying when wind speeds are too high, use of improper nozzles that produce fine droplets, or to a host of other factors that we can just chalk up to "bad sprayer decisions or set-up at the time of application." There's no doubt that physical drift of dicamba has occurred this season and that this is one of the major reasons for off-target movement of dicamba. But it isn't the only reason. I have visited and talked with many farmers and applicators who have done it right and still experienced movement of dicamba away from the direction of the prevailing winds at application.

A second way that dicamba can move off-target is through tank contamination. This usually occurs due to improper spray tank cleanout. Unfortunately, many have learned the hard way that it takes very, very little dicamba in the tank to cause problems on non-Xtend soybean that are sprayed after a dicamba application. There's no doubt that some portion of our issues with off-target movement of dicamba have been due to improper sprayer cleanout and tank contamination. However, many growers with injured soybean fields didn't even plant any Xtend soybean or spray a dicamba product through their sprayers. Some retailers also have dedicated sprayers for dicamba products only.

Another way that tank contamination can occur is through contamination of an actual herbicide product, such as what Monsanto says has occurred with a certain generic glufosinate product. I'm not aware that any trade names of glufosinate products have been put forth or of any actual data presented about this potential problem at the time of this writing, but of course contaminated glufosinate could not explain any of the injury we have seen on Roundup Ready or conventional soybean, or any of the other vegetable or ornamental crops or trees that have been injured by dicamba.

A third way that dicamba can move away from its intended target is through temperature inversions. Temperature inversions usually occur in the evening hours around sunset when the air nearest the earth's surface becomes cooler than the air above it. This cooler air forms a stable mass that can be moved horizontally along the earth's surface and then can deposit anything that may have been in it once it dissipates. So for example, if an application of an approved dicamba product is made at 7 or 8 PM into a temperature inversion, any fine droplets that may have been part of this application may not land on the intended target, but instead may be redistributed some distance away once the temperature inversion dissipates the next morning. As a result of our work on temperature inversions over the past several years, our data indicates that we usually experience a temperature inversion at least one-half to two-thirds of the days in June and July, and that these inversions typically start around 6 to 8 PM and persist for 8 to 10 hours. Also as a result of funding from Missouri soybean growers, we now have a network of weather stations (http://agebb.missouri.edu/weather/realTime/maps/index.php#temp_inversion) in Missouri that are able to tell users whether or not an inversion is occurring. There is some off-target movement of dicamba that occurred in 2017 that can be explained by spraying directly into a temperature inversion, but in my opinion most of our applicators are now very aware of this possibility and have avoided these evening or nighttime applications. However, another possible way that dicamba droplets could end up in an inversion is through volatilization, which brings me to the fourth point.

The final way that dicamba can move away from its intended target is through volatility. Dicamba is an inherently volatile herbicide. We know that the older formulations of dicamba are more volatile and are illegal to apply. So if illegal applications of the older generic dicamba products have been applied, I have no doubt that dicamba has moved off-site in those applications through volatility. But in my experiences and discussions with farmers and retailers throughout the state, it does not seem that illegal applications of these older formulations have occurred on a wide scale with any regularity. I do not believe that the scope and scale of this issue can be explained away by illegal applications of older dicamba formulations.

As most on all sides of this issue are well aware, both BASF and Monsanto have taken steps and invested a lot of money to make these newly approved formulations less volatile. And they are less volatile. But as many have said, less volatile does not mean not volatile. We have been in the process of gathering volatility data on these newly approved dicamba products for several months. All of our results thus far indicate that we can detect dicamba in the air following an application of Engenia or XtendiMax/Fexapan for as many as 3 or 4 days following the application. University weed scientists in surrounding states are seeing similar results in their research. And so we come to the crux of the matter. I have yet to hear any manufacturer of the approved dicamba products say that volatility is one of the possible ways that dicamba has moved away from its intended target in 2017. But yet many university weed scientists like myself believe this is one of the major routes by which off-target movement of dicamba has occurred, because our air sampling data, field volatility studies, and field visits indicate that to be the case. To say that all of these problems have occurred due to physical drift, tank contamination, or temperature inversions but not volatility is, in my opinion, disingenuous at best.

My recommendation. We are in the process of trying to understand how or if these cases can be correlated back to any particular environmental condition such as air or soil temperature, moisture, humidity, etc. That process isn't easy and it can't be done quickly, and any conclusions we can make will only be as good as the data we can get. I'm not sure what that process will yield, but from where I sit right now the only conclusions I can make are that the areas in Missouri that planted the most of the Xtend trait and sprayed the most Engenia, XtendiMax, or Fexapan are the areas where we saw the greatest amount of off-target movement and damage.

I know farmers are looking for answers and will soon be making decisions about their traits and weed management programs for next year. So my recommendation for those growers who wish to plant the Xtend technology is to go back to using dicamba at a timeframe and in a manner when it has been used "successfully" in the past. Based on our history of dicamba use in corn in April and May, and even on our experiences this year using these approved dicamba products in pre-plant burndown applications prior to June, we have seen far fewer problems with off-target movement of dicamba in that timeframe than what we experienced in June, July, and August. Even this season I was not notified of any problems with off-target movement of dicamba until early June, and the Missouri Department of Agriculture didn't receive their first dicamba complaint until June 13th. It seems that almost all of the problems with off-target movement occurred once in-crop, post-emergence applications started to be made for waterhemp and Palmer amaranth. Most of those occurred in June and July this season. I wish I had some definite date for a cutoff but at this time I do not; we will be conducting more weather analyses in the coming weeks and hopefully this process will help us understand which factors lead to more risk when applying these herbicides.

So for the sake of neighboring non-Xtend soybean fields, trees, vegetable crops, gardens, ornamentals, and our industry as a whole, my recommendation for those who want to plant the Xtend trait in 2018 is to use the approved dicamba products for the control of resistant horseweed (a.k.a. marestail), ragweed species and winter annuals in the pre-plant burndown where these products have a great fit, but to abstain from applying these products later in the season. In Xtend soybean, resistant waterhemp will have to be managed using an integrated approach that includes cultural practices like cover crops, narrow row spacings, etc. along with an overlapping residual herbicide program. For more information on managing waterhemp in different soybean system, see this multi-state publication: *Waterhemp Management in Soybean* (http://weedscience.missouri.edu/publications/50737_3_TA_FactSheet_Waterhemp.pdf).

Printed from: https://ipm.missouri.edu
E-mail: IPM@missouri.edu

From: Sorokin, Nicholas
To: AO OPA OMR CLIPS
Subject: Reuters: U.S. farmers confused by Monsanto weed killer"s complex instructions, 8/21/17
Date: Monday, August 21, 2017 10:06:14 AM

Reuters
http://www.reuters.com/article/us-usa-pesticides-labels-idUSKCN1B110K
U.S. farmers confused by Monsanto weed killer's complex instructions
By Tom Polansek and Karl Plume, 8/21/17

CHICAGO (Reuters) - With Monsanto Co's (MON.N) latest flagship weed killer, dicamba, banned in Arkansas and under review by U.S. regulators over concerns it can drift in the wind, farmers and weed scientists are also complaining that confusing directions on the label make the product hard to use safely.

Dicamba, sold under different brand names by BASF (BASFn.DE) and DuPont (DD.N), can vaporize under certain conditions and the wind can blow it into nearby crops and other plants. The herbicide can damage or even kill crops that have not been genetically engineered to resist it.

To prevent that from happening, Monsanto created a 4,550-word label with detailed instructions. Its complexity is now being cited by farmers and critics of the product. It was even singled out in a lawsuit as evidence that Monsanto's product may be virtually impossible to use properly.

At stake for Monsanto is the fate of Xtend soybeans, it largest ever biotech seed launch.

Monsanto's label, which the U.S. Environmental Protection Agency (EPA) reviewed and approved, instructs farmers to apply the company's XtendiMax with VaporGrip on its latest genetically engineered soybeans only when winds are blowing at least 3 miles per hour, but not more than 15 mph.

Growers must also spray it from no higher than 24 inches above the crops. They must adjust spraying equipment to produce larger droplets of the herbicide when temperatures creep above 91 degrees Fahrenheit. After using the product, they must rinse out spraying equipment. Three times.

"The restriction on these labels is unlike anything that's ever been seen before," said Bob Hartzler, an agronomy professor and weed specialist at Iowa State University.

The label instructions are also of interest to lawyers for farmers suing Monsanto, BASF and DuPont over damage they attribute to the potent weed killer moving off-target to nearby plants.

A civil lawsuit filed against the companies in federal court in St. Louis last month alleged it might be impossible to properly follow the label. Restrictions on wind speed, for example, do not allow for timely sprayings over the top of growing soybeans, according to the complaint.

The companies failed "to inform the EPA that their label instructions were unrealistic," the lawsuit said.

Monsanto said that while its label is detailed, it is not difficult to follow.

"It uses very simple words and terms," Scott Partridge, Monsanto's vice president of strategy, told Reuters. "They are not complex in a fashion that inhibits the ability of making a correct application." BASF and DuPont could not immediately be reached for comment on the lawsuit on Friday.

Monsanto and BASF have said they trained thousands of farmers to properly use dicamba. Monsanto also said the crop damage seen this summer likely stemmed largely from farmers who did not follow label instructions.

Those detailed instructions led some growers and professional spraying companies to avoid the herbicide altogether.

Richard Wilkins, a Delaware farmer, abandoned plans to plant Monsanto's dicamba-resistant soybeans, called Xtend, this year because a local company would not spray the weed killer.

"The clean-out procedure that you have to go through to ensure that you don't have any residue remaining in the applicator equipment is quite onerous," he said.

In Missouri, farm cooperative MFA Inc said it stopped spraying dicamba for customers last month partly because high temperatures made it too difficult to follow the label.

STUDYING WIND, TEMPERATURES

The EPA is reviewing label instructions following the reports of crop damage.

Monsanto has a lot riding on the EPA review. The company's net sales increased 1 percent to $4.2 billion in the quarter ended on May 31 from a year ago, partly due to higher U.S. sales of Xtend soybeans. Since January, the company has increased its estimate for 2017 U.S. plantings to 20 million acres from 15 million.

One confusing requirement on its dicamba label, farmers said, prohibits spraying during a "temperature inversion," a time when a stable atmosphere can increase the potential for the chemical to move to fields that are vulnerable.

To follow the rule, some growers used their smart phones to check weather websites for wind speeds and information on inversions.

"You have to be a meteorologist to get it exactly right," said Hunter Raffety, a Missouri farmer who believes dicamba damaged soybeans on his farm that could not resist the chemical.

Nicholas Sorokin
Office of Media Relations Intern

U.S. Environmental Protection Agency
Telephone: (202) 564-5334
sorokin.nicholas@epa.gov

From: Green, Jamie
To: Kenny, Daniel; Baris, Reuben; Jones, Arnet; Chism, William; Pease, Anita; Wormell, Lance; Vizard, Elizabeth; Lott, Don
Cc: Frizzell, Damon; Hackett, Shawn
Subject: FW: Dicamba update 8-17-17
Date: Sunday, August 20, 2017 10:31:49 AM
Attachments: Dicamba update 08-17-2017.pptx

Latest report – contains some information on specialty crops, etc. that have been damaged in addition to soybeans. Also has an interesting graph illustrating the number of complaints they received both pre and post their SSURO and revised labeling. It's not clear to me whether the reductions in complaints were due primarily to the label changes or is more related to the bulk of the applications occurring earlier.

From: Slade, Darryl [mailto:Darryl.Slade@mda.mo.gov]
Sent: Friday, August 18, 2017 2:48 PM
To: Green, Jamie <Green.Jamie@epa.gov>; Frizzell, Damon <Frizzell.Damon@epa.gov>; Hackett, Shawn <hackett.shawn@epa.gov>
Cc: paul.bailey@mda.mo.gov
Subject: Dicamba update 8-17-17

Dicamba update 8-17-17. I have added one new slide to the presentation. A chart tracking Dicamba complaints received per time period and comparing when SSURO and 24c labels were issued.

Darryl Slade
Enforcement Program Coordinator
Missouri Department of Agriculture
Plant Industries Division
Office: (573) 751-5511
agriculture.mo.gov

MISSOURI DEPARTMENT of AGRICULTURE

DICAMBA UPDATE

August 17, 2017

Agriculture.Mo.Gov

2016 DICAMBA COMPLAINTS

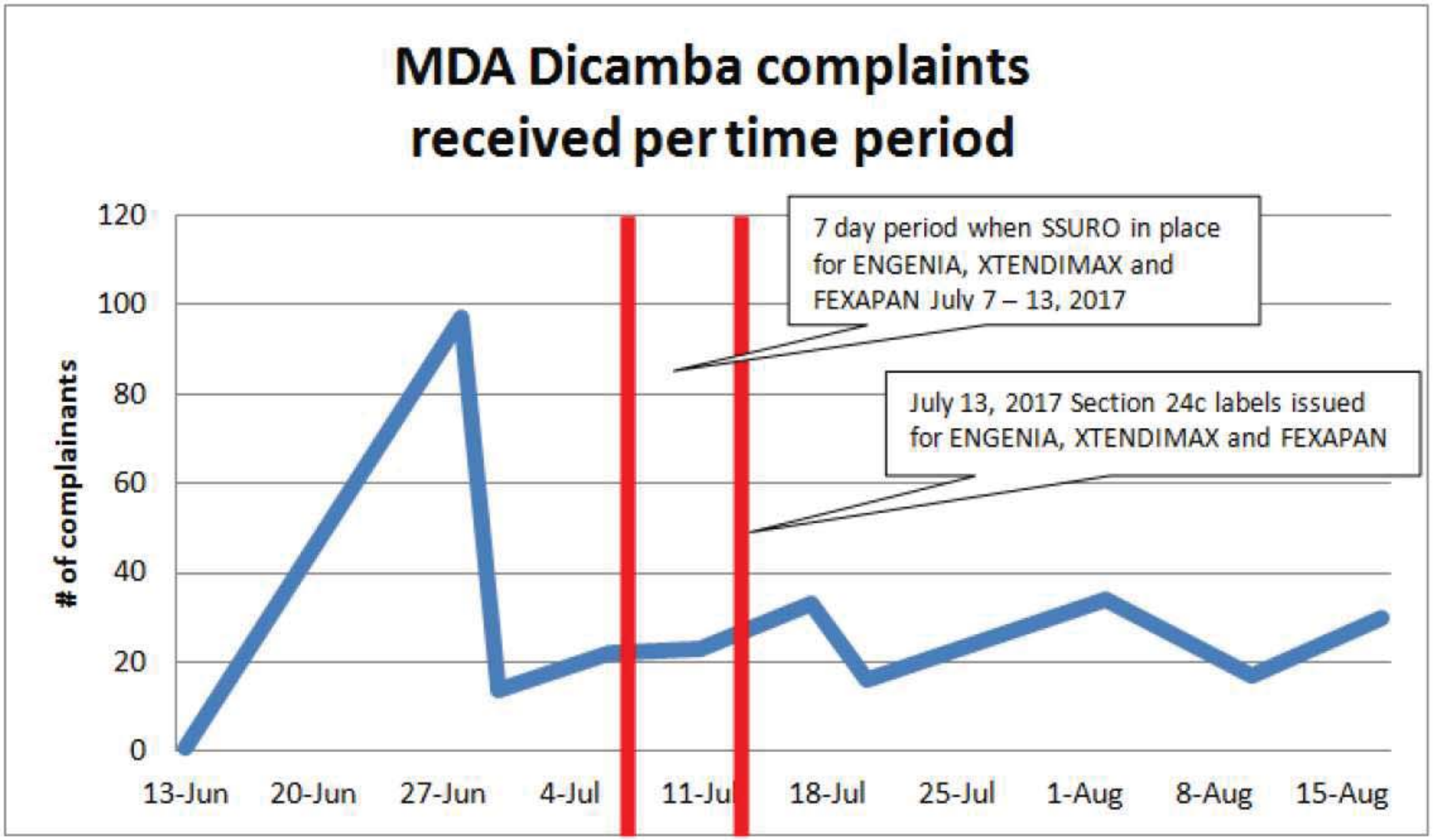
- 130 – Total Dicamba complaints for 2016
- June 22, 2016 - Received first Dicamba complaint

2017 DICAMBA COMPLAINTS

- 287– Dicamba complaints received (as of COB 8/17/2017)
- June 13, 2017 - Received first Dicamba complaint

Agriculture.Mo.Gov

2017 DICAMBA COMPLAINTS



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2017 DICAMBA COMPLAINTS

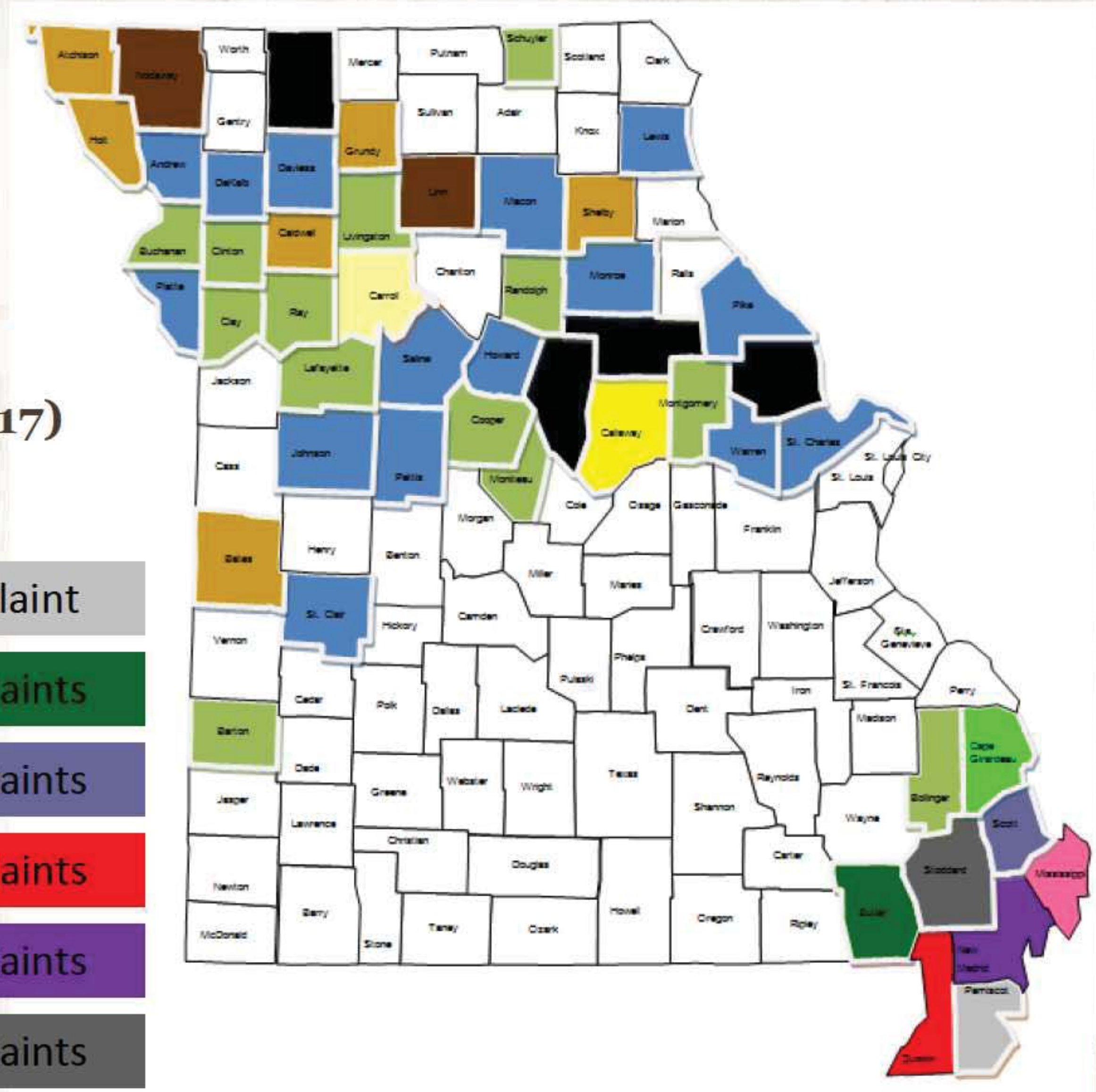
Crops damaged as identified by complainants:
(as of 8/17/2017)

- 106,687 acres of soybeans
- 18,904 tomato plants
- 758 acres of peaches
- 130 acres rice
- 122 acres of watermelons
- 122 acres of vineyards
- 35 acres of alfalfa
- 24 acres certified organic vegetables
- 15 acres of pecan trees
- 12 acres of apple trees
- 11 commercial gardens
- 10 acres of cantaloupes
- 2 acres of pumpkins
- 900 mums
- 34 residential properties (gardens/trees/shrubs)

Agriculture.Mo.Gov

2017 Dicamba Complaints
(as of COB 8/17/2017)

1 Complaint	
2 Complaints	12 Complaint
3 Complaints	14 Complaints
4 Complaints	19 Complaints
5 Complaints	24 Complaints
6 Complaints	28 Complaints
10 Complaints	31 Complaints
11 Complaints	59 Complaints

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From: Bradley, Kevin
To: Baris, Reuben
Subject: Re: WSSA committee
Date: Friday, August 18, 2017 12:03:06 PM
Attachments: A68295E2-4431-4EF5-944A-3488169A97FC[7].png
5939E0CA-ECB1-4FAB-9D4D-0C2C4E8C81AE[7].png
DC0AC5B9-FA42-47CB-A189-C396E5A5E7E4[7].png

Reuben, this is what we have come up with at this point in time. Is this what you had in mind?

The following species sensitivity rankings are based on published literature and/or studies:

Extremely Sensitive:
Grapes
Lima Bean
Southern Pea
Snap Bean
Soybean
Tobacco
Peach
Elderberry
Dogwood
Oaks
Viburnum

Very Sensitive:
Cotton
Pepper
Pumpkin
Tomato
Watermelon

Moderately Sensitive:
Cantaloupe
Cucumber
Squash
Apple
Maple
Elm
Redbud
Rose

Dogwoods

Low Sensitivity:
Peanut
Broccoli
Cabbage
Kale
Mustard
Turnip
Walnut
Pecan
Raspberry
Strawberry
Sweetgum
Crabapple
Hydrangea

Species which appear to be sensitive based on observations from the field but no published data:
Ginkgo
Paulinao
Frindge
Sycamores
Cypress
Boxelder
Birch
Catalpa
Honeylocus
Spruce
Poplar

Kevin Bradley, PhD
Associate Professor,
Division of Plant Sciences
University of Missouri

Weed Science Website: http://weedscience.missouri.edu
Weed ID Website: http://weedid.missouri.edu

Follow us on:

From: "Baris, Reuben" <Baris.Reuben@epa.gov>
Date: Tuesday, August 15, 2017 at 12:36 PM
To: Kevin Bradley <bradleyke@missouri.edu>
Subject: RE: WSSA committee

Hi Kevin,
Thanks for the quick response. If you don't mind holding off on scheduling the call, I think that will allow us to better formulate and organize our thoughts around a larger teleconference. In the meantime, there is one item that I think the committee would be able to provide quick feedback on, and that is a list of sensitive plants. Either stemming what has been formally/informally reported in terms of complaint or incidents or your observations from the field. We have been so focused on soybeans that we have not discussed (in as granular a focus) all the other sensitive crops, fruits, vegetables, ornamentals, and trees (etc.). The idea being that this would potentially feed into training and stewardship.
Thank you again for your continued engagement. It certainly is extremely helpful to know we have a wealth of knowledge and experience just a short call away.
Sincerely,
Reuben

Reuben Baris | Acting Chief | Herbicide Branch
U.S. Environmental Protection Agency, Office of Pesticide Programs | (703) 305-7356

From: Bradley, Kevin [mailto:bradleyke@missouri.edu]
Sent: Tuesday, August 15, 2017 1:21 PM
To: Baris, Reuben <Baris.Reuben@epa.gov>
Subject: Re: WSSA committee

Can you propose a time, or several times, that you are available next week and we can schedule a call then? Or do you just want to wait until you know for sure you need something?

Kevin

From: "Baris, Reuben" <Baris.Reuben@epa.gov>
Date: Tuesday, August 15, 2017 at 10:04 AM
To: Kevin Bradley <bradleyke@missouri.edu>
Subject: RE: WSSA committee

Hi Kevin,
Sorry for the delay in getting back to you regarding the WSSA committee. We are still in negotiations with the Registrants on label changes. So I'm not exactly sure what's needed in terms of help at this very moment. But in the next few days or early next week we will certainly need feedback from you and your colleagues on the registration structure. That is to say once we have a better handle on

how these products will be structured for the 2018 growing season. I think a conference call in the next week would be helpful to provide WSSA's feedback to the agency.

Thank you.
Reuben

REUBEN BARIS | ACTING CHIEF | HERBICIDE BRANCH
U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF PESTICIDE PROGRAMS | (703) 305-7356

From: Bradley, Kevin [mailto:bradleyke@missouri.edu]
Sent: Thursday, August 10, 2017 7:56 PM
To: Baris, Reuben <Baris.Reuben@epa.gov>
Cc: McFarland Janis USGR <janis.mcfarland@syngenta.com>; Mike Barrett <mbarrett@uky.edu>
Subject: WSSA committee

Reuben,

As per our phone conversation the other day, I wanted to let you know that the WSSA has formed a special committee to be used as a resource by you (EPA) pertaining to off target movement of dicamba. This committee is comprised of 9 university academics as well as two individuals from ag co-operatives that are closely associated with spraying these products across large acreages in the Midwest and mid-south. Now that we have the committee formed, I wanted to reach out to you directly and ask how we might be able to help? What information can we provide? Would you like for me to arrange a conference call between you and the committee? If you tell me what information you are looking to obtain, I can work with the committee to get that to you. If you are looking for opinions and thoughts about a variety of topics related to all this, a call might be better at least initially. Thanks.

Kevin Bradley

From:	Baris, Reuben
To:	"MARVIN, THOMAS [AG/1920]"; "Maximilian M Safarpour"; "Patricia.G.Devine@dupont.com"
Cc:	Keigwin, Richard; Goodis, Michael; Rosenblatt, Daniel; Kenny, Daniel
Subject:	dicamba follow up
Date:	Thursday, August 17, 2017 4:45:00 PM

Hello,
I am writing to you all in an attempt to remove any ambiguity on the next steps and action items stemming from recent discussions on dicamba between EPA and registrants of pesticide products approved for use on dicamba-tolerant soybean and cotton. Our expectation was for you all to send the EPA your proposed label changes pursuant to the elements discussed in these meetings (e.g., RUP, wind speed restrictions, tractor speed restrictions, application timing, clarification on buffer requirements, temperature restrictions, growth stage restrictions, second cropping, etc). Our task will be to ensure consistency across the registrations.

There will be a lot more discussions in short order in terms of implementing any meaningful changes to your registrations, but we need to understand what the amendments will be in order to better inform the implementation discussions. As Rick indicated in these meetings, our goal is to ensure these technologies are available to growers for the 2018 season, but we are moving very quickly implementing regulatory changes in an effort to ensure growers are able to make the most informed decisions for the 2018 season. We are working in partnership with our state regulatory colleagues to overcome any potential hurdles in the state registration process, and ultimately we are working collaboratively with each of you.

We look forward to receiving your revised labels. Please let me know if you have any questions.
Thank you.
Reuben

Reuben Baris | Acting Chief | Herbicide Branch
U.S. Environmental Protection Agency, Office of Pesticide Programs | (703) 305-7356

From: Green, Jamie
To: Baris, Reuben; Kenny, Daniel; Jones, Arnet; Pease, Anita; Miller, Michele; Wormell, Lance; Hopkins, Yvette; Lott, Don; Vizard, Elizabeth
Subject: FW: Article
Date: Thursday, August 10, 2017 2:48:20 PM

FYI

From: Slade, Darryl [mailto:Darryl.Slade@mda.mo.gov]
Sent: Thursday, August 10, 2017 1:35 PM
To: Green, Jamie <Green.Jamie@epa.gov>; Hackett, Shawn <hackett.shawn@epa.gov>; Frizzell, Damon <Frizzell.Damon@epa.gov>
Subject: FW: Article

https://www.arktimes.com/arkansas/farmer-vs-farmer/Content?oid=8526754

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Enforcement Program Coordinator
Missouri Department of Agriculture
Plant Industries Division
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agriculture.mo.gov

From: May, Melissa
Sent: Thursday, August 10, 2017 1:31 PM
To: Bailey, Paul; Wall, Dawn; Slade, Darryl; Grundler, Judy
Subject: FW: Article

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From: Jason Robertson [mailto:Jason.Robertson@aspb.ar.gov]
Sent: Thursday, August 10, 2017 12:33 PM
To: May, Melissa
Subject: Article

https://www.arktimes.com/arkansas/farmer-vs-farmer/Content?oid=8526754

Good dicamba article

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NEWS » COVER STORIES AUGUST 10, 2017

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Farmer vs. farmer

The fight over the herbicide dicamba has cost one man his life and turned neighbor against neighbor in East Arkansas.

By David Koon

click to enlarge

BRIAN CHILSON

IN MONETTE: Karen Wallace, widow of Mike Wallace, wants to see the pesticide dicamba banned.

At the peak of summer in the little town of Monette in Craighead County, the soybeans and cotton in surrounding fields a jealous green, the pear tree that stands 20 feet from the grave of Mike Wallace looks like it has been blowtorched, every leaf blighted, curled and black at the edges. It's the ugly residue of drifting dicamba, the herbicide for which Wallace literally gave his life.

According to investigators, on Oct. 27, 2016, Wallace, who farmed 5,000 acres of corn, soybeans and cotton near the Arkansas/Missouri border, arranged by phone to meet a farmhand named Allan Curtis Jones, 26, of Arbyrd, Mo., on West County Road 38 north of the Mississippi County town of Leachville to discuss Wallace's suspicions that the farm where Jones worked was the source of drifting dicamba that had damaged some of Wallace's crops. Wallace, who had been vocal in his opposition to the herbicide, had been quoted in an August 2016 story in The Wall Street Journal, telling the newspaper that at least 40 percent of his soybean crop had been damaged by drifting dicamba since June. He'd filed complaints twice with the Arkansas State Plant Board, the state agency that oversees claims of crop damage, about damage from drifting dicamba and had encouraged other farmers to report their damage as well.

When Wallace and Jones met outside of Leachville, Jones brought along his cousin and a gun. According to statements issued by Mississippi County Sheriff Dale Cook at the time of the shooting, Jones told investigators that an argument had ensued. In the midst of it, Wallace, who was not carrying a weapon, grabbed Jones by the arm. At that point, investigators say, Jones pulled away, pulled his pistol, and fired into Wallace's body until the magazine was empty. Wallace, a father of two who'd farmed in Mississippi County since he was a boy, was hit at least four times, and died in the dust on the south shoulder of the county road, with Jones' cousin using his shirt in a futile attempt to stop the bleeding. Jones soon was arrested on a charge of first-degree murder, and later released on $150,000 bond.

Whether the shooting was self-defense or homicide will be up to a jury. Jones is scheduled to go to trial Sept. 11. A spokesman for the Mississippi County Sheriff's Office referred all questions about Wallace's murder to the prosecutor for Mississippi County. The prosecutor handling the case did not return a call seeking comment at press time. Calls to the Blytheville defense attorney representing Jones also went unreturned at press time.

However the case against Jones turns out, Wallace's family has been working since his death to see justice done in another way: by trying to get the use of dicamba banned statewide. A 120-day ban was put in place in early July, the fine for illegal spraying of the herbicide increased 25-fold on Aug. 1, and a task force was established to look for solutions.

But a permanent ban on dicamba would run afoul of the needs of farmers, who are facing a shrinking pool of options in the fight against herbicide-resistant weeds, and of corporate investment in genetically modified, dicamba-tolerant crop technology that is easily worth billions. It's a quest that has put Wallace's family at odds with many of their neighbors and, in some ways, even their own best interests as farmers. But they say it is a fight Mike Wallace would make if he were alive.

On the wind

Developed in 1958 by the German-based chemical company BASF and first used on corn crops in the mid-1960s, dicamba is a plant-hormone-mimicking herbicide that's deadly to a host of weeds and other plants, including many common vegetable crops and species of ornamental flowers and trees, like the Bradford pear that stands near Wallace's grave. While it works like gangbusters against pigweed, which has been a bane of row crop agriculture long before the plant began developing a stubborn genetic resistance to glyphosate-based herbicides like Roundup, cotton and soybean farmers in East Arkansas didn't use it much during the growing season because dicamba is highly lethal to those crops, which have long been the lifeblood of the area. Even a light dose of dicamba on soybeans can cause curled leaves, stunted plants and a reduction in yield. A medium-to- heavy misting can kill them outright. That, combined with dicamba being prone to drift if applied improperly and its "volatility" — the tendency to change back to a vapor, lift off of crops and float away to neighboring fields under the right atmospheric conditions — would have made the idea of Arkansas farmers spraying large amounts of dicamba in high summer unthinkable 10 years ago, not to mention illegal. Until this year, spraying dicamba beyond April 15, after vulnerable crops had emerged from the soil, was against the law in Arkansas, with violations carrying up to a $1,000 fine. When it was used, dicamba was mostly employed as a "burn down" herbicide to clear an agricultural slate in preparation for planting, before the plants it might harm had sprouted or leafed out.

But that was then. This is now.

click to enlarge

ALLAN CURTIS JONES

In 2015, the Missouri-based agricultural giant Monsanto released its Xtend brand cottonseed. A year later it put out Xtend soybeans. Both are genetically modified to be tolerant of dicamba. Potentially worth billions, the GMO technology promised to be a new weapon in farmers' ongoing fight against several stubborn weed varieties, including pigweed, resulting in higher yields and incomes. To farmers stretched thin, it must have sounded like a godsend.

The new dicamba-tolerant seeds hit the market quickly, and more cotton and soybean farmers began to plant them. But they could not yet use a legal dicamba-based herbicide on their crops, because one was not available. BASF's Engenia, advertised as being less likely to drift off target, was not approved for use in the state until fall 2016, and another low-volatility dicamba formulation, Monsanto's Xtendimax with Vapor Grip, is still not approved for use in Arkansas.

Early adopters who had purchased dicamba-tolerant seed with the expectation they'd soon be able to spray their fields with reformulated dicamba and watch weeds melt away were disappointed with the progress of getting the lower volatility formulas approved. Whether out of greed, historically tight financial margins or desperation at out-of-control weeds, some farmers became outlaws in 2015 and 2016, spraying older, more drift- and volatility-prone formulas of dicamba on their dicamba-tolerant crops, knowing that even if they got caught, the $1,000 fine amounted to a speeding ticket when compared to the increased profits they stood to reap. In the same August 2016 Wall Street Journal article that featured Wallace speaking out about dicamba damage, an assistant director of enforcement with the Arkansas State

Plant Board was quoted as saying she'd been openly told by farmers spraying dicamba in violation of the law: "We'll write you a check." If a farmer has 5,000 acres or more under cultivation, all planted with dicamba-tolerant seed, it's not hard to divide by $1,000 and do the financial math.

With some farmers planting dicamba-tolerant crops in proximity to their neighbors' dicamba-susceptible crops and then spraying the older formulations of dicamba, the result in recent years has been like dropping a bomb on East Arkansas agriculture. According to a report released July 25 by a scientist at the University of Missouri, 17 states have received reports of dicamba-related crop damage since the dicamba-tolerant seeds were introduced, with an estimated 2.5 million acres affected. Arkansas was the hardest hit by far, according to the report, with an estimated 850,000 acres of crops in the state damaged. As of early August, the State Plant Board had received over 840 complaints of suspected dicamba-related issues. Gardens and landscaping, some of it miles away from the nearest dicamba-tolerant fields, were scorched and stunted. In a moment that might be funny if it wasn't so indicative of the chaos that's been sown in East Arkansas, the damage this year included 100 acres of soybeans unexpectedly whacked by drifting dicamba at the University of Arkansas's Northeast Research and Extension Center in Mississippi County. A June press release on the damage noted ironically that the damaged soybean plots, which had to be plowed under and replanted, were to be used in research on dicamba drift and volatility. In another irony that might be shocking if it weren't so sad, members of Mike Wallace's family, who have every reason in the world to hate dicamba and what the controversial herbicide has done to relationships in the close-knit farming communities of Northeast Arkansas, planted a sizable part of their acreage this year in dicamba-tolerant crops, solely in self-defense. Tales of defensive planting of dicamba-tolerant seeds have become common, with a kind of forced monopoly-by-attrition taking hold. According to Monsanto, 18 million acres of dicamba-tolerant soybeans were planted in the U.S. this year, including 1.5 million acres in Arkansas — about half the total estimated soybean crop in the state.

Having approved the use of BASF's Engenia in the fall of 2016 over the objections of the Wallace family, the State Plant Board reversed itself on June 23 and voted to recommend a temporary ban on the "in-crop" use of dicamba-based herbicides, a decision that soon received the approval of Governor Hutchinson. A statement released by Monsanto after the Plant Board's vote said the board didn't allow farmers who had already planted dicamba-tolerant seeds to describe how a ban would affect their operations. "Instead," the statement read, "the Board based its decision on off-target movement claims that are still being investigated and have not been substantiated. ... Arkansas farmers should not be forced to continue to operate at a disadvantage to farmers in other states where bans like the board's current proposed action do not exist."

The issue was referred to a joint meeting of the state House and Senate committees on agriculture, economic development and forestry on July 7. By the time the joint committee meeting started at 9 a.m. that day, the room's large, curved gallery was packed, legislators in suits shoulder to shoulder with farmers in plaid shirts and mesh trucker caps who'd driven through the dawn from East Arkansas to be there. The public comment period was crowded and divided: farmers talking about their extensive dicamba-related crop damage vs. farmers talking about the need for the new technology to help solve their herbicide-resistant weed problems. A representative from a small poultry producer told the committee that his niche business model of selling non-GMO chicken was being threatened by damage to the soybeans his business grows for feed. Weed scientist Dr. Ford Baldwin, who called dicamba the biggest train wreck to ever hit agriculture, told the assembled legislators that the day before the meeting, a farmer in that very room had been involved in a fistfight with another farmer over crop damage. He didn't say whether the farmer in question was for or against the ban.

As it has been at every state-level meeting on dicamba that's been held since October 2016, Wallace's family was there, pushing for a ban. Kerin Hawkins, Wallace's sister, addressed the committee. The month after her brother's death, she and other members of her family had pleaded with the Plant Board to ban dicamba, but BASF's lower-volatility formulation Engenia had been approved with restrictions, including a quarter-mile buffer zone between dicamba spraying and non-dicamba-tolerant crops. Hawkins appeared again in July to ask the joint committee to support the ban. She said that in addition to damage to her family's peanut crops, their 10-acre garden patch inside the city of Leachville, which she said is over a quarter mile from any dicamba spraying, had also been damaged by drift.

After the joint committee voted to recommend the ban, an eight-member subcommittee of the Arkansas Legislative Council officially took no action on the plan, which allowed the 120-day ban on in-crop dicamba use to go into effect on July 11. A $25,000 fine for illegal spraying of the herbicide went into effect last week.

click to enlarge

KNOWING THE KILLER HERBICIDE: Weed scientist Dr. Ford Baldwin.

An act of man

State Rep. Joe Jett, a Republican who lives at Success in far Northeast Arkansas, is a retired farmer and looks the part. A supporter of the temporary ban, Jett attended the July 7 meeting and invited Baldwin to speak. Jett said heavy rains in Northeast Arkansas this spring helped keep dicamba damage from being worse this year, simply because farmers couldn't get into the waterlogged fields to spray. "Had it not been for that," Jett said, "I think the atmosphere would have really loaded up with dicamba and you would have seen a lot more widespread damage than what we saw as it was."

Jett said he is in favor of advanced technology to help farmers, including genetically modified seeds, but wouldn't use dicamba himself "in good, clear conscience" given the damage he's seen in Northeast Arkansas. "Knowing that we're going to go out here and hurting people and putting ourselves in front of our neighbors? I can't get my head wrapped around that," he said. "Obviously you're always going to have some folks out there who don't care what's right and who are going to take care of themselves. But I think a lot of it is that the margins are just so tight [in farming], and farmers need every break they can get. They're willing to look the other way and be more worried about themselves surviving than they are about their neighbors surviving. I think that's a lot of it."

Asked whether members of the legislature have discussed a way to financially assist farmers in the state hit by dicamba-related crop loss, Jett said the state is on a tight budget and will be unlikely to help. "I don't know how you could ever get into that," he said. "Farmers have insurance, but [the damage] can't be manmade. It has to be an act of God. To answer your question: No, I think that's probably beyond the state. We don't have the means to help in that regard." Federal crop insurance only covers losses due to drought, flood or natural disasters. The only remedy for those farmers whose incomes were damaged by dicamba may be to sue, and some are doing that. There are at least two civil suits against Monsanto and BASF over dicamba use in Arkansas, one representing farmers who planted non-Xtend crops and suffered losses due to dicamba drift, and another by farmers who planted Xtend seeds expecting to be able to use the lower-volatility formulations of dicamba but can't because of the ban. Both lawsuits are seeking class-action status.

Terry Fuller, a member of the State Plant Board who runs Fuller Seed and Supply in Poplar Grove in Phillips County and farms 3,000 acres near the Indian Bay community, spoke in favor of the ban at the July 7 meeting. While he said farmers in his area appear to be abiding by the dicamba ban for the most part, he believes the reduction in yields to non-dicamba resistant crops caused by damage early in the season could be severe.

click to enlarge

BRIAN CHILSON

DRIFT: A Bradford pear tree near her Wallace's grave shows the damage dicamba causes to vegetation, including crops.

"It's going to be dire because we didn't ban it sooner," Fuller said. "It's crazy how much damage we've got, and it's going to be real damage. It's going to amount to millions." Fuller, who told the joint committee in July that he couldn't leave his house in any direction without seeing extensive crop damage caused by dicamba, said he believes the companies behind the dicamba-tolerant seed and low-volatility herbicide are engaging in "a strategy to force everybody to plant" the dicamba-tolerant seed. While the chemical companies have tried to put at least some of the blame for damage in Arkansas this year on misapplication of Engenia, Fuller said he doesn't buy it. "I contend that we've got world-class farmers; the best there are anywhere in the world," he said. "I don't just believe they were applying [Engenia] right, I absolutely, positively know that a lot of it was applied exactly right."

The sad part, Fuller said, is that some of those world-class farmers are the ones getting the black eye. "We're trespassing on our neighbors, and we're trespassing on our neighbors in town," he said. "It's not just our neighbor farmers. There's a lot of damage in yards. You hate to say that and call attention to it, but it is a reality."

Baldwin agrees, and has similar concerns about how the dicamba damage will play to a public already spooked about herbicides. A respected weed scientist who worked for the University of Arkansas for 27 years, Baldwin retired in 2002 and now runs a consulting business, Practical Weed Consultants, with his wife. Baldwin has been something of the Paul Revere of the chaos dicamba-resistant-seed technology could potentially bring to agriculture.

"I said four years ago that dicamba would drive a wedge between farmers, which it has," Baldwin told the Arkansas Times. "You've got 50 percent that wants the technology and 50 percent that doesn't want the technology and don't want the dicamba sprayed on them. And it's going to drive a wedge between agriculture and nonagriculture. I'm not being critical of anybody or slamming anybody. It's just the way it is."

In his testimony before the joint committee in July, Baldwin spoke of his suspicions that even the new, officially less-volatile formulation of dicamba is moving from field to field or even traveling miles away due to volatility and temperature inversions that pull the chemical off sprayed crops and into the air at night. Ford talked of farmers inadvertently "loading the air" with dicamba, which then floated around in the atmosphere like invisible smoke until temperature fluctuations forced it down on farms and yards, decimating crops and ornamental plants almost as if it was sprayed there on purpose.

Baldwin said he never believed he'd see farmers show such disregard for each other as they have since dicamba-tolerant crops were introduced. He called the murder of Wallace "the low point" of his career. "I never dreamed I would see farmers show the insensitivity toward each other in some cases," Baldwin said. "That doesn't apply across the board. But you know some farmers just have the attitude: 'My neighbor knew I was planting Xtend crops, so it's his own fault that I damaged him. He should have planted Xtend crops, too.' Well, hell, he's got a right to plant anything he wants to plant and not have it damaged."

Though the less-volatile forms of dicamba seem like a solution to the drift problems being experienced by farmers, Baldwin said the science of the herbicide seems to show that dicamba's volatility may be a very difficult problem to solve

— one he believes the companies have downplayed. "The problem is there's a difference between less volatile and nonvolatile," Baldwin said. "It's my understanding that there were some totally nonvolatile dicambas developed back in the early days of the herbicide. The problem was that the weed-control efficacy declined as the volatility declined. ... That doesn't mean it couldn't be revisited, but the best information we have right now is there is a relationship between volatility and weed control efficacy [in dicamba]."

Baldwin doesn't believe operator error in spraying BASF's less-volatile version of dicamba and scofflaws continuing to spray older, cheaper formulations of the herbicide in violation of the law account for all the damage he saw early in the 2017 growing season.

"If you go east to Crowley's Ridge, every single field that's not a dicamba [tolerant] crop is basically damaged, and has the same level of damage," he said. "A lot of these fields are several miles away from where any dicamba was applied. You can't do that with physical drift. Drift is the blowing of physical spray particles, and you can't blow those as far as a lot of people think before you blow them completely away. Now you can do a lot of damage close to the source, don't get me wrong. But when you go in areas where every field looks exactly the same over a countywide area or multiple county area, common logic tells you that you're getting the same dose rate of a herbicide spread over a vast number of acres. The only way you can do that is to load the air — load stable air masses during temperature inversions and move it that way."

From the beginning, Baldwin said, everybody knew dicamba-tolerant crops had to be an "all or nothing technology," which will have to be planted on 100 percent of acres before damage to nontolerant crops will cease. But even if farmers plant every acre of cotton and soybeans in the state in dicamba-resistant seeds, Baldwin notes, that still doesn't solve the problem of damage to landscaping, trees, ornamental plants, vegetable gardens and other vegetable crops. He believes that aspect will be bad for agriculture as a whole.

"You get into the horticultural crops, then you get into the home gardens and you get into the trees in town," he said. "To me, the more dicamba we put in the air, the more you're going to affect these other types of vegetation. You might solve the soybean issue short term, but you're going to get this thing outside of agriculture. All of a sudden, when peoples' gardens are affected, when the trees in their yards are affected, then they're going to start asking the questions: 'Is this stuff safe for me to eat? Is it safe for me to breathe?'"

click to enlarge

THE WALLACE FAMILY: Mike kneels on right.

The long row

In a house at the edge of a cotton field in Monette, the crops stretching away to the edge of the world in all directions, Karen Wallace talked about the husband she has to go on without. He was born within three miles of the spot, and started his first crop at 17. Married her at 18. Put her through college so she could realize her own dream of being a teacher. Raised two kids and saw them have children of their own. He was, she said, a man always thinking of the community, the kind of guy who would go around town with his own equipment after rare snowfalls and clear the driveways of elderly folks who'd plowed their lives into the soil of Craighead and Mississippi counties.

"He wasn't a farmer that farmed out of the seat of his truck," Karen said. "He was a hands-on farmer. He was in the field daylight until dark. That was just his life." Which is, of course, what makes his death so hard to understand.

Karen said that in 2015, Mike attended one of the first meetings in the area about the introduction of dicamba-resistant seed at Delta Crawfish in Paragould. "At the meeting, Monsanto just kept discussing that they were going to release the seed, though the herbicide had not been approved yet, but kept telling farmers that by growing season it would be," she said. "We didn't plant any dicamba [tolerant] cotton that year, but we had neighbors that did." Wallace estimates they suffered $150,000 worth of crop damage from dicamba that first year. The issues in the area have only accelerated since then.

"I don't think I've ever seen anything like this that has turned farmer against farmer," Mike's sister, Pam Sandusky, said. "They've always been there to help each other do whatever." Karen Wallace agreed that dicamba-tolerant crops have turned the ethics of farming topsy-turvy. "It was like the farmers who turned their neighbors in [for illegal dicamba use], they're the bad guys," Karen said. "It was like, 'You're causing something we really need to be taken away.' It's just crazy to me."

The day her husband was killed, Wallace said, she'd run an errand in Kennett, Mo. The harvest done, he was leveling ground. Though she knows now that Mike had gotten a number for Allan Curtis Jones from an acquaintance, she said he'd never mentioned the name to her or their son, Bradley, and didn't tell either of them he planned to meet outside of Leachville.

"He told me, 'I'll be right back,' " Wallace said, "and that was that. I never talked to him again."

As soon as her husband was killed, everybody seemed to know it immediately. Word got back to her quickly. Not knowing what else to do, she and several family members met at the gin in Monette, which is run by Mike's cousin. She called her sister in Jonesboro, pleading with her to get to her daughter, Kimberly, who was attending an event at Arkansas State University. By the time she did, Kimberly had already heard through a post on Facebook.

"This man is probably going to claim self-defense," Karen said. "Mike is 56 years old. This man was 26. He's 30 years younger than him, probably 50 pounds heavier. He went and got his cousin. Mike never carried a gun. We don't know why he decided to shoot him."

There were over 1,000 people at Mike Wallace's funeral, the line to pay respects stretching out the door of the First Baptist Church and into the parking lot. When he was buried in the little cemetery in Monette, the farmers for miles around brought their tractors, a burbling second line, and ringed the paved lane around the graveyard. "I knew Mike had a lot of friends," Karen said. "But for that many people to pay their respects to Mike was just unbelievable. It was overwhelming."

The death has been hard on the whole family. Kerin Hawkins, another Wallace sister, displayed two photos. One is of their mother, Mary, standing in deep cotton with son Mike two weeks before his death. Another shows Mary, at least 30 pounds lighter, surrounded by family at this year's Fourth of July celebration.

"I didn't even realize it until we took this picture in July," Hawkins said. "I thought, 'We're losing her.'

"They took Mike from us. They took Mike from his family, from his grandchildren. He had a grandchild born this year, his first grandson with the Wallace name. His grandson will never know him."

Still, both Wallace and Hawkins say they joined many of their neighbors and planted dicamba-tolerant crops in self-defense, knowing they might take a hit bad enough to wipe them out if they didn't. "That's what my husband and my sons did this year," Hawkins said. "We've got all dicamba cotton. ... We were afraid of what would happen to us. It wasn't that we necessarily wanted to plant it. It's that we had to."

Mike Wallace was more than a brother to them, Hawkins and Sandusky said. Abandoned by their biological father when he was a teenager, Mike Wallace stepped up, becoming a father figure, protector, counselor and friend. "One of the first things I said to my husband whenever I found out what happened and that Mike was gone, was, 'I feel like an orphan,' " Sandusky said. "I never realized how much I looked to him, because our dad kind of walked out of our lives. I never realized how much I looked to him for answers, for help, for everything. He took over, and I never realized it until we lost him."

Farming has changed since Wallace started, Karen Wallace said, and not for the better. "I think we're in a society where we want the easiest way out," she said. "The easiest way, the fastest way, regardless of who it hurts or what happens. But farming is not like that. Farming is hard work. Mike was willing to put out the work." There's work to be done now, and Wallace is not here to do it, so Sandusky, Hawkins, Karen Wallace and other family members will keep making the long drive to Little Rock any time there's a meeting on dicamba. They want to see the state's temporary ban made permanent.

"We were raised to be there for each other," Hawkins said. "If one person was hurting in the family, you were there for them. You were there to back them up. You always had their back. It didn't matter. He would have done the same for us. He would be there fighting for us, and we're not going to let him down. We cannot let them get away with what they've done and what they've taken from us."

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Speaking of...

Legislative Council approves dicamba ban

January 19, 2018

by Max Brantley

The Legislative Council today signed off without discussion on a Plant Board rule to ban the use of the herbicide dicamba between April 16 and Oct. 31. /**more**/

UPDATE: Arkansas Plant Board votes again to ban controversial herbicide dicamba

January 3, 2018

by David Koon

The Arkansas State Plant Board is holding a special meeting at this hour to discuss changes to their proposed ban on the controversial herbicide dicamba in the coming growing season. /**more**/

Dicamba task force report to Plant Board recommends ban on herbicide after April 15

September 13, 2017

by Benjamin Hardy

Some regulatory progress is being made on addressing the damage dicamba has caused to many Arkansas farmers. The report says that almost 1,000 complaints alleging dicamba misuse have been filed with the state plant board as of September 1. /**more**/

Monsanto urges state not to ban dicamba

September 7, 2017

by Lindsey Millar

In a letter to Governor Hutchinson on Thursday, agriculture giant Monsanto asked the state to reject a state task force's recommendation that Arkansas ban the use of dicamba herbicides after April 15, 2018. The Arkansas Legislative Council previously imposed a 120-day ban on dicamba use effective July 11. Also, Reuters reports the EPA is considering banning the spraying of dicamba after a certain date next year. /**more**/

Governor backs Plant Board on new pesticide rules

January 4, 2017

by Max Brantley

Gov. Asa Hutchinson has approved the state Plant Board's proposed rule changes to place additional restrictions on the herbicde dicamba. /**more**/

Herbicide use leads to slaying in Mississippi County UPDATE

October 29, 2016

by Max Brantley

KARK reported yesterday the shooting death of a Mississippi County farmer, Mike Wallace of Monette, and the arrest of another farm worker, Allan Jones, in an argument over herbicide drift. /**more**/

NPR: herbicide-resistant GMO soybeans from Monsanto inviting damage from East Ark. scofflaws.

August 1, 2016

by David Koon

A new piece from NPR about chemical giant Monsanto's roll-out of a herbicide-resistant soybean — and the damage drifting sprays are doing to the crops of East Arkansas soybean farmers who haven't made the switch to Monsanto's frankenseeds — is worth a read. /**more**/

Mike Wallace interviews Orval Faubus

April 9, 2012

by Max Brantley

CBS correspondent Mike Wallace died Saturday at 93, leaving a career with more reportorial milestones than you could easily count. /**more**/

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Attachments:	17-VP5-TSPB-report with temp.pdf ATT00001.htm

Sent from my iPhone

Begin forwarded message:

> **From:** "Steckel, Larry" <lsteckel@utk.edu>
> **Date:** July 28, 2017 at 12:15:43 PM EDT
> **To:** "'Baris, Reuben'" <Baris.Reuben@epa.gov>
> **Cc:** "Mueller, Thomas C" <tmueller@utk.edu>
> **Subject: TN data**

Effect of adding Roundup PowerMax to Engenia on vapor losses under field conditions

Thomas C Mueller
University of Tennessee

July, 2017

Background

Dicamba injury to soybeans widespread throughout soybean producing regions of Tennessee

This study requested by Tennessee Soybean Promotion Board (TSPB)

Specific question :

What is the effect (if any) on dicamba volatility from adding RoundupPowermax (Rmax) to the tank while applying Engenia

Methods

- Field plots established using farmer-scale equipment (30 foot boom, T nozzles) following label rates and instructions (late June 2017)
- Plot size = 200*200 ft (~ 1 acre per each treatment)
- High Volume air samplers used to collect dicamba vapors from within the treated area
- Samples collected at 4 different intervals at various hours after treatment (HAT), with 4 samplers in each treated plot
  - 0-6 HAT (morning of application)
  - 6-12 HAT (afternoon of application)
  - 12-24 HAT (overnight)
  - 24-36 (day after initial application)

Methods

Herbicide treatments included:

ngenia alone at 12.8 fl oz/acre

ngenia at same rate + Rmax at 32 fl oz/acre

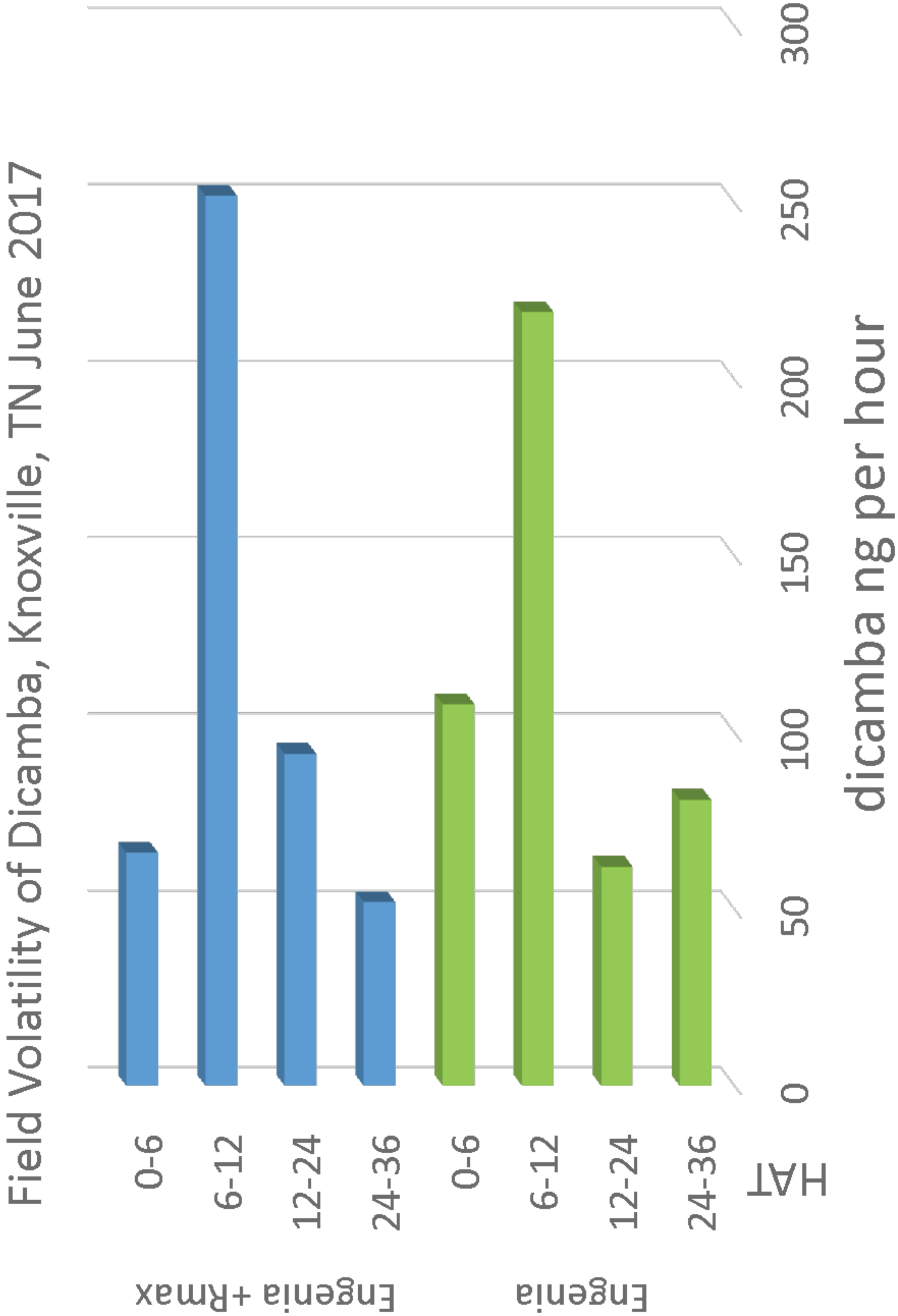
Untreated control

pplications were made early in the AM of first day (0 HAT)

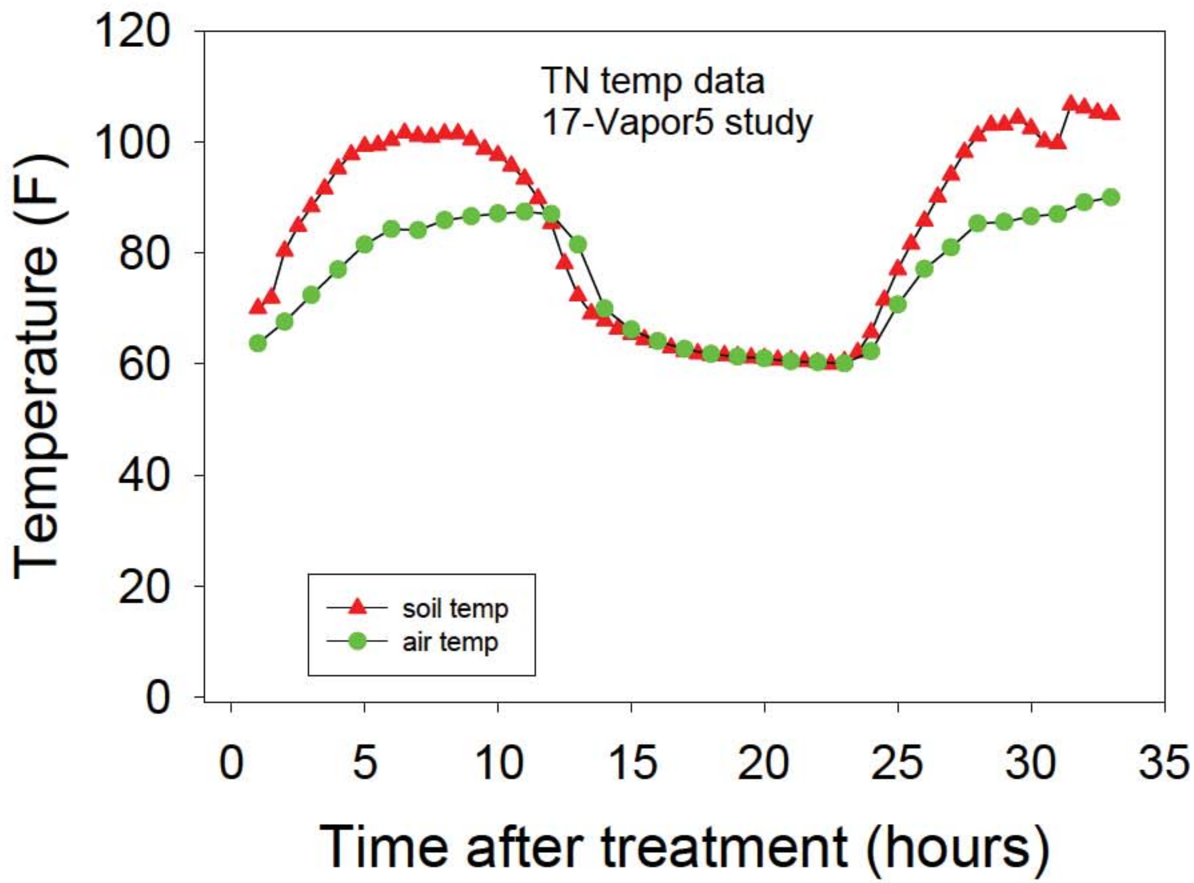
urface condition of plots was small soybeans (V2-3) planted in a igh residue, long-term no-till environment

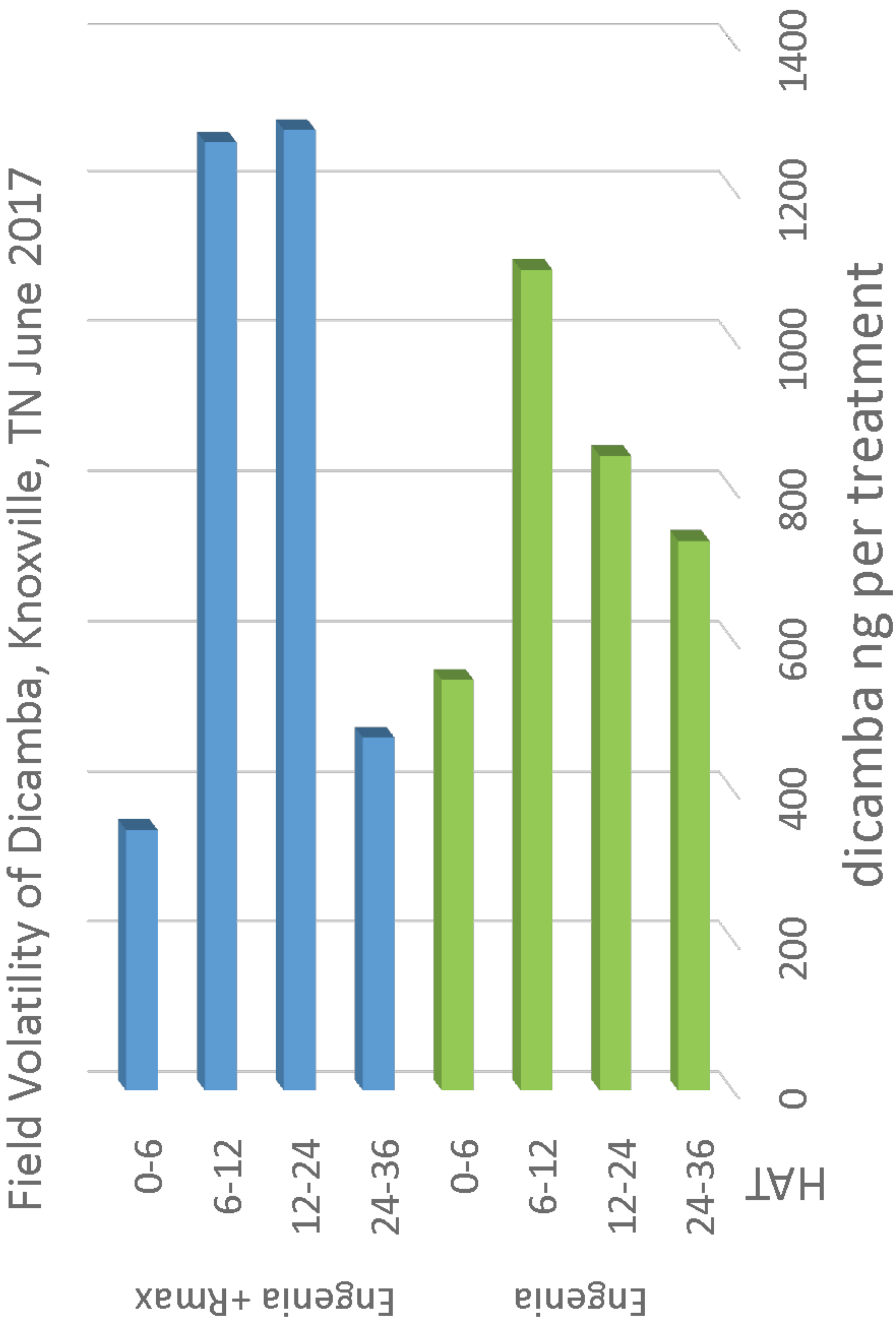
oil was a medium textured silt loam (pH 6.2, OM = 1.3)

o rainfall occurred during the sampling period


Field Volatility of Dicamba, Knoxville, TN June 2017
dicamba ng per hour
0
50
100
150
200
250
300
HAT
0-6
6-12
12-24
24-36
0-6
6-12
12-24
24-36
Engenia +Rmax
Engenia

temperature




Field Volatility of Dicamba, Knoxville, TN June 2017
dicamba ng per treatment
0
200
400
600
800
1000
1200
1400
HAT
0-6
6-12
12-24
24-36
0-6
6-12
12-24
24-36
Engenia +Rmax
Engenia

Observations

All samples had detected concentrations of dicamba

No apparent effect of adding Rmax on dicamba volatility from Engenia

Greatest dicamba concentrations at 6-12 and 12-24 HAT sampling intervals

Most dicamba loss to atmosphere per hour was in the first afternoon after spraying (6-12 HAT)

Comments

is data indicates the dicamba (from Engenia) is moving from t
e of application into the air immediately above the treated fie

bsequent later movement in air is to be expected

ven sensitivity of soybeans to POST dicamba, these data indic
at soybean injury in adjacent areas should be expected from
por movement of dicamba after application

eld effects from this injury, or multiple injuries (from multiple
isodes of dicamba drift) are unknown, but yield reductions m
possible.

Comments

- This research was requested and funded by the Tennessee Soybean Promotion Board
- Mention of any products does not imply endorsement by the University of Tennessee Institute of Agriculture, The Tennessee Soybean Promotion Board or its agents
- Always read and follow all label instructions for all crop protection products

UTIA INSTITUTE OF AGRICULTURE THE UNIVERSITY OF TENNESSEE Real. Life. Solutions.

TENNESSEE SOYBEAN PROMOTION BOARD

From: Ryan, Emily
To: Baris, Reuben; Montague, Kathryn V.; Kenny, Daniel; Rowland, Grant; Rosenblatt, Daniel; Goodis, Michael; Wormell, Lance; Keigwin, Richard; Amy Bamber; Giguere, Cary (Cary.Giguere@vermont.gov); tony.cofer@agi.alabama.gov; tdrake@clemson.edu; Paluch, Gretchen; Meadows, Sarah; Strauss, Linda; Sisco, Debby; Berckes, Nicole; Miller, Wynne; Chism, William; Ambrosino, Helene; Trivedi, Adrienne; Lott, Don; Sheryl.Kunickis@osec.usda.gov; Schroeder, Jill; fcorey@micmac-nsn.gov
Cc: OPP FEAD GISB; Beck, Nancy; Jakob, Avivah; Bennett, Tate; Ryan, Emily; Han, Kaythi; Riggs, Rebecca; Becker, Jonathan; Pease, Anita; Wire, Cindy; Nitsch, Chad; Dudley Hoskins; Cynthia Edwards; Keller, Kaitlin; Green, Jamie
Subject: Follow-up Call on Dicamba with AAPCO/SFIREG via [redacted] - with agenda - UPDATED TIME AND ROOM
Start: Wednesday, August 2, 2017 2:00:00 PM
End: Wednesday, August 2, 2017 4:00:00 PM
Location: PYS 12100
Attachments: Agenda Dicamba Meeting with AAPCO 08022017.docx

Hi all,

Sorry for any confusion/technical difficulties. This should be the final version of the Outlook invite. Please feel free to get in touch with any questions.

Agenda is attached and below.

Thanks,

Emily

Dicamba: Meeting with State Lead Agencies (AAPCO/SFIREG)

August 2, 2017

Agenda

I. Meeting Introductions (OPP)

II. Meeting Format (OPP/RD)

III. Input on Dicamba Incidents: EPA is soliciting feedback from State Lead Agencies focusing on information that could help remedy the unacceptable dicamba incidents in the field. The following questions will be used to focus the discussion:

1. What is the progress on the investigations in your state? What have you learned from these investigations? What is your read on compliance?
2. What regulatory changes have been implemented in your state for the 2017 growing season? What worked? What did not?
3. Based on the leading causes, and information you have received, so far, what approaches does your state recommend to fix the problem?

IV. Available Data

V. Additional Discussion and Questions (time permitting)

VI. Closing Remarks/next steps

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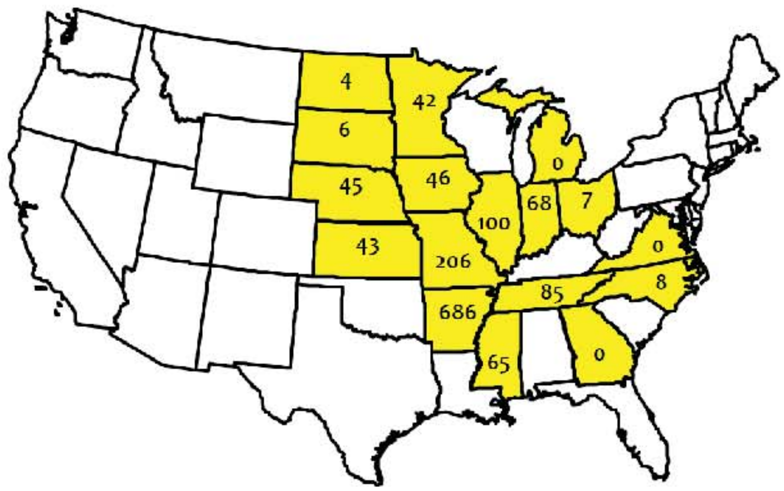
Official Dicamba-related Injury Investigations as Reported by State Departments of Agriculture (*as of July 19, 2017)



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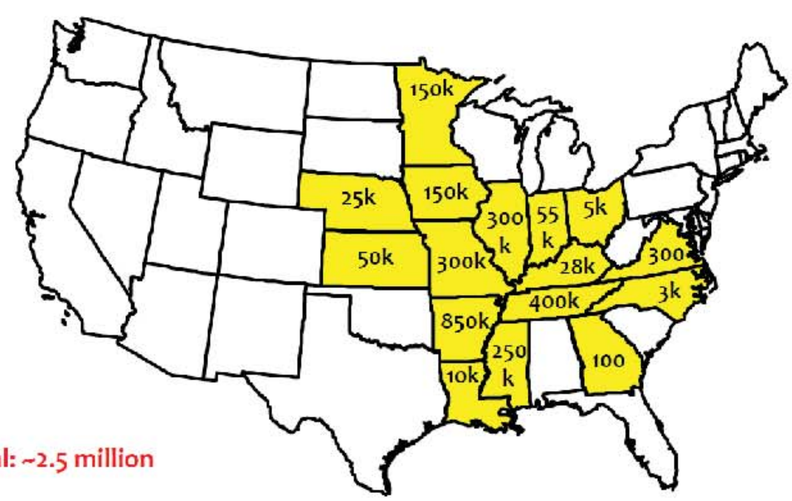
Estimates of Dicamba-injured Soybean Acreage in the U.S. as Reported by State Extension Weed Scientists (*as of July 19, 2017)



*Total: ~2.5 million

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Dicamba Call with APCO 8/2/2017

EPA Representatives from RD, BEAD, FEAD, OECA, Regions 7 and 4; Representatives from WSSA, and USDA-OPMP; State representatives from AAPCO, Universities, Departments of Agriculture from Alabama, Arizona, Arkansas, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, South Carolina, South Dakota, Tennessee, Vermont, Virginia, Washington, Wisconsin, and Wyoming.

Questions to the call participants from OPP:

1. What is the progress on the investigations in your state? What have you learned from these investigations? What is your read on compliance?

2. What regulatory changes have been implemented in your state for the 2017 growing season? What worked? What did not?

3. Based on the leading causes, and information you have received, so far, what approaches does your state recommend to fix the problem?

Available Data?

Alabama:

- No reported incidents, but may have damage with no reports.
- Upon registration, developed a 24c with wind speed restriction (10 mph) and mandatory training.
- Planned on making state restricted use, but not enough time.
- Not many great regulatory options, especially with no record keeping requirements - don't know who has product, or where it's going.
- The delay in registration with seed going out earlier seems to have empowered applicators to misuse.
- Unprecedented amount of damage nationally
- Alabama may not be getting damage, because 95% are using Xtend, possibly scared people into new technology.
- Difficult to follow label, even with major training, plus a very unforgiving chemistry.
- This is a major resource drain on the state groups.

Arizona:

- No use.

Arkansas:

- 873 complaints.
- Taking photos of damage and furthering investigation
- Forming dicamba task force
- Also damage on gardens, non-cropland.
- Dicamba damage with no dicamba treated fields for miles.

Question from EPA: What's your read on compliance? Hard to track, buffer violations. Other violations, but not in every case.

Question: State regulatory intervention that took place, is it for 2017 only? 120 days temporary emergency rule. Use season is pretty much over for this year. Arkansas has had inversion regulations on the books for years with specific temperature requirements. Temperature weather stations across the state, track when temperature inversions are occurring – available online for all applicators.

Question: Are complaints diminishing? No. Some people may still be applying and some complaints are coming in late, although effects were initiated a while ago. Ban went into effect July 21st, symptomology can be 10-14 days past. $25,000 fine went into effect 8/1/17. Previously was $1000 fine.

Florida:

- No complaints yet.
- Possibly due to Organoauxin rule that has been in effect for a long time.

Georgia:

- No official reports, a few informal cases.
- Auxin training started 3 years ago, anticipated registration, growers thought the training was mandatory and have responded well to training. 24c labels requiring training.
- Drift is #1 problem in Georgia, want to continue training on other pesticide applications.
- Conducted dealer education and outreach as well.
- Technology is working. 2 million acres of cotton and soy have been treated. Successful and positive, overwhelmingly.

Question: is Georgia still considering hooded sprayers? Yes, but they want more information from the registrants.

Indiana:

- 96 dicamba complaints, slowed down a little,
- no state restrictions yet.
- Proposing state restricted use, waiting on final vote at end of the month.
- Investigating, forensic evidence, sample collection and analysis. Trying to assess whether drift or volatilization. Cases are taking time to finalize, no hard data.
- Certain cases appear that directions were not followed – buffers were not followed.
- Some cases damage seen with no identified source.
- Some across field damage, no drift. Checking for failure to clean spray equipment.
- Rumor that glufosinate is contaminated with dicamba, as liberty link beans are the most damaged.
- Recommends that epa makes product federeally restricted. Require certification, good records and fines that encourage people to comply.
- Trying to approach scientifically to determine cause of incident.
- Higher rates than used on corn and much higher numbers.

Comment from Arkansas – Monsanto sent Arkansas possible contamination data.

Question from Indiana: Are registrants under obligation to report what they are finding? Yes, they are required to share, but only from legal use - we need to follow up with OGC. Are agency registration decisions based on unreasonable adverse effects? What are reasonable adverse effects? Is it a quantifiable number? When does it become an unreasonable adverse effect if the applications were made legally. Good questions, we are required to take into account the benefits as well.

Question from EPA: Regarding federally restricted use request – is that primarily for record keeping? Yes. Prefer certified applicator only, or under supervision of? Less critical for certified applicator only, but possible removal of RUP license is a strong deterrent. Missouri: if you consider reclassifying, you would have to make all dicamba products RUP. Indiana is going to make any dicamba products over 6% state restricted. Arkansas requires record keeping for all dicamba products. Registrant needs to put marker in products that doesn't break down as quickly as compound. Need a way to differentiate the product. Marker would need to be volatile as well. Can't track the product after it moves, just where it was sprayed.

Vermont: Drift is a symptom, real issue is the seed, and the gene. No issues where the seed isn't being planted. States have process to control pesticide, but need a way to control the seed. EPA doesn't have statutory oversite for the seed. Trying to have more synchronous decision making between agencies.

Kentucky:

- no complaints officially.
- Relatively minor problems

Louisiana:

- 1 official complaint, dicamba symptomology showing up without complaints.
- Not sure why since so close to Arkansas. Possibly not much dicamba was sprayed. Good control from residual herbicides this year. Dicamba has always been state restricted use, along with 2,4-D.
- Dept of ag required dealers and applicators who purchase and those who apply to take a training.

Kansas:

- Fence to fence symptomology.
- Vapor drift or inversion problem.
- Common throughout state.

Iowa:

- investigations are all still in progress. Too early to make firm conclusions. Probably more info in September.
- Tank contamination issues, some physical drift with wind speed and direction.
- Not much info. on inversions, or incorrect formulation of product applied.
- Large scale cupping of soybean fields. Volatilization.
- Later season than some other states.

- Need help how to handle response to large scale damage and lack of people reporting the issues.
- Having major questions on actual utility of tool.
- 74 complaints.

Illinois:

- 150 complaints
- ½ million acres of non-dicamba soy damaged.
- Other non- soy crops effected.
- Getting calls from media.
- No additional restrictions as of yet.
- Retail group is very concerned, put out survey to applicators. Certain retail suppliers have put out stop sales. EPA would be interested in survey results.

Minnesota:

- 89 reports of dicamba damage, probably a fraction of actual damage.
- Less than half have investigations so far.
- People are hesitant to make complaints about their neighbors.
- Concerns where financial responsibility will fall. People are hearing different things from insurance companies.
- Put together a dicamba webpage and online survey. Asking anyone who experienced damage to complete the survey, reduced volume through complaint line.
- No estimate of number of acres. No investigations concluded. Getting info from complainant and collecting samples.
- Hearing from a lot of people that they are not getting the supplemental labels and don't have them in hand when applying. Asked registrants how were going to ensure end user had supplemental label. 2 companies said they planned to follow epa's website supplemental label directions. One registrant said they would make them online only.

Question from EPA: Uses on gmo crop are only allowed via supplemental label. Some folks used the product, without the supplemental label? That is the way it was distributed? Yes. One retailer asked if they are responsible for giving the sup label to end user.

- Many acres of damaged soybeans. Registrants have giving nozzles to commercial applicators, but private applicators are not using correct nozzles possibly

Mississippi:

- 64 dicamba complaints – all soy.
- Mostly label violations, wind, nozzles, buffers.
- State restricted use, required training, 10 mph wind restriction.
- Only one violation was over 15 mph.

Missouri:

- 240 complaints, mostly northeast.

- Implemented 24c for 3 post products, with timing and wind restrictions. Can't tell if it's helped yet. Haven't visited many applicators yet.
- Soybean damage, watermelons, vineyards, peaches, trees. Small towns with all trees damaged.
- Farmers are very upset, as they feel backed into a corner. Want liberty link, but may need to buy dicamba tolerant soy. Dilemma in state.
- Entire fields have been effected.
- EPA needs to make a decision or make no decision, so states can move forward. Growers will be making decisions soon, and are asking states what rules will be.
- There is a human element, that needs to be considered.
- Rumor 'next year will be payback'. Threats of 2,4-d misuse next year.
- 240 complaints are 3 years of work in 1 month. Need assistance from federal level, or will have to protect on state level. Freedom to farm situation.
- Monsanto is complaining that UPI's glufosinate products are contaminated. Other crops have been damaged, it's not just liberty crops. Family farm on island in Mississippi River - 660 acres of true conventional beans, all beans are damaged. .5 mile of woods between field and treated area. Growers can't keep product on the field.

Nebraska:

- 70 cases with 1 inspector.
- Ceased collecting samples due to funding issues.
- For every field with cupped beans, samples have shown dicamba residues.
- Allegation of dicamba contamination in glufosinate contamination is troubling. Should we look at glyphosate for contamination?

New Jersey:

- no complaints or issues.
- Most dicamba is applied to turf.

North Carolina:

- 13 cases of dicamba drift reported.
- 24cs with 10 mph restriction with mandatory training. Think the training is what worked.
- Extension has much higher number, but people don't want to complain about neighbor, and think that soy will recover.
- Tobacco is major issue. Tobacco so damaged that it won't be able to be sold. Tobacco is ultra-sensitive to dicamba. No tobacco samples have shown detection of dicamba.
- Some drift patterns and some corner to corner damage.
- Growers don't have supplemental labels and 24cs in hand. Dealers aren't giving them out.
- Buffer zone label language and sensitive areas language was confusing. Very concerned that greenhouses were allowed within buffers.
- No cases with ornamentals yet. 1 peanut case.
- 24c may be more restrictive next year, time 9-4.
- Certified applicator restriction may not help.
- Growers made some good decisions due to weather and wind speeds, postponed spraying.

- Hard to get the weather data.
- Growers are working out things themselves, and then call the dept of ag if not resolvable.
- 1 Sweet potato damage case.

North Dakota:

- 16 cases, 43 people have called.
- Significant injury in southern red river valley.
- Liberty, Rup ready, and conventional beans are showing problems.
- Seeing drift patterns and tank contamination patterns.
- Increasingly seeing fence to fence damage.
- Geography makes it difficult to identify where dicamba is coming from.
- Not sure if it is illegal formulations at this point.
- Severe drought, damage on beans is much more pronounced. Beans growing slowly because of drought stress. Typical cupping, no flowers or pods. Adjacent DT beans with 6 pods normally growing.
- Most followed label or at least tried. Collecting samples, gathering info. Wind, tips, buffers.

Ohio:

- People calling extension more than dept of ag.
- 14 incidents.
- 1 was tank contamination.
- No lab results yet. What are the quantifiable levels?

Nebraska – test down to 1 ppb. 2.5-15 ppb is what samples are showing – taken 3-4 weeks after application. Are you looking for the metabolite? Yes, but it only is detectable on intolerant beans. Genetic mod beans detoxify beans. APCO's dicamba website has all of the lab information.

- Less was sprayed postemergent, so fewer issues.
- Possible issues from flooded dicamba fields running to another.

Oregon:

- Very few acres of soybeans – interested in glufosinate and glyphosate contamination.
- Finding insecticides contaminated with other insecticides. Wants to stay in contact those testing and looking for contaminates.

South Carolina:

- 3 official cases this week are first cases.
- Issues not being reported.
- No regulatory changes for state registration.

South Dakota:

- 60 complaints officially filed.
- 50 complaints from 1 ag retailer, but none went through to dept of ag.
- No documentation of incorrect products being used.

- 75% of dicamba samples run so far have detected.
- No extra restrictions for state.
- Drought, and same leaf symptoms as North Dakota.
- Some calls about gardens damaged.
- Some want products banned.
- Some retailers aren't going to sell the product next year.
- No one is looking at the tank mixing website.

North Dakota was in survey from Dr. Bradley, but it was too early to report acreage.
Epa is always looking for more estimates of acreage.

Question: tank mixing website? People aren't paying attention? Website isn't cutting it.

Label is really complicated and hard to follow.

Georgia is hoping hooded sprayers would relax the tank mix restrictions. Hooded sprayer stays in contact with ground and moves at low speed, so no drift. There still could be volatility though.

Tennessee:

- 100 complaints, taking time.
- July 12th, emergency rules started through October 1st.
- Must keep records, prohibit old dicamba formulations, required to be applied by a certified applicator, 9-4 window for application, applying dicamba over top of cotton after first bloom is prohibited.
- Putting together a work group.
- Fields have all had a second incident of damage.

Question: have the restrictions helped at all? Any trend in incidents decreasing? Can't say yet.

Vermont:

- sfiereg should look into formulation contamination complaints.

Virginia:

- no complaints.
- Weed scientists provided best estimates on acreage effected.
- No negative comments, some positive comments on tool.
- Comments on label being too complicated.
- No state restrictions.
- Basf rep reached out and asked if there were any complaints.
- Some commercial applicators are hesitant to use product.

Wisconsin:

- Similar to Virginia, no complaints on dicamba applied to soy.
- One corn application damaged the adjacent soy.
- Not many people are using it,

- No state restrictions.
- Continuing education and outreach.
- Some ag suppliers are hesitant to use new labels, so not recommending it.
- Yields are not as good with extend soy.
- Less weed pressure

Wyoming:

- no complaints

Question from Alabama: adverse effects reporting – has epa received anything from registrants? No 6a2 for 2016-2017 yet. The agency does find that concerning.

Question about adoption rates: high or low, highly adopted on cotton in Georgia. Some states are protected, because no one is using it, some are protected because everyone is using it.

Right to farm, should be able to grow what you want.

Has epa established a timeline for a decision? No, however, we have heard loud and clear the timing needs for an intervention. We are working on the premise that we would aggressively continue information gathering. We need this to be a science based call, as the registration was a science based decision.

Are we contemplating additional label restrictions for 2018? Nothing is off the table.

Minnesota: on last call, someone asked what data or information epa may need. Answer was looking at pattern of damage – edge to edge vs drift? Any other information that is helpful? Yes: yield data, what type of damage (drift, volatility, etc.), looking for data from universities. Compliance – what's not being followed and why.

Asked for minutes from the phone meetings.

From:	Meadows, Sarah
To:	Rowland, Grant; Montague, Kathryn V.; Rosenblatt, Daniel; Baris, Reuben; Kenny, Daniel
Subject:	FW: Notes from Friday"s meeting
Date:	Tuesday, August 01, 2017 10:41:31 AM
Attachments:	Dicamba Call 7.28.17.docx

From: Meadows, Sarah
Sent: Tuesday, August 01, 2017 10:40 AM
To: Kenny, Daniel <Kenny.Dan@epa.gov>
Subject: Notes from Friday's meeting

Dicamba Call 7/28/2017

EPA representatives from BEAD, OECA, RD, EFED, FEAD, Region 7; USDA; WSSA; APCO

State representatives from: Alabama, Arkansas, Georgia, Illinois, Indiana, Iowa, Kansas, Ohio, Mississippi, Missouri, Nebraska, Tennessee,

Kevin Bradley collected information from state departments of agriculture, and mapped incident sites. Data was compiled July 19th. This data is out of date at this point, as the number of incidents is increasing every day. Maps show an estimated 2.5 million acres of soybean damaged throughout the US.

Arkansas:

- Northeast Arkansas is the worst – 8 counties in particular showing soybean injury
- Arkansas dicamba fact sheet: https://www.uaex.edu/publications/pdf/FSA-2181.pdf
- Atmospheric loading is causing 90% of damage
- 850,000 acres of damage in those 8 counties due to high use of the product, multiple applications of product
- Product is volatilizing off soil, moving and coming down with inversions.
- Still have 1% driftable fine droplets even with required TTI nozzle.
- Fines are evaporating and are dispersed over great distances, especially when hung within an inversion.
- Also physical drift and dicamba in dust.
- 5-6 trials initiated for volatility of dicamba. Most started within last 2 weeks.
- Damage to horticulture crops, trees, shrubbery, etc.
- The largest bee grower in state said that in the 8 counties, honey production has plummeted, compared to other areas with less dicamba application. Dicamba is causing reduction in flowering (Dave Mortenson's work).
- Temperature is a major cause of evaporation of fines and volatilization issues.
- Possible could have a cut-off date for use of products. May only work for Arkansas.
- 771 complaints as of this morning.
- Complaints from many varied scenarios
- Arkansas had extensive mandatory training program, but still had a major problem with people not following buffer zone (label violation). Area for further education, but physical drift is not the main problem.
- Vast scale drift scenarios - not a physical drift problem.
- Majority of dicamba applied was Engenia.
- Dicamba in 10 mph or less wind with standard nozzles. Norsworthy showed this data to EPA in October. Showed that dicamba moved over 500 feet.

Georgia:

- Not experiencing the problem
- Official complaints are very low.
- Only soybean fields that had damage, damage explainable as poor decision, physical drift, and volatility.

- They are spraying dicamba on cotton, but haven't seen or heard about any issues.
- Soybeans currently R2and R3 stage – only 180,000 acres of soy.

Illinois:

- 125 complaints so far - 2400% increase from last year.
- South of I80, 50% of non GE soy is damaged.
- Also seeing tank mix carryover and damage from sprays to corn in soy.
- Many custom applications
- Volatility and inversion seems to be cause for majority of incidents.
- Damage across the fields.
- Applications occurring when environmental conditions were not correct.
- Maybe an application cutoff date could help.
- Temperature seems to be a big problem.
- Starting data collection - looking at multiple doses to soy.

Indiana:

- Worst year (weather) to bring out new application - major temperature and wind issues.
- Dicamba in corn has been used for decades - soybeans are damaged by corn dicamba every year.
- Weather was major contributor, compressed windows for application.
- Data - exposure work with 2,4-d and dicamba. Single exposure events to soybean growth stages and what plant does differently depending.
- No tomato plants incident reports yet – State label restriction: Don't spray dicamba if you're within ½ mile of tomatoes.
- Problems with applicators not following buffers, not paying attention to inversion, lying with wind speeds etc on spray reports.
- Need to make fines more hefty as deterrent

Question: What growth stage was corn was when drift complaints came in for soy damage? It varied, as corn was sprayed over a long time this year. Planted by 5/24, sprayed 1 month later.

Question – What formulation of dicamba was used on corn? All forms.

Early post applications were made when non-dicamba beans were stressed by lack of rain, complaints started occurring when stress lessened.

Iowa:

- 64 complaints.
- Volatility, drift, runoff from fields.
- Don't know specifics of when applications occurred, just looking at symptoms.
- Solutions: Application date deadline may help a bit, but won't solve all issues. Restricting dicamba to pre, would eliminate the important use for controlling post, as June applications are when they get the most benefit.

- Many custom applications, like Illinois.
- Boom height - strong cause for movement. It was difficult for custom applicator to follow the label.
- The buffer wouldn't help even if they were followed.
- Not much to do to eliminate the problem or to even minimize it.
- Even if can prove there is no loss of yield (as Monsanto says) growers still don't want damage from others applications
- 24 inch is too low of a boom practically with equipment. The growers aren't following, commercially they are worried about damaging their equipment.

Kansas:

- Complaints mostly from north central and eastern Kansas.
- West Kansas has less complaints, as Xtend soy is protected from corn dicamba applications.
- Cutoff date not practical.
- Add label restrictions for temperature at application. Not apply when temperature is above X or forecasted to be above X degrees.
- Not aware of any data or research on temperature thresholds that could help develop restrictions

Question: Relative humidity, anyone has been looking at it? There is data on old formulations that is all over the place. No strong opinion on that at this point, conflicting viewpoints

Kentucky:

- 10,000 acres.
- Can obviously see tolerant vs non-tolerant.
- Probably atmospheric loading (volatility and other ways of getting in air).
- Possibly more restricted use, to help track use.
- Cut-off dates, or cut-off times of day are things they are thinking about implementing.

Mississippi:

- Thought that the education was very thorough, but obviously not enough.
- Seemed to be a pattern at first, but now seeing larger blocks with no discernable pattern.
- Can't tell where originated.
- Yards, gardens, trees, cypress trees are all damaged. Affecting people outside farming industry which is bringing much more attention.
- Research - soybean response to multiple exposures. Looking at additives that are listed on tank mixing website.

Question: Does proximity to river or surface water have an effect in incidents? Dicamba seems to have moved across the Mississippi river.

Missouri:

- 1st of June was first issue. Major problems have continued since then.
- Didn't have rain or other weather issues early on - typical season spray schedule.

- Stop sale on July 7th for 6 days, then released with additional restrictions.
- Largest commercial retail outfit that does most spraying in area made decision prior to July 7th to not spray any more dicamba for the rest of the year.
- Not sure if anyone has used a buffer, and not sure if it would work anyway.
- Most fields have damage across the field.
- Most problems are due to volatility
- Old formulations are not causing the majority of problems.
- Solutions: possible stop sale date.
- Regardless of what happens, trait is still on marketplace. Even if we remove products, still have to worry about illegal applications.

Question: With Banvel volatility, don't remember seeing injury across the field. Could damage be tank contamination? Thinks it's more atmospheric loading. 5 fields managed by 2 growers, had own sprayers. Was def. not tank contamination.

Question: Is sprayer contamination check a normal part of investigation? Damage has been uniform across thousands of acres. Uniform symptomology, even on crops that haven't been sprayed at all. Most damage is not tank contamination. Missouri first inspects the person who is spraying to see if they've sprayed dicamba, leads to many growers not calling in reports as they are irritated that they need to be investigated first. Georgia: driftor and driftee are often both at calls. Neighbors are often called to let people know they were going to spray and measured off buffers together. Some calls are only the victim, some calls have both victim and person who caused are present.

Question: Does weather data show temperature inversions? Data show ½-2/3 of days or nights had an inversion and temperature changes. Likelihood of an inversion in mornings in June and July is very likely.

Ohio:

- Agrees with mechanism of movement – atmospheric loading.
- People are not complaining, as they think their neighbor did nothing wrong or they don't want to get neighbor in trouble.
- Some dealers declined to spray at post, most apps were pre.
- Dicamba was in ditch, flooded in to field and caused damage. Field to field damage via water.
- Application in early June, big rainfall in early July, saw damage more than 1 month after application.
- Soybeans planted late this year, later timing of damage may cause more yield loss since beans are damaged later.
- Solution: Restrict to preplant, cutoff use after early may.

Tenenssee:

- Has also seen field movement through water.
- Farmers have been drifted on 2-3 times, and this is even after new rules were in place.
- Starting July 11th, restricted applications to 9-4, but still seeing damage through volatility.
- Believes that people followed stricter guidelines, but they didn't work.
- 25% increased sales in generic dicamba. 600% of proposed engenia sales goals were met.

- Most in season June-July applications were Engenia and Xtendimax.
- Weed control in state is best in 10 years. Liberty, enlist and xtend have all played a role.
- Divided agriculture like nothing else. Can see both sides.
- Cannot keep boom 24 inches above ground. Totally impractical.

Question: What boom height would be practical? 3 foot at least, maybe more depending on field.

Question: Is the excellent weed control seen widely? Any signs of resistance? Some sites seeing only 40-50% control on palmer pigweed. Dicamba isn't as effective near the river. Others have seen great control, which may lead to more use and more damage in the future. Dicamba is a 2 shot program for certain weed control – yes is effective, but also bad since 2 opportunities for drift.

Question: More incidents near river? Yes, 8 counties in Arkansas are adjacent to river. PPO resistant pigweed is higher there as well, so use of dicamba is higher.

Slide Set

3x increase in volatility with soy and corn vegetative application, rather than bare soil applications. Temperature is cause, and increased plant canopies later in date.

Carrier volume might have influence, 15 GPA vs. 10. Higher carrier volume might reduce volatility.

Droplet size coarse has 3x lower volatility than fines.

Engenia and xtendimax were tested in January compared to banvel. Dramatic reduction in volatility, but similar to untreated. 2 technologies that would complement each other - Can BASF and Monsanto partner to add vapor grip to BAPMA Engenia?

Question: What's the temp of vapor chambers. 87 degrees 50-60 humidity.

Volatility over time. In humidome. No dew, or other environmental conditions. With more time, dicamba continues to volatilize. Even past 3 to 7 days.

Preliminary field trial going on throughout country. Banvel vs Clarity, treated soil flats adjacent to soy fields, Engenia wasn't better than clarity, Xtendimax was better, but Xtendimax tank mix was not better. Need to consider tank mixture effects on volatility. Roundup Powermax in mix may be causing increase in volatility. You get more fines due to the surfactant in Rup Pmax. Premix may be behaving differently than tank mix.

Question: AMS? It's not on the label, but might be added in error. AMS is causing much more volatility.
Question: Checking pH of spray solutions? No, but could be replicated.

Restriction of AMS is a good thing on the label.

Low tunnel trial: Damaged plants after being in treated field for 24 hours after application. 50% damage to plants.

Simultaneous applications, covered plants with buckets for various time periods. Engenia does reduce risk for off-target movement, but does not eliminate the risk for movement, compared to clarity.

Question: Will these studies track yields as well? Plenty of data available for yield response with clarity, but not with Engenia.

Scale of study drastically effects results. This is all very preliminary.

EFED wants to relate visual injury to plant height and weights to capture appropriate endpoints. Leaf cupping doesn't reduce height or weight, but may cause increased weed control needs and is what results in a complaint.

Sentiments from field: Willing to tolerate injury and understand that this is new technology, but this level of damage is unacceptable.

Registrant data shows less volatile, not no volatile. This is challenging in the traditional agricultural research format.

From:	Adeeb, Shanta
To:	Kenny, Daniel
Subject:	Dicamba notes form July 28th
Date:	Tuesday, August 01, 2017 12:02:29 PM
Attachments:	Dicamba Call 07 28 2017 S. Adeeb Notes.docx

Dan,

Please see the attached notes. Please keep in mind that I left the meeting 30 mins early so I wasn't able to capture that part of the meeting.

Shanta Adeeb, M.S.
Risk Manager
Herbicide Branch
Registration Division
Office of Pesticide Programs
U.S. Environmental Protection Agency
Email: adeeb.shanta@epa.gov
Number: 703-347-0502

Dicamba Call 7/28/2017 S. Adeeb Notes

Attendees:

At Potomac yard: Reuben Baris, Mike Goodis, Dan Rosenblatt, Shanta Adeeb, Kay Montague, Dan Kenny, Bill Echols, Yevette Hopkins, Meretta E…., Anita Peas, Mark Corbin, Ed Odin, Brain ?. Linda?

EPA On Phone: Johnathan Becker, Bill Chism, Sarah Meadows, Adrian, Trenetti, Stacy H., Nicole Burgers, Jamie Grand, Shawn Hackent, Mich Mercer

USDA: Cheryl Knicks, Jill Schroder

States: Missouri: Kevin Bradley, Dr. Marrubus; Arkansas: Norsworthy, Tom., Dr. Bengr…; Tennessee: Lary, Tom Muller; Indiana: Bill Johnson, Joe Liker, Brian Young; Ohio: Mark; Kansas: ????; Iowa: Mike; Illinois: ??????; Georgia: Dr. Cru…; Mississippi: Jason; Nebraska:?????; Alabama: Greg

Agenda

Mike Goodis RD/OPP: Thanks for being on the phone. Agency is concerned about the incidences of crop damage. This talk with extension agents and APPCO so everyone is better informed about the incidences. We think it's important to have these conversations so that the right use of these chemicals happen

Cheryl USDA
Appreciates working w/ EPA to get lessons learned. Thanks extension folks for working on the issue and on the ground. Appreciates all the work everyone is doing on this.

Dan Kenny EPA
Thanks your perspective is great. We would like to hear anything you feel is important and what you feel is the chief root cause that you can share with the agency. What do you think would be fixes in the field that could prevent incidences?

Format
Mapping incidences from university Weed Scientists and the Extension Agents

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Kevin
The incidence maps are already out of date. A few weeks ago EPA spoke with state Ag Departments to find out what was happening. First map as of July 29th was what Kevin could het from state Departments of Ag. Second map, major soybean areas estimate of damage. Estimated approx. 2.5 million acres of damage as of July 19th.

Reuben EPA
Looking for info that can help remedy the situation. [Goes through the three questions from the agenda.]

Arkansas

[Approx.] 850,000 acre estimate from 8 counties. More damage in North East Arkansas in 8 counties. Ninety percent of damage is a result of atmospheric loading. Inversions, high use if product, multiplied with PPO resistant pigweed. Reduce the number of fines with the nozzle. The fines from the nozzle when evaporated can get dispersed great distances. Also physical drift, dust, etc. Has data on volatility and secondary movement on dicamba. Has gotten a call that growers of horticulture crops have also been effected. Largest bee keeper has honey production plummeted, lower honey production. Will be testing for dicamba. Path forward, volitization, evaporation of fines. Temp is a major cause of incidences. Consider having a state specific cutoff date for this use. [Approx.] 771 complaints as of 7/28/2017. Physical drift and directions for use this year. Even with an extensive training program [in this state] there has been a major issue with people not following the buffer zones. But drift was often beyond what the buffer would have been. The majority of dicamba that went out was Eugenia. Dicamba still moves when the label directions are followed.

Georgia

Official complaints have been very low. Not having the issues of other states. Dicamba being sprayed on cotton but just not seeing problems. Either not happening or not reported. Soybean growth stage R2 and R3 currently. Approx. 180 acres of soybeans

Illinois

Number of complaints approx. 125. In the past there were 5 complaints per year, [complaints] up 2400% from last year. Most incidences are south of interstate 80 about 50% of non dicamba soybeans have damage. West going to St. Louis, damage drops to 5 based on geography. Three issues: physical drift, spray tank contamination, volatility. Uniform symptoms. Approx. 10 million acres of soybean grown in the state. Temp is playing a huge role. Application cutoff date will help but not the only answer. Looking at effects of multiple exposure events to soybeans, working on getting data.

Indiana

Same issues as other states discussed. 80/100 complaints this year are dicamba related. In the past huge…[??????] you couldn't have picked a worst year to introduce a tool based in the weather in the state which is a major contributor. Used dicamba on corn for a lot of decades. June 19th was when first report of dicamba injury. Steady 2-4 incidents per day since. Weather and compressed windows for [pesticide] application. Do have some data for single exposure events and how it effects soybean growth and the yields. The preseason work to educate about dicamba drift on tomatoes worked. No tomato incidents. [Restriction] don't spray dicamba within ½ mile of tomatoes. [To strengthen enforcement efforts] make sure [monetary] fines work/hurt when misuse happens. Applicators lying on spray report. Need more verification of wind conditions.

Q: How does growth stage of corn relate to dicamba use?

A: Could be used from seeding to waist high [corn].

This year corn dicamba use was sprayed over a very long time. No idea about which dicamba formulations are/were used on corn.

Illinois
Had a dry period, symptoms showed up after rain event

Iowa

Sixty-four official complaints. Volatility, drift, runoff. When extension visits fields [where damaged occurred] the applicator isn't present, only the farmer with damage is present. This makes it hard to get incident data. Having an early cutoff for application date wouldn't work due to temp variability. [Dicamba] mostly used to control water hemp. [Date restriction] would limit utility of product [to control water hemp]. Boom height negatively effects the off target movement. Short application season makes following directions hard. Buffer makes the technology hard to use. Doesn't see much that can be done to eliminate or minimize the problem. Magnitude of problem based on treated acres is scary. It is disingenuous to say drift doesn't affect yield. Growers don't want any crop damage even if it doesn't affect yield.

Boom height and drift

Most application equipment cannot run at 24 inches above target. With the equipment they [applicators/farmers] use they cannot follow directions. [The boom height is an] impractical direction that would cause damage to equipment.

Kansas
Instead of a cutoff date more guidelines with temp restrictions.
Q from EPA: Thoughts about relative humidity with temp.

Answer: Data all over when it comes to humidity

Kentucky
Tolerant vs non tolerant soybean fields can be easily distinguished. More restricted use, Eugenia or all dicamba formulas. Cutoff dates or times of dicamba.

Mississippi

Had extensive training program going into this year. Didn't see anything different from the other states. First 2 – 3 weeks a patter to [dicamba] movement. From June to July large block without a visible path. Seeing it in yards, gardens, trees. CRP planting have seen dicamba damage. Beyond agricultural damage. Hitting people beyond the industry, has a program for soybean for response to multiple exposures. Looking at additives added to products. Proximity to river and surface water in delta. Delta areas my effect movement. Dicamba move across rover. Application in Arkansas moved to Mississippi. River effects the movement.

Missouri

Timeline: around June 1st was when incidents started. Don't really have issues about weather messing them [applicators] up. People sprayed when needed. On July 7th Ag Dept. started a stop sale. Released again in Missouri with more restrictions. MFA doe most spray work [in state] and prior to July 7th decided not to spray any more dicamba. Buffer may never work, likely doesn't make a difference. More fields with injury across than with clear drift events. Most are due to volatility. Doesn't believe the old formulas are the problem here. MFA will probably do a stop date/ Missouri Dept. of ag. Looking at a stop date. May reduce number of complaints but not solve the problem. Regardless of what happens the [GMO] trait is still in the marketplace.

Q: Is it possible sprayer tank contamination is a bigger issue than volatility?

A: Tank contamination would get less over time.

Missouri Continued

Inversions, and atmospheric loading, volatility into an inversion may be happening.

Q EPA: Potential of sprayer contamination, is this a normal part of investigations that are being tested.

A: Can't imagine tank contamination is getting to a whole crop. A field or two would be possible. A lot of crops weren't sprayed when symptoms were seen in the crops. Contaminated fields look different from [drift/ volatility]. Checking tanks/ tank mix for contamination is not typical. Missouri Dept. of Ag inspects the grower calling in an incident [this may be the reason for less calls about incidents]

Georgia

Both sides

Arkansas
Even when buffers were measured damage was seen. [When incidents are reported in this state] with dicamba calls both the applicator and the person with damaged field [come during the inspection]

Q EPA: Has anyone noticed high temps with inversions prior to incidents?

A: About 2/3 to ½ of days in July have inversion in Missouri. In June/July likelihood of inversion id high.

[Dicamba] volatizing and then getting into temperature inversion.

Ohio

Not seeing much particle drift. People not calling much [to report incidents]. More pre-plant [use] than post emergence. Not seeing pre-plant incidents. Some applicators refused to do post emergence spray this year. In NW Ohio due to flooding dicamba is moving into ditches and field to field. [Dicamba is] going to be unmanageable if flooding is causing injury/movement. When beans are under stress they won't grow/recover from injury [and have lower yield].

Tennessee

Movement with water into adjacent fields after a big rain event. Complaints coming in from double crop soybeans. Farmers getting drifted in 2nd and 3rd times. Incidents occurred after new rules took place (July 11th or 12th. Rule Applications can only be made from 9 am to 4 pm. A lot of folks adhered to new rule about applying after 9 am, it didn't work. Sales folks have been selling lots of Eugenia. Eugenia was used on a lot of acres. Most in season was Eugenia was Extenda Max.

From: Baris, Reuben
To: Rosenblatt, Daniel; Kenny, Daniel; Adeeb, Shanta; Montague, Kathryn V.; Meadows, Sarah
Subject: RE: copy of my notes
Date: Friday, July 28, 2017 2:10:41 PM
Attachments: dicamba - teleconference with extension - 7-28.docx

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Wow. Thanks Dan! This is great! I think between all of us we should be able to capture most if not all of the major discussion points (as well as a lot of the nuances…).

Reuben Baris | Product Manager, Team 25 | Herbicide Branch
U.S. Environmental Protection Agency, Office of Pesticide Programs | (703) 305-7356

From: Rosenblatt, Daniel
Sent: Friday, July 28, 2017 1:40 PM
To: Kenny, Daniel <Kenny.Dan@epa.gov>; Baris, Reuben <Baris.Reuben@epa.gov>; Adeeb, Shanta <Adeeb.Shanta@epa.gov>; Montague, Kathryn V. <Montague.Kathryn@epa.gov>
Subject: copy of my notes

I didn't' catch everything – but wanted to share this.

Attendees

Missouri ; Arkansas ; Tennessee; Indiana; Ohio; Iowa ; Georgia; Mississippi; Nebraska; Alabama ; (also Tony Cofer from Deprt of Ag in Alabama; Amy Bamber; USDA – Sheryl Kunickiis

EPA: RD, EFED, BEAD, FEAD

Kevin Bradley – generated map of U.S. – in order to get national picture – data requested was damage incidence – time window is as of July 19th . Bradley acknowledges his numbers are underestimate and out of date. He only sought damage reports for soybeans – not other crops. Overall total is that 2.5M acres of soybeans have been damaged. Take away is that this is major – national problem.

Arkansas – Jason Norsworthy – NE Arkansas is most impacted area of his state – covers 8 counties – where damage seen – 90% of damage. His diagnosis is that movement is result of combination of atomospheric factors where environmental loading and movement is possible. 850,000A of soybeans in AR have been damaged. DT soybeans growing and there was high use of dicamba product – sometimes multiple applications. Volatility is part of problem. Another point is that the TTI nozzle doesn't eliminate 'fines' – higher temperatures – help make the 'fines' dispersable – also there is physical drift – with dicamba on dust – Jason has 5-6 trials on volatility and secondary movement – data underway now – 2017 – damage is extensive – beyond soybeans – horticultural crops – bee grower in state – very low levels of honey production seen. Dave Mortenson studying relationship between dicamba and flowering. Temperature is big factor. Jason suggesting that one path forward for mitigating risk is to set a date cut off for use. AR has large number of complaints - 770 complaints to state. AR did extensive training program to smooth out introduction concerns – but didn't seem to work.

GA – not experiencing problem – official complaints very low – either not happening or extension not hearing about it – GA is using dicamba on cotton – so it's either not happening or we're not hearing any concerns. GA hardly grows any soybeans. Those are now at R2 or R3 stage –

Illinois – Aaron Hager – complaints – up to 125 complaints – typical year they get very small number. 50 % of non DT soybeans have symptoms – but there is variable experiences across different geographies. – so some places not experiencing problems. Attribution of problem could involve spray contamination – volatility – and other causes. Illinois often uses custom application. Path forward 'very challenging' – 10 M acres of soybeans – in state – temperature playing big role – application cutoff date makes sense – he is collecting data on multiple exposure events to soybeans –

IN – Bill Johnson – can blame it on everything that's been mentioned- 80 complaints involve dicamba – this year – difficult to introduce new technology – wet weather compressed – planting – also windy year – have used dicamba in corn for decades – and that hasn't been too problematic. June 19 start of dicamba injury – claims ramped up . Johnson suggests that the enforcement fine needs to be severe and meaningful – will help make growers follow label requirements – people will lie to say wind speed is ok – IN has pockets where the complaints are coming in – this year – corn sprayed over long period of time –

IA – 64 official comtraplaints – they see it as no 'one' problem – volatility – physical drift and run off all at play – typically – it's the injured party who complains – and the applicator tends to not be available in reviewing the situation – IA concerned about the idea of an application cut off – it would help some – but likely not solve issues. They might offer that the pre-emergence use could be restricted – In IA waterhemp is key pest – June applications help control waterhemp – IA had short application season – buffers don't resolve the problem – they make the technology hard to use – not sure there is much we can do to reduce or eliminate the problems – frightening to think about the future – relatively small number of beans that were treated this year in IA – Rob Fraley – (company rep?) claiming yields won't be seriously impacted – also 24 inch boom height is too strict – won't be readily followed – because it's too low.

KS - poor phone connection - Doesn't support cut off date – suggests instead – more guidelines on temperature restrictions – older dicamba had more restrictions regarding temperature – –

KY – easy to pick out DT versus non – DT soybean – tend to attribute it to loading – KY not doing work right now – Open to consideration for more restricted use (for new and old) formulations - cut offs – and times of day –

MS – Bond – growers had extensive training – going in – felt very prepared – first two weeks or so – pattern – then by later in season – more larger blocks seen to be impacted – these are more of an unknown – not understandable – yards – gardens – cypress trees – impacted – forestry areas damaged – so issue is bigger than row crop areas – MS is pulling data – impacts of multiple exposures to soybeans – suggestion on what to attribute this – proximity to river and amount of surface water a potential factor – dicamba can move across the MS River – instance of application in AR and dicamba moved to MS –

MO – Bradley – nothing new – to add- MO saw issues beginning June 1 – and problems ongoing – MO didn't have troublesome season – in other words they could work in the fields – people had openings to spray thanks to good weather – July 7 MO Ag department imposed six day ban – MFA (a commercial dealer – sprayer who supports many growers) voluntarily decided not to spray dicamba on their own – for the rest of the year. No buffer size seems feasible – many fields are injured edge to edge – believes most of problems due to volatility – whole fields seem to be injured – formulation – don't really believe old formulations are culprit – solutions – MO dept of ag and commercial applicators will probably put a stop date regardless of what EPA may do – likely there will be stop date of June 1 imposed by MO dept of Ag. Complex issue – trait is in the market place – so that's background consideration – so that means people will be tempted to use illegal product. This is novel - no history of damage across the whole fields?

AR – some very careful applications still seen to be resulting in damage – one drift incident seen where drift is ½ mile away. Inversion events extremely common – with – ½ to 2/3 of nights in AR in summer time involve inversion conditions – almost all of June and July –

OH – low incidents of reports – they used product pre plant this year – low complaints because injury seen as not malicious – people doing their best and no one did anything wrong so no complaint typically filed. Dicamba has moved out of ditches and damaged field – and saw field to field movement via water – also application followed by heavy rain can move dicamba very far – not a lot of data of more mature soybeans being hit by dicamba – likely to see yield problems. Ohio see post emergence use as 'not manageable' – earlier cut off of use may need to be imposed.

TN – Steckel – seen it move with water – where goes to adjacent fields – last few days he's gotten flurry of complaints – farmers – angry. Expanded label means some fields get drifted on 2 or 3 times. On July 11 TN issued new rules to try and avoid inversions – narrowed time of day – thinks growers following label – did outreach for growers – you tube and personal letters – but 'didn't work' – BASF sells 3 generics – but also selling a lot of Engenia – 600 percent of what they projected – so Engenia probably highly used – CPS went Extendimax – and sales of that were strong too. Need to apply after 9 am and before 4 pm. This is to avoid inversions. Weed control is 'best in a decade' exceptionally good. Liberty working – Enlist works – Extend works very well – divided agriculture 'like nothing I've ever seen' – He believes registrants need a lower volatility formulation. Also applicators cannot use booms at 24 inches in TN – impractical – too many hills – need at least 3 feet limitation for booms – otherwise – booms break too often.

Larry – there are problems with weed control – some pigweed at 50 percent control – AR – (Jason) closer to river populations are more resistant – can slow it down – 50 to 80 miles away from the year performance is good – proximity to river could be key. Pigweed often needs to be sprayed twice – especially near the river –

Round up may be doing something to impact volatility – AMS should not be in tank – in midwest. AMS not used in all regions.

Difficult to detect dicamba analytically – much more practical to use visual symptoms. Data should be done on bigger scale. Small plots don't mimic actual use. TN data suggests dicamba products with and without roundup will all volatilize . united soybean board funded a study looks at visual injury vs. other factors - they can share that data with epa. Jason has 20 fields studying height yield, injury in a thesis. This can be shared with EPA

This is 'an unacceptable situation' – comment – by extension – (not sure who)

EPA RA relied upon the boom height being only 24 inches. Also – no focus in the RA on movement thanks to drift and run off. Gaps that exist.

From: Kenny, Daniel
To: Baris, Reuben
Subject: FW: Conference Call with EPA on Dicamba
Date: Tuesday, July 25, 2017 2:38:00 PM

From: Kenny, Daniel
Sent: Monday, July 10, 2017 8:26 PM
To: 'john.ewell@tn.gov' <john.ewell@tn.gov>; paul.bailey@mda.mo.gov; 'Susie.Nichols@aspb.ar.gov' <Susie.Nichols@aspb.ar.gov>; 'Dale.Scott@TexasAgriculture.gov' <Dale.Scott@TexasAgriculture.gov>; scottde@purdue.edu; Green, Jamie <Green.Jamie@epa.gov>; Klevs, Mardi <klevs.mardi@epa.gov>; Vargo, Steve <Vargo.Steve@epa.gov>; Toney, Anthony <Toney.Anthony@epa.gov>; 'stanley@uga.edu' <stanley@uga.edu>; 'lsteckel@utk.edu' <lsteckel@utk.edu>; 'jnorswor@uark.edu' <jnorswor@uark.edu>; 'tbarber@uaex.edu' <tbarber@uaex.edu>; 'bradleyke@missouri.edu' <bradleyke@missouri.edu>; 'Jill.Schroeder@ARS.USDA.GOV' <Jill.Schroeder@ARS.USDA.GOV>; 'DeniseC@mdac.ms.gov' <DeniseC@mdac.ms.gov>; 'Barrett, Michael' <mbarrett@uky.edu>
Cc: Rowland, Grant <Rowland.Grant@epa.gov>; Montague, Kathryn V. <Montague.Kathryn@epa.gov>; Dan Rosenblatt <Rosenblatt.Dan@epa.gov>; Goodis, Michael <Goodis.Michael@epa.gov>; Keigwin, Richard <Keigwin.Richard@epa.gov>
Subject: Conference Call with EPA on Dicamba

Greetings,

As I am sure all of you are aware, extremely large numbers of complaints of crop damage are being received by a number of states and are reportedly associated with the new uses of dicamba on dicamba-tolerant crops, especially soybeans. The EPA takes this situation very seriously and is working to gather information from the field as quickly as possible. In that light, we would be very interested in and appreciative for the opportunity to speak with representatives from these states. The EPA is organizing a conference call for this Thursday, July 20th, from 3:00 – 5:00 EDT to discuss the matter and would like to learn from your experience to get a better understanding of these incidents.

The following conference line information will be used:

Conference Number: [redacted]
Conference Code: [redacted]

An agenda will follow in the very near future. I am hoping that you can join us on the call. I apologize for the short notice, but we would like to gather information as quickly as we can in this case.

Please let me know if you have any questions. Thank you for your help with this meeting.

Daniel Kenny
Chief, Herbicide Branch
Registration Division
Office of Pesticide Programs
U.S. Environmental Protection Agency
703-305-7546

From:	Meadows, Sarah
To:	Kenny, Daniel; Montague, Kathryn V.; Baris, Reuben; Rowland, Grant
Cc:	Rosenblatt, Daniel
Subject:	Notes from dicamba states call
Date:	Tuesday, July 25, 2017 9:10:46 AM
Attachments:	Dicamba Meeting 7.13.17.docx

Dicamba Meeting 7/13/2017

In person and call-in attendees: EPA - OPP, EPA - Region 4,5,6,7, USDA, WSSA, APCO, and representatives from state universities, departments of agriculture, or extension services from Alabama, Arkansas, Colorado, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Mississippi, Missouri, Nebraska, North Carolina, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Virginia, West Virginia, and Wisconsin.

Arkansas:

- Investigating 686 alleged dicamba complaints, with only 9 employees in the office.
- They are photo-documenting the symptomology.
- It seems that different fields have been hit multiple times.
- They have been having success tracking the dicamba in some cases.
- Probably a combo of drift and symptomology.
- Asking farmers to assess acres affected, as the state agency cannot make that call legally, just if there is symptomology.
- Sales were banned on Tuesday.
- Of what they've seen so far, ~90% was drift or due to spraying at night and inversions. Remaining was either volatility, tank contamination.
- 8 counties in NE Arkansas where most of the complaints are occurring.
    - 35-40% Xtend soy, 70-80% cotton (total 300,000 acres of cotton and 7-800,000 soy)
    - Some areas where no dicamba has been sprayed in 3 miles are showing even injury distribution across the field
    - Seeing damage in soy, cotton, trees, tomatoes, vegetable, watermelons
    - 900,000 acres of soy have cupping – concerned with multiple hits on the same field
- Most of the areas in the rest of the state are traceable
- Some sites have been revisited recently, and some have recovered at this point.
- Jason Norsworthy mentioned there seems to be a correlation between amount of spraying and amount of injury. In those 8 counties, fields usually have 2 applications of 2,4-D or dicamba to attack PPO resistant pigweed
- Some areas look to have had 5 or 6 exposures to dicamba
- Seems to be greater occurrence of damage as temperature increases. Seems to be volatility.
- Have seen cotton damage, but soy is much more sensitive to low doses of dicamba.
- Have seen damage in peanuts too.

Indiana

- 143 total drift complaints – think 50 of those involve dicamba. Late spring this year, so complaints only started mid-June.
- Damage seems to be to non dicamba-tolerant beans
- Documenting symptomology and collecting samples for residues. If you don't collect soon after application, you won't find dicamba in the samples. They've look for the tank mix partner if they can't find dicamba.
- Will be late in the year before they can review all cases.
- Trying to make all ag. use dicamba restricted use, so they can track source of dicamba.

- Going to be a challenge to identify source, and associate blame.
- Lab needs to look as low as 10 ppb, they are also looking for metabolites. Difficult to get to this level. Need good extraction techniques, and good equipment. [Jason Norsworthy - even when the plant shows 40-50% damage and can't find any dicamba in the samples – why is Indiana looking for residues? Indiana mentioned they don't have a lot of residue experience]
- Indiana did a lot of upfront work for dicamba and 2,4-D for 10 years, and a lot of training, especially face-to-face

Question from EPA: Is there any indication if incidence reports are for the new dicamba products vs. the old? Indiana and Arkansas seem to think it's Engenia or Xtendimax.

Missouri

- Dicamba complaints, less than 5 in 2014 and also in 2015
- 2016 135 cases
- 2017 176 cases so far. First complaint was 6/13/2017.
- Before dicamba, 80 complaints per year total.
- Not taking residue samples this year, just photographic evidence, due to cost, time, difficulty, not seeing good results.
- Complaints are regarding applications by both commercial and private applicators
- Seeing border to border damage across fields. Some exceptions show drift, but mostly field-wide.
- Some soybean fields seem to have been hit 2 or more times.
- Also damaged tomatoes, watermelon, cantaloupe, peach orchard, pumpkins, organic, greenhouses, mums, residential damage.
- Damage in 35 counties so far.
- Some farmers approved and monitored their neighbor's application, and then saw damage a couple of days later.
- State wide stop sale for all dicamba was issued last Friday.
- 24cs have been issued, with extra restrictions on wind speed and direction, no application before 9 am or after 3 pm, all applications must be made by certified applicator, must complete a form to notify prior to application. Also requiring good record keeping.
- Suspect some of older formulations still being used, but some growers have said they are applying new products properly and it still resulted in movement.

Question from ND: Requested Dr. Bradley talk about volatility.

Kevin Bradley (Missouri):

- For every one incident case that is submitted, there are 5 that aren't.
- 275,000 acres of damage (info in weekly estimates from extension)
- 'Less volatile' formulation means less, not 'not volatile'.
- Have been able to pick dicamba up in air 4-5 days after application.
- All data, even preliminary, is on their website.
- Legal applications have occurred – most of injury is from new products.

- Growers that he trusts don't understand why the fields in the opposite direction of the wind are showing damage.

Nebraska

- No cases last year, 30 cases so far this year.
- Yet to find a field of soy that shows a standard drift gradient. Seeing damage across entire field.
- Old dicamba products legally applied in corn, 2 applications in corn due to resistant waterhemp.
- Soybeans have stayed 6 inches nearby for 1 month - yield issues. 50-60% of what they've seen will not yield
- In areas with heavy resistant weed issues, 60-70% acres planted dicamba tolerant soy, remaining soy is cupped.
- Using a South Dakota lab that can get down to 1 ppm of the primary metabolites to analyze samples
- Estimated 500,000 acres were planted with tolerant beans.

Tennessee

- 85 complaints so far since end of May. 12 counties involved.
- Emergency rule in place. Must be licensed applicator to apply dicamba. No ag. uses between 9 am - 4 pm, 60-80 window for first bloom. Products older than 2017 cannot be used.
- Sample Results have come back positive for dicamba and 2,4-D
- Never seen this before, not normal drift pattern but a landscape level movement.
- One case - a historically good farmer near vineyard, followed label exactly. Nearby cypress trees are brown from top to bottom.
- Damage in yard on oak trees.
- Seems to be Engenia, as the sales numbers are high.

Georgia

- Much different story - no official complaints of dicamba drift or 2,4-d drift.
- May be due to the extensive mandatory training or 24c labels
- 1-1.1 million acres of xtend cotton and soy - still planting.
- Treated close to 2 million acres of ground.
- Paraquat and glyphosate and 2,4-d from old sprayers have been more of an issue.
- Received a lot of positive comments. Has been a great and important tool.

Mississippi

- 65 complaints so far.
- Focus group put together in 2013.
- New technologies have been reclassified as state restricted use.
- Educational tools, 6 modules. Had to show that you took and passed them before you could purchase.

North Dakota

- Still very early in season.

- Mid-late June applications of dicamba to xtend soy. 6-7th of July they heard of some issues.
- No official complaints so far.
- 30 or so incidents, 9 fields in Fargo.

North Carolina

- 6 official complaints on tobacco and non-dicamba soy.
- Growers are scared that tobacco companies will embargo their crops, so are not complaining officially. NC is leaving the grower anonymous.
- Made training mandatory and had 10 mph wind restriction on 24c.
- 3000 applicators took training with Dr. York and Dr. Everman.
- Sweet potatoes may be damaged.
- Assume they'll be getting more calls soon.

Minnesota

- 9 complaints formally submitted - soybean and garden veg, flowers, ornamentals.
- Mostly in southern Minnesota. 7 counties.
- No training or additional requirements.
- Applications were made in third week of June.
- July 1st was the first complaint.

Illinois

- 160 misuse cases. 42 involved dicamba. 20 of those in last week.
- 23 counties

EPA Regional Offices Question – Seeing a drift gradient patterns vs fence to fence?

ND has seen drift pattern, but also signs of fence to fence damage

Illinois has seen both

Texas

- 170,00 acres of soy in state. Not large issue.
- 6.6 million acres of cotton, 75-80% is xtend.
- So far 98 complaints, 4 mention dicamba.
- 17 samples sent to lab to test for dicamba. 8 have shown dicamba.
- Dicamba is a state limited use, requires applicators and dealers to have a license. Also a regulated pesticide (unique county rules?)
- New technology is exempt as long as tolerant crop applied by ground equip with wind speeds less than 10 mph

Iowa

- 18 out of 116 complaints have been dicamba.
- Ornamental plots, 125 acres in size, and 40-125 acre soybean plots.

- 2- 3 weeks after application the damage shows.
- Collecting samples.
- Expecting more calls.
- Lots of talk in fields related to insurance claims.

Ohio

- Only 3 dicamba complaints.
- Growers are not calling dept of ag, but calling OSU.
- Seeing patterns of drift and edge to edge damage. Also, dicamba carry-over in tanks.
- The chemical reps are going out on the complaints.

Comments:

- Significant number of growers will be making planting and herbicide decisions in September, so something needs to be decided ASAP.
- There won't be much liberty link seed next year, as it's been drifted on. Tennessee will most likely be all xtend next year.
- What's happening with enlist cotton in the south? Arkansas only has 15% enlist cotton, no complaints.
- 250-400,000 acres of soy in Georgia - no issues yet.
- Is there info EPA needs from states to determine if the registration changes after 2 years or even earlier?
- This amount of damage surpasses any issues from aerial application in Arkansas
- Training was really good and redundant. He doesn't think the applicators missed the message. Companies had good stewardship as well.
- These conversations should continue – monthly check-ins.
- How many 6a2 reports? Growers are contacting registrants; wouldn't that be 6a2?
- There is a personal component to this as well.

From:	Kenny, Daniel
To:	john.ewell@tn.gov; paul.bailey@mda.mo.gov; Susie.Nichols@aspb.ar.gov; Dale.Scott@TexasAgriculture.gov; scottde@purdue.edu; Green, Jamie; Klevs, Mardi; Vargo, Steve; Toney, Anthony; stanley@uga.edu; lsteckel@utk.edu; jnorswor@uark.edu; tbarber@uaex.edu; bradleyke@missouri.edu; Jill.Schroeder@ARS.USDA.GOV; DeniseC@mdac.ms.gov; Barrett, Michael; Gray, Thomas; Creger, Tim
Cc:	Rowland, Grant; Montague, Kathryn V.; Dan Rosenblatt; Goodis, Michael; Keigwin, Richard
Subject:	Conference Call with EPA on Dicamba - July 13, 3:00 EDT
Date:	Wednesday, July 12, 2017 7:05:00 PM
Attachments:	Dicamba Meeting with States 07-13-17 - Agenda and Items of Interest.docx

Hello everyone. This is just a reminder, as I hope you are able to join us this Thursday, July 13th, at 3:00 eastern daylight time to discuss the current issues with dicamba incidences in your state. We would very much appreciate the opportunity to learn from your experience. I have attached an agenda to this email for your information. Although there are many items on the agenda, these are only intended to convey items of high interest to us here at the EPA. This meeting is really designed to be an opportunity for you to discuss information that you would like to share that you think is important, so anything that you can offer, whether it's included in the agenda or not, are most welcome.

Again, thank you for your help with this meeting.

Daniel Kenny
Chief, Herbicide Branch
Registration Division
Office of Pesticide Programs
U.S. Environmental Protection Agency
703-305-7546

Dicamba: Meeting with State Representatives

Background: Since June 2017, the EPA has been receiving reports regarding a high number of crop damage incidents involving the active ingredient dicamba. The number of complaints is especially high in Arkansas, Missouri, Mississippi, and Tenessee. Recently, a number of other states are reporting complaints including more northern states.

Dicamba was registered by the Agency for use on dicamba tolerant cotton and soybeans late in 2016 (Monsanto's DGA in November and BASFs BAPMA in December). EPA would appreciate the opportunity to discuss these damage incidents with representatives from the States.

Agenda

I. Meeting Introductions (Dan Kenny - RD)

II. Meeting Objectives (Rick Keigwin - OPP)

III. State Input on Dicamba Incidences (State representatives) - *EPA would like to solicit feedback from state experts (Arkansas, Georgia, Indiana, Mississippi, Missouri, Nebraska, Tennessee) concerning experiences from within their state reflecting damages observed from use of dicamba in the 2017 growing season. Items of particular interest to the Agency are:*

A. What is the scope of damage witnessed so far?
    a. Are there estimates of acres damaged? How does that compare to the acres planted with soybeans that are not dicamba tolerant?
    b. Are there estimates of yield loss?
    c. Is recovery expected?
    d. Is significant damage occurring to other crops?
    e. What is the percent (acres) of tolerant crops vs non tolerant crops being planted in your state?

B. What is/are the source(s) of the damage?
    a. Does damage seem to arise from volatility or drift/temperature inversions/tank contamination? Evidence or Data to support?
        i. Are there indicative symptoms or patterns of each?
        ii. What do you attribute the damage to?
    b. Are approved products being used or is there misuse of unapproved products?
    c. If only approved products are being used, do you believe they are being used according to the label? Are restrictions being followed?
    d. If restrictions are not being followed on approved labels, does it appear intentional or does it appear to be based on misunderstanding the label directions? Are there trends in which restrictions are not being followed?
    e. What suggestions do you have for improving the clarity of the product labels currently registered?

C. What kind of training was conducted in your state?
- a. Was it face to face and/or farm visits vs online training?
- b. Was training widely attended?
- c. Did growers participate in training?
- d. Did registrants participate in training activities?
- e. Did custom applicators/retailer participate?

D. Are there measures that can be identified that, if employed, would likely have helped avoid damage?
- a. What additional measure would you recommend for your state specifically and could they be implemented more widely?

E. What can the state's share regarding their on-going investigations?
- a. What kind of investigation are ongoing?
- b. Are you collecting data on the conditions at the time of the incidents?
- c. Are samples being collected and analyzed?
- d. What is your timeline for reporting results and conclusions from incidents?

IV. Closing Remarks/Discuss Possibility of Additional Meetings (OPP)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

MEMORANDUM

Date: November 7, 2016

Subject: Response to Public Comments Received Regarding the New Use of Dicamba on Dicamba-Tolerant Cotton and Soybeans
Docket ID: EPA-HQ-OPP-2016-0187
Application Date: April 21, 2010 and July 26, 2012

The Agency received 21,710 comments in response to the public participation process (Docket ID: EPA-HQ-OPP-2016-0187) regarding the Environmental Protection Agency's (EPA or the Agency) proposed decision for the application to register the use of dicamba on genetically-engineered (GE) cotton and GE soybean that have been engineered to be resistant to dicamba.[1] Comments received were both in favor of and opposed to the decision to register the new uses which will provide growers with additional tools to control broadleaf weeds. The EPA welcomes input from the public during the decision process when registering significant new uses for registered pesticides and is committed to thoroughly evaluating these comments and determining whether mitigation measures are necessary to meet the applicable statutory standards. Also, EPA strives to document and explain the basis of its regulatory decisions through these and other public documents. Due to the large volume and similar themes of many of the submitted public comments, the EPA is responding to these comments by grouping them together by subject matter.

These new dicamba uses were originally proposed by the Monsanto Company to be added to the currently registered herbicide product M1691 (EPA Registration Number 524-582). This is the specific formulation that was listed in the Agency's Proposed Decision released for public comment earlier this year. Since the proposed decision was published, the Agency assessed a lower volatility dicamba formulation (M1768, with the brand name Xtendimax™ with VaporGrip™ Technology, EPA Registration Number 524-617). This lower volatility formulation is expected to further reduce the potential off site movement of generic dicamba formulations. The M1768 product contains the same active ingredient as M1691, diglycolamine (DGA) salt of dicamba, and is to be used with equivalent application rates and the same application techniques. Because the two products contain the same active ingredient used at the same rates with the same methods, all of the environmental and human health assessments completed and made public in connection with the proposed registration decision for the M1691 apply to M1768. After assessing volatility studies conducted on the M1768 formulation (discussed in the document, "Final Registration of Dicamba on Dicamba-Tolerant Cotton and Soybean," available in this docket), EPA has determined that the new lower volatility formulation of M1768 offers the user a product with less potential to volatilize off-

[1] The terms "genetically-engineered to be resistant to dicamba" and "dicamba-tolerant" are considered to have the same meaning in this document.

model of spray nozzle rather than a performance standard for suitable nozzles.

Response: EFED is working with stakeholders to expand the number of suitable nozzles available and the range of conditions under which the new dicamba products can be applied. Concurrently, EPA is participating in ongoing efforts to implement drift reduction technologies (DRT) to reduce off site movement. EPA will work to expand the range of conditions for this and other products where those conditions have been quantitatively demonstrated to be sufficiently protective of the apical endpoints used in EFED ecological risk assessments. Until that effort is complete, requiring this specific nozzle is protective.

E. Tank Mixes/Synergy

Numerous comments were received regarding tank mixtures and the need for farmers to be able to tank mix multiple herbicides to provide effective control of multiple weed species in one pass. There was also concern that restricting tank mixing prevents a multiple-mode-of-action approach for weed resistance management.

Response: EPA has considered these comments and agrees that the benefits of tank mixing, in general, are compelling and meaningful, however whether to include tank mixing restrictions is made on a case-by-case basis. A further issue for assessing the need for tank mixing restriction is whether the U.S. Patent and Trademark Office has granted a patent for that specific combination, or EPA has information that shows true synergism (*i.e.* greater than additive toxicity between different active ingredients) with tank mixing. EPA believes synergism to be a rare event, and intends to follow the National Research Council's recommendation for government agencies to proceed with estimating effects of pesticide mixtures with the assumption that the components have additive effects in the absence of any data to support the hypotheses of a synergistic interaction between pesticide active ingredients. However, EPA also acknowledges that at least some data appear to exist in connection with patent claims filed with the U.S. Patent and Trademark Office of synergism for specific combinations of dicamba with other herbicides. Those data have not yet been reviewed by EPA and will be further evaluated. Accordingly, the Agency is continuing its work with that information in order to better understand the scope of these uncertainties for these specific combinations and to develop an approach that best manages the potential risks while still maintaining the important benefits derived from tank mixing. While evaluation of these data are still in progress, we are requiring a restriction on the end-use product labels that prohibits tank mixing. If the Agency determines that sufficient data do not exist to support true synergistic effects with a particular active ingredient, then that active ingredient may be added to the list of acceptable tank mix combinations.

Comment: Concern about compatibility and potentially increased drift/volatility when tank mixing the diglycolamine salt of dicamba with another pesticide.

Response: EFED's ecological risk assessments considered the M1691 and M1768 diglycolamine salt of dicamba formulations, and the fact that tank mixtures weren't allowed according to the labeling. The scenario described in this comment illustrates the conceptual intent behind the tank mix prohibition on the approved labels, *i.e.*, chemistry changes in the applicator's tank may alter the risk associated with pesticide application.

Comment: A greenhouse study recently conducted in the Southeast does not support the premise that dicamba tank-mixed with various active ingredients (e.g., glyphosate, *S*-metolachlor, acetochlor) causes more injury to soybean than dicamba applied alone. The study tested tank mixtures at simulated drift rates from 1/15X to 1/1600X and found that only the 1/15X rate resulted in significantly reduced plant height and biomass compared to dicamba alone. Since drift rates are far less than the 1/15X rate, there are no data to support the premise that mixtures are synergistic at true drift rates.

Response: The referenced study quantitatively documents effects relative to the apical endpoints in a way that could be translated to EFED's ecological risk assessment for the chemical combinations tested. However, EFED is aware of patent claims for synergism of dicamba and gylphosate filed with the U.S. Patent and Trademark Office. Thus, while the referenced study may not demonstrate an enhanced effect of mixtures relative to dicamba alone at realistic field drift levels, these patent claims are still being evaluated.

Comment: Adjuvants that pass the compatibility mixture test should be approved by EPA and made publicly accessible before the planting season begins.

Response: A list of EPA approved adjuvants will be publicly accessible via a URL to be included on the final label.

F. Plant Toxicity

Comment: Greenhouse studies do not represent the field and significantly over-estimate damage that is noted in field studies receiving the same treatment.

Response: Although terrestrial plant ecotoxicity endpoints were determined from greenhouse studies, additional higher tier field-level data, provided by registrants and/or found in the open literature, were considered in EFED's risk assessments for dicamba use on dicamba-tolerant soybean and cotton.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C., 20460

OFFICE OF
CHEMICAL SAFETY AND
POLLUTION PREVENTION

PC Code: 128931
DP Barcode: 435792

MEMORANDUM

DATE: November 3, 2016

SUBJECT: M-1691 Herbicide, EPA Reg. No. 524-582 (Active Ingredient: Dicamba Diglycolamine Salt) and M-1768 herbicide, EPA Reg. No. 524-617 (AI: Diglycolamine Salt with VaporGrip™) – Review of EFED Actions and Recent Data Submissions Associated with Spray and Vapor Drift of the Proposed Section 3 New Uses on Dicamba-Tolerant Soybean and Cotton

TO: Grant Rowland, Risk Manager Reviewer
Kathryn Montague, Product Manager 23
Daniel Kenny, Branch Chief
Herbicide Branch
Registration Division (7505P)

FROM: Nathan Miller, Biologist
Michael Wagman, Biologist
Gabe Rothman, Environmental Scientist
William P. Eckel, Ph.D., Senior Science Advisor
Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)

11/03/2016

THRU: Mark Corbin, Branch Chief
Monica Wait, RAPL
Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)

The Environmental Fate and Effects Division's March 2011 risk assessment for the proposed new use of dicamba diglycolamine (DGA) on dicamba-tolerant soybean discussed the potential for adverse effects on non-target plants due to spray drift and identified volatility (*i.e.*, vapor drift) as an uncertainty requiring additional evaluation (USEPA 2011).

In 2014, EFED issued an addendum to the 2011 risk assessment that looked more closely at the risk to terrestrial non-target organisms exposed to dicamba through spray drift and vapor drift using additional information submitted by Monsanto Company (USEPA 2014). The 2014 addendum acknowledged that volatility had been associated with dicamba historically, but did not quantitatively assess the risk for the new use on dicamba-tolerant soybeans, and acknowledged that it was an uncertainty in the assessment. Based on the weight of evidence analysis, it was concluded that the dominant route of off-field exposure to non-target terrestrial and aquatic organisms was more likely to be a result of spray drift and runoff than the volatilized mass of dicamba from a treated field. The 2014 addendum concluded that without product- and nozzle-specific drift curves based on empirical data, the off-field distance that effects are expected for terrestrial plants remained uncertain. The addendum also noted that the uncertainties associated with estimated dicamba vapor concentrations in air and estimated deposition on plants would be greatly reduced by the submission of a terrestrial plant vapor phase toxicity study measuring both toxic response and air exposure concentrations.

In March 2016, EFED issued a second addendum to the 2011 risk assessment that incorporated new field trial data (based on applications conducted in accordance with the draft label requirements {*e.g.* nozzles, spray pressures, ground speeds} designed to reduce spray drift), data from plant damage incidents, laboratory volatility data, and terrestrial plant reproductive effects data, all in relation to spray drift and volatilization (USEPA 2016a). Also in March 2016, EFED finalized a Section 3 new use risk assessment for use of dicamba DGA on dicamba-tolerant cotton (USEPA 2016b).

The March 2016 addendum and risk assessment concluded that based on the available data, a volatilization buffer equal to the spray drift buffer, extending 110 feet (for the 0.5 lb ae/A application rate) in all directions from the treated field, was justified. Among the available data, one open literature study (Egan and Mortensen 2012) directly addressed the potential for volatilization and transport of dicamba and the potential for damage to the most sensitive tested species, soybean (non dicamba-tolerant). Based on damage assessments of non dicamba-tolerant soybean plants placed near treated fields after spray drift from a 0.5 lb/A dicamba DGA salt application had dissipated, the authors estimated the exposure at distance by correlation to known dose-damage correlations. Egan and Mortensen estimated the 95% upper bound vapor exposure would drop below the soybean no-observed-adverse-effect-concentration (NOAEC) at a distance of approximately 25 meters (82 feet). This is well within the 110-foot downwind-only spray drift buffer proposed for the 0.5 lb/A rate. Thus, the March 2016 addendum and risk assessment concluded that the 110-foot buffer distance should be adequately protective of EPA's apical endpoints of plant height and yield following potential volatilization exposure.

Two product formulations of dicamba are discussed below. M-1691, a diglycolamine (DGA) salt of dicamba, is less volatile than older dicamba formulations such as dimethylamine (DMA) salts. (Dicamba DMA salts were not considered for use on genetically engineered soybeans or cotton). M-1768, or VaporGrip™, also a DGA salt, is formulated to be even less volatile than M-1691.

Recent data submissions, including field volatility (flux) studies of both M-1691 and M-1768 in Georgia and Texas, laboratory vapor-phase toxicity studies, and laboratory vapor-phase exposure (humidome) studies, provide evidence that decrease concerns and address earlier uncertainty about off-site vapor-phase exposure. The fair weather conditions (characterized by high temperatures in the low 90^0s F during the day and a strong diurnal cycle of heating and cooling, humidity, and mixing conditions) throughout the study periods for both TX and GA made for near-idealized conditions for volatilization occurring after applications. These data indicate that off-site volatility exposures will be less than the terrestrial plant level of concern (LOC) for listed plants (the NOAEC) for the M-1768 formulation, and will be between the NOAEC and the lowest-observed-adverse-effect-concentration (LOAEC) for M-1691. The margin between the expected exposure for M-1691 and the LOAEC is about ten-fold.

Based on the data described in the Appendix below, including the registrants' field studies and volatilization modeling, the 110-foot omnidirectional buffer for volatilization is no longer warranted for the M-1768 formulation, because the expected exposure at field's edge is less than the NOAEC. A buffer for the M-1691 formulation is also not warranted, taking the uncertainty of exposure and toxicity estimates into account, because the exposure is ten-fold less than the lowest effect level (LOAEC) at the edge of the field.

However, EFED finds that the in-field spray drift buffer of 110 feet downwind (0.5 lb/A rate) or 220 feet (1.0 lb/A) at the time of application must be maintained, because spray drift remains the main concern for potential off-site exposure.

As with all risk assessments, conclusions are made within the bounds of the stated uncertainties. In this case, these principally include whether the submitted field volatility studies adequately encompass the extremes of conditions that cause volatilization, and the statistical uncertainty in the calculation of the level of concern, which is based on the no-effect level for the most sensitive tested plant, soybean. It is possible that volatilization could be greater under conditions outside the scope of the submitted studies. Within these uncertainties, we conclude that no volatilization buffers are needed.

Results of the Georgia and Texas field volatility studies indicate that exposures from the M-1691 formulation are between the NOAEC and LOAEC for the most sensitive plant, while those from the M-1768 formulation are below the NOAEC. Thus, the M-1768 formulation is less likely to cause off-field effects from volatilization.

In August 2016, EPA's Office of Enforcement and Compliance Assurance issued a Compliance Advisory entitled "High number of complaints related to alleged misuse of dicamba raises concerns" (USEPA, 2016c). This document noted that 117 plant damage incidents affecting 42,000 acres have been reported to the Missouri Department of Agriculture (MDA) in the summer of 2016 due to alleged illegal "over-the-top" (post-emergent) use of currently registered dicamba products on dicamba-resistant cotton and soybeans and noted that similar reports have been received by Alabama, Arkansas, Illinois, Kentucky, Minnesota, Mississippi, North Carolina, Tennessee and Texas. These alleged applications would have been inconsistent with the label approved at that time because the over-the-top use had not yet been registered by EPA. Since the over-the-top use has not yet been approved, the labels on these products would not have had the restrictions on the current draft label (*e.g.,* specifying extremely-coarse or ultra-coarse nozzles, spray pressures, equipment speeds and the use of a 110 foot in-field buffer) designed to reduce spray drift. It is not clear at this time what caused these incidents. It is also not clear how the reported damage relates to the apical endpoints (plant height and weight) that are the basis of EPA's risk assessment. As more information becomes available on these and any other incidents, EPA will evaluate the incidents.

If registration of M-1691 and/or M-1768 is granted, EFED recommends analysis of any post-registration incident reports associated with their usage to confirm the findings in this analysis concerning the volatilization route of exposure. Comprehensive post-registration documentation of any incidents should include: wind and other weather conditions surrounding the associated application, whether label language designed to reduce spray drift was followed, and the distance between the application and the location with plant damage.

EFED's March 2016 addendum discussed previous incidents (2012-2015) that had been associated with dicamba use on dicamba-tolerant crops and noted that the Missouri Department of Agriculture had concluded that one incident was a result of volatilization of dicamba, rather than spray drift. EFED also noted in the March 2016 addendum that the incident observations were qualitative measures of visual injury (*e.g.* leaf spotting or curling), rather than quantitative estimates of damage (*i.e.* directly relating to EPA's apical endpoints of plant height, biomass and survival). Submission of field data that quantitatively link visual estimates of plant damage from dicamba to EPA's apical endpoints would be helpful for understanding the nature of the reported incidents and better incorporating any such data into future risk characterization of dicamba's potential effects due to potential volatilization.

Appendix. EFED Summary Conclusions on Vapor-Phase Toxicity of Dicamba and M-1691 and M-1768 Field Volatility (Flux) Studies and Deposition Analysis

Dicamba Vapor Phase (*Humidome*) *Study Conclusions*

A dicamba vapor toxicity response laboratory study was conducted and submitted by Monsanto Company to EPA in 2016 (Gavlick, 2016; MRID 49925703, supplemental suitable for quantitative use). The goal of this dose-response study was to identify a no-effect dicamba air exposure concentration for non-dicamba-tolerant soybean plants. Analytical and biological results were obtained. The analytical results explain that, percent acid equivalency dicamba applied being equal, the DGA form of applied dicamba is less volatile than the other dicamba formulations (*i.e.*, dicamba DMA and dicamba acid) as indicated by the amount of dicamba extracted from the polyurethane foam filter compared to the other formulations. The biological results indicate that soybean height (the only apical endpoint measured) is not significantly reduced compared to control plants following 24 hours of exposure (at 85°F for 16 hours and 70°F for 8 hours with 40% relative humidity) to vapor-phase dicamba at concentrations less than or equal to 0.0177 $\mu g/m^3$; however, 24 hour exposure (at 85°F for 16 hours and 70°F for 8 hours with 40% relative humidity) to concentrations of vapor-phase dicamba greater than or equal to 0.539 $\mu g/m^3$ significantly reduced soybean height compared to control plants (~32% reduction at the LOAEC of 0.539 $\mu g/m^3$). It is notable that the dose spacing in this study results in an approximately 30x difference between the NOAEC and LOAEC, creating uncertainty as to where effects to plants from vapor-phase exposure to dicamba may occur. Generally, definitive toxicity studies are conducted with lower dose-spacing (*e.g.* 1.5-3x geometric spacing between doses). Additional data examining a range of doses between the NOAEC and LOAEC from this study would reduce the uncertainty.

A separate humidome study was conducted by Monsanto Company to compare the volatility differences among dicamba DMA, dicamba DGA, and dicamba DGA plus VaporGrip™ (MRID 49770303). Nominally, 14.48 mg of dicamba acid was applied to 200 in^2 of bare soil in replicate humidomes (three humidomes for dicamba DGA, four humidomes for dicamba DGA plus VaporGrip™) which approximates the maximum single application rate of 1 pound dicamba a.e. per acre. For dicamba DGA applied alone, the study showed 0.0008% of the amount of dicamba applied volatilized off the soil, based on filter recoveries. The vapor-phase concentrations were determined to be 0.0407 $\mu g/m^3$, in line with upper bound concentration predicted by PERFUM from the flux data described in the field volatility study summaries (see next section titled: *Field Volatility (Flux) Studies and Deposition Estimates*), above the vapor-phase NOAEC, but below the vapor-phase LOAEC as determined in MRID 49925703. For dicamba DGA plus VaporGrip™, the study showed 0.00006% of the amount of dicamba applied volatilized off the soil, based on filter recoveries. The vapor-phase concentration was determined to be 0.00298 $\mu g/m^3$, which is below the vapor-phase NOAEC determined in MRID 49925703.

Field Volatility (Flux) Studies and Deposition Estimates

Field volatility research on the dicamba DGA salt formulation (M-1691) and dicamba DGA plus VaporGrip™ additive (M-1768) was conducted by Monsanto Company on treated fields in Georgia and Texas in 2015/2016 and submitted to EPA (Jacobson 2016a-d, respectively MRIDs 49888401, 49888403, 49888501 & 49888503). The fair weather conditions (characterized by high temperatures in the low 90^0s F during the day and a strong diurnal cycle of heating and cooling, humidity, and mixing conditions) throughout the study periods for both TX and GA made for near-idealized conditions for volatilization occurring after applications. The flux data were incorporated into the EPA recommended AERMOD dispersion model[1] to estimate dicamba acid-equivalent (a.e.) deposition downwind from the treated field. Furthermore, the PERFUM model,[2] which is a post-processor for EPA recommended dispersion models, was used to provide estimated peak air concentrations for dicamba. Findings and deficiencies noted during review of these two studies and submitted deposition modeling by the registrant are discussed in greater detail below.

Upper-bound deposition and peak air concentrations predicted by AERMOD and PERFUM, respectively, from the flux data in these studies resulted with the M-1691 formulation. As a conservative estimate of vapor drift, the combined 90^{th} upper-bound percentile predicted deposition (*i.e.* upper-bound predicted dry plus upper-bound predicted wet deposition) at 5-meters from the edge of field would be 3.12×10^{-5} lb a.e./A for the M-1691 formulation in Georgia, and the predicted peak air concentration is 6.03×10^{-2} µg/m^3. Deposition estimates are generally an order of magnitude lower than the most sensitive vegetative vigor NOAEC, 2.61×10^{-4} lb a.e./A for soybean height from the available vegetative vigor data for terrestrial plants. The peak air concentration estimates, however, are above the NOAEC from the vapor-phase study discussed above (0.0177 µg/m^3), but well below the LOAEC of 0.539 µg/m^3 for soybean height. The upper-bound predicted combined deposition at 5-meters from the edge of field was ~ 50-60% lower for the M-1768 formulation (1.29×10^{-5} and 8.95×10^{-6} lb a.e./A deposition values or 2.08×10^{-2} and 8.80×10^{-3} µg/m^3 peak air concentration values, respectively, in Georgia and Texas) compared to the M-1691 applications.

Based on the results from the deposition and air concentration analyses and considering the degree of uncertainty with these analyses (discussed in detail in the deficiencies section below), vapor drift occurring due to volatilization appears unlikely to be a concern for impacts off the treated field. Although the predicted peak air concentration for the M-1691 formulation exceeds the soybean vapor-phase exposure toxicity study NOAEC, it is well below the study's LOAEC. Additionally, the predicted upper bound peak air concentration values for the M-1768 formulation are essentially at or below the soybean vapor-phase NOAEC. Therefore, it is expected that the unidirectional spray drift buffer currently on labels mitigates deposition of dicamba material off the treated field.

The uncertainties associated with the flux data and deposition analysis, especially for the flux data from Texas, could result in underestimates of vapor drift under conditions more conducive

[1] Available on-line: https://www3.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod
[2] Available on-line: http://www.exponent.com/experience/probablistic-exposure-and-risk-model-for-fumigants/?pageSize=NaN&pageNum=0&loadAllByPageSize=true

to codistillation than were tested in these studies. These are fully described below but include a) the lack of off-field sample data from the TX studies to determine volatilization flux during the application, b) volatilization flux during the applications measured at the GA site was not considered in the flux profile constructed for the modeling inputs and, and therefore not accounted for in modeling inputs, c) the time duration for deposition values are not specified in the study report and confounds the comparison of accumulated deposition with respect to toxicological endpoints, and d) applications timings occurred later in the day and missing the morning transition window of what would include the greatest differences in relative humidity and heating with conditions vulnerable to codistillation (this is particularly true for both M-1691 and M-1768 TX applications and the GA application with M-1691). However, the amount of uncertainty in the exposure estimates is small enough that it is very unlikely that the exposure will exceed the effect threshold (NOAEC). Refer to the fifth discussion point within the Deficiencies section below for further detailed information.

These uncertainties could be addressed through submission of the additional off-field sample data from TX, additional research on applications conducted during the morning weather transition window described above, and measured flux at the time of application with its incorporation into the deposition modeling analysis. Furthermore, the time duration for accumulation of deposition should be clarified to enable a more definitive comparison of exposure from vapor drift to available toxicological endpoints. Additionally, where incidents occur (that could be a result of either exposure to spray drift or volatilization), submission of information regarding the climatic conditions (temperature, relative humidity, wind speed and direction) both under which the suspect application occurred and following the application would assist with understanding the conditions under which volatilization exposure can occur. Additional incident data that would be informative includes quantitative measurements of damage comparable to EPA's apical endpoints (*i.e.* plant height, biomass, yield, etc.)

Findings As Gathered From Field Volatility (Flux) Studies (MRIDs 49888401, 49888403, 49888501, 49888503) and Results from AERMOD Deposition Modeling (MRIDs 49925701 – 02)

1. **Applications During Flux Studies** - The applications encompassing the M-1691 and M-1768 formulations were less than one kilometer apart in GA (pre-emergent app.) and several kilometers apart in TX (post emergent/foliar app. to cotton crop) and applications for both formulations occurring within 1 -2 hours of each other at each site.

2. **Weather Conditions After Applications During Flux Studies** - The fair weather conditions throughout the study periods for both TX and GA lend themselves to near-idealized conditions for volatilization occurring after applications. First, afternoons throughout all studies at both sites were very warm with maximum temperatures in the low 90's F. Furthermore, conditions for codistillation appear to be ideal with the weather as there is a strong diurnal cycle between the stable nocturnal regime (characterized by high relative humidity, relatively cool temps., and stagnant conditions) and convective daytime regime (characterized by relatively hot, low relative humidity, and more mixed conditions) at both sites after the applications.

3. **Flux/Concentration Magnitudes Observed in Flux Studies** - Very small concentrations (on the order of <0.06 μg/m^3) and resulting fluxes (on the order of <0.0081 μg/m^2-sec) found throughout the studies appear to be well supported by good recoveries from the Polyurethane Foam (PUF) analytical method evaluation and field spikes.

4. **Flux Events Observed in Flux Studies** - In most instances over both TX and GA, the highest levels of flux occurred at the time of application which occurred throughout the morning to early afternoon. Furthermore, there appears to be a strong diurnal signal with the timings of subsequent peak flux events. These subsequent events may be dependent on both the maximum heating of the day and/or the transitional periods between morning (relatively cool, high relative humidity, stagnant conditions) and afternoon (hot, low relative humidity, more mixing conditions). In most cases, peak flux events occurred between the hours of 7 – 20 after the application.

5. **Summary of AERMOD Deposition Modeling Estimates:**
Upper-bound estimates of deposition indicate reduced deposition and air concentrations following the M-1768 formulation applications as compared to the M-1691 formulation. **Table 1** shows the AERMOD and PERFUM estimates of the upper bound 90th percentile deposition and concentration, respectively, 5-meters from edge of field:

Table 1. AERMOD estimates of the upper 90th percentile 5-meters from edge of field

Depostion and Air Conc. Model Runs**	Study Site Flux Basis	AERMOD Dry Depostion* (lbs. dicamba a.e./A)	AERMOD Wet Deposition* (lbs. dicamba a.e./A)	AERMOD Upper-Bound Combined (Dry + Wet) Deposition (lbs. dicamba a.e./A)	PERFUM Upper-Bound Peak Air Conc. *,*** (μg/m^3)
Dicamba DGA Formulation (M-1691)					
1-3	Georgia	2.08×10^{-5} – 3.10×10^{-5}	2.60×10^{-8} – 2.34×10^{-7}	**3.12×10^{-5}**	**6.03×10^{-2}**
4-6	Texas	9.99×10^{-6} – 1.89×10^{-5}	4.92×10^{-8} – 1.78×10^{-7}	1.91×10^{-5}	2.48×10^{-2}
Dicamba DGA VaporGrip Formulation (M-1768)					
7-9	Georgia	8.52×10^{-6} – 1.28×10^{-5}	2.03×10^{-8} – 1.14×10^{-7}	**1.29×10^{-5}**	**2.08×10^{-2}**
10-12	Texas	5.15×10^{-6} – 8.86×10^{-6}	2.43×10^{-8} – 8.68×10^{-8}	8.95×10^{-6}	8.80×10^{-3}

Maximum values shown in **bold**.

*Range of upper 90th percentile estimates presented of AERMOD estimates from 3 model runs (see next note below).
**Three iterations of model runs encompass different weather conditions coupled with flux profiles input into AERMOD (deposition) or PERFUM (air concentrations). One year of weather data from Lubbock,

TX (surface) and Amarillo, TX (Upper Air); Peoria, IL (Surface) and Lincoln, IL (Upper Air); Raleigh, NC (Surface) and Greensboro, NC (Upper Air) used in analysis only during time of year with dicamba application windows. Phoenix, AZ weather data are also briefly cited but uncertain how that was used based on the study report alone.

***Peak estimated concentrations are one-hour concentrations.

Deficiencies with Field Volatility (Flux) Studies (MRIDs 49888401, 49888403, 49888501, 49888503) and AERMOD Deposition Modeling Analysis (MRIDs 49925701 – 02)

1. **Air Sampling during Application with Flux Studies** - Flux during the application was captured in the GA field volatility studies for both formulations using off-field samplers (indirect method). However, this was not done in any of the TX field volatility studies. While off-field samplers were included as part of the studies in TX, the data were discarded by the study authors briefly stating that samples possibly contained dicamba from other sources than volatilization. Submission of this discarded data would reduce some of the uncertainties discussed in this document.

2. **Weather Conditions During Application with Flux Studies**
   The application timings for each flux study on each formulation is presented in the table below. As mentioned above, there are two weather phenomenon which may contribute to loss of dicamba via volatilization-related processes. The first is codistillation which may occur during the transition from high relative humidity (rh) conditions in the early morning to low relative humidity conditions in the late morning to early afternoon. The second is direct volatilization which may occur during the heating of the day.

   The Georgia flux studies, particularly for the M-1691 formulation, may have only partially captured the impact of the transition from high rh to low rh conditions, and therefore losses could have been greater if applied earlier. Average relative humidities did fall from levels of 68 percent at 9 am to 51 percent at 10 am then to 34 percent at 11 am. However, rh was substantially higher earlier around 7 am with a maximum value of 94 percent observed. The M-1691 formulation was applied later in the morning, while the M-1768 formulation was applied more encompassing the morning transition (**Table 2**). Therefore, given that this transition may drive codistillation, comparisons in flux between the M-1691 and M-1768 may be confounded by the fact that the M-1768 formulation was possibly applied under potentially more vulnerable conditions for enhanced volatilization and resulting vapor drift.

   For both Texas studies, both dicamba formulations occurred after the morning transition and into the more convective part of the day. While heating may have been a driver for volatilization, applications prior to the morning transition could have provided a more vulnerable set of conditions for loss of dicamba from the field.

Table 2. Dicamba formulation application timing and relative humidity

Formulation Applied	Application Timing	Average RH Range During Day of Study After Application Start	Maximum RH During Day of Study
Georgia Studies			
Dicamba DGA (M-1691)	9:54 am May 5, 2015	68 percent falling to 10 percent	94 percent 7 am
Dicamba DGA VaporGrip (M-1768)	8:05 am May 5, 2015	87 percent falling to 10 percent	
Texas Studies			
Dicamba DGA (M-1691)	11:10 am June 8, 2015	38 percent falling to 18 perent	96 percent 7 am
Dicamba DGA VaporGrip (M-1768)	1:15 pm June 8, 2015	23 percent falling to 18 percent	

3. **Potential for Cross-Contamination Between M-1691 and M-1768 Plots During Flux Studies** To determine flux values ultimately used to estimate air concentrations and deposition, flux values need to be determined from a single field of application in order to arrive at an accurate amount of dicamba material that volatilizes and is ultimately driftable. This stated, it appears that the Georgia M-1691 and M-1768 application plots are very close to each other, within 500 meters of each other. In Texas, the two treated plots for each formulation are farther apart, about 5 kilometers from each other. In both cases, the plots with the M-1768 formulations could potentially have been influenced by dicamba material blowing downwind from the plots treated with the M-1691 formulations **(Figure 1**). Furthermore, the typical logarithmic decrease of concentrations with height for flux studies was not strong immediately after the application for the Texas M-1768 application, indicating that there may have been some confounding impacts from cross-contamination. However, this was also the case immediately after the application for the Texas M-1691 application which was applied before the M-1768 application. There were no such anomalies in the vertical concentration profile in the Georgia studies where the concentrations with height over the field exhibited the expected logarithmic decreasing trend.

While cross-contamination can theoretically exist with dicamba applications to multiple fields over a local area, the deposition analysis submitted by the registrant includes up to an 80-acre field treated with each dicamba formulation. This is a large area treated and the resulting exposure to plants off the treated field conveyed in the registrant’s analysis would be expected to capture any potential impacts of cross-contamination that can occur accumulated from smaller fields. However, to reiterate, results from a discretely treated field is desired considering the purposes of a field volatility study described above.

Figure 1. Map of GA field sites (top) and TX field sites (bottom). Site 1 delineates M-1691-only application. Site 2 delineates M-1768 application.

4. **Environmental Chemistry Methods and Method Validation Supporting Flux Studies** – Upon review, it appears that the field volatility study reports include an adequate evaluation of the polyurethane foam (PUF) sampling procedure employed in air samples for these studies. However, an independent laboratory validation demonstrating repeatable performance could not be found. A GLP compliance statement was submitted.

5. **Flux Modeling.** Flux during the application period was not modeled for either the GA or TX site. Flux was not reported for the application period in TX; the measured flux in GA was 1.6 to 1.7 times higher (M-1691 and M-1768, respectively) than in any later measurement period. Even if additional flux of this magnitude was included in the modeling exercise, the total exposure from volatilization would still be below the vapor-phase LOAEC and vegetative vigor NOAEC for M-1691. Modeled exposures would also be below vapor-phase and vegetative vigor endpoints for M-1768.

6. **Interpretation of AERMOD Deposition Values** – In all AERMOD deposition values provided by the registrant, the time durations of the deposition values (e.g., one-hour, four-hour, or 24-hour) is not specified. Since deposition reflects a cumulative value of mass accumulation over time, it becomes difficult to compare exposure impacts to toxicological impacts over a period of time if this information is not provided. However, for the PERFUM air concentration modeling analysis, the registrant did provide sufficient air concentration time averages (e.g., 1-hour, 4-hour, 8-hour, and 24-hour period averages) for appropriate comparisons to the toxicological endpoints.

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Comment submitted by National Family Farm Coalition

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

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Comment

As a coalition representing 25 grassroots member organizations comprised of thousands of family farmers, ranchers, fishermen, rural residents and advocates for fair food and agriculture policy, the National Family Farm Coalition urges the US Environmental Protection Agency to deny Monsanto the permission to release their dicamba-tolerant cotton and soy.

Our growers have expressed concerns over the continued and expanded use of similar deadly herbicides, including increased cases of cancer, Parkinson's disease and other serious illnesses in areas where herbicides are regularly sprayed; 'dead' soil requiring more and more chemical nutrients; diminished biodiversity, particularly the loss of essential pollinator species; and fewer non-GM cotton and soy options. In addition, the use of more herbicides and pesticides leads to the increased use of more herbicides and pesticides as undesirable plants become tolerant. There are other ways to grow these crops using rotations, cover crops and other methods in line with agroecology and healthier, less polluting means; releasing these dicamba-tolerant cotton and soybeans means a step in the wrong direction.

Thank you for the opportunity to submit these comments on behalf of our members.

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Navigating a Critical Juncture for Sustainable Weed Management

DAVID A. MORTENSEN, J. FRANKLIN EGAN, BRUCE D. MAXWELL, MATTHEW R. RYAN, AND RICHARD G. SMITH

Agricultural weed management has become entrenched in a single tactic—herbicide-resistant crops—and needs greater emphasis on integrated practices that are sustainable over the long term. In response to the outbreak of glyphosate-resistant weeds, the seed and agrichemical industries are developing crops that are genetically modified to have combined resistance to glyphosate and synthetic auxin herbicides. This technology will allow these herbicides to be used over vastly expanded areas and will likely create three interrelated challenges for sustainable weed management. First, crops with stacked herbicide resistance are likely to increase the severity of resistant weeds. Second, these crops will facilitate a significant increase in herbicide use, with potential negative consequences for environmental quality. Finally, the short-term fix provided by the new traits will encourage continued neglect of public research and extension in integrated weed management. Here, we discuss the risks to sustainable agriculture from the new resistant crops and present alternatives for research and policy.

Keywords: agriculture production, agroecosystems, transgenic organisms, sustainability, biotechnology

Overreliance on glyphosate herbicide in genetically modified (GM) glyphosate-resistant cropping systems has created an outbreak of glyphosate-resistant weeds (Duke and Powles 2009, NRC 2010). Over recent growing seasons, the situation became severe enough to motivate hearings in the US Congress to assess whether additional government oversight is needed to address the problem of herbicide-resistant weeds (US House Committee on Oversight and Government Reform 2010). One of our coauthors (DAM) delivered expert testimony at these hearings, in which he expressed the views described in this article. Biotechnology companies are currently promoting second-generation GM crops resistant to additional herbicides as a solution to glyphosate-resistant weed problems. We believe that this approach will create new resistant-weed challenges, will increase risks to environmental quality, and will lead to a decline in the science and practice of integrated weed management (IWM). The rapid rise in glyphosate-resistant weeds demonstrates that herbicide-resistant crop biotechnology is sustainable only as a component of broader integrated and ecologically based weed management systems. We argue that new policies are needed to promote integrated approaches and to check our commitment to an accelerating transgene-facilitated herbicide treadmill, which has significant agronomic and environmental-quality implications (figure 1).

Effective weed management is critical to maintaining agricultural productivity. By competing for light, water, and nutrients, weeds can reduce crop yield and quality and can lead to billions of dollars in global crop losses annually. Because of their ability to persist and spread through the production and dispersal of dormant seeds or vegetative propagules, weeds are virtually impossible to eliminate from any given field. The importance of weed management to successful farming systems is demonstrated by the fact that herbicides account for the large majority of pesticides used in agriculture, eclipsing inputs for all other major pest groups. To no small extent, the success and sustainability of our weed management systems shapes the success and sustainability of agriculture as a whole.

In the mid-1990s, the commercialization of GM crops resistant to the herbicide glyphosate (Monsanto's Roundup Ready crops) revolutionized agricultural weed management. Prior to this technology, weed control required a higher level of skill and knowledge. In order to control weeds without also harming their crop, farmers had to carefully select among a range of herbicide active ingredients and carefully manage the timing of herbicide application while also integrating other nonchemical control practices. Glyphosate is a highly effective broad-spectrum herbicide that is phytotoxically active on a large number of weed and crop species across a wide range of taxa (Duke and Powles 2009). Engineered to express enzymes that are insensitive to or can metabolize glyphosate, GM glyphosate-resistant crops have enabled farmers to easily apply this herbicide in soybean, corn, cotton, canola, sugar beet, and alfalfa and to control problem weeds without harming the crop (Duke and Powles 2009).

Growers were attracted to the flexibility and simplicity of the glyphosate and glyposhate-resistant crop technology package and adopted the technology at an unprecedented rate. After emerging on the market in 1996,

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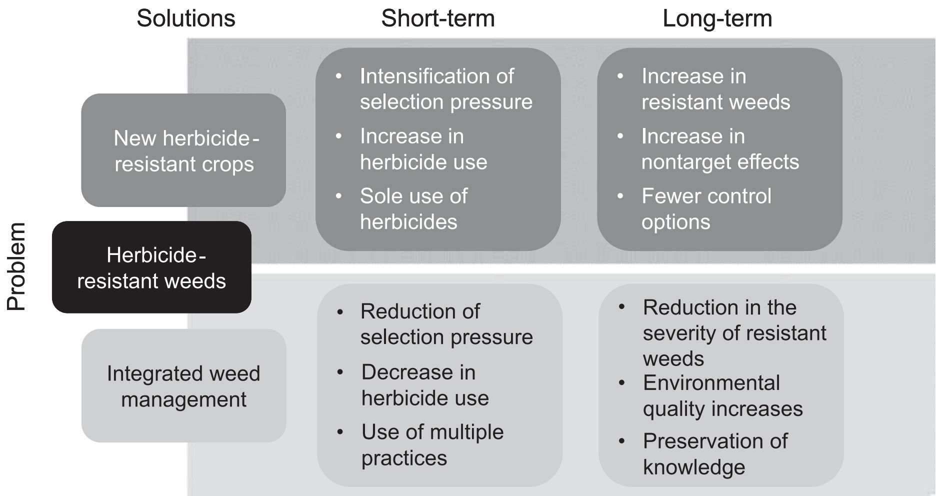

Figure 1. A conceptual model of the alternative solutions—and their potential consequences—presently available for addressing glyphosate-resistant weed problems.

glyphosate-resistant soybeans accounted for 54% of US hectares by 2000 (Duke and Powles 2009). In 2008, crops resistant to glyphosate were grown on approximately 96 million hectares (ha) of cropland internationally and account for 63%, 68%, and 92% of the US corn, cotton, and soybean hectares, respectively (Duke and Powles 2009). The technology is effective and easy to use, and farmers have often responded to these benefits by exclusively planting glyphosate-resistant cultivars and applying glyphosate herbicide in the same fields, year after year (Duke and Powles 2009, NRC 2010).

Unfortunately, this single-tactic approach to weed management has resulted in unintended—but not unexpected—problems: a dramatic rise in the number and extent of weed species resistant to glyphosate (Heap 2011) and a concomitant decline in the effectiveness of glyphosate as a weed management tool (Duke and Powles 2009, NRC 2010). As the area planted with glyphosate-resistant crops increased, the total amount of glyphosate applied kept pace, creating intense selection pressure for the evolution of resistance. This dramatic increase in glyphosate use would not have been possible without glyphosate-resistant crop biotechnology. The number and extent of weed species resistant to glyphosate has increased rapidly since 1996, with 21 species now confirmed globally (Heap 2011). Although several of these species first appeared in cropping systems where glyphosate was being used without a resistant cultivar, the most severe outbreaks have occurred in regions where glyphosate-resistant crops have facilitated the continued overuse of this herbicide. The list includes many of the most problematic agronomic weeds, such as Palmer amaranth (*Amaranthus palmeri*), horseweed (*Conyza canadensis*), and Johnsongrass (*Sorghum halepense*), several of which infest millions of hectares (Heap 2011).

The next generation of herbicide-resistant crops

To address the problem of glyphosate-resistant weeds, the seed and agrichemical industries are developing new GM cultivars of soybean, cotton, corn, and canola with resistance to additional herbicide chemistries, including dicamba (Monsanto) and 2,4-D (2,4-dichlorophenoxyacetic acid; Dow AgroSciences) (Behrens MR et al. 2007, Wright et al. 2010). Dicamba and 2,4-D are both in the synthetic auxin class of herbicides, which have been widely used for weed control in corn, cereals, and pastures for more than 40 years. These herbicides mimic the physiological effects of auxin-type plant-growth regulators and can cause abnormal growth and eventual mortality in a wide variety of broadleaf plant species. In addition to species with recently evolved resistance, several important broadleaf weed species are naturally tolerant to glyphosate but susceptible to synthetic auxins. In cropping systems where glyphosate-resistant or -tolerant weeds are major problems, dicamba and 2,4-D applications would provide an effective weedmanagement tool. Although several other transgene–herbicide combinations are currently in the research and development pipeline (Duke and Powles 2009), these modes of action already have significant resistant-weed issues or do not control weeds as effectively as dicamba or 2,4-D herbicides. Consequently, we expect that synthetic auxin–resistant cultivars will be embraced by growers and planted on rapidly increasing areas in the United States and worldwide over the next 5–10 years.

In addition to their weed management utility, there are a number of agronomic drivers that may further accelerate the adoption of the new resistant cultivars. First, soybean, cotton, and many other broadleaf crops are naturally extremely sensitive to synthetic auxin herbicides and show distinctive injury symptoms when they encounter trace doses (figure 2; Breeze and West 1987, Al-Khatib and Peterson 1999, Everitt and Keeling 2009, Sciumbato et al. 2004). Most US growers rely on commercial applicators to spray herbicides, and when susceptible and synthetic auxin–resistant fields are interspersed, there may be a high probability for application mistakes in which susceptible fields are accidentally treated with dicamba or 2,4-D. Second, synthetic auxins are extremely difficult to clean from spray equipment (Boerboom 2004), and low residual concentrations of these compounds in equipment could damage susceptible cultivars. Growers and applicators may need to have equipment dedicated to dicamba or 2,4-D to avoid damage from residual concentrations. Third, some formulated products of

Figure 2. Photo of soybean responding to a drift-level exposure to dicamba herbicide, exhibiting typical symptoms of cupped-leaf morphology and chlorotic-leaf margins. Photograph: J. Franklin Egan.

dicamba and 2,4-D have high volatility (Grover et al. 1972, Behrens R and Lueschen 1979), and the combination of particle and vapor drift may generate frequent incidents of significant injury or yield loss to susceptible crops. Moreover, the seed and chemical industries are becoming increasingly consolidated, making it more difficult for growers to find high-yielding varieties that do not also contain transgenic herbicide-resistance traits. Combined, these four agronomic drivers suggest that once an initial number of growers in a region adopts the resistant traits, the remaining growers may be compelled to follow suit in order to reduce the risk of crop injury and yield loss.

If herbicide-resistant-weed problems are addressed only with herbicides, evolution will most likely win

Glyphosate-resistant weeds rapidly evolved in response to the intense selection pressure created by the extensive and continuous use of glyphosate in resistant crops. Anticipating the obvious criticism that the new synthetic auxin–resistant cultivars will enable a similar overuse of these herbicides and a new outbreak of resistant weeds, scientists affiliated with Monsanto and Dow have argued that synthetic auxin–resistant weeds will not be a problem because (a) currently very few weed species globally have evolved synthetic auxin resistance, despite decades of use; (b) auxins play complex and essential roles in the regulation of plant development, which suggests that multiple independent mutations would be necessary to confer resistance; and (c) synthetic auxin herbicides will be used in combination or rotation with glyphosate, which will require weeds to evolve multiple resistance traits in order to survive (Behrens MR et al. 2007, Wright et al. 2010). Although these arguments have been repeated in several high-profile journals, the authors of those arguments have conspicuously left out several important facts about current patterns in the distribution and evolution of herbicide-resistant weeds.

First, similar arguments were made during the release of glyphosate-resistant crops. Various industry and university scientists contended that details of glyphosate's biochemical interactions with the plant enzyme EPSPS (5-enolpyruvylshikimate-3-phosphate synthase) combined with the apparent lack of resistant weeds after two decades of previous glyphosate use indicated that the evolution of resistant weeds was a negligible possibility (Bradshaw et al. 1997).

Second, it is not the case that "very few" weed species have evolved resistance to the synthetic auxin herbicides. Globally, there are 28 species, with 6 resistant to dicamba specifically, 16 to 2,4-D, and at least 2 resistant to both active ingredients (table 1). And although many of these species are not thought to infest large areas or cause significant economic harm, data on the extent of resistant weeds are compiled through a passive reporting system, in which area estimates are voluntarily supplied by local weed scientists after a resistant-weed problem becomes apparent. Synthetic auxin–resistant weeds may appear unproblematic because these species currently occur in cropping systems in which other herbicide modes of action are used that can effectively mask the extent of the resistant genotypes (Walsh et al. 2007). Furthermore, the claim that 2,4-D resistance is unlikely to evolve because of the complex and essential functions that auxins play in plants is unsubstantiated. In many cases in which resistance has evolved to synthetic auxins, the biochemical mechanism is unknown. However, in at least two cases, dicamba-resistant *Kochia scoparia* (Preston et al. 2009) and dicamba-resistant *Sinapis arvensis* (Zheng and Hall 2001), resistance is conferred by a single dominant allele, indicating that resistance could develop and spread quite rapidly (Jasieniuk and Maxwell 1994).

The final dimension of the industry argument is that by planting cultivars with stacked resistant traits, farmers will be able to easily use two distinct herbicide modes of action and prevent the evolution of weeds simultaneously resistant to both glyphosate and dicamba or 2,4-D. The logic behind this argument is simple. Because the probability of a mutation conferring target-site resistance to a single-herbicide mode of action is a very small number (generally estimated as one resistant mutant per 10^{-5} to 10^{-10} individuals [Jasieniuk and Maxwell 1994]), and because distinct mutations are assumed to be independent events, the probability of multiple target-site resistance to two modes of action is the product of two very small numbers (i.e., 10^{-10} to 10^{-20}). For instance, if the mutation frequency for a glyphosate-resistant allele in a weed population is 10^{-9}, and the frequency for a dicamba mutant is also 10^{-9}, the frequency of individuals simultaneously carrying both resistant alleles would be 10^{-18}. If the population density of this species is assumed to be around 100 seedlings per square meter (m^2) of cropland (10^6 per ha), it would require 10^{12} ha of cropland to find just one mutant individual with resistance to both herbicides. For point of reference, there are only about 15×10^8 ha of cropland globally. Therefore, even if the weed species were globally distributed, and all of the world's crop fields

Table 1. Global diversity and extent of the 28 weed species with resistance to synthetic auxin herbicides.

Year	Common name	Scientific name	Herbicides	Location	Acres
1952	Wild carrot	*Daucus carota*	2,4-D	Ontario	<1
1957	Spreading dayflower	*Commelina diffusa*	2,4-D	Hawaii	No data
1964	Field bindweed	*Convolvulus arvensis*	2,4-D	Kansas	No data
1975	Scentless chamomile	*Matricaria perforata*	2,4-D	France	101–500
1975	Scentless chamomile	*Matricaria perforata*	2,4-D	United Kingdom	101–500
1979	Canada thistle	*Cirsium arvense*	MCPA	Sweden	No data
1981	Musk thistle	*Carduus nutans*	2,4-D, MCPA	New Zealand	1001–10,000
1983	Gooseweed	*Sphenoclea zeylanica*	2,4-D	Philippines	1–5
1985	Canada thistle	*Cirsium arvense*	2,4-D, MCPA	Hungary	No data
1985	Common chickweed	*Stellaria media*	Mecoprop	United Kingdom	No data
1988	Yellow starthistle	*Centaurea solstitialis*	Picloram	Washington	1–5
1988	Tall buttercup	*Ranunculus acris*	MCPA	New Zealand	1001–10,000
1989	Globe Fingerrush	*Fimbristylis miliacea*	2,4-D	Malaysia	51–100
1990	Wild mustard	*Sinapis arvensis*	2,4-D, dicamba, dichloprop, MCPA, mecoprop, picloram	Manitoba	51–100
1993	Wild carrot	*Daucus carota*	2,4-D	Michigan	11–50
1993	Corn poppy	*Papaver rhoeas*	2,4-D	Spain	10,001–100,000
1994	Wild carrot	*Daucus carota*	2,4-D	Ohio	1001–10,000
1995	Kochia	*Kochia scoparia*	Dicamba	North Dakota	101–500
1995	Kochia	*Kochia scoparia*	Dicamba, fluroxypr	Montana	1001–10,000
1995	Yellow Burhead	*Limnocharis flava*	2,4-D	Indonesia	1001–10,000
1995	Gooseweed	*Sphenoclea zeylanica*	2,4-D	Malaysia	No data
1996	False cleavers	*Galium spurium*	Quinclorac	Albera	51–100
1997	Italian thistle	*Carduus pycnocephalus*	2,4-D	New Zealand	No data
1997	Kochia	*Kochia scoparia*	Dicamba	Idaho	1–5
1998	Barnyardgrass	*Echinochloa crus-galli*	Quinclorac	Louisiana	501–1,000
1998	Common hempnettle	*Galeopsis tetrahit*	Dicamba, fluroxypr, MCPA	Alberta	101–500
1998	Yellow Burhead	*Limnocharis flava*	2,4-D	Malaysia	11–50
1999	Barnyardgrass	*Echinochloa crus-galli*	Quinclorac	Brazil	1–5
1999	Barnyardgrass	*Echinochloa crus-galli*	Quinclorac	Arkansas	1–5
1999	Gulf cockspur	*Echinochloa crus-pavonis*	Quinclorac	Brazil	1–5
1999	Wild radish	*Raphanus raphanistrum*	2,4-D	Australia	10,001–100,000
1999	Carpet burweed	*Soliva sessilis*	Clopyralid, picloram, triclopyr	New Zealand	6–10
2000	Junglerice	*Echinochloa colona*	Quinclorac	Colombia	11–50
2000	Gooseweed	*Sphenoclea zeylanica*	2,4-D	Thailand	11–50
2002	Smooth crabgrass	*Digitaria ischaemum*	Quinclorac	California	11–50
2002	Marshweed	*Limnophila erecta*	2,4-D	Malaysia	501–1,000
2005	Common lambsquarters	*Chenopodium album*	Dicamba	New Zealand	11–50
2005	Indian hedge-mustard	*Sisymbrium orientale*	2,4-D, MCPA	Australia	51–100
2006	Wild radish	*Raphanus raphanistrum*	2,4-D, MCPA	Australia	1–5
2007	Prickly lettuce	*Lactuca serriola*	2,4-D, dicamba, MCPA	Washington	101–500
2008	Wild mustard	*Sinapis arvensis*	Dicamba	Turkey	101–500
2009	Barnyardgrass	*Echinochloa crus-galli*	Quinclorac	Brazil	No data

Note: Some species have evolved resistance to various synthetic auxin herbicides on multiple independent occasions in different locations. Compiled from Heap (2011).
2,4-D, 2,4-Dichlorophenoxyacetic acid; MCPA, 2-methyl-4-chlorophenoxyacetic acid.

were treated with both herbicides, it would appear virtually impossible to select a single weed seedling exhibiting multiple resistance.

The problem with this reassuring analysis is that it contradicts recent evidence. Weed species resistant to multiple herbicide modes of action are becoming more widespread and diverse (figure 3). There are currently 108 biotypes in 38 weed species across 12 families possessing simultaneous resistance to two or more modes of action, with 44% of these having appeared since 2005 (Heap 2011). Common waterhemp (*Amaranthus tuberculatus*) simultaneously resistant to glyphosate, ALS, and PPO herbicides infests 0.5 million ha of corn and soybean in Missouri (Heap 2011). Rigid ryegrass (*Lolium rigidum*) populations resistant to seven distinct modes of action infest large areas of southern Australia (Heap 2011). Weeds can defy the probabilities and evolve multiple resistance through a number of mechanisms.

First, when a herbicide with a new mode of action is introduced into a region or cropping system in which weeds resistant to an older mode of action are already widespread and problematic, the probability of selecting for multiple target-site resistance is not the product of two independent, low-probability mutations. In fact, the value is closer to the simple probability of finding a resistance mutation to the new mode of action within a population already extensively resistant to the old mode of action. For instance, in Tennessee, an estimated 0.8–2 million ha of soybean crops are infested with glyphosate-resistant horseweed (*C. canadensis*) (Heap 2011). Assuming seedling densities of 100 per m^2 or 10^6 per ha (Dauer et al. 2007) and a mutation frequency for synthetic auxin resistance of 10^{-9}, this implies that next spring, there will be 800–2000 horseweed seedlings in the infested area that possess combined resistance to glyphosate and a synthetic auxin herbicide ((2×10^6 ha infested with glyphosate resistance) × (10^6 seedlings per ha) × (1 synthetic auxin–resistant seedling per 10^9 seedlings) = 2000 multiple-resistant seedlings). In this example, these seedlings would be located in the very fields where farmers would most likely want to plant the new stacked glyphosate- and synthetic auxin–resistant soybean varieties (the fields where glyphosate-resistant horseweed problems are already acute). Once glyphosate and synthetic auxin herbicides have been applied to these fields and have killed the large number of susceptible genotypes, these few resistant individuals would have a strong competitive advantage and would be able to spread and multiply rapidly in the presence of the herbicide combination.

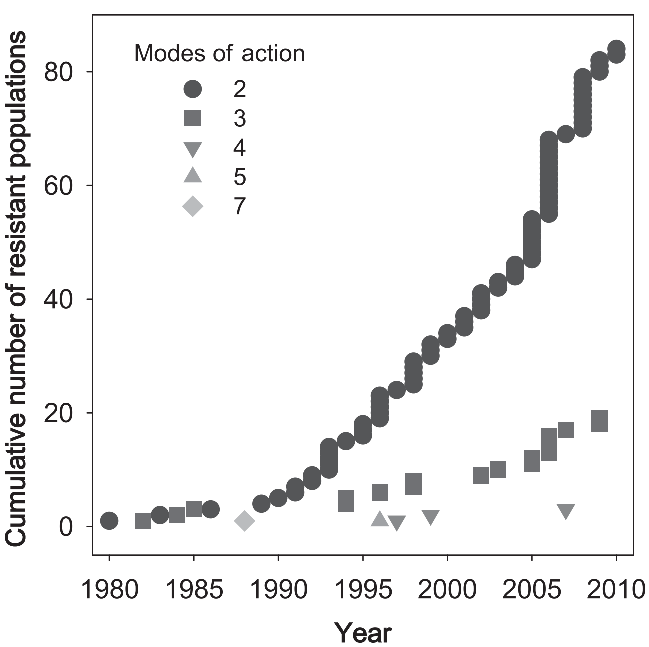

Figure 3. Global increases in the number of weed populations since 1980 across 38 species that exhibit simultaneous resistance to two or more distinct herbicide modes of action (MOA). Data compiled from Heap 2011.

Second, several weed species have evolved cross-resistance, in which a metabolic adaptation allows them to degrade several different herbicide modes of action. Mutations to cytochrome P450 monooxygenase genes are a common mechanism for cross-resistance (Powles and Yu 2010). Plant species typically have a large number of P450 genes (e.g., the rice genome contains 458 distinct P450 genes), which are involved in a variety of metabolic functions, including the synthesis of plant hormones and the hydrolyzation or dealkylation of herbicides and other xenobiotics. Weeds with P450 mediated resistance are widespread and increasingly problematic. For instance, across Europe and Australia, numerous populations of *L. rigidum* and *Alopecurus myosuroides* occur with various combinations of P450 resistance to the ALS-, ACCase-, and photosystem II–inhibitor herbicides (Powles and Yu 2010). Given the diversity and ubiquity of P450 monoxygenases in plant genomes, it is possible that in the near future, a weed species could evolve a mutation that enables it to degrade glyphosate and the synthetic auxins.

Historically, the use of the synthetic auxin herbicides has been limited to cereals or as preplant applications in broadleaf crops. The new transgenes will allow 2,4-D and dicamba to be applied at higher rates, in new crops, in the same fields in successive years, and across dramatically expanded areas, creating intense and consistent selection pressure for the evolution of resistance. Taken together, the current number of synthetic auxin–resistant species, the broad distribution of glyphosate-resistant weeds, and the variety of pathways by which weeds can evolve multiple resistance suggest that the potential for synthetic auxin–resistant or combined synthetic auxin– and glyphosate-resistant weeds in transgenic cropping systems is actually quite high. One hundred ninety-seven weed species have evolved resistance to at least 1 of 14 known herbicide modes of action (Heap 2011), and the discovery and development of new herbicide active ingredients has slowed dramatically over recent decades. Given that herbicides are a cornerstone of modern weed management, it seems unwise to allow the new GM herbicide-resistant crops to needlessly accelerate and exacerbate resistant-weed evolution.

Increasing herbicide applications and the consequences for environmental quality

In the early promotions of their new resistant cultivars, scientists from Dow and Monsanto have been advocating herbicide programs that combine current rates of glyphosate with 225–2240 grams (g) per ha of dicamba (Arnevik 2010) or 560–2240 g per ha of 2,4-D (Olson and Peterson 2011). Therefore, the technology will not involve a substitution of herbicide active ingredients but will instead lead to additional herbicide use. If the rate of adoption of this technology follows the general trajectory of glyphosate-resistant crops, the result could be a profound increase in the total amount of herbicide applied to farmland (figure 4). This trend would move us in the opposite direction of the reduced chemical inputs that scientists in sustainable agriculture have long advocated. As the seed and agrichemical industries move closer to the commercialization of new resistant traits, it is worth pausing to ask what the environmental-quality consequences of this increase may be.

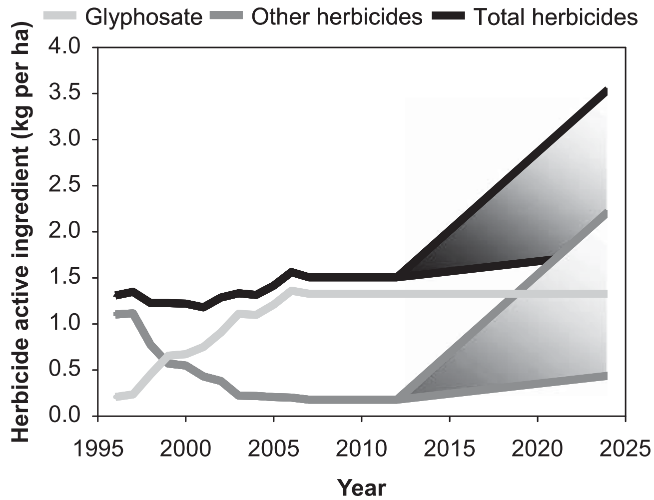

Figure 4. Total herbicide active ingredient applied to soybean in the United States. The data from 1996 to 2007 are adapted from Figure 2-1 in NRC (2010), and the projected data are based on herbicide programs described by Arnevik (2010) and Olson and Peterson (2011). To forecast herbicide rates from 2008 to 2013 we assumed that the applications of glyphosate and other herbicides will remain constant at 2007 levels until 2013, when new resistant soybean varieties are likely to become available. We estimated yearly increases in synthetic auxin herbicides (assumed to drive increases in other herbicides) by assuming that the adoption of stacked synthetic auxin–resistant cultivars mirrors the adoption of glyphosate-resistant cultivars, such that 91% of soybean hectares are resistant to synthetic auxin herbicides within 12 years. We further assumed that all soybean hectares with stacked resistance to glyphosate and synthetic auxin herbicides will receive an annual application of glyphosate and dicamba or 2,4-D. We assumed that the use rates of glyphosate will remain at current levels, and our estimates for dicamba and 2,4-D encompass lower (0.28 kilograms [kg] per hectare [ha]) and higher (2.24 kg per ha) use rates, which are in line with the rates currently used on tolerant crops (i.e., corn and wheat) and with rates being researched and promoted by Dow and Monsanto.

Dicamba and 2,4-D have been widely used in agriculture for over 40 years, and recent US Environmental Protection Agency (USEPA) reviews have classified both herbicides as being relatively environmentally benign (USEPA 2005, 2006). Both herbicides have low acute and chronic toxicities to mammalian, bird, and fish model organisms; degrade fairly rapidly in the soil; and are not known to bioaccumulate. Not surprisingly, however, both dicamba and 2,4-D are extremely toxic to broadleaf plants. For many terrestrial and aquatic plant species, the USEPA assessments rank the ecotoxicological risks for both dicamba and 2,4-D well above their set levels of concern (USEPA 2005, 2006). In a relative-risk assessment comparing a suite of 12 herbicides commonly used in wheat, Peterson and Hulting (2004) reported the risk to terrestrial plants for dicamba and 2,4-D as being 75 and 400 times greater than glyphosate, respectively.

All herbicides can have negative impacts on nontarget vegetation if they drift from the intended areas either as wind-dispersed particles or as vapors evaporating off of the application surface. Because of their volatility and effects at low doses, past experience with injury to susceptible crops has indicated that the synthetic auxin herbicides may be especially prone to drift problems (Behrens R and Lueschen 1979, Sciumbato et al. 2004, US House Committee on Oversight and Government Reform 2010). Research has shown that using recommended application equipment (e.g., spray nozzle types) and applying herbicides under appropriate weather conditions can reduce particle drift. Modern formulations and chemistries of synthetic auxin products also can minimize vapor drift. However, growers and commercial applicators do not always use appropriate or recommended herbicide application practices, especially if these technologies are more costly. The new resistant cultivars will enable growers to apply synthetic auxin herbicides several weeks later into the growing season, when higher temperatures may increase volatility and when more varieties of susceptible crops and nontarget vegetation are leafed out, further increasing the potential for nontarget drift damage.

Plant diversity plays fundamental roles in agroecosystem sustainability, and major increases in dicamba and 2,4-D use may negatively affect multiple aspects of this important resource. First, as was discussed above, herbicide drift or misapplications could create a strong incentive for growers to plant resistant seeds as insurance against crop damage from herbicide drift or applicator mistakes, even if they are not interested in applying synthetic auxin herbicides themselves. This effect could further augment the portion of the seed market and of the landscape garnered by the resistant seed varieties, which would reduce genotypic diversity and restrict farmers' access to different crop varieties. Second, a large number of agronomic, fruit, and vegetable crops are susceptible to injury and yield loss from drift-level exposures to these herbicides (figure 2; Breeze and West 1987, Al-Khatib and Peterson 1999, Everitt and Keeling 2009). In the past, growers have reported issues with injury from drift and have recently voiced concerns about the expanded use of the synthetic auxin herbicides (Behrens R and Lueschen 1979, Boerboom 2004, Sciumbato et al. 2004, US House Committee on Oversight and Government Reform 2010). Landscapes dominated by synthetic auxin–resistant crops may make it challenging to cultivate tomatoes, grapes, potatoes, and other horticultural crops without the threat of yield loss from drift. Finally, a growing body of research has demonstrated that wild plant diversity in uncultivated, seminatural habitat fragments interspersed among crop fields helps support ecosystem services valuable to agriculture, including pollination and biocontrol (Isaacs et al. 2009). More research is needed in order to understand the impact that increased synthetic auxin applications may have on the quality and function of these plant diversity resources.

IWM: An alternative path forward

Glyphosate-resistant weeds—and herbicide-resistant weeds in general—represent a significant challenge to our food system. However, simply inserting additional resistant traits into crops and promoting the continuous application of glyphosate and dicamba or 2,4-D is by no means the only available or practical solution to this problem (figure 1). Growers and scientists have been working together for decades to develop a robust set of management practices that could be implemented to address resistant-weed issues.

Integrated weed management is characterized by reliance on multiple weed management approaches that are firmly underpinned by ecological principles (Liebman et al. 2001). As its name implies, IWM integrates tactics, such as crop rotation, cover crops, competitive crop cultivars, the judicious use of tillage, and targeted herbicide application, to reduce weed populations and selection pressures that drive the evolution of resistant weeds. Under an IWM approach, a grain farmer, instead of relying exclusively on glyphosate year after year, might use mechanical practices such as rotary hoeing and interrow cultivation, along with banded pre- and postemergence herbicide applications in a soybean crop one year, which would then be rotated to a different crop, integrating different weed management approaches. In fact, long-term cropping-system experiments in the United States have demonstrated that cropping systems that employ an IWM approach can produce competitive yields and realize profit margins that are comparable to, if not greater than, those of systems that rely chiefly on herbicides (Pimentel et al. 2005, Liebman et al. 2008, Anderson 2009). In one study, herbicide inputs were reduced by up to 94%, and profit margins were comparable to those of a conventional system (Liebman et al. 2008).

The introduction of glyphosate-resistant crops was a key factor enabling no-till crop production, which increased from 45 million to 111 million ha worldwide between 1999 and 2009 (Derpsch et al. 2010). Although no-till production can provide soil-quality and conservation benefits, it is dependent on herbicides, and the overreliance on glyphosate now threatens its sustainability. Effective IWM typically involves some tillage, such as interrow cultivation over a multiyear crop rotation. Despite a common misconception that tillage is always destructive to soil, a growing body of cropping systems research has demonstrated that where limited tillage is balanced in an IWM context with soil-building practices such as cover-cropping or manure applications, high levels of soil quality can be maintained. For example, rotational-tillage systems have recently been reported to accumulate and store more soil organic matter than no-till systems (Venterea et al. 2006). Greater soil carbon and nitrogen were observed in integrated systems that used tillage, cover crops, and manure than in a conventionally managed no-till system, regardless of whether cover crops were used in the no-till system (Teasdale et al. 2007). These results illustrate that soil-quality benefits associated with no-till systems can also be achieved using IWM that includes limited tillage.

Recent research has also demonstrated that IWM strategies are effective in managing herbicide-resistant weeds. For example, glyphosate-resistant horseweed in no-till soybean can be controlled by integrating cover crops and soil-applied residual herbicides (Davis VM et al. 2009). In a recent experiment in which the integration of tillage and cover crops was evaluated for controlling glyphosate-resistant Palmer amaranth in Georgia, the combination of tillage and rye cover crops reduced Palmer amaranth emergence by 75% (Culpepper et al. 2011). In addition to cultivation and cover crops, other practices can be used to manage resistant-weed populations. Researchers in Australia suggested two cultural weed management practices for reducing glyphosate-resistant weed populations: increasing a crop's competitive ability through higher seeding rates and preventing seed rain of resistant weeds by collecting or destroying weed seed at harvest (Walsh and Powles 2007). Area-wide management plans in which farmers cooperate to limit the hectares over which a single herbicide is applied can prevent the spread of a resistant species across a landscape (Dauer et al. 2009).

Unfortunately, the knowledge infrastructure needed to practice IWM in the future may be atrophying. Although seed and chemical companies can generate enormous revenues through the packaged sales of herbicides and transgenic seeds, the IWM approaches outlined above are based on knowledge-intensive practices, not on salable products, and lack a powerful market mechanism to push them along. For instance, delaying the planting date one or two weeks until after a flush of summer annual weeds have germinated can facilitate the control of these weeds with burndown herbicides and eliminate the need for postemergence herbicide applications. To apply this IWM practice, a farmer would need detailed, region-specific information on crop and weed ecology in order to choose the planting date that optimizes a tradeoff between better weed control and a shorter growing season (Nord et al. 2011). Because the use of this practice might reduce the need for herbicide inputs, modern seed-chemical firms would have little incentive to pursue the required research or to extend the knowledge to growers. IWM knowledge serves as a public good, and it requires locally adapted and ongoing public research, combined with effective extension education programs, in order to address current and future weed management challenges.

In his congressional testimony, Troy Roush (Indiana farmer and vice president of the American Corn Grower's Association) remarked that farmers are "working on the advice largely of industry anymore.… Public research is dead; it's decimated" (US House Committee on Oversight and Government Reform 2010). Indeed, several trends indicate that the public support needed for IWM research and extension is declining. First, the formula funds in the US Farm Bill that have historically provided support for land-grant universities to pursue farming systems research tailored to their growing regions have been steadily phased out in favor of competitive grant programs, in which the research topics and agendas are set by federal funding agencies (Huffman et al. 2006, Schimmelpfennig and Heisey 2009). The total amount of federal public funding for agriculture has basically remained flat since 1980, whereas private research investments have steadily increased (Schimmelpfennig and Heisey 2009). During this period, partnerships between land-grant universities and chemical and biotechnology companies have increased in number and extent (Schimmelpfennig and Heisey 2009), and in several respects, research activities in public colleges of agriculture have transitioned to parallel the activities and priorities of the biotechnology industry (Welsh and Glenna 2006). A recent survey of the membership of the Weed Science Society of America suggests that these patterns are influencing the research priorities of scientists who specialize in weed management (Davis AS et al. 2009). As of 2007, 41% of the membership reported topics related to herbicide efficacy as their primary research focus, whereas only 22% reported focusing on topics with a broader integrated perspective.

When the next major weed management challenge arrives, will we be prepared with the knowledge and skilled workforce capable of implementing an integrated solution?

Policies to cultivate IWM

Several changes in policy could reduce the likelihood that the next generation of herbicide-resistant crops will result in negative consequences for food production and the environment and could ensure that IWM thrives as a sustainable alternative in the future. To be clear, we are not advocating the prohibition of herbicide-resistant crops; there is ample evidence attesting to the economic and environmental benefits that can be realized if these technologies are used judiciously (Duke and Powles 2009). Rather, we are advocating that concrete policy steps be taken to ensure that we learn from our problematic experiences with glyphosate resistance, such that the new herbicide-resistant crops are adopted as only one component of fully integrated weed management systems. Such policies could include USEPA-mandated resistant-weed management plans, fees discouraging single-tactic weed management, improved grower education programs implemented through industry–university–government collaborations, and environmental payments that connect IWM to broader environmental goals.

First, the USEPA, and similar agencies in other countries, should require that registration of new transgene–herbicide crop combinations explicitly address herbicide-resistant-weed management. Weed scientists and industry spokespeople have frequently expressed skepticism that resistance management regulations would be enforceable and have instead placed the burden on education and promotional efforts by agribusinesses or the responsible behavior of individual growers (NRC 2010). However, in *Bacillus thuringiensis* (Bt) cropping systems, regulations requiring non-Bt refugia have largely prevented the evolution of insect resistance to Bt and protected the effective and sustainable use of this biotechnology (NRC 2010), although improvements may be needed in monitoring and compliance (NRC 2010). For herbicides, regulations need not be focused on local refugia but could implement spatially explicit, area-wide management plans that work to reduce selection pressure at landscape or regional scales. These plans could mandate carefully defined patterns of herbicide rotation or could set upper limits on the total sales of a specific herbicide active ingredient or of a resistant seed variety within an agricultural county. Efficient allocation of crop hectares treated with a specific herbicide or planted with a resistant variety could be achieved through a tradable-permit system.

Second, fees directly connected to the sale of herbicide-resistant seeds or the associated herbicides could provide a disincentive for overreliance on the technology package (Liebman et al. 2001). These fees could be scaled to specifically discourage overuse, such that a grower or applicator would be charged only if a specified threshold in planted hectares or successive applications were exceeded. The proceeds from the fees could be funneled directly into funds for public university research and education programs that promote the understanding and adoption of IWM techniques among farmers. In Iowa, similar levies on pesticides are used to fund Iowa State University's Leopold Center, which has played a significant role in the development of IWM science (Liebman et al. 2001).

Third, stronger partnerships among industry, universities, and government could foster IWM through more effective education and extension efforts. When new herbicide active ingredients or herbicide-resistant crop varieties are brought to market, seed and agrichemical companies often develop product-stewardship plans intended to educate growers, applicators, and salespeople on IWM practices to prevent or manage herbicide-resistant weeds. However, because past and current stewardship plans have been developed by an industry driven by herbicide sales, the IWM concept articulated in these plans is largely reduced to simply rotating or combining herbicide active ingredients and fails to promote a more comprehensive set of chemical and nonchemical weed management practices. The ever-growing number of herbicide-resistant weeds (figure 3; Heap 2011) indicates that a solely industry-led approach to herbicide stewardship and IWM education is insufficient and ineffective. Before synthetic auxin–resistance traits are brought to market, stewardship plans could be revised with more comprehensive participation and oversight from government and universities. For instance, sales literature and labels for resistant crops and the associated herbicides could include more extensive detail on a wider set of resistance-management practices available to growers and could provide access to university or government IWM information resources. Industry-sponsored field days and promotional events could be required to include university scientists and to provide ample time devoted to IWM education. Renewal of herbicide or GM trait registrations could be made contingent on compliance with these more aggressive stewardship plans.

Finally, as research continues to develop and refine IWM practices, their adoption could be enhanced through environmental-support payments that connect weed management to broader environmental issues. This approach is working in Maryland, where, following growing public concern and awareness of declining water quality and hypoxic "dead zones" from nutrient loading caused by agriculture, the Maryland Department of Agriculture launched a cost-sharing program that provided growers in the Chesapeake Bay watershed with economic incentives to grow winter cover crops (MDA 2011). Cover crops can reduce nutrient losses from fields (Munawar et al. 1990), and by creating weed-suppressive mulches, they can also be a valuable component of IWM systems. This program has been widely embraced by farmers and contributed to cover crops' being planted on hundreds of thousands of hectares, which has had a positive impact on water quality and promoting IWM techniques. This effort is supported by state and federal tax dollars and has been sustained because citizens living within the watershed were provided with information regarding the impact that agricultural practices have on water quality, resulting in a willingness to pay for mitigation efforts, including cover crop cost-sharing programs. The foundation of successful IWM is diversity, which is also a well-recognized pillar of sustainable agroecosystem management. Similar opportunities may exist to connect IWM practices to a range of environmental goals, including on-farm energy efficiency, soil-quality management, or agrobiodiversity conservation, and may help advance toward a more multifunctional agriculture (Boody et al. 2005). Research and extension programs exploring these connections would need to be scaled up if sufficient willingness to pay for alternatives can be achieved.

No single policy will adequately address our growing overreliance on a transgenic approach to weed management. Rather, a combination of policies will be necessary to secure a more sustainable agriculture, including (a) regulatory mandates for resistant-weed management, (b) enhanced funding for IWM research and education, (c) collaboratively designed herbicide stewardship plans, and (d) environmental payment incentives for the adoption of IWM practices. Next-generation GM herbicide-resistant crops are rapidly moving toward commercialization. Given this critical juncture, it is time to consider the implications of accelerating the transgene-facilitated herbicide treadmill and to rejuvenate our commitment to alternative policies that safeguard agriculture and the environment for the long term.

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CENTER FOR FOOD SAFETY

Dicamba: New Use on Herbicide-Tolerant Cotton and Soybeans
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Docket No. EPA-HQ-OPP-2016-0187

Comments on the Proposed Unconditional Registration for the New Uses of Dicamba on Genetically Engineered, Dicamba-Resistant Soybean and Cotton

The Center for Food Safety (CFS) hereby submits the following comments on the United States Environmental Protection Agency (EPA or the Agency)'s proposed unconditional registration for the new uses of the herbicide dicamba on genetically engineered (GE), dicamba-resistant soybean and cotton. The proposed new uses will be added to Monsanto Company's currently registered herbicide product M1691 (EPA Registration No. 524-582), which contains 58.1% of the active ingredient dicamba, diglycolamine salt (dicamba or dicamba DGA) for both pre- and post-emergence applications to Monsanto's dicamba-resistant soybean and cotton.

CFS is a national, nonprofit public interest and environmental advocacy organization working to protect human health and the environment by curbing the use of harmful food production technologies. In furtherance of this mission, CFS uses legal actions, groundbreaking scientific and policy reports, books and other educational materials, and grassroots campaigns, on behalf of its nearly 750,000 members. CFS is a recognized national leader on the issue of GE organisms and pesticides, and has worked on improving their regulation and addressing their impacts continuously since the organization's inception in 1997.

The comments submitted by CFS herein also incorporate by reference and supplement the detailed legal and scientific comments and supporting reference materials and studies that CFS submitted at earlier stages of this agency proposal, specifically, the 2012 notice of receipts of new use applications published by EPA, Docket No. EPA-HQ-OPP-2012-0841. CFS will not duplicate and repeat comments that it has already submitted numerous times, nor the detailed critiques and demands for lawful compliance and proper scientific analysis that EPA has yet to answer, address, or explain. Rather, these comments will incorporate previously unaddressed points and add to them with further deficiencies in EPA's proposed new use registration.

As explained in detail in CFS's previous comments and the comments submitted herein, EPA's proposed registration of dicamba for use on dicamba-resistant cotton and soybean violates all applicable statutes, specifically, the Agency's duties under the Federal

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Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Federal Food, Drug, and Cosmetic Act (FFDCA), the Migratory Bird Treaty Act (MBTA), and the Endangered Species Act (ESA). EPA's assessment underestimates the true costs of the proposed new use registration, relies on erroneous assumptions and uncertainties, as well as unenforceable mitigation measures. EPA has not made the requisite finding, mandated under FIFRA, to approve the proposed registration of dicamba on dicamba-resistant GE cotton and soybean. Similarly, EPA's approach to assessing effects to listed species is contrary to the ESA's legal mandate. EPA's current assessment fails to consider available data and literature that identify the significant environmental, human health, and socioeconomic risks of the proposed new uses, as well as effects to listed species and their critical habitats. The proposed registration of dicamba for use on dicamba-resistant cotton and soybean would not only result in unreasonable adverse effects to the environment, but will also jeopardize federally protected species and their critical habitats. Rather than approving the proposed new uses of dicamba on dicamba-resistant, GE cotton and soybean, EPA must cure the numerous legal and scientific deficiencies in their current risk assessments.

RELEVANT LEGAL STANDARDS

The Federal Insecticide, Fungicide, and Rodenticide Act

FIFRA authorizes EPA to regulate the registration, use, sale, and distribution of pesticides in the United States. FIFRA defines pesticides broadly to include herbicides—"any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccants."[1] Under FIFRA, EPA is "charged to consider the effects of pesticides on the environment."[2]

Pursuant to FIFRA, EPA oversees both initial registration of an active ingredient as well as any new uses of the registered active ingredient of a pesticide. FIFRA mandates that prior to approving any pesticide registration and any new uses of the pesticide, EPA consider the "impacts on human health, occupational risks, and environmental risks"[3] of the proposed pesticide formulation and its proposed uses. FIFRA "protects human health and prevents environmental harms from pesticides" by requiring EPA to conduct a risk-benefit analysis of the pesticides.[4] Under FIFRA, EPA cannot register the pesticide unless EPA concludes that the proposed new use "will not generally cause unreasonable adverse effects on the environment" when "perform[ing] its intended function" and "when used in accordance with widespread and commonly recognized practice."[5] FIFRA defines "unreasonable adverse effects on the environment" as "<u>any</u> unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and

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[1] 7 U.S.C. § 136(u)(2).
[2] *Fairhurst v. Hagener*, No. CV-03-67-BU-SHE, 2004 U.S. Dist. LEXIS 30161, at *49 (D. Mont. Mar. 24, 2004).
[3] EPA, Overview of Risk Assessment in the Pesticide Program (May 9, 2012), at http://www.epa.gov/pesticides/about/overview_risk_assess.htm.
[4] *Wash. Toxics Coalition v. EPA*, 413 F.3d 1024, 1032 (9th Cir. 2005).
[5] 7 U.S.C. § 136a(c)(5).

benefits of the use of any pesticide."[6] FIFRA defines "environment" broadly to include "water, air, land, and all plants and man and other animals living therein, and the interrelationships which exist among these."[7] In sum, FIFRA's broad statutory definition of the phrase "unreasonable adverse effects on the environment" mandates that EPA consider all economic, social and environmental risks, including risks that are interrelated and indirect results of the proposed registration, in the agency's review of a proposed registration.

Section 3(c) of FIFRA states that a manufacturer must submit an application to register the use of a pesticide.[8] Section 3(c) of FIFRA outlines two types of pesticide use registrations: unconditional or conditional.[9] Under Section 3(c)(5) of FIFRA, EPA shall register a pesticide if the agency determines that the pesticide "will perform its intended function without unreasonable adverse effects on the environment" and that "when used in accordance with widespread and commonly recognized practice[,] it will not generally cause unreasonable adverse effects on the environment."[10] EPA may also conditionally register a pesticide or proposed new use conditionally, under section 3(c)(7) of FIFRA. Of relevance to the present applications to register dicamba for uses on dicamba-resistant, GE cotton and soybean, EPA may conditionally amend the existing dicamba registration if EPA determines that "the pesticide and proposed use are identical or substantially similar to any currently registered pesticide and use therefor, or differ only in ways that would not significantly increase the risk of unreasonable adverse effects on the environment," and that "approving the registration or amendment in the manner proposed by the applicant would not significantly increase the risk of any unreasonable adverse effect on the environment."[11] Alternatively, EPA "may conditionally amend the registration of a pesticide to permit additional uses of such pesticide," but only if EPA concludes that "the applicant has submitted satisfactory data pertaining to the proposed additional use," and that "amending the registration in the manner proposed by the applicant would not significantly increase the risk of any unreasonable adverse effect on the environment."[12]

Alternatively, where there are data gaps and missing information, EPA can register a pesticide with conditions (conditional registration) under Section 3(c)(7) of FIFRA "for a period reasonably sufficient for the generation and submission of required data," but only if EPA also determines that the conditional registration of the pesticide during that time period "will not cause any unreasonable adverse effect on the environment, and that use of the pesticide is in the public interest."[13]

FIFRA also mandates that, as part of the registration of a pesticide and its proposed

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[6] 7 U.S.C. § 136(bb) (emphasis added).
[7] 7 U.S.C. § 136(j).
[8] 7 U.S.C. § 136a(c)(1); 40 C.F.R. § 152.42.
[9] 7 U.S.C. § 136a(c)(5), (7).
[10] 7 U.S.C. § 136a(c)(5).
[11] 7 U.S.C. § 136a(c)(7)(A).
[12] 7 U.S.C. § 136a(c)(7)(B).
[13] 7 U.S.C. §136a(c)(7)(C).

uses, EPA shall classify the pesticide and its use as either "general use" or "restricted use."[14] Under FIFRA, EPA must classify a pesticide and its proposed use as "restricted use" if "the pesticide, when applied in accordance with its directions for use, warnings and cautions and for the uses for which it is registered, or for one or more of such uses, or in accordance with a widespread and commonly recognized practice, may generally cause, without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator."[15]

The culmination of the registration process is EPA's approval of a label for the pesticide, including use directions and appropriate warnings on safety and environmental risks. It is a violation of FIFRA for any person to sell or distribute a "misbranded" pesticide.[16] A pesticide is misbranded if the "labeling accompanying it does not contain directions for use which … if complied with … are adequate to protect health and the environment."[17]

The Federal Food, Drug, and Cosmetic Act

The FFDCA[18] prohibits the introduction of "adulterated" food into interstate commerce.[19] The Act requires that where use of a pesticide will result in any pesticide residue being left on food, the EPA must either set a "tolerance" level for the amount of allowable pesticide residue that can be left on the food, or set an exemption of the tolerance requirement.[20] The tolerance or exemption requirements apply to raw agricultural commodities such as dicamba-resistant cotton and soybean.[21]

The FFDCA mandates EPA to "establish or leave in effect a tolerance for a pesticide chemical residue in or on a food only if the EPA Administrator determines that the tolerance is safe".[22] For a tolerance level to be "safe," the statute requires EPA determine "that there is a reasonable certainty that no harm will result from aggregate exposure to the pesticide chemical residue, including all anticipated dietary exposures and all other exposures for which there is reliable information."[23] "Aggregate exposure" includes not only dietary exposure through food consumption, but also exposure from all nonoccupational sources, including "exposures through water and residential uses," as well as the cumulative effects of the particular pesticide's residues "and other substances that have a common

[14] 7 U.S.C. § 136a(d)(1)(A).
[15] 7 U.S.C. § 136a(d)(1)(C).
[16] 7 U.S.C. § 136j(a)(1)(E).
[17] 7 U.S.C. § 136(q)(1)(F).
[18] 21 U.S.C. § 301 *et seq.*
[19] 21 US.C. § 331.
[20] 21 U.S.C. § 346a(1).
[21] 21 U.S.C. § 321(r) defines "raw agricultural commodities" as "any food in its raw or natural state, including all fruits that are washed, colored or otherwise treated in their unpeeled natural form prior to marketing."
[22] 21 U.S.C. § 342a(2)(A) (emphasis added); *see also* 40 C.F.R. § 180.1(f).
[23] 21 U.S.C. § 346a(2)(A)(ii).

mechanism of toxicity." [24] The Act further requires that, in determining the "safe" tolerance level, EPA must specifically consider potential routes of exposure to infants and children, and apply additional margin of safety for the pesticide residue and other sources of exposure to ensure that the tolerance level will be safe for infant and children.[25]

The 1996 passage of the Food Quality Protection Act ("FQPA"), Pub. L. No. 104-170, 110 Stat. 1489, amended EPA's statutory duties under both FIFRA and the FFDCA. Specifically, the FQPA mandates that EPA gives extra consideration to account for risks to infants and children from pesticide exposure.[26] As such, the FFDCA directs that in determining the tolerance level, "an additional tenfold margin of safety for the pesticide residue and other sources of exposure shall be applied … with respect to exposure to toxicity to infants and children."[27] However, the presumptive 10X FQPA safety factor is not always required; the FFDCA provides that the EPA "*may* use a different margin of safety for the pesticide chemical residue," but "only if, on the basis of reliable data, such margin will be safe for infants and children."[28]

Endangered Species Act

As recognized by the Supreme Court, the ESA is "the most comprehensive legislation for the preservation of endangered species ever enacted by any nation."[29] The ESA's statutory scheme "reveals a conscious decision by Congress to give endangered species priority over the 'primary missions' of federal agencies."[30] Federal agencies are obliged "to afford first priority to the declared national policy of saving endangered species."[31]

Section 7(a)(2) of the ESA requires every federal agency to consult the appropriate federal fish and wildlife agency—Fish and Wildlife Service (FWS), in the case of land and freshwater species and the National Marine Fisheries Service (NMFS) in the case of marine species—to "insure" that the agency's actions are not likely "to jeopardize the continued existence" of any listed species or "result in the destruction or adverse modification" of critical habitat.[32]

The ESA's implementing regulations broadly define agency action to include "all activities or programs of any kind authorized, funded or carried out … by federal agencies," including the granting of permits and "actions directly *or* indirectly causing modifications to the land, water or air."[33] The scope of an action, or "action area," is also broadly defined,

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[24] 21 U.S.C. § 346a; *see Natural Res. Def. Council v. Whitman*, No. C 99-03701-WHA, 2001 WL 1221774 (N.D. Cal. Nov. 7, 2001).
[25] 21 U.S.C. § 346a(c).
[26] *See* 21 U.S.C. § 346a(b)(2)(C).
[27] *Id.*
[28] *Id.* (emphases added).
[29] *Tenn. Valley Authority v. Hill*, 437 U.S. 153, 180 (1978).
[30] *Id*. at 185.
[31] *Id.*
[32] 16 U.S.C. § 1536(a)(2); *see also* 50 C.F.R. § 402.01(b).
[33] 50 C.F.R. § 402.02 (emphasis added).

and includes "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action."[34] The potential "effects" of an action that an agency must consider are similarly broad, and include both "direct" and "indirect" effects of the action and all activities "interrelated or interdependent" with that action.[35] Finally, a species' "critical habitat" includes those areas identified as "essential to the conservation of the species" and "which may require special management considerations or protection."[36]

FWS and NFMS have adopted joint regulations governing the Section 7(a)(2) consultation process. Every federal agency, using the "best scientific and commercial information available,"[37], must first determine whether its actions—here, EPA's proposed registration of dicamba use on dicamba-resistant GE cotton and soybean—"may affect" any listed species or designated critical habitat, and if so initiate a Section 7(a)(2) consultation with NMFS or FWS.[38] The threshold for a "may affect" determination is very low, and includes "any possible effect, whether beneficial, benign, adverse, or of an undetermined character."[39]

The ESA requires each federal agency that plans to undertake an action to request information from the expert agency "whether any species which is listed or proposed to be listed [as an endangered species or a threatened species] may be present in the area of such proposed action."[40] If FWS/NMFS advises the agency that listed species or species proposed to be listed <u>may</u> be present, the agency <u>must</u> then prepare a biological assessment for the purpose of identifying any such species that are likely to be affected by the proposed agency action.[41] If, based on a biological assessment, an agency determines that its proposed action may affect any listed species and/or their critical habitat, the agency generally must engage in consultation with FWS/NMFS.[42]

ESA consultation may in some cases be informal.[43] If, after informal consultation, the expert federal wildlife agency concurs in writing that the action is "not likely to adversely affect" any listed species or critical habitat, the process ends.[44] Otherwise, the agency must enter formal consultation.[45] Formal consultation "is a process between the Service and the [f]ederal agency that commences with the [f]ederal agency's written request for consultation under section 7(a)(2) of the Act and concludes with the Service's issuance of

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[34] *Id.*
[35] *Id.*
[36] 16 U.S.C. § 1532(5)(A).
[37] 16 U.S.C. § 1536(a)(2).
[38] 50 C.F.R. § 402.14(a).
[39] *See* 51 Fed. Reg. 19,926, 19,949 (June 3, 1986) (Codified at 50 C.F.R. pt. 402).
[40] 16 U.S.C. § 1536(c)(1); *see also* 50 C.F.R. § 402.12(c).
[41] *Id.*
[42] 50 C.F.R. § 402.14.
[43] 50 C.F.R § 402.13(a).
[44] 50 C.F.R. § 402.14(b).
[45] 50 C.F.R. § 402.14(a).

the biological opinion under section 7(b)(3) of the Act."[46] At the end of the formal consultation, FWS/NMFS must provide the agency with a "biological opinion" detailing how the proposed action will affect the threatened and endangered species and/or critical habitats.[47] If FWS/NMFS concludes that the proposed action will jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat, the biological opinion must outline "reasonable and prudent alternatives" to the proposed action that would avoid violating ESA section 7(a)(2).[48]

Pending the completion of formal consultation with the expert agency, an agency is prohibited from making any "irreversible or irretrievable commitment of resources with respect to the agency action which has the effect of foreclosing the formulation or implementation of any reasonable and prudent alternative measures."[49]

Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) implements the obligations of the U.S. under several international treaties and conventions for the protection of migratory birds.[50] The MBTA mandates that proposed projects must avoid the take of migratory birds entirely and must minimize the loss, destruction, and degradation of migratory bird habitat.[51] The vast majority of U.S. native birds are protected under the MBTA, even those that do not participate in international migrations.[52] Under the MBTA, "[n]o person may take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, or barter, any migratory bird, or the parts, nests, or eggs of such bird except as may be permitted under the terms of a valid permit."[53]

COMMENTS

As analyzed in detail below and CFS's previously-submitted comments and supporting documents to Docket No. EPA-HQ-OPP-2012-0841, EPA's proposed new use registration of dicamba for use on Monsanto's dicamba-resistant GE cotton and soybean mark a significant departure from existing use patterns of dicamba on existing varieties of cotton and soybean. The novelty of the proposed new use on two widely planted agricultural crops in the United States demands that EPA carefully consider all of the "economic, social, and environmental costs" against any purported benefits associated with the proposed new uses in its risk assessments.[54] Under FIFRA, EPA cannot approve the proposed new use of dicamba on dicamba-resistant GE cotton and soybean if the Agency's assessment reveals that the proposed registration may result in unreasonable adverse

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[46] 50 C.F.R. Id. § 402.02.
[47] 16 U.S.C. § 1536(b); 50 C.F.R. § 402.14.
[48] 16 U.S.C. § 1536(b)(3)(A).
[49] 16 U.S.C. § 1536(d).
[50] 16 U.S.C. § 701.
[51] *Id.* § 701–12.
[52] *See* 50 C.F.R. § 10.13.
[53] *Id.* § 21.11.
[54] 7 U.S.C. §136(bb).

effects on the environment. EPA must also ensure that "there is a reasonable certainty that no harm to humans, including sensitive populations, will result from aggregate exposure" to dicamba.[55]Separately, the ESA requires that EPA consult the appropriate federal expert agency to "insure" that the agency's actions are not likely "to jeopardize the continued existence" of any listed species or "result in the destruction or adverse modification" of critical habitat.[56] The MBTA mandates that proposed projects must avoid the take of migratory birds entirely and must minimize the loss, destruction, and degradation of migratory bird habitat.[57] EPA's current assessments fail to meet these statutory duties. To the contrary, EPA's assessments demonstrate that the proposed new uses of dicamba would result in unreasonable adverse effect on the environment, to the detriment of threatened and endangered species and their critical habitats. EPA must revise and supplement its current risk assessments, and conduct the requisite ESA consultation, before moving forward with the proposed approval of dicamba use on dicamba-resistant GE cotton and soybean.

I. EPA's Assessment of the Impacts to Threatened and Endangered Species from the Proposed New Uses of Dicamba on Dicamba-Resistant GE Cotton and Soybean Is Legally Deficient.

EPA's assessment of the potential risks to federally listed threatened and endangered species from the proposed approval is legally deficient, in violation of the ESA and FIFRA. EPA's current assessment is unlawful because the Agency improperly assumed that some level of effect to listed species is acceptable. Despite initially finding that exposure to the proposed new uses of dicamba carried great risks for numerous federally listed and threated species, the Agency unilaterally eliminated its "may affect" finding and instead switched to "no effect" determinations by narrowing the "action area" and relying on unrealistic mitigation measures such as buffer zones. EPA's approach here violates the ESA, as well as the agency's stated approach in assessing pesticide risks to listed species. EPA also failed to adequately consider various direct and indirect effects to non-target species, including listed species, such as exposure to dicamba from drift, volatilization, other forms of dicamba degradation and contamination of the environment, as well as synergistic effects of dicamba toxicity when used with other pesticides.[58] EPA's lack of sufficient analysis violates the Agency's duty under the ESA and FIFRA.

First, EPA's current approach to considering potential impacts to threatened and endangered species is legally deficient, in violation of the ESA. EPA uses "levels of concern" and "risk quotients" to determine if listed species will be effected throughout its ESA risk assessments, from screening level through more refined assessments. For example, "EPA determines that there is "no effect" on listed species if, at any step in the screening level assessment, no levels of concern are exceeded. If, after performing all the steps in the screening level assessment, a pesticide still exceeds the Agency's levels of concern for listed

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[55] 21 U.S.C. § 346a.
[56] 16 U.S.C. § 1536(a)(2); *see also* 50 C.F.R. § 402.01(b).
[57] *Id.* § 701–12.
[58] *Id.*

species, EPA then conducts a species-specific refined assessment to make effects determinations for individual listed species…."[59] At the species-specific level, EPA also uses "levels of concern" and "risk quotients" based on modeling exposure to predicted environmental exposure.[60]

These determinations are not based on whether there is any effect at all, but on whether any effects predicted are of concern to EPA. This is contrary to the ESA's definition of "may affect," which is broadly defined to include "any possible effect, whether beneficial, benign, adverse, or of an undetermined character."[61] EPA's current approach, relying on "risk quotients" and "levels of concern," falls short of the agency's duty under the ESA.

Second, EPA's current approach is also unlawful because EPA improperly switches from a "may affect" to a "no effect" finding after unilateral analysis. EPA's own policy provides that where a screening level assessment shows the risk threshold is exceeded for a listed species, EPA may conduct further refined analysis, but such refined analysis will not determine "no effect" and avoid consultation. Instead, the agency's refined assessment is only used to make the "not likely to adversely affect"/"likely to adverse effect" determination, which then can be used to allow EPA to forego formal consultation, but only if the expert wildlife agency concurs in writing with EPA's determination after informal consultation. [62]

Here, EPA's initial assessments of the various states concluded that there are numerous species that may be directly or indirectly affected by dicamba use. EPA switched to "no effect" findings after the agency's unilateral further analyses with three "refined endangered species assessments" for soybean and cotton, for 3 different sets of states. In these documents, EPA drills down to particular listed species and their habitats and requirements to determine ESA "no effect" or "may effect" designations:

- In the Addendum Assessment for 16 states, 183 listed species were identified as occurring in counties where soybeans and cotton are grown. At the screening level, EPA concluded that 10 of these species would be expected to occur on the fields themselves where they would be exposed to dicamba and its metabolites, triggering a "May Affect" determination under the ESA. Yet, EPA proceeded with unilateral further refined analysis, whereby EPA reverted to "no effect" findings for 9 of the species. EPA only gave 1 of these

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[59] EPA, *Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6-dichlorosalicylic ac id (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 16 states (Arkansas, Illinois, Iowa, Indiana, Kansas, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin)* 2-3 (Mar. 24, 2016) [hereinafter *Addendum Assessment for 16 States*].
[60] *See, e.g.*, EPA, *Addendum Assessment for 16 States*, at 7.
[61] *See* 51 Fed. Reg. 19,926, 19,949 (June 3, 1986) (Codified at 50 C.F.R. pt. 402).
[62] EPA, *Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs, U.S. Environmental Protection Agency. Listed and Threatened Species Effects Determinations* (2004); *see also* EPA, *Assessing Pesticides under the Endangered Species Act,* http://www2.epa.gov/endangered-species/assessing-pesticides-under-endangered-species-act.

species a "May Affect" determination, and "Likely to Adversely Affect": Spring Creek Bladderpod, found only in Wilson County, TN.[63]

- For its assessment of risks to listed species in the 7 states (Alabama, Georgia, Kentucky, Michigan, North Carolina, South Carolina, and Texas),[64] of 307 listed species in cotton and soybean counties, EPA concluded that 10 species would be expected to occur on the fields themselves and thus be exposed and may be affected. During refined assessments, EPA gave all but 1 "No effect" determinations.[65] The Eskimo Curlew (bird) was given a "May Affect" determination, and although potentially found in 23 counties in Nebraska and 1 in Texas, is "presumed extinct," so was designated "Not Likely to Adversely Affect."

- For its assessment of risks to listed species in 11 states (Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia),[66] of 322 listed species in cotton and soybean counties, EPA concluded that 14 species would be expected to occur on the fields themselves and thus be exposed and may be affected. During refinement, all but 1 were given "No effect" determinations by EPA.[67] The Audubon Crested Caracara (bird) was given a "May Affect" and "Not Likely to Adversely Affect" determination for Palm Beach County in Florida, only.

- For all three ESA refined assessments, all critical habitats were given a "No Modification" determination. Most "No Modification" determinations were based EPA's assessment that the associated listed species did not use cotton or soybean fields and hence cannot be impacted by on-field exposure to dicamba DGA. For the few critical habitats of species that EPA determined do use cotton or soybean fields, EPA first assumed there may be modification, then unilaterally arrived at a "No Modification" determination after a more refined analysis that focused on the species' exposure to dicamba within cotton and soybean fields, and that assumed there would be an acceptable

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[63] EPA, *Addendum Assessment for 16 States*, at 3-4.
[64] EPA, *Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 7 states (Alabama, Georgia, Kentucky, Michigan, North Carolina, South Carolina, and Texas)* 3-4 (Mar. 24, 2016) [hereinafter *Addendum Assessment for 7 States*].
[65] *Id.*
[66] EPA, *Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6-dichlorosalicylic ac id (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 11 states (*Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia) 4 (Mar. 24, 2016) [hereinafter *Addendum Assessment for 11 States*].
[67] *Id.* at 4.

threshold of impact based on the Agency's "risk quotients" and "levels of concern."[68]

EPA cannot unilaterally undo a "may affect" finding as it did here in refining assessments. EPA's most-recent guidance on assessing pesticide risks to listed species notes that "any species or critical habitat that overlaps with the action area *will be considered a 'May Affect.'*"[69] The guidance confirms unequivocally: "For species and critical habitats that do overlap with the action area, the call *will be 'May Affect,'* and the analysis *will proceed* with [informal consultation with FWS]." [70] Here, EPA reached "may affect" findings for 24 unique listed species based on habitat co-occurrence with dicamba use on cotton and soybean fields and did not consult the expert agencies, in contravention of the ESA's legal triggers and the Agency's own guidance on ESA assessments.

In addition, EPA determined that there would be no effect on almost all of the hundreds listed species identified at the screening level as co-occurring in counties where cotton and soybeans are grown by unrealistically narrowing the "action area" to <u>only within</u> GE cotton or GE soybean fields that had been sprayed with dicamba DGA. EPA similarly concluded that there would be no modification to listed species' critical habitats solely based on the fact that the species did not use cotton or soybean fields. EPA's approach is unlawful under the ESA.

As detailed below, EPA's approach is arbitrary and capricious, and scientifically indefensible, in violation of the agencies' duties under ESA and FIFRA.

1. Exposure to listed species from off-site movement of dicamba

EPA's rationale for limiting the potential impacts of dicamba on listed species to within the boundaries of treated fields is based on putting mitigation measures in the label language that EPA states will result in <u>no direct dicamba exposure</u> outside of those fields (terrestrial species), or <u>exposure below EPA's level of concern</u> (critical habitats, aquatic species) .[71]

EPA's rationale is faulty. EPA's own calculations of movement of dicamba do in fact predict that this registration action will result in off-site dicamba transport, and thus potentially expose those listed species and critical habitats that occur outside of treated fields, requiring a "may effect" finding for more species than EPA has so far determined.

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[68] EPA, *Addendum Assessment for 7 States*, at 29-31; EPA, *Addendum Assessment for 11 States*, at 25-26; EPA, *Addendum Assessment for 16 States*, at 100-101.
[69] EPA, *Interim Approaches for National-Level Pesticide Endangered Species Act Assessments Based on the Recommendations of the National Academy of Sciences April 2013 Report*, at 4, *available at* http://www2.epa.gov/sites/production/files/2015-07/documents/interagency.pdf.
[70] *Id.*
[71] EPA, *Addendum Assessment for 11 States*, at 6.

For example, in the Proposed Registration Document,[72] EPA describes how the proposed buffer distances were determined, and concludes that "[u]sing these buffers, expected residues at the field's edge from spray drift would be below apical endpoints for the most sensitive tested species (i.e. NOAEC for soybean plant height)."

For volatilization, EPA admits that it doesn't have enough information to determine if the proposed in-field buffers are sufficient.[73] Rather than require more data before taking this registration action, and ignoring incident data showing injury to sensitive crops well beyond its chosen buffer distances, EPA is going to reconsider the efficacy of the buffer distances "if" it receives more volatility data.[74] In the meantime, listed species far away from application sites may be affected by exposure to dicamba from volatilization. This violates EPA's duties under both ESA and FIFRA.

EPA finds that dicamba residues will leave treated fields into surrounding waterways via runoff, where many kinds of aquatic and semi-aquatic organisms could be directly exposed,[75] and also terrestrial plants[76] Terrestrial animals also may come into contact with dicamba-contaminated runoff.

In fact, EPA shows over and over throughout the environmental assessments in the docket,[77] that even with mitigation measures in place, some dicamba is expected outside of field boundaries due to spray drift, volatilization and runoff.[78] Stating categorically that terrestrial species outside of field boundaries are "not expected to be directly exposed to dicamba DGA" is thus at odds with EPA's own models and calculations - assessments EPA has done for this very registration action, and is contrary to the agency's legal mandates under the ESA.

For aquatic organisms, EPA's rationale for "no effect" determinations based on exposures below levels of concern is unlawful, as discussed above, since EPA does estimate particular levels of dicamba in runoff. In addition, EPA has estimated an environmental

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[72] EPA, *Proposed Registration of Dicamba on Dicamba-Tolerant Cotton and Soybean* 17 (Mar. 31, 2016) [hereinafter *Proposed Registration Document*].
[73] *See* EPA, *Proposed Registration Document*, at 17; EPA, *Dicamba DGA: Second Addendum to the Environmental Fate and Ecological Risk Assessment for Dicamba DGA Salt and Its Degradates, 3,6-dichlorosalicylic acid (DCSA) for the Section 3 New Use on Dicamba-Tolerant Soybean* 10 (Mar. 24, 2016) [hereinafter *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean*].
[74] EPA, *Proposed Registration Document*, at 17.
[75] *See* EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant* Soybean, at 21, 31-33; EPA, *Ecological Risk Assessment for Dicamba DGA Salt and Its Degradates, 3,6-dichlorosalicylic acid (DCSA), for the Proposed Post-Emergence New Use on Dicamba-Tolerant Cotton (MON87701)* 14 (Mar. 24, 2016) [hereinafter *Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Cotton*].
[76] EPA, *Addendum Assessment for 16 States* at 6.
[77] *See* EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 2-11 (especially, using new data on drift and volatilization)
[78] *See* EPA, *Proposed Registration Document*, at 16-18.

concentration for surface waters from dicamba applications to dicamba-resistant cotton[79] that is much higher than concentrations shown to cause endocrine effects in fish.[80]

Besides offsite movement of dicamba admitted by EPA, there are deficiencies in EPA's assumptions about off-field exposure to dicamba and dicamba metabolites that lead to underestimates of exposure for both terrestrial and aquatic species.

For example, EPA assumes that terrestrial mammals and birds will only ingest DCSA, a toxic metabolite of dicamba, if those animals are within sprayed fields: "Based on the available plant metabolism data for DCSA on non-DT plants, EFED assumed that any exposure for terrestrial vertebrates occurs as a result of feeding solely on DCSA in DT soybean and no exposure to DCSA is expected for terrestrial vertebrates feeding off the field, even if dicamba residues should occur following spray drift or volatilization. This is because the conversion of dicamba to DCSA in plants is only expected to occur in crops modified to be tolerant to dicamba."[81]

EPA does not consider exposure to dicamba and DCSA from ingestion of dicamba-resistant crop material that leaves the field via wind or runoff, even though detritus from crop fields is well known to move away from fields and to persist in the environment, and to serve as a reservoir of pesticides and metabolites in aquatic and terrestrial areas.[82] This is a serious omission, and may affect both terrestrial and aquatic animals.

Insects and other arthropods that have fed on dicamba-resistant crop tissues and thus are contaminated with dicamba and DCSA[83] could be consumed by animals outside of the field boundaries. Many insects come and go from crop fields. EPA did not include this likely occurrence when assessing risks to listed species. Both terrestrial and aquatic animals that eat insects may be affected.

Increases in total dicamba usage are likely, and will result in higher levels of exposure to more listed organisms.[84] This is a cumulative impact that EPA did not adequately consider, as it is not taken into account in EPA's risk assessment models. For example, rivers and streams in watersheds where dicamba is used on dicamba-resistant crops are likely to have higher dicamba contamination levels, but this is not taken into account.

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[79] EPA, *Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Cotton*, at 14.
[80] Zhu et al. 2015.
[81] *See* EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 14; *see also* EPA, *Proposed Registration Document* at 20.
[82] *See, e.g.,* Tank et al. 2010 and other studies of Bt in corn detritus cited in CFS's previously-submitted comments.
[83] *See* EPA, *Proposed Registration Document* at 20.
[84] *See* Exhibit B, at 74 (attached) (01/18/2013 CFS's Science Comments to EPA's Notice of Receipt of Application to Register New Use of Dicamba on Monsanto's Dicamba- and Glufosinate-Resistant MON 88701 Cotton, Docket No. EPA-HQ-OPP-2012-0841).

Dicamba contamination is already widespread in surface waters in the US and EPA must consider the cumulative impacts on both terrestrial and aquatic species of increased dicamba use in watersheds where it is already applied to other crops.[85]

For all these reasons, EPA's assumption that exposure of terrestrial and aquatic species will be confined to fields where applications occur is scientifically indefensible and legally erroneous.

2. *EPA's fails to adequately consider effects to listed species of using dicamba formulations on dicamba-resistant cotton and soybeans because toxicity of all the components of likely end-use products has not been considered.*

In addition to the toxicity of the each ingredient, EPA must consider possible additive and synergistic effects from various components of the end-use product formulation. If synergy is present, there can be greater effects from the same exposure to the pesticide than predicted, and thus effects at longer distances from the application site.

Although EPA is only considering registration of Monsanto's dicamba DGA salt formulation in this action, it is well known that Monsanto plans to combine dicamba with glyphosate, and perhaps with other herbicides such as glufosinate, to apply in fields planted with crops that have multiple herbicide resistance traits. Monsanto is already marketing such crops for 2016. Therefore EPA needs to consider impacts of likely mixtures of herbicide active ingredients now in order to understand complete costs and benefits.

Synergy can result from combining any of the components in the formulation, including synergy from combining different active ingredients and also between inerts (surfactants and other components added to the formulation before sale), adjuvants (surfactants and other components added to the formulation by applicators, as in tank mixes), and other components of the formulation and the active ingredient(s).

Synergy concerns are not limited to premixes and tank mixes where the components are applied to fields simultaneously. It is also relevant for pesticides applied on the same field before or after dicamba formulations are applied. For example, in a patent, Monsanto describes synergy between dicamba and glyphosate applied at different times:[86]

> In accordance with the invention, methods and compositions for the control of weeds are provided comprising the use of plants exhibiting tolerance to glyphosate and auxin-like herbicides such as dicamba. As shown in the working examples, dicamba and glyphosate allow use of decreased amounts of herbicide to achieve the same level of control of glyphosate-tolerant weeds and thus this embodiment

[85] *See* Exhibit A (attached), at 54-55 (09/21/2012 CFS's Science Comments to EPA's Notice of Receipt of Application to Register New Use of Dicamba on Dicamba-Resistant Soybean, Docket No. EPA-HQ-OPP-2012-0841); Exhibit B, at 62-63.

[86] Feng and Brinker 2014, at 9.

provides a significant advance for the control of herbicide tolerance in commercial production fields. In one embodiment, a tank mix of glyphosate and dicamba is applied pre- and/or post-emergence to plants. Glyphosate and dicamba may additionally be applied separately. In order to obtain the ability to use decreased amount of herbicide, the glyphosate and dicamba are preferably applied within a sufficient interval that both herbicides remain active and able to control weed growth.

This embodiment therefore allows use of lower amounts of either herbicide to achieve the same degree of weed control as an application of only one of the herbicides.

EPA admits that there are uncertainties regarding impacts of mixtures of different herbicide active ingredients, and has added a mitigation measure to compensate for the uncertainty: a requirement that no other herbicides be tank-mixed with dicamba DGA.[87] However, this is an inadequate mitigation measure for several reasons: 1) other types of pesticides than herbicides, such as insecticides and fungicides, could also interact synergistically in the formulation and are not included in the tank mixing restriction, 2) adjuvants that do not increase spray drift are allowed to be tank mixed without consideration of synergistic toxicity even though adjuvants are often chosen specifically because they synergistically enhance toxicity of the active ingredient,[88] and 3) synergism can occur between pesticides that are applied before or after each other in addition to being applied concurrently.[89]

EPA's failure to consider synergistic effects between dicamba and other chemicals is unlawful in light of the Agency's recognition that the proposed new use would be used concurrently with glyphosate and other pesticides on soybean and cotton. Under FIFRA, EPA must consider "any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide" prior to approving a pesticide use. Here, EPA improperly segmented its cost-benefit analysis and neglected to consider the environmental costs associated with the use of the dicamba on GE soybean and cotton resistant to both dicamba and glyphosate. As a result of EPA's improper segmentation, EPA fails to consider the increased costs associated with the synergistic and additive effects of using both glyphosate and dicamba together.

3. *EPA's conclusion that the proposed buffer zones would effectively reduce exposure of listed species to dicamba is unsupported*

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[87] EPA, *Proposed Registration Document* at 22; M1691 Herbicide DT Cotton Label M1691 EPA Reg. No. 524-582, EPA Docket ID EPA-HQ-OPP-2016-0187-0014, at 22; M1691 Herbicide DT soybean Label - EPA Reg. No. 524-582, EPA Docket ID EPA-HQ-OPP-2016-0187-0015, at 4.
[88] Sun 2012.
[89] Feng and Brinker 2014 at 9.

Finally, assumptions EPA used to design mitigation measures—buffer zones—to reduce exposure of listed species to dicamba DGA are unrealistic.[90] For example, EPA does not analyze how often applicators are likely to spray when wind speeds are greater than allowed, when weather conditions are unpredictable, or how often rain events occur when not forecast. Nor does EPA assess the likelihood that nozzles will be adjusted improperly, or buffer zone distances miscalculated. Without a realistic assessment of mitigation measures, risks cannot be predicted accurately and are likely to be underestimated.

II. EPA's Assessment Neglects Any Potential Impacts on Migratory Birds.

Based on the same reasoning above, EPA's current risk assessment is also unlawful under the MBTA. EPA's own risk assessments acknowledged that the proposed registration of dicamba use on dicamba-resistant, GE cotton and soybean poses potential risks to avian species, including numerous listed migratory avian species, yet EPA failed to properly consider and disclose its obligations to migratory birds, never even mentioning its responsibilities under the MBTA. The MBTA prohibits the take of migratory birds entirely and mandates that the loss, destruction, and degradation of migratory bird habitat must be minimized. Under EPA's proposed approval, dicamba would be used in fields visited by hundreds of species of birds protected under the MBTA. Rather than determining whether the proposed use of dicamba on dicamba-resistant GE cotton and soybean would have adverse effects on species protected under the MBTA, EPA simply ignores this significant issue. EPA must cure this defect by conducting a new risk assessment.

III. EPA's Current Assessment Does Not Adequately Consider Unreasonable Adverse Effects and Potential Risks to Pollinator Species.

EPA's current assessments regarding potential adverse effects to honey bees, other bees and pollinator species, and other beneficial terrestrial invertebrates, is also legally deficient under FIFRA. A recent study of dicamba impacts on nectar resources found that very low levels of dicamba, such as occur during drift of dicamba into areas adjacent to treated fields, caused reduced and delayed flowering and fewer visits by honey bees to the dicamba-injured plants.[91] Given the importance and imperilment of beneficial invertebrates such as pollinators, EPA needs to do a full assessment before taking this registration action instead of delaying until the upcoming dicamba registration review that won't be completed for several years.[92]

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[90] For detailed analysis, see previous comments for similar mitigation measures in Exhibit C (attached) (01/30/2014 CFS's comments to EPA on the Proposed New Use of Enlist Duo on 2,4-D-Resistant Crops, Docket No. EPA-HQ-OPP-2014-0195), and Exhibit D (attached) (12/15/2014 CFS's comments to EPA on the Proposed New Use of Enlist Duo on 2,4-D-Resistant Crops in Ten Additional States, Docket No. EPA-HQ-OPP-2014-0195).
[91] Bohnenblust et al. 2016.
[92] EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 16-17.

EPA's own *Guidance for Assessing Pesticide Risks to Bees* sets out a risk assessment process for assessing potential risks to honey bees and other pollinators.[93] Here, EPA admitted that the initial 2011 risk assessment for the proposed uses "included no quantitative analysis of the risks" to beneficial insects and pollinators, and recognized that since then, EPA itself has "identified additional honeybee life stage testing and longer duration effects tests for adults [bees]…as potentially important to the risk assessment process."[94] Nonetheless, EPA fails to adhere to its current guidance and require all the necessary data and studies in order to adequately assess the potential risks to honey bees and other insects, including pollinators and federally listed terrestrial invertebrates, as part of the current risk assessment. Without these data and studies, EPA cannot ascertain that the proposed use of dicamba would not have "unreasonable adverse effects to the environment" or that it would not affect listed terrestrial invertebrates, in violation of FIFRA and the ESA.

For assessment of impacts to pollinators, there are important data gaps. For example, there are no data on levels of dicamba residues and metabolites in parts of the crops that pollinators use, such as pollen, nectar, or guttation fluids, without which no risk assessment can be meaningfully conducted.[95] There are no data on toxicity of the major metabolite of dicamba in dicamba-resistant crop tissues, glucosylated DCSA, which has not been tested for toxicity to any species. Also, toxicity data from studies of surrogate species used by EPA are unreliable because of vastly different life histories.[96]

These and other deficiencies in EPA's pollinator risk assessments are discussed by CFS for dicamba use with dicamba-resistant soybean and cotton at length in previous comments.[97]

IV. EPA's Current Assessment Entirely Fails to Consider Toxicity of Conjugated Metabolites of Dicamba.

All of EPA's risk assessments that involve animals, including listed animals, which may ingest dicamba-treated, dicamba-resistant crop tissues are deficient because toxicity of the major metabolite of dicamba is unknown and unaccounted for.

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[93] EPA, *Guidance for Assessing Pesticide Risks to Bees* (2014), *available at* https://www.epa.gov/sites/production/files/2014-06/documents/pollinator_risk_assessment_guidance_06_19_14.pdf
[94] EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 16.
[95] *See, e.g.,* EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 20, where EPA uses levels of DCSA in seeds instead.
[96] *See, e.g.,* EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 18 - 20, where aquatic invertebrates are used as surrogates for chronic effects of dicamba exposure, and then this assessment is extended to all terrestrial invertebrates.
[97] *See* Exhibit A (attached), at 62-64; Exhibit B (attached), at 70-73; Exhibit E (attached), at 15-23 (10/10/2014 CFS's Science Comments to USDA's Draft Environmental Impact Statement on Monsanto Petitions (10-188-01p and 12-185-01p) for Determinations of Nonregulated Status for Dicamba-Resistant Soybean and Cotton Varieties, Docket No. APHIS 2013-0043).

By far the most common metabolite present at the highest level after spraying dicamba on dicamba-resistant soybeans or cotton is a conjugate of DCSA that has been modified by the addition of a sugar: glucosylated (also called glycosylated) DCSA (. This metabolite is a novel addition to the food supply for both humans and animals that eat dicamba-treated, dicamba-resistant crops, particularly forage and fodder, and also perhaps other plant-derived foods such as nectar, pollen, guttation fluids.[98]

EPA does not report any toxicology studies of glucosylated DCSA for any kind of organism. Based on studies with other conjugated metabolites, during digestion toxic DCSA could be released as the sugar is cleaved from the glucosylated form. CFS discusses this in previous comments.[99]

Given the novelty of glucosylated DCSA in the food and feed supply, and the fact that it is the major metabolite of dicamba in dicamba-resistant crops, EPA's risk assessments are incomplete, and may significantly underestimate adverse effects.

V. EPA Lacks Sufficient Information to Make the No "Unreasonable Adverse Effects" Finding Required Under FIFRA.

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) mandates that EPA can register a pesticide use only if it can ensure that the use will not cause unreasonable adverse effects on man or the environment, taking into account the economic, social, and environmental costs and benefits of the pesticide's use.[100] Here, EPA has failed to assess and account for several significant economic and social costs of the proposed uses, in violation of FIFRA.

1. EPA's assessment of dicamba resistance in Weeds

EPA acknowledges that weeds resistant to glyphosate and other heavily used herbicides have imposed "yield and economic losses" on farmers. In fact, the chief benefit claimed for the proposed uses of dicamba is to facilitate better control of these resistant weeds.[101]. However, EPA also acknowledges that these new uses on dicamba-resistant soybeans and cotton could lead to "expansion of dicamba-resistant weeds and the development of [dicamba] resistance by some additional weed species."[102] Dicamba-resistant weeds, like those resistant to glyphosate, would impose costs on growers. Therefore, EPA must assess any potential benefits of the new uses (i.e. controlling

[98] *See* EPA, *Dicamba. Section 3 Registration for the Amended Use of Dicamba on Dicamba-Tolerant Cotton. Summary of Analytical Chemistry and Residue Data* 19 (Mar. 29, 2016); *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 14.
[99] *See* Exhibit A (attached), at 58-61; Exhibit B (attached), at 65-70; Exhibit E (attached), at 26-28.
[100] *See* 7 U.S.C. § 136a(c)(5).
[101] EPA, *Review of Benefits as Described by the Registrant of Dicamba Herbicide for Postemergence Applications to Soybean and Cotton and Addendum Review of the Resistance Management Plan as Described by the Registrant of Dicamba Herbicide for Use on Genetically Modified Soybean and Cotton* 2 (Mar. 20, 2016) [hereinafter *Benefits Analysis*].
[102] *Id.* at 4.

glyphosate-resistant weeds) and weigh them against costs (emergence of dicamba resistance).

However, EPA's Benefits Analysis that is supposed to address weed resistance is deficient in several respects. In brief:

1) It only describes purported benefits, not costs;
2) The treatment of weed resistance is extremely cursory and descriptive in nature, erroneous in certain respects, and entirely lacking any quantitative or semi-quantitative analysis of the dicamba-resistant weed threat;
3) EPA explicitly limits itself to the registrant's viewpoints and information, neglecting relevant scientific literature, a key assessment by the US Department of Agriculture, and public comments that EPA was aware of;
4) EPA's failure to properly assess the dicamba-resistant weed threat has led it to propose an herbicide resistance management plan that will be ineffective and unworkable.

EPA's description of the purported benefits of the new dicamba uses is just six pages (minus appendices), with no accounting of costs.[103] It is explicitly keyed to "benefits as described by the registrant" and "Monsanto's submitted information." Only two peer-reviewed studies on weed resistance are cited, and a handful of farm press articles and extension publications. Even in those few instances where EPA cites non-registrant studies or data, it does so in a way that inexplicably minimizes resistance issues. For instance, EPA cites Godar et al. (2015) and Sandell et al. (2012) for the statement that "glyphosate-resistant kochia populations have been identified in Kansas … and Nebraska." However, Godar et al. (2015) actually report glyphosate-resistant [GR] kochia not just in Kansas and Nebraska, but in ten states and three Canadian provinces: "As of 2014, presence of GR kochia populations has been reported in ten Great Plains states (Colorado, Idaho, Kansas, Montana, Nebraska, North Dakota, Oklahoma, Oregon, South Dakota, and Wyoming) and three Canadian provinces (Alberta, Saskatchewan, and Manitoba).[104]

EPA provides no discussion of the resistance-promoting features of herbicide-resistant crop systems in general or the news uses with dicamba-resistant soybeans or cotton in particular. EPA also fails to provide any quantitative or semi-quantitative assessment of the factors conducing to weed resistance, or of the extent or costs of dicamba-resistant weeds that the proposed uses would foster. Though EPA makes regular use of quantitative projections and modeling in assessing new uses of pesticides, and has done so in certain respects with dicamba,[105] such analysis is entirely lacking here with respect to weed resistance.

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[103] EPA, *Benefits Analysis* at 1-6.
[104] Godar et al. 2015. EPA's citation to this study (*see EPA Benefits Analysis* at 12, with first author's name misspelled as "Bodar") specifies the abstract "(abstr.)." Thus, EPA may have missed the statement quoted here, which appears in the body of the paper, by scanning only the title and abstract.
[105] For instance, EPA used drift modeling software to provide quantitative estimates of how far and what concentrations dicamba would drift.

This cursory treatment contrasts sharply with the approach taken by others to assess the issue of herbicide- and dicamba-resistant weeds. For instance, weed scientist Paul Neve has created a quantitative simulation model to assess how rapidly weed resistance would evolve under various herbicide usage scenarios.[106] Neve found that using an herbicide as it is typically used with an herbicide-resistant crop "very substantially increases risks of resistance evolution" relative to typical uses of the same herbicide with conventional crops. While the cited paper focuses on glyphosate, the model is applicable to other herbicides.

The U.S. Department of Agriculture (USDA) provided a detailed, quantitative assessment of dicamba use in its Environmental Impact Statement on Monsanto's petition to deregulate dicamba-resistant (DR) soybeans and cotton, based in part on data provided by Monsanto.[107] This assessment is highly relevant to the dicamba-resistant weed threat posed by the new uses on DR crops. USDA's assessment was based on quantitative estimates of acreage planted to dicamba-resistant soybeans and cotton and sprayed with dicamba; the number of dicamba applications per season to each DR crop, and the rate (i.e. lbs./acre) at which dicamba would be applied. Based on these projections, tens of millions of acres of DR crops would receive two to three applications of dicamba per season. Because resistance risk generally rises with the frequency of application, and most herbicides are applied just once per season, dicamba-resistant weeds are likely to emerge rapidly on millions of acres of DR cropland (see analysis in Exhibit F[108]). USDA deregulated DR soybeans and cotton without restriction despite its conclusion that doing so would increase selection pressure for dicamba-resistant weeds.[109] USDA took this action in the expectation that EPA was "thoroughly analyzing" the weed resistance impacts of the proposed new uses of dicamba, and would establish effective weed resistance management requirements as part of its registration.[110] Yet EPA makes no reference to this clearly relevant USDA assessment, despite the fact that the two agencies are supposed to be collaborating to address weed resistance risks associated with herbicide-resistant crop systems.

Mortensen et al. (2012) discuss many implications of the introduction of soybeans genetically engineered for resistance to dicamba (Monsanto) and 2,4-D (Dow). They provide quantitative projections of DR/2,4-D-resistant soybean acreage and associated

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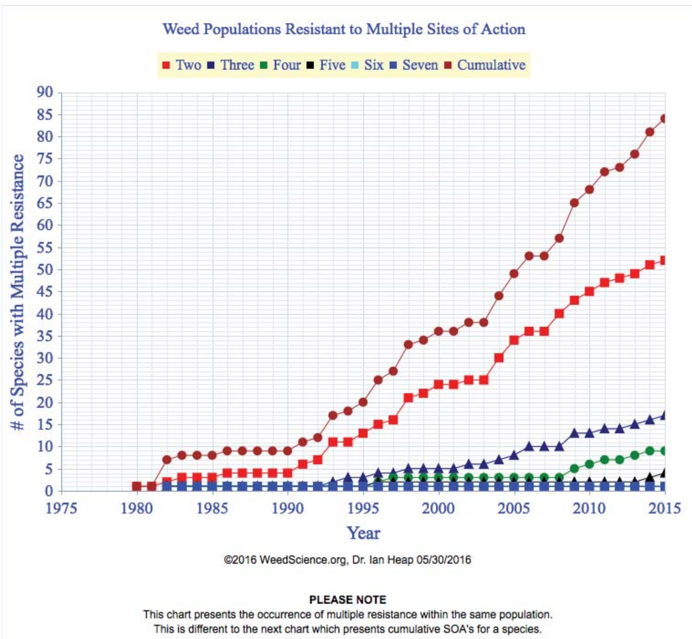
[106] Neve 2008.
[107] USDA, *Monsanto Petitions (10-188-01p and 12-185-01p) for Determinations of Nonregulated Status for Dicamba Resistant Soybean and Cotton Varieties Final Environmental Impact Statement* (December 2014), *available at* https://www.aphis.usda.gov/brs/aphisdocs/dicamba_feis.pdf. [hereinafter *USDA Dicamba FEIS*].
[108] Exhibit F (attached) (10/10/2014 CFS's Science I Comments to USDA's Animal and Plant Health Inspection Service on the Agency's draft Environmental Impact Statement on Monsanto Petitions (10-188-01p and 12-185-01p) for Determinations of Nonregulated Status for Dicamba-Resistant Soybean).
and Cotton Varieties, Docket No. APHIS-2013-0043).
[109] USDA, *Record of Decision, Monsanto Petitions (10-188-01p and 12-185-01p) for Determinations of Nonregulated Status for Dicamba Resistant Soybean and Cotton Varieties 20* (2015), *available at* https://www.aphis.usda.gov/brs/aphisdocs/dicamba_feis_rod.pdf. [hereinafter *USDA Dicamba ROD*].
[110] *USDA Dicamba ROD*, at 21.

usage of dicamba/2,4-D. They discuss the weed resistance risk posed by introduction of these crops. Among their relevant findings are that weeds resistant to dicamba and/or 2,4-D (closely related "auxin" herbicides) are more common than generally recognized, and that the new uses of dicamba (and 2,4-D) pose a high risk of generating dicamba/2,4-D-resistance in weeds already resistant to glyphosate, resulting in weeds resistant to both herbicides. They also discuss the dramatically increasing prevalence of such multiple herbicide-resistant weeds in U.S. and world agriculture (see graph below), which increases weed control costs as much as six-fold.[111] Additional dicamba-resistance in weeds already resistant to glyphosate (and sometimes other herbicides) will limit weed management options for farmers,[112] are often more difficult and costly to control, and more likely to be managed with soil-eroding tillage, as discussed below.



Source: International Survey of Herbicide Resistant Weeds. http://www.weedscience.com/Graphs/MultipleResistance.aspx, 3/30/16.

EPA's cursory review makes no reference to this much-cited study; nor does it provide any assessment of the threat posed or costs imposed by multiple herbicide-resistant weeds generated by the proposed uses. In fact, EPA appears unaware that populations of the damaging weed kochia that have evolved resistance to dicamba in Kansas (mentioned at EPA Benefits Analysis on page 4) already have multiple resistance to glyphosate and other classes of herbicide as well as dicamba[113], illustrating EPA's general failure to consider the threat of multiple herbicide-resistant weeds.

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[111] Service 2013.
[112] Following Monsanto, EPA states that registration of dicamba "would expand weed management options for growers by providing an additional MOA [mode of action] in the growing season" (EPA Benefits Analysis, t 2). However, EPA fails to discuss the limitation of weed management options that will result with the evolution of dicamba- and multiple-herbicide resistant weeds.
[113] HR Kochia 1 & 2 (2015).

Finally, EPA itself has provided careful quantitative projections of the resistance risks associated with toxins introduced into first-generation genetically engineered corn and cotton that target above-ground pests like European corn borer. EPA conducted rigorous analysis, and consulted independent scientific literature in making these projections, and in establishing mandatory insect resistance management plans to prevent (or greatly delay) emergence of insect pest resistance to these toxins.[114] Weed resistance shares many characteristic features with insect resistance, yet EPA has provided nothing approaching this level of analysis of weed resistance risks in its cursory "benefits" memorandum or its proposed registration. As discussed below, EPA has also failed to require effective measures to prevent or greatly delay emergence of dicamba resistance.

Dicamba-resistant weeds that evolve with the proposed uses will likely spread to the fields of other farmers via seed dispersal and cross-pollination, including farmers who use other forms of dicamba on non-DR crops. This spread of dicamba resistance would likely impose increased weed control costs on such farmers, costs which EPA has not assessed or even mentioned. For instance, wheat growers who use dicamba may be forced to replace/supplement dicamba use with more costly/additional herbicides. EPA has failed to assess this issue. In contrast, USDA provided a quantitative assessment of such costs imposed on other farmers in a precisely analogous case: that is, costs associated with the projected spread to wheat farmers' fields of 2,4-D-resistant weeds fostered by the use of Enlist Duo on 2,4-D-resistant corn and soybeans.[115]

The discussion above is far from comprehensive, and is meant only to suggest the wealth of relevant resources and facts that EPA ignored in its cursory description of weed resistance, and to highlight assessment approaches and factors that EPA must employ or consider in projecting the costs of dicamba-resistant weeds under the proposed uses.

2. EPA's assessment failure undermines proposed herbicide resistance management plan

EPA has proposed an herbicide resistance management plan that will very likely be ineffective and unworkable, a predictable outcome given the Agency's failure to assess the very problem it purports to address, as discussed above. CFS has provided a detailed discussion of the flaws of EPA's herbicide-resistance management plan for the new uses, based on the Agency's plan for Enlist Duo, upon which the dicamba plan is closely modeled.[116] We provide a brief summary of these comments below, and also address elements that are new and specific to EPA's proposed herbicide-resistance management plan for the new dicamba uses.

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[114] *See, e.g.* EPA IRM 2001.
[115] USDA, *Final Environmental Impact Statement on Dow AgroSciences Petitions (09-233- 01p, 09-349-01p, and 11-234-01p) for Determinations of Nonregulated Status for 2,4-D-Resistant Corn and Soybean Varieties* (2014), *available at* https://www.aphis.usda.gov/brs/aphisdocs/24d_feis.pdf, [hereinafter *USDA 2,4-D FEIS*].
[116] Exhibit F (attached), at 32-35.

1) EPA fails to require any effective measures to prevent or substantially delay emergence of weed resistance to dicamba. The most effective measures would involve reducing selection pressure by limiting the frequency with which dicamba is applied, in a single season and/or over years, in line with the recommendations of many weed scientists. In the analogous case of inhibiting evolution of glyphosate resistance, scientists recommend annual rotation between a Roundup Ready and non-Roundup Ready crop, with glyphosate applied every other year instead of every year.[117] Syngenta's Chuck Foresman similarly recommended limiting glyphosate use to two applications in a two-year period.[118] EPA does not discuss or even mention the possibility of placing limits on the frequency of dicamba use as a condition of the proposed registration.

2) EPA's plan relies on farmers detecting weed resistance once it has already occurred by scouting their fields both before and after application of dicamba. It is unreasonable to expect busy growers who often farm thousands of acres to make the substantial time commitment thorough scouting would entail; to the extent such scouting occurs, it is often difficult to detect resistance until it is far advanced, and too late to effectively control.

3) EPA delegates most authority for implementing this plan to the registrant; yet Monsanto has failed to properly implement a very similar insect resistance management plan for genetically engineered Bt corn targeting corn rootworm, resulting in broad emergence of resistant pests. To the limited extent the plan has value, it is unlikely to be properly implemented due to the registrant's conflicts of interest.

4) EPA's resistance management recommendations rely heavily on use of dicamba sequentially with different types of herbicide, which are supposed to inhibit evolution of dicamba resistance. However, use of multiple herbicides is increasingly ineffective with the rapid emergence of multiple herbicide-resistant weeds (e.g. kochia resistant to two and four herbicide modes of action in Kansas, discussed above), which EPA fails to consider. For a fuller discussion of this issue, including examples of the failure of the multiple herbicide approach to forestalling weed resistance.[119]

5) EPA relies heavily on a recommendation that growers of DR crops use non-dicamba pre-emergence herbicides with residual activity to kill emerging weeds six to eight weeks after application to help forestall dicamba resistance.[120] However, this is extremely unlikely to occur in the case of DR soybeans, for several reasons:

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[117] *See, e.g.*, Heap 1997.
[118] NGSF I 2004, at 26.
[119] *See* Exhibit F (attached), at 15-30; *see also* Mortensen et al. (2012).
[120] EPA, *Benefits Analysis*, at 3.

a. Soybean farmers have already shifted away from use of pre-emergence herbicides with residual activity in favor of reliance on glyphosate, which does not have residual activity;
b. USDA's more robust assessment of DR soybeans directly contradicts EPA's assumption on this point. USDA projects that "....substantive PRE [pre-emergence] non-glyphosate applications ***will likely be eliminated***, as may more than half of POST non-glyphosate applications."[121] The upshot of USDA's analysis is that most DR soybean farmers will rely entirely on dicamba and glyphosate[122] (to which DR soybeans are also resistant), generating intense selection pressure for evolution of dicamba resistance, often in weeds already resistant to glyphosate.
c. EPA fails to appreciate that dicamba has (limited) residual activity, as indicated by the waiting intervals for its pre-emergence use on conventional crops,[123] and is thus a likely choice for those growers who choose to make pre-emergence applications. This is also indicated by the fact that the proposed registration permits one or more pre-emergence applications of dicamba.
d. EPA's failure to conduct a proper real-world assessment of herbicide use practices and consult USDA's more robust assessment has led it to rely heavily on an herbicide resistance management method that will for the most part not be implemented.

6) EPA has proposed a minimum rate of 0.5 lb./acre per application of dicamba for post-emergence (in-crop) use as a resistance management measure for both DR soybeans and DR cotton.[124] Normally, the Agency prescribes only maximum pesticide rates. However, there is disagreement in the scientific literature on the utility of using "full herbicide rates" to inhibit weed resistance. In a comprehensive review of the effects of using reduced herbicide rates, Blackshaw et al. (2006) found that "reduced doses of herbicides are likely to have a neutral effect on weed resistance development, especially if used within an integrated weed management system." Beckie & Kirkland (2003) found that reducing ACCase inhibitor herbicide rates "decreased the proportion of resistant [wild oat] individuals in the population," especially when reduced rates were combined with increasing crop competition with a higher seeding rate. This suggests that prescribing a high minimum dicamba rate of 0.5 lb./acre might actually exacerbate rather than reduce resistance problems. Using the label-recommended (full rate) of glyphosate with Roundup Ready crops has always been Monsanto's chief recommendation for reducing the emergence of glyphosate-tolerant and glyphosate-resistant weeds, but

[121] *USDA Dicamba FEIS*, at 143 (emphasis added). For detailed discussion, *see* Exhibit F (attached).
[122] These two herbicides are not permitted to be used together in a tank mix, according to the proposed registration, but there is no bar to a farmer using them sequentially.
[123] Waiting intervals of two to four weeks between application of dicamba and planting of conventional soybeans and cotton are imposed for pre-emergence uses to allow dicamba to degrade or dissipate to levels that will not kill or damage the emerging crop (EPA, *Benefits Analysis*, Table 1). This same residual activity provides some level of weed control during these intervals.
[124] EPA, *Proposed Registration Document*, at 3.

many weed scientists disagree with this approach. At the National Glyphosate Stewardship Forum, a meeting convened specifically to address the emerging threat of glyphosate-resistant weeds, Iowa State University weed scientist Micheal Owen found that "reduced glyphosate rates, at times, may increase returns without increased weed problems."[125] In addition, glyphosate-resistant weeds have emerged in epidemic fashion despite Monsanto's "full rate" exhortations, and despite steadily increasing glyphosate use rates. Thus, prescribing a minimum rate of dicamba would be unlikely to inhibit emergence of dicamba resistance, and could exacerbate the problem.

7) USDA data show that dicamba, to the very limited extent it is used in soybeans, is currently applied to soybean fields on average at less than half the minimum rate proposed by EPA (0.1 to 0.2 lbs./acre).[126] Prescribing more than double the usual rate for post-emergence new use applications would likely increase farmer dicamba use and expenditures beyond, and perhaps well beyond, what they would otherwise be. The rate of herbicide needed to provide acceptable weed control varies dramatically in particular regions and fields based on numerous factors: which weed species are present, the number and size of the weeds, environmental factors like weather, crop production practices (tillage, seeding rate, etc.), which other herbicides (if any) are used, and the farmer's "tolerance" for weed presence. Weed scientists find that reduced herbicide rates are consistent with maintaining yield and increased overall production returns, even in cases where there is increased weed seed production.[127] This is particularly true when reduced rates are part of an integrated weed management program that involves cultural practices like higher crop seeding rates, diverse crop rotations, specific fertilizer placement and cover crops.[128] Thus, prescribing a high minimum rate of dicamba would likely increase farmer production costs and reduce farmer returns, without accomplishing the intended purpose of inhibiting resistance. In addition, this high minimum rate would also likely have negative environmental costs, for instance reductions in populations of field-edge flowering plants, given dicamba's propensity to drift and high efficacy on broadleaf weeds.

8) EPA's resistance management plan relies heavily on inclusion of various items of information and directions regarding weed resistance management on the dicamba label. However, weed resistance management statements similar though less extensive than those recommended now by EPA have been included on herbicide product labels since at least 2004,[129] and have obviously been ineffective, especially with respect to inhibiting glyphosate-resistant weed development. Participants at

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[125] NGSF I 2004, at 18.
[126] *See* https://quickstats.nass.usda.gov/results/2513DF3C-9C21-3487-A36B-BA460678756C#0DC606AB-2494-3C85-8F7E-1C6920C4BA7A. One reason for the low rate is that dicamba is sometimes applied in mixtures with other herbicides.
[127] Hamill et al. 2004.
[128] Beckie & Kirkland 2003, Blackshaw et al. 2006.
[129] NGSF I 2004, at 36-37.

the second National Glyphosate Stewardship Forum, which included weed scientists, farmers and representative of commodity groups and industry, found that resistance management statements on labels have "low impact" at inhibiting resistance to glyphosate.[130] EPA provides no empirical evidence to support the efficacy of label statements concerning resistance management, and no empirical assessment of the factors (e.g. economic, time constraints) that influence farmers' real-world herbicide choices and the degree to which they do or do not implement herbicide resistance management directions. For instance, as discussed above several recommendations involve use of additional herbicides that represent additional production costs that growers may find excessive, or scouting for potential resistance that many farmers will not have time for.

9) EPA proposes a "5-year time limited registration … so that any unexpected weed resistance issues that may result from the proposed uses can be addressed before granting an extension…."[131] This time period is too long. Weed resistance to dicamba will likely emerge within this five-year time limit, and perhaps on an extremely widespread basis that inflicts significant costs on growers. Two considerations support this. First, EPA is greatly overestimating the efficacy of the herbicide resistance management plan, as discussed above. Second, weed resistance is known to evolve very rapidly when an herbicide is used as part of an herbicide-resistant crop system. For instance, glyphosate-resistant horseweed emerged within just three years in Delaware fields planted continuously to glyphosate-resistant soybeans treated with glyphosate.[132] Similarly, glyphosate-resistant (GR) horseweed was first reported in Tennessee cotton and soybean fields in 2001, and by 2004, just three years later, it had infested an estimated 1.5 million acres of Tennessee cropland.[133] Stahlman et al. (2013) found that "[g]lyphosate-resistant kochia spread rapidly ***throughout the central U.S. Great Plains within 4 years of discovery***" (emphasis added). These examples illustrate how quickly resistant weeds have evolved and spread in glyphosate-resistant crop systems, and suggest a similar potential for rapid and widespread evolution of resistance with the new uses of dicamba. EPA provides no rationale for choosing a 5-year time limit, and provides no assessment of the speed or extent of resistant weed evolution or spread, as modeled for example by Neve (2008).

3. Dicamba-Resistant Cotton Will Compromise Boll Weevil Eradication Efforts

Both volunteer cotton and cotton stalks remaining after harvest can harbor boll weevil larvae. Thus, cotton growers in several states (e.g. Texas, Tennessee) are legally required to control cotton volunteers and destroy cotton stalks as part of boll weevil eradication efforts. Agronomists have found this task to be more difficult with the advent of glyphosate- and glufosinate-resistant cotton varieties, and anticipate still greater problems

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[130] NGSF I 2004, at 36-37.
[131] EPA, *Proposed Registration* Document, at 28.
[132] VanGessel 2001.
[133] NGSF I 2004, at 60.

with the introduction of Monsanto's dicamba, glyphosate- and glufosinate-resistant cotton and Dow's 2,4-D-, glyphosate- and glufosinate-resistant cotton. This is because glyphosate, 2,4-D, dicamba and glufosinate are among the few herbicides that provide effective control of volunteer cotton and cotton stalks. Registration of the new dicamba use on cotton would encourage farmer adoption of DR cotton, and hence potentially compromise boll weevil eradication efforts, or substantially increase the associated costs. This subject is addressed in more detail, with citations, in the attached Exhibit B, at 38-40. EPA did not address this issue in its proposed registration documents.

4. Increased tillage and soil erosion

Typical herbicide use patterns with herbicide-resistant crops foster rapid evolution of herbicide-resistant weeds, which in some cases are controlled through the use of tillage. Tillage in turn renders the soil more prone to erosion. A National Research Council committee reported increased use of tillage by farmers to control glyphosate-resistant weeds fostered by Roundup Ready cropping systems.[134] Many farmers employed tillage to control glyphosate-resistant horseweed infesting 1.5 million acres of Tennessee cropland, leading to a dramatic 50% reduction in the use of conservation tillage in Tennessee cotton, and a 30% reduction in the state as a whole.[135] Reduced use of conservation tillage due to GR weeds has also been reported in Missouri and Arkansas. A decline in no-till acreage in U.S. cotton and corn from 2007-2010 and in soybeans from 2008-2010 was attributed to greater use of tillage to control glyphosate-resistant weeds.[136] USDA reported a drop in the use of conservation tillage in soybeans from 2006 to 2012, which likely reflects more tillage to combat glyphosate-resistant weeds.[137]

As weeds with resistance to multiple herbicides continue to emerge and expand, herbicidal management options will continue to decline, meaning more and more farmers will turn to tillage for weed control. For instance, Godar & Stahlman (2015) report higher than expected use of tillage in Kansas to control kochia, which "might indicate failure to control kochia with herbicides." They report that the efficacy of glyphosate + dicamba on kochia has declined dramatically since 2007, as confirmed by reports of kochia with verified resistance to dicamba, glyphosate and other herbicides in Kansas.[138]

By promoting the emergence of weed resistance to dicamba (often in combination with resistance to glyphosate and other herbicides), registration of the proposed new uses will exacerbate the trend to increased use of tillage and soil erosion in American agriculture. Soil erosion on U.S. cropland is already occurring at rates far above soil formation rates,[139] meaning an ongoing loss of valuable topsoil that poses an extremely

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[134] NRC 2010.
[135] NGSF I 2004, at 60.
[136] Owen 2011, Table 1.
[137] Based on USDA Agricultural Resource Management Surveys (ARMS). Data accessible at: http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices/tailored-reports-crop-production-practices.aspx.
[138] HR Kochia 1 & 2 (2015).
[139] Montgomery 2007, USDA NRCS 2015.

serious long-term threat to American agriculture and American society more broadly. The increased soil erosion expected with the new dicamba uses are significant social costs that EPA has not considered in its assessment of the proposed registration.

5. Dicamba, DR crops and land consolidation

Economists have found that herbicide-resistant crop systems tend to reduce labor needs on the farm.[140] USDA agricultural economists MacDonald et al. agree: "HT [herbicide-tolerant] seeds reduce labor requirements per acre."[141] MacDonald's team examined factors responsible for the continuing increase in farm size in American agriculture. They found that innovations like herbicide-resistant seeds that reduce the amount of labor required for field operations allow farming more acres. Large growers of herbicide-resistant crops are generally in a better position to absorb the costs of buying or leasing additional land for expansion, and so outcompete small and medium-size growers, who are thereby put at a competitive disadvantage and potentially out of business. Thus, MacDonald et al. find that herbicide-resistant seeds are a likely contributor to increased consolidation among field crop farmers since 1995.[142]

EPA should assess the impacts of the proposed new uses of dicamba on labor, farm size, land consolidation, welfare of small to medium-size farmers, and the economic health of rural communities. The discussion above suggests that registration of the new uses could have significant social costs.

Under FIFRA, EPA cannot approve a proposed registration or proposed use if there would be "unreasonable adverse effects on the environment" from the pesticide use, defined as "any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide." Yet, EPA's Benefits Analysis fails to affirm or assess Monsanto's claimed benefits, and entirely fails to show that the purported benefits outweigh the unreasonable adverse effects of the proposed use. Instead, as explained above, EPA's assessment fails to critically assess numerous unreasonable adverse effects of approving the proposed use. EPA also failed to quantitatively or meaningfully assess the significant environmental and economic costs of these adverse effects against the purported benefits of the propose use. EPA's Benefits Analysis failed to make the requisite legal finding that the benefits of the proposed approval would outweigh its risks such that approving the proposed dicamba use on dicamba-resistant cotton and soybean would not have "unreasonable adverse effects on the environment." EPA must critically reassess the potential benefits of the proposed use against its numerous significant environmental and economic costs.

VI. EPA's Assessment of Human Health Risks Violates FIFRA and the FFDCA.

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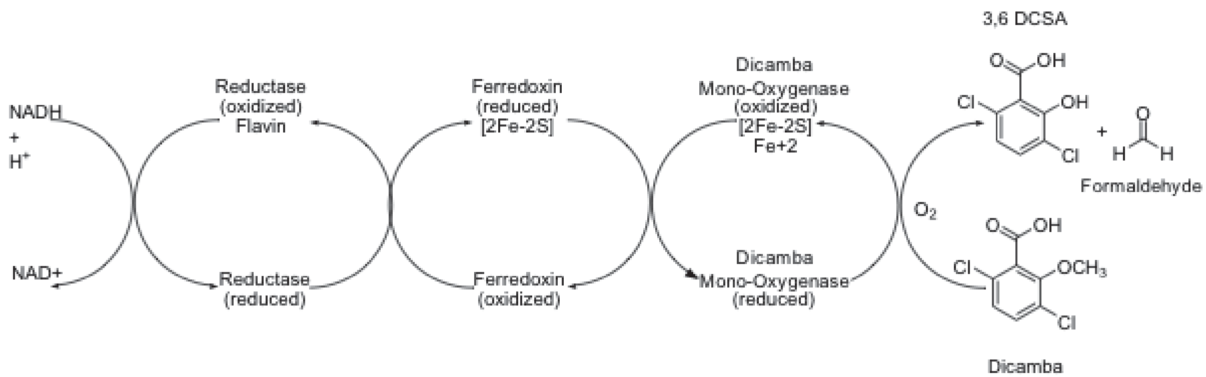
[140] Gardner et al. 2009.
[141] MacDonald et al. 2013, p. 28.
[142] MacDonald et al. (2013).

Monsanto's genetically engineered, dicamba-resistant soybeans and cotton enable the entirely novel uses of dicamba that EPA has proposed to register: spraying the herbicide at high levels directly on growing dicamba-resistant soybeans or cotton to kill nearby weeds throughout the growing season. Because of dicamba's toxicity to conventional soybeans and cotton, it is little used in conventional production of these crops. When used, it is applied primarily "pre-emergence" to clear a field of weeds prior to crop "emergence" to avoid crop injury.

Dicamba resistance is conferred by genetically engineering a gene encoding an enzyme, dicamba mono-oxygenase (DMO), into dicamba-resistant (DR) soybeans and cotton. This DMO enzyme, derived from a soil bacterium, is expressed in the DR crops and demethylates dicamba to form metabolites, chiefly 3,6-dichlorosalicylic acid (DCSA) and formaldhyde, that are generated at levels that are not toxic to the plant, as depicted below. DCSA is not found, or only at extremely low levels, in conventional crops that come into contact with it.



EPA's Assessment of the Carcinogenicity of Dicamba

Animal experiments

EPA describes two animal studies (rat and mouse) on the potential carcinogenicity of dicamba.[143] In the rat study, four groups of 60 animals of each sex were either untreated (control) or fed one of three doses of dicamba for 115 (male) or 117 (female) weeks. Seven percent (4 of 60) of the male rats in each of the two higher-dose groups contracted malignant lymphomas, while no lymphomas were found in the control group or low-dose group (each 0 of 60). In addition, 0/60, 2/60 and 5/60 male rats in the low, medium, and high-dose groups, respectively, contracted thyroid parafollicular cell carcinomas, along with 1/60 males in the control group.

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143 EPA, Dicamba and Dicamba BAPMA Salt: Human Health Risk Assessment for Proposed Section 3 New Uses on Dicamba-tolerant Cotton and Soybean 74-76 (Mar. 29, 2016) [hereinafter *Human Health Risk Assessment*].

EPA notes that: "The Cochran-Armitage trend test showed a statistically significant ($p \leq 0.05$) tendency for the proportion of animals with tumors to increase steadily with increase in dose." Thus, for two forms of cancer, the study exhibited "dose-response," an important indicator that the tumors are related to the treatment (dicamba) rather than due to chance. However, EPA dismissed the statistically significant trends for both cancers because a second statistical test involving pairwise comparisons did not show statistical significance.

EPA followed accepted practice in analyzing the carcinogenicity data with a trend test, and the Cochran-Armitage test is most commonly used for this purpose. It is also accepted practice to make a pairwise comparison of the incidences of animals with tumors in the high dose and control groups.[144] However, the highest dose used in the study should be based on the "maximum tolerated dose,"[145] which was not the case here. In the context of carcinogenicity experiments, the maximum tolerated dose (MTD) is defined as "[t]he highest dose … which, when given for the duration of the chronic study, is just high enough to elicit signs of minimal toxicity without significantly altering the animal's normal lifespan due to effects other than carcinogenicity."[146]

However, no toxicity other than cancers was observed in this experiment. EPA notes that the rats treated with dicamba did not exhibit ***any*** signs of systemic toxicity,[147] that the animals would likely have tolerated substantially higher doses, and that "an MTD was not achieved." Thus, EPA's dismissal of the statistically significant trend of increasing number of tumors with increasing dose of dicamba based on lack of statistical significance in the pairwise comparison of control and high-dose groups is not legitimate, because the study did not incorporate a maximum tolerated dose as demanded by accepted protocol for animal carcinogenicity experiments with chemicals.

In the mouse study, five groups of mice of each sex were either untreated (control group) or received one of four doses of dicamba for 89 (males) or 104 (females) weeks. Of the 10 groups (5 male, 5 female), EPA reports the number of animals with tumors for only two. Eight of the 52 female mice (15%) that were fed the second-lowest dose of dicamba contracted lymphosarcomas, compared to only 2 of 52 (4%) in the control group. The pairwise comparison of these two groups shows a statistically significant increase in lymphosarcomas, but EPA dismissed this finding due to a lack of dose-response (the presence of which was dimissed in the rat study), and because different groups of untreated control mice from entirely different studies tended to have a higher incidence of the tumor than the control group in this study (concurrent control). As in the rat study, the mouse study did not incorporate a maximum tolerated dose. EPA notes that in 1995, its RfD/Peer Review Committee had found that this "mouse carcinogenicity study was not tested at a high enough doses [sic] to evaluate carcinogenicity in the mouse." However, this

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[144] Rahman & Armitage 2012.
[145] NRC 1993;FDA 2008; Rahman & Armitage 2012.
[146] FDA 2008 (citing the U.S. Interagency Staff Group on Carcinogens, 1986).
[147] "Treatment had no adverse effect on survival, body weight, body weight gain, food consumption, hematology, clinical chemistry, urinalysis, organ weights or gross pathology."

determination was overturned here, without explanation, and the study will not be repeated.

Both studies revealed statistically significant evidence of carcinogenicity. EPA dismissed the significant dose-response trend of increasing tumors with increasing dicamba dose in male rats because pairwise comparisons were not significant. A significant pairwise comparison result in the mouse study was dismissed because dose-response was not significant. Neither study incorporated a maximum tolerated dose, which is critical for legitimate application of the pairwise comparison test. Unless or until studies that incorporate maximum tolerated doses are conducted and their results definitively refute the present findings, based on existing evidence EPA should properly find that dicamba is carcinogenic.

Human evidence

Epidemiological studies have associated dicamba exposure with increased incidence of a number of cancers in pesticide applicators. In 1992, epidemiologists with the National Cancer Institute (NCI) found that Iowa and Minnesota farmers who were first exposed to dicamba prior to 1965 had increased incidence of non-Hodgkin's lymphoma (NHL) relative to controls, with an odds ratio of 2.8.[148] A subsequent study in Canada also found an association between exposure to dicamba and NHL.[149] A study of cancer in Iowa farmers associated exposure to benzoic herbicides[150] with increased risk of multiple myeloma,[151] which has since been identified as a subtype of non-Hodgkin's lymphoma.[152] A comprehensive meta-analysis of epidemiology assessing non-Hodgkin's lymphoma and exposure to agricultural pesticides also found an association with dicamba exposure.[153]

Exposure to pesticides has long been suspected as a risk factor in non-Hodgin's lymphoma due to a striking fact. While farmers are generally healthier, and have lower ***overall*** cancer rates than the general population, they have higher than average risk of contracting NHL and several other cancers.[154] This fact lends weight to epidemiology studies that find correlations between these cancers and and specific pesticides, such as dicamba. EPA does not discuss the increased incidence of NHL or any other cancer in farmers or pesticide applicators.

EPA fails to assess these studies, though CFS brought most of them to the Agency's attention several years ago.[155] Neither does EPA remark on or assess the commonality in cancer type (lymphatic system) in animal experiments and epidemiology: malignant lymphomas (male rats), lymphosarcomas (female mice), and non-Hodgkin's lymphoma

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[148] A 2.8-fold higher risk of cancer than the unexposed control group. *See* Cantor et al 1992, Table 6.
[149] McDuffie et al 2001.
[150] Dicamba is the most widely used benzoic acid herbicide.
[151] Burmeister 1990.
[152] Schinasi and Leon 2014.
[153] Schinasi and Leon 2014.
[154] Blair & Zahm 1995.
[155] *See* Exhibit B (attached).

(pesticide applicators). This may well indicate that dicamba has a common mechanism of action targeting the lymphatic system in animals and humans.

The only epidemiology study assessed by EPA in its six-sentence treatment of epidemiology data.[156] is from the Agricultural Health Study,[157] Samanic et al. found found suggestive associations between dicamba exposure and both lung and colon cancer, with statistically significant exposure-response trends in both cases.[158] EPA's cursory review of Samanic et al. (2006) is biased, incomplete and erroneous, failing to report even the specific types of cancer – lung and colon – for which the authors found dicamba dose-response trends when the referent group was low-exposed applicators. EPA reports that they found a significant trend (p = 0.02), failing to specify this trend was between dicamba exposure and **lung** cancer. Contrary to EPA, this lung cancer trend was ***not*** "largely due to elevated risk at the highest exposure level." The authors identified a still more significant trend for **colon** cancer (p = 0.002), and it is this trend that was largely due to elevated risk at the highest exposure level. Samanic et al. describe their results in part as follows:

> "When the reference group comprised low-exposed applicators, we observed a positive trend in risk between lifetime exposure days and lung cancer (p = 0.02), but none of the individual point estimates was significantly elevated. We also observed significant trends of increasing risk for colon cancer for both lifetime exposure days and intensity-weighted lifetime days, although these results are largely due to elevated risk at the highest exposure level."

EPA also fails to assess a previous Agricultural Health Study[159] that likewise found "a positive trend in risk for lung cancer with lifetime exposure days for dicamba…" (as quoted in Samanic et al. 2006).

Samanic et al. find that "the patterns of association observed for lung and colon cancers warrant further attention" and propose to re-examine dicamba "when larger numbers will allow for a more comprehensive evaluation of lung and colon cancer, as well as additional cancer cites." With registration of the proposed new uses, many more farmers would be exposed to higher levels of dicamba than ever before, providing epidemiologists with additional cancer cases to analyze.

EPA has failed to properly assess either animal or human evidence of dicamba's potential carcinogenicity, or to consider the implications of the common cancer types (lymphatic system) found in animal studies and human epidemiology studies.

<u>EPA's Assessment of the Chronic Toxicity of Dicamba and its Metabolites</u>

Point of Departure based on the DSCA study

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[156] EPA, *Human Health Risk Assessment*, at 29-30,
[157] Samanic et al. 2006.
[158] Weichenthal et al 2010.
[159] Alvanaja et al. 2004.

EPA assessed a number of animal feeding studies with dicamba and its major metabolite (DCSA) in dicamba-resistant soybeans and cotton to establish a purported "safe" level of chronic (long-term) human dietary exposure. The studies were submitted by the registrant, and involved long-term administration of dicamba or DCSA to rats, rabbits or dogs at various levels to assess potential reproductive, developmental or neurological toxicity, among other endpoints.[160] Consistent with its standard practice, EPA chose the registrant-submitted study that revealed adverse effects at the lowest dose as its "point of departure" for calculating the highest level of long-term dietary exposure to dicamba that is presumed "safe" for human beings, known as the chronic reference dose (cRfD).

The "point of departure" study chosen by EPA was a two-generation rat reproduction study involving DCSA. In this study, following pre and/or post-natal exposure, rat pups exhibited signs of toxicity (decreased body weight) at levels of DSCA that were approximately ten-fold lower than did adult rats.[161] EPA established the lowest observed adverse effect level (LOAEL) at 37 mg/kg/day, and the no observed adverse effect level (NOAEL) at 4 mg/kg/day.[162] After applying the standard 100X uncertainty factor to the NOAEL for application of these findings to humans (10X for interspecies extrapolation; 10X for intraspecies variation), EPA established a chronic reference dose (cRfD) of 0.04 mg/kg/day. Even though rat pups were 10-fold more sensitive to DCSA than adults, EPA did not apply the additional 10X safety factor demanded by the Food Quality Protection Act (FQPA) when toxicology tests demonstrate that the young are more susceptible than adults. Thus, based on the findings in the DCSA point of departure study, EPA should have applied the FQPA safety factor and set the cRfD at 0.04 x 0.1 = 0.004 mg/kg/day rather than 0.04 mg/kg/day.

Point of Departure based on beagle study not considered by EPA

EPA failed to consider another study in its database that the Agency once used to establish a still lower cRfD. In this study, beagle dogs were administered dicamba in their diets for two years at three different doses, in addition to an untreated control group. The doses of 5, 25 or 50 ppm corresponded to 0.125, 0.625 or 1.25 mg/kg/day. Based on the observation of reduced body weight in males at the 25 ppm = 0.625 mg/kg/day dose, EPA identified an NOAEL of 5 ppm = 0.125 mg/kg/day based on this study. After application of a standard uncertainty factor of 100X, EPA established a chronic reference dose of 0.0013 mg/kg/day.[163] A National Research Council committee recommended a very similar acceptable daily intake (ADI) level (equivalent to cRfD) for dicamba of 0.00125 mg/kg/day,[164], as noted by EPA.[165]

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[160] EPA, Human Health Risk Assessment, Tables A.2.4, A.2.5, A.2.6.
[161] EPA, *Human Health Risk Assessment*, at 21.
[162] EPA, *Human Health Risk Assessment*, at 21, 25.
[163] EPA 1987.
[164] NRC 1977.
[165] EPA 1987.

EPA provides no assessment of this study in any of the registration documents, though it was brought to the Agency's attention three years ago by CFS.[166]

Estimated exposure relative to alternative cRfD values

EPA provides estimates of human dietary exposure (food + water) to dicamba and its metabolites that greatly exceed both alternative cRfD values discussed above. Chronic dietary exposure to dicamba is estimated at 0.006319 mg/kg/day for the general U.S. population and 0.016988 mg/kg/day for the most highly exposed subgroup, children 1-2 years of age.[167] Below we compare these exposure levels to the alternative cRfD values.

Population	**Dietary exposure**	**DCSA study (adj. 10X FQPA)**		**Beagle study (EPA 1987)**	
		cRfD	**% exceedance**	**cRfD**	**% exceedance**
General U.S.	0.006319	0.004	58%	0.0013	386%
1-2 yrs. old	0.016988	0.004	325%	0.0013	1207%

Based on the DSCA study with application of the 10X FQPA safety factor and EPA's estimates of human dietary exposure to dicamba, the general U.S. population and children 1-2 years old are exposed to levels of dicamba that exceed the cRfD by 58% and 325%, respectively. Based on the beagle study that EPA used to set a chronic reference dose in 1987, the estimated exposure of the U.S. population and 1-2 year old children to dicamba is nearly 400% and 1200% greater than the cRfD, respectively. Thus, Americans' exposure to dicamba as estimated by EPA is far above the level the Agency formerly regarded as safe.

Unfortunately, this would not be the first time the Agency has sharply increased the level of exposure to a pesticide it regards as safe, based on unexplained dismissal or dubious reinterpretation of old studies in favor of newer ones that sharply raise the "safe" level of exposure. For instance, EPA radically and unjustifiably altered its interpretation of a key study on the herbicide 2,4-D to accommodate the greatly increased use and exposure that would result from rising use of 2,4-D on corn and soybeans engineered to resist it.[168] In the case of glyphosate, EPA has raised the maximum "safe" level of exposure 17.5-fold since just 1983.[169]

Formaldehyde exposure

Formaldehyde is generated as a byproduct when dicamba is metabolized in DR soybeans and cotton to DCSA (see figure above). EPA should consider potential human health impacts from exposure to formaldehyde in food or feed derived dicamba-resistant soybeans and cotton that has been treated with dicamba.

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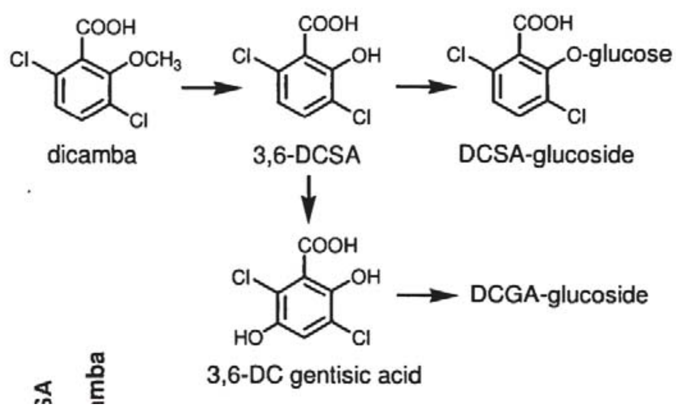
166 *See* Exhibit B (attached).
167 EPA, *Human Health Risk Assessment*, at 37 Table 5.4.6.
168 Callahan 2015.
169 EPA 1983; *see also* CFS 2015, *Glyphosate and cancer risk: frequently asked questions*, *available at* http://www.centerforfoodsafety.org/files/glyphosate-faq_64013.pdf.

Metabolites of dicamba

When dicamba is applied to dicamba-resistant soybeans and cotton, the herbicide is absorbed and translocated internally to various plant tissues. The novel DMO enzyme expressed in DR soybeans and cotton converts dicamba to 3,6-DSCA and formaldehyde, as discussed above. DCSA in turn undergoes a process known as conjugation – the attachment of sugar molecules to the chemical to form compounds known generically as glycosides. When the sugar molecule that is attached is glucose, the "conjugates" are known glucosides. In dicamba-resistant soybeans, a metabolism study using radioactively labeled dicamba shows that the major dicamba metabolite is DCSA-glucoside (see figure below).

> "A new metabolism study submitted by the registrant on dicamba resistant soybean shows that the identified dicamba metabolites were DCSA glucoside (60.32-74.48% of TRR), which was the major component in dicamba-tolerant soybean, DCSA HMGglucoside (1.14-7.62% of TRR), DCGA glucoside (0.75-4.32%), DCGA malonylglucoside (0.73-5.46% of TRR), DCSA (1.54- 4.08% of TRR), in addition to two minor un-identified metabolites characterized as mixtures of unknown DCSA and DCGA conjugates, each constituted less than 2.0% of the TRR."[170]



Source: Feng, PCC (2013). Methods and composition for improving plant health. U.S. Patent 2013/0217576 A1, August 22, 2013. Figure 11: Metabolism of 14C-dicamba to DCSA and conjugation to glucoside in whole plant studies.

DCSA glucoside represents roughly 60-74% of the total recovered radioactivity (TRR); that is, 60-74% of the radioactively labeled dicamba that was applied to the plant and recovered when the plants were analyzed. In contrast, DCSA in its unconjugated or free form represents just 1.5-4% of the TRR, on the order of 20- to 40-fold less than DCSA glucoside.

[170] EPA, *Human Health Risk Assessment*, at 30.

It is well known that intestinal bacteria have the general capacity to split off the glucoside component of conjugated chemicals like DCSA glucoside, thus liberating the non-glucoside component (here, DCSA).[171] Thus, there is a clear potential for animals or human beings that consume feed or food derived from dicamba-resistant soybeans to be exposed not only to the relatively small amount of free DCSA they contain, but also to the much larger amount of DCSA that may be liberated from the DCSA-glucoside conjugate upon ingestion. The same is true of other conjugated metabolites of dicamba (e.g. DCGA-glucoside).

Thus, EPA must consider the potential exposure to DCSA and other metabolites of dicamba that are released from glucoside-conjugated forms of these metabolites when animals or humans consume food or feed derived from dicamba-resistant soybeans and cotton that have been treated with dicamba. This issue is also discussed in the context of potential environmental impacts in the section of our comments addressing potential risks to threatened and endangered species.

CFS addresses additional potential health concerns of the proposed new uses of dicamba in prior comments submitted to the Agency.[172]

CONCLUSION

For the reasons described above and discussed in detail in the attached exhibits and CFS's previously submitted comments, CFS requests EPA comply with FIFRA, FFDCA, MBTA, and the ESA by critically considering the effects to listed species and their critical habitats, as well as the numerous unreasonable adverse human health, environmental, and socioeconomic effects stemming from proposed new uses of dicamba on dicamba-resistant, GE cotton and soybean.

Submitted by,
Center for Food Safety

[171] Stella 2007.
[172] *See* Exhibits A-B (attached).

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USDA Dicamba FEIS (2014). Final Environmental Impact Statement for Monsanto Petitions (10-188-01p and 12-185-01p) for Determinations of Nonregulated Status for Dicamba-Resistant Soybean and Cotton Varieties. US Department of Agriculture, December 2014.

Exhibit A

Center for Food Safety Comments
Docket No. EPA-HQ-2016-0187
Submitted May 31, 2016

The impact of the proposed registration on evolution of herbicide-resistant weeds

Summary

U.S. agriculture's undue reliance on single-tactic, chemical-intensive weed control generates huge costs in the form of herbicide-resistant weeds – costs that could be avoided or greatly lessened with sustainable integrated weed management techniques that emphasize non-herbicidal tactics. Herbicide-resistant crop systems promote more rapid evolution of resistant weeds than do other (non HR crop) uses of the pertinent herbicide(s). This is clearly demonstrated by the history of glyphosate-resistant weeds, which have emerged almost exclusively in the Roundup Ready crop era. Weeds resistant to synthetic auxin herbicides, the class to which dicamba belongs, are already numerous, indicating that auxin-resistance is prevalent in the plant world. The proposed registration would facilitate greatly increased dicamba use on weeds already resistant to glyphosate and other herbicides, leading to still more intractable, multiple herbicide-resistant weeds. Clear evidence of cross-resistance and/or tolerance to auxin herbicides among weed species exacerbates the threat. Multiple herbicide-resistant weeds lead to increased selection pressure for resistance to evolve to the ever fewer remaining effective herbicidal control options. In light of these considerations, weed scientists have recently called for mandatory stewardship practices to address the likely emergence of auxin-resistant weeds with auxin-resistant crop systems. Volunteer HR soybeans with resistance to multiple herbicides may become ever more problematic weeds. Monsanto's stewardship recommendations for MON 88708 are entirely inadequate. Because herbicide-resistant weeds, once evolved, can spread their resistance traits via cross-pollination and seed dispersal, stewardship recommendations that focus on persuading individual growers to "do the right thing" are ineffective, and risk undermining the utility of valuable herbicides for non HR crop uses. Regulation is a rational response to this "tragedy of the commons" dilemma, in which the susceptibility to weeds is the common resource rapidly being squandered.

Weed management vs. weed eradication

Weeds can compete with crop plants for nutrients, water and sunlight, and thereby inhibit crop growth and potentially reduce yield. While less dramatic than the ravages of insect pests or disease agents, weeds nevertheless present farmers with a more consistent challenge from year to year. However, properly managed weeds need not interfere with crop growth. For instance, organically managed corn has been shown to yield as well as conventionally grown varieties despite several-fold higher weed densities (Ryan et al. 2010). Long-term cropping trials at the Rodale Institute reveal that average yields of organically grown soybean were equivalent to those of conventionally grown soybean, despite six times greater weed biomass in the organic system (Ryan et al. 2009). Weeds can even benefit crops – by providing ground cover that inhibits soil erosion and attendant loss of soil nutrients, habitat for beneficial organisms such as ground beetles that consume weed seeds, and organic matter that when returned to the soil increases fertility and soil tilth (Liebman 1993). These complex interrelationships between crops and weeds would seem to call for an approach characterized by careful management rather than indiscriminate eradication of weeds.

Farmers have developed many non-chemical weed management techniques, techniques that often provide multiple benefits, and which might not be utilized specifically or primarily for weed control (see generally Liebman & Davis 2009). For instance, crop rotation has been shown to significantly reduce weed densities versus monoculture situations where the same crop is grown each year (Liebman 1993). Cover crops – plants other than the main cash crop that are usually seeded in the fall and killed off in the spring – provide weed suppression benefits through exudation of allelopathic compounds into the soil that inhibit weed germination, and when terminated in the spring provide a weed-suppressive mat for the follow-on main crop. Common cover crops include cereals (rye, oats, wheat, barley), grasses (ryegrass, sudangrass), and legumes (hairy vetch and various clovers. Intercropping – seeding an additional crop amidst the main crop – suppresses weeds by acting as a living mulch that competes with and crowds out weeds, and can provide additional income as well (Liebman 1993). One common example is intercropping oats with alfalfa. Higher planting densities results in more rapid closure of the crop "canopy," which shades out and so inhibits the growth of weeds. Fertilization practices that favor crop over weeds include injection of manure below the soil surface rather than broadcast application over the surface. Techniques that conserve weed seed predators, such as ground beetles, can reduce the "weed seed bank" and so lower weed pressure. In addition, judicious use of tillage in a manner that does not contribute to soil erosion is also a useful means to control weeds.

Unfortunately, with the exception of crop rotation and tillage, such techniques are little used in mainstream agriculture. This is in no way inevitable. Education and outreach by extension officers, financial incentives to adopt improved practices, and regulatory requirements are just a few of the mechanisms that could be utilized to encourage adoption of more integrated weed management systems (IWM) that prioritize non-chemical tactics (Mortensen et al. 2012). Meanwhile, the problems generated by the prevailing chemical-intensive approach to weed control, exacerbated by the widespread adoption of herbicide-resistant crops, are becoming ever more serious.

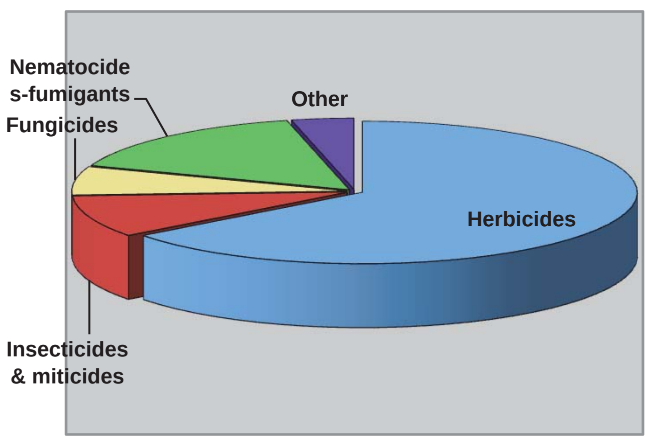
The high costs of herbicide-only weed control

In 2007, U.S. farmers spent $4.2 billion dollars to apply 442 million lbs of herbicide, and uncounted billions more on technology fees for herbicide-resistance traits in major crops. Overall, the U.S. accounts for one-quarter of world herbicide use (EPA Pesticide Use 2011, Tables 3.1, 5.2, 5.6). Surely this intensive herbicidal onslaught should make American fields among the most weed-free in the world. But such is not the case. As farmers gradually came to rely more on herbicides as the preferred and then often the sole means to control weeds, herbicide-resistant weeds have become increasingly severe and costly.

The first major wave of herbicide-resistance came in the 1970s and 1980s as weeds evolved resistance to the heavily used triazines, such as atrazine (see Benbrook 2009a for this discussion). The next major wave of resistance comprised weeds resistant to ALS inhibiting herbicides in the 1980s and 1990s. Just five years intervened between introduction of the first ALS inhibitor herbicide in 1982 and the first resistant weed population (1987). One of the major factors persuading farmers to adopt Roundup Ready, glyphosate-resistant crops was the prevalence of weeds resistant to ALS inhibitors. Weeds have evolved resistance at least 21 "modes of action," or herbicide classes, in the world (ISHRW HR Weed Ranking 9/20/12).

According to the USDA's Agricultural Research Service, up to 25% of pest (including weed) control expenditures are spent to manage pesticide (including herbicide) resistance in the target pest (USDA ARS Action Plan 2008-13-App. II). With an estimated $7 billion spent each year on chemical-intensive weed control (USDA ARS IWMU-1), herbicide-resistant weeds thus cost U.S. growers roughly $1.7 billion (0.25 x $7 billion) annually. These expenditures to manage resistance equate to tens and perhaps over 100 million lbs of the over 400 million lbs of agricultural herbicide active ingredient applied to American crops each year (see figure below), as growers increase rates and make additional applications to kill expanding populations of resistant weeds

Agricultural Pesticide Use in the U.S. by Type: 2007



Herbicides comprise by far the largest category of pesticides, defined as any chemical used to kill plant, insect or disease-causing pests. In 2007, the last year for which the Environmental Protection Agency has published comprehensive data, weedkillers (herbicides) accounted for 442 million lbs of the 684 million lbs of chemical pesticides used in U.S. agriculture, nearly seven-fold more than the insecticides that many associate with the term "pesticide." Source: "Pesticides

Industry Sales and Usage: 2006 and 2007 Market Estimates," U.S. Environmental Protection Agency, 2011, Table 3.4 (EPA Pesticide Use 2011 in supporting materials).

Increasing the rate and number of applications, however, rapidly leads to further resistance, followed by adding additional herbicides into the mix, beginning the resistance cycle all over again, just as overused antibiotics breed resistant and then multiple-drug resistant bacteria. This process, dubbed the pesticide treadmill, has afflicted most major families of herbicides, and will only accelerate as U.S. agriculture becomes increasingly dependent on crops engineered for resistance to one or more members of this by far largest class of pesticides (Kilman 2010).

Besides costing farmers economically via herbicide-resistant weeds, the chemical-intensive pest control regime of HR crop systems also has serious public health and environmental consequences. Various pesticides are known or suspected to elevate one's risk for cancer, neurological disorders, or endocrine and immune system dysfunction. Epidemiological studies of cancer demonstrate that farmers in many countries, including the U.S., have higher rates of immune system and other cancers (USDA ERS AREI 2000). Little is known about the chronic, long-term effects of exposure to low doses of many pesticides, especially in combinations. Pesticides deemed relatively safe and widely used for decades (e.g. cyanazine) have had to be banned in light of scientific studies demonstrating harm to human health or the environment. Pesticides also pollute surface and ground water, harming amphibians, fish and other wildlife.

Herbicide-resistant weeds thus lead directly to adverse impacts on farmers, the environment and public health. Adverse impacts include the increased costs incurred by growers for additional herbicides to control them, greater farmer exposure to herbicides and consumer exposure to herbicide residues in food and water, soil erosion and greater fuel use and emissions from increased use of mechanical tillage to control resistant weeds, environmental impacts from herbicide runoff, and in some cases substantial labor costs for manual weed control. These are some of the costs of unsustainable weed control practices, the clearest manifestation of which is evolution of herbicide-resistant weeds.

Why herbicide-resistant crop systems promote rapid evolution of resistant weeds

Herbicide-resistant (HR) crop systems such as MON 87708 soybeans involve post-emergence application of one or more herbicides to a crop that has been bred or genetically engineered to survive application of the herbicide(s). These HR crop systems promote more rapid evolution of herbicide-resistant weeds than non-HR crop uses of the associated herbicides. This is explained by several characteristic features of these crop systems.

HR crops foster more ***frequent*** use of and ***overreliance*** on the herbicide(s) they are engineered to resist. When widely adopted, they also lead to more ***extensive*** use of HR crop-associated herbicide(s). Herbicide use on HR crops also tends to occur ***later in the season***, when weeds are larger. Each of these factors contributes to rapid evolution of resistant weeds by favoring the survival and propagation of initially rare individuals that have genetic mutations lending them resistance. Over time, as their susceptible brethren are killed off, these rare individuals become more numerous, and eventually dominate the weed population.

High frequency of use means frequent suppression of susceptible weeds, offering (at frequent intervals) a competition-free environment for any resistant individuals to thrive. Overreliance on the HR crop-associated herbicide(s) means little opportunity for resistant individuals to be killed off by alternative weed control methods, thus increasing the likelihood they will survive to propagate and dominate the local weed population. Widespread use of the HR crop system increases the number of individual weeds exposed to the associated herbicide(s), thus increasing the likelihood that there exists among them those individuals with the rare genetic predisposition that confers resistance. The delay in application fostered by HR crop systems means more weeds become larger and more difficult to kill; thus, a greater proportion of weeds survive to sexual maturity, and any resistant individuals among them are more likely to propagate resistance via cross-pollination of susceptible individuals or through deposition of resistant seeds in the seed bank; in short, a higher likelihood of resistance evolution.

Below, we discuss these resistant weed-promoting features of HR crop systems in more detail, with particular reference to systems involving glyphosate-resistance (Roundup Ready) and auxin-resistance.

GE seeds in general, including HR seeds, are substantially more expensive than conventional seeds (Benbrook 2009b). Their higher cost is attributable to a substantial premium (often called a technology fee) for the herbicide-resistance trait. This premium constitutes a financial incentive for the grower to fully exploit the trait through frequent and often exclusive use of the associated herbicide(s), and a disincentive to incur additional costs by purchasing other, often more expensive herbicides.

> The cost of RR [Roundup Ready] alfalfa seed, including the technology fee, is generally twice or more than that of conventional alfalfa seed. Naturally, growers will want to recoup their investment as quickly as possible. Therefore, considerable economic incentive exists for the producer to rely solely on repeated glyphosate applications alone as a weed control program. (Orloff et al. 2009, p. 9).

To our knowledge, Monsanto has not revealed its pricing for MON 87708 seed, but it is likely to be considerably more expensive than currently available GE varieties.

Overreliance is especially favored when the associated herbicide(s) are effective at killing a broad range of weeds, which tends to make other weed control practices less needed, at least until weed resistance emerges. Glyphosate is such a broad-spectrum herbicide; dicamba provides control of most broadleaf weeds. Applied together or sequentially, glyphosate and dicamba would initially provide broad-spectrum control of soybean weeds, making use of other weed control measures unnecessary until the inevitable rapid evolution of auxin resistance, often in populations already resistant to glyphosate and/or other herbicides. Greater use of non-chemical weed control tactics is the only way to avoid the evolution of increasingly intractable, multiple HR weeds.

Frequent use and overreliance are also fostered when the HR crop-associated herbicide(s) are inexpensive relative to other herbicides. Monsanto lowered the price of Roundup herbicide (active ingredient: glyphosate) in the late 1990s to encourage farmers to adopt Roundup Ready crop systems and rely exclusively on glyphosate for weed control (Barboza 2001),[13] and the price has fallen further since then. Dicamba is even cheaper than glyphosate, and in fact is one of the least inexpensive herbicides on the market (U of Tenn 2011, p. 94). As suggested by Orloff et al. (2009), quoted above, overreliance on HR crop-associated herbicide(s) is particularly favored when the HR trait premium is high and the price of the associated herbicide(s) is low, the likely scenario with MON 87708 soybeans. Any price premium for a dicamba product registered for use on MON 87708 would encourage farmers to use cheaper and more drift-prone formulations.

One of the key changes wrought by herbicide-resistant crop systems is a strong shift to post-emergence herbicide application, which generally occurs later in the season on larger weeds, versus early-season use on smaller weeds or prior to weed emergence that is more characteristic of conventional crops. It is important to understand that facilitation of post-emergence herbicide use as the sole or primary means of weed control is the *sine qua non* of HR crop systems, not an incidental feature. Early-season uses include soil-applied herbicides put down around the time of planting; these herbicides have residual activity to kill emerging weeds for weeks after application. The Roundup Ready soybean system has practically eliminated use of soil-applied, or indeed of any herbicide other than glyphosate.

Weed scientist Paul Neve has simulated the rate at which weeds evolve resistance to glyphosate under various application regimes (Neve 2008). His results show unambiguously that the post-emergence use of glyphosate unique to glyphosate-resistant crop systems fosters resistant weeds much more readily than traditional uses ("prior to crop emergence") typical of conventional crops. This is consistent with the massive emergence of glyphosate-resistant weeds only after glyphosate-resistant crops were introduced (see below):

> Glyphosate use for weed control prior to crop emergence is associated with low risks of resistance. These low risks can be further reduced by applying glyphosate in sequence with other broad-spectrum herbicides prior to crop seeding. Post-emergence glyphosate use, associated with glyphosate-resistant crops, very significantly increases risks of resistance evolution. (Neve 2008)

Glyphosate-resistant crop systems have fostered later post-emergence applications than many agronomists anticipated, which increases the potential for resistant weed evolution.

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[13] Monsanto has greatly increased the price of RR seed to compensate for reduced income from sale of Roundup.

> Growers rapidly adopted glyphosate-resistant crops and, at least initially, did not have to rely on preventive soil-applied herbicides. Growers could wait to treat weeds until they emerged and still be certain to get control. ***Many growers waited until the weeds were large in the hope that all the weeds had emerged and only one application would be needed. Today, experts are challenging this practice from both an economic and a sustainability perspective.*** (Green et al. 2007, emphasis added)

> Following the widespread adoption of glyphosate-resistant soybean, ***there has been a subtle trend toward delaying the initial postemergence application longer than was once common***. Because glyphosate provides no residual weed control and application rates can be adjusted to match weed size, ***producers hope that delaying the initial postemergence application will allow enough additional weeds to emerge so that a second application will not be necessary.*** (Hagar 2004, emphasis added)

University of Minnesota weed scientist Jeff Gunsolus notes that: "Larger weeds are more apt to survive a postemergence application and develop resistance." (as quoted in Pocock 2012). University of Arkansas weed scientist Ken Smith notes that application of Ignite (glufosinate) to cotton plants with dual resistance to glyphosate and glufosinate (Widestrike varieties) in order to control large glyphosate-resistant weeds risks generating still more intractable weeds resistant to both herbicides (as quoted in Barnes 2011, emphasis added):

> Many growers who use Ignite on WideStrike varieties do so after they discover they have glyphosate-resistant weeds, according to Smith. To combat this, ***growers will make an application of Ignite on weeds that, on occasion, have grown too big to be controlled by the chemistry. This creates a dangerous scenario which could possibly encourage weeds to develop resistance to glufosinate***, the key chemistry in Ignite. ***The end-result, according to Smith, would be disastrous***.

It should be noted that Dr. Smith's concern is that weeds will evolve resistance to the same two herbicides to which the HR crop is resistant, which both undermines the utility of the crop and creates a potentially noxious HR weed that becomes extremely difficult to control. As discussed further below, this tendency for weeds to mimic the herbicide resistances in the crop is a general feature of HR crop systems, and sets up a futile and costly chemical arms race between HR crops and weeds.

Overview of glyphosate-resistant crops and weeds

A discussion of glyphosate-resistant (GR) crops and weeds is important for two reasons. First, the rapid emergence of GR weeds in RR crop systems is evidence of the resistant weed-promoting effect of HR crop systems in general, as discussed above, and provides insight into the risks of resistant weed evolution in the context of the MON 87708 soybean system. Second, the prevalence of glyphosate-resistant weeds is the motivating factor in Monsanto's introduction and farmers' potential adoption of MON 87708 under the proposed registration.

Glyphosate-resistant crops represent by far the major HR crop system in American and world agriculture, and provide an exemplary lesson in how HR crop systems trigger HR weeds (see Benbrook 2009a for following discussion). Glyphosate was first introduced in 1974. Despite considerable use of the herbicide, for the next 22 years there were no confirmed reports of glyphosate-resistant weeds. A few small and isolated populations of resistant weeds – mainly rigid and Italian ryegrass and goosegrass – emerged in the late 1990s, attributable to intensive glyphosate use in orchards (e.g. Malaysia, Chile, California) or in wheat production (Australia).

Significant populations of glyphosate-resistant weeds have only emerged since the year 2000, four years after the first Roundup Ready (RR) crop system (RR soybeans) was introduced in 1996, followed by RR cotton & canola in 1997 and RR soybean in 1998. According to the International Survey of Herbicide-Resistant Weeds (ISHRW), multiple populations of 23 weed species are resistant to glyphosate in one or more countries today; of these, 26 populations of ten species are also resistant to herbicides in one to three other families of chemistry in addition to glyphosate (ISHRW GR Weeds 4/22/12).[14] Based on acreage infested, GR weeds have emerged overwhelmingly in soybeans, cotton and soybean in countries, primarily the U.S., where RR crop systems predominate (see CFS RRSB 2010, which has further analysis of GR weeds).

The first glyphosate-resistant (GR) weed population confirmed in the U.S., reported in 1998, was rigid ryegrass, infesting several thousand acres in California almond orchards (ISHRW GR Weeds 4/22/12). Beginning in the year 2000 in Delaware, glyphosate-resistant horseweed rapidly emerged in Roundup Ready soybeans and cotton in the East and South. Just twelve years later, glyphosate-resistant biotypes of 13 species are now found in the U.S., and they infest millions of acres of cropland in at least 27 states (ISHRW GR Weeds 4/22/12).[15]

Based on Center for Food Safety's periodic compilation of data from the ISHRW website over the past four years, glyphosate-resistant weeds in the U.S. have evolved at an accelerated rate in recent years. As of November 2007, ISHRW recorded eight weed species resistant to glyphosate, covering up to 3,200 sites on up to 2.4 million acres. By Sept. of 2012, as many as 440,000 sites on up to 18,700,000 acres were documented to be

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[14] A population of one additional weed species (for 24 total) has evolved resistance to glyphosate since the cited 4/22/12 list was compiled, spiny amaranth in Mississippi. See http://www.weedscience.org/Case/Case.asp?ResistID=5682.
[15] Now 14 weed species, in at least 30 states. GR weeds have been documented in three additional states since this 4/22/12 list was compiled. For South Dakota and Wisconsin, see list at http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=12&FmHRACGroup=Go. For Montana, see AgNews (2012). Thus, all 10 major soybean growing states how have GR weeds.

infested by glyphosate-resistant weeds (CFS GR Weed List – 9/20/12). This astonishing proliferation of resistant weeds – an over 130-fold increase in number of sites and 8-fold increase in acreage – is portrayed in the figure at the end of this section.

However, the true extent of GR weeds is much greater than even the maximum figures shown in the graph, because "...the voluntary basis of the contributions [to ISHRW] likely results in underestimation of the extent of resistance to herbicides, including glyphosate" (NRC 2010, p. 2-12). Many examples could be cited to illustrate to what extent ISHRW underestimates the extent of GR weed populations, but one will suffice. Illinois weed scientist Bryan Young recently reported 5-6 million acres of Illinois cropland infested with glyphosate-resistant waterhemp (as quoted in Lawton 2012, confirmed with Dr. Young, personal communication). Yet ISHRW lists GR waterhemp as infesting just 100 acres in Illinois (ISHRW Illinois Waterhemp). Inclusion of this single updated report in the ISHRW system would raise the GR weed infested acreage by one-third. It appears that much or all of this waterhemp is resistant to ALS inhibitors as well, with a significant portion also resistant to PPO inhibitors and/or triazine herbicides (Tranel 2010).

Dr. Ian Heap, who manages the ISHRW website cited above, confirms that: "The survey is definitely too low because researchers report the first cases and enter in the area infested. Often they don't return in subsequent years to keep updating the survey." Dr. Heap estimates that "there are about 40 million acres affected by glyphosate-resistant weeds," but notes that if one accounts for "overlapping acres" infested with more than one GR weed, "the estimate probably comes down to about 30 million actual acres" (Heap 2012). Dow has an even higher estimate of GR weed-infested acreage of 60 million acres (Bomgardner 2012). Thus, actual acreage infested with glyphosate-resistant weeds is double to triple the 18.7 million acres reported by ISHRW and shown in the figure below. However, the figure can be assumed to accurately capture the extremely rapid pace of GR weed emergence.

Early on, most resistant weed populations were driven by intensive glyphosate use associated with RR soybeans and RR cotton. However, adoption of corn with the Roundup Ready trait has increased sharply in recent years, from 20% to 72% of national corn acres from just 2004 to 2011. The increasing reliance on glyphosate associated with the growing use of RR soybean/RR corn rotations is the major factor driving the rapid emergence of resistant weeds in the Midwest and Northern Plain states. In general, more GR weeds are emerging on agricultural land planted to several crops that are predominantly Roundup Ready in the U.S., which since 2008 includes sugar beets. The most recent example is the emergence of GR common waterhemp on land planted to soybeans, corn and sugar beets in North Dakota (ISHRW GR Weeds 4/22/12).

Populations of some glyphosate-resistant weeds, such as GR Palmer amaranth, GR horseweed, GR kochia, and GR common waterhemp, are properly regarded as noxious weeds. The increased use of herbicides and increased use of soil-eroding tillage operations to control them cause harm to the environment and natural resources (e.g. loss of soil and increased runoff of agricultural chemicals). When not properly managed due to the difficulty of controlling them, these noxious weeds can sharply reduce yields, while successful control efforts often involve a several-fold increase in weed control costs, in either case harms to the interests of agriculture. A brief, documented overview of these harms is provided in Benbrook (2009a, Chapter 4).

Synthetic auxin-resistant crops and weeds

Synthetic auxin herbicides like dicamba act by mimicking plant growth hormones such as indole acetic acid. Monsanto maintains that "there is a low potential for dicamba-resistant broadleaf weed populations to arise from the use of dicamba applied to MON 87708 integrated into the Roundup Ready soybean system," and gives the following reasons for this opinion (Monsanto 2010, p. 601).

1) Dicamba will be used together with glyphosate, with recommended use of a soil residual herbicide, and such use of multiple modes of action "is a primary way to delay the development of resistance;"
2) Resistance to auxin herbicides has developed slowly, hypothetically due to multiple sites of action within plants, suggesting that resistance is determined by multiple genes as a quantitative trait;
3) Only four broadleaf weeds have confirmed as resistant to dicamba in the U.S., while relatively low numbers of weed species have confirmed resistance to synthetic auxin herbicides in general; and
4) Confirmed dicamba- and auxin-resistant weeds are found primarily in the West rather than in major soybean production regions, and weeds with known dicamba resistance are not major soybean weeds.

There are several serious flaws in these arguments, which were persuasively rebutted by Mortensen et al. (2012). First, Monsanto's two points regarding past history of auxin- and dicamba-resistant weed emergence have little bearing on the future course of resistance with introduction of MON 87708 under the proposed registration. As explained above, use of an herbicide in the context of an HR crop system very significantly elevates the risk of resistant weed emergence relative to non-HR crop uses of the same herbicide. Monsanto officers cannot fail to understand this, given the history of glyphosate-resistant weeds with their RR crops, but apparently prefer to ignore the lesson.

However, even to the limited extent that past resistance is relevant, Monsanto is in error. The ISHRW website lists 50 biotypes[16] of 30 different weed species with resistance to synthetic auxin herbicides internationally (ISHRW SynAux Weeds 9/20/12). Of the 21 herbicide modes of action to which weeds have evolved resistance, synthetic auxin-resistant weeds rank fourth in terms of number of resistant species, in the top quintile (ISHRW HR Weed Ranking 9/20/12). Contrary to Monsanto, this is a quite high number of resistant species relative to other modes of action. While this is in no way determinative of which weed species will evolve resistance in the future, it does indicate that the genetic

[16] We use the term "biotype" to refer to a single listing on the ISHRW website. For instance, four biotypes of the single species kochia have evolved auxin resistance in four different states.

predisposition to survive auxin treatment is quite prevalent in the plant world. Moreover, five new auxin-resistant biotypes and 1 new species have been recorded by ISHRW over just the past five months,[17] indicative of continuing and perhaps accelerated emergence of auxin-resistant weeds.

Nine biotypes of five different weed species have confirmed resistance to dicamba: lambsquarters (1), common hempnettle (1), kochia (4), prickly lettuce (1) and wild mustard (2) (see ISHRW SynAux Weeds Table 9/20/12 for following discussion). One other biotype highly resistant to 2,4-D also exhibits reduced sensitivity to dicamba (common waterhemp in Nebraska, discussed further below). Interestingly, four biotypes of four species have confirmed resistance to dicamba and other auxin herbicides, while one other population has multiple resistance to dicamba and several ALS inhibitors. The cross-resistance of dicamba-resistant weeds to other auxin herbicides is troubling, because it removes alternative weed control options, and could undermine the utility of both auxin-resistant soybean varieties. Many auxin-resistant weeds have not been tested for dicamba resistance, so there could be considerably more weed species and biotypes that are immune to the herbicide.

The argument that auxin-resistant weeds have developed slowly due to multiple sites of action in the plant is also specious. In most cases, scientists have not elucidated the precise mechanisms by which weeds evolve resistance, making predictions about the likelihood of weed resistance on this basis extremely hazardous. This is particularly true of auxin resistance, the precise mechanisms of which have yet to be elucidated. Monsanto scientists likewise predicted very little chance of glyphosate-resistant weed evolution in the 1990s (Bradshaw et al. 1997), and for much the same reasons: dearth of resistance from past use of glyphosate, and the molecular nuances of glyphosate's mode of action.[18] These predictions were of course disastrously wrong, but they did help quell concerns about GR weed evolution and forestall efforts to establish mandatory weed resistance management programs as Monsanto was introducing its Roundup Ready crops. Interestingly, only one GR weed had been identified by the time the first RR crop was introduced in 1996 (ISHRW GR Weeds 4/22/12), in contrast to the 30 weed species with biotypes resistant to auxins today.

The experience with glyphosate-resistant weeds demonstrates that neither a narrow focus on the biochemical nuances of resistance mechanisms, nor the frequency of resistance evolution in the past, provide an accurate basis for forecasting what will happen when the herbicide in question is used in the context of an herbicide-resistant crop system. What it does demonstrate is that the characteristic ways in which HR crop systems are used in the field, as discussed above, make them far more likely to trigger evolution of resistant weeds than non-HR crop uses of those same herbicides.

[17] 45 biotypes and 29 species when CFS last recorded these data (compare ISHRW SynAux Weeds 4/22/12 to ISHRW SynAux Weeds 9/20/12).
[18] Interestingly, another reason put forward by Monsanto scientists Bradshaw and colleagues for the unlikelihood of GR weed evolution was Monsanto's past failures in multiple attempts to engineer glyphosate-resistant plants, the arrogant presumption being that Nature could certainly not accomplish what had proven so difficult for Monsanto's scientists.

Monsanto's third argument, that use of both dicamba and glyphosate on MON 87708 soybean stacked with glyphosate resistance will hinder evolution of weeds resistant to either one, also lacks merit. This argument ignores the obvious fact that the huge extent of existing GR weed populations – with many billions of individual weeds on 30 to 60 million infested acres – make it near certain that some among them will have the rare genetic mutations conferring resistance to dicamba ***as well***. Mortensen et al. (2012) provide the mathematical exposition (emphasis added):

> First, when an herbicide with a new mode of action is introduced into a region or cropping system in which weeds resistant to an older mode of action are already widespread and problematic, the probability of selecting for multiple target-site resistance is not the product of two independent, low-probability mutations. In fact, the value is closer to the simple probability of finding a resistance mutation to the new mode of action within a population already extensively resistant to the old mode of action. For instance, in Tennessee, an estimated 0.8–2 million ha of soybean crops are infested with glyphosate-resistant horseweed (C. canadensis) (Heap 2011). Assuming seedling densities of 100 per m^2 or 10^6 per ha (Dauer et al. 2007) and a mutation frequency for synthetic auxin resistance of 10^{-9}, ***this implies that next spring, there will be 800–2000 horseweed seedlings in the infested area that possess combined resistance to glyphosate and a synthetic auxin herbicide*** ((2×10^6 ha infested with glyphosate resistance) x (10^6 seedlings per ha) x (1 synthetic auxin–resistant seedling per 10^9 seedlings) = 2000 multiple-resistant seedlings). In this example, these seedlings would be located in the very fields where farmers would most likely want to plant the new stacked glyphosate- and synthetic auxin–resistant soybean varieties (the fields where glyphosate-resistant horseweed problems are already acute). Once glyphosate and synthetic auxin herbicides have been applied to these fields and have killed the large number of susceptible genotypes, these few resistant individuals would have a strong competitive advantage and would be able to spread and multiply rapidly in the presence of the herbicide combination.

The upshot is that dicamba-resistant crop systems like MON 87708 soybean will very likely foster rapid evolution of weeds resistant to dicamba and glyphosate. In those cases where the GR weed populations in dicamba-treated crop fields already have resistance to one or more additional modes of action, the result will be evolution of still more intractable weeds with multiple-herbicide resistance, including to dicamba and glyphosate.

Multiple herbicide-resistant crops and weeds

Mortensen et al. (2012) note that there are currently 108 biotypes of 38 weed species possessing simultaneous resistance to two more classes of herbicide, and that 44% of them have appeared since 2005. Since herbicide-resistant weeds began to emerge in a significant way around 1970 (triazine-resistant weeds),[19] this means that nearly half of multiple HR weed biotypes have emerged in just the past seven years of our 40-year history of significant weed resistance. This global trend is also occurring in the U.S., where acreage infested with multiple HR weeds has increased by 400% over just the three years from November 2007 to November 2010 (Freese 2010, p. 15). There are at least 12 biotypes of weeds resistant to glyphosate and one or more other herbicide families in the U.S. (11) and Canada (1) that are attributable to RR crop systems, all but one having emerged since 2005 (CFS GR Weed List 9/20/12).

The progressive acquisition of resistances to different herbicide classes has the insidious effect of accelerating evolution of resistance to those ever fewer herbicides that remain effective. This is well-expressed by Bernards et al. (2012) with reference to multiple-herbicide-resistant waterhemp, though it applies more generally:

> The accumulation of multiple-resistance genes within populations and even within individual plants is of particular concern. This resistance stacking limits chemical options for managing waterhemp and, where weed management depends primarily on chemical weed control, results in additional selection pressure for the evolution of resistance to the few herbicides that are still effective.

There is already evidence that the scenario of dicamba resistance evolving in weeds already resistant to one or more herbicide classes, as depicted by Mortensen et al. (2012), will occur with four especially problematic species of weeds: horseweed, Palmer amaranth, waterhemp and kochia. These are the four weed species deemed most likely to evolve problematic populations of dicamba-resistant weeds by weed scientists (Crespo 2011).

i. Horseweed

Horseweed, or marestail, is the most prevalent GR weed. First discovered in 2000 in Delaware, GR horseweed has emerged in just over a decade to infest up to 8.4 million acres in 20 states (CFS GR Weed List 9/20/12[20]), up from 3.3 million acres in 16 states in February 2009 (Benbrook 2009a, p. 35). It is particularly prevalent in Tennessee, Kansas and Illinois, with populations infesting up to 5 million, 2 million and 1 million acres, respectively. GR horseweed in Mississippi is also resistant to paraquat, the first time multiple resistance to these two herbicides has been documented, while in California a population of horseweed's Conyza relative, hairy fleabane, with dual resistance to glyphosate and paraquat was recently reported to infest up to 1 million acres. Ohio has glyphosate/ALS inhibitor-resistant[21] horseweed.

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[19] A few auxin-resistant biotypes emerged in the 1950s and 1960s.
[20] Consult this chart for data in the following discussion. It should also be noted that these acreage-infested estimates are highly conservative, in view of the underreporting in the ISHRW system, as discussed above.
[21] CFS suspects that GR weeds that are also resistant to ALS inhibitor herbicides are greatly underreported by ISHRW; this is certainly the case with waterhemp (see discussion below).

Weed scientists regard GR horseweed as a "worst-case scenario" in RR cropping systems because this weed is well adapted to no-tillage planting systems popular among GR crop growers. It also produces up to 200,000 seeds per plant, and its seeds can disperse extremely long distances in the wind (Owen 2008), which may partly explain the prevalence of GR horseweed.

GR horseweed can reduce cotton yields by 40 to 70% (Laws 2006), and is also problematic in soybeans. In 2003, Arkansas weed scientist Ken Smith estimated that Arkansas growers would have to spend as much as $9 million to combat glyphosate-resistant horseweed in 2004 (AP 2003). An uncontrolled outbreak of GR horseweed in Arkansas could reduce the income of cotton and soybean farmers by nearly $500 million, based on projected loss in yield of 50% in 900,000 acres of cotton and a 25% yield loss in the over three million acres of soybeans (James 2005). Tennessee is especially hard hit, with up to 5 million acres of both cotton and soybeans infested with GR horseweed.

Because GR horseweed is often controlled with tillage, it has led to abandonment of conservation tillage practices on substantial cotton acreage in Tennessee and Arkansas, with similar trends reported in Mississippi and Missouri (Laws 2006) and perhaps other states. This in turn increases soil erosion. An NRC committee reported that increased tillage and increased herbicide use are common responses to glyphosate-resistant weeds (NRC 2010). Evolution of multiple herbicide-resistance reduces options for chemical control and so increases the chances for still more soil-eroding tillage.

The many farmers with GR and multiple-HR horseweed would be prime candidates for MON 87708. Yet Purdue University weed scientists have flagged horseweed as a plant with the genetic "plasticity" to readily evolve resistance to multiple herbicides:

> Multiple-resistant and cross-resistant horseweed populations have evolved to various combinations of the previous herbicide modes of action in Israel, Michigan, and Ohio (Heap 2009), providing evidence for the plasticity of this weed. (Kruger et al. 2010a).[22]

These same scientists have already founded increased tolerance to dicamba and 2,4-D in several horseweed populations, demonstrating the high potential for horseweed to evolve additional resistance to dicamba in the context of heavy postemergence use enabled by the proposed registration:

> "Population 66 expressed almost twofold greater tolerance to 2,4-D ester and approximately three- to fourfold greater tolerance to diglycolamine salt of dicamba than populations 3 and 34 (Table 1). Population 43 was more

[22] As noted above, horseweed has also evolved dual resistance to glyphosate and paraquat in Mississippi; in California, a glyphosate/paraquat-resistant biotype of the closely related *Conyza* weed hairy fleabane was recently reported to infest up to 100,000 fields on as much as 1 million acres. See http://www.weedscience.org/Case/Case.asp?ResistID=5250.

> sensitive to growth regulators than population 66 but expressed slightly higher levels of tolerance to 2,4-D ester and diglycolamine salt of dicamba than populations 3 and 34 based on dry weight measurements." (Kruger et al 2010b)

It is significant that these two populations each exhibit increased tolerance to both dicamba and 2,4-D, indicating the potential for evolution of resistance to both herbicides if either one is used. In addition, the increased tolerance to dicamba of both populations was found only with the diglycolamine, but not the dimethylamine salt of dicamba, suggesting that the proposed registration might more readily lead to auxin-resistant horseweed than would other forms of dicamba.

Kruger et al also predict that auxin herbicides will be applied later to larger horseweed plants in the context of auxin-resistant crop systems (Kruger et al 2010a). In follow-up research, they found that larger plants are much more difficult to control with auxin herbicides:

> ***While it is realistic to expect growers to spray horseweed plants after they start to bolt,*** the results show that timely applications to [small] horseweed rosettes are the best approach for controlling these weeds with growth regulator herbicides [dicamba and 2,4-D]. ***Growers should be advised to control horseweed plants before they reach 30 cm in height because after that the plants became much more difficult to control***. (Kruger et al. 2010b, emphasis added)

As discussed above, increased survival of larger weeds means a greater likelihood of resistant individuals among them surviving to propagate resistance via cross-pollination or seed production. And as the authors acknowledge, it is "realistic" to expect late application of dicamba with MON 87708, because that is precisely how growers use these crop systems, as demonstrated with the history of RR crops.

This tendency to delay application to kill larger weeds will be greatly facilitated by the high-level dicamba resistance of MON 87708, since larger weeds require higher rates to control. The proposed label permits 2 post-emergence applications of up to 0.5 lb./acre each, up through the time when soybeans are in full bloom (R2). But much higher rates could be used without risk of crop injury. In fact, the developers of dicamba-resistant soybeans report resistance to dicamba at rates 5 to 10-fold higher than the maximum proposed single application rate (2.5 to 5 lbs./acre):

> "Most transgenic soybean events showed resistance to treatment with dicamba at 2.8 kg/ha and 5.6 kg/ ha under greenhouse conditions (fig. S9) and complete resistance to dicamba at 2.8 kg/ha (the highest level tested in field trials) (Fig. 3)" (Behrens et al 2007).

As discussed above in relation to RR crops, farmers delay application in order to avoid the trouble and expense of a second application, whether this is a wise tactic or not. Thus, advising growers to spray weeds when they are small will likely not be any more effective with MON 87708 than were similar recommendations made for glyphosate with Roundup Ready crops.

Cultivation of MON 87708 under the proposed registration is quite likely to promote rapid evolution of horseweed resistant to dicamba and perhaps 2,4-D as well, often in combination with glyphosate-resistance. As noted above, tillage is a frequent response to glyphosate-resistant horseweed, and will be a still more frequent response to dicamba/glyphosate-resistant horseweed, since dicamba will be eliminated as an alternative control option. This would lead to further reductions in conservation tillage and increased soil erosion.

ii. Waterhemp

Waterhemp is regarded as one of the worst weeds in the Corn Belt. It grows to a height of 2-3 meters, and emerges late into the growing season. Controlled trials in Illinois demonstrated that late-season waterhemp reduced corn yields in Illinois by 13-59%, while waterhemp emerging throughout the season cut yields by up to 74% (Steckel & Sprague 2004).

ISHRW lists 12 biotypes of GR waterhemp, all of which have emerged since 2005 in corn, soybeans, cotton and/or sugar beets, almost certainly all in RR crop systems (CFS GR Weed List 9/20/12). While ISHRW records up to 1.1 million acres infested with GR waterhemp, this is a vast underestimate. As noted above, Illinois weed scientist Bryan Young estimates a substantial 5-6 million acres infested with GR waterhemp in his state.

Waterhemp has an astounding ability to evolve resistance to herbicides. Biotypes resistant to one to four herbicide families have been identified in several Midwest and Southern states, from North Dakota to Tennessee (see CFS GR Weed List 9/20/12 for those resistant to glyphosate). Triple herbicide-resistant waterhemp infests up to one million acres in Missouri, while populations resistant to four herbicide classes, sardonically called "QuadStack Waterhemp" (Tranel 2010), have arisen in Illinois. Tranel's investigations suggest that the 5-6 million acres of GR waterhemp in Illinois noted above are all resistant to ALS inhibitors, with some additionally resistant to PPO inhibitors and/or triazines.

Tranel states that multiple herbicide-resistant waterhemp "appears to be on the threshold of becoming an unmanageable problem in soybean," and is quite concerned that if already multiple herbicide-resistant waterhemp evolves resistance to additional herbicides, "soybean production may not be practical in many Midwest fields" (Tranel et al 2010). Corn is often rotated with soybeans, and so could be similarly affected.

In early 2011, waterhemp was identified as the first weed with resistance to a relatively new class of herbicides, HPPD inhibitors, the fifth mode of action to which waterhemp has evolved resistance (Science Daily 2011), prompting weed scientist Aaron Hagar to comment that "we are running out of options" to control this weed. Populations of waterhemp in Iowa and Illinois are resistant to HPPD inhibitors and two other modes of action (ISHRW Waterhemp 2012).

Just months later, a waterhemp population highly resistant to 2,4-D and with significantly reduced sensitivity to dicamba was discovered (Bernards et al 2012), and it is potentially resistant to the popular corn herbicides atrazine and metolachlor as well, which would make it particularly difficult to manage (UNL 2011). The weed scientists who discovered this resistant weed population clearly understand the likelihood that auxin-resistant crops – "if used as the primary tool to manage weeds already resistant to other herbicides," the hallmark of these systems – will lead to still more intractable, multiple herbicide-resistant weeds:

> New technologies that confer resistance to 2,4-D and dicamba (both synthetic auxins) are being developed to provide additional herbicide options for postemergence weed control in soybean and cotton. The development of 2,4-D resistant waterhemp in this field is a reminder and a caution that these new technologies, if used as the primary tool to manage weeds already resistant to other herbicides such as glyphosate, atrazine or ALS-inhibitors, will eventually result in new herbicide resistant populations evolving. (UNL 2011)

In a peer-reviewed publication about this same waterhemp population, these scientists call for mandatory weed resistance prevention measures for MON 87708 soybean and other auxin-resistant crops:

> ***The commercialization of soybean, cotton and corn resistant to 2,4-D and dicamba should be accompanied by mandatory stewardship practices*** that will minimize the selection pressure imposed on other waterhemp populations to evolve resistance to the synthetic auxin herbicides. (Bernards et al. 2012, emphasis added)

A close reading of this paper helps explain their concerns. First, the 2,4-D-resistant waterhemp population is resistant to extremely high rates of 2,4-D, with some plants surviving application of 35,840 grams/hectare of 2,4-D, equivalent to 32 lbs/acre, or 32 times the maximum single 2,4-D application rate in the proposed label for 2,4-D use on MON 87708 soybean. Second, this population also has significantly reduced sensitivity to dicamba. This is important because it suggests that waterhemp has the capacity to evolve simultaneous resistance to both 2,4-D and dicamba, even without application of dicamba (no dicamba use was reported on the field where this weed evolved 2,4-D resistance); and because the elimination of 2,4-D as an effective control option is compounded by the elimination or at least erosion of the efficacy of a second important control tool, dicamba. Third, as noted above, waterhemp is one of the most damaging weeds in the Corn Belt, and multiple herbicide-resistance makes it still more damaging and expensive to control.

It is interesting to note that the field where this waterhemp evolved resistance to 2,4-D and tolerance to dicamba had also been regularly treated with atrazine and metolachlor: "Since

1996, atrazine, metolachlor, and 2,4-D were applied annually to control annual grasses and broadleaf weeds" (Bernards et al. 2012). This suggests the possibility of resistance to atrazine and/or metolachlor as well: "Research is underway at UNL to determine whether this waterhemp population has developed resistance to additional herbicide mechanisms-of-action" (UNL 2011).

Use of multiple herbicides is supposed to forestall evolution of resistance to any single herbicide. At least in the case of this waterhemp population, this strategy apparently did not work. Atrazine-resistant waterhemp has been reported in Nebraska and other states, and is particularly prevalent in Kansas, with up to 1 million infested acres reported.[23] Thus, it is possible that this population had previously evolved resistance to atrazine, demonstrating the potential for "resistance-stacking." However, there is only one report of a confirmed metolachlor-resistant weed population in the entire world, rigid ryegrass in Australia, and just seven reports of resistance to the chloracetamide class of herbicides to which it belongs.[24] Monsanto's recommendation that farmers use a soil residual herbicide in addition to dicamba and glyphosate with MON 87708 will most likely not be followed, as explained above. However, this waterhemp population suggests that the herbicidal onslaught approach may not always be successful even if utilized. In addition, Bernards and colleagues' call for mandatory stewardship practices suggests that HR crops, as explained above, are particularly prone to foster rapid evolution of weed resistance.

iii. Palmer amaranth

Perhaps the most destructive and feared weed in all of U.S. agriculture is glyphosate-resistant Palmer amaranth (see Benbrook 2009a, Chapter 4). Second only to GR horseweed in prevalence, GR Palmer amaranth is estimated to infest 112,000 to over 220,000 fields covering up to 7.0 million acres in 12 states, all but one in corn, cotton and/or soybeans (CFS GR Weed List 9/20/12). Best known for plaguing cotton and soybean growers in Southern states, this weed is rapidly emerging in Corn Belt states like Illinois and Missouri; populations have recently been reported in Michigan (ISHRW GR Weed List 4/22/12) and Ohio (Ohio Farmer 2012). In California, a population of GR Palmer amaranth has just been reported infesting three predominantly Roundup Ready crops (alfalfa, corn, cotton) as well as orchards, vineyards, roadways and fencelines.[25] Palmer amaranth is feared especially because of its extremely rapid growth – several inches per day – which means it can literally outgrow a busy farmer's best attempts to control it while still small enough to be killed. It also produces a huge number of seeds, so just one mature weed can ensure continuing problems in future years by pouring hundreds of thousands of resistant weed seeds into the "weed seed bank." Left unchecked, its stem can become baseball bat breadth, and is tough enough to damage cotton pickers. Glyphosate-resistant Palmer amaranth can dramatically cut yields by a third or more, and occasionally causes

[23] See entries for "photosystem II inhibitors," the class of herbicides to which atrazine belongs, at http://www.weedscience.org/Summary/USpeciesCountry.asp?lstWeedID=219&FmCommonName=Go.
[24] http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=18&FmHRACGroup=Go
[25] http://www.weedscience.org/Case/Case.asp?ResistID=5690.

abandonment of cropland too weedy to salvage. In Georgia, Arkansas and other states, farmers have resorted to hiring weeding crews to manually hoe this weed on hundreds of thousands of acres, tripling weed control costs (Haire 2010). Herbicide regimes of six to eight different chemicals, including toxic organic arsenical herbicides such as MSMA otherwise being phased out (EPA 2009, p. 3), are recommended to control it (Culpepper and Kichler 2009).

At least three states (Mississippi, Georgia and Tennessee) have Palmer amaranth resistant to both glyphosate and ALS inhibitors; the most recent one, reported in 2011, infests over 100,000 sites covering up to 2 million acres in Tennessee (CFS GR Weed List 9/20/12). Palmer amaranth belongs to the same genus as common waterhemp (*Amaranthus*), and to some extent can interbreed with it. Both have considerable genetic diversity. The demonstrated ability of waterhemp to evolve resistance to auxin herbicides suggests that a similar potential likely exists in Palmer amaranth. Growers with GR and multiple HR Palmer amaranth would be prime candidates to adopt MON 87708, and utilize them under the proposed registration. Palmer amaranth must be judged a high-risk weed for evolution of resistance to dicamba and other auxin herbicides, which would undermine the efficacy of existing, pre-emergence use of dicamba in battling this serious weed threat.

iv. Kochia

Kochia is a fourth serious weed, described further at CFS (2010). It has evolved widespread resistance to many different herbicides, and is on the ISHRW's list of the top ten most important herbicide-resistant weed species (ISHRW Worst HR Weeds). Limited populations of glyphosate-resistant kochia first emerged in Kansas in 2007, but recent reports suggest that it is now likely prevalent in the entire western third of Kansas, as well as parts of Colorado (Stahlman et al. 2011). A second population identified in Nebraska (2009) was first listed on ISHRW in December of 2011; a third in South Dakota (2011) infests up to 10,000 acres and was first listed in May of 2012; while a fourth infesting up to 1,000 acres in North Dakota was first listed in August of 2012. Kochia resistant to both glyphosate and ALS inhibitors was recently identified in Alberta, Canada (2012).[26] All of the US populations emerged in corn, soybeans and/or cotton (almost certainly RR versions), while the Canadian population emerged in cereals and "cropland" that may also include RR crops.

Stahlman et al. (2011) state that the original four populations in Kansas likely evolved glyphosate-resistance independently, but the rapid emergence across such a broad swath of the state suggests the potential for spread of the original populations, perhaps by resistant seed dispersal, as kochia "tumbleweed" can disperse seeds at considerable distances (see CFS 2010). CFS (2010) also documents that kochia is a serious weed of both alfalfa and sugarbeets, Roundup Ready versions of which have been recently introduced and are widely grown. GR kochia infesting these RR crops would seriously impair the efficacy of the RR trait; likewise, selection pressure from glyphosate use with these crop

[26] See entries under Kochia at http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=12&FmHRACGroup=Go.

systems (especially in rotation with other RR crops, as seen particularly with RR sugar beets, which are frequently rotated with RR corn and/or RR soybeans) could rapidly lead to still more extensive emergence of GR kochia.

Four biotypes of kochia have also evolved resistance to dicamba in Montana, Idaho, North Dakota, and most recently Nebraska. The Nebraska population first emerged in corn in 2010, and Nebraska is a major soybean producing state. Nearly half of all confirmed dicamba-resistant weed populations in the world are kochia biotypes, which may suggest a genetic proclivity in this species to evolve resistance to this herbicide. The extremely rapid emergence of GR biotypes in RR crop systems may induce growers to adopt MON 87708 to control it; and kochia's demonstrated propensity to evolve resistance to dicamba make it a prime candidate to evolve multiple resistance to dicamba, glyphosate and other herbicides.

Stewardship

It is highly doubtful whether Monsanto's stewardship plan for MON 87708 soybean will be effective in forestalling weed resistance to 2,4-D. For at least 15 years, companies and weed scientists have touted voluntary stewardship guidelines and best management practices as the chief bulwark against evolution of resistant weeds in the context of HR crop systems. These programs and exhortations have demonstrably failed with Roundup Ready crops, or there would not be an epidemic of glyphosate-resistant weeds. A critical assessment of Monsanto's failed stewardship messages, practices and actions with Roundup Ready crops is essential to inform its current plans with respect to the use of MON 87708 under the proposed registration.

Monsanto insisted that weeds would not evolve glyphosate resistance to any serious extent when RR crops were first being introduced, based mostly on assumptions concerning the presumed rarity of glyphosate-resistance mutations, the lack of glyphosate-resistant weed evolution up to that time, and nuances of the herbicide's mode of action (Bradshaw et al. 1997). Many weed scientists were not convinced, and called for serious measures to forestall evolution of GR weeds (Freese 2010, question 1). Monsanto introduced its RR crops as "RR crop systems" designed for sole reliance on glyphosate for weed control. Even several years after GR weeds first emerged in RR soybeans and then cotton, Monsanto promoted "glyphosate-only" weed control programs in farm press advertisements dating to 2003 and 2004, ads that leading weed scientists castigated as irresponsible for promoting weed resistance (Hartzler et al. 2004). Interestingly, this ad campaign was designed to encourage farmers to adopt Roundup Ready corn, in which farmers had shown little interest up to that time, in contrast to Roundup Ready soybeans and cotton, which had been readily adopted. The effect of Monsanto's glyphosate-only, RR corn ad campaign was to promote glyphosate-only weed control programs in RR corn/RR soybean rotations. (Up to that time, most corn/soybean farmers had rotated RR soybeans with conventional corn, utilizing primarily non-glyphosate herbicides with the latter.) The subsequent rapid rise of RR corn in combination with existing RR soybeans led directly to emergence of GR weeds in Midwest and Northern Plains states beginning in 2005. Thus, Monsanto not only failed to promote proper stewardship practices to forestall GR weed emergence; it actively promoted practices that led directly to the expanding GR weed epidemic in corn/soybean country.

As discussed above, dicamba use on non-dicamba-resistant corn will likely increase considerably with significant adoption of MON 87708 under the proposed registration. This will result in more acres treated every year with dicamba in popular corn/soybean rotations. Monsanto's planned introduction of dicamba-resistant corn in a few years would greatly exacerbate matters, since the elimination of corn injury concerns will make dicamba-resistant corn a more attractive option for farmers.

Monsanto's recommendation to use a soil residual herbicide in addition to dicamba and glyphosate with MON 87708 will not be followed by the majority of growers, and as discussed above in relation to waterhemp is of questionable value for those who do. If Monsanto were a responsible steward of dicamba-resistant technology, the company would strongly advise growers of MON 87708 to abstain from dicamba use when rotating to corn (or small grains crops like wheat); and it would not have developed dicamba-resistant corn at all, which if introduced will almost surely lead to tens of millions of acres treated with dicamba each year in rotations of dicamba-resistant corn and soybeans, and thus to massive evolution of dicamba-resistant weeds.

Dow's introduction of competing 2,4-D resistant crops may not offer much help in terms of diversifying selection pressure, due to clear emerging evidence that resistance to either auxin herbicide may often confer resistance or at least increased tolerance to the other. Two weed populations have confirmed resistance to both dicamba and 2,4-D (prickly lettuce in Washington, and wild mustard in Canada, see ISHRW SynAux Weeds Table 9/20/12). The recently discovered 2,4-D-resistant waterhemp in Nebraska has significantly decreased sensitivity to dicamba as well. And preliminary research strongly suggests that horseweed populations with increased tolerance to 2,4-D also have increased tolerance to dicamba. Finally, it is interesting to note that MON 87708 itself possesses increased tolerance to three tested phenoxy herbicides – 2,4-D, MCPA and 2,4-DB (Monsanto 2010 at 76-77). While the precise mechanisms of auxin resistance in weeds have not been fully elucidated, the evidence presented above suggests strongly that cross-resistance among auxin herbicides is a frequent occurrence.

This suggests the need to consider the cumulative impacts of all auxin-resistant crops together for purposes of assessing their potential for fostering auxin-resistant weeds. This is surely the reasoning that prompted Bernards et al. (2012) to call for "mandatory stewardship practices" for "soybean, cotton and corn resistant to 2,4-D and dicamba." Furthermore, the demand for "mandatory" practices is an implicit acknowledgement of the failure of voluntary programs such as Monsanto's.

Spread of weed resistance and tragedy of the commons

Weeds evolve resistance through strong selection pressure from frequent and late application as well as overreliance on particular herbicides, as fostered especially by HR crop systems. However, once resistant populations of out-crossing weeds emerge, even small ones, they can propagate resistance via cross-pollinating their susceptible counterparts (Webster & Sosnoskie 2010). It is estimated that common waterhemp pollen can travel for one-half mile in windy conditions, and so spread resistance to neighbors' fields via cross-pollination (Nordby et al. 2007). A recent study was undertaken to measure waterhemp pollen flow because "[p]ollen dispersal in annual weed species may pose a considerable threat to weed management, especially for out-crossing species, because it efficiently spreads herbicide resistance genes long distances," because the "severe infestations and frequent incidence [of waterhemp] arise from its rapid evolution of resistance to many herbicides," and because "there is high potential that resistance genes can be transferred among populations [of waterhemp] at a landscape scale through pollen migration" (Liu et al. (2012). The study found that ALS inhibitor-resistant waterhemp pollen could travel 800 meters (the greatest distance tested) to successfully pollinate susceptible waterhemp; and that waterhemp pollen can remain viable for up to 120 hours, increasing the potential for spread of resistance traits.

A second recent study made similar findings with respect to pollen flow from glyphosate-resistant to glyphosate-susceptible Palmer amaranth (Sosnoskie et al. 2012). In this study, susceptible sentinel plants were planted at distances up to 250-300 meters from GR Palmer amaranth. From 20-40% of the progeny of the sentinel plants at the furthest distances proved resistant to glyphosate, demonstrating that glyphosate resistance can be spread considerable distances by pollen flow in Palmer amaranth.

Whether out-crossing or inbreeding, those resistant individuals with lightweight seeds can disperse at great distances. Dauer et al. (2009) found that the lightweight, airborne seeds of horseweed, the most prevalent GR weed (CFS GR Weed List 2012), can travel for tens to hundreds of kilometers in the wind, which is likely an important factor in its prevalence. Hybridization among related weeds is another potential means by which resistance could be spread, for instance by weeds in the problematic *Amaranthus* genus (Gaines et al. 2012). Movement of resistant seed via waterways when excessive rainfall leads to flooding has been suggested as one explanation for the epidemic spread of glyphosate-resistant and multiple herbicide-resistant waterhemp[27] in the sugarbeet production region of Minnesota and North Dakota (Stachler et al 2012).

Thus, even farmers who employ sound practices to prevent emergence of herbicide-resistant weeds themselves can have their fields infested with resistant weeds from those of other farmers. With reference to GR weeds, Webster & Sosnoskie (2010) present this as a tragedy of the commons dilemma, in which weed susceptibility to glyphosate is the common resource being squandered. Since responsible practices by individual farmers to prevent evolution of weed resistance in their fields cannot prevent weed resistance from spreading to their fields as indicated above, there is less incentive for any farmer to even try to undertake such prevention measures.

[27] For the recent confirmation of multiple HR waterhemp, see http://www.ag.ndsu.edu/homemoisture/cpr/weeds/herbicide-resistance-in-waterhemp-in-mn-and-nd-and-management-in-sugarbeet-corn-and-soybean-5-24-12.

The weed science community as a whole has only begun to grapple with the implications of the ***spread*** of resistance, particularly as it relates to the efficacy of weed resistance management recommendations based solely on individual farmers reducing selection pressure. It may not be effective or rational for farmers to commit resources to resistance management in the absence some assurance that other farmers in their area will do likewise. This suggests the need for a wholly different approach that is capable of ensuring a high degree of area-wide adoption of sound weed resistance management practices. This represents still another reason to implement mandatory stewardship practices to forestall emergence of dicamba -resistant weeds in the context of MON 87708 soybean and similar auxin-resistant crops.

Volunteer MON 87708 soybean

Volunteer soybeans are not normally considered problematic weeds, but with the advent of RR soybeans there are some reports that glyphosate-resistance makes them more difficult to control. For instance, York et al. (2005) report that volunteer glyphosate-resistant soybean can be a problematic weed in glyphosate-resistant cotton planted the next season. They note in general that: "Volunteer crop plants are considered to be weeds because they can reduce crop yield and quality and reduce harvesting efficiency." York and colleagues tested several herbicidal options to control GR soybean volunteers, including pyrithiobac, trifloxysulfuron, and each herbicide mixed with MSMA, an arsenic-based herbicide that EPA is in the process of phasing out due to its toxicity, though an exemption has been made for continued use in cotton to control GR Palmer amaranth (EPA 2009). They also note that paraquat can be used to control GR soybean volunteers prior to emergence of cotton. Some farmers have also reported problematic volunteer RR soybean in the following year's corn, and sought advice from extension agents on how to deal with it (Gunsolus 2010). Recommendations include use of 2,4-D, dicamba, atrazine and/or other herbicides. In both cases, it is glyphosate-resistance that has made volunteer soybean a control problem for farmers, and necessitated the use of more toxic herbicides for control.

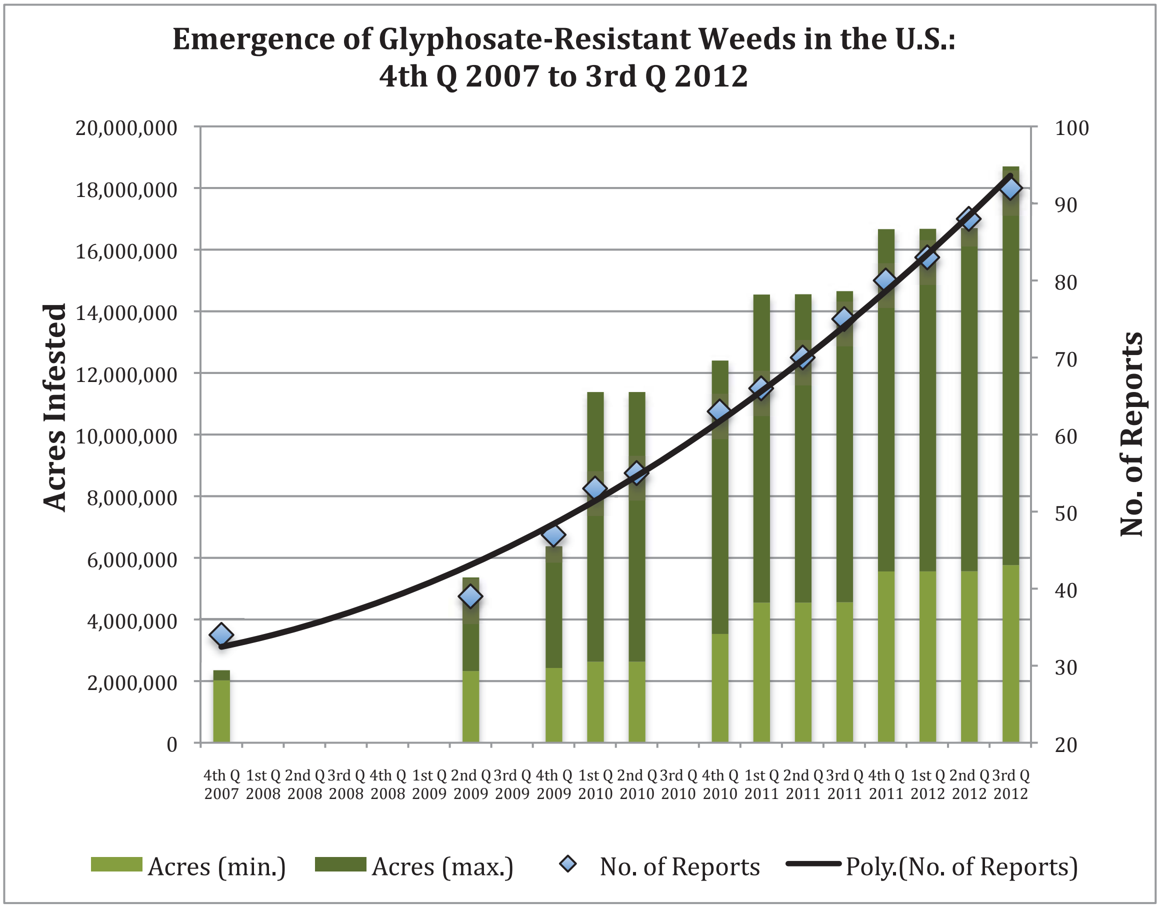
MON 87708 soybean volunteers (stacked with Roundup Ready) would possess resistance to dicamba as well glyphosate, eliminating dicamba and glyphosate and reducing the efficacy of 2,4-D as herbicidal control options. These volunteer soybeans weeds would thus be still more of a management challenge than RR soybean volunteers, and lead to use of more toxic herbicides (e.g. MSMA, paraquat, atrazine) or tillage to control.

Soybean is primarily a self-pollinating crop, but the potential for perhaps considerable cross-pollination is suggested by the frequency with which pollinators – bees (honeybees and wild bees), wasps and flies – visit soybean fields (Anonymous 2012, O'Neal & Gill 2012). Insect pollinators are known to effect pollination at considerable distances from the source plants, including from primarily self-pollinating crops (e.g. Pasquet et al. 2008).

In addition to MON 87708, three other HR soybean events are presently pending deregulation by USDA: Dow's 2,4-D- and glufosinate-resistant soy, BASF's isoxaflutole-resistant soy, and Bayer's imidazolinone-resistant variety.[28] While multiple HR soybean volunteers via cross-pollination would likely be an infrequent occurrence, it could trigger serious weed management challenges where it does occur.

As a general matter, such "resistance stacking" speeds evolution to those herbicides that remain effective. It limits chemical options for managing weeds, and "where weed management depends primarily on chemical weed control, results in additional selection pressure for the evolution of resistance to the few herbicides that are still effective" (Bernards et al. 2012). While this statement was made with reference to HR waterhemp, it applies more generally to multiple HR weeds, including HR soybean volunteers.

[28] See entries at http://www.aphis.usda.gov/biotechnology/not_reg.html, last visited 8/22/12.



Legend: This chart plots data on glyphosate-resistant weeds in the U.S. compiled from the International Survey of Herbicide-Resistant Weeds (ISHRW) as of September 20, 2012. See CFS GR Weed List (2012) for the data upon which this chart is based. The ISHRW lists reports of confirmed herbicide-resistant weeds submitted by weed scientists.[29] Each report normally contains the year of discovery, the number of sites and acreage infested by the resistant weed population, the crop or non-crop setting where the weed was found, whether or not the population is expanding, and date the report was last updated. Note that months to several years can elapse before a putative resistant weed population is confirmed as resistant and listed on the website. ISHRW reports sites and acreage infested in ranges due to the difficulty of making precise point estimates. CFS aggregated ISHRW data for all glyphosate-resistant weed reports on 13 dates – 11/21/07, 2/2/09, 11/19/09, 2/25/10, 5/18/10, 11/30/10, 1/6/11, 7/5/11, 9/28/11, 12/31/11, 3/28/12, 7/2/12 and 9/20/12 – corresponding to the 13 bars in the graph above. The bars were assigned to the appropriate quarterly period on the x-axis. The minimum and maximum acreage values represent the aggregate lower- and upper-bound acreage infested by all glyphosate-resistant weeds listed by ISHRW on the given date. The number of reports is plotted on the secondary y-axis. The figures shown here are very conservative, because ISHRW is a voluntary reporting system and many GR weed populations are never reported, or if reported are often not updated to account for expansion. ISHRW organizer Dr. Ian Heap concedes that these figures are "way too low," and in August 2012 estimated that 40 million acres were infested with a GR weed (30 million if overlapping acres infested with more than one GR weed are counted just once) (see Heap 2012). As noted in the text, Dow estimates 60 million GR weed-infested acres. This suggests that GR weed prevalence is roughly

[29] Each report may be accessed by (and corresponds to) a link at: http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=12&FmHRACGroup=Go.

twice to three times the upper-bound estimates shown here. Even so, this graph provides a sense of the rapid course of GR weed emergence in the U.S.

Exhibit F

Center for Food Safety Comments
Docket No. EPA-HQ-2016-0187
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amaranth. From 20-40% of the progeny of the sentinel plants at the furthest distances proved resistant to glyphosate, demonstrating that glyphosate resistance can be spread considerable distances by pollen flow in Palmer amaranth.

Whether out-crossing or inbreeding, those resistant individuals with lightweight seeds can disperse at great distances. Dauer et al. (2009) found that the lightweight, airborne seeds of horseweed, the most prevalent GR weed (CFS GR Weed List 2012), can travel for tens to hundreds of kilometers in the wind, which is likely an important factor in its prevalence. Hybridization among related weeds is another potential means by which resistance could be spread, for instance by weeds in the problematic *Amaranthus* genus (Gaines et al. 2012). Movement of resistant seed via waterways when excessive rainfall leads to flooding has been suggested as one explanation for the epidemic spread of glyphosate-resistant and multiple herbicide-resistant waterhemp[13] in the sugarbeet production region of Minnesota and North Dakota (Stachler et al 2012).

Thus, even farmers who employ sound practices to prevent emergence of herbicide-resistant weeds themselves can have their fields infested with resistant weeds from those of other farmers. With reference to GR weeds, Webster & Sosnoskie (2010) present this as a tragedy of the commons dilemma, in which weed susceptibility to glyphosate is the common resource being squandered. Since responsible practices by individual farmers to prevent evolution of weed resistance in their fields cannot prevent weed resistance from spreading to their fields as indicated above, there is less incentive for any farmer to even try to undertake such prevention measures.

The weed science community as a whole has only begun to grapple with the implications of the ***spread*** of resistance, particularly as it relates to the efficacy of weed resistance management recommendations based solely on individual farmers reducing selection pressure. It may not be effective or rational for farmers to commit resources to resistance management in the absence some assurance that other farmers in their area will do likewise. This suggests the need for a wholly different approach that is capable of ensuring a high degree of area-wide adoption of sound weed resistance management practices. This represents still another reason to implement mandatory stewardship practices to forestall emergence of dicamba -resistant weeds in the context of MON 87708 soybean and similar auxin-resistant crops.

Stewardship

APHIS presumes that EPA will put in place a weed resistance management program for dicamba use on dicamba-resistant crops that is similar to the one the Agency has proposed (but not finalized) for application of Enlist Duo (a mix of 2,4-D and glyphosate) to Dow's 2,4-D-resistant (Enlist) crops (DEIS, pp. 140, 174-75, 180). An EPA official was recently quoted as saying that the proposed Enlist Duo program would serve as the model for future

[13] For the recent confirmation of multiple HR waterhemp, see http://www.ag.ndsu.edu/homemoisture/cpr/weeds/herbicide-resistance-in-waterhemp-in-mn-and-nd-and-management-in-sugarbeet-corn-and-soybean-5-24-12.

herbicide-resistant crop systems (Hopkinson 2014). In the discussion below, we refer to "auxin-resistant crops" and "auxins" to encompass both Enlist and Xtend crop systems.

The major flaw in EPA's Enlist Duo plan, which would apply equally to dicamba resistant crop systems, is that the Agency has entirely failed to mandate any effective measures to ***prevent*** evolution of auxin resistance in weeds, but rather proposed only ***monitoring*** to detect them after they have already emerged. An approach based solely on monitoring is doomed to failure, because the emergence of a resistant weed population is a slow, incremental process. In most cases it will begin with a ***single plant*** with the rare mutation that confers resistance to the herbicide, which then over the course of years of exposure to the herbicide gradually multiplies until it becomes an at all noticeable ***population*** of resistant weeds. Busy farmers may well fail to notice a few weeds that survive treatment with an herbicide; or if noticed, assume that they are simple "escapes" that were missed during a spraying operation. Crespo (2011) notes that resistance often escapes detection until at least 25% of the individual weeds in a particular population carry the resistance mutation. By that time, it may well be too late to effectively control the resistant weeds, especially in the case of outcrossing weeds able to disperse the resistance trait long distances via cross-pollination, or weeds with the ability (like horseweed) to disperse their resistant seeds even greater distances to infest neighboring or distant fields.

It is also perverse that the EPA would propose such an ineffectual monitoring plan in light of the Agency's long experience with managing insect resistance to the Bt toxins in GE, insect-resistant corn and cotton, so-called Bt crops. EPA has had great success in ***preventing*** resistance to the first generation of Bt crops, which carry toxins that kill above-ground pests like the European corn borer and cotton bollworms. But this success was only realized because EPA established strict "refuge" requirements under which growers had to plant (in most cases) 20% of their field to a non-Bt variety to prevent resistant pests from evolving in the first place. This "spatial refuge" approach is appropriate for mobile insects, while for sessile weeds a "temporal refuge" would accomplish the same purpose. This would involve imposing restrictions on the frequency with which an auxin herbicide could be applied to a particular field during a single season and over years. This is precisely the approach that many weed scientists have proposed. Frustrated by the rapid increase in glyphosate- and multiple-resistant weed populations, six weed scientists recently stated that: "The time has come to consider herbicide-frequency reduction targets in our major field crops" (Harker et al. 2012). Shaner and Beckie (2014) likewise recognize the need for "reasonable [herbicide-]frequency use intervals" to forestall evolution of weed resistance.

That EPA would propose only monitoring is also disappointing in light of the Agency's failure to prevent insect resistance from evolving to the second-generation of Bt corn, which targets the soilborne pest, corn rootworm. This failure is directly attributable to a dramatic weakening of refuge requirements – the resistance prevention component – in favor of a monitoring-based approach that is quite similar to the Enlist Duo plan (CFS Corn Rootworm 2013).

Even to the limited extent that monitoring for resistance after it has emerged would be useful, the proposed plan is undermined by EPA's delegation of virtually all responsibilities to Dow. Dow is put in charge of developing diagnostic tests used to evaluate potential resistance; investigating farmer reports of potential resistant weeds; collecting material for testing; eradicating weeds that Dow judges to be "likely resistant" based on its diagnostic tests; and informing growers and other stakeholders of likely and confirmed resistance. Dow is also required to report periodically to EPA on any findings of resistant weeds.

While this might look good on paper, delegation of these responsibilities to Dow represents a clear conflict of interest. Dow's financial interests militate directly against any finding of resistance, for several reasons. First, 2,4-D resistant weeds would represent a failure of the Enlist system, which Dow is naturally motivated to sell to growers; sales would not be promoted, but could well suffer, if Dow were to determine that weeds are resistant to 2,4-D. This is all the more true since Dow is obligated to publicize local or widespread failure of the Enlist system to growers and other stakeholders. Second, a finding of resistance could lead to EPA modification or cancellation of Enlist Duo registration. While EPA would be extremely unlikely to undertake such an action, the possibility would further incentivize Dow to avoid finding resistant weeds in the first place, to avoid loss of Enlist Duo herbicide and/or Enlist crop seed sales.

The Dow-led implementation of the monitoring program would open up many possibilities for avoiding a 2,4-D resistance determination. For instance, Dow-developed diagnostic tests could be made intentionally insensitive; Dow could drag its feet in responding to grower reports of non-compliance; reports to EPA could be incomplete or doctored; to name just a few of the possibilities. These are not idle speculations. EPA has already had experience of such machinations in the context of insect resistance management (IRM) for the Bt corn targeting corn rootworm, discussed above. Here too, EPA delegates all responsibilities for IRM to the crop developer, which happens to be Monsanto. Rootworm resistance to Monsanto's Bt corn has emerged rapidly from at least 2008, but Monsanto – in charge of investigating grower complaints of potential resistance – delayed investigations, submitted incomplete reports to EPA, and set an inappropriately "high bar" for what exactly constituted "resistance." Bt-resistant rootworm were only confirmed in 2011, at least three years after their emergence, by public sector entomologists, not Monsanto. Monsanto then first denied the resistance finding, then when it became undeniable, downplayed its significance (Philpott 2011, Gustin 2011).

There is no reason to think that Monsanto would do a better job of stewarding its dicamba-resistant crops to prevent dicamba-resistant weeds if EPA establishes a weed resistance monitoring program similar to that proposed for the Enlist system.

Neither does Monsanto's past conduct with its Roundup Ready crops give any reason for confidence. Monsanto insisted that weeds would not evolve glyphosate resistance to any serious extent when RR crops were first being introduced, based mostly on assumptions concerning the presumed rarity of glyphosate-resistance mutations, the lack of glyphosate-resistant weed evolution up to that time, and nuances of the herbicide's mode of action (Bradshaw et al. 1997). (Interestingly, Monsanto is now presenting quite similar and equally species arguments regarding the supposedly low risk of dicamba-resistant weeds with Xtend crops – specious because they leave out the all-important factor of selection pressure (Monsanto Weed 2014, p. 12)). Many weed scientists were not convinced, and called for serious measures to forestall evolution of GR weeds, which were never implemented (Freese 2010, question 1). Even several years after GR weeds first emerged in RR soybeans and then RR cotton, Monsanto promoted "glyphosate-only" weed control programs in farm press advertisements dating to 2003 and 2004, ads that leading weed scientists castigated as irresponsible for promoting weed resistance (Hartzler et al. 2004). Interestingly, this ad campaign was designed to encourage farmers to adopt Roundup Ready corn, in which they had shown little interest up to that time, in contrast to Roundup Ready soybeans and cotton, which had been readily adopted. The effect of Monsanto's ad campaign was to promote glyphosate-only weed control programs in RR corn/RR soybean rotations. Until then, most corn/soybean farmers had rotated RR soybeans with conventional corn, utilizing primarily non-glyphosate herbicides with the latter, which effectively prevented GR weeds from evolving. The subsequent rapid rise of RR corn in combination with existing RR soybeans led directly to emergence of GR weeds in Midwest and Northern Plains states beginning in earnest in 2005 (ISHRW GR Weeds 10-8-14). Thus, Monsanto not only failed to promote proper stewardship practices to forestall GR weed emergence; it actively promoted practices that led directly to the expanding GR weed epidemic in corn/soybean country. We can expect no better from the company today with respect to stewardship of dicamba-resistant crops.

It is interesting to note that just as Monsanto was encouraging farmers to rely completely on glyphosate every year in "all Roundup Ready" crop rotations – the perfect recipe for GR weed emergence – it also acquired the rights to the dicamba resistance trait from the University of Nebraska, where it was developed (Miller 2005). This report coyly noted that dicamba-resistant crops would be useful for farmers with "hard to control" weeds. Of course, no farmer would have any interest in dicamba-resistant crops if the Roundup Ready crop system were still effective – that is, if hard to control glyphosate-resistant weeds were not prevalent. Finally, it is perhaps relevant to note that Monsanto's original patent on the Roundup Ready trait in RR soybeans expires this year, in 2014, and that it will no longer collect royalties on the sale of seed that bears it (Pollack 2009).

Just to be clear, CFS is not suggesting that Monsanto set out in some nefarious way to intentionally foster glyphosate-resistant weeds. Rather, we are suggesting only that the most profitable path for the company was to maximize sales of Roundup Ready crop seed and Roundup herbicide, which it indisputably did, and that this also happened to be the path most conducive to emergence of GR weeds, which have in turn now created a new market opportunity for the company in the form of dicamba-resistant crops.

In contrast, serious weed resistance management would require restrictions on the frequency with which dicamba resistant seeds are planted and dicamba herbicide applied to them. Because this would reduce sales and profits, one can never expect Monsanto or any other company to promote or acquiesce to such constraints. That is why the USDA and/or EPA would have to impose such restrictions.

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Your Voice in Federal Decision-Making

C Comment submitted by J. R. Paarlberg

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

Comment Period Closed
May 31 2016, at 11:59 PM ET

ID: EPA-HQ-OPP-2016-0187-0832
Tracking Number: 1k0-8pxd-fdtq

Comment

James R Paarlberg, Paarlberg Farms

Attachments (1)

Comment

View Attachment: DOC PDF

Document Information

Date Posted:
Jun 10, 2016

RIN:
Not Assigned

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Dear EPA,

My son's and I are corn, soybean and specialty crop producers, including processing tomatoes in Indiana. We are opposed to the registration as it reads today of dicamba use, on dicamba tolerant cotton and soybeans until the EPA (1) Adopts residue tolerances for common food crops, (2) Adopts additional restrictions on the use and (3) reclassify all dicamba AI products to restricted use.

The reason there is a need of this technology is because of the resistance to glyphosate. I see comments already made by grain organizations, state Farm Bureaus, PhD's, crop advisors, farmers, etc… all widely stating we must have another "tool" in our tool box of chemistry because we have resistance. The "new tool" (dicamba) is a "old tool" we already had for crops already on it's label. I believe all could agree, we have resistance because the end user over used one tool and now has consequences.

The "new tool" dicamba since it has been an "old tool" has documented risk associated with it's use. I have personal experience with it moving onto my crops causing damage. So I ask the EPA to help protect the off target crops, those that grow them and those that process them. The economic damage has the potential to be devastating to the producer, processor, insurance companies, applicator and farmer.

1. Today it states "0 residue tolerance for common foodcrops". Please do not register until a tolerance is established. Wide use of this "new tool" will likely create residue. Who will pay for such lose? Manufacture? Processor? Applicator? As it stands today applicators do not have enough liability coverage to cover the probable losses. And how could it be traced?
2. Additional restrictions for the "new tool" uses are needed before registration. The buffer zone should be at least 400 feet to help mitigate the risk of volatilization to off target crops. Winds should be away from off target crops. Applied by a certified applicator. Apply only after consulting the "Driftwatch" website where specialty crop fields are registered. And maybe register it's use.
3. Reclassify all dicamba AI products to restricted use so all would have to follow the application rules. There is a likelihood that applicators and farmers will be tempted to use a cheaper old formulation of dicamba that presents greater risk to moving off target. Monsanto and BASF could step up and be proactive to help ensure the effective use of the "new tools" and protect us from the old formulations.

I again ask the EPA to delay the registration until these issues are evaluated for the risks they pose. The unintended consequences to off target crops could potentially cause total loss of that crop. So who would pay for that Monsanto, BASF, PhD's, crop advisors, insurance companies, applicators, farmers? Me and our family farm!

Thank you for consideration.

James R Paarlberg, Paarlberg Farms

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Your Voice in Federal Decision-Making

Anonymous public comment

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

Comment Period Closed
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Not Assigned

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Comment

Oliver Winery grows 60 acres of wine grapes in northwest Monroe County, Indiana. We respectfully oppose the labeling of Dicamba for use on Dicamba resistant soybeans without the greatest degree of protection provided to Dicamba sensitive crops such as wine grapes. Our vineyard lies immediately adjacent to two fields commonly planted in soybeans. These fields are to the south, and west of our vineyard and this fact is of an important point in our opposition to the labeling of Dicamba containing herbicides for use on Dicamba resistant soybeans. Winds are most commonly from the south, southwest and west during the summer months.
We have in our twenty one year history had two instances of significant herbicide drift damage to our vineyard. One resulted in a complete crop loss. Both were caused by 2,4,d herbicide. We continue to see 2,4d symptoms on a nearly annual basis due to volatilization drift.
Widespread use of Dicamba later in the season due to broad use on soybeans will no doubt compound an already tenuous situation.
While new formulations of Dicamba are less volatile and could in theory reduce (but not eliminate) volatilization drift issue, older highly volatile formulations are available to farmers. It is imperative that these older formulations become restricted use pesticides and not labeled for use on Dicamba resistant soybeans.
The current proposal of a 400' buffer distance between Dicamba application and sensitive crops is insufficient. Our prior drift injury included significant damage to plants well beyond a 400' distance from the sprayed field. I propose a minimum 1000' protection zone around sensitive crops in which Dicamba will not be allowed for use.
Of additional concern is the presence of Dicamba residue in our grapes and our finished product, wine. As the EPA has no current threshold for allowable Dicamba residue in grapes or wine, any amount detected will render these products unfit for sale. I additionally urge the EPA to set limits on the allowed limit of Dicamba in grapes and wine.
Wine grapes are a high value, value added crop. Their cultivation should be encouraged and supported by federal departments. The prospect of mid-season application of Dicamba near wine grapes only

serves to undermine this growing industry. Not providing the highest level of protection for grapes and other sensitive crops only serves to perpetuate the current near monoculture of beans and corn on Midwestern farm ground. I urge the EPA to place the highest consideration to the protection of other crops.

Comment of SOCC - Docket No. EPA-HQ-OPP-2016-0187

COMMENT OF:
SAVE OUR CROPS COALITION
[Docket No. EPA-HQ-OPP-2016-0187]

May 31, 2016

ELECTRONIC SUBMISSION

Re: Dicamba: New Use on Herbicide Tolerant Cotton and Soybeans

The Save Our Crops Coalition (SOCC) is a grassroots coalition of farm interests organized for the specific purpose of preventing injury to non-target crops from exposure to 2,4-D and dicamba. SOCC does not oppose advances in plant technology, particularly genetic modification, but does oppose actions that would result in substantial injury to non-target crops and to the habitats necessary for their pollinators.

Non-target plant damage associated with herbicide spray drift and volatilization is a major concern for specialty crop growers and processors. Credible estimates project significant increases in the amount of dicamba that will be applied upon the introduction of dicamba-tolerant crops. Dicamba, because of its potential to drift and volatilize, has proven to be one of America's most dangerous herbicides for non-target plant damage.

Thus, SOCC respectfully submits the following comment regarding EPA's proposed registration of dicamba on dicamba-tolerant cotton and soybeans. This comment requests the Environmental Protection Agency (EPA) withhold registration until EPA: (a) adopts residue tolerances for common food crops, (b) adopts the additional registration restrictions as suggested below, and (c) undertakes a classification review of pesticide products with the active ingredient dicamba.[1]

Commenter

SOCC represents nearly every segment of American agriculture, from growers to processors, both conventional and organic. All SOCC growers cultivate specialty crops, but they also cultivate significant acreages of major agronomic crops, like corn and soybeans.

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[1] EPA, *Posting EPA-HQ-OPP-2016-0187 to Regulations.gov for Public Access* ("*Posting EPA-HQ-OPP-2016-0187*"), (March 31, 2016), at: https://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2016-0187-0001

SOCC is over 2,000 growers strong, including grower organizations such as the Indiana Vegetable Growers Association and the Ohio Produce Growers and Marketers Association, and is supported by major processors like Red Gold.

Factual Background

Drift and Volatilization

Due to the potential for crop injury, pesticide spray drift and volatilization from agronomic crops is a major concern for specialty crop growers and processors. Spray drift is the airborne movement of pesticide spray particles to a non-target site. Spraying during windy conditions or using nozzles or pressures that result in the creation of fine spray particles increase the risk of spray drift. Volatilization is the airborne movement of pesticide vapor to a non-target site. Volatilization occurs when a pesticide is applied to a target site, subsequently evaporates, and moves off-target. The calm windless conditions that minimize drift, ironically, only increase the potential for volatilization.

All pesticides may have harmful effects on non-target crops if they drift or volatize away from their intended areas of application; however, dicamba has proven especially prone to cause damage.[2] A survey of state pesticide control officials listed dicamba as the pesticide third most commonly involved in drift incidents for two years in a row.[3] This incidence of drift damage far outpaces the relative use of dicamba. Dicamba does not even make the list of the top 25 most commonly applied pesticide active ingredients.[4] Drift concerns have led some states to enact safeguards, such as requiring the use of lower volatility formulations, restrictions on application timing, and even bans on use.[5] Thus, SOCC regards dicamba as one of America's most dangerous herbicides for non-target plant damage.

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[2] Sciumbaro, Audie S., et al. *Determining Exposure to Auxin-Like Herbicides. I. Quantifying Injury to Cotton and Soybean*, Weed Technology, Vol. 18, 1125-1134 (2004).
[3] *2005 Pesticide Drift Enforcement Survey Report*, Association of American Pesticide Control Officials (2005), available at:
http://aapco.ceris.purdue.edu/doc/surveys/DriftEnforce05Rpt.html
[4] *Pesticides Industry Sales and Usage: 2006 and 2007 Market Estimates*, EPA (Feb. 2011) available at:
http://www.epa.gov/opp00001/pestsales/07pestsales/market_estimates2007.pdf.
[5] 4 Tex. Admin. Code § 7.50 (2011); Or. Admin. R. 603-057-0301 (2012); Wash. Admin. Code 16-228-1250 (2012)

Dicamba-tolerant crops heighten drift and volatilization concerns. The introduction of dicamba-tolerant crops is anticipated to increase the amount of dicamba that will be used, especially in soybean producing regions. Because these regions also produce substantial acreages of broadleaf crops that are sensitive to dicamba, the environmental impacts in these regions are anticipated to be especially intense.

The introduction of dicamba-tolerant crops would also permit applications of dicamba weeks later in the growing season. Applications at this time of year occur when other crops are 'leafed out,' further increasing the risk of non-target damage.[6] High temperatures also substantially increase the potential for herbicide volatilization.[7] These risks are particularly alarming in the case of dicamba, because dicamba causes substantial plant damage effects at very low application rates, and is prone to volatilize at high temperatures.

Dicamba Drift Has Substantial Harmful Effects at Very Low Application Rates

Researchers at the Ohio State University Department of Horticulture and Crop Science conducted a study on the effect of simulated dicamba drift and volatilization on tomatoes grown for processing.[8] Their objective was to quantify the impact of low rates of dicamba on broadleaf crops with respect to plant injury and the potential for yield losses.

Their conclusions are startling. Simulated dicamba drift and volatilization caused tomato bloom to "abort." Applications of dicamba at levels as low as 1/300th of the soybean field rate caused statistically significant losses of tomato crops. The late drift of dicamba, during bloom, caused a 17-77% reduction in marketable fruit when applied at 1/100th of the field rate. *See* Figure 1, below.

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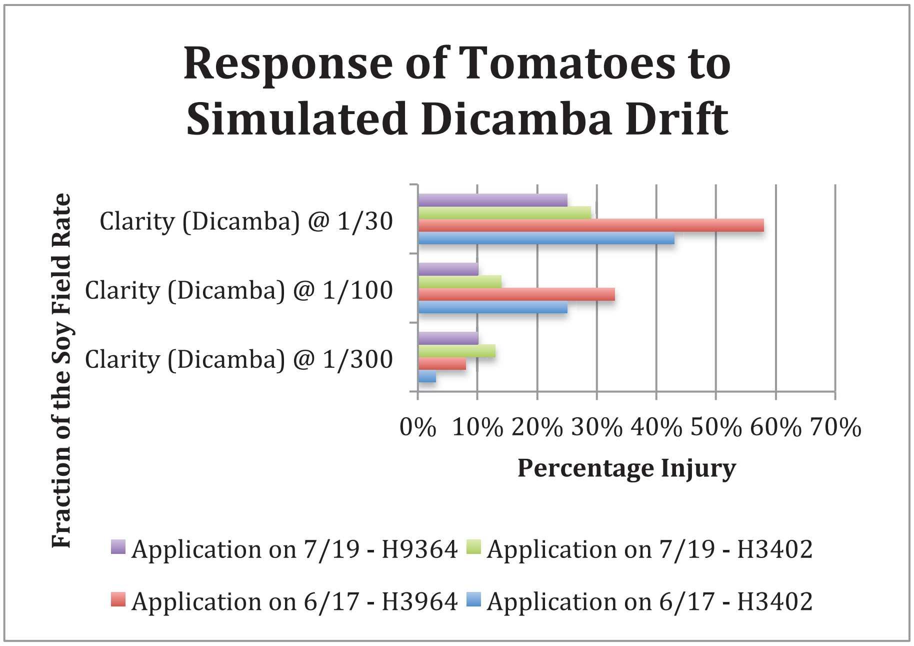
[6] *Determining Exposure to Auxin-Like Herbicides. I. Quantifying Injury to Cotton and Soybean.*
[7] Atkins, Peter and Loretta Jones, *Chemical Principles: The Quest for Insight*, 310-311 (4th ed. 2008).
[8] Doohan, Doug and Koch, Tim, *Effect of Simulated Dicamba and 2, 4-D Drift on Processing Tomatoes*, Ohio State University/OARDC (2010).

Figure 1.



Effect of Dicamba-tolerant Crops on the Use of Dicamba

The rationale presented by Monsanto for dicamba-tolerant crops, is that they would provide another weed management tool for farmers, because they would offer, "... an option to delay or prevent further resistance to glyphosate and other critically important soybean herbicides, in particular, herbicides in the ALS and PPO class of chemistry..."[9] Thus, dicamba-tolerant crops represent a replacement for, or complement to, glyphosate tolerant crops, because the widespread use of glyphosate has contributed to glyphosate resistant weed populations.

Monsanto's own petitions to USDA for non-regulated status of dicamba-tolerant crops have indicated that, upon peak adoption, dicamba use will approximately double its 1994 peak historical use level, or reach about 25 million pounds annually.[10] However, it should be noted that the use of dicamba has declined precipitously from its peak levels. Monsanto's petitions omit describing the intensity of the rate of sudden change in dicamba

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[9] *Monsanto Petition for Determination of Nonregulated Status of Event MON 87708*, APHIS (Jul. 13, 2012), available at: http://www.regulations.gov/#!documentDetail;D=APHIS-2012-0047-0002, at 5.
[10] *Monsanto Petition for Determination of Nonregulated Status of Event MON 87708*, at 210-211.

use from current use levels. The latest figures place the amount of dicamba applied at about 2.7 million pounds annually.[11] Monsanto's projected use pattern would represent an approximately 925% increase in pounds applied over current levels, an almost 250% increase in the total acreage treated, and a 5660% increase in soybean acreage treated.[12] Such an increase would represent a dramatic shift in the utilization of an herbicide both in total pounds applied and in total acreage treated. Even the increase in the use of glyphosate upon the introduction of glyphosate tolerant crops, an increase of almost 600% in pounds applied, would be eclipsed by this shift in use.[13]

Proximity of Agronomic Crop Acreage to Broadleaf Crop Acreage in the Midwest

The map, below, produced by USDA's CropScape, is a close-up of a portion of Monroe County, Michigan.[14] Growers in Monroe County cultivate fruit and vegetable crops in proximity to major agronomic crops like soybeans. This proximity is representative of the Midwest generally. The large grey-pink portion in the middle of the map is a tomato field surrounded by corn and soybean fields. Tomatoes are a broadleaf crop. *See* Figure 2.

As noted above, dicamba has substantial harmful effects on unmodified broadleaf crops even at very low applications rates, and because dicamba-tolerant crops will be grown in such close proximity to unmodified broadleaf crops, such as tomatoes, the potential for non-target plant damage caused by drift and volatilization is tremendous.

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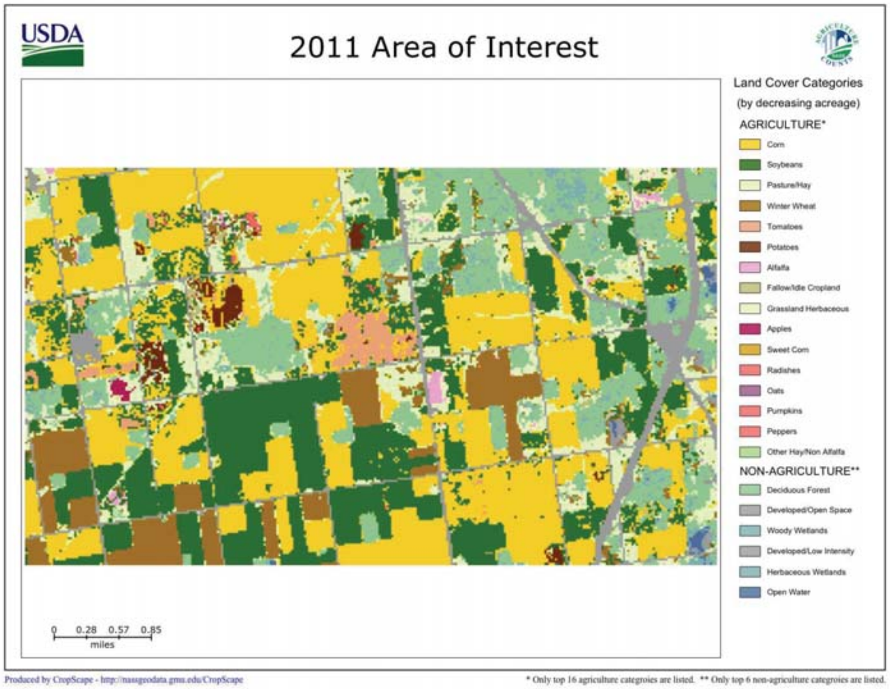
[11] *Monsanto Petition for Determination of Nonregulated Status of Event MON 87708*, at 198.
[12] *Monsanto Petition for Determination of Nonregulated Status of Event MON 87708*, at 223-224.
[13] Gianessi, L. P. and N. Reigner, *Pesticide Use in U.S. Crop Production: 2002 with Comparison to 1992 and 1997*, (2006) available at: http://www.croplifefoundation.org/Documents/PUD/NPUD%202002/Fung%20&%20Herb%202002%20Data%20Report.pdf
[14] *2011 Area of Interest*, USDA/NASS (Apr. 14, 2012) available at: http://nassgeodata.gmu.edu/CropScape/

Figure 2.



Discussion

Statutory and Regulatory Authority

The Federal Insecticide Fungicide and Rodenticide Act (FIFRA) requires EPA to regulate the sale and use of pesticides in the United States through registration and labeling of pesticide products.[15] The sale of any pesticide is prohibited unless it is registered and labeled.[16] EPA is directed to restrict the use of pesticides as necessary to prevent unreasonable adverse effects on people and the environment.[17] Pursuant to FIFRA, "unreasonable adverse effects on the environment" is defined as "(1) any unreasonable risk to man or the environment taking into account the economic, social, and environmental costs and benefits of the use of any pesticide, and (2) a human dietary risk from residues that result from a use of a pesticide in or on any food inconsistent with the standard under 408 of the Federal Food, Drug, and Cosmetics Act."[18]

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[15] 7 U.S.C. § 136, *et seq.*
[16] 7 U.S.C. §§ 136a(a), 136a(c)(5)(B).
[17] 7 U.S.C § 136a(a).
[18] 7 U.S.C § 136(bb).

If EPA is not satisfied that a pesticide "will perform its intended function without unreasonable adverse effects on the environment" or "when used in accordance with widespread and commonly recognized practice it will not generally cause unreasonable adverse effects on the environment," EPA may refuse to register said pesticide.[19]

The Federal Food, Drug, and Cosmetics Act (FFDCA) prohibits the shipment, in interstate commerce, of "adulterated food."[20] A food is considered adulterated "if it bears or contains a pesticide chemical residue that is "unsafe."[21] A pesticide is "unsafe" unless (1) EPA has established a tolerance for the pesticide on a particular commodity or in a particular food, and the pesticide residue is within that tolerance, or (2) with respect to a particular commodity or processed food, EPA has exempted the pesticide from the requirement for a tolerance.[22] Therefore, before agriculture commodities containing pesticide residues can be sold or distributed, EPA must adopt a "tolerance," a permissible level of residue, or an exemption.[23]

SOCC Petition for Residue Tolerances

On December 18, 2012, SOCC petitioned EPA to establish tolerances for dicamba residues on certain specialty crops anticipated to be grown in close proximity to the dicamba-tolerant crops. The very next day, December 19, 2012, EPA noticed receipt of petitions requesting the establishment of regulations for residues of dicamba in or on dicamba-tolerant cotton.[24] EPA published its proposal to register dicamba on dicamba-tolerant cotton and soybeans on March 31, 2016.[25] To date, more than three years after receipt of said petitions, EPA has not established tolerances for common food crops, like tomatoes, that are likely to be grown in close proximity to dicamba-tolerant crops.[26]

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[19] 7 U.S.C §§ 136a(c)(5), 136a(c)(6).
[20] 21 U.S.C. §331
[21] 21 U.S.C. §342(a)(2)(B)
[22] 21 U.S.C. §346a(a)(1)
[23] 21 U.S.C. §§346a, 346a(c)(2)(A)
[24] *Notice of Receipt of Several Pesticide Petitions Filed for Residues of Pesticide Chemicals in or on Various Commodities*, EPA, 77 Fed. Reg. 75082 (Dec. 19, 2012), available at: http://www.gpo.gov/fdsys/pkg/FR-2012-12-19/pdf/2012-30450.pdf
[25] *Posting EPA-HQ-OPP-2016-0187*, at 1.
[26] 40 CFR §180.227

Failure to establish tolerances for food crops is likely to have an "unreasonable adverse [Effect] on the environment"

In its proposed registration, EPA states, "Permanent tolerances for dicamba are established under 40 CFR §180.227 for a wide variety of crops and livestock commodities."[27] Unfortunately, this is just not the case. Any fair reading of 40 CFR § 180.227 would indicate that the proscribed residue tolerances for dicamba in and on food crops are *very narrow*. Residue tolerances have been established for only the following crops: Asparagus, Barley, Corn, Grass, Millet, Oats, Rye, Sorghum, Soybeans, Sugarcane, Teff, and Wheat.[28]

This situation may be tolerable for a grower of asparagus or one of the major agronomic crops listed above, however, for the growers and processors of the food crops listed in Federal Crop Groups 8 (fruiting vegetables) and 9 (cucurbit vegetables), which are likely to be grown in close proximity to dicamba-tolerant cotton and soybeans, as noted above, this situation poses an unacceptable threat.[29]

Specifically, EPA has not established residue tolerances for the food crops listed within Federal Crop Groups 8 and 9, which SOCC requested in its petition to EPA, dated December 18, 2012. More than three years ago as of the date of this comment. It may be worth noting that the U.S. Department of Health and Human Services (HHS) and USDA suggest a daily intake for Americans of at least two and one-half cups of vegetables.[30] Below please find a list of the food crops for which SOCC requested tolerances:

- Grape (Vitis spp.)
- Eggplant (Solanum melongena)
- Groundcherry (Physalis spp.)
- Pepino (Solanum muricatum)
- Pepper (Capsicum spp.) (includes bell pepper, chili pepper, cooking pepper, pimento, sweet pepper)
- Tomatillo (Physalis ixocarpa)
- Tomato (Lycopersicon esculentum)

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[27] *Posting EPA-HQ-OPP-2016-0187*, at 9.
[28] 40 CFR § 180.227
[29] 40 CFR § 180.41
[30] *U.S. Department of Health and Human Services and U.S. Department of Agriculture. 2015 – 2020 Dietary Guidelines for Americans*, 8th Edition, (December 2015). *See*: http://health.gov/dietaryguidelines/2015/guidelines/.

- Chayote (fruit) (Sechium edule)
- Chinese waxgourd (Chinese preserving melon) (Benincasa hispida)
- Citron melon (Citrullus lanatus var. citroides)
- Cucumber (Cucumis sativus)
- Gherkin (Cucumis anguria)
- Gourd, edible (Lagenaria spp.) (includes hyotan, cucuzza); (Luffa acutangula, L. cylindrica) (includes hechima, Chinese okra)
- Momordica spp. (includes balsam apple, balsam pear, bitter melon, Chinese cucumber)
- Muskmelon (hybrids and/or cultivars of Cucumis melo) (includes true cantaloupe, cantaloupe, casaba, crenshaw melon, golden pershaw melon, honeydew melon, honey balls, mango melon, Persian melon, pineapple melon, Santa Claus melon, and snake melon)
- Pumpkin (Cucurbita spp.)
- Squash, summer (Cucurbita pepo var. melopepo) (includes crookneck squash, scallop squash, straightneck squash, vegetable marrow, zucchini)
- Squash, winter (Cucurbita maxima; C. moschata) (includes butternut squash, calabaza, hubbard squash); (C. mixta; C. pepo) (includes acorn squash, spaghetti squash)
- Watermelon (includes hybrids and/or varieties of Citrullus lanatus)

In failing to adopt residue tolerances, EPA has flipped its statutory mandate, to prevent "unreasonable adverse effects," on its head. EPA is directed to restrict the use of pesticides as necessary to prevent unreasonable adverse effects on people and the environment.[31] "Unreasonable adverse effects on the environment" are defined to include "…(2) a human dietary risk from residues that result from a use of a pesticide in or on any food inconsistent with the standard under 408 of the Federal Food, Drug, and Cosmetics Act."[32] Presently, if even just a trace amount of dicamba is found on a food crop without a tolerance, such crop is unmarketable, and must be thrown away. EPA may have avoided true consideration of its statutory mandate to prevent "human dietary risk" by not considering residue tolerances for the various food crops that are likely to be grown in close proximity to dicamba on dicamba-tolerant cotton and soybeans, however, having done so, EPA has itself created an "(1) unreasonable risk to man or the environment taking

[31] 7 U.S.C § 136a(a).
[32] 7 U.S.C § 136(bb).

into account the economic, social, and environmental costs and benefits of the use of any pesticide," another basis upon which EPA should withhold this proposed registration.[33]

The use of dicamba on dicamba-tolerant cotton and soybeans without tolerances for most food crops presents an "unreasonable adverse effects on the environment," because it presents an "unreasonable risk" to food crop growers and processors and to the Americans who eat their crops, when taking into account the economic, social, and environmental costs and benefits of the use of dicamba.[34] Because dicamba on dicamba-tolerant cotton and soybeans cannot "perform its intended function without unreasonable adverse effects on the environment," EPA should withhold its proposed registration, until such time as EPA is able to promulgate food tolerances on common specialty crops, such as those listed within Federal Crop Group 8 (fruiting vegetables) and Group 9 (cucurbit vegetables). [35]

Proposed registration is likely to have an "unreasonable adverse effect on the environment"

Notwithstanding the failure of EPA to provide dicamba residue tolerances on food crops, this proposed registration of dicamba on dicamba-tolerant crops would significantly increase the risk of unreasonable adverse effects on the environment, as identified in the "Factual Background" section above.[36]

SOCC appreciates the work that EPA has done to prepare its proposed registration and its willingness to engage in a dialogue with SOCC regarding its concerns. However, SOCC still regards additional measures as necessary to mitigate the potential for drift and volatilization damage to non-target plants caused by this new pattern of use. Below SOCC suggests several modifications to the proposed registration, which would mitigate the risks of unreasonable adverse effects on the environment.[37]

SOCC would suggest modifying the "B. Labeling Requirements" in the following way:[38]

1. As a matter of emphasis, at "4. Spray Drift Management; Wind Speed," SOCC recommends striking "Drift potential is lowest between wind speed of 3 to

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[33] 7 U.S.C § 136(bb).
[34] 7 U.S.C § 136(bb)
[35] 7 U.S.C §§ 136a(c)(5), 136a(c)(6); 40 CFR § 180.41
[36] 7 U.S.C § 136(bb)
[37] 7 U.S.C § 136(bb)
[38] *Posting EPA-HQ-OPP-2016-0187*, at 33-34.

10 miles per hour" and replacing said labeling with "There is less risk of drift between 3 to 10 miles per hour." SOCC believes that applicators could claim that, if they applied when the "Drift potential is lowest," they were operating under 'safe haven' established by EPA. SOCC is certain EPA would agree that it is best to express label language in terms of risk, instead of relative safety.

2. At "5. Protection of Sensitive Areas, a. Buffer," SOCC would strongly recommend that EPA follow the example set by the Arkansas Plant Board and adopt a buffer of 400 feet. Although EPA has already specifically considered this question in its proposed registration decision, SOCC would respectfully request EPA to reconsider its approach.[39] Arkansas has created a reasonable restriction based on observable evidence of damage. The language of the proposed registration indicates that EPA may be unwilling to consider the practical knowledge of its colleagues in the states, simply because those state pesticide officials did not use the same methodology as EPA. This is unfortunate. SOCC is appreciative of the work these officials do to investigate and resolve claims, and believes the precautionary approach outlined by the Arkansas Plant Board is appropriate given the risks of non-target plant damage outlined above.

SOCC is certain that EPA would agree that it is just as important for EPA to mitigate the potential for drift and volatilization damage to non-target plants caused by this new pattern of use. Thus, SOCC would suggest modifying the "C. Registration Terms," in the following way:[40]

1. By including "EPA has determined that certain registration terms are needed to ensure that likely spray drift concerns as discussed in Section III, A., 4."
2. By including "1a. Spray Drift Management Plan," which would state, "Monsanto must have a Spray Drift Management Plan for M1691 Herbicide developed and approved by EPA before final registration can be issued. Such Plan must focus on educating applicators on the appropriate use of the M1691 Herbicide. EPA is requiring that such Spray Drift Management Plan include the following measures, which may assist in reducing the risk of adverse impacts on the environment."

[39] *Posting EPA-HQ-OPP-2016-0187*, at 17-18.
[40] 40 CFR § 152.115(3)(c); *Posting EPA-HQ-OPP-2016-0187*, at 29-33.

3. By including "1a. Spray Drift Management Plan, a. Investigation and Remediation," which would state, "Monsanto or its representative must investigate reports of spray draft and volatilization incidents, when requested by an interested person, and assist interested persons in the diagnosis and resolution of alleged non-target claims."
4. By including "1a. Spray Drift Management Plan, b. Recordkeeping," which would state, "Monsanto must commit to include terms within its Technology Use Agreements for dicamba-tolerant crops that require growers and applicators to keep accurate records of the locations where dicamba tolerant crops are planted and where dicamba is applied, and to retain invoices for all dicamba-tolerant seed and dicamba herbicide purchases. Further, Monsanto must commit to include language in its Product Use Guide for use of dicamba on dicamba tolerant crops that recommends applicators keep accurate spray records, including application location, timing, and wind speed."
5. By including at "1a. Spray Drift Management Plan, c. Auditing," which would state, "Monsanto commits to utilize an independent third party to collect seed and pesticide sales data that will help identify applicators that use any form of dicamba that has not been labeled for use on dicamba tolerant crops."
6. At "2. EPA's Continued Control over the Registration," by including in the first clause of the first sentence, "…and because the issue of spray drift and volatilization is an extremely important issue to keep under control and can be very fast moving," and noting in the second sentence that EPA can work to address any unexpected spray drift in volatilization issues that may result from "the proposed uses before granting an extension or allowing the registration to terminate, if necessary," as well.

As demonstrated by the "Factual Background" section, above, "(a) Without [the additional registration terms listed above, the M1691 Herbicide] when used in accordance with warnings, cautions and directions for use or in accordance with widespread and commonly recognized practices of use may cause unreasonable adverse effects on the environment; and (b) The decrease in risks as a result of [additional registration terms] would exceed the decrease in benefits as a result of [additional registration terms]."[41] Thus, EPA's own regulations give it the authority to impose additional registration terms. In the interest of the thousands of growers and processors of SOCC, and, more broadly, for the

[41] 40 CFR § 152.171

welfare of American agriculture, EPA should act to mitigate the potential for drift and volatilization damage to non-target plants caused by this new pattern of use.

Notwithstanding the failure of EPA to provide dicamba residue tolerances on food crops, this proposed registration of dicamba on dicamba-tolerant crops, without modification, would significantly increase the risk of unreasonable adverse effects on the environment. In order to mitigate the risks of unreasonable adverse effects on the environment identified above, prior to finalizing its registration, EPA should adopt the suggested modifications to its proposed registration, as listed in this section.

SOCC Petition To Conduct a Classification Review of Products with Active Ingredient Dicamba

As requested in SOCC's petition to EPA, prior to finalizing this proposed registration, EPA should undertake a classification review to determine whether many, if not all, products with the active ingredient dicamba, without additional regulatory restrictions, when applied in accordance with its directions for use, warnings and cautions and for the uses for which it is registered, or in accordance with a widespread and commonly recognized practice, may cause unreasonable adverse effects on the environment.[42] Classifying certain forms of dicamba as restricted use, including a requirement that only certified applicators apply such forms of dicamba and records of such application are kept, could mitigate the potential for unreasonable adverse effects on the environment.

Conclusion

On September 11, 2012, SOCC announced the successful conclusion of discussions with Dow AgroSciences (Dow) regarding its 2,4-D tolerant cropping system. SOCC was satisfied that Dow had adopted effective measures to protect against non-target plant damage associated with the introduction of 2,4-D tolerant crops. SOCC was also impressed with Dow's 2,4-D choline salt formulation. Only 2,4-D choline salt, the lowest volatility 2,4-D formulation available, would be approved for use on 2,4-D tolerant crops, and Dow has committed to strongly discourage the unlawful use of older, cheaper, highly volatile generic formulations on 2,4-D tolerant crops. Unfortunately, SOCC has not been able to reach a similar agreement with Monsanto. EPA has a responsibility to American agriculture to use

[42] Save Our Crops Coalition, *Citizen's Petition to Classify Pesticides with Active Ingredient Dicamba as Restricted Use*, (May 24, 2016), available at: http://saveourcrops.org/wp-content/uploads/2016/05/FINAL-SOCC-Petition-RUP-Generic-Dicamba-160524.pdf.

its authority to protect those growers and processors of food crops throughout the country, and, therefore, in this instance, EPA must act.

SOCC hopes that EPA will recognize that SOCC is requesting only reasonable accommodations to avoid what are likely unreasonable consequences -- accommodations that the competitors of Monsanto and BASF have already agreed are in the best interests of American agriculture. In light of the foregoing, SOCC requests that, prior to final registration, EPA adopt residue tolerances for food crops, adopt SOCC's suggested modifications to the proposed registration, and undertake a classification review of pesticide products with the active ingredient dicamba.

Respectfully submitted,

__________/s/_____________

Steve Smith
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PESTICIDE ACTION NETWORK • NORTH AMERICA

RECLAIMING THE FUTURE OF FOOD AND FARMING

May 31, 2016

US EPA/OSCPP/OPP 7505P
Environmental Protection Agency
1200 Pennsylvania Ave. NW
Washington DC 20460

RE: Docket No. EPA-HQ-OPP-2016-0187, Dicamba: proposed new use on herbicide resistant cotton and soybeans

ELECTRONIC SUBMISSION via www.regulations.gov

Pesticide Action Network North America (PANNA) submits the following comment regarding EPA's proposed registration of dicamba for use on genetically engineered dicamba-resistant cotton and soybeans.

PANNA is a non-profit, public interest organization representing the concerns of over 100,000 supporters across the country, including farmers, farmworkers, health professionals, members of sustainable agriculture, labor, environmental and consumer groups and individuals concerned with the safety, sustainability, fairness and integrity of our food and agricultural system.

Our members are deeply concerned about the serious social, economic, environmental and health harms to farmers, workers and rural communities that would accompany EPA registration of dicamba for use on genetically engineered dicamba-resistant crops. We therefore urge EPA to reject Monsanto's petition for use of dicamba on these crops.

Drift damage to vulnerable crops, farmers' livelihoods and ecosystems

Dicamba products on the market today are highly volatile. Dicamba has been identified by the Association of American Pesticide Control Officials as the third most commonly involved herbicide in drift occurrences.[1] Volatilization leading to drift occurs more readily at higher temperatures (e.g. midseason, when dicamba could still be applied to Monsanto's dicamba-resistant varieties). Mechanical spray drift alone (e.g. when the herbicide is applied during commonly occurring wind conditions or with incorrect farm equipment) readily causes damage to vulnerable crops and adds to the threat of volatilization drift.

Dicamba residues are also difficult to remove from pesticide applicators' equipment. Because miniscule, residual amounts left in a sprayer can harm crops that are subsequently sprayed with other herbicides, the likelihood that vulnerable crops treated by an applicator's dicamba-contaminated equipment will be harmed increases.

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[1] Association of American Pesticide Control Officials (AAPCO). "2005 AAPCO Pesticide Drift Enforcement Survey Report." 2005. On file and available at http://aapco.ceris.purdue.edu/doc/surveys/DriftEnforce05Rpt.html. Accessed May 3, 2013.

Dicamba is also highly toxic to broadleaf plants. Incidences of both mechanical spray and volatilization drift, as well as unintended contamination of spray equipment, are likely to rise sharply, and because of the herbicide's high toxicity, threatens growers of specialty crops and non-dicamba-resistant commodity crops with severe crop damage and yield loss. Highly sensitive crops include nearly all fruits, vegetables, seed and nut crops, such as grapes, beans, lettuce, tomatoes, soybeans, sunflower, cotton and peanuts, among others. The specialty crop industry as well as seed and vegetable oil and fiber production, would be seriously impacted.

With USDA's 2015 deregulation of dicamba-resistant cotton and soybean, followed by its 2016 deregulation of dicamba-resistant corn, the window for dicamba spraying will be significantly widened, with more dicamba applications likely to occur mid-season when temperatures are warmer and volatilization occurs more readily and when vulnerable crops have leafed out and are extremely susceptible to dicamba damage. The acreage on which dicamba will be applied will also increase from current levels, as farmers begin to cultivate dicamba-resistant crops. The likelihood of dicamba drift causing crop injury and severe harm to specialty crop and organic farmers, as well as non-target species, poses a severe and unacceptable risk for thousands of American farmers.

Other non-crop broadleaf plants e.g. in hedge rows, at field-edge or throughout the larger landscape, are also likely to be harmed, destroying critical habitat, food and reproductive sites for birds and other beneficial species critical to agroecosystem health (pollinators, natural enemies). Commodity growers' efforts to diversify their farms with perennials and other crops, support agriculturally critical ecosystem services, reduce wind and water erosion and diversify sources of farm income, would be undermined.

Herbicide resistance and weed management

U.S. farmers are facing an unprecedented crisis in the spread of herbicide-resistant weeds. USDA's approval and the subsequent widespread planting of Monsanto's Roundup Ready varieties have led directly to the current weed crisis, in which glyphosate-resistant weeds now cover over 70 million acres of farmland. With the expected surge in dicamba use that USDA and Monsanto both acknowledge will accompany cultivation of Monsanto's dicamba-resistant cotton and soybean varieties, farmers are likely to face the spread of intractable dicamba-resistant weed populations.

Already several weed species are resistant to dicamba, and with resistance in the case of at least two weed species conferred by a single dominant allele, that resistance could spread swiftly.[2] Furthermore, a number of weed species have developed multiple resistance (to more than one herbicide) and/or cross-resistance (in which a metabolic adaptation in a weed species enables it to degrade several different herbicide modes of action at once).

The spread of weed populations resistant to dicamba, the evolution of dicamba resistance in weed species and the emergence of volunteer dicamba-resistant corn and soybean plants all pose serious threats to the future of American farming.

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[2] Mortensen, David et al. 2012. Navigating a critical juncture for sustainable weed management. BioScience 62(1): 75-84.

An EPA registration decision will spur a dramatic increase in use of an already problematic herbicide, exacerbate the weed problem by escalating the emergence and spread of resistant weeds, further trapping farmers on an out-of-control pesticide treadmill, and pushing many struggling family farmers out of business. This trajectory represents the polar opposite of the direction that American farming should be headed, namely that of ecologically-based, biodiversified, resilient farming that relies on least-toxic ecological approaches to insect and weed pest management.

Economic harm from loss of inter-state and global commerce

Economic harm due to crop damage and product loss caused by dicamba drift has been discussed above. Organic farmers whose crops are drifted on by dicamba face the additional possibility of losing organic certification of their crops.

The absence of established tolerances for dicamba on many fruit and vegetable crops also threatens interstate commerce in these crops. This exposes specialty crop growers to risk of enforcement action by FDA, since interstate commerce is prohibited for produce lacking tolerances or exemptions. These enforcement actions could include crop confiscation and destruction, with the economic loss — whether due to crop destruction or simply to loss of market value — borne by the specialty crop growers themselves.

Finally, conventional soybean and cotton growers may find themselves under extreme pressure to buy Monsanto's dicamba-resistant varieties, so that their own crops are not destroyed by dicamba drift. Those who have been exporting clean, non-GE soybean and cotton product to non-GE markets in Europe or Japan may find themselves unable to maintain their non-GMO production due to dicamba drift damage. The loss of these export markets will be devastating to their businesses.

Health harms to farmers, workers and rural communities

Adverse health effects associated with exposure to dicamba provide additional reason to reject Monsanto's proposed uses. Epidemiology studies have linked dicamba to increased rates of cancer—including non-Hodgkin's lymphoma and multiple myeloma— in pesticide applicators and farmers.[3] Preconception exposure to dicamba has also been linked to increased risk of birth defects in farmers' male offspring, in the Ontario Farm Family Health Study.[4] Dicamba has also been listed in the U.S. Toxic Release Inventory as a developmental toxin. Because dicamba has moderate persistence in the environment, is frequently detected in surface waters, and is expected to be applied more frequently throughout the growing season, the general population will also likely be more frequently exposed to dicamba than under current practice, rendering the increased risk of adverse health effects wholly unacceptable.

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[3] Schinasi, L and M. Leon, 2014. Non-Hodgkin lymphoma and occupational exposure to agricultural pesticide chemical groups and active ingredients: a systematic review and meta-analysis. Int J Environ Res Public Health. 2014 Apr 23;11(4):4449-527. doi: 10.3390/ijerph110404449.

[4] Arbuckle, T., Z. Lin and L. Mery, 2001. An exploratory analysis of the effect of pesticide exposure on the risk of spontaneous abortion in an Ontario farm population. Environ Health Perspect. 2001 Aug; 109(8): 851–857.

Conclusion

In sum, we call on EPA to reject Monsanto's petition for new uses of dicamba on genetically engineered dicamba-resistant crops. EPA must protect the public against severe harms that would be exacerbated by continued and increased use of dicamba in these cropping systems. These harms include:

- *economic harms* to farmers' businesses and livelihoods caused by dicamba drift damage to vulnerable crops as well as crop loss, the cost of managing spread of intractable dicamba-resistant weeds, the emergence of dicamba-resistant soybean and cotton plants as noxious weeds themselves, restrictions on inter-state commerce, loss of organic certification for drift-damaged organic farmers and loss of access to valuable export markets;
- *environmental harm* from increased dicamba application accompanying the planting of dicamba-resistant cotton and soybean, including reduction in farm- and landscape-scale plant diversity that provide alternative income sources as well as protection from wind and water erosion; loss of habitat and food and reproductive resources for birds, beneficial arthropods and other species; and loss of critical ecosystem services such as pollination and natural pest control;
- *health harm* from exposure of pesticide applicators, farmers and rural communities to dicamba, including potential increased risks of cancers such as non-Hodgkin's lymphoma and multiple myeloma, birth defects and developmental toxicity; and
- *socio-cultural harm* to rural communities arising from increased conflict between neighboring farmers around issues of drift, crop damage and liability.

We therefore urge EPA to prioritize the public interest and reject Monsanto's registration petition for use of dicamba on dicamba-resistant crops.

Thank you for your consideration.

Sincerely,

Marcia J. Ishii-Eiteman

Marcia Ishii-Eiteman, PhD

Senior Scientist

CENTER *for* BIOLOGICAL DIVERSITY *Because life is good.*

May 31, 2016

Dicamba: New Use on Herbicide-Tolerant Cotton and Soybeans
Environmental Protection Agency
Mailcode 28221 T
1200 Pennsylvania Ave, NW
Washington, DC 20460

Re: Comments on Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean (Docket #: EPA-HQ-OPP-2016-0187).

Please accept the following comments on behalf of the Center for Biological Diversity ("Center") in response to the Environmental Protection Agency's ("EPA") proposed new use registration for dicamba as part of its registration process under the Federal Insecticide, Fungicide, and Rodenticide Act ("FIFRA").

The Center is a non-profit environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law. The Center has more than one million members and online activists dedicated to the protection and restoration of endangered species and wild places. The Center has worked for many years to protect imperiled plants and wildlife, open space, air and water quality, and overall quality of life. The Center's Pesticides Reduction Campaign aims to secure programmatic changes in the pesticide registration process and to stop toxic pesticides from contaminating fish and wildlife habitats. We appreciate the opportunity to provide comment.

THE EPA HAS NOT COMPLIED WITH ITS DUTIES UNDER THE ENDANGERED SPECIES ACT

The EPA's proposed registration of this new use of dicamba does not comply with the mandates Congress established in Section 7 of the Endangered Species Act (ESA), as interpreted by the expert wildlife agencies in the ESA regulations and handbook, the courts, and as recently set forth by the National Academies of Sciences. Instead, for assessments of new herbicide tolerant crop uses, such as the proposed use of dicamba on herbicide tolerant corn and soybean, the EPA applies its FIFRA risk assessment to unlawfully avoid lawful ESA "may affect" determinations. These "may affect" determinations require either informal consultation and written concurrence from the wildlife agencies or formal consultation and a biological opinion.

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The new Interim Approaches for effects determination, based on the National Academies of Sciences report entitled "*Assessing Risks to Endangered and Threatened Species from Pesticides,*"[1] (hereafter "NAS report") lays out an approach that the EPA should use as a guide to begin to comply with its obligations under the Endangered Species Act ("ESA").

Following the publication of the NAS report in 2013, the agencies have developed two policy documents to guide consultations on pesticide review and approvals moving forward: (1) *Enhancing Stakeholder Input in the Pesticide Registration Review and ESA Consultation Processes*,[2] and (2) *Interim Approaches for National-level Pesticide Endangered Species Act Assessments Based on Recommendations of the National Academy of Science April 2013* (Hereafter "*Interim Approaches*").[3]

As laid out in the NAS report and *Interim Approaches*, the risk assessment and consultation process should follow three steps.[4] These steps generally follow the three inquiries of the ESA consultation process: (1) the "no effect"/ "may affect" determination (2) the "not likely to adversely affect"/ "likely to adversely affect" determination (3) the jeopardy/no jeopardy and adverse modification/no adverse modification of critical habitat determination.

The agencies made clear at a November 15, 2013 public meeting that it would apply the NAS recommendations and *Interim Approaches* "day forward"[5] and in November of 2014 made the same statement in a report to Congress.[6] However, the EPA arbitrarily decided that it will only apply the *Interim Approaches* in the context of registration review.[7] For new herbicide tolerant crop uses, the EPA states it will do "Overview Document-compliant" endangered species assessments.[8] The Overview Document, and the assessment conducted for this new use of dicamba, reverts to the same

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[1] National Academy of Sciences. 2013. *Assessing Risks to Endangered and Threatened Species from Pesticides* (hereafter NAS REPORT), Committee on Ecological Risk Assessment under FIFRA and ESA Board on Environmental Studies and Toxicology Division on Earth and Life Studies National Research Council (April 30, 2013).

[2] U.S. Environmental Protection Agency 2013, Office of Chemical Safety and Pollution Prevention- Office of Pesticide Programs, Enhancing Stakeholder Input in the Pesticide Registration Review and ESA Consultation Processes and Development of Economically and Technologically Feasible Reasonable and Prudent Alternatives, Docket ID #: EPA-HQ-OPP-2012-0442-0038 (March 19, 2013).

[3] Available at https://www.epa.gov/sites/production/files/2015-07/documents/interagency.pdf

[4] NAS REPORT at Figure 2-1.

[5] INTERAGENCY APPROACH FOR IMPLEMENTATION OF NATIONAL ACADEMY OF SCIENCES REPORT: ASSESSING RISKS TO ENDANGERED AND THREATENED SPECIES FROM PESTICIDES, Public Meeting Silver Spring NOAA Auditorium (Nov. 15, 2013).

[6] Interim Report to Congress on Endangered Species Act Implementation in Pesticide Evaluation Programs. U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the U.S. Department of Agriculture. November 2014. Page 9. Available at: https://www.epa.gov/sites/production/files/2015-07/documents/esareporttocongress.pdf

[7] *Id.* at 21-22.

[8] *Id.* at 22. The link to the "Overview Document" in the Interim Report to Congress, *supra* n. 8, does not appear to work. However, the EPA is most likely referring to: EPA 2004. Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs, U.S. Environmental Protection Agency. Available at: https://www.epa.gov/sites/production/files/2014-11/documents/ecorisk-overview.pdf. Notably, for authorization of pesticides with new active ingredients, the EPA does not intend to do ESA effects determinations. Interim Report to Congress at 22.

"Risk Quotient" and "Level of Concern" approach that the NAS found is not adequate to determine the effects on endangered and threatened species. While EPA may not be legally bound by the NAS recommendations or the *Interim Approaches*, EPA is not free to violate the ESA.

The effects determinations associated with over-the-top dicamba usage on soybean and cotton do not fulfill EPAs obligations under the ESA. Listed below are inadequacies that have been identified with the current approach for assessing risk to endangered species that is encompassed in the following documents[9] (Hereafter "Current Approach") as well as measures that could be taken by EPA to become compliant with the ESA moving forward.

EPA Makes Improper "No Effect" Determinations

As the U.S. Fish and Wildlife Service ("FWS") and National Marine Fisheries Service ("NMFS") (collectively the "Services") joint consultation handbook explains, an action agency such as the EPA is permitted to make a "no effect" determination, and thus avoid undertaking informal or formal consultations, only when "the action agency determines its proposed action will not affect listed species or critical habitat."[10] To put this in context, the Services define "may affect" as "the appropriate conclusion when a proposed action may pose ***any*** effects on listed species or designated critical habitat."[11] The phrase "may affect" has been interpreted broadly to mean that "any possible effect, whether beneficial, benign, adverse, or of an undetermined character, triggers the formal consultation requirement."[12] For this initial stage of review, exposure to a pesticide does not require that effects reach a pre-set level of significance or intensity to trigger the need to consult (e.g. effects do not need to trigger population-level responses). Under the Services' joint regulations implementing the ESA, if an effect on a listed species is predicted to occur or is

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[9] EPA documents "Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6-dichlorosalicylic ac id (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 16 states (Arkansas, Illinois, Iowa, Indiana, Kansas, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin)." "Addendum to Dicamba Diglycolamine (DGA) Salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Cotton and Soybean in 7 U.S. States (Alabama, Georgia, Kentucky, Michigan, North Carolina, South Carolina, and Texas)" "Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 11 U.S. States: (Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia)." (Identified as docket ID documents EPA-HQ-OPP-2016-0187-0002, EPA-HQ-OPP-2016-0187-0003, and EPA-HQ-OPP-2016-0187-0004, respectively)
[10] U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. *Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act* (hereafter CONSULTATION HANDBOOK) at 3-13.
[11] *Id*. at xvi (emphasis in original).
[12] *Western Watersheds Project v. Kraayenbrink*, 632 F.3d 472, 496 (9th Cir. 2011) (brackets omitted) (quoting 51 Fed. Reg. at 19,949). The threshold for triggering ESA consultation "is relatively low." *Lockyer v. U.S. Dep't of Agric.*, 575 F.3d 999, 1018 (9th Cir. 2009); *Karuk Trib of Cal. V. U.S. Forest Serv.*, 681 F.3d 1006, 1027 (9th Cir. 2012) (*en banc*) ("any possible effect" on species or their habitat is sufficient).

documented, then the EPA must undergo consultations with the Services.[13] The courts have made abundantly clear that the "may affect" threshold is very low.[14] A "may affect" determination is required when any "*possible* effect, whether beneficial, benign, adverse, or of an undetermined character" occurs.[15]

Therefore, the no effect/may affect threshold is a *very low* bar. In the Current Approach, EPA uses Risk Quotients ("RQ") and Levels of Concern ("LOC") to make "no effect" findings -- thereby ruling out impacts to all aquatic plants and animals and all invertebrates that don't have associated indirect effects. The RQ/LOC approach, which conflates a FIFRA determination with an ESA determination, is much too high of a threshold for an ESA "no effect" determination. Therefore, EPA has made a policy judgment that some level of impact to these species represents an acceptable level of risk. This is not permitted under the ESA, which requires consultation with the expert wildlife agencies whenever there is "any possible effect," either through informal consultation and a written concurrence or formal consultation and a biological opinion.[16]

The NAS report made several significant conclusions about the current ecological risk assessment process and its use of RQs, including:

- The EPAs "concentration-ratio approach" for its ecological risk assessments "is ad hoc (although commonly used) and has unpredictable performance outcomes."[17]

- "RQs are not scientifically defensible for assessing the risks to listed species posed by pesticides or indeed for any application in which the desire is to base a decision on the probabilities of various possible outcomes."[18]

- "The RQ approach does not estimate risk…but rather relies on there being a large margin between a point estimate that is derived to maximize a pesticide's environmental concentration and a point estimate that is derived to minimize the concentration at which a specified adverse effect is not expected."[19]

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[13] 50 C.F.R. § 402.14(a); *Karuk Tribe*, 681 F.3d at 1027 ("[A]ctions that have any chance of affecting listed species or critical habitat—even if it is later determined that the actions are 'not likely' to do so—require at least some consultation under the ESA").
[14] *Karuk Tribe*, 681 F.3d at 1027 (quoting Lockyer, 575 F.3d at 1018); *Colorado Envt'l Coalition v. Office of Legacy Management*, 819 F. Supp. 2d 1193, 1221-22 (D. Colo. 2011)
(citing cases).
[15] *Center for Biological Diversity v. BLM*, 698 F.3d 1101 (9th Cir. 2012) (emphasis added).
[16] 50 C.F.R. §§ 402.13, 402.14; *Washington Toxics Coalition v. FWS*, 457 F.Supp.2d. 1158, 1178 (W.D. Wash. 2006); *see also Defenders of Wildlife v. EPA,* 420 F.3d 946, 961 (9th Cir. 2005); *Thomas v. Peters* 753 F.2d 754, 763 (9th Cir. 1985).
[17] NAS Report at 149.
[18] *Id*. at 15.
[19] *Id*. at 14.

The Current Approach uses the RQ/LOC method to preclude taxa from undergoing co-occurrence analyses (provided there were no possible indirect effects) as well as to make "no effect" findings for species that may co-occur with pesticide use.

The use of RQs and LOCs cannot be reasonably anticipated to accurately reflect the no effect/may affect threshold and should not be used to make effects determinations. At Step 1, the EPA must gather sufficient data to complete the following two related inquiries: (1) the EPA must determine whether pesticide use areas will overlap with areas where listed species are present, including whether a use area overlaps with any listed species' critical habitat (2) the EPA must determine whether off-site transport of pesticides will overlap with locations where listed species are present and/or critical habitat is designated. Off-site transport must include considerations of downstream transport due to runoff as well as downwind transport due to spray drift and volatilization when the best available science indicates such transport is occurring.[20]

In making endangered species assessments, EPA categorically and arbitrarily assumes zero off-site exposure of listed species to dicamba via spray drift and volatilization, and either assumes zero or inconsequential exposure of aquatic and terrestrial organisms via runoff, despite clear evidence that dicamba may move off-site including into aquatic areas, even with field buffers in place. There is considerable uncertainty regarding the movement of dicamba off field, with one third of studies indicating that the labeled buffers may not be adequately protective.[21] Furthermore, the available incident data indicate that dicamba use can cause significant harm to plants adjacent to treated fields.[22] Incidents in Arkansas and Missouri indicate that plant damage can occur following dicamba treatment 1300 feet from the site of application (an order of magnitude greater than the current field buffers).[23] In addition, post-emergence treatment will occur later in the year than typical pre-emergence treatment and may increase off site transport.[24] With the uncertainty surrounding the off-site movement of dicamba, even with full field buffers, it is simply indefensible to assume that zero off-site exposure will occur in the effects determinations.

What the EPA should do to meet the legal requirements of the ESA is use the best available spatial data regarding where cotton and soybeans are grown and the distribution and range

[20] The Center acknowledges that in many areas, atmospheric transport is difficult to model and assess. However, in some areas, the impacts of atmospheric transport of pesticides are well understood. A recent study found that a variety of pesticides are accumulating in the Pacific chorus frogs (*Pseudacris regilla*) through atmospheric deposition at remote, high-elevation locations in the Sierra Nevada mountains, including in Giant Sequoia National Monument, Lassen Volcanic National Park, and Yosemite National Park Smalling, K.L., et al. 2013. *Accumulation of Pesticides in Pacific Chorus Frogs (Pseudacris regilla) from California's Sierra Nevada Mountains*, Environmental Toxicology and Chemistry, 32:2026–2034.
[21] EPA, 2016. Ecological Risk Assessment for Dicamba DGA Salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA), for the Proposed Post-Emergence New Use on Dicamba-Tolerant Cotton (MON 8770 I) (Docket ID EPA-HQ-OPP-2016-0187-0005). Page 26
[22] *Id.* at 29-33.
[23] *Id.* at 32.
[24] *Id.* at 36.

of listed species to determine whether a pesticide's use overlaps with species, and then make a "may affect"/"no effect" determination. The FWS ECOS website provides GIS-based data layers for each listed species with designated critical habitat.[25] These maps are scalable and can achieve the precision needed to make accurate effects determinations regarding whether a pesticide will have "no effect" or "may affect" a listed species and are accurate enough to make determinations as to whether the use of a pesticide represents adverse modification of critical habitat. For species without associated critical habitat, EPA should request the most refined range data from experts at the FWS and NMFS.

Other sources provide additional data on the distribution and life history of threatened and endangered species. NatureServe provides detailed life history information, including spatial distribution, for native species across the United States.[26] In addition, many State governments collect detailed information on non-game species through their State Wildlife Action Plans.[27] In short, there are many sources of data that can provide EPA with the detailed information it needs to conduct an effects determination for each species. If there are species where it believes information is still lacking, EPA should make it clear to all stakeholders which species, specifically, it believes such data are lacking early in the process such that this information can be collected from the Services and other sources.

Fortunately, these data have already been compiled in draft form for the nationwide ESA consultation that was recently completed for chlorpyrifos.[28] The GIS data have not been made available to the public, so we have not had a chance to scrutinize these data to make sure they truly reflect not only the species' range, but also the habitat needed for recovery. But, nevertheless, this analysis has already been done and is available for the EPA to use right now.

As far as the spatial data on crop use, these data have been compiled as well.[29] Importantly, the data compiled for the nationwide ESA consultation for chlorpyrifos spatially represents potential agricultural use sites for each crop, including soybeans and cotton. Furthermore, it aggregates the use data for the previous 5 years to account for crop rotations, which are common for these two crops. Some refinement to these maps will be needed, as they were generated based on offsite travel of chlorpyrifos.

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[25] US Fish and Wildlife Service Environmental Conservation Online System. http://ecos.fws.gov
[26] NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life Version 7.0. NatureServe, Arlington, VA. USA. Available from http://explorer.natureserve.org
[27] State Wildlife Action Plans. http://teaming.com/state-wildlife-action-plans-swaps
[28] EPA. Biological Evaluation Chapters for Chlorpyrifos ESA Assessment. ATTACHMENT 1-6: Co-Occurrence Analysis. Species ranges were provided to EPA from FWS and NMFS in the form of GIS mapping data. Available at https://www.epa.gov/endangered-species/biological-evaluation-chapters-chlorpyrifos-esa-assessment
[29] EPA. Biological Evaluation Chapters for Chlorpyrifos ESA Assessment. ATTACHMENT 1-2, 1-3, 1-6. Cropland data layer (CDL) and Census of Agriculture (CoA) provided by USDA. Available at https://www.epa.gov/endangered-species/biological-evaluation-chapters-chlorpyrifos-esa-assessment

Therefore, the EPA already has mapping data on the range and habitat of every single listed species in the U.S. and mapping data on all cotton and soybean field sites in the U.S. **In short, all of the information needed to run a proper Step 1 "no effects" determination has been compiled and is available for the EPA to use right now**. Many scientists at the EPA and other agencies put in a lot of work to generate these data in a good faith effort to ensure proper compliance with the ESA moving forward in pesticide registrations. To disregard these data would violate the ESA mandate that the action agency (EPA) use the best available science to conduct its effects determination.

Effects Thresholds Are Not Protective And "Best Available Science" Is Not Used

The use of surrogate animals is an essential part of the risk assessment process. When measuring risk to humans, the EPA will often apply uncertainty factors to offset the assumptions that mice or rats are an appropriate surrogate for human toxicity. Since lab animals are generally inbred strains with little genetic heterogeneity between individuals (unlike the human population), EPA will apply a 10x uncertainty factor to account for this. An extra 10x uncertainty factor will be applied to account for probable differences in sensitivities between the test species and humans. Another 10x uncertainty factor is occasionally applied to account for heightened toxicity of the developing fetus and young children.

Uncertainty factors are problematic because they are not science based, but at least they partially offset some of the many assumptions that are made during risk assessment. In the current ecological risk assessment approach that EPA uses, no uncertainty factors are used for anything. That means that the sensitivity of the surrogate animal is assumed to be *identical* to every species in its taxa (and occasionally other taxa as well). So a bobwhite quail is assumed to have the exact same sensitivity to a pesticide as a hummingbird, a lizard and a salamander. In reality, this extensive use of surrogates will overestimate toxicity to some species and drastically underestimate it for others.

The failure to account for and incorporate this uncertainty into the ecological risk assessment is putting many species at risk of harm. This is especially true when it comes to endangered or threatened species. Every listed species has a population that is in peril, making potential harm to individuals much more likely to lead to adverse effects on the species' population. Therefore, appropriate protections need to be put in place during the effects determination process to account for this extensive use of surrogacy and other uncertainties inherent with using models and estimating exposure. Not doing so would be a direct acknowledgement that harm may occur to some listed species.

The NAS report lays out an approach of using best available science and protective toxicity thresholds. The EPA has clearly relied on registrant supplied guideline studies for most of the analysis, and it is unclear to what extent the primary and gray literature were searched for studies related to toxicity. However, considerable efforts need to be taken so that studies with the most appropriate surrogate data are used. Studies should be of high scientific rigor but not necessarily comply with Good Laboratory Practice ("GLP") guidelines. GLP guidelines were designed to prevent fraud and do not necessarily indicate a study is of higher scientific quality.

Many times, studies with more appropriate surrogates will not be available. In the Current Approach, the LD_{50} or "no observable adverse effect level" ("NOAEL") of the most appropriate surrogate species are used to estimate toxicity to listed species. These toxicity values are not protective enough, especially with the uncertainty associated with them. When EPA uses LD_{50}, the concentration required to kill 50% of a population, as a threshold for acute toxicity, the end result is not the prevention of species extinction, but the enabling of it. The *Interim Approaches* and the current draft effects determination for chlorpyrifos lay out effects thresholds that are appropriately protective of listed species during the effects determination and consultation process.[30] Importantly, the threshold for direct effects is the concentration that would result in a one in a million chance of causing mortality to an individual or the NOAEL, whichever is lower.

Using protective toxicity thresholds is the only way EPA can make effects determinations that comply with the mandates of the ESA. As noted above, the "may affect" threshold is very low, necessitating the use of these protective toxicity values. Furthermore, as described in the consultation handbook, the "Not Likely to Adversely Affect" ("NLAA") threshold is also quite low. The Services define NLAA as "when effects on listed species are expected to be discountable, insignificant, or completely beneficial." Discountable effects are those that are extremely unlikely to occur and that the Services would not be able to meaningfully measure, detect, or evaluate" because of their insignificance.[31] In the context of pesticides, only if predicted negative effects are discountable or insignificant can the EPA avoid the need to enter formal consultations with the Services, although such a determination requires informal consultation and a written concurrence from the Services.

The one in a million threshold is widely accepted in environmental regulation and used by EPA (including the Office of Pesticides Program), Food and Drug Administration ("FDA"), European Food Safety Authority ("EFSA") and Canada's Pest Management Regulatory Agency ("PMRA") as the standard for negligible risk. Though mainly used to assess the probability of developing cancer due to chemical exposure, this negligible risk standard was adopted to reflect a risk that was so small as to not cause concern from a regulatory or public health perspective. In other words, a risk that is discountable or insignificant. The one in a million mortality threshold for "may affect" and "likely to adversely affect" reflects the

[30] EPA. Biological Evaluation Chapters for Chlorpyrifos ESA Assessment. ATTACHMENT 1-4; Process for Determining Effects Thresholds (DOCX). Available at https://www.epa.gov/endangered-species/biological-evaluation-chapters-chlorpyrifos-esa-assessment
[31] U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. *Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act*. at xv.

ESA's and the Consultation Handbook's requirements – requirements that need to be met when assessing harm to listed species.

We note that this will likely have two effects: one will be the expansion of the pesticide exposure area beyond what current EPA models show, and the other will be more "may affect" and "likely to adversely affect" findings, due to the lower threshold of toxicity.

EPA Does Not Follow The Effects Determination Process Outlined In The ESA:

In the Current Approach, EPA comes to many "may affect" findings only to revert back to a "no effect" finding after further analysis. This is not an appropriate protocol to use to determine effects to listed species. For instance in the endangered species assessment for 16 states, the EPA makes "may affect" findings for 10 species based on habitat co-occurrence with dicamba use in soy and cotton fields.[32] EPA subsequently does an additional analysis and determines that all but one should be given a "no effect" designation. Once a "may affect" finding is made, EPA cannot simply revert back to a "no effect" finding. If EPA believes that the initial "may affect" finding is discountable or insignificant, then it must make a NLAA finding. An NLAA finding requires written concurrence with the Services, an essential step in the ESA consultation process.[33]

In addition, by categorically excluding off-site transport and runoff, and by assuming that some negative impacts would not exceed levels of concern, the EPA merged the "no effect"/"may affect" inquiry with the "not likely to adversely affect"/"likely to adversely affect" inquiry of Step 2 that requires concurrence with FWS or NMFS. This is the one thing that the EPA may not do because it is not the expert agency on assessing risks to endangered species. As the federal courts have made clear, Section 7 of the ESA "requires that EPA, in contemplating even actions deemed NLAA, 'consult' with the Services to ensure that its action be not likely to jeopardize listed species."[34]

EPA makes indefensible NLAA findings.

Once EPA has determined that some species may co-occur with soybean and corn fields, they then turn to a qualitative analysis of FWS recovery plan documents to try to tease out species' habitats. To do this, they take one to two sentence narratives from these documents to support their conclusions that most species' habitat does not co-occur with soy and cotton fields. This is completely inadequate. First of all, a species habitat encompasses a broad

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[32] EPA. Memorandum. Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6 dichlorosalicylic ac id (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 16 states (Arkansas, Illinois, Iowa, Indiana, Kansas, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, orth Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin). Docket ID EPA-HQ-OPP-2016-0187-0002.

[33] 50 C.F.R. § 402.13(a).

[34] *Washington Toxics Coalition v. FWS*, 457 F.Supp.2d. 1158, 1178 (W.D. Wash. 2006); *see also Defenders of Wildlife v. EPA,* 420 F.3d 946, 961 (9th Cir. 2005); *Thomas v. Peters* 753 F.2d 754, 763 (9th Cir. 1985).

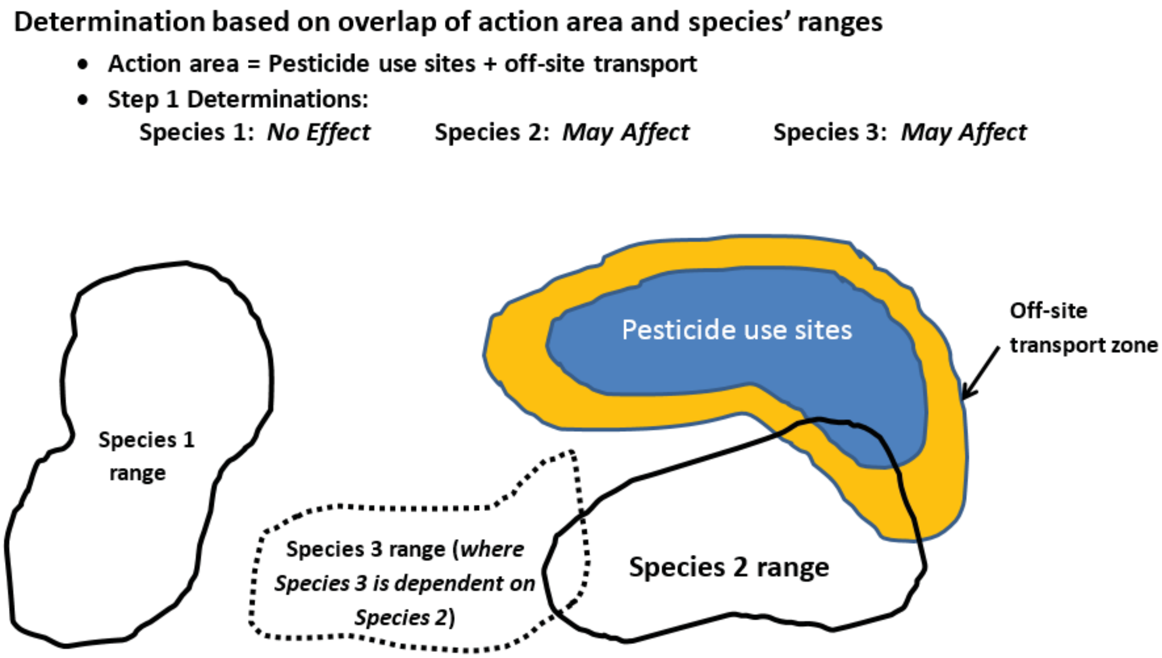
contiguous area. Just because a listed butterfly prefers open areas with wild lupines does not mean that it spends 100% of its time in those areas. Many species have to travel throughout a large area of habitat to seek food or nesting materials or a mate. Second, just because a species habitat is not directly affected does not mean indirect effects are not occurring. For example, a cave dwelling species may never leave the cave that it lives in, but its primary food source may come from outside the cave and potentially be harmed by dicamba use.

The ESA requires that EPA use the best available science to analyze effects to listed species. Descriptions of a species' habitat in written documents are not the best science available and this is not even a scientific approach. Rather, the EPA has cherry-picked a few sentences and then made a sweeping assumption about an extremely complex issue. As mentioned above, maps of species ranges and habitats have been compiled along with maps of soy and cotton fields. Once the maps of cotton and soy fields are refined to reflect true offsite migration of dicamba, a simple overlay of these two maps is all that needs to be done. It seems as though EPA is going out of its way to make this as difficult and unscientific as possible.

EPA Does Not Properly Measure Indirect Effects Or Critical Habitat Modification

In the Current Approach, EPA includes some species in the co-occurrence analysis based on possible indirect effects, however, proceeds to make "no effect" determinations if the species' habitat does not overlap with soy or cotton fields. This conveys a complete lack of understanding of how indirect effects work. The following is a figure from the chlorpyrifos draft ESA assessment conducted by EPA.[35]

[35] EPA. Biological Evaluation Chapters for Chlorpyrifos ESA Assessment. Figure 1-6 in Chapter 1. Available at https://www.epa.gov/endangered-species/biological-evaluation-chapters-chlorpyrifos-esa-assessment



Note that Species 3 habitat does not overlap with the pesticide use site, yet it still gets a "may effect" determination because it is dependent on a species that does overlap with pesticide use. This analysis was done properly, with correct assumptions being made about how species interact with one another and how seemingly safe pesticide use could have major unintended consequences.

Therefore, the Current Approach EPA uses to analyze indirect effects to listed species falls short of what is mandated under the ESA and unjustly discounts those effects. The protocol outlined in the *Interim Approaches* should be used to measure indirect effects to listed species.

Section 7 of the ESA prohibits agency actions that would result in the "destruction or adverse modification of [critical] habitat."[36] This inquiry is separate and distinct from the question as to whether a pesticide approval will result in jeopardy to any listed species. A no jeopardy finding (or a NLAA finding in an informal consultation) is *not* equivalent to a finding that critical habitat will not be adversely modified. While there is much overlap between these two categories (for example, as in *Tennessee Valley Authority v. Hill*[37] where the proposed agency action to build a dam would both destroy a species' habitat and kill individual members of the species in the same time) many agency actions do result in adverse modification to critical habitat without causing direct harms to species that do rise to

[36] 16 U.S.C. § 1536(a)(2).
[37] 437 U.S. 153 (1978)

the level of jeopardy.[38] Indeed, the ESA's prohibition on "destruction or adverse modification" of critical habitat does not contain any qualifying language suggesting that a certain species-viability threshold must be reached prior to the habitat modification prohibition coming into force.

In the current effects determination, this is completely disregarded. For example, in the ESA assessment of 16 states[39] 53 out of 59 critical habitats were judged "no modification" based on the sole criterion that the species did not use cotton or soybean fields. That is an incorrect way to come to a "no modification" determination and does not comply with the ESA.

As three federal circuit courts have made abundantly clear, avoiding a species' immediate extinction is not the same as bringing about its recovery to the point where listing is no longer necessary to safeguard the species from ongoing and future threats. Therefore, Section 7 requires that critical habitat not be adversely modified in ways that would hamper the *recovery* of listed species.[40] These potent pesticides with known adverse ecological effects have the potential to adversely modify critical habitat by altering ecological community structures, impacting the prey base for listed species, and by other changes to the physical and biological features of critical habitat. Accordingly, the informal consultation must separately evaluate whether these pesticide products and formulations will adversely modify critical habitat regardless of whether these pesticide products jeopardize a particular listed species. For example, if plant communities alongside a water body that has been designated as critical habitat suffer increased mortality, and this then results in increased temperatures or increased sedimentation, then that would represent adverse modification of critical habitat. Likewise, if pesticides are toxic to species lower in the food chain, and a threatened or endangered species feeds on those affected prey species, this impact to the food web would represent a clear example of adverse modification to critical habitat.

EPA's evaluation must address impacts to critical habitat even if the direct effects on listed species fall below the NLAA or jeopardy thresholds.

EPA Must Assess Product Mixtures

Just as the EPA must consult with the Services regarding the registration of an active pesticide ingredient, EPA must also consult with the Services regarding the registration or approval of end use and technical pesticide products. Such consultations must also occur at

[38] *See* Owen, D. 2012. *Critical Habitat and the Challenge of Regulating Small Harms*. Florida Law Review 64:141-199.
[39] EPA. Memorandum. Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6 dichlorosalicylic ac id (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 16 states (Arkansas, Illinois, Iowa, Indiana, Kansas, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, orth Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin). Docket ID EPA-HQ-OPP-2016-0187-0002.
[40] *See Gifford Pinchot Task Force v. FWS*, 378 F.3d 1059, 1069-71 (9th Cir. 2004) (finding a FWS regulation conflating the requirements of survival and recovery to be unlawful); *see also N.M. Cattle Growers Ass'n v. FWS*, 248 F.3d 1277, 1283 n.2 (10th Cir. 2001); *Sierra Club v. FWS*, 245 F.3d 434, 441-42 (5th Cir. 2001)

the earliest possible time to ensure that specific product formulations do not result in jeopardy for a listed species or adversely modify critical habitat.

In addition, because end use formulations may result in mixes of the active ingredient with "other ingredients" before application, the EPA must consider during the consultation process the effects of these "inert" or "other" ingredients together with the active ingredient on listed species and set appropriate conservation restrictions accordingly. As noted in *Washington Toxics Coalition v. U.S. Dept. of Interior*, "other ingredients" within a pesticide end product may cause negative impact to listed species even if they are less toxic than the active ingredient being reviewed.[41] "Other ingredients," such as emulsifiers, surfactants, anti-foaming ingredients, and fillers may harm listed species and adversely modify critical habitat. Many of the more than 4,000 potentially hazardous additives allowed for use as pesticide additives are environmental contaminants and toxins that are known neurotoxins and carcinogens.[42] The EPA has routinely failed to consult with the Services on the registration of "other ingredients," potentially compounding harms to listed species by allowing such ingredients to be introduced widely into the environment. EPA must, as part of the consultation process, consider the range of potential impacts by using different concentrations and different formulations of the active ingredient, as well as the potential negative impacts of "other ingredients" used in end use products.

The EPA and Services must consider the environmental baseline as well as all cumulative effects when determining if the approval pesticides, formulations, or uses will jeopardize any threatened or endangered species. The Services define environmental baseline as "the past and present impacts of all Federal, State, or private actions and other human activities in an action area, the anticipated impacts of all proposed Federal projects in an action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions that are contemporaneous with the consultation in process."[43] Cumulative effects are defined as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation."[44] Pesticide consultations must consider the interactions between the active ingredient under review and other pollutants in the present in the environment.

The Food Quality Protection Act of 1996 ("FQPA") requires EPA to measure risk of a pesticide based on "… available information concerning the cumulative effects on infants and children of such residues and other substances that have a common mechanism of toxicity." The EPA has interpreted this to mean that only pesticides with a common

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[41] 457 F. Supp. 2d 1158 (W.D. Wash 2006).
[42] Draft BiOp at 113, lines 4062-68; 120-121, lines 4262-308; 127, lines 4445-4455; Northwest Coalition for Alternatives to Pesticides, et al., Petition to Require Disclosure of Hazardous Inert Ingredients on Pesticide Product Labels. 2006. http://www.epa.gov/opprd001/inerts/petition_ncap.pdf.
[43] *Id*. at xiv.
[44] *Id*. at xiii.

mechanism of action be assessed in a cumulative risk assessment. We strongly disagree with this interpretation. First, the term "other substances" can include chemicals other than pesticides and also stressors that are not chemicals, like radiation and climate change. The EPA itself defines cumulative risk as "the combined risks from aggregate exposures to multiple agents or stressors," where agents or stressors can be chemicals or "may also be biological or physical agents or an activity that, directly or indirectly, alters or causes the loss of a necessity such as habitat."[45] Second, the term "common mechanism of toxicity" does not dictate that the EPA only consider agents or stressors with a common mechanism of action. The National Research Council has recommended that the EPA use the endpoint of common adverse outcome rather than common mechanism of action to group agents that could act cumulatively.[46] EPAs European counterpart, EFSA, has announced that it intends to measure cumulative risk based on cumulative assessment groups. EFSA notes that this new methodology "….rests on the assumption that pesticides causing the same specific phenomenological effects, well defined in terms of site and nature, can produce joint, cumulative toxicity – even if they do not have similar modes of action."[47]

As for how this relates to EPA's duty under the ESA, cumulative risk in the ESA needs to be interpreted very broadly as this piece of legislation is a precautionary document meant to ensure that no harm comes to listed species. Although the EPA interprets the scope of cumulative risk assessments under FQPA to be limited to the common mechanism effect, **there is absolutely no such written or intended limit in the ESA**. The EPA needs to begin discussions on how it will test true cumulative risk, the way it is broadly defined in the ESA, because current metrics and protocols that measure cumulative risk under FQPA are inadequate for the EPA to meet its legal obligations under the ESA.

Pesticides and their residues and degradates do not occur in single exposure situations and many different mixtures of pesticides occur in water bodies at the same time.[48] The mixtures of these chemicals can combine to have additive or synergistic effects that are substantially more dangerous and increase the toxicity to wildlife.[49] Thus, to fully understand the ecological effects and adverse impacts, the EPA and the Services must consider the pesticide's use in the context of *current* water quality conditions nationwide. In particular, the use of pesticides in watersheds that contain threatened or endangered species

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[45] U.S. Environmental Protection Agency 2003. Framework for Cumulative Risk Assessment. U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, Washington Office, Washington, DC, EPA/600/P-02/001F, 2003. Pg. xvii.

[46] National Research Council (US) Committee on the Health Risks of Phthalates. Phthalates and Cumulative Risk Assessment: The Tasks Ahead. Washington (DC): National Academies Press (US); 2008. Page 4.

[47] EFSA. Press release. Pesticides: breakthrough on cumulative risk assessment. Available at: http://www.efsa.europa.eu/en/press/news/160127. Accessed 1/28/2016.

[48] NMFS 2011, *Endangered Species Act Section 7 Consultation Draft Biological Opinion for the Environmental Protection Agency's Pesticide General Permit for Discharges from the Application of Pesticides (*hereafter Draft BiOp) at 118-119, lines 4209-31; Gilliom, R.J. et al. 2006. *Pesticides in the Nation's Streams and Ground Water, 1992–2001—A Summary*, available at http://pubs.usgs.gov/fs/2006/3028/.

[49] Draft BiOp at 127-129, lines 4471-4515; Gilliom, R.J. 2007. *Pesticides in the Nation's Streams and Ground Water*; Environmental Science and Technology, 413408–3414.

and where water quality is already impaired could be particularly problematic. Therefore, the agencies must use the best available data to fully inform its ecological risk assessment by considering water quality.

The EPA must also analyze the mixtures of dicamba and other active ingredients, such as glyphosate to be compliant with the ESA. More information on this is discussed below.

In conclusion, the EPA should obtain the needed spatial data from within its own agency to make an informed "no effect" or "may affect" finding for *each* listed species that will likely overlap with the use of these pesticides or come into contact with its environmental degradates. If there is overlap, EPA must at a minimum conclude that the use of these pesticides "may affect" listed species. Where this occurs, EPA has a choice—(1) the EPA can elect to complete an informal consultation through a biological assessment (also known as a biological evaluation), or (2) the EPA can undergo formal consultation with the Services. If EPA completes a biological assessment and implements geographically-tailored conservation measures through *Bulletins Live! Two*, it may be able to reach NLAA determinations via the informal consultation process and alleviate the need for formal consultations. In the alternative, the EPA can move directly to formal consultation after making "may affect" determinations for species where the impacts of pesticides are more complex and will take additional expertise to develop sufficient conservation measures.

The NAS report recognized that without real-world considerations of where listed species are located, the relative conservation status of listed species, the environmental baseline, and the interaction of pesticides with other active ingredients, pesticide degradates, and other pollutants, the EPA risk assessment process will not be able to make meaningful predictions about which endangered species will be adversely affected. Until the EPA can conduct realistic assessments, it should take a precautionary approach and enter into formal consultations with the Services as outlined in the *Interim Approaches* document. Implementing the recommendations above will help ensure that the EPA meets its obligations under both FIFRA and the ESA.

<u>THERE ARE SERIOUS CONCERNS WITH EPA'S RISK ASSESSMENT METHODS</u>

The Current Process For Evaluating New Uses

We find it odd that Monsanto has decided to apply for a new use for dicamba with a single product (M1691 Herbicide EPA Reg. No. 524-582) that, quite frankly, won't have much utility for farmers. Dicamba is not an herbicide that will be particularly effective at controlling weeds in cotton and soybean fields alone. It is a broadleaf herbicide that has very little activity against weeds that farmers will commonly encounter, such as ryegrass in cotton fields.[50]

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[50] EPA. Memorandum. Review of Benefits as Described by the Registrant of Dicamba Herbicide for Postemergence Applications to Soybean and Cotton *and* Addendum Review of the Resistance Management Plan as Described by the

It's no secret that the entire point of this new use application is so that Monsanto can sell a companion product for its dicamba/glyphosate resistant soybean and cotton seeds, likely to be named Roundup® Xtend, that will contain both dicamba and glyphosate in the same formulation. Yet it has decided to go through the process of getting the new use registration for a product that has only one active ingredient and a mildly restrictive label (no tank mixing with other herbicides allowed) presumably to make it through the "new use" registration process more easily. If the new use registration is finalized, the Roundup® Xtend product may go through the much less rigorous process of "product registration." This is very troubling for multiple reasons:

1) Under FIFRA, every pesticide registration is a cost-benefit analysis. By splitting up the approval of Roundup® Xtend between the new use registration and the product registration, the environmental costs associated with the use of this product will likely be split between the two and, ultimately, diluted out. The costs of 1) the "over-the-top" use and 2) the synergistic/additive action of the two active ingredients used together will, therefore, be assessed separately. While at the same time, the purported benefits (i.e. use on glyphosate resistant weeds, reduced tillage) will likely be the same with the new use registration and the product registration. So the costs get split up while the benefits remain the same. The benefits that were used in the new use registration of dicamba cannot simply be reused in a possible product registration of Roundup® Xtend. Those benefits were already taken into account and weighed against the costs of the over-the-top use. Therefore, the only benefit that should be taken into account in any possible product registration decision for Roundup® Xtend is the convenience of having these two ingredients premixed in one formulation (not much of a benefit when weighed against the costs of synergistic/additive toxicity, as discussed below).

2) If history is any indication, any possible product registration decision for Roundup® Xtend may not go through public comment. In the past, EPA has often registered single ingredients for use with stakeholder comments only to later approve labels of specific formulations that contain multiple active ingredients without a public comment period. In fact, a conditional registration was granted for the M1769 Premix Herbicide[51] that contains both dicamba and glyphosate without any public comment period that we're aware of. It is unclear if the conditions of this registration have been met, or if synergistic/additive effects of dicamba and glyphosate were analyzed for this product registration. This is in direct conflict with an open and accountable process for pesticide approvals and it would be especially glaring if this same thing were to happen with Roundup® Xtend or if the existing M1769 label were to simply be amended to include over-the-top use of dicamba.

Registrant of Dicamba Herbicide for Use on Genetically Modified Soybean and Cotton. Document ID EPA-HQ-OPP-2016-0187-0012. Page 3.

[51] M1769 PREMIX HERBICIDE. Monsanto Co. EPA Registration Number: 524-616. Conditional Registration granted 4/22/2014. Label available at https://www3.epa.gov/pesticides/chem_search/ppls/000524-00616-20140422.pdf

Last year Dow Agrosciences applied for registration of a product similar to Roundup® Xtend called Enlist Duo®, which combined glyphosate with 2,4-D. The process that Dow went through to gain approval of Enlist Duo® was consistent with its intentions. We strongly disagree with EPA's decision to register it, but, nevertheless, combining the registration of the signature product with the new use registration allowed for stakeholders to grasp the big picture of how a registration decision would impact pest management techniques and human and environmental health. Splitting up this process undermines EPA's ability to accurately assess the costs and benefits associated with registration and deprives stakeholders the ability to meaningfully comment on the big picture of how this registration will negatively impact farming, human health and the environment. At the very least, we urge EPA to open up a public comment period for any product that contains dicamba mixed with another active ingredient and, moving forward, hope EPA will put safeguards in place to ensure that the system cannot be "gamed," so to speak, for future registration decisions.

Literature Review

It is essential that the EPA have every bit of information available in order to make an informed decision on the risk of exposure to pesticides. The EPA must require that that the registrant provide all necessary data and studies, including, but not limited to any previously identified data or study gaps, additional studies to evaluate effects on pollinators in accordance with the *Guidance for Assessing Pesticide Risks to Bees,*[52] information concerning estrogen or other endocrine disruption effects,[53] and any information that this pesticide may have synergistic effects. Moreover, without a catalogue of the studies that were analyzed in the open- and gray-literature, it is impossible to determine why certain studies were not utilized for this risk assessment. An open and transparent literature review is vital to ensuring that all applicable studies were analyzed, not just industry-funded guideline studies.

Industry-funded studies are furnished to the EPA for analysis, but data from third party researchers generally have to be searched for in databases. This creates a bias in the studies that EPA analyzes because there is always the potential that third party research may be missed or wrongly discounted. Furthermore, the funding source of a study can create a bias that is more favorable towards the desired outcome of those who fund the research.[54] This makes it extremely important that all available studies are analyzed, so as to mitigate any bias associated with the risk assessment. Without further information it is impossible to tell if there were any studies that were missed or whether any were wrongly discounted.

Before a registration decision is made, EPA needs to provide to the public:

1) The databases that were searched for open- and gray-literature studies
2) The search terms used to identify those studies and the dates the searches were conducted

[52] EPA 2014. Guidance for Assessing Pesticide Risks to Bees. Available at https://www.epa.gov/sites/production/files/2014-06/documents/pollinator_risk_assessment_guidance_06_19_14.pdf
[53] *See* 21 U.S.C. §§ 346a(d)(2)(A)(x) and 346a(p).
[54] Boone, M., et al., *Pesticide Regulation amid the Influence of Industry.* Bioscience, 2014. 64(10): p. 917-922.

3) An appendix listing all of the publications that were found in the literature search
4) A brief description of why any study was eliminated from review for the risk assessment, why a study was deemed qualitative instead of quantitative, any potential source of study bias (including the funding source), and the relative weight each study was given in any weight of evidence analysis.

This added transparency will help ensure that comprehensive literature searches are carried out and that all relevant studies are analyzed before a registration decision is made. Additionally, the NAS has recommended to the EPA that stakeholders be given the opportunity to comment on data collection at the earliest stage and throughout the risk assessment process.[55] We are simply asking for the EPA to be more transparent with this vital part of the risk assessment process.

Increased Use

The EPA's risk assessment approach is not designed to analyze risk due to increased total usage of a pesticide compared to current levels. It is simply designed to estimate exposure to a single chemical based on labeled usage rates on specific crops. This exposes one of the great shortcomings in EPA's risk assessment approach – it is very short sighted. It takes a narrow approach to assess risk without taking into account the bigger picture of total usage of a particular pesticide or combined usage of multiple pesticides. Therefore, risk is typically underestimated and potential increases in total pesticide usage are not accurately assessed for potential harms.

The EPA recognizes this and states that "[a]lthough the risks, based on standard risk assessment methods used by the Environmental Fate and Effects Division (EFED), are not expected to differ from the previous assessment done for dicamba use on soybeans (because the rates are similar to those already assessed), there is potential for other ecological concerns that would not normally be captured using our standard risk assessment methods. These concerns are related to a potential increase in usage of dicamba products and the proposed changes in the timing of applications."[56] And, "[t]hough the rates are similar to those in currently registered dicamba pesticide products, there is potential for ecological concerns related to a potential increase in acres treated with dicamba products, resulting in additional acres with residues of DCSA in dicamba-tolerant soybeans."[57]

It is incredibly likely that this proposed "new use" dicamba approval will result in increased usage of dicamba on cotton and soybean. The EPA cites a government testimony and a personal

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[55] National Academy of Sciences. 2013. *Assessing Risks to Endangered and Threatened Species from Pesticides*, Committee on Ecological Risk Assessment under FIFRA and ESA Board on Environmental Studies and Toxicology Division on Earth and Life Studies National Research Council (April 30, 2013). Page 45.
[56] EPA. Memorandum. Ecological Risk Assessment for Dicamba and its Degradate, 3,6-dichlorosalicylic acid (DCSA), for the Proposed New Use on Dicamba-Tolerant Soybean (MON 87708). Docket ID: EPA-HQ-OPP-2016-0187-0008.
[57] EPA. Proposed Registration of Dicamba on Dicamba-Tolerant Cotton and Soybean. Docket ID EPA-HQ-OPP-2016-0187-0016.

communication to support this position,[58] however, more lines of evidence exist.[59] Furthermore, Monsanto did an analysis on possible future increase in use of dicamba for USDA when applying for deregulation of genetically engineered ("GE") dicamba/glyphosate resistant soybean and cotton. Monsanto predicted that annual commercial dicamba use on soybeans would increase from 233,000 pounds in 2011 to 20.5 million pounds at the time of peak (40%) GE crop adoption.[60] This is a nearly 100-fold increase in dicamba usage just on soybean and could be even higher if these GE crops are more widely adopted. Similar projections were made for dicamba use on cotton from 364,000 pounds applied annually in 2011 to 5.2 million pounds at the time of peak (50%) adoption.[61] Assuming peak adoption of dicamba resistant soybean and cotton would occur in the next 3-4 years, the U.S. is looking at a more than 25 million pound increase in dicamba usage for these two crops by 2020.

Although this is likely an underestimate, as crop adoption rates may be much higher and current labels urge users to spray higher than typical rates to slow weed resistance, it is a starting point for the EPA to begin to analyze the effects of total pesticide load on human and environmental health. This increase in dicamba usage would not likely displace other herbicide use. The EPA needs to view registration decisions as not only a way to analyze the effects of labeled pesticide usage, but also as a way to ensure that total pesticide use does not increase. The EPA could take this into account in the cost-benefit analysis by analyzing the associated costs of labeled pesticide use as well as the costs associated with total pesticide load in the environment.

The Use Of Historical Controls

Concurrent controls are always the best cohort to use. If there is reason to believe that the concurrent control data are significantly out of line with recent historical control data and may not be representative of a true control cohort, then historical control data may be used to inform the interpretation of study data. But extreme care needs to be taken, as a scientist or a regulatory agency may be tempted to use the control cohort that will give an anticipated or desirable outcome. This is why guidelines with specific protocols need to be developed and followed if concurrent control data are suspect.

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[58] EPA. Memorandum. Ecological Risk Assessment for Dicamba DGA Salt and its Oegradate, 3,6-dichlorosalicylic acid (DCSA), for the Proposed Post-Emergence New Use on Dicamba-Tolerant Cotton (MON 8770 I). Docket ID EPA-HQ-OPP-2016-0187-0005. Page 36.

[59] Mortensen, DA, Egan, JF, Maxwell, BD, Ryan, MR, Smith, RG. Navigating a Critical Juncture for Sustainable Weed Management. BioScience (2012) 62 (1): 75-84. doi:10.1525/bio.2012.62.1.12. and Bohnenblust, EW, Vaudo, AD, Egan, JF, Mortensen, DA, Tooker, JF. Effects of the herbicide dicamba on nontarget plants and pollinator visitation. Environ Toxicol Chem. (2016) 35(1): 144-51. doi: 10.1002/etc.3169.

[60] USDA. *Monsanto Petitions (10-188-01p and 12-185-01p) for Determinations of Nonregulated Status for Dicamba Resistant Soybean and Cotton Varieties. Final environmental impact statement. EIS appendix, Table 4-9 and page 4-16.* 2014; Available from: http://www.aphis.usda.gov/brs/aphisdocs/dicamba_feis_appendices.pdf.

[61] USDA. *Monsanto Petitions (10-188-01p and 12-185-01p) for Determinations of Nonregulated Status for Dicamba Resistant Soybean and Cotton Varieties. Final environmental impact statement. EIS Appendix, Table 4-12 and page 4-19.* 2014; Available from: http://www.aphis.usda.gov/brs/aphisdocs/dicamba_feis_appendices.pdf.

In the current risk assessment, EPA states that: "The screening-level risk assessment for the proposed new use on soybeans (USEPA, 2011. D378444) used the chronic endpoint from the rat 2-generation study (MRID 43137101), a NOAEL of 45 mg/kg-bw, based on decreased pup weight at 136 mg/kg-bw compared to the concurrent controls. The Health Effects Division (HED) recently reanalyzed the data from this study (USEPA, 2016a; D431873) in comparison to the historical control database range and determined that the NOAEL and LOAEL should be raised to 136 and 450 mg/kg-bw, respectively, because pup weights in each generation in the 136 mg/kg-bw treatment group were within the historical control range and above the historical control mean for the F1, F2A and F2B generations."[62]

EPA currently has some internal guidance on how to use historical control data in assessing tumor development that could also be used in assessing pup weight.[63] This guidance states that "Generally speaking, statistically significant increases in tumors should not be discounted simply because incidence rates in the treated groups are within the range of historical controls or because incidence rates in the concurrent controls are somewhat lower than average. Random assignment of animals to groups and proper statistical procedures provide assurance that statistically significant results are unlikely to be due to chance alone." But if historical control data are to be used, then "The most relevant historical data come from the same laboratory and the same supplier and are gathered within 2 or 3 years one way or the other of the study under review; other data should be used only with extreme caution."[64]

From the information given in the risk assessment, it is impossible to tell whether EPA is following its own guidelines or those of internationally recognized organizations like the Organisation for Economic Co-operation and Development (OECD).[65] More information needs to be available to the public regarding the historical control data that were used; including a detailed explanation of why concurrent control data were deemed insufficient and detailed information on the animals used in the historical control cohort.

Herbicide Resistance Management

Due to the indiscriminate use of glyphosate over vast acreage of Roundup Ready® crop monocultures, glyphosate-resistant weeds have evolved and are now present on an estimated 100

[62] EPA. Memorandum. Ecological Risk Assessment for Dicamba DGA Salt and its Oegradate, 3,6-dichlorosalicylic acid (DCSA), for the Proposed Post-Emergence New Use on Dicamba-Tolerant Cotton (MON 8770 I). Docket ID EPA-HQ-OPP-2016-0187-0005. Page 12.
[63] EPA. (2005) Guidelines for Carcinogen Risk Assessment. EPA/630/P-03/001F, Accessed at: https://www.epa.gov/sites/production/files/2013-09/documents/cancer_guidelines_final_3-25-05.pdf
[64] *Id*. at 2-21
[65] OECD. (2012) Guidance Document 116 on the Conduct and Design of Chronic Toxicity and Carcinogenicity Studies, Supporting Test Guidelines 451, 452 and 453, 2nd Edition Series on Testing and Assessment No. 116. Avail. at: http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/JM/MONO(2011)47&doclanguage=en

million acres in 36 different states.[66] So far, these herbicide resistant weeds have cost farmers more than $1 billion in damages[67] and have increased costs to farmers by as much as 7-fold.[68]

The proposed Herbicide Resistance Management ("HRM") plan is insufficient to deal with the current and future problem of dicamba resistance in weed species. EPA acknowledges that weed resistance is a significant problem and that certain populations of weeds that occur in soybean and cotton fields have **already** developed resistance to dicamba.[69] The HRM plan provides absolutely no resistance *prevention* strategies. Resistance prevention is really where the focus needs to be; after all, preventing weed resistance is much more efficient and beneficial than managing the resistant species that are certain to develop.

There are some weak label requirements designed to prevent weed resistance from *spreading*. These requirements are, of course, dependent on individual farmers' vigilance. Some farmers are likely to be very vigilant in scouting for dicamba "lack of performance," while others will be less so. This decentralization of oversight will likely hamper management efforts and regionalize the severity of resistance that develops.

Furthermore, Monsanto has been put in control of confirming and reporting any dicamba weed resistance to the EPA -- and the proposed registration may terminate in 5 years if EPA determines that this a problematic issue. It will, therefore, be in Monsanto's best financial interest if there are no weed resistance issues that are reported. This sets up an inherent conflict of interest that should preclude Monsanto from being involved in this important data-gathering step. Monsanto, of course, should foot the bill, but a third party needs to do this analysis so as to avoid the inherent conflict of interest this situation presents.

This data-gathering step on the spread of dicamba resistance in the HRM plan is a baby step in the right direction, but without any serious *prevention* strategies, we are unsure what it will accomplish in the grand scheme of things. Having data to analyze doesn't really provide much comfort when the problem has already spread and is too late to stop. In addition, all of the data collected will be reliant on individual reporting, a very unreliable source of information that will lead to significant underestimation of the true scope of the problem.

Sure, Monsanto will have to set up a website and a hotline, but other than that most of the responsibility for identifying and reporting weed resistance is placed squarely on the farmer or user.

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[66] Landrigan, PJ, Benbrook, CM. GMOs, Herbicides, and Public Health. *New England Journal of Medicine*. 2015. Available at: http://www.nejm.org/doi/full/10.1056/NEJMp1505660.
[67] Koba, M. 'Superweeds' Sprout Farmland Controversy Over GMOs. NBC News. 2014. Available at: http://www.nbcnews.com/business/economy/superweeds-sprout-farmland-controversy-over-gmos-n214996.
[68] Service, RF. What Happens When Weed Killers Stop Killing? *Science*. 2013. Available at: http://science.sciencemag.org/content/341/6152/1329.
[69] EPA. Proposed Registration of Dicamba on Dicamba-Tolerant Cotton and Soybean. Docket ID EPA-HQ-OPP-2016-0187-0016. Page 24.

Farmers have enough to worry about during the growing season, including ensuring that they are in compliance with pesticide labels that can be 80 pages or longer and incredibly complex. So now not only will farmers be on the hook for label compliance, but also for preventing the spread of herbicide resistant weeds. This HRM plan continues the troubling trend of farmers and users bearing all of the responsibility for ensuring that pesticides are used in a lawful manner while the companies that are profiting off of the sale of these pesticides get to wash their hands of any meaningful responsibility once a pesticide is registered.

The HRM plan is reactionary as opposed to proactive. It needs better resistance *prevention* strategies, including a requirement that dicamba be used only as a last resort as part of an integrative pest management strategy. The prophylactic use of herbicides is a key driving factor in weed resistance and this problem cannot be tackled if current agricultural practices are allowed to continue.

Moreover, the EPA's proposed registration is vague as to the expiration of the registration after 5 years. If the EPA decides to register this new use of dicamba, which the Center opposes without lawful compliance with the ESA and supportable risk assessment, the EPA must clarify that the expiration at the end of 5 years is a term of registration and would occur without any additional process. If it does not, the EPA will be in the same situation it has experienced with its conditional registration of flubendiamide.[70] In addition, the EPA must provide additional public participation if it intends to remove the 5 year expiration date as a term of the registration and set forth what criteria would warrant allowing an extension of the registration.

Mixtures

EPA states that "The current draft label for dicamba use on tolerant soybean and cotton plants specifies that tank mixes may only be used for products that have been tested and found not to have unreasonable adverse effects on the spray drift properties of M1691 Herbicide. EFED believes that guideline laboratory studies of effects to terrestrial plants should be required for any product or tank mixture combining dicamba and other active ingredients to assess risks associated with any tank mixture for use on dicamba-tolerant soybeans or cotton. Testing of such products should include the standard suite of tested species from the already submitted dicamba and tank mixed active ingredient vegetative vigor studies as well as those that the open literature and patent data indicate potential for synergistic effects."[71]

We are optimistic that EPA is beginning to take the issue of pesticide mixtures seriously, as this is the strongest language we've seen from EPA concerning data requirements for co-applied pesticides. These required studies, as well as studies in the primary literature and data from patents

[70] Bayer CropScience LP et al., EPA Docket Number FIFRA-HQ-2016-0001.
[71] EPA. Memorandum. Dicamba DGA: Second Addendum to the Environmental Fate and Ecological Risk Assessment for Dicamba DGA salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA) for the Section 3 New Use on Dicamba-Tolerant Soybean. Docket ID EPA-HQ-OPP-2016-0187-0007. Page 22.

that make claims of synergy, need to be analyzed before any registration decision can be made for a product that contains multiple active ingredients or label language allowing co-application of any ingredient.

In the current proposed registration decision EPA also states that "[h]owever, at this time, the topic of synergy and multiple stressors is an uncertainty in assessing risk to non-target plants including endangered species. Therefore, EPA is proposing a tank mix prohibition on the M1691 label to address this uncertainty."[72] **Unfortunately this is not correct**. The label language for M1691 states "RESTRICTIONS: DO NOT TANK MIX ANY OTHER <u>HERBICIDE</u> WITH M1691 HERBICIDE."[73] So any pesticide that is not categorized as an herbicide would be able to be tank mixed with this product under the current draft label language.

It is incorrect to assume that just because a pesticide has not been designed to kill plants means that it does not. In fact, it is well known that certain insecticides and fungicides can act synergistically with one another to kill insects.[74] So just because a particular pesticide is categorized as only killing insects or fungi or plants, does not mean that there is no crossover in toxicity. The same goes with dicamba: other pesticides could work synergistically with dicamba to kill plants and/or dicamba could work synergistically with other pesticides to kill insects or other animals. Until such possibilities are ruled out, more restrictive label language should be applied (see below).

The proposed label also states that the "M1691 Herbicide may only be tank-mixed with adjuvants that have been tested and found by EPA not to have an unreasonable adverse effect <u>on the spray drift properties</u> of M1691 Herbicide."[75] This language only restricts tank mixing with adjuvants that affect the spray drift properties of the herbicide, not the *toxicity* of the herbicide. There are many claims of synergistic toxicity with dicamba and adjuvants or inerts in patent applications (see below). Therefore, until all of those claims are assessed, more restrictive label language needs to be applied.

Furthermore, prohibiting tank mixing does not preclude someone from spraying their field with dicamba in one pass and then making another pass with another herbicide. Dicamba and glyphosate tolerant cotton and soybeans have already been deregulated and sold to farmers for the 2016 growing season. If this new dicamba use is approved, there will be an extensive amount of co-application of herbicides (possibly not in the same tank, but on the same field within a short period

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[72] EPA. Proposed Registration of Dicamba on Dicamba-Tolerant Cotton and Soybean. Docket ID EPA-HQ-OPP-2016-0187-0016. Page 21-22.
[73] Draft M1691 Herbicide label. EPA Reg. No. 524-582. Docket ID EPA-HQ-OPP-2016-0187-0015. Page 4. Emphasis added.
[74] Pilling, ED, Jepson, PC. Synergism between EBI fungicides and a pyrethroid insecticide in the honeybee (*Apis mellifera*). *Pesticide Science* (1993) 39 (4): 293–297 and Zhu, W, Schmehl, DR, Mullin, CA, Frazier, JL. Four Common Pesticides, Their Mixtures and a Formulation Solvent in the Hive Environment Have High Oral Toxicity to Honey Bee Larvae. *PLoS One*. (2014) 9(1):e77547. doi: 10.1371/journal.pone.0077547.
[75] Draft M1691 Herbicide label. EPA Reg. No. 524-582. Docket ID EPA-HQ-OPP-2016-0187-0015. Page 4. Emphasis added.

of time of one another). Whether these herbicides are applied at the exact same time or within a couple days of each other, the same toxicity concerns are possible. Once again, more restrictive label language needs to be applied.

The proposed label language is clearly not as restrictive as it needs to be to ensure product safety. The draft label language for the M1691 Herbicide should be amended to read:

- "No herbicide, insecticide, fungicide or other pesticidal active ingredient or adjuvant may be applied in the same area as this product in the same growing season."

Since mixture toxicity has not been assessed, the above label language would be a necessary change to adequately protect human and environmental health.

As mentioned above, a dicamba/glyphosate co-formulation is the impetus for this new use application and is the product that will likely account for the bulk of new dicamba use if it is approved. Therefore, it is absolutely essential that EPA analyze all available data and require additional study to assess potential synergistic and additive effects from mixtures. From the above quoted language used in the current risk assessment, it appears that EPA is committed to doing this.

The EPA has indicated its awareness of the Dow Agrosciences LLC patent[76] claiming synergy between glyphosate and dicamba for multiple species of plants in the risk assessment.[77] Although Dow is not the applicant for this new use, they did try, unsuccessfully, to patent the combination of these two chemicals for use on certain weeds. In doing so, they generated experimental data indicating that glyphosate and dicamba were able to synergistically kill certain plant species.

It is important to be aware that patent applications are very different from scientific publications. The latter are very descriptive and data intensive, while the former provide the bare minimum of information required to convince the patent office that their claim is legitimate. This does not mean that experimental data provided in patent applications are somehow less scientifically valid, only that more data may be available from the patent applicant/assignee than was provided to the patent office. In many cases the patent applicant/assignee will have additional data on synergism in their possession, as extensive experimentation is usually done before a company will invest the time and money to develop a product that they intend to market. Therefore, the EPA should make every effort to attain all of the necessary data from patent holders before an analysis of synergy is performed.

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[76] Satchivi, N and Wright, T. Synergistic herbicidal composition containing a dicamba derivative and a glyphosate derivative. Untied States patent publication no. US 20110275517 A1. Application number US 13/099,552. 10 November 2011.

[77] EPA. Memorandum. Dicamba DGA: Second Addendum to the Environmental Fate and Ecological Risk Assessment for Dicamba DGA salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA) for the Section 3 New Use on Dicamba-Tolerant Soybean. Docket ID EPA-HQ-OPP-2016-0187-0007. Page 22.

In addition to the primary literature and Dow patent that EPA cited in regards to mixture toxicity of glyphosate and dicamba, a patent by Monsanto is available that makes findings of synergy for dicamba and glyphosate (Appendix A).[78] In Example 8 of this awarded patent, the inventors state: "Further, it has unexpectedly been found that dicamba in combination with glyphosate allows control of glyphosate tolerant and susceptible weeds at lower application rates." When the Colby equation[79] is applied to the data provided in Table 8 of this patent, synergy is evident for some conditions even though it is not directly stated or measured by the applicants. This document covers the patent space on synergy between dicamba and glyphosate and was one of the reasons that Dow's patent application was ultimately rejected by the U.S. patent office (Appendix B).[80]

A couple of things should be kept in mind when analyzing this patent. 1) Although the available experimental data indicate that synergy is only occurring on glyphosate resistant marestail, the chemical concentrations used are too high to make any meaningful conclusions regarding glyphosate tolerant marestail. The applicant, Monsanto, is likely in possession of further data that was not included in the patent for the reasons outlined above and the fact that they state in the patent that this combination allows control of "glyphosate tolerant ***and*** susceptible weeds at lower application rates." (Example 8, emphasis added). 2) This patent does not diminish the data provided in the Dow patent application, it only means that Monsanto was the first to make the claim.

It appears that Monsanto did not furnish these data to the EPA even though they relate directly to this registration application. Furthermore, these data were likely not furnished to the EPA before the approval of the M1769 Premix Herbicide[81] that was conditionally registered in 2014. Pursuant to 40 CFR §159.195(a)(3) the registrant is required to submit information that indicates "Use of a pesticide may pose any greater risk than previously believed or reported to the Agency."

As long as there is no enforcement of this provision, registrants will continue to be non-compliant. It happened with Enlist Duo® and countless times before and it's happening right now. Chemical companies are using synergy to demonstrate that chemical combinations have some sort of novelty associated with them and are, therefore, patentable; yet when it comes to the toxicities associated with this synergy, somehow this information never makes it to the EPA.

Dicamba synergy does not stop with glyphosate. There are patents that make synergy claims for dicamba and other active ingredients, adjuvants and inerts. In fact, with just ten minutes of searching the U.S. Patent and Trademark Office database, we found many patents that identify synergistic interactions between dicamba and other pesticides, adjuvants and commonly used inerts.

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[78] Feng, PCC, Brinker, RJ. METHODS FOR WEED CONTROL USING PLANTS HAVING DICAMBA-DEGRADING ENZYMATIC ACTIVITY. Applicant: Monsanto Technology LLC. Patent number RE45048.
[79] Colby, S. R. 1967. Calculation of the synergistic and antagonistic response of herbicide combinations. Weeds 15:20-22.
[80] USPTO. Final rejection letter for application no. 13/099,552. Examiner Andriae Holt. 7/07/2014
[81] M1769 PREMIX HERBICIDE. Monsanto Co. EPA Registration Number: 524-616. Conditional Registration granted 4/22/2014. Label available at https://www3.epa.gov/pesticides/chem_search/ppls/000524-00616-20140422.pdf

Nonetheless, searching for patents can be a very difficult process that takes considerable time and knowledge. Many times the pesticide is not referred to by name in the patent, making a simple keyword search insufficient to identify all applicable patents. The EPA should not rely on stakeholders to provide all of the necessary information from patent applications, but rather a protocol needs to be developed to guide this process that places the burden to produce this information where it belongs – on the applicant.

1) Applicants need to be made aware that failure to submit relevant data to the EPA will be a violation of their duties under Section 6(a)(2) of FIFRA. When applicable, enforcement should be pursued.
2) To identify patent data that are not affiliated with the pesticide registrant, EPA needs to use a stepwise approach of doing a keyword and structure search for patents concerning the pesticide of interest followed by a rigorous analysis of the claims in the patent.
3) Any claims of synergy need to be assessed for relevance given the label restrictions for the pesticide (or lack thereof) and the inert ingredients that are present in any formulation up for approval.
4) Appropriate measures need to be taken to ensure that any registration decision is compliant with FIFRA. This may include label restrictions on mixing, increased in-field buffers, lower application rates or even cancellation.

We realize this gets very complicated due to the sheer number of pesticide combinations that are possible, but this is a problem of EPA's own making. This agency has been way too lenient on tank mixing and coapplication of pesticides and adjuvants, rarely putting any restrictions on what a pesticide can be mixed with in the field. In the past, the EPA has been reluctant to analyze the effects of chemical mixtures, citing lack of experimental data to come to a scientifically defensible conclusion. Fortunately, it is evident from patent applications that pesticide registrants have these data available for the EPA to analyze. This is a previously unknown and unappreciated source of much needed data.

The real problem, however, is that when assessing pesticide mixtures, the EPA treats the *lack of data* the same way it would treat a conclusive negative result. The outcome for both is to allow a particular pesticide use to occur. When there are no data available, a scientifically defensible conclusion is impossible. Assuming "no enhanced toxicity" of a mixture is just as scientifically indefensible as assuming "enhanced toxicity." The only difference is that one is a cautious approach and the other is a risky approach.

Conclusions

While the Center is very encouraged that the EPA has finally recognized that it must comply with the ESA when it registers new pesticide products and uses under FIFRA, the EPA's determination that this new dicamba use would not adversely affect any endangered species is not based on the plain language of the ESA, the best available science, is otherwise not supported by substantial evidence and is arbitrary and capricious. Dicamba will have impacts on listed species and triggers the may affect requirement for Section 7 consultations under the ESA. There are also serious issues regarding mixtures and methodologies that similarly need to be addressed in order appropriately assess risk.

Respectfully submitted,

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May 27, 2016

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Docket: EPA-HQ-OPP-2016-0187
Dicamba: New Use on Herbicide-Tolerant Cotton and Soybeans

Kalsec, Inc. very much appreciates the opportunity afforded by the US EPA to comment on the proposed decision to register dicamba for use on genetically engineered crops. We are opposed to such expanded use in the absence of more serious consideration and amelioration of issues related to dicamba residue levels in off target crops.

Kalsec, Inc. is an agriculturally based and dependent company that manufactures spice, herb and vegetable extracts for the food and beverage industry. Our products are highly functional colors, flavors, antioxidants, and nutritional ingredients that are sold globally. We operate our own farming facilities in Texas, and work closely with contracted farmers in Oklahoma and elsewhere in the US and around the world. We grow highly specialized crops, namely, rosemary, chillies, carrots and paprika in close proximity to large operations where cotton and soybeans are grown. Our manufacturing process can concentrate pesticide residues in our extract products, including those resulting from overspray.

The proposed regulatory decision to register dicamba to control weeds in cotton and soybean that has been genetically engineered to tolerate dicamba is highly problematic for us. Sufficiently high levels of overspray may kill our plants or damage them in ways which reduce yield. More importantly, even if plants survive, overspray and other forms of pesticide drift will have a negative impact on our operations due to unintentional and unavoidable contamination of our crops and downstream products with dicamba and its decomposition products. This contamination renders our products unfit or less fit for sale. We already suffer from overspray and drift problems associated with other agricultural chemicals, such as tribufos (a defoliant). We spend considerable time, effort and expense in sampling and analyzing our crops to measure and control the extent of this contamination. Sometimes the contamination levels are unacceptably high and we are forced to dispose of portions of our crop. Contamination from overspray requires us to manage the harvest and the subsequent manufacturing processes in ways that cost us time and money and makes us less able to compete with our competitors in India and China.

In the US, there is no statutory tolerance for non-label pesticide residues in our crops and the extracts made from them. The European Commission (EC) has established default MRLs for unauthorized pesticides in food commodities at 0.01 mg/kg (EC Regulation 396/2005). In the absence of a US MRL for a non-label pesticide in our crops, we rely on the European MRLs for guidance. By a strict interpretation of the US regulations, any residue from a non-label pesticide in the US renders the contaminated crop and downstream products adulterated and illegal to sell. Therefore, it would be very helpful for companies such as ours, who are plagued by overspray of non-label pesticides, if the US adopted EC default tolerances for non-label pesticides in full. We recognize that the political sensitivities associated with such a move make it unlikely for this to happen. We suggest, however, that if a wholesale adoption of Codex MRLs can't be made, then the EPA should adopt EC MRLs on a case-by-case basis for non-target crops as part of each registration or re-registration process. We urge you to start this practice in this case.

Consumers around the globe are becoming more concerned about the potential health effects of pesticide residues in food. They want to see less pesticide use and fewer, not more pesticides being used. EPA's proposed extension of the registration of dicamba would dramatically increase the acreage of dicamba use and the impact of dicamba contamination via overspray and other mechanisms of transport.
To ensure there is reduced off-field movement of dicamba, the EPA is stipulating:

- The pesticide may not be applied from aircraft.
- The pesticide may not be applied when wind speed is over 15 mph.
- A within-field buffer that ranges from 110 to 220 feet in all directions, depending on application rate, has been set to protect endangered plants and will also further protect bystanders and non-target plants.

While these measures are helpful, they are insufficient for a variety of reasons:

- Insufficient enforcement of requirements.

It is not clear how these requirements are to be enforced or if enforcement on such a large scale is even possible. Guidance is given at the website – https://www.epa.gov/compliance/inspections-under-federal-insecticide-fungicide-and-rodenticide-act.

This website states - Agricultural inspections include the inspection of pesticide applications in conjunction with the production of agricultural commodities. Agricultural commodities are defined in 40 CFR section 171.2(a)(5) as, "[a]ny plant, or part thereof, or animal or animal product, produced by a person (including farmers, ranchers, vineyardists, plant propagators, Christmas tree growers, aquaculturists, floriculturists, orchardists, foresters, or other comparable persons) primarily for sale, consumption, propagation, or other use by man or animals."

There are simply not enough inspectors to enforce the requirements. Given the large acreage under cultivation in the United States that falls under such a broad definition - and the relatively small number of federal, state and tribal Federal Insecticide Fungicide and Rodenticide Act (FIFRA) inspectors available - it is certain that dicamba will be applied outside these restrictions. This is particularly likely in the area where our crops are grown in the high plains of west Texas and in central Oklahoma. Average wind speeds and peak gust data from the National Climactic Data Center are shown in Table 1 for locations near our Texas and Oklahoma sites. Wind gusts of up to 50-70 mph are common throughout the year, making application without transport outside the target area very difficult. Even if application is limited to times when wind speeds are below 15 mph, there is another significant mechanism of pesticide drift that can occur after the application period which operates completely outside of the proposed EPA strictures (see below).

Table 1. Wind Speed Averages (SPD) and Peak Gusts from National Climactic Data Center (1930-1996) for sites near our facilities.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Burns Flat Clinton OK	SPD	12	12	14	14	14	12	9	9	10	10	10	12
	PGU	52	62	68	68	70	60	67	54	60	47	51	56
Lubbock TX	SPD	13	14	15	15	15	14	12	10	11	12	13	13
	PGU	59	64	77	71	74	85	72	59	58	52	63	64

https://www.ncdc.noaa.gov/sites/default/files/attachments/wind1996.pdf

- Insufficient consideration of alternate drift mechanisms.

Pesticides are distributed by another important drift mechanism besides overspray – the dispersion of pesticides adsorbed on wind-blown particles [Glotfelty et al., (1984)]. Dicamba binds tightly to soil particles and has a half-life of 30-60 days [National Pesticide Information Center - Dicamba General Fact Sheet]. Degradation products of dicamba, namely 3,6-dichlorosalicylic acid (3,6-DSCA) and perhaps 3,6-dichlorogentisic acid are more persistent than dicamba [Koskinen, et al. 1998]. For this reason, the EU has directed that dicamba residual concentrations in foods should include dicamba plus its two main degradation products [EFSA, 2013]. Because of surface area considerations, pesticides are generally found in higher concentrations on smaller soil particles. Smaller soil particles are dispersed more easily and widely than larger particles due to their smaller mass. According to a report from the European Commission – Health and Consumer Protection Directorate-General [Kubiak et al. 2008], "this [wind-blown particles] process is most important for herbicides as they are applied either at pre-emergence or post-emergence at an early growth stage of the crops when there is low soil coverage." "Wind erosion events shortly after application of a pesticide with high initial residues on the topsoil can therefore result in significant emission rates." Our neighbor's soil containing dicamba will inevitably end up in our production fields and we will see dicamba and breakdown product residues in our crops and downstream products if this proposed decision to register dicamba in genetically engineered crops is allowed.

- Insufficient regulation of application equipment and techniques.

The type of application equipment, including nozzles, etc., used in applying the herbicide, as well as the techniques used in the application have a dramatic effect on the level of overspray that is observed. Clear specifications and restrictions on the kinds of application equipment and techniques that can be used to apply dicamba should be made. Doing so, however, creates yet more conditions that need to be inspected and enforced by an overwhelmingly inadequate number of inspectors.

- Insufficient consideration of dicamba decomposition product lifetimes.

The degradation of dicamba has been seen as mitigating the risk of its high mobility. Using field lysimeters to determine ^{14}C-dicamba persistence, Koskinen et al. demonstrated that while only 5.5% of dicamba was present in the soil one month after application, the degradation product 3,6-dichlorosalicylic acid was present at 26.7% of original concentration one month after application [Koskinen et al., 1998]. The compound degraded much more slowly and was present at an average of 13% at 2 to 6 months after application and 11.2% at 12 to 16 months after application. A considerable portion of the ^{14}C was present in unknown forms that were unextractable.

As stated earlier, the European Union requires that MRLs for dicamba be calculated as the sum of dicamba and its degradation products.
Product distribution of extractable ^{14}C in the top 10 cm of soil (From Koskinen et al. [1998])

	Months after application					
	0	1	2	6	12	16
Chemical	**% of applied ^{14}C**					
dicamba	95.6	5.5	2.2?	1.7?	1.4?	1.0?
3,6-DCSA	3.4?	27.6	15.2	11.0	12.9	9.4
5-HO-dicamba	0.4?	0.2?	0.2?	0.2?	0.2?	0.1?
nonpolar	0.1	0.2	0.2	0.2	0.2	0.2
Polar	0.4	2.3	2.4	2.0	2.1	0.2
unextractable	0	58.2	36.2	38.8	30.3	31.8

? indicates that identity of the ^{14}C could not be determined.

As stated earlier, Kalsec grows chillies, paprika and rosemary in Texas and Oklahoma, in areas where significant amounts of cotton are grown. We already suffer from contamination of our crops with tribufos, a defoliant used widely on cotton. While tribufos is permitted to be applied aerially, this application method is not generally used in our location. The contamination we observe is a result of ground application. It is interesting, therefore, to compare the stipulations / restrictions that EPA is suggesting for dicamba relative to the stipulations / restrictions in place for tribufos. According to the registration documents for Def®6 Emulsifiable Defoliant (tribufos), "[T]the pesticide should only be applied when the potential for drift to adjacent sensitive areas (e.g. residential areas, bodies of water, known habitat for threatened or endangered species, **non-target crops**) is minimal (e.g. when wind is blowing **away** from the sensitive area" [emphases added] [. This label also states "Drift potential is lowest between wind speeds of 2- 10 mph. [" These stipulations are more restrictive than the stipulations for dicamba where application can occur at wind speeds up to 15 mph and where there is no mention of restricting application when wind is blowing toward non-label crops. The label does state that when applying dicamba to sensitive crops, "do not spray near sensitive crops if the wind is gusty or in excess of 5 mph and moving in the direction of sensitive crops." This has nothing to do with drift leading to contamination of non-target, non-labeled plants – it is to avoid damaging the crop being protected from weed incursion. Sensitive crops are defined as "desirable trees and plants, particularly beans, cotton, flowers, fruit trees, grapes, ornamentals, peas, potatoes, soybeans, sunflowers, tobacco, tomatoes and other broadleaf plants." We already experience drift from tribufos. Since the proposed stipulations for application of dicamba are largely less restrictive, we will undoubtedly experience contamination of our crops from dicamba and its degradation products – leading to economic harm.

The EPA recognizes that glyphosate overspray was a leading cause of the very serious and concerning development of glyphosate resistance in a number of target weeds. The EPA proposes to manage dicamba resistance by:

- Robust monitoring and reporting to EPA;
- Grower education and remediation programs
- A time limited registration of the proposed uses that would expire in 5 years, allowing for EPA to address any unexpected weed resistance issues that may result.

These measures are admirable, but are almost certain to fail in practice because the EPA does not have adequate resources to carry them out. Additionally, one of the restriction elements designed to reduce overspray will actually encourage the development of dicamba tolerance and resistance in weeds. The requirement to maintain a within-field buffer that ranges from 110 to 220 feet in all directions will provide the perfect environment to encourage the development of tolerant weeds – a zone where weeds are continually exposed to sub-lethal levels of dicamba.

We find it hard to believe that the EPA will allow the registration to expire after five years, once farmers have become dependent on dicamba.

In summary: Kalsec, Inc. is opposed to the registration of dicamba for use in genetically engineered soy and cotton because insufficient consideration has been given to the impact on contamination in non-target, non-label crops. The proposed restrictions for the application of dicamba to genetically modified cotton and soybean dealing with overspray do not take into account other important post-application transport phenomena. The proposed restrictions for application of dicamba to cotton are less restrictive than for the application of tribufos. Our crops grown in the vicinity of cotton are already beleaguered by contamination from tribufos.

References:

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Koskinen, W. C.; Sorenson, B. A.; Buhler, D. D.; Wyse, D. L.; Strand, E. A.; Lueschen, W. E.; Jorgenson, M.D.; Cheng, H. H. (1998). Use of Field Lysimeters to Determine 14C-Dicamba Persistence and Movement in Soil. ACS Symposium Series, 699, 115-121.

Kubiak, R.; Bürkle, L.; Cousins, I.; Hourdakis, A.; Jarvis, T.; Jene, B.; Koch, W.; Kreuger, J.; Maier, W.- M.; Millet, M.; Reinert, W.; Sweeney, P.; Tournayre, J.-C.; Van den Berg, F., Report of the FOCUS Working Group on Pesticides in Air, EC Document Reference SANCO/10553/2006 Rev 2 (June 2008).

National Pesticide Information Center – Dicamba General Fact Sheet: http://npic.orst.edu/factsheets/dicamba_gen.pdf

Respectfully submitted,

P. Douglas Williams
Director, Regulatory Affairs

Donald R. Berdahl
Executive VP / CTO

Anonymous public comment

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

Comment Period Closed
May 31 2016, at 11:59 PM ET

ID: EPA-HQ-OPP-2016-0187-0666
Tracking Number: 1k0-8por-8hmc

Document Information

Date Posted:
May 25, 2016

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Comment

I raise corn and soybeans in Central Illinois.

I am OPPOSED to Genetically Engineered Dicamba traited seed for the following reasons:

1) Dicamba is a synthetic "auxin" herbicide, acting as an artificial plant hormone that disrupts the normal growth processes of a plant. This results in deformed leaves, stems, roots, seed heads and ultimately plant death. For growers of vulnerable crops such as tomatoes, lettuce, beans, grapes, peaches, sunflowers, peanuts, timber, & non dicamba resistant soybeans & cotton, etc. dicamba drift will pose quite possibly the biggest threat to their farms' production and thus, their economic survival.

Pesticide drift occurs in two basic ways: spray drift (when pesticides are blown off their intended target at time of spraying) and volatilization drift (when the chemical evaporates in the days or even weeks after application, and can drift for miles before landing on and often destroying someone else's crops). Dicamba does both.

Currently we already have substantial 2-4D and dicamba drift injury in Central Illinois, because these relatively inexpensive herbicides are "burn down" products for winter annuals and early germinating broadleaf weeds when applied pre-plant for soybeans. The damage is limited to emerging landscape plants that have vulnerable small emerging foliage since most other crops have yet to emerge or even be planted. Most damage is explained away by winter kill, frost injury, extended cold temperature effects, etc.

However, with the new traited seed, the damage to off target flora and fauna will dramatically increase because everything will be fully leafed out and all fields will be emerged when the June and July applications will be made. The higher temperature and humidity @ this time of the year will only compound the problem exponentially.

While applicators can "try" to manage spray drift only God can manage volatilization drift.

2) It's important that we can all continue to responsibly farm the land together, without harming someone else's crop, timber, or landscape in the process.

3) We've already seen what nearly 20 years of reliance on RoundUp has brought us......million acres of farmland infested with RoundUp-resistant "superweeds". We need leadership towards agricultural sustainability that encourages wise use of herbicide technology by rotating herbicides, crops, along with other integrated pest management practices.

For these reasons I urge the approval be denied.

Thank you for your consideration.

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Your Voice in Federal Decision-Making

Anonymous public comment

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

Comment Period Closed
May 31 2016, at 11:59 PM ET

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Tracking Number: 1k0-8p9u-py5a

Comment

As a homeowner in a rural farm-economy dominated area, I own a home that is adjacent to a corn and soybean field. I am concerned about the volatility of the Dicamba products. Dicamba has the potential if used improperly to kill/destroy trees, landscaping plants, and my lawn. The burdens of increasing yield in Farm crops has come at a cost, at times, from the homeowners that surround these fields. Overspray and a lack of management of drift have killed landscape plants, reduced home property values, and caused interactions with our Farming neighbors to be less than friendly at times. Farmers that spray near property lines of Homeowners with trees and landscaping adjacent to the fields should be 100% liable to replace all lost value items to their original pre-spraying condition. A 20 foot pine tree that is lost to poor drift management must be replaced with a 20 foot pine tree, not a starter tree. Without rules and liability in place with the Farmers and Producers of these non-discriminatory killers of plant-life, the burden (as it normally does) of replacing lost home-value will fall to the Homeowners when it should rest firmly and squarely on the shoulders of those benefitting from the use of these chemicals (Farmers and Chemical Herbicide Producers).

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Not Assigned

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Comments to: EPA-HQ-OPP-2016-0187
Revised May 25, 2016

Dear EPA,

While it is undisputed that dicamba is an extremely valuable herbicide to American agriculture, broadly expanding its use pattern into genetically modified crops resistant to dicamba will greatly increase the risk of unintentional plant injury due to drift of the compound off the application target area as well as increase the potential for increased broadleaf weed resistance to other herbicide modes of action.

Drift

Use of dicamba on crops genetically modified to be tolerant to applications of dicamba will significantly change dicamba's use pattern. Applying dicamba to growing tolerant soybeans and cotton will mean much more dicamba is being applied at a time when other crops and vegetation are most vulnerable to dicamba injury. This use will also promote dicamba use in other areas of the country growing a diverse number of crops. Couple these new usage profiles with the risk that farmers will use the dicamba product during inappropriate or non-recommended weather conditions probably guarantees dicamba spray drift will become a major problem.

It appears the dicamba product Monsanto is registering for use on the dicamba tolerant crops will be the diglycolamine salt of dicamba, same as BASF Clarity among others. This low volatile salt of dicamba was first introduced by Sandoz in 1987. While volatility, as opposed to spray drift, is a drift threat that can somewhat be controlled by a registrant's product formulation, there is still no guarantee that dicamba volatilization drift injury cannot occur especially when dicamba usage is greatly expanded. Has EPA considered factors more than just comparative volatility between dicamba product formulations? The diglycolamine salt of dicamba is still volatile, just at a slower rate. What will happen when dicamba will be slowly volatilizing from thousands of acres of soybeans?

M1691 product labeling prohibits application of M1691 to Roundup Ready Xtend crops with anything other than water and certain approved adjuvants. Yet, the Roundup Ready Xtend crops and weed control system were designed for application of glyphosate and dicamba. The M1691 label recommends tank mixing other herbicides, including glyphosate, when applying for other crops. Is EPA assuming this prohibition of tank mixing will be strictly followed when tank mixing of pesticides is a standard agricultural practice? Tank mixing herbicides often provides better weed control, but always saves farmers time and money. Has EPA considered what will occur when the diglycolamine salt of dicamba is tank mixed with another pesticide salt, such as glyphosate isopropylamine? Dicamba is a very strong acid (pK_a 1.87), stronger than most pesticide active ingredient acids, including glyphosate (pK_a 2.6, 5.6, and 10.3). In solution, the stronger acid will bond with the stronger base, so in the case of tank mixing diglycolamine salt of dicamba with glyphosate isopropylamine, it would be a dicamba isopropylamine salt applied instead of the diglycolamine salt of dicamba, thus increasing the risk of dicamba drift due to volatility.

When considering the risk pesticide drift presents to adjacent plants and crops, one must consider the nature of the pesticide itself. Dicamba is a very powerful herbicide and plant growth regulator. Very small amounts of dicamba can cause severe damage to sensitive crops, such as tomatoes and cotton. In the late 1990's a simulated drift study to compare levels of various herbicide injury was performed on Pima cotton in California. Included in this simulation were the herbicides, 2,4-D and dicamba. The results were dramatic. At the minute rates expected from application drift, the 2,4-D moderately injured the cotton, but the dicamba nearly killed the cotton. It appeared the dicamba injury was ten times more severe than from 2,4-D.

Broadleaf Weed Resistance

There already exists broadleaf weed biotypes, such as kochia, that have developed resistance to dicamba in areas where dicamba is/was routinely used for weed control in row crops. It would be naive to think widespread weed resistance to dicamba will not occur. Introduction of crops tolerant to dicamba is only a temporary band-aid to fix a weed resistance problem widespread use of genetically engineered crops caused.

While with the introduction of dicamba tolerant crops, registrants and regulators have stated there will be weed resistance management plans in place to keep weed resistance from spreading, one need not overlook the obvious. Crops genetically modified to be tolerant to certain herbicides make weed control in those crops simple and relatively cheap. Farmers are people and some people will always take the easy way out, so it should be expected that all farmers will not adhere to weed resistance management plans when dicamba is controlling their weed problems...today. Applying only dicamba as M1691 will speed the natural selection evolution process to weed resistance. Once another broadleaf weed is identified as resistant to dicamba there has likely been several more created and some of these biotypes will be resistant to multiple herbicide modes of action sending American agricultural into a worse weed control crisis.

There are many herbicides currently on the market today that control those weeds now tolerant to glyphosate. A large number of these herbicides have been effectively used for over twenty-five, even forty, years without weeds becoming resistant to their mode of action. Why haven’t weeds become resistant to many of the older herbicides? Maybe it was because they were only used when needed and herbicide treatments were changed when field conditions changed. Certainly this was not the case with the Roundup Ready crops where glyphosate was applied continuously.

Farmers have had to re-learn how to use these pre-Roundup Ready herbicides and are controlling glyphosate resistant weeds, yet they understandably yearn for the return of the easy "one herbicide fits all" approach to weed control. As stated before this will only create more and harder to control herbicide resistant weeds.

Numerous "authorities" have stated that older herbicides are more toxic. More toxic than what? Glyphosate? Wouldn't the World Health Organization International Agency for Research on Cancer's finding that glyphosate is probably carcinogenic to humans render that comparison of toxicity invalid? These "authorities" have also stated that farmers are using more herbicides due to weed resistance. Compared to what? Spraying glyphosate across the same field four to five times a growing season? No wonder resistance to glyphosate is wide spread. Now EPA is wanting to let Monsanto entice farmers to do the same with dicamba?

Monsanto has done an excellent job of marketing their product to the farming community, Monsanto stock holders, and promoting its need to EPA. Good marketing is not good science and can prove to be harmful in the long run. McDonald's Happy Meals were tremendously successful marketing concepts, but feeding them to children everyday on the way home from school has helped foster an unhealthy and overweight bunch of children who grow into unhealthy, overweight adults. There are many more examples of harmful marketing. Should the Marlboro Man be mentioned?

Hopefully, one or more of the facts stated above could convince EPA that moving forward with expanding dicamba use into crops genetically modified to be tolerant to dicamba application is a bad idea.

While I am not ashamed to voice my comments, I am a farmer, an agrochemical company employee, and a member of numerous agricultural organizations, including CropLife, I prefer to submit these comments anonymously to avoid any backlash from those wanting this technology.

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Your Voice in Federal Decision-Making

Comment submitted by Dennis M. Dixon, Field Representative, Hartung Brothers Incorporated

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

Comment Period Closed
May 31 2016, at 11:59 PM ET

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Tracking Number: 1k0-8pjq-ci49

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May 23, 2016

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Not Assigned

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Comment

May 10, 2016

U.S. EPA
To whom it may concern:

Below are some salient points that I would think you have seen and previously and considered, as it pertains to the use of 2,4-D and or dicamba herbicides.

Until there are residue tolerances, NO approval should be granted

The Arkansas restrictions on buffer zones of 400' seems like a reasonable safeguard against volatility for the "safer" formulations, Engenia and M1691

The Arkansas restriction on a one-mile buffer zone for the older generic formulations should be utilized

Making the older generic formulations a Restricted Use Pesticide will add to the safety by limiting access and establishing more complete records of application

The language of "wind cannot be blowing towards a commercially grown" sensitive crop as defined in the label is a critical safeguard and is to be commended

I work for the Hartung Brothers Incorporated of Madison, WI. What I do for them is oversee the production of pickling cucumbers mostly in Indiana, but with some involvement in Michigan, Ohio and from time to time Illinois. My background is in the custom application business, both aerial and ground, as well as, for the past 35 years, the commercial production of vegetables both fresh market and processing.

I have experience with both herbicides and I understand that those chemistries are very effective in their ability to control resistant broad leaf weeds. Unfortunately, my experience, with these herbicides includes first-hand knowledge of the unintended damage that they can and often do cause to susceptible crops. I have personally seen dicamba damage crops a few miles from the application site. Drift can be bad enough but volatility is the 800 lb. gorilla in the room. I understand that new formulations are promoted as being less volatile. I also know that some users of these materials will use lower cost formulations.

In a nutshell, I understand and appreciate both the great benefits and potential catastrophic consequences involved in the use of these technologies. My position is that the five bullet points listed would be the best approach at this juncture.

Dennis M. Dixon
Field Representative
Hartung Brothers Incorporated
Dennis.Dixon@hartungbrothers.com

Comment submitted by T. Kreuger

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

Comment Period Closed
May 31 2016, at 11:59 PM ET

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Tracking Number: 1k0-8pen-15cp

Comment

As a Commercial Applicator I have many concerns about dicamba. I went through the launch of Roundup and thus will be much worse. The amount of off target claims will be much higher thus costing the insurance companies lots of money. No matter how hard we try to do things right, there will be off target issues. This technology would be best suited for burndown applications not post applications. The chance of off target damage will be significantly less because non tolerant crops most likely won't be planted during burndown applications. The companies that have participated in the development of this trait have written the proposed lable as to put all responsibility on the applicator. We as applicators will only have a very limited amount of proper days to, by label , make applications. Dr Kevin Bradley at the University of Missouri did research to see how many days in the planting and growing season the wind in Missouri are under the 10 MPH threshold. He discovered that there really isn't that many. Most of the chemistry we currently use have many of the same regulations that dicamba will have. The big difference is volatility and drift. If we screw up spraying with dicamba it won't necessarily cause an economic to the affected party but it will look like it has and in turn cause an investigation which I will have to involve my insurance company and Missouri Department of Ag. The benefit of this product is only truly going to help those Farmers who abused the roundup trait and didn't properly use the chemistry that they had. I applaude the chemical industry for always trying to invent new chemistry and biotechnology companies to develop seed to use the chemistry but this di
camba trait and chemistry is to much for most areas to handle.
Tommy Kreuger
tommykreuger@gmail.com

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May 19, 2016

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Anonymous public comment

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Comment

Dicamba has always been limited use herbicide in the US with application confined primarily to grass crops such as sorghum and corn. Even with limited applications, there are already two weed species in the US, kochia and prickly lettuce, which have developed resistance to the dicamba. Dicamba-tolerant cotton and soybean will not be the "silver bullet" to cure the current problem with glyphosate resistant species in these two crops. On the contrary, it seems likely that trouble species, particularly from the Amaranthus family, with develop yet another means of resistance.

As a wine grape and cotton grower in the Texas High Plains, we are concerned about the drift of dicamba onto our vineyard (a highly sensitive species), cotton fields which are not tolerant to dicamba herbicide, and other non-target plants such as trees, shrubs, and flowers. The potential wide-spread use of auxin herbicides during the growing season on dicamba tolerant broadleaf crops is unprecedented, so there is no way of predicting the level of damage which will ensue if dicamba herbicide were to become approved for use in cotton and soybean. And while Monsanto claims that the Roundup Xtend and Xtendimax formulations reduce driftable fines up to 97-99%, this still leaves 1-3% available for off-target movement onto sensitive crops.

Even without the wide spread approved use of dicamba, last year we had two mature (~20-30 year-old trees) at our rural Texas home which suffered severe damage due to auxin herbicide drift from our neighbor who sprayed his ditch. We were hopeful that the trees would recover this season, but the symptoms have persisted and threaten to cause permanent and potentially lethal damage (see attached photos).

After three years of careful tending and over $60,000 of investment in our vineyard, we hope to see our first grape production in 2016 after many years of neglect from the previous tenant. We have intentionally diversified our operation to make our family farm more sustainable for our children (now 14 and 11), especially as water becomes less available. It would be heartbreaking to see the entire vineyard lost due to a single, careless dicamba application.

On our cotton acres, we've always enjoyed the flexibility of choosing the variety that best suits our operation and budget. We not only have to consider input costs, but also the price at the end of the season. With the tight market we currently find ourselves in, we plan to plant conventional, non-GMO cotton for the first time since 1998. Additionally, the Fibermax varieties (which do not have dicamba tolerance) have given us consistent high fiber quality and yield, allowing us to maximize the price we get paid at harvest. The wide spread use of dicamba will put all cotton farmers in a defensive position - forcing us to consider the use of high cost, dicamba tolerant seed that may not provide the best yield or fiber quality at the end of the season. We do not want to be forced to plant dicamba tolerant cotton just to protect our farm from neighbors who choose to plant it!

Finally, a recent study at Penn State University showed that a simulated drift rate equivalent to approximately 1% of the field rate, caused delayed flowering and reduced the number of flowers in species such as alfalfa. This also caused pollinators to visit these fields less often. The full ecological impact can only be speculative, but it is likely that wide spread use of dicamba during the growing season will upset a delicate balance in the bee population which is just now beginning to recover from decline due to nosema fungi, deformed wing virus, and Varroa mites.

For all of these reasons, I strongly encourage the EPA to not approve the use of dicamba in cotton and soybean genetically engineered to tolerant the herbicide.

Attachments (4)

Photograph 1

View Attachment: JPG PDF

Photograph 2

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Photograph 3

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Photograph 4

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Anonymous public comment

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

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Tracking Number: 1k0-8p6j-ybha

Comment

While I understand the situation with Resistant weeds I do not think Dicamba resistant cotton can be deregulated safely. In season application of Dicamba will be disastrous in the Plains where there is a lack of vegetation or natural barriers to mitigate drift. The persistent wind on the plains will make farmers do things that will be off label. While Monsanto has done all the research and will make recommendations that mitigate their responsibility the reality of the location will mean that most applications will be in marginal conditions at best. Woody species such as trees and vines will suffer consistent and devastating losses. As a vineyard owner I experience 2-4 D damage every year already with relatively small acreage applications compared to what may be expected if the Dicamba is approved for in season use. Monsanto will present supporting documentation demonstrating that Dicamba can be used safely even in the Plains. When this chemical is used in large areas and not just experimental blocks we will see the damage to woody species. Current Round-up damage in woody species is bad enough. Use is so widespread in the plans cotton growing regions that glyphosate damage is a regular occurrence. Vines and trees are affected annually but since glyphosate is not auxin based the plants can be encouraged to grow out of it. That is not the case with 2-4D based herbicides. Their damage persists years after exposure. There are many herbicide options available already. It is not necessary to have this extremely dangerous herbicide approved for in season use. If it is there will be more rich lawyers and dead trees and vines on the Plains.

I

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Your Voice in Federal Decision-Making

Comment submitted by Scott E. Rice, Rice Farms Tomatoes, LLC

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

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May 9, 2016

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Comment

Dear EPA,

As a producer of processing tomatoes in Indiana, my sons and I are opposed to the current plan of labeling for use on tolerant soybeans and cotton. We believe stronger safeguards are a must before this technology can hit the market. Our tomato crop is highly susceptible to any amount of drift from dicamba.

We are particularly concerned about soybean growers using older and more volatile formulations of dicamba due to the current depressed economics in the corn/soybean belt, even though this would be off-label. A devastating off-target event occurred in Arkansas due to this type of use.

Also, there is currently NO residue tolerance for dicamba on our tomato crop. If our processor finds any residue, they would mandate crop destruction as our crop would be unusable. At a field value in excess of $5,000 per acre, most applicators liability insurance would be exhausted long before they could pay our claim.

At the very least, we would ask that minimum buffers be increased to at least 400 feet instead of the proposed 110 feet. Also, Monsanto and BASF will need to do a much better job of training prospective applicators about the inherent risks of spraying anywhere near sensitive food crops such as tomatoes.

In summary, we understand the need to fight resistant weeds in the corn belt. We are also corn and soybean producers. However we must not do this at the expense of our existing specialty crop production in the Midwest. That would be devastating not only to the individual farms affected, but also to the larger economy that these high-value crops bring to our region.

We urge you to go slow with this pending approval, try to fully evaluate the risks of "unintended consequences", and consult closely with the specialty crop industry to avoid catastrophic crop injuries.

Thank you for your consideration.

Best Regards,

Scott E. Rice
Rice Farms Tomatoes, LLC

Utterback Farms, Inc. is a family-owned business located in Alexandria, Indiana, a town in Madison County, Indiana. We started raising tomatoes in 2000 as a way to diversify our farming operation. We are concerned with the likelihood of plant damage from drift or volatilization that can happen with dicamba.

Non-target plant damage associated with herbicide spray drift and volatilization is a major concern for specialty crop growers and processors. Credible estimates project significant increases in the application levels of dicamba upon the introduction of dicamba tolerant crops. Dicamba, because of its potential to drift and volatilize, has proven to be America's most dangerous herbicide for non-target plant damage.

Utterback Farms is worried that there is still no residue tolerance for dicamba on most food crops. Even an off-target movement of dicamba could result in crop destruction, which would be a very large loss, for our farm.

We also believe that the 110' buffer is not adequate against volatility risk to specialty crops. I believe that a 400' buffer would be more reasonable, similar to what Arkansas has imposed.

Respectfully Submitted,

Curt Utterback, Secretary
Utterback Farms, Inc.
4545 W. 1000 N.
Alexandria, IN 46001

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Your Voice in Federal Decision-Making

Comment submitted by D. Dolliver

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

Comment Period Closed
May 31 2016, at 11:59 PM ET

ID: EPA-HQ-OPP-2016-0187-0360
Tracking Number: 1k0-8p78-vmuh

Comment

I am an employee of Red Gold, Inc., a tomato processing company, and I am very concerned with the release of Dicamba and the impact that it may have when it volatiles onto tomato crops. The economic impact on the Red Gold Company would be a tremendous loss, but also the economic impact on the tomato growers would be devastating. Since there is no residue tolerance for Dicamba on tomato crops, entire fields would need to be abandoned, with the possibility of no insurance (since losses of this size most likely would go beyond the insurance coverage of nearly all applicators).
Unfortunately, Arkansas served as an example of what can happen when applicators do the wrong thing. I would like to see the new Arkansas restrictions incorporated into any approved label.
~ Danna Dolliver; Agriculture Administration Manager

Document Information

Date Posted:
Apr 28, 2016

RIN:
Not Assigned

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Your Voice in Federal Decision-Making

Comment submitted by Randall Woolsey, Woolsey Bros. Farm Supply

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

Comment Period Closed
Apr 30 2016, at 11:59 PM ET

ID: EPA-HQ-OPP-2016-0187-0285

Tracking Number: 1k0-8oyh-kx45

Comment

April 8, 2016
Say NO to Dicamba!
My family has owned and operated an Ag service company for the past 60 years. We custom apply liquid fertilizer and pesticides for farmers.
I am writing this as I am very concerned about Dicamba Beans. The problems that I see are as follows:

90% of the bean acreage we service are no-tilled. I now use paraquat for burn down because: Roundup and 2-4,d will not kill waterhemp or marestail.

Drift will be a problem. I do not want the responsibility or liability of dealing with this.

Dicamba is very hard to rinse out of spray equipment. It will take alot of extra time to get our equipment ready for other chemical applications.

I have informed my customers that I will not spray Dicamba beans.

Randall Woolsey
Woolsey Bros. Farm Supply

Document Information

Date Posted:
Apr 21, 2016

RIN:
Not Assigned

Show More Details

MEMORANDUM

SUBJECT: Posting EPA-HQ-OPP-2016-0187 to Regulations.gov for Public Access

FROM: Dan Kenny
Branch Chief
Herbicide Branch, Registration Division US EPA/OSCPP/OPP
Signature: 3/31/2016

THRU: Susan Lewis
Director
Registration Division, US EPA/OSCPP/OPP
Signature: for Susan Lewis 3/31/16

This memorandum authorizes the posting of EPA-HQ-OPP-2016-0187 to Regulations.gov for public access.

Monsanto Company has submitted an application to amend their M1691 Dicamba Herbicide for use on dicamba tolerant cotton and soybeans. This is an issue of high public interest and concern so the Agency feels it is important to get feedback from stakeholders before a final decision is reached.

This document will be open for public comment from 03/31/2016 to 04/30/2016.

Submit your comments, identified by Docket ID No. EPA-HQ-OPP-2016-0187, by one of the following methods:

- Electronically: www.regulations.gov: Follow the on-line instructions for submitting comments.
- Mail: Dicamba: New Use on Herbicide-Tolerant Cotton and Soybeans Environmental Protection Agency, Mailcode 28221T, 1200 Pennsylvania Ave, NW, Washington, DC 20460.
- Hand Delivery: Hand Delivery: Environmental Protection Agency, Mail code 28221T, 1200 Pennsylvania Avenue, NW, Washington, DC 20460. Such deliveries are only accepted during the Docket's normal hours of operation, and special arrangements should be made for deliveries of boxed information.

Follow the online instructions for submitting comments. Once submitted, comments cannot be edited or removed from Regulations.gov. The EPA may publish any comment received to its public docket. Do not submit electronically any information you consider to be Confidential Business Information (CBI) or other information whose disclosure is restricted by statute. Multimedia submissions (audio, video, etc.) must be accompanied by a written comment. The written comment is considered the official comment and should include discussion of all points you wish to make. The EPA will generally not consider comments or comment contents located outside of the primary submission (i.e. on the web, cloud, or other file sharing system). For additional submission methods, the full EPA public comment policy, information about CBI or multimedia submissions, and general guidance on making effective comments, please visit: http://www.epa.gov/dockets/commenting-epa-dockets.

FOR FURTHER INFORMATION CONTACT: Susan Lewis, Registration Division, US EPA/OSCPP/OPP 7505P, Environmental Protection Agency, 1200 Pennsylvania Ave, NW, Washington, DC 20460; telephone number: (703) 305-7090 email address: RDFRnotices@epa.gov

Proposed Registration of Dicamba on Dicamba-Tolerant Cotton and Soybean

Approved by: ____________________
Jack Housenger, Director
Office of Pesticide Programs

Date: 3/31/16

and soil. Under anaerobic soil conditions, the dicamba parent molecule has a half-life of 141 days. It is not persistent under aerobic conditions; aerobic soil metabolism is the main degradative process for dicamba, with a half-life of 6 days. Dicamba was found in two acceptable field dissipation studies in soil segments deeper than 10 cm with half-lives ranging from 4.4 to 19.8 days. In aquatic systems, dicamba degrades more rapidly when sediment is present and has an aerobic soil metabolism half-life in sediment-water system of ~24 days.

The major degradate of dicamba is 3,6-dichlorosalicylic acid (DCSA). It is persistent when formed under anaerobic conditions, comprising more than 60% of the applied dose after 365 days of anaerobic incubation in sediment-pond water system. DCSA is not persistent when formed under aerobic conditions and degrades roughly at the same rate as the parent dicamba with a half-life of 8.2 days. Like the parent molecule, DCSA is mobile and was also found in the two acceptable field studies in soil segments deeper than 10 cm. If it were to reach anaerobic groundwater, it would likely persist; however, EPA does not expect DCSA to reach groundwater at levels that would be of concern. DCSA is formed in aerobic soil under laboratory conditions at the maximum of 17.4 % of the applied parent dose. Other minor dicamba degradates of concern are DCGA and 5-OH-dicamba, and both are less toxic than the parent molecule and DCSA. The formation of DCGA in the laboratory studies did not exceed 3.64%, and the formation of 5-OH dicamba did not exceed 1.9 % in soil-water system during anaerobic aquatic degradation of dicamba under laboratory conditions. DCSA was also a major metabolite in plant metabolism and magnitude of residue studies for dicamba-tolerant soybean and cotton, comprising approximately 80% and 20%, respectively, of dicamba-related residues in plant tissues for these crops.

2. Mobility

Dicamba is very soluble and mobile. It may reach surface water via field/site runoff, spray drift during application, and by vapor drift from volatilization. It is not expected to bioaccumulate in aquatic organisms as it is an anion at environmental pHs. Since dicamba is not persistent under aerobic conditions, very little dicamba is expected to reach groundwater. The major degradage of dicamba, DCSA, is persistent under anaerobic conditions; however EPA does not expect DCSA to reach groundwater at levels that would be of concern. The major route of exposure to non-target organisms is likely spray drift and runoff. Also, multiple literature studies show that there is a high vapor drift from soybean fields resulting in non-target plant injury. The assessments related to these routes of exposure are described in the sections below.

3. Runoff

The Agency has considered the potential effects due to runoff, and has developed proposed mitigation to limit off-site runoff. A component of the model used to assess terrestrial risk assumes that the mass of pesticide running off the treated field is directly related to the pesticide's solubility in water. In the case of dicamba DGA salt, the dissociated salt yields highly soluble dicamba acid. The model assumes that the high solubility of the acid results in a runoff mass of 5 percent of the field-applied mass, which is considered to be a highly conservative estimate because the model does not account for loss of chemical from degradation, partitioning, or the temporal aspects of runoff (e.g., a rain event following application that exceeds soil's field capacity).

4. Spray Drift

The Agency considers spray drift exposure to be the principal risk issue associated with the proposed label use of dicamba DGA salt, owing to a variety of lines of evidence, including past experience with other dicamba formulations. In addition, visual observations of off-field plant damage have been reported following dicamba applications, likely the result of subsequent spray drift and/or volatilization of dicamba residues.

The Agency used a weight of evidence approach incorporating spray drift modeling, a spray drift droplet deposition study, and raw data from field trials to determine an appropriate in-field buffer to avoid dicamba exposure to non-target organisms (e.g., endangered plants). EPA has also determined that the label must specify that nozzles must be used that produce extra-course and ultra-course droplet spectra for application to reduce the potential for spray drift. Based on the weight of evidence approach, EPA determined that labels must include language to maintain an in-field buffer (to the edge of the field in all directions) of 100 feet when applying at the 0.5 lb a.e./A application rate and 220 feet when applying at the 1.0 lb a.e./A application rate in order to restrict the movement of residues to the field. Using these buffers, expected residues at the field's edge from spray drift would be below apical endpoints for the most sensitive tested species (*i.e.* NOAEC for soybean plant height).

5. Volatilization

After reviewing submitted data relating to the volatility of dicamba, the Agency had concerns regarding the volatility of dicamba, and possible post-application, vapor-phase off-site transport that might damage non-target plants. Monsanto responded to these concerns with a submission that acknowledged the long-recognized volatility of dicamba acid and described measurements of the volatilization in the different formulations.

Though the Agency found the information helpful, the submission did not include enough detail to verify the measurements in the studies. Therefore, in order to be protective of potential effects to non-target plants from volatilization, labels must include language to maintain an in-field buffer (to the edge of the field in all directions) of 100 feet when applying at the 0.5 lb a.e./A application rate and 220 feet when applying at the 1.0 lb a.e./A application rate. Although the Agency is not requiring additional data to be submitted at this time, if EPA receives volatility data under varied conditions of temperature and relative humidity, as these factors play a strong role in volatility under field conditions, it may reconsider whether this mitigation requirement is necessary.

EPA is aware that for use of dicamba in Arkansas, the Arkansas Plant Board has an in-field buffer that is greater than what is being proposed by EPA (400 feet as opposed to 110 to 220 feet). EPA has reviewed the information associated with the larger buffer in Arkansas to assess why these differences exist. EPA's buffer is determined by evaluation of plant toxicity data required under FIFRA and conducted under GLP conditions where apical endpoints, plant height, and yield, are used as measures of plant growth and reproduction. Once the no observed adverse effect concentration (NOAEC) was determined for the most sensitive endpoint (*i.e.,* plant height) for the most sensitive plant species tested (*i.e.,* soybeans), EPA uses field studies and modeling to determine the distance from site of application to where the NOEC is not expected to be exceeded. It is further noted that the labels for the proposed uses will specify a spray nozzle and pressure combination that is expected to reduce drift of the herbicide, which are drift reduction measures not on the previously registered dicamba formulations and could also influence the size of a protective buffer. In telephone conversations between EPA and the Arkansas Plant Board, it was reported that Arkansas' buffer distance of 400 feet was not computed as a result of submitted data, but as a precautionary measure that was based on information and observations from extension specialists from Arkansas and neighboring states, discussions with Monsanto, and historical information involving qualitative visual observations of damage in the field with products not containing the specific nozzle and pressure requirements contained on the proposed label. The Arkansas Plant Board felt that a 400 foot buffer should exceed what would be necessary to protect neighboring crop fields that are directly adjacent to fields receiving dicamba treatment. The Arkansas Plant Board also reports that their buffer requirement may be revisited and/or removed after a period of initial use (if registered) once additional observations are made.

B. Ecological Risk

Ecological risk characterization integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. The process of integrating the results of exposure with the ecotoxicity data is called the risk quotient method. For this method, risk quotients (RQs) are calculated by dividing exposure estimates by ecotoxicity values, both acute and chronic (RQ = Exposure / Toxicity). RQs are then compared to EPA's levels of concern (LOCs). The LOCs are criteria used by the Agency to indicate potential risk to non-target organisms. The criteria indicate whether a pesticide, when used as directed, has the potential to cause adverse effects to non-target organisms.

For terrestrial animals, the Agency's acute risk LOCs are set at 0.5 for non-listed species and 0.1 for listed species. For aquatic animals, acute risk LOCs are also set at 0.5 for non-listed species but for listed species, they are set at 0.05. The chronic risk LOC is set at 1.0 for both terrestrial and aquatic animals. For plants, acute risk LOCs are set at 1 for both non-listed and listed species. The potential difference in sensitivity for listed plant species compared to non-listed plant species is addressed through the use of different toxicity endpoints in the RQ equation [the concentration causing effects to 25% of the test population (EC25) for non-listed plants vs the NOEC or concentration causing effects to 5% of the test population (EC05) for listed species]. Chronic risk is not assessed for plants.

Dicamba is currently registered for use on several food and non-food use sites, including cotton and soybean. The proposed uses on dicamba-tolerant soybeans and cotton would expand the timing of applications from pre-emergence and pre-harvest only for soybeans and pre-emergence and post-harvest only for cotton to allowing post-emergence over-the-top applications. The maximum yearly application rates would remain 2.0 lb a.e./acre for both cotton and soybeans. However, as detailed in section I of this document, the applicator could now split the 2.0 lb a.e./acre between pre-emergence and post-emergence applications.

EPA has a specific process based on sound science that it follows when assessing risks to listed species for pesticides like dicamba that will be used on seeds that have been genetically modified to be tolerant to the pesticide. The Agency begins with a screening level assessment that includes a basic ecological risk assessment based on its 2004 Overview of the Ecological Risk Assessment Process document. [USEPA, 2004, available at http://www.epa.gov/oppfead1/endanger/litstatus/riskasses.htm]. That assessment uses broad

No. 17-70196

UNITED STATES COURT OF APPEALS
FOR THE NINTH CIRCUIT

NATIONAL FAMILY FARM COALITION, *et al*.,

Petitioners,

v.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, *et al*.,

Respondents,

and

MONSANTO COMPANY,

Intervenor-Respondent.

ON PETITION FOR REVIEW FROM THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

PETITIONERS' EXCERPTS OF RECORD VOLUME IV

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INDEX TO PETITIONERS' EXCERPTS OF RECORD

VOLUME I			
Date	**Admin. R. Doc. No.**[1]	**Document Description**	**ER Page No.**
11/9/2016	A.493[2]	Final Registration of Dicamba on Dicamba-Tolerant Cotton and Soybean	ER 001
11/9/2016	A.924	Final Product Label for XtendiMax™ with VaporGrip™ Technology - EPA Reg. No. 524-617 (For Use on Dicamba-Tolerant Soybeans)	ER 037
11/9/2016	A.895	Final Product Label for XtendiMax™ with VaporGrip™ Technology - EPA Reg. No. 524-617 (For Use on Dicamba-Tolerant Cotton)	ER 049
11/9/2016	A.750	PRIA label Amendment: Adding New Uses on Dicamba-Tolerant Cotton and Soybeans	ER 060
10/12/2017	K.99	Amended Registration of Dicamba on Dicamba-Resistant Cotton and Soybean	ER 072

[1] Unless otherwise specified, the document identifier numbers record to their document numbers as listed in the Certified Amended Index, ECF No. 63-3.

[2] Respondent United States Environmental Protection Agency (EPA) did not produce, but only provided hyperlinks to, publicly available documents. *See* ECF No. 63-3. For the Court's convenience, Petitioners have produced those hyperlinked documents in their entirety in the Excerpts of Record.

[3] This e-mail contains a hyperlink to an online article. *See* David Bennett, *Might Dicamba be Affecting Pollinators*?, Delta Farm Press, Sept. 26, 2017. For the Court's convenience, Petitioners have produced this and other similarly hyperlinked articles in the Excerpts of Record.

9/27/2017	K.32	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: FW: Many U.S. Scientists to skip Monsanto summit on dicamba	ER 188
9/27/2017	K.93	E-mail from Nicholas Sorokin (EPA) to EPA recipients of Office of Public Affairs media clips re: Reuters: Exclusive: U.S. scientists to skip Monsanto summit on controversial weed killer	ER 189
9/26/2017	K.46	E-mail from Reuben Baris (EPA) to Jonathan Becker (EPA) re: FW: yield data forwarded 10 journal articles on yield impact resulting from dicamba exposure	ER 192
9/21/2017	K.19	E-mail from Pesticide Action Network to Rick Keigwin (EPA) re: EPA: Pull Monsanto's crop-killing dicamba now	ER 278
9/21/2017	K.80	E-mail from Caleb Hawkins (EPA) to Jonathan Becker and others at EPA forwarding Reuters article on dicamba[4]	ER 280
9/13/2017	K.39	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Record number of pesticide misuse claims by Iowa farmers due to dicamba drift problems[5]	ER 285
9/12/2017	K.35	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: More Dicamba = Monsanto Petition to Arkansas State Plant Board	ER 291

[4] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* Tom Polansek, *U.S. Regulator Aiming to Allow Controversial Herbicide Use with Safeguards*, Reuters, Sept. 20, 2017.

[5] This e-mail contains a hyperlink to an online article that Petitioners have reproduced in its entirety. *See* Donnelle Eller, *Iowa Farmer Makes Record Number of Pesticide Misuse Claims*, The Des Moines Register, Sept. 12, 2017.

9/11/2017	K.63	E-mail from Kevin Bradley (Professor Division of Plant Sciences, University of Missouri) to Reuben Baris (EPA) re:slides from several university weed scientists on volatility testing on new dicamba forumulations	ER 293
9/7/2017	K.41	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: article on Dicamba from Delta Farm Press[6]	ER 346
9/6/2017	K.33	E-mail from Nancy Beck (EPA) to Rick Keigwin (EPA) re: FW: Meeting Request from Monsanto	ER 352
9/6/2017	K.47	E-mail from Liz Bowman (EPA) to Nancy Beck (EPA) re: FW: Daily Caller: EPA May Curtail the Use of Chemical Spray That Could Cut Into Monsanto's Bottom Line	ER 353

VOLUME III			
Date	**Admin. R. Doc. No.**	**Document Description**	**ER Page No.**
9/5/2017	K.91	E-mail from Nicholas Sorokin (EPA) to EPA recipients of Office of Public Affairs media clips re: Reuters: Exclusive: EPA eyes limits for agricultural chemical linked to crop damage.	ER 355
8/31/2017	K.79	E-mail from TJ Wyatt (EPA) to Jonathan Becker (EPA) and to other EPA staff forwarding Washington Post article on Dicamba	ER 358

[6] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* David Bennett, *Dicamba Tests Showing Similar Results from Scattered Locations*, Delta Farm Press, Sept. 6, 2017.

8/29/2017	K.51	Ten articles on Dicamba send as a Google Alert to Reuben Baris (EPA)[7]	ER 364
8/23/2017	K.101 (Second Am. Certified Index, ECF No. 69-3)	Notes from 8/23/2017 EPA meeting with various state officials	ER 369
8/22/2017	K.31	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Letter to Topeka paper	ER 372
8/22/2017	K.38	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Off-target Movement of Dicamba in Missouri. Where Do We Go From Here?[8]	ER 374
8/21/2017	K.92	E-mail from Nicholas Sorokin (EPA) to EPA recipients of Office of Public Affairs media clips re: Reuters: Exclusive: U.S. farmers confused by Monsanto's weed killer's complex instructions	ER 379
8/20/2017	K.27	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Dicamba update	ER 382
8/18/2017	K.88	E-mail from Kevin Bradley (University of Missouri) to R. Baris (EPA) regarding WSSA committee	ER 390

[7] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See EPA Responds to Dicamba Complaints*, Ag. Professional, Aug. 29, 2017.

[8] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* Kevin Bradley, *Off-target Movement of Dicamba in Missouri: Where Do We Go from Here?*, Integrated Pest Mgmt., Univ. Mo., Aug. 21, 2017.

8/17/2017	K.12	E-mail from Reuben Baris (EPA) to Dicamba registrants regarding next steps on dicamba	ER 394
8/10/2017	K.21	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: FW Article from Arkansas times[9]	ER 395
8/3/2017	K.49	E-mail from Reuben Baris (EPA) to Mark Corbin (EPA) re: Fwd: TN data Effect of adding Roundup PowerMax to Engenia on vapor losses under field conditions	ER 406
8/2/2017	K.20	E-mail-calendar invite from Emily Ryan (EPA) to Reuben Baris (EPA) and other internal and external parties re: follow-up on Dicamba with AAPCO/SFIREG and agenda for 8/2/17	ER 417
8/2/2017	K.100 (Second Am. Certified Index, ECF No. 69-3)	Notes from 8/2/2017 EPA meeting with various state officials	ER 420
8/1/2017	K.37	E-mail from Sarah Meadows (EPA) to Grant Rowland (EPA) re: FW: Notes from Friday's meeting on Dicamba call (7/28/17) with state reps	ER 428
8/1/2017	K.14	E-mail from Shanta Adeeb (EPA) to Dan Kenny (EPA) re: Dicamba Notes from July 28th meeting with states on dicamba incidents	ER 435
7/28/2017	K.66	E-mail from Reuben Baris (EPA) to Dan Rosenblatt (RPA) re: EPA notes taken during dicamba teleconference with state extension representatives on 7/28/17	ER 441

[9] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* David Koon, *Farmer vs. Farmer*, Ark. Times, Aug. 10, 2017.

7/25/2017	K.22	E-mail from Dan Kenny (EPA) to Reuben Baris (EPA) re: FW Conference Call with EPA on Dicamba 7/25/17 (conference call information will be redacted)	ER 445
7/25/2017	K.59	E-mail from Sarah Meadows (EPA) to Dan Kenny (EPA) re: Notes from Dicamba meeting with states on 7/13/17	ER 447
7/12/2017	K.5	E-mail from Dan Kenny (EPA) to state representatives regarding EPA Dicamba Meeting with States	ER 453
11/7/2016	A.765	Excerpt of Response to Public Comments Received Regarding the New Use of Dicamba on Dicamba-Tolerant Cotton and Soybeans	ER 456
11/3/2016	A.170	M-1691 Herbicide, EPA Reg. No. 524-582 (Active Ingredient: Dicamba Diglycolamine Salt) and M-1768 herbicide, EPA Reg. No. 524-617 (AI: Diglycolamine Salt with VaporGrip™) – Review of EFED Actions and Recent Data Submissions Associated with Spray and Vapor Drift of the Proposed Section 3 New Uses on Dicamba-Tolerant Soybean and Cotton	ER 459
6/20/2016	A.863	Comment submitted by National Family Farm Coalition	ER 473
6/15/2016	A.57	Mortensen *et al.*, *Navigating a Critical Juncture for Sustainable Weed Management*, BioScience, Jan. 2012, at 75-84 (submitted as an attachment to comment submitted by Sylvia Wu, Center for Food Safety)	ER 474
6/15/2016	A.473	Comments submitted by The Center for Food Safety, including Excerpts from Exhibits A and F.	ER 485
6/10/2016	A.304	Comment submitted by J. R. Paarlberg	ER 554

VOLUME IV			
Date	**Admin. R. Doc. No.**	**Document Description**	**ER Page No.**
3/30/2016	A.734	Review of Benefits as Described by the Registrant of Dicamba Herbicide for Postemergence Applications to Soybean and Cotton and Addendum Review of the Resistance Management Plan as Described by the Registrant of Dicamba Herbicide for Use on Genetically Modified Soybean and Cotton	ER 633
3/24/2016	A.802	Excerpt of Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 16 states (Arkansas, Illinois, Iowa, Indiana, Kansas, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin).	ER 649
3/24/2016	A.640	Excerpt of Addendum to Dicamba Diglycolamine (DGA) Salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Cotton and Soybean in 7 U.S. States (Alabama, Georgia, Kentucky, Michigan, North Carolina, South Carolina, and Texas)	ER 682

3/24/2016	A.285	Excerpt of Addendum to Dicamba Diglycolamine Salt (DOA) and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in in 11 U.S. States: (Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia). Phases 3 and 4	ER 702
3/24/2016	A.611	Excerpt of Ecological Risk Assessment for Dicamba DGA Salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA), for the Proposed Post-Emergence New Use on Dicamba-Tolerant Cotton (MON 8770 I)	ER 713
3/24/2016	A.45	Excerpt of Dicamba DGA: Second Addendum to the Environmental Fate and Ecological Risk Assessment for Dicamba DGA salt and its Degradate	ER 716
2014	I.28	Egan, J. F., Barlow, K. M., and Mortensen, D. A. 2014. A meta-analysis on the effects of 2,4-D and dicamba drift on soybean and cotton. Weed Science 62:193-206.	ER 724
3/8/2011	A.91	Excerpt of Ecological Risk Assessment for Dicamba and its Degradate	ER 740
9/17/2010	B.12	Comment submitted by Bill Freese, The Center for Food Safety	ER 774
6/4/2010	B.0024	Scott Kilman, *Superweed Outbreak Triggers Arms Race*, Wall St. J. (submitted as an attachment to the comment submitted by Ryan Crumley, The Center for Food Safety)	ER 782

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C., 20460

MAR 30 2016

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

MEMORANDUM

SUBJECT: Review of Benefits as Described by the Registrant of Dicamba Herbicide for Postemergence Applications to Soybean and Cotton *and* Addendum Review of the Resistance Management Plan as Described by the Registrant of Dicamba Herbicide for Use on Genetically Modified Soybean and Cotton

FROM: Leonard Yourman, Plant Pathologist
Bill Chism, Senior Biologist
Biological Analysis Branch

THRU: Colwell Cook, Acting Chief
Biological Analysis Branch
Biological and Economic Analysis Division (7503P)

TO: Kathryn Montague, Product Manager
Herbicide Branch
Registration Division (7504P)

Product Review Panel: October 28, 2015

INTRODUCTION

Monsanto has requested a new use registration of the herbicide dicamba to be applied postemergence during the growing season over genetically modified dicamba-resistant cotton and soybean. Current registered uses of dicamba in cotton allow for a preplant application (except west of the Rockies) or a fall postharvest treatment for conventional or conservation tillage systems. The currently registered use of dicamba on soybeans allows for preplant application as well as a preharvest broadcast or spot treatment application after soybean pods are mature. As part of the regulatory review process BEAD here provides its review regarding the statements of benefits claimed by Monsanto (Reeves and Cubbage, 2015). As part of the regulatory review process BEAD also provides its review and recommendations regarding the resistance management and stewardship plan provided by Monsanto (Reeves and Cubbage, 2015).

BENEFITS ACCORDING TO THE REGISTRANT

The registrant submitted the following information in support of the benefits of a postemergence dicamba product:

1. Postemergence application of dicamba on dicamba-resistant crops during the growing season will help to control glyphosate-resistant weeds (14 species in the U.S.) including marestail, giant ragweed, common waterhemp, and Palmer amaranth. While glyphosate remains a valuable weed management tool the addition of dicamba will add another mechanism of action (MOA) that will reduce the chance that further glyphosate-resistant weeds will survive and reproduce.
    a) The new postemergence use of dicamba would provide a broad spectrum of weed control, especially for weeds that are resistant to glyphosate.
    b) Dicamba use can help reduce or delay resistance to other herbicide classes that might be used such as acetolactate synthase (ALS) or protoporphyrinogen oxidase (PPO) inhibitors.
2. According to the registrant, dicamba has been used for over 50 years on numerous crops, with both preemergence and postemergence applications to the crop, with little weed resistance to dicamba. Therefore, the availability of a postemergence use of dicamba during the season on cotton and soybean crops may enable growers who have relied heavily on glyphosate to use a different active ingredient with little known weed resistance. The registrant concluded that this use will achieve "simplicity, flexibility, and effectiveness" and positive economic returns in weed management. Monsanto has submitted a resistance management plan to address potential issues of resistance or apparent resistance by weeds to dicamba.
3. The product label will indicate a type of nozzle that will limit drift onto non-target crops. The proposed labels include additional restrictions to reduce drift, including wind speed and direction, spray volume, equipment ground speed and boom height, temperature and humidity, and temperature inversions.
4. Lastly, Monsanto claims that the use of dicamba "will provide environmental and economic benefits by enabling the continued use of reduced tillage agronomic practices and reducing the input required for farmers to produce a successful crop" (Reeves and Cubbage, 2015).

BEAD REVIEW OF MONSANTO'S SUBMITTED INFORMATION

1. Growers throughout the United States have experienced yield and economic losses due to weeds developing resistance to the herbicide glyphosate and other heavily used herbicides. The need for additional tools to manage these resistant weeds has become important as resistance to both glyphosate and other herbicides has become a significant financial, production, and pest managment issue for many cotton and soybean growers. Weeds such as marestail, giant ragweed, common waterhemp, and Palmer amaranth can be difficult to control during the growing season. New postemergence uses of dicamba on genetically modified cotton and soybeans would expand weed management options for growers by providing an additional MOA during the growing season. Dicamba used during the growing season would target new flushes of weeds and could have the effect of reducing populations

of these weeds and particularly would help reduce weed seed banks (i.e., viable seeds in the soil) to reduce populations of a new generation of weeds. Postemergence use of dicamba on genetically modified cotton and soybean during the growing season will expand options for broadleaf weed control, including glyphosate-resistant biotypes. Currently registered uses of dicamba in cotton allow for a preplant application (except west of the Rockies) or a fall postharvest treatment for conventional or conservation tillage systems (Tables 1 and 2). The currently registered use of dicamba on soybeans allows for preplant application as well as a preharvest broadcast or spot treatment application after soybean pods are mature (Tables 1 and 2). Information for dicamba use on corn is provided in Tables 1 and 2, as a reference.

a) There are currently several other herbicides registered that can be used for postemergence broadleaf weed control soon after plant emergence, but not throughout the growing season. On soybeans, registered herbicides include PPO inhibitors fomesafen + fluthiacet, acetochlor (chloroacetamide), acifluorfen (PPO), bentazon (PS-2-A), chlorimuron (ALS), lactofen (PPO), and some others (e.g., Curran and Lingenfelter, 2013). On cotton, for example, fluometuron (PS-2), trifloxysulfuron sodium (ALS), and pyrithiobac sodium (ALS) are registered (e.g., Morgan et al., 2013). Timing of applications is critical for all postemergence herbicides since efficacy is reduced as weed size increases beyond approximately four inches (e.g., Prostko, 2015). In general, herbicides are more effective when applied to weeds that are at early growth stages. Unlike currently registered postemergence herbicides that are restricted to early crop growth stages, dicamba used postemergence on dicamba-resistant crops could be applied throughout the growing season to control new flushes of weeds. This application timing may be a benefit for managing glyphosate-resistant weeds that may have developed where glyphosate-resistant soybeans have been extensively grown.
b) Dicamba is generally effective against certain broadleaf weeds, including weeds that may result in substantial financial inputs of additional labor and pesticides, such as marestail and Palmer amaranth. However, depending on the location and weed pressure, other herbicide MOAs will still be needed to manage weeds where dicamba is not effective, such as for ryegrass in cotton fields.
c) Dicamba used on dicamba-resistant crops would not eliminate the use of other herbicides. For example, because dicamba does not control weeds before they emerge, growers would continue to find various registered preemergence herbicide treatments of value to optimize weed management for up to six to eight weeks (e.g., Bradley et al., 2008; Stalcup, 2015). Preemergence herbicides provide early season weed control, which is critical to reduce weed competition for light, nutrients, and water while cotton and soybean crops become established.

Table 1. Current and proposed dicamba (Clarity®) use pattern restrictions.

Crop	Application Timing
Corn (current label, for comparison)	• Prior to planting to early postemergence with corn at 5 true leaf, or 8 inches, late postemergence with corn 8 to 36 inches tall or 15 days before tassel emergence
Cotton (current label)	• Prior to planting, wait 21 days before planting. Do not apply west of Rockies. • Fall postharvest
Dicamba-resistant cotton – (proposed label)	• Prior to planting and up to 7 days pre-harvest.
Soybean (current label)	• Prior to planting, wait 14 days before planting at 4 oz rate and 28 days for 16 oz rate. • Preharvest treatment is with pods a mature brown color and 75% leaf drop and at least 7 days between treatment and harvesting.
Dicamba-resistant soybean - (proposed label)	• Burndown/early preplant, preplant, at-planting, and preemergence through post-emergence up to and including bloom (R1 stage).

Table 2. Dicamba—Current average annual total area treated of field crops (2010-2014).

CROP	Average Total Area Treated per Year
Corn (for comparison)	11,740,000
Cotton	1,050,000
Soybean	1,440,000

Market Research Data

2. Although the registrant stated that there is not much pest resistance to dicamba, BEAD's review determined that in the U.S. dicamba-resistant biotypes of two weed species, Kochia and prickly lettuce, have been identified (Weed Science, 2015). Kochia has infested millions of acres of both soybean and cotton. In addition, glyphosate-resistant Kochia populations have been identified in Kansas (Godar et al., 2015) and Nebraska (Sandell et al., 2012). An increase in dicamba usage on soybean and cotton acreage could increase selection pressure for the expansion of dicamba-resistant weeds and the development of resistance by some additional weed species. Glyphosate-resistant weeds exposed to dicamba have the potential to develop resistance to both groups of herbicides. After consulting with extension specialists and crop groups the EPA is recommending that the registrant include instructions for the grower or user to scout fields and should include instructions for reporting to the registrant lack of product performance. Monsanto has submitted an Herbicide Resistance Management Plan that is designed to mitigate occurrences of herbicide resistance. Monsanto's proposed label includes recommendations to scout fields before and after applications. BEAD is recommending that Monsanto's final resistance managment plan incorporate all of the elements as outlined in the Resistance Management section in the Addendum.

3. With increased dicamba applications over crops during the growing season on large acreages of soybean and/or cotton, there is a chance for increases in the incidences of off-site crop damage (e.g., Egan et al., 2014; Johnson et al., 2012; Davis, 2012; Reynolds, 2015). The chance of off-site damage may be increased because the use of dicamba during the growing season would occur when off-site sensitive crops are actively growing. The

proposed labels indicate measures to reduce the possibility of drift, including the use of large droplet-producing nozzles, spray volume requirements, equipment ground speed restrictions, spray boom height, temperature and humidity considerations, wind speed, and tank-mix restrictions. These may reduce the potential for drift to off-target sites.

a) The proposed labels state that "applicators are required to ensure that they are aware of the proximity to sensitive areas, and to avoid potential adverse effects from off-target movement" of dicamba. The proposed label also state that "commercially grown tomatoes and other fruiting vegetables…cucurbits…and grapes are sensitive to dicamba" and applications should not be made "when the wind is blowing toward adjacent commercially grown sensitive crops", including soybeans not resistant to dicamba, which are sensitive to even small concentrations of dicamba (e.g., Egan et al., 2014; Tims, 2014).
b) The proposed label indicates that wind speeds of 3-10 mph are optimal for applications, although maximum wind speeds of 10-15 mph are allowed if not blowing toward sensitive areas. Due to state-specific concerns there may be alternative state regulations regarding the use of the pesticide in their state (e.g., Arkansas State Plant Board, 2014; Johnson et al., 2012; Reynolds, 2015).
c) According to the proposed labels ("Drift Reduction Agents"), drift reduction agents (DRA) can be added to further reduce fine droplets.
d) To reduce the chance of off-site damage from drift or volatility (e.g. Hartzler, 2001; Reynolds, 2015) the proposed labels contain buffer requirements.

4. No-till practices are used by farmers of many field crops for soil erosion control and water conservation. Monsanto has estimated that about 40% of soybean acreage is no-till (USDA-APHIS, 2013). In statements made by the registrant in support of the benefits of this product, there was an implication that no-till practices would be at risk without postemergence use of dicamba. The registrant stated that "registering dicamba will provide environmental and economic benefits by enabling the continued use of reduce tillage agronomic practices and reducing the inputs required for farmers to produce a successful crop." However, no data were submitted to support this idea.

CONCLUSION—BENEFITS

The postemergence use of dicamba would provide growers of genetically modified soybean and cotton to be resistant to dicamba with an additional mode of action to help manage difficult-to-control broadleaf weeds, especially glyphosate-resistant weeds. The use of dicamba on an actively growing crop may help to reduce seed banks of broadleaf weeds during the growing season and, thus, help to reduce populations of future generations of weeds. Until now, the use of dicamba has not resulted in substantial resistance among weed species, although dicamba-resistant Kochia populations have been identified in some areas of the U.S. (e.g., Godar et al., 2015; Sandell et al., 2012) and, overall, Kochia has been a problem weed on millions of acres of soybean and cotton. The efficacy of several herbicides has been compromised over the years for various reasons, including poor resistance management practices, leading to ineffective weed control. Glyphosate-resistant weeds (including glyphosate-resistant Kochia) have developed from the longtime extensive use of glyphosate (e.g., Fraser, 2013). The widespread adoption of dicamba-resistant crops will increase the population of weeds exposed to dicamba during the growing season and the possibility, therefore, that selection pressure could increase the incidence of dicamba-resistant weeds. This could continue the unfortunate cycle of a new herbicide use soon followed by resistance to that herbicide. Weed species that are difficult to control in one location or cropping system may not be problematic in others. Resistance management programs designed for local conditions by state extension agencies that provide guidelines for the appropriate measures for controlling local problem weeds, are important in stemming the increasing incidences of resistance over the long-term.

Additionally, an increased number of applications of dicamba to large acreage may increase the likelihood of off-site damage to surrounding sensitive plants through drift and/or volatility. Some crops, such as soybean not resistant to dicamba, are sensitive to extremely small doses of dicamba (e.g., Kelley et al., 2005). Mitigation through label restrictions of wind speed, droplet size, buffers, etc. should reduce the chance of off-site damage.

In addition to label restrictions, communication between extension specialists and farmers will be an important resource for growers for determining optimal weed control and drift prevention measures for local growing areas. Best management practices indicate that at least two effective modes of action be used to manage weeds, which suggests that additional herbicides will likely be needed in order to manage glyphosate-resistant grasses or broadleaf weeds not controlled by dicamba or glyphosate. Furthermore, best management practices will be essential for growers where dicamba and glyphosate resistant populations have been identified.

ADDENDUM—RESISTANCE MANAGEMENT PLAN

This Addendum presents resistance management steps that may serve to alleviate the increasing development of weed resistance to dicamba (or any) herbicide. The resistance management plan submitted by Monsanto includes some of these elements (see below "Comments on Resistance Management Plan for Dicamba"), but all of these elements (Table A) should be incorporated in Monsanto's final resistance management plan.

RESISTANT WEED SPECIES

Dicamba is a synthetic auxin (Weed Science Society of America [WSSA] Group 4). This MOA has eight resistant weed species in the United States. In the U.S. dicamba has two resistant weed biotypes Kochia (*Kochia scoparia)* and prickly lettuce (*Lactuca serriola).*

ELEMENTS OF RESISTANCE MANAGEMENT PLANS

The EPA announced at the Herbicide Resistance Summit II (sponsored by the National Academy of Sciences, September 10, 2014) that it would take a more proactive role in developing regulatory approaches for managing resistant weeds. The EPA finds benefits for developing an Herbicide Resistance Management (HRM) plan that will promote herbicide resistance management efforts for all crops, including genetically engineered crops. This is part of a holistic, proactive approach being developed as a result of recommendations by crop consultants, commodity organizations, professional/scientific societies, researchers, and registrants themselves. The following table lists eleven items that should be addressed in these plans (Table A).

Table A. Recommended elements for any resistance management or stewardship plan

Element	Description
1	List Mechanism of Action (MOA) Group Number[1] ➢ Registrant lists this on the label
2	List seasonal and annual maximum number of applications and pounds ➢ Registrant lists this on the label
3	Resistance Management language from PR Notice 2001-5, and/or Best Management Practices[2] (appropriate to crop) from Weed Science Society of America (WSSA) & Herbicide Resistance Action Committee (HRAC), and/or HRAC proposed guidelines for herbicide labels ➢ Registrant lists this on the label
4	Include instructions for scouting before and after application ➢ Registrant lists this on the label ➢ User must follow the label.
5	Definition of Likely Resistance[3] ➢ Registrant lists this on the label
6	Include instructions for reporting lack of performance to registrant or their representative ➢ Registrant lists this on the label ➢ User must follow the label.
7	List confirmed resistant weeds in a separate table and list effective or recommended rates for these weeds with the table ➢ Registrant lists this on the label

	➢ User must follow the label
8	Registrant reports new cases of likely and confirmed resistance to EPA and users yearly This will be in addition to any adverse effects reporting
9	For sites of high concern registrant provides growers with: • Resistance Management Plan • Remedial Action Plan (to control resistant weeds this season or next season) • Educational materials on resistance management Plans should be locally developed and easily modified. We recommend registrants work with Extension, Consultants, Crop Groups, HRAC, & USDA. ➢ Registrant is responsible to provide educational materials
10	For any approved combination products with multiple MOA, list which herbicide is controlling what weed to avoid unnecessary applications (for example, a 3-way mixture may only have one effective MOA for some problem weeds). List minimum recommended rate if resistance is suspected. • Registrant is responsible to list on label or otherwise provide information
11	Any additional specific requirements (e.g. mandatory crop rotation, unique agronomic aspects, additional training, time limited registration, etc.) ➢ Registrant lists on the label or otherwise provide information

[1]Mechanism of Action Group number identified by WSSA.
[2]Best Management Practices (BMP) language is found in Appendices I through III.
[3]Definition of "likely resistance" is found in Norsworthy, et al. (2012).

The proposed dicamba labels ("Weed Resistance Management" section) indicate that fields should be scouted before and after application. Fields should be scouted before the application of dicamba in order to identify the weed species that are present as well as their stage of growth. Fields should be scouted after each application to identify poor performance or likely resistance. In the event that a user encounters a non-performance issue the label includes information on how the user can contact the registrant or its representative (see definition of "lack of herbicide efficacy," below). Identifying herbicide resistance is not necessarily obvious. When a lack of herbicide efficacy is identified, the registrant or its representative will investigate and conduct a site visit (if needed) to evaluate the lack of herbicide efficacy using decision criteria identified by leading weed science experts (Norsworthy, et al., 2012) in order to determine if "likely herbicide resistance" is present.

"Lack of herbicide efficacy" refers to inadequate weed control with various possible causes including, but not limited to: application rate, stage of growth, environmental conditions, herbicide resistance, equipment malfunction, mixer/loader/applicator error, post-application weed flush, unexpected weather events, weed misidentification, etc (Appendix II). EPA recognizes that it can be challenging to distinguish emerging weed resistance from other causes at an early plant growth stage. Therefore, EPA has modified criteria from Norsworthy, et al. (2012) to determine if these weeds do in fact demonstrate "likely herbicide resistance." These "likely herbicide resistance" criteria are: (1) failure to control a weed species that is normally controlled by the herbicide at the dose applied, especially if control is achieved on adjacent weeds; (2) a spreading patch of uncontrolled plants of a particular weed species; and (3) surviving plants mixed with controlled (affected) individuals of the same species (Norsworthy, et al., 2012). The identification of one or more of these criteria in the field indicates that the weed species is "likely herbicide resistant".

The registrant should annually report to EPA findings of likely herbicide resistance or confirmed resistance in new locations. In addition, prior to implementing control measures, the registrant should attempt to obtain samples of the likely herbicide resistant weeds and/or seeds, and as soon as practicable, submit them for laboratory or greenhouse testing in order to confirm whether resistance is the cause of lack of herbicide efficacy. When the registrant or its representative applies the Norsworthy, et al. (2012) factors (cited above) and likely herbicide resistance is identified, then the registrant should proactively engage with the grower to control and contain likely resistant weeds in the infested area. This may be accomplished by recommendations to re-treat with an effective herbicide or implement mechanical control methods. After implementing these measures the registrant should follow-up with the growers, to the extent possible and with the growers' permission, to determine if the likely resistant weeds have been controlled or take some further actions if not successful.

Beginning January 15th, 2017, and on or before January 15th of each year, the registrant should submit annual summary reports to EPA. These reports should include a summary of the number of instances of likely and confirmed resistance to dicamba listing weed species, crop, county, and state. The reports should also summarize the status of laboratory or greenhouse testing for resistance and address the disposition of incidents of likely or confirmed resistance reported in previous years. The registrant also should report annually to relevant stakeholders (i.e., crop consultants, extension, growers, university, etc.) the specifics regarding a lack of control of confirmed or likely-resistant weeds.

CATEGORIES OF CONCERN FOR HERBICIDE RESISTANCE

The recommendation in this analysis is part of a more proactive and holistic approach to slow the development and spread of herbicide-resistant-weeds. This approach has been recommended by crop consultants, commodity organizations, professional/scientific societies, researchers, and the registrants themselves. The framework considers the inherent risk of weed resistance developing for a given herbicide as well as the target weeds and the agronomic practices of the registered crops. The framework divides 28 herbicide MOAs into three categories of concern (low, moderate, high) based on the risk of developing herbicide-resistant weeds (Table B). OPP is proposing to implement herbicide resistance measures for existing chemicals during registration review, and to implement herbicide resistance measures for new chemicals and new uses at the time of registration. In registration review, proposed herbicide resistance elements will be included in every herbicide preliminary interim decision.

The category of high concern will include any 1) new or novel herbicide MOA, 2) herbicides that will be applied to a crop that is resistant to that MOA (conventionally bred or genetically engineered), or 3) herbicide MOA with the most resistant weed species. Herbicide MOA that currently have no resistant weed species will be placed in the low concern category. The remaining MOAs will be placed into the category of moderate concern. If new resistant weed species are found, then an herbicide or mechanism of action may be moved into a category of higher concern. Table B also identifies the minimum resistant management elements recommended for each of the categories.

Dicamba used on herbicide resistant cotton and soybeans is of high concern for herbicide resistance, therefore, all of the resistant management elements listed above should be implemented.

Table B. Herbicide Resistance Categories of Concern and Resistance Management Elements for Use by Risk Managers [1, 2]

Low Concern	Moderate Concern	High Concern
Mechanisms of Action (MOA) with no resistant weed species in the U.S.	MOA with only a few resistant weed species in the U.S.	• Any new herbicide with a new or novel MOA, or • Herbicide resistant crop(s) (conventionally bred or GM), or • MOA with the most resistant weeds in U.S.
1. MOA on Label 2. List seasonal and annual maximum number of applications and pounds 3. Resistance management language from PRN 2001-5, BMPs and or HRAC 4. Include instructions for scouting before and after application	***Elements 1 through 4 plus:*** 5. Definition of likely herbicide resistance 6. Include instructions for reporting lack of performance to registrant or its agent 7. List confirmed resistant species in separate table and list effective or recommended rates for these weeds with the table 8. Registrant report new cases of likely and confirmed resistance to EPA & users yearly	***Elements 1 through 8 plus:*** 9. Provide growers with: Resistance Management Plan, Remedial Action Plan, Educational materials on resistance management 10. For combination products with multiple MOA, list what herbicide is controlling what weed and minimum recommended rate 11. Any additional specific requirements (e.g. mandatory crop rotation, unique agronomic aspects, time limited registration, etc.).

[1] Resistance management elements are taken from Table B, which indicates placement on the label or as a term of registration.

[2] If new resistant weed species are found an herbicide MOA may move to a category of greater concern.

COMMENTS ON RESISTANCE MANAGEMENT PLANS FOR DICAMBA

A Resistance Management Plan and labels proposed by the registrant for the postemergence use of dicamba were reviewed to determine if the Elements from Table A had been addressed.

Element 1. Mechanism of Action (MOA) Group Number is currently on the proposed label.

Element 2. Seasonal, but not annual, maximum number of applications and pounds were listed. Annual maximum amounts should be on the label.

Element 3. Included on the label are some, but not all, information provided in the Resistance Management sections of PR Notice 2001-5, and or Best Management Practices (appropriate to crop) from WSSA & HRAC (Appendix I and III).

Element 4. Instructions to scout before and after application is on the proposed label.

Element 5. Definition of "Likely Resistance" (Appendix II) was included on the proposed label.

Element 6. The label tells the user to report a lack of performance to the registrant or their representative and includes a telephone number.

Element 7. In future discussions with the registrant, we will emphasize the value of listing confirmed resistant weeds in a separate table along with the recommended rates for these weeds.

Element 8. Registrant will report new cases of likely and confirmed resistance to EPA and users annually (as part of the terms of registration).

Element 9. The submitted materials did not indicate if the registrant will provide growers with the Resistance Management Plan, Remedial Action Plan, and Educational materials on resistance management.

Element 10. If used in a formulation with multiple mechanisms of action the registrant should provide a list of what herbicide is controlling what weed and minimum recommended rate.

Element 11. The registrant did not list any additional specific requirements for resistance management.

OTHER CONCERNS

For Drift Reduction BEAD suggests that the registrant use information from the Best Management Practices for Boom Spraying developed by the American Society of Agricultural and Biological Engineers (ASABE) 2012.

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APPENDIX I. Guidance for Pesticide Registrants on Pesticide Resistance Management Labeling (EPA, 2001)

Herbicides

1. The following general resistance management labeling statements are recommended for herbicide products containing only a single active ingredient or only active ingredients from the same group:

a. "For resistance management, (name of product) is a Group (mode of action group number) herbicide. Any weed population may contain or develop plants naturally resistant to (name of product) and other Group (mode of action group number) herbicides. The resistant biotypes may dominate the weed population if these herbicides are used repeatedly in the same field. Other resistance mechanisms that are not linked to this mode of action but are specific for individual chemicals, such as enhanced metabolism, may also exist. Appropriate resistance-management strategies should be followed."

For products containing active ingredients from different groups, the statement should be modified to reflect the situation, for example:

b. "For resistance management, please note that (name of product) contains both a Group (mode of action group number) and a Group (mode of action group number) herbicide. Any weed population may contain plants naturally resistant to Group (mode of action group number) and/or Group (mode of action group number) herbicides. The resistant individuals may dominate the weed population if these herbicides are used repeatedly in the same fields."

2. The following additional resistance management labeling statements are recommended for herbicides, although each bulleted statement may not be appropriate or pertinent for every product label:

"To delay herbicide resistance:

a. Rotate the use of (name of product) or other Group (mode of action group number) herbicides within a growing season sequence or among growing seasons with different herbicide groups that control the same weeds in a field.

b. Use tank mixtures with herbicides from a different group if such use is permitted; Use the less resistance-prone partner at a rate that will control the target weed(s) equally as well as the more resistance-prone partner.

c. Adopt an integrated weed management program for herbicide use that includes scouting and historical information related to herbicide use and crop rotation, and that considers tillage (or other mechanical control methods), cultural (e.g., higher crop seeding rates; precision fertilizer application method and timing to favor the crop and not the weeds), biological (weed-competitive crops or varieties) and other management practices.

d. Scout after herbicide application to monitor weed populations for early signs of resistance development. Indicators of possible herbicide resistance include: (1) failure to control a weed species normally controlled by the herbicide at the dose applied, especially if control is achieved on adjacent weeds; (2) a spreading patch of uncontrolled plants of a particular weed species; (3) surviving plants mixed with controlled individuals of the same species. If resistance is suspected, prevent weed seed production in the affected area by an alternative herbicide from a different group or by a mechanical method such as hoeing or tillage. Prevent movement of resistant weed seeds to other fields by cleaning harvesting and tillage equipment when moving between fields, and planting clean seed.

e. If a weed pest population continues to progress after treatment with this product, discontinue use of this product, and switch to another herbicide with a different target mode of action, if available.

f. Have suspected resistant weed seeds tested by a qualified laboratory to confirm resistance and identify alternative herbicide options.

g. Contact your local extension specialist or certified crop advisors for additional pesticide resistance-management and/or integrated weed-management recommendations for specific crops and weed biotypes.

h. For further information or to report suspected resistance, contact (company representatives) at (toll free number) or at (Internet site)."

APPENDIX II. Definition of Likely Resistance

Likely Resistance

Indicators of likely herbicide resistance (called "possible resistance" *in* Norsworthy et al., 2012; Pp 39) include (1) failure to control a weed species normally controlled by the herbicide at the dose applied, especially if control is achieved on adjacent weeds; (2) a spreading patch of uncontrolled plants of a particular weed species; and (3) surviving plants mixed with controlled individuals of the same species. Likely resistant weeds are assumed to be present if any of these criteria are met.

APPENDIX III. Best Management Practices for Herbicide Resistant Weeds [1]

The following resistance management labeling statements are recommendations for herbicide products and are listed here as a reference.

Crop Selection and Cultural Practices:

1. Understand the biology of the weeds that are present.
2. Use a diversified approach toward weed management focusing on preventing weed seed production and reducing the number of weed seeds in the soil seed-bank.
3. Emphasize cultural practices that suppress weeds by using crop competitiveness.
4. Plant into weed-free fields, keep fields as weed-free as possible, and note areas where weeds were a problem in prior seasons.
5. Incorporate additional weed control practices whenever possible, such as mechanical cultivation, biological management practices, crop rotation, and weed-free crop seeds as part of an integrated weed control program.
6. Do not allow weed escapes to produce seeds, roots or tubers.
7. Manage weed seed at harvest and post-harvest to prevent a buildup of the weed seed-bank.
8. Prevent field-to-field and within-field movement of weed seed or vegetative propagules.
9. Thoroughly clean plant residues from equipment before leaving fields.
10. Prevent an influx of weeds into the field by managing field borders.
11. Fields should be scouted before application to ensure herbicides and application rates will be appropriate for the weed species and weed sizes present.
12. Fields should be scouted after application to confirm herbicide effectiveness and to detect weed escapes.
13. If resistance is suspected, treat weed escapes with an alternate mode of action or use non-chemical methods to remove escapes.
14. Avoid outcrossing to weedy relatives, in crops that outcross. Control weedy relatives in surrounding field margins. Research has demonstrated that the pollen can move hundreds of feet.

Herbicide Selection:

1. Use a broad spectrum soil applied herbicide with a mechanism of action that differs from this product as a foundation in a weed control program.
2. A broad spectrum weed control program should consider all of the weeds present in the field. Weeds should be identified through scouting and field history.
3. Difficult to control weeds may require sequential applications of herbicides with alternative mechanisms of action.
4. Fields with difficult to control weeds should be rotated to crops that allow the use of herbicides with alternative mechanisms of action.

5. Apply full rates of this herbicide for the most difficult to control weed in the field. Applications should be made when weeds are at the correct size to minimize weed escapes.
6. Do not use more than two applications of a particular herbicide or any herbicide with the same mechanism of action within a single growing season unless mixed with another mechanism of action herbicide with overlapping spectrum for the difficult to control weeds.
7. Report any incidence of non-performance of this product against a particular weed species to the registrant's representative (list contact information here).

[1] Most items are taken from the Herbicide Resistance Action Committee/Weed Science Society of America list of Best Management Practices.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, DC 20460

OFFICE OF CHEMICAL SAFETY AND POLLUTION PREVENTION

PC Code: 128931
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Date: March 24, 2016

MEMORANDUM

Subject: Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 16 states (Arkansas, Illinois, Iowa, Indiana, Kansas, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin).

To: Grant Rowland, Risk Manager
Kay Montague, Product Manager Team 23
Dan Kenny, Branch Chief
Herbicide Branch
Registration Division (7505P)
Office of Pesticide Programs

From: Elizabeth Donovan, M.S., Biologist [signature] 3/24/16
Michael Wagman, M.S., Biologist [signature] 3/24/16
Monica Wait, Risk Assessment Process Leader Monica Wait 3/24/16
Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)
Office of Pesticide Programs

Through: Mark Corbin, Branch Chief [signature] 3-24-16
Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)
Office of Pesticide Programs

Prior to conducting this refined Endangered Species Assessment, the Environmental Fate and Effects Division (EFED) performed a screening level ecological risk assessment for a Federal action involving proposed new uses of the diglycolamine salt of dicamba (dicamba DGA) on dicamba herbicide-tolerant soybean on March 8, 2011 (DP 378444); an amendment to the assessment was issued on May 20, 2014 (DP 404138, 404806, 405887, 410802, and 411382). Concurrent with this refined Endangered Species

Assessment, a Section 3 New Use dicamba DGA salt on dicamba-tolerant cotton screening-level assessment (DP 404823) and a subsequent addendum for the use of dicamba DGA on dicamba-tolerant soybean (DP 426789) that addresses multiple issues (risk to terrestrial invertebrates, spray drift buffers, runoff, and updated mammalian toxicological endpoints for parent dicamba and its degradate DCSA) have been finalized. As a result of the analyses in the screening level risk assessments and the new addendum (DP 426789), potential direct risk concerns could not be excluded for:

- mammals (chronic, from the soybean use only, due to residues from dicamba's metabolite, DCSA, rather than from parent dicamba);
- birds (acute from parent dicamba for both soybean and cotton uses; chronic from DCSA residues only in soybean but not cotton), considered surrogates for reptiles, and terrestrial-phase amphibians; and
- terrestrial plants (soybean and cotton uses).

In the screening level risk assessments, indirect effect risk concerns for all taxa were possible for any species that have dependencies (e.g., food, shelter, and habitat) on mammals, birds, reptiles, terrestrial-phase amphibians, or terrestrial plants. Additionally, the screening level assessment showed that direct risk concerns were unlikely (*i.e.* levels of concern were not exceeded) for:

- mammals (acute) and (chronic—for the cotton use only);
- birds, reptiles, and terrestrial-phase amphibians (chronic from parent dicamba or DCSA degradate from use on cotton);
- terrestrial insects (acute and chronic);
- freshwater fish (acute and chronic);
- aquatic-phase amphibians (acute and chronic);
- estuarine/marine fish (acute and chronic);
- freshwater invertebrates (acute and chronic); estuarine/marine invertebrates (acute and chronic); and
- aquatic plants[1]

The screening assessment for dicamba DGA on dicamba-tolerant cotton (D404823) and the recent addendum to the screening level risk assessment for the use of dicamba DGA on dicamba-tolerant soybean (D426789) used updated terrestrial mammal endpoints for dicamba and its metabolite, DCSA.

EPA has a specific process based on sound science that it follows when assessing risks to listed species for pesticides like dicamba that will be used on seeds that have been genetically modified to be tolerant to the pesticide. The Agency begins with a screening level assessment that includes a basic ecological risk assessment based on its 2004 Overview of the Ecological Risk Assessment Process document. [USEPA, 2004, available at http://www.epa.gov/oppfead1/endanger/litstatus/riskasses.htm]. That assessment uses broad default assumptions to establish estimated environmental concentrations of particular pesticides. If the screening level assessment results in a determination that no levels of concern are exceeded EPA concludes its analysis. On the other hand, where the screening level assessment does not rule out potential effects (exceedances of the level of concern) based on the broad default assumptions, EPA then uses increasingly specific methods and exposure models to refine its estimated environmental exposures. At each screening step, EPA compares the more refined exposures to the toxicity of the pesticide active

[1] The listed species LOC was exceeded for non-vascular aquatic plants, however there are no listed species of this taxa.

ingredient to determine whether the pesticide exceeds levels of concern established for listed aquatic and terrestrial species. EPA determines that there is "no effect" on listed species if, at any step in the screening level assessment, no levels of concern are exceeded. If, after performing all of the steps in the screening level assessment, a pesticide still exceeds the Agency's levels of concern for listed species, EPA then conducts a species-specific refined assessment to make effects determinations for individual listed species. The refined assessment, unlike the screening level assessment, takes account of species' habitats and behaviors to determine whether any listed species may be affected by use of the pesticide.

The screening level ecological risk assessment generates a series of taxonomic (e.g., mammals, birds, fish, etc.) risk quotients (RQs) that are the ratio of estimated exposures to acute and chronic effects endpoints. These RQs are then compared to EPA established levels of concern (LOCs) to determine if risks to any taxonomic group are of concern. The LOCs address risks for both acute and chronic effects. Acute effects LOCs range from 0.05 for aquatic animals that are Federally-listed threatened or endangered species (listed species) to 0.5 for aquatic non-listed animal species and 0.1 to 0.5 for terrestrial animals for listed and non-listed species. The LOC for chronic effects for all animal taxa (listed and non-listed) is 1. Plant risks are handled in a similar manner, but with different toxicity thresholds (NOAEC/EC_{05} and $EC_{25,}$ respectively) used in RQ calculation for listed and non-listed species and an LOC of 1 used to interpret the RQ. When a given taxonomic RQ exceeds either the acute or chronic LOC, a concern for direct toxic effects is identified for that particular taxon. If RQs fall below the LOC, a no effect determination is identified for the corresponding taxon.

The purpose of this document is to explain the refined risk assessment conducted for Federally-listed threatened or endangered (listed) species that could potentially be impacted by this pesticide registration. The refined assessment was conducted based on the 2004 Overview document, as discussed above. The assessment of risks to listed species posed by the use of Dicamba DGA has been conducted in phases covering a specific set of states, assessing risk to all the listed species covered in those states. This assessment covers the endangered species analysis for 16 states: Arkansas, Illinois, Iowa, Indiana, Kansas, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin. Based on EFED's LOCATES v.2.4.0 database and information from the U.S. Fish and Wildlife Service (USFWS), 183 species in the 16 states proposed for registration were identified as within the action area (at a preliminary county-wide level of resolution) associated with the new herbicide-tolerant soybean and cotton uses. **Table 1** presents a summary of this assessment. Separate concurrent assessment phases cover the endangered species analysis for 7 states (D422305, covering AL, GA, KY, MI, NC, SC, and TX) and 11 states (D425049, covering AZ, CO, DE, FL, MD, NM, NJ, NY, PA, VA and WV).

EPA consulted U.S. Fish and Wildlife Service Recovery Plans to determine whether listed species in these states would be expected to occur in an action area encompassing the treated soybean and corn fields. The refined assessment was then conducted on those species that could not be excluded from the action area. EPA also consulted the recovery plans in the refined assessment for additional habitat information and incorporated species biological information regarding dietary items (used to model dicamba DGA residues in prey tissue) and body weight (used to determine food consumption rates and scale ecotoxicity data from the tested surrogate species, the bobwhite quail and rat, to the body weight of the listed species).

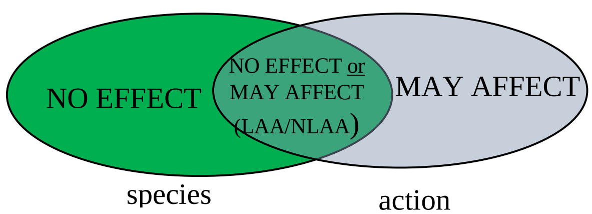
Table 1. Summary of species effects determinations and critical habitat modification determinations for Federally listed threatened or endangered species in AR, IL, IA, IN, KS, LA, MN, MS, MO, NE, ND, OH, OK, SD, TN, and WI for dicamba DGA use on genetically modified cotton and soybeans.

Species	**Effects Determination**	**Comments**
Spring Creek Bladderpod	**May Affect, Likely to Adversely Affect**	Found in Wilson Co., TN
All other species (terrestrial and aquatic)	No Effect	None
Critical Habitat	**Modification Determination**	**Comments**
All Critical Habitats	No Modification	None

<u>Making an Effects Determination</u>

The bullets below outline EFED's process for making an effects determination for the Federal action:

- For listed individuals inside the action area but **NOT** part of an affected taxa **NOR** relying on the affected taxa for services (involving food, shelter, biological mediated resources necessary for survival/reproduction), use of a pesticide would be determined to have NO EFFECT.
- For listed individuals outside the action area, use of a pesticide would be determined to fall under NO EFFECT.
- Listed individuals inside the action area may either fall into the NO EFFECT or MAY AFFECT (LIKELY or NOT LIKELY TO ADVERSELY AFFECT) categories depending upon their specific biological needs, circumstances of exposure, etc.



- LIKELY or NOT LIKELY TO ADVERSELY AFFECT determinations are made using the following criteria:
  - Insignificant - The level of the effect cannot be meaningfully related to a "take."
  - Highly Uncertain - The effect is highly unlikely to occur.
  - Wholly beneficial - The effects are <u>only</u> good things.

Spray Drift Mitigation

EFED's refined endangered species risk assessment took into account the spray drift mitigation language that was added to the most recent proposed label submitted by the registrant. An accounting of federally-listed threatened or endangered species within the 16 states (covered in this assessment) proposed for dicamba DGA use on genetically modified cotton and soybeans is included in **Appendix 1** (183 species). Specifically, the spray drift mitigation language on the M1691 Herbicide Supplemental labels for the use dicamba DGA salt on ROUNDUP READY 2 XTEND™ soybean and BOLLGARD II® XTENDFLEX cotton includes the following limitations:

- Specifying the use of a nozzle (Tee Jet® TTI11004) with ASABE S-572 ultra-coarse and extremely coarse droplet spectra and a maximum operating pressure of 63 psi.
- A maximum equipment ground speed of 15 miles per hour and ground boom height of 24 inches above the target pest or crop canopy.
- Restricting all applications when wind speeds are < 3 mph or > 15 mph and restricting applications when wind is blowing towards sensitive areas at > 10 mph. Maintaining use of a 110 foot in-field buffer for a 0.5 lb a.i./A application (220 foot in-field buffer for a 1 lb a.i./A application) when the wind is blowing towards any areas that are not fields in crop cultivation, paved areas, or areas covered by buildings and other structures.
- Applications done in low relative humidity conditions are to use equipment set to produce larger droplet spectra to compensate for evaporation.
- Applications are not be conducted during temperature inversions.
- In order to prevent effects to non-target susceptible plants, the label also includes the following language: "do not apply under circumstances where spray drift may occur to food, forage or other plantings that might be damaged or the crops thereof rendered unfit for sale, use or consumption. Avoid contact of herbicide with foliage, green stems, exposed non-woody roots of crops, and desirable plants, including beans, cotton, flowers, fruit trees, grapes, ornamentals, peas, potato, soybean, sunflower, tobacco, tomato, and other broadleaf plants because severe injury or destruction may result, including plants in a greenhouse. Applicators are required to ensure that they are aware of the proximity to sensitive areas, and to avoid potential adverse effects from the off-target movement of M1691 Herbicide. The Applicator must survey the application site for neighboring sensitive areas prior to application. The applicator also should consult sensitive crop registries for locating sensitive areas where available."
- Finally, in order to prevent unintended damage from the drift of M1691 Herbicide, the label says not to apply this product when the wind is blowing towards adjacent commercially grown sensitive crops.

The incorporation of the spray drift mitigation measures into the product labeling as outlined above would result in exposure to dicamba DGA from spray drift at a level where effects are expected only within the confines of the treated field and so the action area is limited to the dicamba DGA treated field. Further, the incorporation of the "susceptible plants" spray drift mitigation language on the label is to avoid damage to these plants (including adjacent crops). Because the risk assessment interprets the threshold for plant damage concern to be based on the most sensitive plant species tested and the screening level ecological risk assessment has demonstrated that these plant effects endpoints constitute the most conservative terrestrial organism levels of effect, it is concluded that the "susceptible plants" requirement requires a level of drift mitigation that would also prevent less sensitive organisms from being exposed at levels of concern. Terrestrial species that are not expected to occur on treated fields under the provisions of the proposed label are not expected to be directly exposed to dicamba DGA, nor are their critical biologically mediated resources expected to be exposed to levels of the herbicide above any effects thresholds of concern. Additionally, as indicated in the screening level ecological risk assessments for cotton and soybean, no aquatic receptor taxa are of concern for drift or runoff exposure (LOCs were not exceeded for aquatic taxa). **Consequently, all but 10 of the listed species originally identified as potentially at-risk are determined to be given a "no effect" (NE) without further refinement because they are not expected to occur in an action area encompassing the treated soybean and cotton fields** (**Appendix 2**). The remaining 10 species are assessed using the refinements set forth in the 2004 Overview document referred to earlier in this assessment.

Exposure through Runoff

The cotton screening-level risk assessment and the concurrently issued soybean addendum characterized risk following exposure to dicamba residues in runoff and found that the predicted concentrations from modeling were lower than the most sensitive taxa's endpoint (soybean plant height). Combining the predictions of this modeling, the toxicological endpoints and that most of the off-site plant community would not experience foliar contact with dicamba DGA in runoff sheet flow, EFED concluded that all available lines of evidence supported a "no effects" determination for runoff exposure for off-field listed plants for the proposed labeled use of dicamba DGA. Additionally, rainfast mitigation on the label would also protect against the risk of exposure to listed species off the treated field.

In addition to the spray drift and runoff mitigation measures contained in the proposed labeling, EFED analyzed species-specific biology, dicamba-specific foliar residue data and dicamba application timing information in this refined endangered species assessment. An accounting of the federally-listed threatened or endangered species within the 16 states proposed for this registration showed 183 listed species as potentially at risk (direct or indirect effects) as a result of the screening-level assessment (**Appendix 1**). The spray drift mitigation label language cannot preclude listed species being exposed to dicamba DGA salt or DCSA residues on treated fields, should a listed species utilize such areas as part of its range and corresponding habitat. Of the 183 listed species within the 16 states (AR, IL, IN, IA, KS, LA, MN, MS, MO, NE, ND, OH, OK, SD, TN, WI) considered part of the proposed Federal decision, the following 10 species were reasonably expected to occur on soybean and cotton fields, which could potentially be treated with dicamba and therefore could not be assumed to be "no effect" solely on the basis of occurrence outside the action area:

- gray wolf (*Canis lupis*)
- Indiana bat (*Myotis sodalis*)
- Ozark bat (*Corynorhinus townsendii ingens*)
- Louisiana black bear (*Ursus americanus luteolus*)
- whooping crane (*Grus americana*)
- Mississippi sandhill crane (*Grus canadensis pulla*)
- lesser prairie-chicken (*Tympanuchus pallidicinctus*)
- gopher tortoise (*Gopherus polyphemus*)
- American burying beetle (*Nicrophorus americanus*)
- Spring Creek bladderpod (*Lesquerella perforata*)

Therefore, species specific biological information (e.g., body size, dietary requirements, and seasonality) and dicamba DGA use patterns were considered in more depth to further refine the assessment and effects determinations.

This assessment also uses the refined exposure values determined in the cotton screening level assessment and the concurrently issued addendum to the soybean screening level risk assessment documents compared to the initial exposure estimates from the soybean screening level assessment. This ESA assessment also evaluates chronic exposures from DCSA separately from the chronic exposure to parent dicamba. Dicamba exposure values were determined from the upper bound of the modeled T-REX run for exposures following spray applications based on the Kenaga nomogram modified by Fletcher *et al* (1984), which is based on a large set of actual field residue data. Modeled dicamba exposure values were identical between the soybean addendum and the cotton screening level risk assessment (since the maximum application rates and minimum application intervals are the same).

Similar modeling of DCSA residues, which are formed inside the tolerant-soybean and tolerant-cotton plants through plant metabolism, is not feasible at this time due to a lack of sufficient data tracking DCSA residues in plant tissues over time to ascertain degradation rates. Therefore, in the soybean addendum and the cotton screening-level risk assessment, EFED used the maximum empirical measured DCSA residue concentrations in dicamba-tolerant soybean (61.1 mg/kg (ppm) DCSA in broadleaf plants and 0.440 ppm in soybean seeds) and cotton plant tissues (6.29 ppm DCSA in cotton gin byproducts and 0.27 ppm in undelinted cotton seed) to evaluate chronic exposures to DCSA for animals foraging on soybean and cotton plants. Residues in arthropods (as a dietary item for birds and mammals consuming insects that have consumed soybean/cotton tissues with DCSA residues) were assumed to follow the Kenaga nomogram relationship between broadleaf plants and arthropods for spray applications (*i.e.* arthropod concentrations estimated to be approximately 70% of the concentrations in broadleaf plant tissues or 42.5 ppm DCSA in arthropods feeding on soybean plants and 4.4 ppm in arthropods feeding on cotton plants). The empirical residue data for cotton indicated that chronic exposures of birds and mammals to dicamba or DCSA in cotton tissues ***would not*** be above any levels of concern. Although the concurrently issued soybean addendum indicates that chronic risk to mammals and birds was only a concern from DCSA residues in plant/prey tissues *and not from residues of parent dicamba*, since the original soybean screening-level assessment (USEPA, 2011) indicated chronic risk to mammals, this assessment presents the estimated exposures and comparisons to threshold toxicity values for both dicamba and DCSA for mammals, but evaluates them separately since their chronic toxicity and exposure profiles differ greatly. For birds, following the conclusions of the screening level assessments and the soybean addendum, only acute risk from dicamba exposures and chronic risk from DCSA exposures is evaluated.

Critical Habitat Analysis

In addition to the species-specific effects determinations, EFED also conducted a critical habitat modification analysis (**Appendix 3)** consistent with the Overview Document (USEPA, 2004) as discussed earlier in this refined assessment. The critical habitat modification analysis is based on an assessment of how dicamba DGA salt would affect the U.S. Fish and Wildlife or National Marine Fisheries Service (the Services) established principle constituent elements (PCE's) of the designated habitat as well as how direct species effects outcomes would impact critical habitat's present and future utility for promoting the conservation of a particular listed species.

The following text discusses the lines of evidence and processes that were used to make effects determinations for listed species identified as potentially at-risk in the screening level assessment.

Refined ecological risk assessment for the remaining species potentially exposed to dicamba and DCSA residues

For the effects determinations for whooping crane, sandhill crane, lesser prairie chicken, gopher tortoise, American burying beetle, spring creek bladderpod, Indiana bat, Ozark bat, gray wolf and Louisiana bear, a refined risk assessment approach was used to evaluate additional lines of evidence to determine whether the conservative generic assumptions in the screening risk assessment apply to a particular species of interest (*e.g.* the whooping crane). In the example of the whooping crane, the refined risk assessment investigated the impacts of more crane-specific data related to:

1. Bird size (as the crane is larger than the 1000g large bird category used in the initial screen)

2. Bird food consumption tailored to:

   a. The true weight of the bird

   b. Energy requirements of the crane

   c. Improvement on the generic food intake model of the screen to assess energy content of the diet and the actual free living energy requirements of a bird the size of a crane

3. Toxicity endpoints were scaled from the weight of the tested surrogate species (bobwhite quail) to reflect the comparatively larger actual size of the whooping crane.

Using the whooping crane as the example to show how EPA made its effects determinations, EPA determined that the whooping crane could be feeding on arthropod prey in treated cotton and soybean fields during its migration from March to May. As stated above, for acute and chronic exposures to dicamba, EPA used the upper bound predicted concentrations of dicamba DGA salt found on arthropods from T-REX modeling. For chronic exposures to DCSA residues, EPA used the maximum measured concentrations found in broadleaf plants, modified by the Kenaga relationship between broadleaf plants and arthropods. This prey analysis is consistent with the preliminary risk concerns identified in the screening assessment. This analysis is conservative as it assumes 1) that 100% of the crane's food consumption comes from exposed arthropods and 2) the level of dicamba DGA residues assumed to be on these prey arthropods is based on the upper bound Kenaga residues expected for arthropods directly exposed to spray applications of dicamba DGA and for exposure to DCSA that residues in the arthropod prey item are based on the maximum measured values in broadleaf plant tissues modified by the Kenaga relationship between residues in arthropods and broadleaf plants following spray applications. EPA determined the field metabolic rate of the whooping crane through the use of a published peer reviewed allometric equation that relates bodyweight to energy requirements. From there the mass of prey consumed per day is determined by dividing the field metabolic rate (kcal/day) by the energy content of the arthropod prey and an assimilation factor that accounts for the ability of birds to absorb that energy from the diet. Values were obtained from a published peer reviewed EPA document produced by the Office of Research and Development for Agency-wide use in conducting ecological risk assessment (Wildlife Exposure Factors Handbook, USEPA, 1993). The mass of dicamba DGA in the insect diet is determined from the T-REX run found in the addendum to the soybean screening-level risk assessment (USEPA, 2016a), issued concurrently with this risk assessment while the mass of DCSA in insect diet was assumed to be 42.5 ppm (70% of the maximum measured residues in soybean hay of 61.1 ppm). The mass of prey consumed per day is then multiplied by the mass of dicamba or DCSA in the insect diet to determine the mass of dicamba or DCSA in the crane's daily diet in mg/day. Then the daily dose that the crane (considering its bodyweight) receives is determined by multiplying the mass of dicamba or DCSA in the daily diet of arthropods (assuming that is the only food item) times the mass of prey consumed per day divided by the bodyweight of the crane. Then EPA scaled the acute toxicity endpoint (based on the most sensitive tested surrogate bird species, bobwhite quail's default weight of 178 grams) to the bodyweight of the whooping crane to determine the acute oral toxicity for the crane. For exposures to

DCSA residues, the chronic toxicity endpoint for the mallard (the most sensitive tested species) was modified by the relationship between the chronic dicamba and DCSA endpoints for rats (a 17x difference). The acute RQ for dicamba exposures is then calculated by dividing the daily dose of dicamba from consuming arthropods by the acute oral toxicity endpoint while the chronic RQ is calculated by dividing the daily dose of DCSA by the chronic toxicity endpoint. In this case the acute RQ for dicamba was 0.03, which is below the endangered species level of concern of 0.1, while the chronic RQ for DCSA was 0.11, which is below the listed and non-listed species chronic LOC of 1.0. At this point, EPA was able to conclude that dicamba and its metabolite DCSA would not have a direct effect on the whooping crane.

Birds

The screening-level assessments showed that birds could be at risk of mortality from acute exposures to dicamba DGA on treated fields, but chronic risk to dicamba was not expected as no chronic RQs exceeded the Agency's LOC (1.0) for chronic risk (USEPA 2011. D378444, p. 15). The concurrently issued soybean addendum did indicate that chronic exposures to DCSA residues in soybean could be a concern, while the screening level cotton assessment indicated that chronic exposures to DCSA residues in cotton would not exceed the Agency's LOC for chronic risk. Therefore, for listed species that could reasonably be expected to occur on treated soybean and cotton fields, EPA conducted a refined assessment for acute (dicamba only) and chronic (DCSA only, and only for soybean) exposures. Of the bird species identified as potentially at acute risk in the sixteen states, three are reasonably expected to occur on treated soybean and cotton fields. Therefore, species specific biological information and dicamba DGA use patterns were considered in more depth to further refine the assessment and effects determinations for those species.

Whooping crane

Dicamba Acute Effects Assessment

Whooping cranes migrate from Texas to Canada from March 25th to May 1st (Canadian Wildlife Service and USFWS, 2007). Whooping cranes are omnivorous and during migration may feed on a variety of foods including frogs, fish, plant tubers, crayfish, insects and agricultural grains. EFED considered the upper bound T-REX predicted concentrations of DGA expected to be found on arthropods as a conservative pesticide load in the prey base. This is considered a conservative approach as modeled residues in arthropods are higher than for the other likely dietary items and 100% of the crane's diet would be considered to consist of exposed arthropods receiving the upper bound Kenaga nomogram dicamba residues from the spray application. Alternative terrestrial vertebrate prey and agricultural grains are expected to have lower residues than those predicted for arthropods. A biologically representative refinement to the screening assessment follows:

> Field metabolic rate kcal/day = $1.146(5826)^{0.749}$ = 757.6 kcal/day (USEPA 1993, body weight Dunning 1984)
>
> Mass of prey consumed per day = 757.6 kcal/day/(1.7 kcal/gX0.72 AE) = 619 g/day
>
> Mass of DGA in insect diet 102.99 mg/kg-bw from T-REX run

Mass of DGA in daily diet mg = 619 g/day X 102.99 mg DGA/kg bird prey X 0.001 = 63.75 mg/day

Daily dose in crane = 63.75 mg DGA/day/5.826 kg = **10.94 mg/kg-bw/day**

Scaling the acute toxicity endpoint by bodyweight (per T-REX methodology), the acute oral toxicity value for the crane is:

Crane LD50 mg/kg-bw = 188 mg/kg-bw $(5826/178)^{(1.15-1)}$ = **317.25mg/kg-bw**

RQ for daily acute exposure for three applications, peak exposure number: RQ = 10.94/317.25 = **0.03.**

An RQ of 0.03 does not exceed the acute LOC of 0.1; **consequently a "no effect" determination is concluded for the whooping crane.**

DCSA Assessment for Whooping Crane consuming prey that had previously consumed soybean forage

EFED considered DCSA residues in arthropods to be the maximum measured DCSA residues from broadleaf plants, modified by the Kenaga nomogram relationship between broadleaf plant and arthropods as a conservative pesticide load in the prey base. This is considered a conservative approach as the estimated residues in arthropods are higher than for the other likely dietary items and 100% of the crane's diet would be considered to consist of exposed arthropods feeding on dicamba-tolerant soybean plants that had the highest measured DCSA residues. Alternative terrestrial vertebrate prey and agricultural grains are expected to have lower residues than those predicted for arthropods. A biologically representative refinement to the screening assessment follows:

Field metabolic rate kcal/day = $1.146(5826)^{0.749}$ = 757.6 kcal/day (USEPA 1993, body weight Dunning 1984)

Mass of prey consumed per day = 757.6 kcal/day/(1.7 kcal/gX0.72 AE) = 619 g/day

Mass of DCSA in insect diet 42.5 mg/kg-bw (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)

Mass of DCSA in daily diet mg = 619 g/day X 42.5 mg DCSA/kg bird prey X 0.001 = 26.31 mg/day

Daily dose in crane = 26.31 mg DCSA/day/5.826 kg = **4.52 mg/kg-bw/day**

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck study for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (17x) results in Avian chronic NOAEC of **40.88 mg/kg-diet.**

RQ for chronic exposure: RQ = 4.52/40.88 = **0.11**

An RQ of 0.11 does not exceed the chronic LOC of 1.0; **consequently a "no effect" determination is concluded for the whooping crane.**

Mississippi sandhill crane

Sandhill cranes are known to feed on farms nearby the Mississippi Sandhill Crane National Wildlife Refuge that they inhabit (USFWS, 1991). Cranes feed on adult and larval insects, earthworms, crayfish, small reptiles, amphibians, roots, tubers, seeds, nuts, fruits and leaves. EFED considered the upper bound T-REX predicted concentrations of DGA expected to be found on arthropods as a conservative pesticide load in the prey base. This is considered a conservative approach as modeled residues in arthropods are higher than for the other likely dietary items and 100% of the crane's diet would be considered to consist of exposed arthropods receiving the upper bound Kenaga nomogram dicamba residues from the spray application. Alternative terrestrial vertebrate prey are expected to have lower residues than those predicted for arthropods. A biologically representative refinement to the screening assessment follows:

Field metabolic rate kcal/day = $1.146(2500)^{0.749}$ = 402.01 kcal/day (USEPA 1993, body weight Dunning 1984)

Mass of prey consumed per day = 402.01 kcal/day/(1.7 kcal/gX0.72 AE) = 328.44 g/day

Mass of DGA in insect diet 102.99 mg/kg-ww from T-REX run

Mass of DGA in daily diet mg = 328.44 g/day X 102.99 mg DGA/kg bird prey X 0.001 = 33.82 mg/day

Daily dose in crane = 33.82 mg DGA/day/2.5 kg = **13.53 mg/kg-bw/day**

Scaling the acute toxicity endpoint by bodyweight (per T-REX methodology), the acute oral toxicity value for the crane is:

Crane LD50 mg/kg-bw = 188 mg/kg-bw $(2500/178)^{(1.15-1)}$ = **279.44 mg/kg-bw**

RQ for daily acute exposure for three applications, peak exposure number: RQ = 13.53/279.44 = **0.05.**

An RQ of 0.05 is less than the acute LOC of 0.1; **consequently a "no effect" determination is concluded for the Mississippi sandhill crane.**

DCSA Assessment for Mississippi sandhill crane consuming prey that had previously fed on soybean forage

EFED considered DCSA residues in arthropods to be the maximum measured DCSA residues from broadleaf plants, modified by the Kenaga nomogram relationship between broadleaf plant and arthropods as a conservative pesticide load in the prey base. This is considered a conservative approach as the estimated residues in arthropods are higher than for the other likely dietary items and 100% of the crane's diet would be considered to consist of exposed arthropods feeding on dicamba-tolerant soybean plants that had the highest measured DCSA residues. Alternative terrestrial vertebrate prey and agricultural grains are expected to have lower residues than those predicted for arthropods. A biologically representative refinement to the screening assessment follows:

Field metabolic rate kcal/day = $1.146(2500)^{0.749}$ = 402.01 kcal/day (USEPA 1993, body weight Dunning 1984)

Mass of prey consumed per day = 402.01 kcal/day/(1.7 kcal/gX0.72 AE) = 328.44 g/day

Mass of DCSA in insect diet 42.5 mg/kg-bw (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)

Mass of DCSA in daily diet mg = 328.44 g/day X 42.5 mg DCSA/kg bird prey X 0.001 = 13.96 mg/day

Daily dose in crane = 13.96 mg DGA/day/2.5 kg = **5.58 mg/kg-bw/day**

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck study for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (17x) results in Avian chronic NOAEC of **40.88 mg/kg-diet.**

RQ for chronic exposure: = 5.58/40.88 = **0.14.**

An RQ of 0.14 does not exceed the chronic LOC of 1.0; **consequently a "no effect" determination is concluded for the Mississippi sandhill crane**

Lesser prairie chicken

The lesser prairie chicken makes use of agricultural fields at specific times of the year. However, as explained below, all available lines of evidence indicate the use of cotton and soybean fields is limited temporally and that the agricultural field is not an ideal habitat for the species because conversion of rangelands to cropland has reduced lesser prairie-chicken populations greatly since the early 1900's (Giesen 1998). An analysis of exposure potential for dicamba DGA use and lesser prairie chickens focused on the seasonal use of soybean and cotton fields by the birds as well as the likely food consumption during those periods.

Available information suggests that the birds do not use agricultural fields during the nesting and rearing cycle. Nesting lesser prairie chickens have been observed to establish nest sites deep within native prairie habitat and similar grass land that affords adequate cover and an understory that allows the young to move. Within these areas, nesting sites are observed to be situated far from edge areas (Jamison, 2000 and Hagen et al. 2007). A review of nesting and brood rearing habitat studies indicates that hens nest in tall, residual grasses or under shrubs in native pasture avoiding shortgrass habitats and cultivated fields and transition to habitats for rearing brood that can be described as areas with abundant bare ground and approximately 25% canopy cover of shrubs, forbs, or grasses <30 cm in height (Jamison, 2000). In Jamison's review of almost a dozen studies of nesting and brood rearing habitat, cotton and soy fields are not included as habitat used by the birds. Similarly, spring and summer foraging habitat has been summarized as including grasses and forbs less than 80 cm in height (Jamison, 2000). In all studies of spring and summer habitat there is no inclusion of cotton or soybean as a cover type utilized by the birds during nesting, brood rearing or foraging.

In contrast to the spring and summer months, the lesser prairie chicken in Finney County of southwestern Kansas has been observed commonly foraging in agricultural fields such as harvested fields of irrigated corn during fall and winter (Jamison, 2000) and this pattern has been confirmed by a radiotelemetry study (Salter et al. 2005). Rob and Schroeder (2005) report similar use of soybean fields by the birds as a fall and winter source of seed and Jamison (2000) cited 17 studies reporting the use of sorghum, corn and other grain fields as fall and winter foraging habitat in areas adjacent to prairie chicken grassland habitat. This utilization of cropland during the fall and winter months for the present waste grain is further supported by Jamison et al. (2002) in their review of 25 habitat studies for the lesser prairie chicken (summarized in **Appendix 5**). Despite cropland comprising a cover type in many of these studies, observations of its actual use are confined to the fall and winter months and consumption of waste grain. The available information indicates that the lesser prairie chicken is attracted to corn and soybean fields in the fall and winter months, where the birds exploit waste seed as an important over-wintering food source.

Based on the reports of over two dozen studies spanning multiple sites across the lesser prairie chicken established range, it is reasonable to expect that utilization of cotton and soybean by lesser prairie chickens occurs during the fall and winter months and is associated with the consumption of waste grain and seed in the fields. However, it is unlikely, given the toxic gossypol content of cotton seed, that the plant provides similar resources as corn and soybean for the bird. This is supported by the position of Timmer (2012) which states that cotton is not considered habitat for this species. Consequently, the exposure refinement for the labeled dicamba DGA product use on soybean and cotton should focus on the consumption of soybean seeds. This may still be considered conservative as 100% of the chicken's diet would be considered to consist of exposed seed receiving the upper bound Kenaga nomogram dicamba residues from the spray application. A biologically representative refinement to the screening assessment follows:

Field metabolic rate kcal/day = $1.146(730)^{0.749}$ = 159.89 kcal/day (USEPA 1993, body weight The Birds of North America, No. 364, 1998)

Mass of seed consumed per day = 159.89 kcal/day/(4.6 kcal/gX0.59 AE) = 58.91 g/day

Mass of DGA in seed diet 16.43 mg/kg-ww from T-REX run

Mass of DGA in daily diet mg = 58.91 g/day X 16.43 mg DGA/kg bird prey X 0.001 = 0.97 mg/day

Daily dose in chicken = 0.97 mg DGA/day/0.73 kg = **1.33 mg/kg-bw/day**

Scaling the acute toxicity endpoint by bodyweight (per T-REX methodology), the acute oral toxicity value for the chicken is:

Chicken LD50 mg/kg-bw = 188 mg/kg-bw $(737/178)^{(1.15-1)}$ = **232.32 mg/kg-bw**

RQ for daily acute exposure for three applications, peak exposure number: RQ = 1.33/232.66 = **0.01.**

An RQ of 0.01 does not exceed the acute LOC of 0.1; **consequently EPA makes a "no effect" determination for the lesser prairie chicken.**

DCSA Assessment for lesser prairie chicken consuming soybean seeds

As above, the exposure for DCSA residues in soybean and cotton should focus on the consumption of soybean seeds. This may still be considered conservative as 100% of the chicken's diet would be considered to consist of exposed seed receiving maximum measured residues in soybean seed. A biologically representative refinement to the screening assessment follows:

Field metabolic rate kcal/day = $1.146(730)^{0.749}$ = 159.89 kcal/day (USEPA 1993, body weight The Birds of North America, No. 364, 1998)

Mass of seed consumed per day = 159.89 kcal/day/(4.6 kcal/gX0.59 AE) = 58.91 g/day

Mass of DCSA in seed diet 0.44 mg/kg-ww (max residues from empirical data on dicamba-tolerant soybean seed).

Mass of DCSA in daily diet mg = 58.91 g/day X 0.44 mg DCSA/kg bird prey X 0.001 = 0.026 mg/day

Daily dose in chicken = 0.026 mg DCSA/day/0.73 kg = **0.036 mg/kg-bw/day**

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck study for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (34x) results in Avian chronic NOAEC of **40.88 mg/kg-diet.**

RQ for chronic exposure for three applications, peak exposure number: RQ = 0.036/40.88 = <**0.01.**

An RQ of <0.01 does not exceed the chronic LOC of 1.0; **consequently a "no effect" determination is concluded for the lesser prairie chicken.**

Reptiles and amphibians

Using birds as a surrogate for reptiles and terrestrial-phase amphibians, consistent with the Overview document (USEPA, 2004), the screening level assessment suggests that reptiles and terrestrial-phase amphibians could be at risk of effects from acute exposures to dicamba DGA or chronic exposures to DCSA on treated fields. Of the reptile and amphibian species identified as potentially at risk in the sixteen states, one reptile is reasonably expected to occur on treated soybean and cotton fields. Therefore, species specific biological information and dicamba DGA use patterns were considered in more depth to further refine the assessment and effects determinations for that species.

Gopher tortoise

The gopher tortoise inhabits droughty, deep sand ridges, xeric communities, originally longleaf pine-scrub oak, and may also be found along fence rows, field edges, power lines, and in pastures (USFWS, 1990). The tortoise feeds on plant material, such as leaves and grass. EFED considers the maximum T-REX predicted concentrations of DGA expected to be found on short grass as a conservative pesticide load in the dietary items. This is considered conservative as it assumes 100% of the tortoise's diet is exposed short grass (for which modeled T-REX residues are higher than any other dietary item) receiving the upper bound Kenaga nomogram dicamba residues from the spray application. A biologically representative refinement to the screening assessment follows:

Field metabolic rate kcal/day = $0.019(4500)^{0.841}$ = 22.44 kcal/day (USEPA 1993)

Mass of soybean plants consumed per day = 22.44 kcal/day/(1.3 kcal/gX0.47 AE) = 36.73 g/day

Mass of DGA in short grass diet 262.94 mg/kg-ww from T-REX run
Mass of DGA in daily diet mg = 36.73 g/day X 262.94 mg DGA/kg tortoise prey X 0.001 = 9.66 mg/day

Daily dose in tortoise = 9.66 mg DGA/day/4.5 kg = **2.15 mg/kg-bw/day**

Appropriate scaling factors are not available for reptiles and amphibians so the acute toxicity value for the bobwhite quail (most sensitive avian species for which acute data are available) serves as a surrogate (USEPA, 2004) toxicity value for the tortoise:

Tortoise LD50 mg/kg-bw = **188 mg/kg-bw**
RQ for daily acute exposure for three applications, peak exposure number: RQ = 2.15/188 = **0.01.**

An RQ of 0.01 less than the acute LOC of 0.1; **consequently a "no effect" determination is concluded for the gopher tortoise.**

DCSA Assessment for gopher tortoise consuming soybean forage

As above, the tortoise feeds on plant material, such as leaves and grass. EFED considers the maximum measured DCSA residues in soybean tissue as a conservative pesticide load in the dietary items. This is considered conservative as it assumes 100% of the tortoise's diet is exposed soybean leaves/stems, which would have the highest DCSA residues. A biologically representative refinement to the screening assessment follows:

Field metabolic rate kcal/day = $0.019(4500)^{0.841}$ = 22.44 kcal/day (USEPA 1993)

Mass of soybean plants consumed per day = 22.44 kcal/day/(0.63 kcal/gX0.47 AE) = 75.79 g/day

Mass of DCSA in soybean forage (broadleaf plant) diet 61.1 mg/kg-ww from max residues from empirical data on dicamba-tolerant soybean forage)

Mass of DCSA in daily diet mg = 75.79 g/day X 61.1 mg DCSA/kg tortoise prey X 0.001 = 4.63 mg/day

Daily dose in tortoise = 4.63 mg DCSA/day/4.5 kg = **1.03 mg/kg-bw/day**

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck (surrogate for reptiles) for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (34x) results in Avian chronic NOAEC of **40.88 mg/kg-diet.**

RQ for chronic exposure: RQ = 1.03/40.88 = **0.03.**

An RQ of 0.03 less than the chronic LOC of 1.0; **consequently a "no effect" determination is concluded for the gopher tortoise.**

Terrestrial Invertebrates

The screening-level risk assessments (USEPA, 2011 D378444 and USEPA, 2016b D404823) did not identify risk concerns for terrestrial invertebrates. Additional analyses in the first addendum to the soybean assessment (USEPA, 2014. D404138+) and the subsequent addendum issued concurrently with this ESA assessment (USEPA, 2016a) indicate that using a screening approach and given the available empirical toxicological data for terrestrial invertebrates showing that dicamba is practically non-toxic to honey bees, acute contact (from exposure to direct sprays of dicamba) and acute dietary (from exposure to dicamba residues in pollen and nectar) risks are not anticipated (*i.e.* acute oral and dietary exposures were below LOCs) to arthropods under the proposed use patterns for dicamba on tolerant soybean and cotton. Though the chronic toxicity of dicamba to adult and larval honey bees is more uncertain, EPA's analysis from the concurrent soybean addendum and cotton assessment using chronic data for other invertebrates (*i.e.* daphnids) also indicates that chronic toxicity to honey bees and other terrestrial invertebrates is anticipated to be low. No other data has been submitted to the Agency for dicamba's toxicity to other arthropods.

No data is available for the acute or chronic toxicity of dicamba's degradate DCSA to honey bees or other pollinators. Although EFED used the toxicity differential between the chronic mammalian studies with dicamba and DCSA to estimate a chronic endpoint for avian organisms, such an approach is not considered appropriate for terrestrial organisms given the greater differences in species biology between arthropod taxa compared to birds and mammals. However, based on the available data including the low DCSA residues measured in dicamba-tolerant seeds (max measured residue of 0.440 ppm), exposures to honey bees and other pollinators from DCSA residues in pollen and nectar of dicamba-tolerant soybean are anticipated to be low.

Despite the addendum and screening-level conclusions that direct risk from dicamba DGA to terrestrial invertebrates is not anticipated, EPA investigated whether there were any arthropod species on treated soybean and cotton fields that might be indirectly impacted by the effect of dicamba on plants on the treated field. One arthropod is reasonably expected to occur on treated soybean and cotton fields. Therefore, species specific habitat information and dicamba DGA use patterns were considered in more depth to further refine the assessment and effects determinations for that species.

American burying beetle

Habitat use and dependencies were explored to determine if any effects on plants would indirectly affect the burying beetle. Except where noted, the information was sourced from the Recovery Plan for the species (USFWS, 1991). The American burying beetle is a carnivorous species. Adults feed on a variety of carrion as well as live insects. The larvae are reared on cached (buried) carrion. Consequently, any effect of dicamba DGA would be mediated through the availability of vegetative cover for the species because direct toxic effects are not expected, and plants do not constitute a necessary food component. Variable habitat and wide soil types make its habitat difficult to describe in anything other than broad terms.

The species exhibits broad vegetation tolerances (from large mowed and grazed fields to dense shrub thickets), though natural habitat may be mature forests. The species has been recorded in grassland, old field shrubland, and hardwood forests. For example, the Block Island population (Rhode Island) occurs on glacial moraine dominated by maritime scrub-shrub community. Plant species include bayberry, shadbush, goldenrod, and various non-native plants. Oklahoma habitats vary from deciduous oak-hickory and coniferous forests atop ridges or hillsides to deciduous riparian corridors and pasturelands on valley floors.

Based on the available data, there are no direct toxicological effects to the burying beetle. Likely, the only potential mechanism for an indirect effect from dicamba would be a reduction in cover provided by plants. The Recovery Plan (USFWS 1991) indicates that vegetative structure and soil types are unlikely to be limiting factors for the burying beetle given its broad historical geographic range. Furthermore, the apparent persistence of the beetle on Block Island suggests broad vegetation (landscape) tolerances. Given that applications of dicamba DGA will occur when the crop is intact, the field is expected to maintain sufficient vegetative cover for the burying beetle. **Consequently, a "no effect" determination is concluded for the American burying beetle.**

Terrestrial Plants

The screening level risk assessment showed that dicot plant species, but not monocots, would be at risk of adverse effects from dicamba applications. Of the terrestrial plant species identified as potentially at risk in the sixteen states, one plant species is reasonably expected to occur on treated soybean and cotton fields.

Spring Creek Bladderpod

Dicamba is highly toxic to broadleaf plant species (most sensitive NOAEC of 0.000261 lbs a.i./A for non-tolerant soybean) and given a maximum single application rate of 1.0 lbs a.i./A, it is assumed that any dicots on the field at the time of application would be considered to be at risk. The Spring Creek bladderpod (a dicot in the Brassicaceae family), is found in northern Wilson County, Tennessee in the watersheds of Spring Creek, Bartons Creek, and Cedar Creek. It is located primarily in the floodplain, in agricultural fields, as well as pastures, glades, and disturbed areas. It is found mainly on newly disturbed sites and requires some degree of annual disturbance to complete its lifecycle (USFWS 2006).

This species is a winter annual that "germinates between September and early October, overwinters as a small rosette of leaves, and fully develops and flowers the following spring. Full sun is required for optimum growth. Flowering usually occurs in March and April. The fruit splits open upon maturity in late April and early May, and the enclosed seeds are dispersed and lie dormant until autumn," when the cycle starts over again (USFWS, 2006). "If conditions are not suitable for germination the following fall, the seeds can remain dormant (but viable) for several years" (USFWS 1996).

It is likely that the species is in flowering stage when dicamba DGA is applied to soybean and cotton fields in the early season. **Consequently, EPA makes a "may effect, likely to adversely affect" determination for the Spring Creek bladderpod.**

Mammals

The screening-level assessments indicated that acute risk to mammals was not expected as no acute RQs exceeded the Agency's LOC (0.1) for acute risk (USEPA 2011. D378444, p. 15). However, the soybean screening-level assessment (USEPA, 2011) indicated that mammals could be at reproductive risk from chronic exposures to dicamba DGA on treated fields, though the cotton screening level and concurrently issued soybean addendum (USEPA, 2016a and USEPA, 2016b) indicated that chronic exposures to dicamba DGA would be below the chronic LOC (1.0). This difference is due to soybean screening level risk assessment's use of a chronic endpoint from the rat 2-generation study (MRID 43137101), of 45 mg/kg-bw for the NOAEL, based on decreased pup weight at 136 mg/kg-bw compared to the concurrent controls. HED recently reanalyzed the data from this study (USEPA, 2016c; D431873) in comparison to the historical control database range and determined that the NOAEL and LOAEL should be raised to 136 and 450 mg/kg-bw, respectively, as pup weights in each generation in the 136 mg/kg-bw treatment group were within the historical control range and above the historical control mean for the F1, F2A and F2B generations. Therefore, the cotton screening level risk assessment, the concurrently issued soybean addendum and this refined endangered species risk assessment use this revised NOAEL for dicamba DGA salt.

The concurrently issued soybean addendum did indicate that chronic exposures to dicamba's metabolite, DCSA, residues in soybean could be a concern, while the screening level cotton assessment indicated that chronic exposures to DCSA residues in cotton would not exceed the Agency's LOC for chronic risk. Therefore, EPA only conducted a refined assessment for chronic exposures to DCSA in soybeans for listed species that could reasonably be expected to occur on treated soybean fields.

Of the mammalian species identified as potentially at risk in the sixteen states, four are reasonably expected to occur on treated soybean fields. Species specific biological information and dicamba DGA use patterns were considered in more depth to further refine the assessment and effects determinations for the four species potentially expected to occur on treated soybean fields.

Gray Wolf

According the USFWS Recovery Plan (USFWS 1982), gray wolves are habitat generalists that live throughout the northern hemisphere. Gray wolves are a carnivorous species that typically feed on ungulate species, such as deer. While not likely to feed on agricultural fields themselves, the primary prey species of the gray wolf may be expected to feed on plant material within the field during the period of applications. Based on this information, it is reasonable to conclude that the gray wolf may be exposed to dicamba DGA residues in prey. A biologically representative modification to the screening assessment follows:

The first step in the refinement process is to calculate dicamba DGA residues in the prey species. Using the conservative assumptions that the prey species is represented by a 1000 g mammal that feeds exclusively on exposed short grass receiving the upper bound Kenaga residues from the spray application of dicamba, EFED calculated the residues based on the following allometric equations (USEPA, 1993):

1000 g mammal prey ingestion rate (dry) = $0.621(1000)^{0.564}$ =30.56 g /day

1000 g mammal prey ingestion rate (wet) = 30.56/0.2 = 152.8 g/day

Dicamba DGA residue in prey eating short grass from T-REX = 262.94 mg dicamba DGA/kg-food (ww) x 0.1528 kg food/kg-bw = **40.17 mg/kg-bw/day**

The next step is to calculate the expected daily dose for a typical 17.7 kg (17700 g) gray wolf, the adjusted NOAEL value and the chronic dose-based RQ for the gray wolf based on the following allometric equations:

Food Intake (wet) = $(0.235(17700)^{0.822})/(1-0.69)/1000$ = 2.35 kg wet/day

Dose-based EEC in wolf eating small mammal= 40.17 mg/kg wet x 2.35/(17700/1000) = **5.33 mg/kg-bw/day**

Adjusted NOAEL = 136 mg/kg-bw $(350/17700)^{(0.25)}$ = **51.00 mg/kw-bw**

Chronic Dose-Based RQ = 5.33/51.00 = **0.10**

An RQ of 0.10 does not exceed the chronic LOC of 1.0; **consequently a "no effect" determination is concluded for the Gray Wolf.**

DCSA Assessment for Gray Wolf consuming prey that had previously consumed soybean forage

The first step in the refinement process is to calculate DCSA residues in the prey species. Using the assumption that the prey species is represented by a 1000 g mammal and the conservative assumptions that the prey animal feeds exclusively on exposed soybean forage containing the maximum measured residues of 61.1 ppm, EFED calculated the residues based on the following allometric equations (USEPA, 1993):

1000 g mammal prey ingestion rate (dry) = $0.621(1000)^{0.564}$ =30.56 g /day

1000 g mammal prey ingestion rate (wet) = 30.56/0.2 = 152.8 g/day

DCSA residue in prey eating soybean forage/hay 61.1 mg DCSA/kg-food (ww) x 0.1528 kg food/kg-bw = **9.34 mg/kg-bw/day**

The next step is to calculate the expected daily dose for a typical 17.7 kg (17700 g) gray wolf, the adjusted NOAEL value and the chronic dose-based RQ for the gray wolf based on the following allometric equations:

Food Intake (wet) = $(0.235(17700)^{0.822})/(1-0.69)/1000$ = 2.35 kg wet/day

Dose-based EEC in wolf eating small mammal= 9.47 mg/kg wet x 2.35/(17700/1000) = **1.24 mg/kg-bw/day**

Adjusted NOAEL = 8 mg/kg-bw $(350/17700)^{(0.25)}$ = **3.00 mg/kw-bw**

Chronic Dose-Based RQ = 1.25/3.00 = **0.41**

An RQ of 0.41 does not exceed the chronic LOC of 1.0; **consequently a "no effect" determination is concluded for the Gray Wolf.**

Indiana Bat

The USFWS Recovery Plan (USFWS 2007) states that most Indiana bat maternity colonies have been found in agricultural areas with fragmented forests. According to the Recovery Plan there are some 235,000 individual bats within the hibernacula of the states subject to the proposed Federal action. The Recovery Plan also indicates that the sex ratio of males to females is roughly equal. Therefore, there are approximately 117,500 female bats within the hibernacula that are found in the states in this proposed Federal action.

While bats may be associated with forested areas proximal to agricultural land, data on the extent and possibility of foraging over agricultural fields is limited. The Recovery Plan states that observations of light-tagged animals and bats marked with reflective bands indicate that Indiana bats typically forage in closed to semi-open forested habitats and forest edges and that radio-tracking studies of adult males, adult females, and juveniles consistently indicate that foraging occurs preferentially in wooded areas, although type of forest varies with individual studies. The Recovery Plan states that Indiana bats hunt primarily around, not within, the canopy of trees, but they occasionally descend to sub-canopy and shrub layers. However, the Recovery Plan also states that Indiana bats have been caught, observed, and radio-tracked foraging in open habitats; analyses of habitats used by radio-tracked adult females while foraging versus those habitats available for foraging have been performed in two states.

In Illinois, floodplain forest was the most preferred habitat, followed by ponds, old fields, row crops, upland woods, and pastures. In Indiana, woodlands were used more often than areas of agriculture, low-density residential housing, and open water, and this latter group of habitats was used more than pastures, parkland, and heavily urbanized sites. Old fields and agricultural areas seemed important in both studies, but bats likely were foraging most often along forest-field edges, rather than in the interior of fields, although errors inherent in determining the position of a rapidly moving animal through telemetry made it impossible to verify this. The Recovery Plan remarks that visual observations suggest that foraging over open fields or bodies of water, more than 50 m (150 ft) from a forest edge, does occur, although less commonly than in forested sites or along edges. The Recovery Plan places feeding within agriculturally managed areas of lesser significance than forested areas and their immediate edges.

The Recovery Plan reports that in Illinois, 67 percent of the land near one colony was agricultural, and in Michigan, land cover consisted of 55 percent agricultural land. Recovery Plan discussion of available proportions of different land covers encompassing foraging habitat are limited, but the available literature suggests that foraging in agricultural lands relative to other habitats is variable with study. Sparks et al. (2005), in radio-tracking bats in Indiana, found that the number of telemetry observations of foraging was closely associated with the availability of agricultural land within the home range of the species and accounted for approximately 35 percent of observations. In contrast, Murray and Kurta (2004) radio-tracked Indiana bats in Michigan and found that, despite the study area being over 60 percent agricultural land, the habitats frequented by 12 of the 13 monitored bats was forest land. It should be noted that exact frequencies could not be established because triangulation of individual observation points precluded exact locations in different cover types with any confidence. Menzel et al. (2005) radio-tracked bats in Illinois and found that bats foraged significantly closer to forest roads and riparian habitats than agricultural lands. A ranking of the foraging use of habitats suggested the following order of preference by bats in this study: roads> forests> riparian areas> grasslands>agricultural lands.

The Recovery Plan indicates that the prey base for the Indiana bat consists primarily of flying insects, with only a very small amount of spiders (presumably ballooning individuals) included in the diet. Four orders of insects contribute most to the diet: Coleoptera, Diptera, Lepidoptera, and Trichoptera. The Recovery Plan concludes that the diet of Indiana bats, to a large degree, may reflect availability of preferred types of insects within the foraging areas that the bats happen to be using, again suggesting that they are selective opportunists.

Given the above information, it is reasonable to conclude that Indiana bats make use of agricultural land as a source of prey and can reasonably be expected to roost in patches of fragmented forest that are adjacent to cotton and soybean fields. They are opportunistic foragers and are expected to forage over many different land covers, including agricultural land, on a broad range of insects/arthropods. A survey of insect populations in agricultural fields reveals a variety of flying, foliage and ground dwelling invertebrates comprising a large number of taxonomic groups that could provide on-field prey sources for bats foraging over these areas. However, the extent of foraging over agricultural land is expected to be less than the degree of foraging around the canopies of forested areas.

Initial screening level risk assessment results for the Indiana bat were refined to account for the bat's biology and contained the conservative assumption that bats would feed exclusively on exposed insects/arthropods having received the upper bound Kenaga residues from the spray application of dicamba.

> Field metabolic rate kcal/day = $0.6167(5.4)^{0.862}$= 2.64 kcal/day (USEPA 1993, body weight reflects screening assumption for the Indiana bat)
>
> Mass of prey consumed per day = 2.64 kcal/day /(1.7 kcal/g ww X 0.87AE)= 1.78 g/day
>
> Mass of DGA in insect diet 102.99 mg/kg-ww from T-REX run
>
> Mass of DGA in daily diet = 1.78 g/day X 102.99 mg DGA/kg-ww mammal prey X 0.001 = 0.18 mg/day
>
> Daily dose in bat = 0.18 mg DGA/day/0.0054 = **33.95 mg/kg-bw/day**
>
> Indiana Bat NOAEL mg/kg-bw/day = 136 mg/kg-bw $(350/5.4)^{(0.25)}$ = **385.88 mg/kg-bw**
> RQ for chronic exposure for three applications, peak exposure number: RQ = 33.95/385.88 = **0.09.**
>
> An RQ of 0.09 does not exceed the chronic LOC of 1.0; **consequently a "no effect" determination is concluded for the Indiana Bat.**

DCSA Assessment for Indiana bat consuming prey that had previously consumed soybean forage

Initial screening level risk assessment results for the Indiana bat were refined to account for the bat's biology and contained the conservative assumption that bats would feed exclusively on exposed insects/arthropods feeding on dicamba-tolerant soybean plant tissues that had the highest measured DCSA residues.

Field metabolic rate kcal/day = $0.6167(5.4)^{0.862}$= 2.64 kcal/day (USEPA 1993, body weight reflects screening assumption for the Indiana bat)

Mass of prey consumed per day = 2.64 kcal/day /(1.7 kcal/g ww X 0.87AE)= 1.78 g/day

Mass of DCSA in insect diet 42.5 mg/kg-ww (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)

Mass of DCSA in daily diet = 1.78 g/day X 42.5 mg DCSA/kg-ww insect prey X 0.001 = 0.076 mg/day

Daily dose in bat = 0.076 mg DCSA /day/0.0054 kg = **14.01 mg/kg-bw/day**

Indiana Bat NOAEL mg/kg-bw/day = 8 mg/kg-bw $(350/5.4)^{(0.25)}$ = **22.70 mg/kg-bw**

RQ for chronic exposure: RQ = 8.00/22.70 = **0.62**

An RQ of **0.62** does not exceeds the chronic LOC of 1.0; **consequently a "no effect" determination is concluded for the Indiana Bat.**

Ozark Bat

The Ozark big-eared bat inhabits caves and cliffs that can be found in large blocks of forest to small forest tracts interspersed with open areas. Land use of surrounding areas does not appear to influence location of occupied maternity caves and hibernacula. The Recovery Plan (USFWS, 1995) indicates that the prey base for the Ozark bat consists primarily of lepidopterans and that edge habitat between forested and open areas is the preferred foraging area. Open areas allow for easy foraging because bats are not obstructed by branches while pursuing prey and are able to discriminate insects at greater distances. Based on this information, the Ozark bat cannot be precluded from foraging on agricultural fields.

Initial screening level risk assessment results for the Ozark bat were refined to account for the bat's biology and contained the conservative assumption that bats would feed exclusively on exposed insects having received the upper bound Kenaga residues from the spray application of dicamba.

Field metabolic rate kcal/day = $0.6167(7.0)^{0.862}$= 3.30kcal/day (USEPA 1993, body weight reflects screening assumption for the Ozark bat)

Mass of prey consumed per day = 3.30 kcal/day /(1.7 kcal/g ww X 0.87AE)= 2.23 g/day

Mass of DGA in insect diet 102.99 mg/kg-ww from T-REX run

Mass of DGA in daily diet = 2.23 g/day X 102.99 mg DGA/kg-ww mammal prey X 0.001 = 0.23 mg/day

Daily dose in bat = 0.23 mg DGA/day/0.007 = **32.81 mg/kg-bw/day**

Ozark Bat NOAEL mg/kg-bw/day = 136 mg/kg-bw $(350/7.0)^{(0.25)}$ = **361.64 mg/kg-bw**

RQ for chronic exposure for three applications, peak exposure number: RQ = 32.81/361.64 = **0.09.**

An RQ of 0.09 does not exceed the chronic LOC of 1.0; **consequently a "no effect" determination is concluded for the Ozark Bat.**

DCSA Assessment for Ozark Bat consuming prey that had previously consumed soybean forage

Initial screening level risk assessment results for the Ozark bat were refined to account for the bat's biology and contained the conservative assumption that bats would feed exclusively on exposed insects/arthropods feeding on dicamba-tolerant soybean plant tissues that had the highest measured DCSA residues.

Field metabolic rate kcal/day = $0.6167(7.0)^{0.862}$= 3.30kcal/day (USEPA 1993, body weight reflects screening assumption for the Ozark bat)

Mass of prey consumed per day = 3.30 kcal/day /(1.7 kcal/g ww X 0.87AE)= 2.23 g/day

Mass of DCSA in insect diet 42.5 mg/kg-ww (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)

Mass of DCSA in daily diet = 2.23 g/day X 42.5 mg DCSA/kg-ww mammal prey X 0.001 = 0.095 mg/day

Daily dose in bat = 0.095 mg DCSA/day/0.007 = **13.54 mg/kg-bw/day**

Ozark Bat NOAEL mg/kg-bw/day = 8 mg/kg-bw $(350/7.0)^{(0.25)}$ = **21.27 mg/kg-bw**

RQ for chronic exposure for three applications, peak exposure number: RQ = 13.54/21.27 = **0.64**

An RQ of **0.64** does not exceed the chronic LOC of 1.0; **consequently a "no effect" determination is concluded for the Ozark Bat.**

Louisiana Black Bear

The Louisiana black bear inhabits bottomland hardwood forest communities, brackish and freshwater marshes, salt domes, wooded spoil levees along canals and bayous, and agricultural fields. Remoteness is an important spatial feature based on forest tract size and presence of roads (US FWS Recovery Plan, 1995). The Recovery Plan further describes black bears as opportunistic omnivores with their diet being determined by food availability and season. Diet includes: grasses, sedges, invertebrates (primarily beetles, grubs, and insects), carrion, garbage, and agricultural crops (including grain from soybean and corn, but consumption of cotton plant parts is unlikely). Personal communication with Deborah Fuller of the USFWS (Fuller 2015) indicates that, by analogy to North Carolina black bears, Louisiana black bears can be expected to feed on cotton boll pests as well as grubs in the fields. The other potential attractive food source in these fields would be soybean grain. On the basis of this information and the expectation that the modeled residues on arthropods (111.14 mg dicamba DGA/kg) would be much higher than modeled residues in soybean pods or seeds (17.74 mg dicamba DGA/kg), a refinement of the screening level assessment for the bear was initiated to reflect the conservative assumptions of exclusive consumption of exposed terrestrial invertebrates having received the upper bound Kenaga residues from the dicamba application in a treated field:

Field metabolic rate kcal/day = $0.800(92000)^{0.813}$= 8682.59 kcal/day (USEPA 1993, body weight reflects screening assumption for the Louisiana black bear)

Mass of prey consumed per day = 8682.59 kcal/day /(1.7 kcal/g ww X 0.87 AE)= 5870.58 g/day

Mass of DGA in terrestrial invertebrate diet 102.99 mg/kg-ww from T-REX run

Mass of DGA in daily diet = 5870.58 g/day X 102.99 mg DGA/kg-ww mammal prey X 0.001 = 604.61 mg/day

Daily dose in bear = 604.61 mg DGA/day/92 kg = **6.57 mg/kg-bw/day**

Louisiana Black Bear NOAEL mg/kg-bw/day = 136 mg/kg-bw $(350/92000)^{(0.25)}$ = **33.78 mg/kg-bw**

RQ for chronic exposure for three applications, peak exposure number: RQ = 6.57/33.78 = 0.19**.**

A chronic RQ of 0.19 does not exceed the chronic LOC of 1.0. **Consequently a "no effect" determination is concluded for the Louisiana black bear.**

DCSA Assessment for Louisiana Black Bear consuming prey that had previously consumed soybean forage

The screening level risk assessment found that DCSA residues in arthropods in cotton fields (based on the empirical residues in broadleaf plant tissues and extrapolated via the Kenaga nomogram to residues in arthropods) would not exceed any chronic levels of concern for mammals. The analysis of the Louisiana Black Bear's recovery plan described above indicates that in soybean fields, the attractive food source in these fields would be soybean grain (seeds). On the basis of this information, the refinement of the soybean screening level assessment was initiated to reflect the conservative assumption of exclusive consumption of exposed soybean grain containing the maximum measured DCSA residues.

Field metabolic rate kcal/day = $0.800(92000)^{0.813}$= 8682.59 kcal/day (USEPA 1993, body weight reflects screening assumption for the Louisiana black bear)

Mass of soybean seeds consumed per day = 8682.59 kcal/day /(0.51 kcal/g ww X 0.85 AE0.43)= 20029.0 g/day

Mass of DCSA in seed diet 0.440 mg/kg-ww (conservative assumption using the maximum value from empirical data for soybean seeds)

Mass of DCSA in daily diet = 20029 g/day X 0.44 mg DCSA/kg-ww mammal prey X 0.001 = 8.88 mg/day

Daily dose in bear =8.8 mg DCSA/day/92 kg = **0.10 mg/kg-bw/day**

Louisiana Black Bear NOAEL mg/kg-bw/day = 8 mg/kg-bw $(350/92000)^{(0.25)}$ = **1.99 mg/kg-bw**

RQ for chronic exposure for three applications, peak exposure number: RQ = 0.10/1.99 = **0.05**

A chronic RQ of **0.05** does not exceed the chronic LOC of 1.0. **Consequently a "no effect" determination is concluded for the Louisiana black bear.**

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Appendix 3. Designated Critical Habitat Modification Determinations

In addition to the species-specific effects determinations, EFED also conducted a critical habitat modification analysis consistent with the Overview Document (USEPA, 2004) as discussed earlier in this refined assessment. The critical habitat modification analysis is based on an assessment of how dicamba DGA salt would affect the U.S. Fish and Wildlife or National Marine Fisheries Service (the Services) established principle constituent elements (PCE's) of the designated habitat as well as how direct species effects outcomes would impact critical habitat's present and future utility for promoting the conservation of a particular listed species. The Agency will conclude 'modification' of designated critical habitat if the range of designated critical habitat co-occurs with the states subject to the Federal action and one or more of the following conditions exist:

1. The available Services' information indicates that cotton or soybean fields are habitat for the species and there is a "may affect" determination for the species associated with exposure to Dicamba DGA salt or its degradate DCSA, as labeled.

2. The available Services' information indicates that the species uses cotton or soybean fields and one or more effects on taxonomic groups predicted for dicamba DGA salt or its degradate DCSA, on cotton or soybean fields would modify one or more of the designated PCEs.

If the above conditions are not met, EPA concludes 'no modification.'

Results of Analysis

Of the 183 listed species within the 16 states there are 173 species identified in the effects determinations as not using cotton or soybean fields and 10 species using these fields. Critical habitats have been designated for 59 of the 183 species. Fifty-three species with critical habitat were judged to not use cotton or soybean fields and so the critical habitat determination for these was no modification. The remaining 6 species with critical habitat designations were assumed to use cotton or soybean fields and so the previous listed species effects determinations were consulted to ascertain if any were determined to be at risk for direct adverse effects. None of the species were determined to be at risk for direct adverse effects, so the PCE's listed in the Services' critical habitat designations were consulted to determine if, in light of the screening assessment risk findings, they would be impacted by on-field exposure to dicamba DGA salt. For all but one of these species, the PCE's are not relatable to agricultural fields and so a determination of no modification has been made for these 5 species.

The only species using cotton or soybean fields and with critical habitat PCE's relatable to agricultural fields was the whooping crane, for which agricultural fields were discussed as providing waste grain as a potential food source for migratory cranes. The potential pathway for applications of dicamba DGA salt to affect this PCE is by making grain potentially toxic to the birds. Because there is unlikely to be any edible waste grain remaining following cotton harvesting, it is unlikely that the proposed dicamba DGA salt use on cotton could affect this PCE. However, the proposed use on soybean could affect this PCE by making waste soybean grain potentially toxic.

The Health Effect Division summarized available soybean grain residues of dicamba in the Human Health Risk Assessment for the Registration Eligibility Decision for Dicamba and Associated Salts (DP317703). Based on the soybean trials results, maximum residues of dicamba were 0.04 ppm in hay, 0.097 ppm in forage, and 8.13 ppm in seed 6-8 days post treatment (MRIDs 43814101 and 44089307). These measured values were used to set the tolerance value of 10 ppm for soybean seeds. The measured residues are not reasonably expected to be at a level raising a concern for direct effects to the whooping crane because the direct effects assessment for this species (presented on pages 9-10 of this assessment) did not establish a concern for residues in other dietary items at much **higher** (~ 1 order of magnitude) concentrations than would occur at the maximum measured residues in seed or if residues were present even at the tolerance level of 10.0 ppm. Because this analysis shows no direct effects of dicamba at levels that would be expected in the fields as waste grain, an indirect effect, there is no modification of critical habitat. Similarly, measured DCSA residues in waste soybean grain (0.44 ppm) would be well below the estimated DCSA concentrations in arthropods (42.5 ppm) used in the direct effects assessment for this species (pp 9-10). Therefore, whooping crane critical habitat within the 16 states would not be modified.

Summary of Determinations for Critical Habitat

The Agency has determined that the proposed labeled use of dicamba DGA salt on cotton and soybeans will not modify designated critical habitat for the 59 species for which such habitats have been designated in AR, IL, IN, IA, KS, LA, MN, MS, MO, NE, ND, OH, OK, SD, TN, and WI.

Summary of listed species identified as not being on agricultural fields with and without critical habitat designations for the first 16 states assessed for dicamba DGA salt

Critical Habitat Designation	Species Name
Species with Critical Habitat Designations (53 Species)[2]	Bean, Purple (*Villosa perpurpurea*)
	Butterfly Plant, Colorado (*Gaura neomexicana* var. *coloradensis*)
	Butterfly, Karner Blue (*Lycaeides melissa samuelis*)
	Cavesnail, Tumbling Creek (*Antrobia culveri*)
	Chub, Slender (*Erimystax cahni*)
	Chub, Spotfin (*Erimonax monachus*)
	Clubshell, Ovate (*Pleurobema perovatum*)
	Clubshell, Southern (*Pleurobema decisum*)
	Combshell, Cumberlandian (*Epioblasma brevidens*)
	Combshell, Upland (*Epioblasma metastriata*)
	Dace, Laurel (*Chrosomus saylori*)
	Darter, Amber (*Percina antesella*)
	Darter, Cumberland (*Etheostoma susanae*)
	Darter, Leopard (*Percina pantherina*)
	Darter, Niangua (*Etheostoma nianguae*)
	Darter, Slackwater (*Etheostoma boschungi*)
	Darter, Snail (*Percina tanasi*)
	Darter, Yellowcheek (*Etheostoma moorei*)
	Dragonfly, Hine's Emerald (*Somatochlora hineana*)
	Elktoe, Appalachian (*Alasmidonta raveneliana*)
	Elktoe, Cumberland (*Alasmidonta atropurpurea*)
	Frog, Dusky Gopher (*Rana sevosa*)
	Kidneyshell, Fluted (*Ptychobranchus subtentum*)
	Kidneyshell, Triangular (*Ptychobranchus greenii*)
	Logperch, Conasauga (*Percina jenkinsi*)
	Lynx, Canada (*Lynx canadensis*)

[2] Critical habitat designation status determined using U.S. Fish & Wildlife Service's Environmental Conservation Online System (ECOS) species profiles.

Critical Habitat Designation	**Species Name**
	Madtom, Chucky (*Noturus crypticus*)
	Madtom, Smoky (*Noturus baileyi*)
	Madtom, Yellowfin (*Noturus flavipinnis*)
	Manatee, West Indian (*Trichechus manatus*)
	Moccasinshell, Alabama (*Medionidus acutissimus*)
	Moccasinshell, Coosa (*Medionidus parvulus*)
	Mucket, Neosho (*Lampsilis rafinesqueana*)
	Mucket, Orangenacre (*Lampsilis perovalis*)
	Mussel, Oyster (*Epioblasma capsaeformis*)
	Pearlymussel, Slabside (*Pleuronaia dolabelloides*)
	Pigtoe, Georgia (*Pleurobema hanleyianum*)
	Pigtoe, Southern (*Pleurobema georgianum*)
	Plover, Piping (Great Lakes DPS, Northern Great Plains DPS) (*Charadrius melodus*)
	Rabbitsfoot (*Quadrula cylindrica cylindrica*)
	Rabbitsfoot, Rough (*Quadrula cylindrica strigillata*)
	Rock-Cress, Braun's (*Arabis perstellata*)
	Sculpin, Grotto (*Cottus sp.*)
	Sea Turtle, Green (*Chelonia mydas*)
	Sea Turtle, Hawksbill (*Eretmochelys imbricata*)
	Sea Turtle, Kemp's Ridley (*Lepidochelys kempii*)
	Sea Turtle, Leatherback (*Dermochelys coriacea*)
	Sea Turtle, Loggerhead Northwest Atlantic DPS (*Caretta caretta*)
	Shiner, Arkansas River (*Notropis girardi*)
	Shiner, Topeka (*Notropis topeka (=tristis*))
	Spruce-Fir Moss Spider (*Microhexura montivaga*)
	Sturgeon, Gulf (*Acipenser oxyrinchus desotoi*)
	Tiger Beetle, Salt Creek (*Cicindela nevadica lincolniana*)
Species without Critical Habitat Designations (123 species)	Acornshell, Southern (*Epioblasma othcaloogensis*)
	Amphipod, Illinois Cave (*Gammarus acherondytes*)
	Aster, Decurrent False (*Boltonia decurrens*)
	Aster, Ruth's Golden (*Pityopsis ruthii*)
	Avens, Spreading (*Geum radiatum*)
	Bat, Gray (*Myotis grisescens*)
	Bean, Cumberland (pearlymussel) (*Villosa trabalis*)
	Bladderpod, Missouri (*Physaria filiformis*)
	Blossom, Green (pearlymussel) (*Epioblasma torulosa gubernaculum*)
	Blossom, Tubercled (pearlymussel) (*Epioblasma torulosa torulosa*)
	Blossom, Turgid (pearlymussel) (*Epioblasma turgidula*)
	Blossom, Yellow (pearlymussel) (*Epioblasma florentina florentina*)
	Bluet, Roan Mountain (*Hedyotis purpurea* var. *montana*)
	Bush-Clover, Prairie (*Lespedeza leptostachya*)
	Butterfly, Mitchell's Satyr (*Neonympha mitchellii mitchellii*)
	Catspaw , White (*Epioblasma obliquata perobliqua*)

Critical Habitat Designation	Species Name
	Cavefish, Ozark (*Amblyopsis rosae*)
	Chaffseed, American (*Schwalbea americana*)
	Clover, Running Buffalo (*Trifolium stoloniferum*)
	Clubshell (*Pleurobema clava*)
	Clubshell, Black (*Pleurobema curtum*)
	Combshell, Southern (*Epioblasma penita*)
	Crayfish, Cave (*Cambarus aculabrum*)
	Crayfish, Cave (*Cambarus zophonastes*)
	Crayfish, Nashville (*Orconectes shoupi*)
	Dace, Blackside (*Phoxinus cumberlandensis*)
	Daisy, Lakeside (*Hymenoxys acaulis var. glabra (herbacea)*)
	Darter, Bayou (*Etheostoma rubrum*)
	Darter, Bluemask (=jewel) (*Etheostoma sp.*)
	Darter, Boulder (*Etheostoma wapiti*)
	Darter, Duskytail (*Etheostoma percnurum*)
	Disc, Iowa Pleistocene (*Discus macclintocki*)
	Fanshell (*Cyprogenia stegaria*)
	Fatmucket, Arkansas (*Lampsilis powellii*)
	Fern, American Hart's-Tongue (*Asplenium scolopendrium* var. *americanum*)
	Ferret, Black-Footed (*Mustela nigripes*)
	Geocarpon minimum (No common name)
	Goldenrod, Blue Ridge (*Solidago spithamaea*)
	Goldenrod, Short's (*Solidago shortii*)
	Grass, Tennessee Yellow-Eyed (*Xyris tennesseensis*)
	Ground-Plum, Guthrie's (=Pyne's) (*Astragalus bibullatus*)
	Harperella (*Ptilimnium nodosum*)
	Heelsplitter, Alabama (=inflated) (*Potamilus inflatus*)
	Hellbender, Ozark (*Cryptobranchus alleganiensis bishopi*)
	Higgins Eye Pearlymussel (*Lampsilis higginsii*)
	Iris, Dwarf Lake (*Iris lacustris*)
	Lampmussel, Alabama (*Lampsilis virescens*)
	Lichen, Rock Gnome (*Gymnoderma lineare*)
	Lilliput, Pale (pearlymussel) (*Toxolasma cylindrellus*)
	Lily, Minnesota Dwarf Trout (*Erythronium propullans*)
	Locoweed , Fassett's (*Oxytropis campestris var. chartacea*)
	Madtom, Neosho (*Noturus placidus*)
	Madtom, Pygmy (*Noturus stanauli*)
	Madtom, Scioto (*Noturus trautmani*)
	Marstonia, Royal (snail) (*Pyrgulopsis ogmorhaphe*)
	Milkweed, Mead's (*Asclepias meadii*)
	Monkeyface, Appalachian (pearlymussel) (*Quadrula sparsa*)
	Monkeyface, Cumberland (pearlymussel) (*Quadrula intermedia*)
	Monkshood, Northern Wild (*Aconitum novoboarense*)
	Mucket, Pink (pearlymussel) (*Lampsilis abrupta*)
	Mussel, Mapleleaf Winged (*Quadrula fragosa*)
	Mussel, Scaleshell (*Leptodea leptodon*)

Critical Habitat Designation	Species Name
	Mussel, Sheepnose (*Plethobasus cyphyus*)
	Mussel, Snuffbox (*Epioblasma triquetra*)
	Orchid , Western Prairie White-fringed (*Platanthera praeclara*)
	Orchid, Eastern Prairie White-fringed (*Platanthera leucophaea*)
	Pearlshell, Louisiana (*Margaritifera hembeli*)
	Pearlymussel, Birdwing (*Lemiox rimosus*)
	Pearlymussel, Cracking (*Hemistena lata*)
	Pearlymussel, Curtis (*Epioblasma florentina curtisii*)
	Pearlymussel, Dromedary (*Dromus dromas*)
	Pearlymussel, Fat Pocketbook (*Potamilus capax*)
	Pearlymussel, Littlewing (*Pegias fabula*)
	Penstemon, Blowout (*Penstemon haydenii*)
	Pigtoe, Cumberland (*Pleurobema gibberum*)
	Pigtoe, Finerayed (*Fusconaia cuneolus*)
	Pigtoe, Flat (*Pleurobema marshalli*)
	Pigtoe, Rough (*Pleurobema plenum*)
	Pigtoe, Shiny (*Fusconaia cor*)
	Pimpleback, Orangefoot (*Plethobasus cooperianus*)
	Pitcher-Plant, Green (*Sarracenia oreophila*)
	Pocketbook, Ouachita Rock (*Arkansia wheeleri*)
	Pocketbook, Speckled (*Lampsilis streckeri*)
	Pogonia, Small Whorled (*Isotria medeoloides*)
	Pondberry (*Lindera melissifolia*)
	Potato-Bean, Price's (*Apios priceana*)
	Prairie-Clover, Leafy (*Dalea foliosa*)
	Purple Cat's Paw (*Epioblasma obliquata obliquata*)
	Quillwort, Louisiana (*Isoetes louisianensis*)
	Rayed Bean (*Vilosa fabalis*)
	Riffleshell, Northern (*Epioblasma torulosa rangiana*)
	Riffleshell, Tan (*Epioblasma florentina walkeri (=E. walkeri*))
	Ring Pink (mussel) (*Obovaria retusa*)
	Riversnail, Anthony's (*Athearnia anthonyi*)
	Rosemary, Cumberland (*Conradina verticillata*)
	Roseroot, Leedy's (*Rhodiola integrifolia ssp. leedyi*)
	Sandwort, Cumberland (*Arenaria cumberlandensis*)
	Sawfish, Smalltooth (*Pristis pectinata*)
	Shiner, Blue (*Cyprinella caerulea*)
	Skullcap, Large-Flowered (*Scutellaria montana*)
	Snail, Painted Snake Coiled Forest (*Anguispira picta*)
	Sneezeweed, Virginia (*Helenium virginicum*)
	Spectaclecase Mussel (*Cumberlandia monodonta*)
	Spiraea, Virginia (*Spiraea virginiana*)
	Squirrel, Carolina Northern Flying (*Glaucomys sabrinus coloratus*)
	Stirrupshell (*Quadrula stapes*)
	Sturgeon, Pallid (*Scaphirhynchus albus*)

Critical Habitat Designation	Species Name
	Tern, Least (*Sterna antillarum*)
	Thistle, Pitcher's (*Cirsium pitcheri*)
	Turtle, Ringed Map (*Graptemys oculifera*)
	Turtle, Yellow-Blotched Map (*Graptemys flavimaculata*)
	Ute, Ladies'-Tresses, (*Spiranthes diluvialis*)
	Vireo, Black-Capped (*Vireo atricapilla*)
	Warbler, Kirtland's (*Dendroica kirtlandii*)
	Wartyback, White (pearlymussel) (*Plethobasus cicatricosus*)
	Watersnake, Northern Copperbelly (*Nerodia erythrogaster neglecta*)
	Whale, Finback (*Balaenoptera physalus*)
	Whale, Humpback (*Megaptera novaeangliae*)
	Woodpecker, Red-Cockaded (*Picoides borealis*)

Summary of listed species identified as being on agricultural fields with and without critical habitat designations for the first 16 states assessed for dicamba DGA salt:

Species Name	Primary Constituent Elements (PCE)	Source
	Species with Critical Habitat Designations (6 Species)[3]	
Bat, Indiana (*Myotis sodalis*)	PCE: Shelter during winter hibernation. Critical habitat designations are either mines or caves.	http://ecos.fws.gov/docs/federal_register/fr161.pdf http://ecos.fws.gov/docs/federal_register/fr83.pdf
Bat, Ozark (*Corynorhinus townsendii ingens*)	PCE: Not specified. Critical habitat designations are caves.	http://ecos.fws.gov/docs/federal_register/fr171.pdf
Bear, Louisiana Black (*Ursus americanus luteolus*)	PCE: Habitat components that provide: (i) Breeding habitat (i.e., within or contiguous to the home range of females in a core breeding population) consisting of hardwood forest areas having a diversity of age class and species and containing sources of hard mast (acorns and nuts) produced by such species as mature oaks, hickories, and pecan, and that may include one or more of the following: (A) Areas containing soft mast provided by a diversity of plant species, including, but not limited to, blackberry, grape, mulberry, sassafras, paw paw, etc., occurring primarily in forest openings, on spoil banks, and in areas adjacent to forested habitat. (B) Areas within forested habitat providing protein sources consisting of beetles and other colonial insects found in rotting and decaying wood found on the forest floor.	http://www.gpo.gov/fdsys/pkg/FR-2009-03-10/pdf/E9-4536.pdf#page=1

[3] Critical habitat designation status determined using U.S. Fish & Wildlife Service's Environmental Conservation Online System (ECOS) species profiles.

Species Name	Primary Constituent Elements (PCE)	Source
	(C) Grasses and sedges found in forest openings, on spoil banks with open canopies, and in vegetated areas adjacent to forested habitats. (D) Secure areas for reproduction, winter dormancy, day bedding, and escape. These include areas with den trees (e.g., bald cypress, overcup oak, American sycamore, etc.); areas with a thick understory, shrub-scrub habitat, openings along spoil banks, vegetated areas adjacent to forests, or any vegetation that provides cover, limits visibility, slows foot travel, or creates noise when traversed; early successional forests (0 to 12 years) with an open canopy and dense understory of shrubs, vines, and saplings; or areas with vegetation such as palmetto, greenbriars, blackberry, dewberry, and downed trees. (ii) Corridors consisting of: (A) Habitat patches 12 acres (5 hectares) or greater in size; or (B) Forested areas greater than 150 feet (46 meters) wide along waterways and sloughs and having a diversity of plant species and age-classes of sufficient area, quality, and configuration, as described in paragraph (2)(i) of this entry, to provide dispersal habitat between breeding populations to maintain genetic variability and promote stable or increasing populations, and to provide habitat supporting safe movement, foraging, and denning.	
Crane, Mississippi Sandhill (*Grus canadensis pulla*)	PCE: Not specified.	http://ecos.fws.gov/docs/federal_register/fr150.pdf
Crane, Whooping (*Grus Americana*)	PCE: All areas proposed in this rule would provide food, water, and other nutritional or physiological needs of the whooping crane during spring or fall migration. (1) Insects, crayfish, frogs, small fish, and other small animals as well as some aquatic vegetation and some cereal crops in adjacent croplands appear to be major items taken during the migration period. Consumption of some cereal crops in adjacent croplands during migration period. (2) Require an open expanse for nightly rooting, especially sand and gravel bars or very shallow water in rivers and lakes. (3) Whooping cranes are territorial and require several acres of undisturbed wetlands. (4) Potential nesting habitat.	http://ecos.fws.gov/docs/federal_register/fr237.pdf http://ecos.fws.gov/docs/federal_register/fr214.pdf
Wolf, Gray (*Canis lupis*)	PCE: Not specified.	http://ecos.fws.gov/docs/federal_register/fr186.pdf

Species Name	Primary Constituent Elements (PCE)	Source
Species without critical habitat designations (4 species)		
Beetle, American burying (*Nicrophorus americanus*)	No critical habitat rules have been published.	n/a
Bladderpod, Spring Creek (*Lesquerella perforata*)[4]	**No critical habitat rules have been published.**	**n/a**
Prairie-chicken, Lesser (*Tympanuchus pallidicinctus*)	No critical habitat rules have been published.	n/a
Tortoise, Gopher (*Gopherus polyphemus*)	No critical habitat rules have been published.	n/a

[4] Bold text indicates assessed species with "may effect, likely to adversely affect" determination.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

OFFICE OF CHEMICAL SAFETY AND POLLUTION PREVENTION

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MEMORANDUM

Subject: Addendum to Dicamba Diglycolamine (DGA) Salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Cotton and Soybean in 7 U.S. States (Alabama, Georgia, Kentucky, Michigan, North Carolina, South Carolina, and Texas)

To: Grant Rowland, Risk Manager Reviewer
Kathryn Montague, Product Manager Team 23
Dan Kenny, Branch Chief
Herbicide Branch
Pesticide Registration Division (7505P)
Office of Pesticide Programs

From: Elizabeth Donovan, Biologist 3/24/16
Michael Wagman, Biologist 3/24/16
Monica Wait, Risk Assessment Process Leader Monica Wait 3/24/16
Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)
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Through: Mark Corbin, Branch Chief 3-24-16
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Office of Pesticide Programs

Prior to conducting this refined Endangered Species Assessment, the Environmental Fate and Effects Division (EFED) performed a screening level ecological risk assessment for a Federal action involving proposed new uses of the diglycolamine salt of dicamba (dicamba DGA) on dicamba herbicide-tolerant soybean on March 8, 2011 (DP 378444); an amendment to the assessment was issued on May 20, 2014 (DP 404138, 404806, 405887, 410802, and 411382). Concurrent with this refined Endangered Species Assessment, a Section 3 New Use dicamba DGA salt on dicamba-tolerant cotton screening-level assessment (DP 404823) and a subsequent addendum (DP 426789) that addresses multiple issues (spray drift buffers, runoff, risk to terrestrial invertebrates and updated mammalian toxicological endpoints for parent dicamba and its degradate, DCSA) have been finalized. In the screening level risk assessment, potential direct risk concerns could not be excluded for:

- mammals (chronic, from the soybean use only, due to residues from dicamba's metabolite, DCSA, rather than from parent dicamba);
- birds (acute from parent dicamba for both soybean and cotton uses; chronic from DCSA residues only in soybean but not in cotton), considered surrogates for reptiles, and terrestrial-phase amphibians; and
- terrestrial plants (soybean and cotton uses)

In the screening level risk assessments, indirect effect risk concerns for all taxa were possible for any species that have dependencies (e.g., food, shelter, and habitat) on mammals, birds, reptiles, terrestrial-phase amphibians, or terrestrial plants. Additionally, the screening level assessments showed that direct risk concerns were unlikely (*i.e.* levels of concern were not exceeded) for:

- mammals (acute) and (chronic—for the cotton use only);
- birds, reptiles, and terrestrial-phase amphibians (chronic from parent dicamba or DCSA degradate from use on cotton);
- terrestrial insects (acute and chronic);
- freshwater fish (acute and chronic);
- aquatic-phase amphibians (acute and chronic);
- estuarine/marine fish (acute and chronic);
- freshwater invertebrates (acute and chronic); estuarine/marine invertebrates (acute and chronic); and
- aquatic plants[1]

EPA has a specific process based on sound science that it follows when assessing risks to listed species for pesticides like dicamba that will be used on seeds that have been genetically modified to be tolerant to the pesticide. The Agency begins with a screening level assessment that includesa basic ecological risk assessment based on its 2004 Overview of the Ecological Risk

[1] The listed species LOC was exceeded for non-vascular aquatic plants, however there are no listed species of this taxa.

Assessment Process document. [USEPA, 2004, available at http://www.epa.gov/oppfead1/endanger/litstatus/riskasses.htm]. That assessment uses broad default assumptions to establish estimated environmental concentrations of particular pesticides. If the screening level assessment results in a determination that no levels of concern are exceeded, EPA concludes its analysis. On the other hand, where the screening level assessment does not rule out potential effects (exceedances of the level of concern) based on the broad default assumptions, EPA then uses increasingly specific methods and exposure models to refine its estimated environmental concentrations. At each screening step, EPA compares the more refined exposures to the toxicity of the pesticide active ingredient to determine whether the pesticide exceeds levels of concern established for listed aquatic and terrestrial species. EPA determines that there is "no effect" on listed species if, at any step in the screening level assessment, no levels of concern are exceeded. If, after performing all of the steps in the screening level assessment, a pesticide still exceeds the Agency's levels of concern for listed species, EPA then conducts a species-specific refined assessment to make effects determinations for individual listed species. The refined assessment, unlike the screening level assessment, takes account of species' habitats and behaviors to determine whether any listed species may be affected by use of the pesticide.

The screening level ecological risk assessment generates a series of taxonomic (e.g., mammals, birds, fish, etc.) risk quotients (RQs) that are the ratio of estimated exposures to acute and chronic effects endpoints. These RQs are then compared to EPA established levels of concern (LOCs) to determine if risks to any taxonomic group are of concern. The LOCs address risks for both acute and chronic effects. Acute effects LOCs range from 0.05 for aquatic animals that are Federally-listed threatened or endangered species (listed species) to 0.5 for aquatic non-listed animal species and 0.1 to 0.5 for terrestrial animals for listed and non-listed species. The LOC for chronic effects for all animal taxa (listed and non-listed) is 1. Plant risks are handled in a similar manner, but with different toxicity thresholds (NOAEC/EC_{05} and $EC_{25,}$ respectively) used in RQ calculation for listed and non-listed species and an LOC of 1 used to interpret the RQ. When a given taxonomic RQ exceeds either the acute or chronic LOC a concern for direct toxic effects is identified for that particular taxon. If RQs fall below the LOC, a no effect determination is identified for the corresponding taxon.

The purpose of this document is to explain the refined risk assessment conducted for Federally-listed threatened or endangered (listed) species that could potentially be impacted by this pesticide registration. The refined assessment was conducted based on the 2004 Overview document, as discussed above. The assessment of risks to listed species posed by the use of Dicamba DGA has been conducted in phases covering a specific set of states, assessing risk to all the listed species covered in those states. This assessment covers the endangered species analysis for 7 states: Alabama, Georgia, Kentucky, Michigan, North Carolina, South Carolina and Texas. Based on EFED's LOCATES v.2.4.0 database and information from the U.S. Fish and Wildlife Service (USFWS), 307 species in the 7 states proposed for registration were identified as within the action area (at a preliminary county-wide level of resolution) associated with the new herbicide-tolerant soybean and cotton uses. **Table 1** presents a summary of this assessment. Separate concurrent assessment phases cover the endangered species analysis for 16 states (D416416, 420160, 420159, 420352, 421434, 421723 covering AR, IL, IA, IN, KS, LA, MN, MS, MO, NE, ND, OH, OK, SD, TN and WI) and 11 states (D425049 covering AZ, CO, DE, FL, MD, NM, NJ, NY, PA, VA and WV).

EPA consulted U.S. Fish and Wildlife Service Recovery Plans to determine whether listed species in these states would be expected to occur in an action area encompassing the treated soybean and corn fields. The refined assessment was then conducted on those species that could not be excluded from the action area. EPA also consulted the recovery plans in the refined assessment for additional habitat information and incorporated species biological information regarding dietary items (used to model dicamba DGA residues in prey tissue) and body weight (used to determine food consumption rates and scale ecotoxicity data from the tested surrogate species, the bobwhite quail and rat, to the body weight of the listed species).
The Environmental Fate and Effects Division (EFED) has completed an endangered species risk assessment for Alabama, Georgia, Kentucky, Michigan, North Carolina, South Carolina, and Texas in support of registering dicamba diglycolamine (DGA) salt on herbicide-tolerant cotton and soybean in these states. **Table 1** presents a summary of the assessment.

Table 1. Summary of species effects determinations and critical habitat modification determinations for Federally threatened or endangered species in Alabama, Georgia, Kentucky, Michigan, North Carolina, South Carolina, and Texas for dicamba DGA use on genetically modified cotton and soybeans.

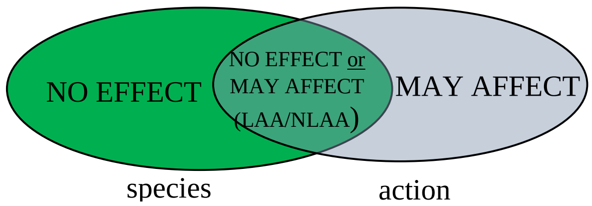
Species	**Effects Determination**	**Comments**
Eskimo Curlew	**May Affect, Not Likely to Adversely Affect**	Found in 24 counties (23 in Nebraska and 1 in Texas)
All other species (terrestrial and aquatic)	No effect	None
Critical Habitat	**Modification Determination**	**Comments**
All Critical Habitats (118 species)	No Modification	None

Making an Effects Determination

The bullets below outline EFED's process for making an effects determination for the Federal action:

- For listed individuals inside the action area but **NOT** part of an affected taxa **NOR** relying on the affected taxa for services (involving food, shelter, biological mediated resources necessary for survival/reproduction), use of a pesticide would be determined to have NO EFFECT.
- For listed individuals outside the action area, use of a pesticide would be determined to have NO EFFECT.

- Listed individuals inside the action area may either fall into the NO EFFECT or MAY AFFECT (LIKELY or NOT LIKELY TO ADVERSELY AFFECT) categories depending upon their specific biological needs, circumstances of exposure, etc.



- LIKELY or NOT LIKELY TO ADVERSELY AFFECT determinations are made using the following criteria:
  - Insignificant - The level of the effect cannot be meaningfully related to a "take."
  - Highly Uncertain - The effect is highly unlikely to occur.
  - Wholly beneficial - The effects are only good things.

Spray Drift Mitigation

EFED's refined endangered species risk assessment took into account the spray drift mitigation language that has been added to the most recent proposed label submitted by the regitstrant. An accounting of federally-listed threatened or endangered species within the 7 states (covered in this assessment) proposed for dicamba DGA use on genetically modified cotton and soybeans is included in **Appendix 1** (307 species). Specifically, the spray drift mitigation language on the M1691 Herbicide Supplemental labels for the use dicamba DGA salt on ROUNDUP READY 2 XTEND™ soybean and BOLLGARD II® XTENDFLEX cotton includes the following limitations:

- Specifying the use of a nozzle (Tee Jet® TTI11004) with ASABE S-572 ultra-coarse and extremely coarse droplet spectra and a maximum operating pressure of 63 psi.
- A maximum equipment ground speed of 15 miles per hour and ground boom height of 24 inches above the target pest or crop canopy.
- Restricting all applications when wind speeds are < 3 mph or > 15 mph and restricting applications when wind is blowing towards sensitive areas at > 10 mph. Maintaining use of a 110 foot in-field buffer for a 0.5 lb a.i./A application (220 foot in-field buffer for a 1 lb a.i./A application) when the wind is blowing towards any areas that are not fields in crop cultivation, paved areas, or areas covered by buildings and other structures.
- Applications done in low relative humidity conditions are to use equipment set to produce larger droplet spectra to compensate for evaporation.
- Applications are not be conducted during temperature inversions.

- In order to prevent effects to non-target susceptible plants, the label also includes the following language: "do not apply under circumstances where spray drift may occur to food, forage or other plantings that might be damaged or the crops thereof rendered unfit for sale, use or consumption. Avoid contact of herbicide with foliage, green stems, exposed non-woody roots of crops, and desirable plants, including beans, cotton, flowers, fruit trees, grapes, ornamentals, peas, potato, soybean, sunflower, tobacco, tomato, and other broadleaf plants because severe injury or destruction may result, including plants in a greenhouse. Applicators are required to ensure that they are aware of the proximity to sensitive areas, and to avoid potential adverse effects from the off-target movement of M1691 Herbicide. The Applicator must survey the application site for neighboring sensitive areas prior to application. The applicator also should consult sensitive crop registries for locating sensitive areas where available."
- Finally, in order to prevent unintended damage from the drift of M1691 Herbicide, the label says not to apply this product when the wind is blowing towards adjacent commercially grown sensitive crops.

The incorporation of the spray drift mitigation measures into the product labeling as outlined above would result in exposure to dicamba DGA from spray drift at a level where effects are expected only within the confines of the treated field and so the action area is limited to the dicamba DGA treated field. Further, the incorporation of the "susceptible plants" spray drift mitigation language on the label is to avoid damage to these plants (including adjacent crops). Because the risk assessment interprets the threshold for plant damage concern to be based on the most sensitive plant species tested and the screening level ecological risk assessment has demonstrated that these plant effects endpoints constitute the most conservative terrestrial organism levels of effect, it is concluded that the "susceptible plants" requirement requires a level of drift mitigation that would also prevent less sensitive organisms from being exposed at levels of concern. Terrestrial species that are not expected to occur on treated fields under the provisions of the proposed label are not expected to be directly exposed to dicamba DGA, nor are their critical biologically mediated resources expected to be exposed to levels of the herbicide above any effects thresholds of concern. Additionally, as indicated in the screening level ecological risk assessments for cotton and soybean, no aquatic receptor taxa are of concern for drift or runoff exposure (LOCs were not exceeded for aquatic taxa). **Consequently, all but 14 of the listed species originally identified as potentially at-risk are determined to be given a "no effect" (NE) without further refinement because they are not expected to occur in an action area encompassing the treated soybean and cotton fields (Appendix 2).** The remaining 16 species are assessed using the refinements set forth in the 2004 Overview document referred to earlier in this assessment.

Exposure through Runoff

The cotton screening-level risk assessment and the concurrently issued soybean addendum characterized risk following exposure to dicamba residues in runoff and found that the predicted concentrations from modeling were lower than the most sensitive taxa's endpoint (soybean plant height). Combining the predictions of this modeling, the toxicological endpoints and that most of the off-site plant community would not experience foliar contact with dicamba DGA in runoff sheet flow, EFED concluded that all available lines of evidence supported a "no effects" determination for runoff exposure for off-field listed plants for the proposed labeled use of dicamba DGA. Additionally, rainfast mitigation on the label would also protect against the risk of exposure to listed species off the treated field.

In addition to the spray drift and runoff mitigation measures contained in the proposed labeling, EFED analyzed species-specific biology, dicamba-specific foliar residue data and dicamba application timing information in this refined endangered species assessment. An accounting of the federally-listed threatened or endangered species within the 7 states proposed for this registration showed 307 listed species as potentially at risk (direct or indirect effects) as a result of the screening-level assessment (**Appendix 1**). The spray drift mitigation label language cannot preclude listed species being exposed to dicamba DGA salt or DCSA residues on treated fields, should a listed species utilize such areas as part of its range and corresponding habitat. Of the 307 listed species within the 7 states (AL, GA, KY, MI, NC, SC, and TX) considered part of the proposed Federal decision, the following 14 species were reasonably expected to occur on soybean and cotton fields, which could potentially be treated with dicamba and therefore could not be assumed to be "no effect" solely on the basis of occurrence outside the action area:

Of these 14 species, a "no effect" determination was reached in the concurrent assessment action for 16 states (DP 416416, 420160, 420159, 420352, 421434, 421723 covering AR, IL, IA, IN, KS, LA, MN, MS, MO, NE, ND, OH, OK, SD, TN, and WI) for the following species and is applicable to the additional seven states in this refined assessment as well:

- American burying beetle (*Nicrophorus americanus)*
- Gopher tortoise (*Gopherus polyphemus*)
- Indiana bat (*Myotis sodalis*)
- Lesser prairie-chicken (*Tympanuchus pallidicinctus*)
- Louisiana black bear (*Ursus americanus luteolus*)
- Whooping crane (*Grus americana*)

This leaves the following species for which the remainder of this document uses species specific biological information and dicamba DGA use patterns in more depth to further refine the assessment and effects determinations:

- Attwater's greater prairie-chicken (*Tympanuchus cupido attwateri*)
- Eskimo curlew (*Numenius borealis*)
- Eastern indigo snake (*Drymarchon corais couperi*)
- Houston toad (*Bufo houstonensis*)

- Virginia big-eared bat (*Corynorhinus (=Plecotus) townsendii virginianus*)
- Ocelot (*Leopardus (Felis) pardalis*)
- Gulf Coast jaguarundi (*Herpailurus (=Felis) yagouaroundi cacomitli*)
- Red wolf (*Canis rufus*)

Therefore, species specific biological information (e.g., body size, dietary requirements, and seasonality) and dicamba DGA use patterns were considered in more depth to further refine the assessment and effects determinations.

This assessment also uses the refined exposure values determined in the cotton screening level assessment and the concurrently issued addendum to the soybean screening level risk assessment documents compared to the initial exposure estimates from the soybean screening level assessment. This ESA assessment also evaluates chronic exposures from DCSA separately from the chronic exposure to parent dicamba. Dicamba exposure values were determined from the upper bound of the modeled T-REX run for exposures following spray applications based on the Kenaga nomogram modified by Fletcher *et al* (1984), which is based on a large set of actual field residue data. Modeled dicamba exposure values were identical between the soybean addendum and the cotton screening level risk assessment (since the maximum application rates and minimum application intervals are the same).

Similar modeling of DCSA residues, which are formed inside the tolerant-soybean and tolerant-cotton plants through plant metabolism, is not feasible at this time due to a lack of sufficient data tracking DCSA residues in plant tissues over time to ascertain degradation rates. Therefore, in the soybean addendum and the cotton screening-level risk assessment, EFED used the maximum empirical measured DCSA residue concentrations in dicamba-tolerant soybean (61.1 mg/kg (ppm) DCSA in broadleaf plants and 0.440 ppm in soybean seeds) and cotton plant tissues (6.29 ppm DCSA in cotton gin byproducts and 0.27 ppm in undelinted cotton seed) to evaluate chronic exposures to DCSA for animals foraging on soybean and cotton plants. Residues in arthropods (as a dietary item for birds and mammals consuming insects that have consumed soybean/cotton tissues with DCSA residues) were assumed to follow the Kenaga nomogram relationship between broadleaf plants and arthropods for spray applications (*i.e.* arthropod concentrations estimated to be approximately 70% of the concentrations in broadleaf plant tissues or 42.5 ppm DCSA in arthropods feeding on soybean plants and 4.4 ppm in arthropods feeding on cotton plants). The empirical residue data for cotton indicated that chronic exposures of birds and mammals to dicamba or DCSA in cotton tissues ***would not*** be above any levels of concern. Although the concurrently issued soybean addendum indicates that chronic risk to mammals and birds was only a concern from DCSA residues in plant/prey tissues *and not from residues of parent dicamba*, since the original soybean screening-level assessment (USEPA, 2011) indicated chronic risk to mammals, this assessment presents the estimated exposures and comparisons to threshold toxicity values for both dicamba and DCSA for mammals, but evaluates them separately since their chronic toxicity and exposure profiles differ greatly. For birds, following the conclusions of the screening level assessments and the soybean addendum, only acute risk from dicamba exposures and chronic risk from DCSA exposures is evaluated.

The following text discusses the lines of evidence and processes that were used to make effects determinations for listed species identified as potentially at-risk in the screening level assessment.

Refined ecological risk assessment for the remaining species potentially exposed to dicamba residues

For the effects determinations for Attwater's prairie-chicken, eskimo curlew, Eastern indigo snake, Houston toad, Virginia big-eared bat, ocelot, Gulf Coast jaguarundi and red wolf, a refined risk assessment approach was used to evaluate additional lines of evidence to determine whether the conservative generic assumptions in the screening risk assessment apply to a particular species of interest (*e.g.* the Attwater's prairie-chicken). In the case of the prairie-chicken, the refined risk assessment investigated the impacts of more chicken specific data related to:

1. Bird size (as the chicken is smaller than the 1000g large bird category used in the initial screen)
2. Bird food consumption tailored to:

   a. The true weight of the bird

   b. Energy requirements of the chicken

   c. Improvement on the generic food intake model of the screen to assess energy content of the diet and the actual free living energy requirements of a bird the size of a chicken

3. Toxicity endpoints were scaled from the weight of the tested surrogate species (bobwhite quail) to reflect the comparatively larger actual size of the Attwater's greater prairie chicken

Using the Attwater's greater prairie chicken as an example to show how EPA made its effects determinations, EPA determined that the chicken could be feeding on arthropod prey in treated cotton and soybean fields. As stated above, for acute and chronic exposures to dicamba, EPA used the upper bound predicted concentrations of dicamba DGA salt found on arthropods from T-REX modeling. For chronic exposures to DCSA residues, EPA used the maximum measured concentrations found in broadleaf plants, modified by the Kenaga relationship between broadleaf plants and arthropods. EPA used the predicted concentrations of dicamba DGA salt found on arthropods as its conservative prey analysis consistent with the preliminary risk concerns identified in the screening assessment. This prey analysis is consistent with the preliminary risk concerns identified in the screening assessments. This analysis is conservative as it assumes 1) that 100% of the chicken's food consumption comes from exposed arthropods and 2) the level of

DCSA residue in prey eating soybean forage/hay 61.1 mg DCSA/kg-food (ww) x 0.1528 kg food/kg-bw = **9.34 mg/kg-bw/day**

The next step is to determine the expected daily dose for a typical 36 kg wolf, the adjusted NOAEL value and the chronic dose-based RQ for the wolf based on the following allometric equations:

Field metabolic rate kcal/day = $0.6167(36000)^{0.862}$= 5219 kcal/day (USEPA 1993, body weight reflects screening assumption for the red wolf from Whitaker and Hamilton (1998))

Mass of prey consumed per day = 5219 kcal/day/(1.7 kcal/g ww X 0.84 AE)= 3654 g/day (1.7 is energy content of prey item from USEPA (1993); 0.84 is assimilation efficiency from USEPA 1993, 1 kg mammal diet from Whitaker and Hamilton (1998))

Mass of DCSA in 1 kg mammal diet 9.34 mg/kg-ww from allometric equations above and maximum empirical residue data.

Mass of DCSA in daily diet = 3654 g/day X 9.34 mg DCSA/kg-ww mammal prey X 0.001 = 34.13 mg/day

Daily dose in wolf = 34.13 mg dicamba DGA/day/36= **0.95 mg/kg-bw/day**

Wolf NOAEL mg/kg-bw/day = 8 mg/kg-bw X $(350/36000)^{(0.25)}$ = **2.51 mg/kg-bw**

The RQ for chronic effects = 0.95/2.51 = **0.38**

A chronic RQ of 0.38 does not exceed the chronic LOC of 1.0. **Consequently, EPA makes a "no effect" determination for the red wolf.**

Critical Habitat Determinations

In addition to the species-specific effects determinations, EFED also conducted a critical habitat modification analysis consistent with the Overview Document as discussed earlier in this refined assessment. The critical habitat modification analysis is based on an assessment of how dicamba DGA salt would affect the U.S. Fish and Wildlife Service or National Marine Fisheries Service (the Services) established principle constituent elements (PCE's) of the designated habitat as well as how direct species effects outcomes would impact critical habitat's present and future utility for promoting the conservation of a particular listed species. The Agency will conclude 'modification' of designated critical habitat if the range of designated critical habitat co-occurs with the states subject to the Federal action and one or more of the following conditions exist:

1. The available Services' information indicates that cotton or soybean fields are habitat for the species and there is a "may affect" determination for the species associated with exposure to dicamba DGA salt or its degradate, DCSA, as labeled.

2. The available Services' information indicates that the species uses cotton or soybean fields and one or more effects on taxonomic groups predicted for dicamba DGA salt or its degradate DCSA, on cotton and soybean fields would modify one or more of the designated PCEs.

If neither of the above conditions are met, EPA concludes "no modification."

Results of Analysis

Of the 307 listed species within the states, there are 292 species identified in the effects determinations as not using cotton or soybean fields and 14 species using these fields (**Appendix 5**). Critical habitats have been designated for 118 of the 307 species. One-hundred thirteen (113) species with critical habitat were judged to not use cotton or soybean fields and so the critical habitat determination for these was "no modification."

The remaining 5 species with critical habitat designations were assumed to use cotton or soybean fields and so the previous listed species effects determinations were consulted to ascertain if any were determined to be at risk for direct adverse effects. None of the species were determined to be at risk for direct adverse effects, so the PCE's listed in the Services' critical habitat designations were consulted to determine if, in light of the screening assessment risk findings, they would be impacted by on-field exposure to dicamba DGA salt. For all but one of these species, the PCE's are not relatable to agricultural fields and so a determination of no modification has been made for these 4 species.

The only remaining species using cotton or soybean fields and with critical habitat PCE's relatable to agricultural fields was the whooping crane, for which agricultural fields were discussed as providing waste grain as a potential food source for migratory cranes. The only way the proposed dicamba DGA salt could affect this PCE is by making grain potentially toxic to the birds. As there is unlikely to be any edible waste grain remaining following cotton harvesting, it is unlikely that the proposed dicamba DGA salt use on cotton could affect this PCE, however the proposed use on soybean could affect this PCE by making waste soybean grain potentially toxic.

The Health Effects Division summarized available soybean grain residues of dicamba in the Human Health Risk Assessment for the Registration Eligibility Decision for Dicamba and Associated Salts (DP317703). Based on the soybean trials results, maximum residues of dicamba were 0.04 ppm in hay, 0.097 ppm in forage, and 8.13 ppm in seed 6-8 days post treatment (MRIDs 43814101 and 44089307). These measured values were used to set the tolerance value of 10 ppm for soybean seeds. The measured residues are not reasonably expected to be at a level raising a concern for direct effects to the whooping crane because the direct effects assessment for this species (presented in the Section 3 Risk Assessment Refined Endangered Species Assessment that assessed risks to endangered species in 16 states (Arkansas, Kansas, Louisiana, Illinois, Indiana, Iowa, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin {DP 416416, 420160, 420159, 420352, 421434, 421723}) did not establish a concern for residues in other dietary items at much **higher** (~ 1 order of magnitude) concentrations than would occur at the maximum measured residues in seed or if residues were present even at the tolerance level of 10.0 ppm. Because this analysis shows no direct effects of dicamba at levels that would be expected in the fields as waste grain, an indirect effect, there is no modification of critical habitat. Similarly, measured DCSA residues in waste soybean grain (0.44 ppm) would be well below the estimated DCSA concentrations in arthropods (42.5 ppm) used in the direct effects assessment for this species (D416516+, pp. 9-10). Therefore, whooping crane critical habitat within the 7 states covered in this assessment would not be modified.

Summary of Determinations for Critical Habitat

The Agency has determined that the proposed labeled use of dicamba DGA salt on cotton and soybeans will not modify designated critical habitat for all 118 species for which such habitats have been designated in AL, GA, KY, MI, NC, SC, and TX.

A summary of listed species identified as not being on agricultural fields with and without critical habitat designations for the seven states assessed for dicamba DGA salt is provided in **Appendix 5**.

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Appendix 1

Threatened and Endangered Species in Alabama, Georgia, Kentucky, Michigan, North Carolina, South Carolina, and Texas

Common Name	Scientific Name	Taxon
Indiana bat	*Myotis sodalis*	Mammal
West Indian Manatee	*Trichechus manatus*	Mammal
Finback whale	*Balaenoptera physalus*	Mammal
Humpback whale	*Megaptera novaeangliae*	Mammal
Gray bat	*Myotis grisescens*	Mammal
Canada Lynx	*Lynx canadensis*	Mammal
Louisiana black bear	*Ursus americanus luteolus*	Mammal
Carolina northern flying squirrel	*Glaucomys sabrinus coloratus*	Mammal
Whooping crane	*Grus americana*	Bird
Eskimo curlew	*Numenius borealis*	Bird
Kirtland's Warbler	*Setophaga kirtlandii*	Bird
Red-cockaded woodpecker	*Picoides borealis*	Bird
Wood stork	*Mycteria americana*	Bird
Piping Plover	*Charadrius melodus*	Bird
Least tern	*Sterna antillarum*	Bird
Black-capped Vireo	*Vireo atricapilla*	Bird
Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*	Bird
Hawksbill sea turtle	*Eretmochelys imbricata*	Reptile
Leatherback sea turtle	*Dermochelys coriacea*	Reptile
Kemp's ridley sea turtle	*Lepidochelys kempii*	Reptile
Green sea turtle	*Chelonia mydas*	Reptile
Alabama red-belly turtle	*Pseudemys alabamensis*	Reptile
Copperbelly water snake	*Nerodia erythrogaster neglecta*	Reptile
Gopher tortoise	*Gopherus polyphemus*	Reptile
Snail darter	*Percina tanasi*	Fish
Spotfin Chub	*Erimonax monachus*	Fish
Slackwater darter	*Etheostoma boschungi*	Fish
Gulf sturgeon	*Acipenser oxyrinchus desotoi*	Fish
Amber darter	*Percina antesella*	Fish
Conasauga logperch	*Percina jenkinsi*	Fish
Blackside dace	*Phoxinus cumberlandensis*	Fish
Boulder darter	*Etheostoma wapiti*	Fish
Cumberland darter	*Etheostoma susanae*	Fish
Arkansas River shiner	*Notropis girardi*	Fish
Blue shiner	*Cyprinella caerulea*	Fish
Smalleye Shiner	*Notropis buccula*	Fish
Pallid sturgeon	*Scaphirhynchus albus*	Fish
Duskytail darter	*Etheostoma percnurum*	Fish
Cumberland bean (pearlymussel)	*Villosa trabalis*	Bivalve

purple cat's paw (=purple cat's paw pearlymussel)	*Epioblasma obliquata obliquata*	Bivalve
Alabama lampmussel	*Lampsilis virescens*	Bivalve
Pale lilliput (pearlymussel)	*Toxolasma cylindrellus*	Bivalve
Cumberland monkeyface (pearlymussel)	*Quadrula intermedia*	Bivalve
Pink mucket (pearlymussel)	*Lampsilis abrupta*	Bivalve
Dromedary pearlymussel	*Dromus dromas*	Bivalve
Littlewing pearlymussel	*Pegias fabula*	Bivalve
White wartyback (pearlymussel)	*Plethobasus cicatricosus*	Bivalve
Finerayed pigtoe	*Fusconaia cuneolus*	Bivalve
Rough pigtoe	*Pleurobema plenum*	Bivalve
Shiny pigtoe	*Fusconaia cor*	Bivalve
Orangefoot pimpleback (pearlymussel)	*Plethobasus cooperianus*	Bivalve
Fat pocketbook	*Potamilus capax*	Bivalve
Spectaclecase (mussel)	*Cumberlandia monodonta*	Bivalve
Southern combshell	*Epioblasma penita*	Bivalve
Rayed Bean	*Villosa fabalis*	Bivalve
Clubshell	*Pleurobema clava*	Bivalve
Cumberlandian combshell	*Epioblasma brevidens*	Bivalve
Appalachian elktoe	*Alasmidonta raveneliana*	Bivalve
Alabama (=inflated) heelsplitter	*Potamilus inflatus*	Bivalve
Orangenacre mucket	*Lampsilis perovalis*	Bivalve
Oyster mussel	*Epioblasma capsaeformis*	Bivalve
Slabside Pearlymussel	*Pleuronaia dolabelloides*	Bivalve
Stirrupshell	*Quadrula stapes*	Bivalve
Fanshell	*Cyprogenia stegaria*	Bivalve
Finelined pocketbook	*Lampsilis altilis*	Bivalve
Northern riffleshell	*Epioblasma torulosa rangiana*	Bivalve
Ovate clubshell	*Pleurobema perovatum*	Bivalve
Southern clubshell	*Pleurobema decisum*	Bivalve
Triangular Kidneyshell	*Ptychobranchus greenii*	Bivalve
Alabama moccasinshell	*Medionidus acutissimus*	Bivalve
Coosa moccasinshell	*Medionidus parvulus*	Bivalve
Southern pigtoe	*Pleurobema georgianum*	Bivalve
Snuffbox mussel	*Epioblasma triquetra*	Bivalve
Rabbitsfoot	*Quadrula cylindrica cylindrica*	Bivalve
Georgia pigtoe	*Pleurobema hanleyianum*	Bivalve
Fluted kidneyshell	*Ptychobranchus subtentum*	Bivalve
Sheepnose Mussel	*Plethobasus cyphyus*	Bivalve
Anthony's riversnail	*Athearnia anthonyi*	Gastropod
Karner blue butterfly	*Lycaeides melissa samuelis*	Insect
Mitchell's satyr Butterfly	*Neonympha mitchellii mitchellii*	Insect
American burying beetle	*Nicrophorus americanus*	Insect
Hine's emerald dragonfly	*Somatochlora hineana*	Insect
Spruce-fir moss spider	*Microhexura montivaga*	Arachnid

Short's bladderpod	*Physaria globosa*	Dicot
Price's potato-bean	*Apios priceana*	Dicot
Braun's rock-cress	*Arabis perstellata*	Dicot
Cumberland rosemary	*Conradina verticillata*	Dicot
No common name	*Geocarpon minimum*	Dicot
Spreading avens	*Geum radiatum*	Dicot
Small whorled pogonia	*Isotria medeoloides*	Monocot
Short's goldenrod	*Solidago shortii*	Dicot
Cumberland sandwort	*Arenaria cumberlandensis*	Dicot
Pitcher's thistle	*Cirsium pitcheri*	Dicot
Leafy prairie-clover	*Dalea foliosa*	Dicot
Roan Mountain bluet	*Hedyotis purpurea var. montana*	Dicot
Dwarf lake iris	*Iris lacustris*	Monocot
Pondberry	*Lindera melissifolia*	Dicot
Eastern prairie fringed orchid	*Platanthera leucophaea*	Monocot
Harperella	*Ptilimnium nodosum*	Dicot
American chaffseed	*Schwalbea americana*	Dicot
Large-flowered skullcap	*Scutellaria montana*	Dicot
Blue Ridge goldenrod	*Solidago spithamaea*	Dicot
Tennessee yellow-eyed grass	*Xyris tennesseensis*	Monocot
Virginia spiraea	*Spiraea virginiana*	Dicot
Running buffalo clover	*Trifolium stoloniferum*	Dicot
Lakeside daisy	*Hymenoxys herbacea*	Dicot
Morefield's leather flower	*Clematis morefieldii*	Dicot
Whorled Sunflower	*Helianthus verticillatus*	Dicot
American hart's-tongue fern	*Asplenium scolopendrium var. americanum*	Ferns
Louisiana quillwort	*Isoetes louisianensis*	Ferns
Rock gnome lichen	*Gymnoderma lineare*	Lichen
Red wolf	*Canis rufus*	Mammal
North Atlantic Right Whale	*Eubalaena glacialis*	Mammal
Sperm whale	*Physeter catodon (=macrocephalus)*	Mammal
Gulf Coast jaguarundi	*Herpailurus (=Felis) yagouaroundi cacomitli*	Mammal
Virginia big-eared bat	*Corynorhinus (=Plecotus) townsendii virginianus*	Mammal
Ocelot	*Leopardus (=Felis) pardalis*	Mammal
Perdido Key beach mouse	*Peromyscus polionotus trissyllepsis*	Mammal
Alabama beach mouse	*Peromyscus polionotus ammobates*	Mammal
Mexican long-nosed bat	*Leptonycteris nivalis*	Mammal
Attwater's greater prairie-chicken	*Tympanuchus cupido attwateri*	Bird
Bachman's warbler (=wood)	*Vermivora bachmanii*	Bird
Northern aplomado falcon	*Falco femoralis septentrionalis*	Bird
Mexican spotted owl	*Strix occidentalis lucida*	Bird
Roseate tern	*Sterna dougallii dougallii*	Bird

Golden-cheeked warbler (=wood)	*Dendroica chrysoparia*	Bird
Southwestern willow flycatcher	*Empidonax traillii extimus*	Bird
Loggerhead sea turtle	*Caretta caretta*	Reptile
Flattened musk turtle	*Sternotherus depressus*	Reptile
Eastern indigo snake	*Drymarchon corais couperi*	Reptile
Texas blind salamander	*Typhlomolge rathbuni*	Amphibian
Houston toad	*Bufo houstonensis*	Amphibian
Red Hills salamander	*Phaeognathus hubrichti*	Amphibian
San Marcos salamander	*Eurycea nana*	Amphibian
Barton Springs salamander	*Eurycea sosorum*	Amphibian
Frosted Flatwoods salamander	*Ambystoma cingulatum*	Amphibian
Jollyville Plateau salamander	*Eurycea tonkawae*	Amphibian
Georgetown salamander	*Eurycea naufragia*	Amphibian
Salado salamander	*Eurycea chisholmensis*	Amphibian
Austin blind salamander	*Eurycea waterlooensis*	Amphibian
Reticulated flatwoods salamander	*Ambystoma bishopi*	Amphibian
Big Bend gambusia	*Gambusia gaigei*	Fish
Clear Creek gambusia	*Gambusia heterochir*	Fish
Comanche Springs pupfish	*Cyprinodon elegans*	Fish
Shortnose sturgeon	*Acipenser brevirostrum*	Fish
Fountain darter	*Etheostoma fonticola*	Fish
Watercress darter	*Etheostoma nuchale*	Fish
Pecos gambusia	*Gambusia nobilis*	Fish
Alabama cavefish	*Speoplatyrhinus poulsoni*	Fish
Pygmy Sculpin	*Cottus paulus (=pygmaeus)*	Fish
Cape Fear shiner	*Notropis mekistocholas*	Fish
Waccamaw silverside	*Menidia extensa*	Fish
San Marcos gambusia	*Gambusia georgei*	Fish
Leon Springs pupfish	*Cyprinodon bovinus*	Fish
Alabama sturgeon	*Scaphirhynchus suttkusi*	Fish
Cherokee darter	*Etheostoma scotti*	Fish
Devils River minnow	*Dionda diaboli*	Fish
Cahaba shiner	*Notropis cahabae*	Fish
Palezone shiner	*Notropis albizonatus*	Fish
Sharpnose Shiner	*Notropis oxyrhynchus*	Fish
Sunfish, spring pygmy	*Elassoma alabamae*	Fish
Goldline darter	*Percina aurolineata*	Fish
Relict darter	*Etheostoma chienense*	Fish
Etowah darter	*Etheostoma etowahae*	Fish
Vermilion darter	*Etheostoma chermocki*	Fish
Smalltooth sawfish	*Pristis pectinata*	Fish
Rush Darter	*Etheostoma phytophilum*	Fish
Yellow blossom (pearlymussel)	*Epioblasma florentina florentina*	Bivalve
Ring pink (mussel)	*Obovaria retusa*	Bivalve
Flat pigtoe	*Pleurobema marshalli*	Bivalve

Heavy pigtoe	*Pleurobema taitianum*	Bivalve
Tar River spinymussel	*Elliptio steinstansana*	Bivalve
Choctaw bean	*Villosa choctawensis*	Bivalve
Cumberland elktoe	*Alasmidonta atropurpurea*	Bivalve
Alabama pearlshell	*Margaritifera marrianae*	Bivalve
Cracking pearlymussel	*Hemistena lata*	Bivalve
James spinymussel	*Pleurobema collina*	Bivalve
Altamaha Spinymussel	*Elliptio spinosa*	Bivalve
Dwarf wedgemussel	*Alasmidonta heterodon*	Bivalve
Southern acornshell	*Epioblasma othcaloogensis*	Bivalve
Purple bankclimber (mussel)	*Elliptoideus sloatianus*	Bivalve
Upland combshell	*Epioblasma metastriata*	Bivalve
Round Ebonyshell	*Fusconaia rotulata*	Bivalve
Carolina heelsplitter	*Lasmigona decorata*	Bivalve
Southern kidneyshell	*Ptychobranchus jonesi*	Bivalve
Oval pigtoe	*Pleurobema pyriforme*	Bivalve
Narrow pigtoe	*Fusconaia escambia*	Bivalve
Shinyrayed pocketbook	*Lampsilis subangulata*	Bivalve
Southern sandshell	*Hamiota (=Lampsilis) australis*	Bivalve
Fat three-ridge (mussel)	*Amblema neislerii*	Bivalve
Dark pigtoe	*Pleurobema furvum*	Bivalve
Gulf moccasinshell	*Medionidus penicillatus*	Bivalve
Ochlockonee moccasinshell	*Medionidus simpsonianus*	Bivalve
Chipola slabshell	*Elliptio chipolaensis*	Bivalve
Fuzzy pigtoe	*Pleurobema strodeanum*	Bivalve
Tapered pigtoe	*Fusconaia burkei*	Bivalve
Noonday globe	*Patera clarki nantahala*	Gastropod
Phantom springsnail	*Pyrgulopsis texana*	Gastropod
Phantom tryonia	*Tryonia cheatumi*	Gastropod
Armored snail	*Pyrgulopsis (=Marstonia) pachyta*	Gastropod
Pecos assiminea snail	*Assiminea pecos*	Gastropod
Diamond Y Spring snail	*Pseudotryonia adamantina*	Gastropod
Tulotoma snail	*Tulotoma magnifica*	Gastropod
Gonzales springsnail	*Tryonia circumstriata*	Gastropod
Lacy elimia (snail)	*Elimia crenatella*	Gastropod
Rough hornsnail	*Pleurocera foremani*	Gastropod
Cylindrical lioplax (snail)	*Lioplax cyclostomaformis*	Gastropod
Flat pebblesnail	*Lepyrium showalteri*	Gastropod
Painted rocksnail	*Leptoxis taeniata*	Gastropod
Plicate rocksnail	*Leptoxis plicata*	Gastropod
Round rocksnail	*Leptoxis ampla*	Gastropod
Slender campeloma	*Campeloma decampi*	Gastropod
Interrupted (=Georgia) Rocksnail	*Leptoxis foremani*	Gastropod
Hungerford's crawling water Beetle	*Brychius hungerfordi*	Insect
Coffin Cave mold beetle	*Batrisodes texanus*	Insect

Kretschmarr Cave mold beetle	*Texamaurops reddelli*	Insect
Tooth Cave ground beetle	*Rhadine persephone*	Insect
Comal Springs riffle beetle	*Heterelmis comalensis*	Insect
Comal Springs dryopid beetle	*Stygoparnus comalensis*	Insect
Saint Francis' satyr butterfly	*Neonympha mitchellii francisci*	Insect
[Unnamed] ground beetle	*Rhadine infernalis*	Insect
Helotes mold beetle	*Batrisodes venyivi*	Insect
[Unnamed] ground beetle	*Rhadine exilis*	Insect
Bee Creek Cave harvestman	*Texella reddelli*	Arachnid
Bone Cave harvestman	*Texella reyesi*	Arachnid
Tooth Cave pseudoscorpion	*Tartarocreagris texana*	Arachnid
Tooth Cave Spider	*Leptoneta myopica*	Arachnid
Cokendolpher Cave Harvestman	*Texella cokendolpheri*	Arachnid
Government Canyon Bat Cave Spider	*Neoleptoneta microps*	Arachnid
Madla's Cave Meshweaver	*Cicurina madla*	Arachnid
Robber Baron Cave Meshweaver	*Cicurina baronia*	Arachnid
Government Canyon Bat Cave Meshweaver	*Cicurina vespera*	Arachnid
Braken Bat Cave Meshweaver	*Cicurina venii*	Arachnid
Peck's cave amphipod	*Stygobromus (=Stygonectes) pecki*	Crustacean
Alabama cave shrimp	*Palaemonias alabamae*	Crustacean
Kentucky cave shrimp	*Palaemonias ganteri*	Crustacean
Diminutive Amphipod	*Gammarus hyalleloides*	Crustacean
Star cactus	*Astrophytum asterias*	Dicot
Pecos (=puzzle, =paradox) sunflower	*Helianthus paradoxus*	Dicot
Neches River rose-mallow	*Hibiscus dasycalyx*	Dicot
Kentucky glade cress	*Leavenworthia exigua laciniata*	Dicot
Fleshy-Fruit Gladecress	*Leavenworthia crassa*	Dicot
Zapata bladderpod	*Lesquerella thamnophila*	Dicot
Ashy dogweed	*Thymophylla tephroleuca*	Dicot
South Texas ambrosia	*Ambrosia cheiranthifolia*	Dicot
Little amphianthus	*Amphianthus pusillus*	Dicot
Tobusch fishhook cactus	*Sclerocactus brevihamatus ssp. tobuschii*	Dicot
Hairy rattleweed	*Baptisia arachnifera*	Dicot
Texas poppy-mallow	*Callirhoe scabriuscula*	Dicot
Small-anthered bittercress	*Cardamine micranthera*	Dicot
Nellie cory cactus	*Coryphantha minima*	Dicot
Bunched cory cactus	*Coryphantha ramillosa*	Dicot
Sneed pincushion cactus	*Coryphantha sneedii var. sneedii*	Dicot
Black lace cactus	*Echinocereus reichenbachii var. albertii*	Dicot
Davis' green pitaya	*Echinocereus viridiflorus var. davisii*	Dicot
Lloyd's Mariposa cactus	*Echinomastus mariposensis*	Dicot
Johnston's frankenia	*Frankenia johnstonii*	Dicot
Dwarf-flowered heartleaf	*Hexastylis naniflora*	Dicot
Slender rush-pea	*Hoffmannseggia tenella*	Dicot
Lyrate bladderpod	*Lesquerella lyrata*	Dicot

Walker's manioc	*Manihot walkerae*	Dicot
Mohr's Barbara button	*Marshallia mohrii*	Dicot
Texas trailing phlox	*Phlox nivalis ssp. texensis*	Dicot
Little Aguja (=Creek) Pondweed	*Potamogeton clystocarpus*	Monocot
Hinckley oak	*Quercus hinckleyi*	Dicot
Miccosukee gooseberry	*Ribes echinellum*	Dicot
Bunched arrowhead	*Sagittaria fasciculata*	Monocot
Green pitcher-plant	*Sarracenia oreophila*	Dicot
Fringed campion	*Silene polypetala*	Dicot
White-haired goldenrod	*Solidago albopilosa*	Dicot
Gentian pinkroot	*Spigelia gentianoides*	Dicot
Navasota ladies'-tresses	*Spiranthes parksii*	Monocot
Texas snowbells	*Styrax texanus*	Dicot
Cooley's meadowrue	*Thalictrum cooleyi*	Dicot
Persistent trillium	*Trillium persistens*	Monocot
Texas wild-rice	*Zizania texana*	Monocot
Large-fruited sand-verbena	*Abronia macrocarpa*	Dicot
Sensitive joint-vetch	*Aeschynomene virginica*	Dicot
Terlingua Creek cat's-eye	*Cryptantha crassipes*	Dicot
Smooth coneflower	*Echinacea laevigata*	Dicot
Chisos Mountain hedgehog Cactus	*Echinocereus chisoensis var. chisoensis*	Dicot
Schweinitz's sunflower	*Helianthus schweinitzii*	Dicot
Swamp pink	*Helonias bullata*	Monocot
Heller's blazingstar	*Liatris helleri*	Dicot
Rough-leaved loosestrife	*Lysimachia asperulaefolia*	Dicot
Michigan monkey-flower	*Mimulus michiganensis*	Dicot
Canby's dropwort	*Oxypolis canbyi*	Dicot
Michaux's sumac	*Rhus michauxii*	Dicot
Alabama canebrake pitcher-plant	*Sarracenia rubra alabamensis*	Dicot
Mountain sweet pitcher-plant	*Sarracenia rubra ssp. jonesii*	Dicot
Houghton's goldenrod	*Solidago houghtonii*	Dicot
Seabeach amaranth	*Amaranthus pumilus*	Dicot
White bladderpod	*Lesquerella pallida*	Dicot
Relict trillium	*Trillium reliquum*	Monocot
Texas prairie dawn-flower	*Hymenoxys texana*	Dicot
Alabama leather flower	*Clematis socialis*	Dicot
Mountain golden heather	*Hudsonia montana*	Dicot
Kral's water-plantain	*Sagittaria secundifolia*	Monocot
Texas ayenia	*Ayenia limitaris*	Dicot
Texas Golden Gladecress	*Leavenworthia texana*	Dicot
White irisette	*Sisyrinchium dichotomum*	Monocot
Golden sedge	*Carex lutea*	Monocot
Florida torreya	*Torreya taxifolia*	Conf/cycds
Black spored quillwort	*Isoetes melanospora*	Ferns
Mat-forming quillwort	*Isoetes tegetiformans*	Ferns

Alabama streak-sorus fern	*Thelypteris pilosa var. alabamensis*	Ferns
False killer whale	*Pseudorca crassidens*	Mammal

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, DC 20460

OFFICE OF CHEMICAL SAFETY AND POLLUTION PREVENTION

PC Code: 128931
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Date: March 24, 2016

MEMORANDUM

Subject: Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in in 11 U.S. States: (Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia).

To: Grant Rowland, Risk Manager Reviewer
Kathryn Montague, Product Manager Team 23
Dan Kenny, Branch Chief
Herbicide Branch
Pesticide Registration Division (7505P)
Office of Pesticide Programs

From: Elizabeth Donovan, Biologist 3/24/16
Michael Wagman, Biologist 3/24/16
Monica Wait, Risk Assessment Process Leader Monica Wait 3/24/16
Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)
Office of Pesticide Programs

Through: Mark Corbin, Branch Chief 3-24-16
Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)
Office of Pesticide Programs

Prior to conducting this refined Endangered Species Assessment, the Environmental Fate and Effects Division (EFED) performed a screening level ecological risk assessment for a Federal action involving proposed new uses of the diglycolamine salt of dicamba (dicamba DGA) on dicamba herbicide-tolerant soybean on March 8, 2011 (DP 378444); an amendment to the assessment was issued on May 20, 2014 (DP 404138, 404806, 405887, 410802, and 411382). Concurrent with this refined Endangered Species Assessment, a Section 3 New Use dicamba DGA salt on dicamba-tolerant cotton screening-level assessment (DP 404823) and a subsequent addendum (DP 426789) that addresses multiple issues (spray drift buffers, runoff, risk to terrestrial invertebrates and updated mammalian toxicological endpoints for parent dicamba and its degradate, DCSA) have been finalized. In the screening level risk assessment, potential direct risk concerns could not be excluded for:

- mammals (chronic, from the soybean use only, due to residues from dicamba's metabolite, DCSA, rather than from parent dicamba);
- birds (acute from parent dicamba for both soybean and cotton uses; chronic from DCSA residues only in soybean but not in cotton), considered surrogates for reptiles, and terrestrial-phase amphibians; and
- terrestrial plants (soybean and cotton uses)

In the screening level risk assessments, indirect effect risk concerns for all taxa were possible for any species that have dependencies (e.g., food, shelter, and habitat) on mammals, birds, reptiles, terrestrial-phase amphibians, or terrestrial plants. Additionally, the screening level assessment showed that direct risk concerns were unlikely (*i.e.* levels of concern were not exceeded) for:

- mammals (acute) and (chronic—for the cotton use only);
- birds, reptiles, and terrestrial-phase amphibians (chronic from parent dicamba or DCSA degradate from use on cotton);
- terrestrial insects (acute and chronic);
- freshwater fish (acute and chronic);
- aquatic-phase amphibians (acute and chronic);
- estuarine/marine fish (acute and chronic);
- freshwater invertebrates (acute and chronic); estuarine/marine invertebrates (acute and chronic); and
- aquatic plants[1]

EPA has a specific process based on sound science that it follows when assessing risks to listed species for pesticides like dicamba that will be used on seeds that have been genetically modified to be tolerant to the pesticide. The Agency begins with a screening level assessment that

[1] The listed species LOC was exceeded for non-vascular aquatic plants, however there are no listed species of this taxa.

includesa basic ecological risk assessment based on its 2004 Overview of the Ecological Risk Assessment Process document. [USEPA, 2004, available at http://www.epa.gov/oppfead1/endanger/litstatus/riskasses.htm]. That assessment uses broad default assumptions to establish estimated environmental concentrations of particular pesticides. If the screening level assessment results in a determination that no levels of concern are exceeded, EPA concludes its analysis. On the other hand, where the screening level assessment does not rule out potential effects (exceedances of the level of concern) based on the broad default assumptions, EPA then uses increasingly specific methods and exposure models to refine its estimated environmental concentrations. At each screening step, EPA compares the more refined exposures to the toxicity of the pesticide active ingredient to determine whether the pesticide exceeds levels of concern established for listed aquatic and terrestrial species. EPA determines that there is “no effect” on listed species if, at any step in the screening level assessment, no levels of concern are exceeded. If, after performing all of the steps in the screening level assessment, a pesticide still exceeds the Agency’s levels of concern for listed species, EPA then conducts a species-specific refined assessment to make effects determinations for individual listed species. The refined assessment, unlike the screening level assessment, takes account of species’ habitats and behaviors to determine whether any listed species may be affected by use of the pesticide.

The screening level ecological risk assessment generates a series of taxonomic (e.g., mammals, birds, fish, etc.) risk quotients (RQs) that are the ratio of estimated exposures to acute and chronic effects endpoints. These RQs are then compared to EPA established levels of concern (LOCs) to determine if risks to any taxonomic group are of concern. The LOCs address risks for both acute and chronic effects. Acute effects LOCs range from 0.05 for aquatic animals that are Federally-listed threatened or endangered species (listed species) to 0.5 for aquatic non-listed animal species and 0.1 to 0.5 for terrestrial animals for listed and non-listed species. The LOC for chronic effects for all animal taxa (listed and non-listed) is 1. Plant risks are handled in a similar manner, but with different toxicity thresholds (NOAEC/EC_{05} and EC_{25}, respectively) used in RQ calculation for listed and non-listed species and an LOC of 1 used to interpret the RQ. When a given taxonomic RQ exceeds either the acute or chronic LOC a concern for direct toxic effects is identified for that particular taxon. If RQs fall below the LOC, a no effect determination is identified for the corresponding taxon.

The purpose of this document is to explain the refined risk assessment conducted for Federally-listed threatened or endangered (listed) species that could potentially be impacted by this pesticide registration. The refined assessment was conducted based on the 2004 Overview document, as discussed above. The assessment of risks to listed species posed by the use of Dicamba DGA has been conducted in phases covering a specific set of states, assessing risk to all the listed species covered in those states. This assessment covers the endangered species analysis for 11 states: Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia (AZ, CO, DE, FL, MD, NM, NJ, NY, PA, VA and WV). Based on EFED’s LOCATES v.2.4.0 database and information from the U.S. Fish and Wildlife Service (USFWS), 322 species in the 11 states proposed for registration were identified as within the action area (at a preliminary county-wide level of resolution) associated with the new herbicide-tolerant soybean and cotton uses. **Table 1** below presents a summary of this assessment. Separate concurrent assessment phases cover the endangered species analysis for 16 states (Arkansas, Kansas, Louisiana, Illinois, Indiana, Iowa, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin (DP 416416, 420160, 420159, 420352, 421434, 421723)) and 7 states (Alabama, Georgia, Kentucky, Michigan, North Carolina, South Carolina, and Texas (DP 422305).

EPA consulted U.S. Fish and Wildlife Service Recovery Plans to determine whether listed species in these states would be expected to occur in an action area encompassing the treated soybean and corn fields. The refined assessment was then conducted on those species that could not be excluded from the action area. EPA also consulted the recovery plans in the refined assessment for additional habitat information and incorporated species biological information regarding dietary items (used to model dicamba DGA residues in prey tissue) and body weight (used to determine food consumption rates and scale ecotoxicity data from the tested surrogate species, the bobwhite quail and rat, to the body weight of the listed species).

The Environmental Fate and Effects Division (EFED) has completed an endangered species risk assessment for Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia in support of registering dicamba diglycolamine (DGA) salt on herbicide-tolerant cotton and soybean in these states. **Table 1** presents a summary of the assessment.

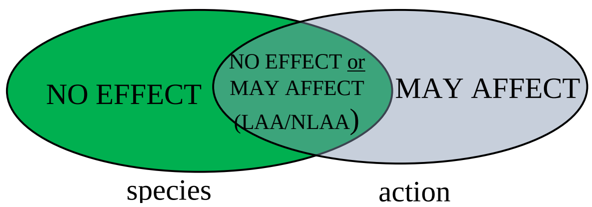
Table 1. Summary of species effects determinations and critical habitat modification determinations for Federally listed threatened or endangered species in Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia for dicamba DGA use on genetically modified cotton and soybeans.

Species	**Effects Determination**	**Comments**
Audubon Crested Caracara	**May Affect, Not Likely to Adversely Affect for Palm Beach County** (Cotton only; concurrence by USFWS pending) No effect (soybean; and for cotton in all other counties except Palm Beach)	The species is found in 22 counties in Florida. However, no county has soybean production and only one county has any cotton: Palm Beach County
All other species (terrestrial and aquatic)	No effect	
Critical Habitat	**Modification Determination**	**Comments**
All Critical Habitats (322 species)	No Modification	None

Making an Effects Determination

The bullets below outline EFED's process for making an effects determination for the Federal action:

- For listed individuals inside the action area but **NOT** part of an affected taxa **NOR** relying on the affected taxa for services (involving food, shelter, biological mediated resources necessary for survival/reproduction), use of a pesticide would be determined to have NO EFFECT.
- For listed individuals outside the action area, use of a pesticide would be determined to have NO EFFECT.
- Listed individuals inside the action area may either fall into the NO EFFECT or MAY AFFECT (LIKELY or NOT LIKELY TO ADVERSELY AFFECT) categories depending upon their specific biological needs, circumstances of exposure, etc.



- LIKELY or NOT LIKELY TO ADVERSELY AFFECT determinations are made using the following criteria:
  - Insignificant - The level of the effect cannot be meaningfully related to a "take."
  - Highly Uncertain - The effect is highly unlikely to occur.
  - Wholly beneficial - The effects are only good things.

Spray Drift Mitigation

EFED's refined endangered species risk assessment took into account the spray drift mitigation language that was added to the most recent proposed label submitted by the registrant. An accounting of federally-listed threatened or endangered species within the 11 states (covered in this assessment) proposed for dicamba DGA use on genetically modified cotton and soybeans is included in **Appendix 1** (322 species). Specifically, the spray drift mitigation language on the M1691 Herbicide Supplemental labels for the use dicamba DGA salt on ROUNDUP READY 2 XTEND™ soybean and BOLLGARD II® XTENDFLEX cotton includes the following limitations:

Specifically, the spray drift mitigation language includes the following limitations:

- Specifying the use of a nozzle (Tee Jet® TTI11004) with ASABE S-572 ultra-coarse and extremely coarse droplet spectra and a maximum operating pressure of 63 psi.

- A maximum equipment ground speed of 15 miles per hour and ground boom height of 24 inches above the target pest or crop canopy.
- Restricting all applications when wind speeds are < 3 mph or > 15 mph and restricting applications when wind is blowing towards sensitive areas at > 10 mph. Maintaining use of a 110 foot in-field buffer for a 0.5 lb a.i./A application (220 foot in-field buffer for a 1 lb a.i./A application) when the wind is blowing towards any areas that are not fields in crop cultivation, paved areas, or areas covered by buildings and other structures.
- Applications done in low relative humidity conditions are to use equipment set to produce larger droplet spectra to compensate for evaporation.
- Applications are not be conducted during temperature inversions.
- In order to prevent effects to non-target susceptible plants, the label also includes the following language: "do not apply under circumstances where spray drift may occur to food, forage or other plantings that might be damaged or the crops thereof rendered unfit for sale, use or consumption. Avoid contact of herbicide with foliage, green stems, exposed non-woody roots of crops, and desirable plants, including beans, cotton, flowers, fruit trees, grapes, ornamentals, peas, potato, soybean, sunflower, tobacco, tomato, and other broadleaf plants because severe injury or destruction may result, including plants in a greenhouse. Applicators are required to ensure that they are aware of the proximity to sensitive areas, and to avoid potential adverse effects from the off-target movement of M1691 Herbicide. The Applicator must survey the application site for neighboring sensitive areas prior to application. The applicator also should consult sensitive crop registries for locating sensitive areas where available."
- Finally, in order to prevent unintended damage from the drift of M1691 Herbicide, the label says not to apply this product when the wind is blowing towards adjacent commercially grown sensitive crops.

The incorporation of the spray drift mitigation measures into the product labeling as outlined above would result in exposure to dicamba DGA from spray drift at a level where effects are expected only within the confines of the treated field and so the action area is limited to the dicamba DGA treated field. Further, the incorporation of the "susceptible plants" spray drift mitigation language on the label is to avoid damage to these plants (including adjacent crops). Because the risk assessment interprets the threshold for plant damage concern to be based on the most sensitive plant species tested and the screening level ecological risk assessment has demonstrated that these plant effects endpoints constitute the most conservative terrestrial organism levels of effect, it is concluded that the "susceptible plants" requirement requires a level of drift mitigation that would also prevent less sensitive organisms from being exposed at levels of concern. Terrestrial species that are not expected to occur on treated fields under the provisions of the proposed label are not expected to be directly exposed to dicamba DGA, nor are their critical biologically mediated resources expected to be exposed to levels of the herbicide above any effects thresholds of concern. Additionally, as indicated in the screening level ecological risk assessments for cotton and soybean, no aquatic receptor taxa are of concern for drift or runoff exposure (LOCs were not exceeded for aquatic taxa). **Consequently, all but 14 of the 322 listed species originally identified as potentially at-risk are determined to be**

given a "no effect" (NE) without further refinement because they are not expected to occur in an action area encompassing the treated soybean and cotton fields (Appendix 2). The remaining 14 species are assessed using the refinements set forth in the 2004 Overview document referred to earlier in this assessment and considering the restictions contained in the proposed labeling, species specific biology, dicamba-specific foliar residue data and dicamba application timing information in this refined endangered species assessment.

Exposure through Runoff

The cotton screening-level risk assessment and the concurrently issued soybean addendum characterized risk following exposure to dicamba residues in runoff and found that the predicted concentrations from modeling were lower than the most sensitive taxa's endpoint (soybean plant height). Combining the predictions of this modeling, the toxicological endpoints and that most of the off-site plant community would not experience foliar contact with dicamba DGA in runoff sheet flow, EFED concluded that all available lines of evidence supported a "no effects" determination for runoff exposure for off-field listed plants for the proposed labeled use of dicamba DGA. Additionally, rainfast mitigation on the label would also protect against the risk of exposure to listed species off the treated field.

In addition to the spray drift and runoff mitigation measures contained in the proposed labeling, EFED analyzed species-specific biology, dicamba-specific foliar residue data and dicamba application timing information in this refined endangered species assessment. An accounting of the federally-listed threatened or endangered species within the 11 states proposed for this registration showed 322 listed species as potentially at risk (direct or indirect effects) as a result of the screening-level assessment (**Appendix 1**). The spray drift mitigation label language cannot preclude listed species being exposed to dicamba DGA salt or DCSA residues on treated fields, should a listed species utilize such areas as part of its range and corresponding habitat. Of the 322 listed species within the 11 states (AZ, CO, DE, FL, MD, NM, NJ, NY, PA, VA and WV) considered part of the proposed Federal decision, the following 14 species were reasonably expected to occur on soybean and cotton fields, which could potentially be treated with dicamba and therefore could not be assumed to be "no effect" solely on the basis of occurrence outside the action area:

Of these 14 species, a "no effect" determination was reached in the concurrent assessment actions for 16 states(DP 416416, 420160, 420159, 420352, 421434, 421723 covering AR, IL, IA, IN, KS, LA, MN, MS, MO, NE, ND, OH, OK, SD, TN, and WI) and 7 states (DP 422305 covering AL, GA, KY, MI, NC, SC, and TX) for the following species and is applicable to these 11 states as well:

- Eastern indigo snake (*Drymarchon corais couperi*)
- Indiana bat (*Myotis sodalis*)
- Lesser prairie-chicken (*Tympanuchus pallidicinctus*)
- Virginia big-eared bat (*Corynorhinus (=Plecotus) townsendii virginianus*)

- Ocelot (*Leopardus (Felis) pardalis*)
- Whooping crane (*Grus americana*)
- Red wolf (*Canis rufus*)
- Gray wolf (*Canis lupus*)

This leaves the following species for which the remainder of this document uses species specific biological information and dicamba DGA use patterns in more depth to further refine the assessment and effects determinations:

- California condor *(Gymnogyps californianus)*
- Audubon's crested caracara (*Polyborus plancus audubonii*)
- Delmarva Peninsula fox squirrel *(Sciurus niger cinereus)*
- Jaguar *(Panthera onca)*
- Florida panther (*Puma (=felis) concolor coryi*)
- Sonoran pronghorn *(Antilocapra americana sonoriensis)*

Therefore, species specific biological information (e.g., body size, dietary requirements, and seasonality) and dicamba DGA use patterns were considered in more depth to further refine the assessment and effects determinations.

This assessment also uses the refined exposure values determined in the cotton screening level assessment and the concurrently issued addendum to the soybean screening level risk assessment documents compared to the initial exposure estimates from the soybean screening level assessment. This ESA assessment also evaluates chronic exposures from DCSA separately from the chronic exposure to parent dicamba. Dicamba exposure values were determined from the upper bound of the modeled T-REX run for exposures following spray applications based on the Kenaga nomogram modified by Fletcher *et al* (1984), which is based on a large set of actual field residue data. Modeled dicamba exposure values were identical between the soybean addendum and the cotton screening level risk assessment (since the maximum application rates and minimum application intervals are the same).

Similar modeling of DCSA residues, which are formed inside the tolerant-soybean and tolerant-cotton plants through plant metabolism, is not feasible at this time due to a lack of sufficient data tracking DCSA residues in plant tissues over time to ascertain degradation rates. Therefore, in the soybean addendum and the cotton screening-level risk assessment, EFED used the maximum empirical measured DCSA residue concentrations in dicamba-tolerant soybean (61.1 mg/kg (ppm) DCSA in broadleaf plants and 0.440 ppm in soybean seeds) and cotton plant tissues (6.29 ppm DCSA in cotton gin byproducts and 0.27 ppm in undelinted cotton seed) to evaluate chronic exposures to DCSA for animals foraging on soybean and cotton plants. Residues in arthropods (as a dietary item for birds and mammals consuming insects that have consumed soybean/cotton tissues with DCSA residues) were assumed to follow the Kenaga nomogram relationship between broadleaf plants and arthropods for spray applications (*i.e.* arthropod concentrations estimated to be approximately 70% of the concentrations in broadleaf plant tissues or 42.5 ppm

DCSA in arthropods feeding on soybean plants and 4.4 ppm in arthropods feeding on cotton plants). The empirical residue data for cotton indicated that chronic exposures of birds and mammals to dicamba or DCSA in cotton tissues ***would not*** be above any levels of concern. Although the concurrently issued soybean addendum indicates that chronic risk to mammals and birds was only a concern from DCSA residues in plant/prey tissues *and not from residues of parent dicamba*, since the original soybean screening-level assessment (USEPA, 2011) indicated chronic risk to mammals, this assessment presents the estimated exposures and comparisons to threshold toxicity values for both dicamba and DCSA for mammals, but evaluates them separately since their chronic toxicity and exposure profiles differ greatly. For birds, following the conclusions of the screening level assessments and the soybean addendum, only acute risk from dicamba exposures and chronic risk from DCSA exposures is evaluated.
The following text discusses the lines of evidence and processes that were used to make effects determinations for listed species identified as potentially at-risk in the screening level assessment.

Refined ecological risk assessment for the remaining species potentially exposed to dicamba residues

For the effects determinations for California condor, Audobon's crested caracara, Delmarva Peninsula fox squirrel, jaguar, Florida panther and Sonoran pronghorn, a refined risk assessment approach was used to evaluate additional lines of evidence to determine whether the conservative generic assumptions in the screening risk assessment apply to a particular species of interest (*e.g.* the California condor). In the case of the California condor, the refined risk assessment investigated the impacts of more condor-specific data related to:

1. Bird size (as the condor is larger than the 1000g large bird category used in the initial screen)

2.. Bird food consumption tailored to:
   a. The true weight of the bird
   b. Energy requirements of the condor
   c. Improvement on the generic food intake model of the screen to assess energy content of the diet and the actual free living energy requirements of a bird the size of a California condor

3. Toxicity endpoints scaled from the weight of the tested surrogate species (bobwhite quail) to reflect the comparatively larger actual size of the condor.

Using the California condor as the example to show how EPA made its effects determinations, EPA determined that the California condor could be primarily feeding on carcasses of large mammals that may have been present in treated cotton and soybean fields. EPA therefore assumed that the predicted concentrations of dicamba DGA salt found in large (1000g) mammals that were exclusively feeding on short grass exposed to dicamba residues from the spray application would be a conservative prey analysis for the condor consistent with the preliminary risk concerns identified in the screening assessments. For chronic exposures to DCSA residues, EPA assumed the prey mammal was feeding exclusively on soybean forage containing the that there is no soybean cropland co-occurrence with pronghorn range, EPA also **concludes a No Effect (NE) determination for pronghorn from soybean uses**

Critical Habitat Determinations

In addition to the species-specific effects determinations, EFED also conducted a critical habitat modification analysis consistent with the Overview Document as discussed earlier in this refined assessment. The critical habitat modification analysis is based on an assessment of how dicamba DGA salt would affect the U.S. Fish and Wildlife Service or National Marine Fisheries Service (the Services) established principle constituent elements (PCE's) of the designated habitat as well as how direct species effects outcomes would impact critical habitat's present and future utility for promoting the conservation of a particular listed species. The Agency will conclude "modification" of designated critical habitat if the range of designated critical habitat co-occurs with the states subject to the Federal action and one or more of the following conditions exist:

1. The available Services' information indicates that cotton or soybean fields are habitat for the species and there is a "may affect" determination for the species associated with exposure to dicamba DGA salt or its degradate, DCSA, as labeled.

2. The available Services' information indicates that the species uses cotton or soybean fields and one or more effects on taxonomic groups predicted for dicamba DGA salt or its degradate DCSA, on cotton and soybean fields would modify one or more of the designated PCEs.

If neither of the above conditions are met, EPA concludes "no modification."

Results of Analysis

Of the 322 listed species within the states, there are 308 species identified in the effects determinations as not using cotton or soybean fields and 14 species using these fields (**Appendix 3**). Critical habitats have been designated for 122 of the 322 species. One-hundred sixteen (116) species with critical habitat were judged to not use cotton or soybean fields and so the critical habitat determination for these species was "no modification."

The remaining 6 species with critical habitat designations were assumed to use cotton or soybean fields and so the previous listed species effects determinations were consulted to ascertain if any were determined to be at risk for direct adverse effects. None of the species were determined to be at risk for direct adverse effects, so the PCE's listed in the Services' critical habitat designations were consulted to determine if, in light of the screening assessment risk findings, they would be impacted by on-field exposure to dicamba DGA salt. For all but one of these species, the PCE's are not relatable to agricultural fields and so a determination of no modification has been made for these 5 species.

The only remaining species using cotton or soybean fields and with critical habitat PCE's relatable to agricultural fields was the whooping crane, for which agricultural fields were discussed as providing waste grain as a potential food source for migratory cranes. The only way the proposed dicamba DGA salt could affect this PCE is by making grain potentially toxic to the birds. As there is unlikely to be any edible waste grain remaining following cotton harvesting, it is unlikely that the proposed dicamba DGA salt use on cotton could affect this PCE, however the proposed use on soybean could affect this PCE by making waste soybean grain potentially toxic.

The Health Effects Division summarized available soybean grain residues of dicamba in the Human Health Risk Assessment for the Registration Eligibility Decision for Dicamba and Associated Salts (DP317703). Based on the soybean trials results, maximum residues of dicamba were 0.04 ppm in hay, 0.097 ppm in forage, and 8.13 ppm in seed 6-8 days post treatment (MRIDs 43814101 and 44089307). These measured values were used to set the tolerance value of 10 ppm for soybean seeds. The measured residues are not reasonably expected to be at a level raising a concern for direct effects to the whooping crane because the direct effects assessment for this species (presented in the Section 3 Risk Assessment Refined Endangered Species Assessment that assessed risks to endangered species in 16 states (Arkansas, Kansas, Louisiana, Illinois, Indiana, Iowa, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin {DP 416416, 420160, 420159, 420352, 421434, 421723})) did not establish a concern for residues in other dietary items at much **higher** (~ 1 order of magnitude) concentrations than would occur at the maximum measured residues in seed or if residues were present even at the tolerance level of 10.0 ppm. Because this analysis shows no direct effects of dicamba at levels that would be expected in the fields as waste grain, an indirect effect, there is no modification of critical habitat. Similarly, measured DCSA residues in waste soybean grain (0.44 ppm) would be well below the estimated DCSA concentrations in arthropods (42.5 ppm) used in the direct effects assessment for this species (D416516+, pp. 9-10). Therefore, whooping crane critical habitat within the 11 states in this refined assessment would not be modified.

Summary of Determinations for Critical Habitat

The Agency has determined that the proposed labeled use of dicamba DGA salt on cotton and soybeans will not modify designated critical habitat for all 122 species for which such habitats have been designated in AZ, CO, DE, FL, MD, NM, NJ, NY, PA, VA and WV.

A summary of listed species identified as not being on agricultural fields with and without critical habitat designations for the seven states assessed for dicamba DGA salt is provided in **Appendix 3**.

References:

Dunning, JB. 1984. Bodyweights of 686 species of North American birds. Western Bird Banding Association Monograph 1.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

PC Code: **128931**
DP Barcode: **404823**
Date: **March 24, 2016**

MEMORANDUM

SUBJECT: Ecological Risk Assessment for Dicamba DGA Salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA), for the Proposed Post-Emergence New Use on Dicamba-Tolerant Cotton (MON 87701)

TO: Grant Rowland, Risk Manager Reviewer
Kathryn Montague, Product Manager Team 23
Daniel Kenny, Branch Chief
Herbicide Branch
Registration Division (7505P)

FROM: Michael Wagman, Biologist 3/24/16
Elizabeth Donovan, Biologist 3/24/16
William P. Eckel, Ph.D., Senior Science Advisor (For BE) 3-24-16
Amy Blankinship, Senior Science Advisor
Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)

THRU: Mark Corbin, Branch Chief 3-24-16
Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)

The Environmental Fate and Effects Division (EFED) has completed a review of the new use request for the herbicide dicamba [M1691 Herbicide, EPA Reg. No. 524-582 (58.1% diglycolamine salt of dicamba (DGA); PC code 128931)] for post-emergent (in-crop) use on dicamba-tolerant cotton (MON 88701, BOLLGARD II® XTENDFLEX™ cotton). Dicamba is currently registered for use on cotton at application rates similar to those proposed for the new use as a pre-emergent and post-harvest application, not to exceed 2 lbs a.e./A per year. The proposed new use is included on the supplemental label of M1691 herbicide for pre-emergence *and* post-emergence (in-crop) use on MON 88701 dicamba-tolerant cotton; this risk assessment is based on the proposed label dated December, 2015. The primary difference between the proposed new use on MON 88701 cotton and the current registration on cotton is the timing of applications. The proposed new use allows equivalents). EFED determined that fate studies conducted with dicamba acid provide "surrogate data" for the dicamba salts and that toxicity data across the acid and salts could generally be combined. (USEPA, 2005a)

MODE OF ACTION

Dicamba is a benzoic acid herbicide similar in structure and mode of action to phenoxy herbicides. Like the phenoxy herbicides, dicamba mimics auxins, a type of plant hormone and causes abnormal cell growth by affecting cell division. Dicamba acts systemically in plants after it is absorbed through leaves and roots. It is easily transported throughout the plant and accumulates in new leaves.

USE CHARACTERIZATION

Monsanto Company submitted a new use request for the herbicide dicamba [M1691 Herbicide, EPA Reg. No. 524-582 (56.8% diglycolamine salt of dicamba)] for use on dicamba-tolerant cotton (MON 87701). M1691 Herbicide is a water-soluble formulation intended for control and suppression of many broadleaf weeds, woody brush and vines. **Table 2** presents the proposed application rates to the dicamba-tolerant cotton. Rates for dicamba salts are normalized to dicamba acid equivalent per acre (a.e./A).

Table 2. Dicamba DGA Proposed Use Pattern for Dicamba-Tolerant Cotton.

Crop	Maximum Individual Application Rate[3] lbs dicamba a.e./A		Number of Applications	Application instructions and intervals (days)	Max Annual Application Rate in lbs dicamba a.e./A/year		Application Method
Dicamba-tolerant cotton MON 87701	Pre-emergence (pre-plant, at planting, or prior to crop emergence)[2]	1.0	1[4]	Pre-plant, at planting, or prior to crop emergence.	1.0	2.0 total	Restricted to ground sprays only
	Post-emergence[1] (Preharvest)	0.5	4[4]	From emergence to 7 days prior to harvest, minimum 7 days between applications	2.0		

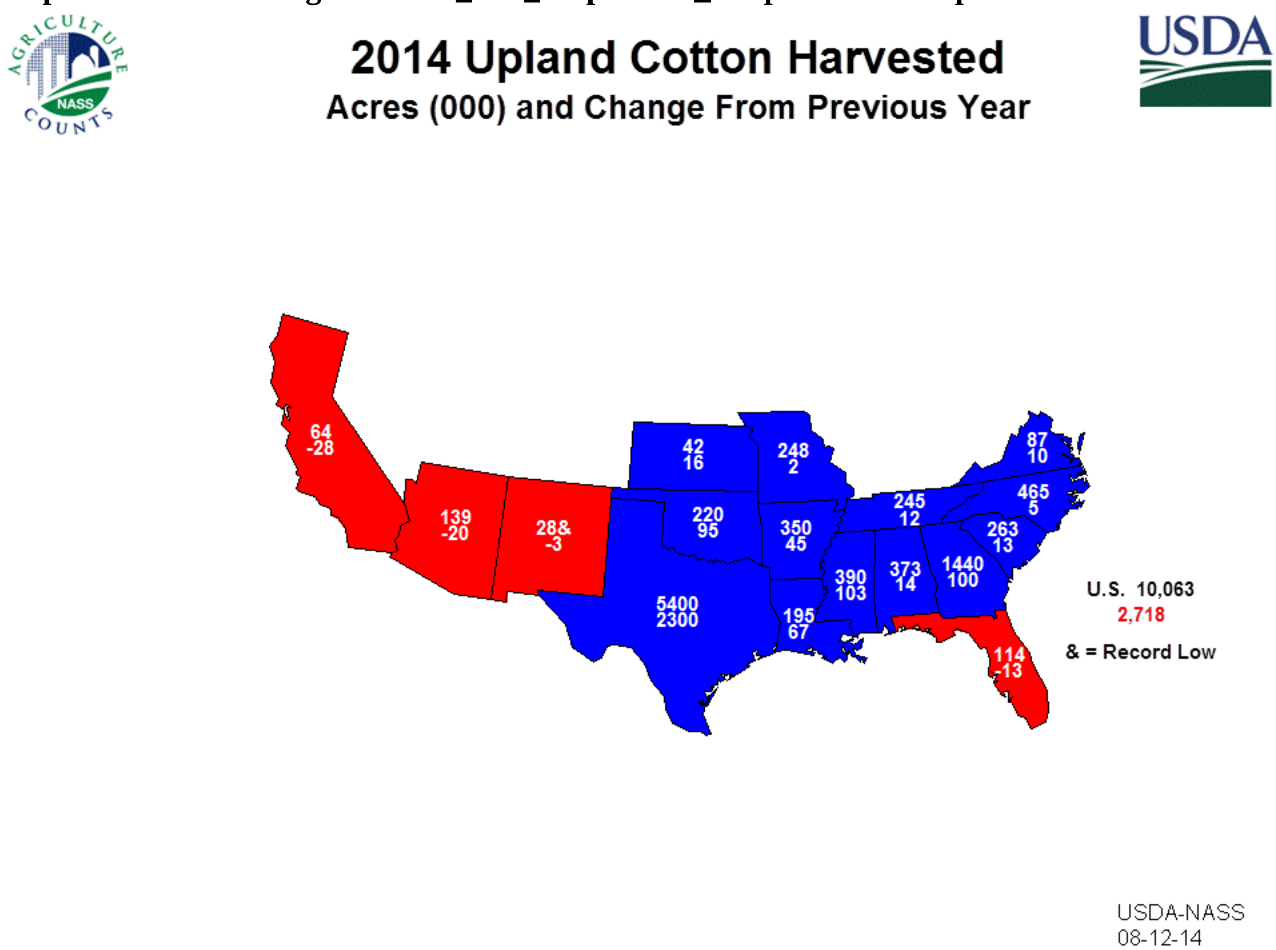
[1]- M1691 Herbicide
[2]- Registered uses
[3]- "Acid equivalent"
[4]- Calculated by dividing the max application rate by the max individual application rate.

It is common for products like this to be tank mixed with other products and pesticide active ingredients, but the label for this use prohibits tank-mixing with other herbicides and only allows tank-mixes with products that have been tested and found not to increase the likekihood of drift/volatility. EFED recommends that additional guideline laboratory plant testing be required if proposed tank mixes include additional active ingredients to account for potential synergistic phytotoxic effects. Testing of such products should include the standard suite of tested species from the already submitted dicamba and other active ingredient's vegetative vigor studies as well as those that the open literature and any other data that may indicate potential for synergistic effects.

According to the proposed label, aerial application of dicamba to dicamba-tolerant cotton is not permitted (*i.e.*, it is restricted to ground applications only).

The proposed dicamba registration is for use on dicamba-tolerant cotton (MON 87701). **Figure 1** shows acres of cotton harvested in 2014 in the U.S., per USDA. It is assumed that the new use of dicamba on dicamba-tolerant cotton would be within this 17-state area. The figure indicates that there were approximately 10 million acres of cotton harvested in 2014. The states shaded in red in the diagram below indicate a decrease in harvested cotton acres from the previous year while blue shading indicates an increase in harvested acres from the previous year.

FIGURE 1. Acres of Cotton Harvested By State in the United States in 2014 (based on information from USDA-NASS)
http://www.nass.usda.gov/Charts_and_Maps/Field_Crops/cotnacm.asp



ENVIRONMENTAL FATE CHACTERIZATION

Dicamba is very soluble (6,100 ppm) and mobile (K_{oc} = 13.4 L/mg o.c.) in the laboratory, and is

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

PC Code: 128931
DP Barcode: 426789
Date: March 24, 2016

MEMORANDUM

SUBJECT: Dicamba DGA: Second Addendum to the Environmental Fate and Ecological Risk Assessment for Dicamba DGA salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA) for the Section 3 New Use on Dicamba-Tolerant Soybean

TO: Grant Rowland, Risk Manager Reviewer
Kathryn Montague, Product Manager 23
Daniel Kenny, Branch Chief
Herbicide Branch
Registration Division (7505P)

FROM: Michael Wagman, Biologist 3/24/16
Amy Blankinship, Senior Science Advisor
William P. Eckel, PhD., Senior Science Advisor (For BE) 3-24-16
Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)

THRU: Mark Corbin, Branch Chief 3-24-16
Monica Wait, RAPL Monica Wait 3/24/16
Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)

This is an addendum to the Environmental Fate and Effects Division's (EFED) ecological risk assessment for dicamba DGA salt (Clarity® formulation or M1691, EPA Reg No. 524-582) and its degradate, 3,6-dichlorosalicyclic acid (DCSA), for the proposed new use on dicamba-tolerant soybean. It includes analysis of information that was not previously included in the original soybean new use risk assessment (USEPA, 2011, DP 378444). Since the original risk assessment was conducted, the registrant, Monsanto, has submitted:

1) field trial data that impacts EFED's previous analysis of spray drift,
2) data for incidents and inquiries from the use of dicamba DGA salt,

3) laboratory volatility data for dicamba DGA and DMA salt formulations, and
4) terrestrial plant reproductive effects data.

Additionally, this addendum includes analysis conducted by EFED regarding:

5) the implication of new mammalian chronic effects endpoints for parent dicamba and the metabolite DCSA from the Health Effects Division (HED; USEPA 2016, D378366+),
6) a revised T-REX run using refined estimates of foliar dissipation half-lives and variable application rates,
7) the potential for effects to beneficial terrestrial invertebrates,
8) effects posed by runoff, and
9) potential synergistic interactions with glyphosate.

1. Spray Drift and Buffers (Field Trial Data)

In the first addendum to the EFED Section 3 risk assessment for dicamba DGA salt for use on dicamba-tolerant soybeans (D404138, 5/20/14), EFED estimated that the distance from the application site to where no effects are observed to sensitive plants (based on the NOAEC for the most sensitive apical endpoint of plant height for the most sensitive tested species, non-dicamba tolerant soybeans) ranged from 100 to 175 feet (for the 0.5 lb a.e./A tolerant-soybean post-emergent application rate). However, based on a weight of evidence approach and refined AgDrift modeling for coarser droplet spectra (coarse to ultra-course droplet distribution), EFED refined this distance to 124 feet (rounded up to 125 feet) or to 107 feet if label language were to restrict the droplet size to solely extra-coarse and ultra-coarse droplet sizes).

EFED further refined this analysis after receiving more information including a spray drift deposition study submitted by BASF (MRID 49067704). In light of this information, Monsanto proposed that the spray drift buffer distance be reduced to 70 feet for M1691 Herbicide using the TTI 11004 nozzle at application spray pressures ≤ 63 psi. EFED's subsequent analysis for submitted field trial data (presented below), however, indicates that a larger buffer may be necessary in order to limit potential effects to sensitive plants to the sprayed field. **Linking this data to our previous modeling efforts and employing a weight of evidence approach, EFED proposes that the label should be modified to include language to maintain a 100 to 110 foot downwind buffer when applying at the 0.5 lbs a.e./A application rate. The July 2015 amended labels subsequently submitted by Monsanto included a 110 foot buffer and 220 foot buffer for 0.5 and 1.0 lbs a.e./A application rates, respectively.**

Field Trial Data Discussion

Subsequent to EPA's 5/20/2014 addendum, Monsanto presented information from academic field research that had not previously been submitted to the Agency for review. EPA requested data from these field trials and Monsanto submitted the raw data (MRID 49612701 pg. 51) on 4/13/2015 along with a response document (MRID 49570501 pg. 1). Monsanto's response document included an analysis that the 70 foot buffer would be protective of the no-effect distance for sensitive plants (the "no-effect" distance is based on the most sensitive NOAEC for the apical endpoint of plant height for the most sensitive tested species, non-dicamba tolerant soybeans) for 7 of the 9 submitted trials and a proposed rationale for why it may not have been protective in the remaining 2 trials. The response document also included Monsanto's statement that the field trial data are not suitable for use in EPA's regulatory decision-making process, but overall support the then-proposed 70 foot buffer.

While EFED agrees that the field trial data are generally not suitable for regulatory decision-making, we believe that they demonstrate additional uncertainty that the previously proposed 70 foot buffer would be sufficient to prevent potential effects to non-target plants that are off the field. In an attempt to conduct a quantitative evaluation of the field trial data, EFED considered that the data could reasonably represent a dose-response effect, with higher treatment doses expected to be closer to the application site. In this context, the distances farthest from the application site were considered to be likely to have little to no dicamba residues and loosely were considered controls. EFED then considered that plant heights and yield (similar to our apical endpoints of plant height and biomass from the standard vegetative vigor plant ecotoxicity tests) at the closer distances (*i.e.* treatment groups) could be compared to those of plants at the "control" distances using statistical hypothesis tests, similar to our standard statistical methodologies for data evaluation of ecotoxicity tests. In an effort to streamline the data analysis process, EFED used standard t-tests in Excel to conduct the analysis.

This statistical analysis indicated that a majority (5/9) of the field trials provided evidence that the proposed 70 foot buffer would not be sufficient to keep any effects to sensitive plants' apical endpoints contained to the field. Three of the nine trial sites had significant inhibitions compared to the "control groups" at distances greater than EFED's refined buffer of 125 feet, though EFED notes Monsanto's rationale for the greater distances in two of those sites (Monmouth, IL and Haubstadt, IN) might be due to applications not conforming to the currently proposed label restrictions for M-1691 Herbicide. The maximum "no effect" spray drift distance that EFED determined for the remaining site (Rower, AR) was 147.5 feet.

Since these field trials involved no true controls and residue analysis was not conducted to confirm the lack of residues in the farthest plants, the magnitude of an effect seen between "treatment" groups and true control plants might be higher than what this analysis indicates. These field trials were all conducted at the 0.5 lbs a.e./A (maximum single post-emergent application rate) and all were conducted using the TTI11004 nozzle in accordance with the label directions. The operating pressures varied across the sites from 30 psi to 50 psi (other than for the Haubstadt trial site, for which nozzle pressures were not recorded), which is less than the labeled maximum operating pressure of 63 psi. Higher operating pressures than used in these field trials (but within the proposed labeled directions for use), may result in an increased proportion of finer spray droplets and consequently result in effects at distances greater than observed in these field trials. The specific process, results and conclusions that EFED used in evaluating Monsanto's submitted field trial data and relating it as an additional line of evidence in determining an appropriate buffer that would result in no adverse effects to EPA's apical endpoints for terrestrial plants (the most sensitive taxa to the herbicide dicamba), is discussed immediately below.

Details of EFED's Process to Determine a "No Effect" Spray Drift Buffer from the Available Field Trial (MRID 49612701 pg. 51) Data:

Transects (at each site or for each swath, where multiple swaths were tested) were combined to determine mean soybean (non dicamba-tolerant) plant heights (14 & 28 DAT) or yields at set distances. The farthest two distances for which plant height or yield data were recorded were considered "controls," though there are considerable uncertainties to this approach. Specifically, no true controls were used, no residue analysis was conducted to confirm that these plants were not exposed to dicamba (or other chemical) residues, data were only recorded when there was at least 5% visual response (which could have been due to a number of factors including potential dicamba residues) and for many of these "controls" the height/yield endpoint may not have been recorded in all transects, resulting in a lower sample size (n) for controls and therefore a decreased power in the statistical t-test.

All analyses were conducted in MS Excel. Means for each distance towards the sprayer were compared to the "control" means to determine the percent inhibition at each distance. T-tests (1-tailed, assumed equal variances unless an F-test {p<0.05} showed unequal variances) were conducted to compare the endpoints of the treatment distances to the controls. Since these were field tests and had considerable uncertainties surrounding the controls, EFED considered significance at the (α=) 0.1 level which increases the conservatism of the analysis. The buffer for a "no effect" distance at each site was considered the first distance greater than the maximum distance which had a significant decrease compared to the control group. For example, at the Brooksville, MS site, the furthest distance which exhibited a significant decrease (p<0.10) in height at 28 DAT compared to the control group was 86.25 feet. The next highest distance at which soybean heights were measured was 96.25 feet (not significant, p=0.19), which therefore was considered the "no effect" distance buffer for that site.

Results of the Analysis of the Field Trial (MRID 49612701) Data

After reviewing this field trial data, EFED made the following findings. Of the nine field trials discussed above, a majority (five) provide evidence that a 70 foot buffer may not be sufficient, and four provide evidence that a 100 foot buffer may not be sufficient (**Table 1**). With a buffer distance of 125 feet for a 0.5 lb a.e./A application rate, 3 sites (33%) would provide evidence that a larger buffer might be necessary, with Monsanto stating (and subsequently providing information) that two of these (Monmouth and Haubstadt) may not have followed the currently proposed label by either using a different formulation or applying when wind speed was lower than required by the current proposed draft label.

Table 1. Distance (in feet) from Site of Application to a "No Effect" *

Site	Height (ft.) 14 DAT	Height (ft.) 28 DAT	Yield (ft.)	Comments
Brooksville, MS	46.25	96.25	66.25	
Rower, AR	7.9	20.6	**248.7****	14 DAT "controls" had only n=2. 28 DAT controls had n=3. ***Note**, for yield, after the 12% inhibition at 223.4', no treatment group was significantly (p<0.1) inhibited compared to controls (inhibitions ranged from 1.03—23.75% after this). The higher inhibitions were not significant due to the use of the nonequal variance t-test, but would have been had we assumed equal variances). Therefore, using best professional judgment informed by the data and t-test results , EFED has reduced the no effect distance for this endpoint to **147.5'**, after which all inhibitions at shorter distances were > 10% (other than only 1.1% inhibition at 7.9 feet).
W. Lafeyette, IN	66.25	26.25	No Data	14 DAT "controls" had n=3, 28 DAT "controls" had n=2
Scott, MS	26.25	26.25	66.25	
Jackson, TN	16.25	16.25	16.25	Yield "controls" had n=4.
Kirkwood, IL	116.25	116.25	16.25	
Monmouth, IL Swath 1	74.2	137.8	0	14 DAT controls had n=4, 28 DAT controls had n=3, Yield controls had n=3
Monmouth, IL Swath 2	53	95.4	254.4	14 DAT controls had n=3, 28 DAT controls had n=2, Yield controls had n=2
Haubstadt, IN Swath 1	30	80	10	Swath 1 only took measurements to a maximum of 100 feet. 14 DAT controls had n=5, 28 DAT controls had n=3
Haubstadt, IN Swath 2	40	80	150	14 DAT controls had n=3, 28 DAT controls had n=3, Yield controls had n=2
Gilbert, IA Swath 1	N/A	N/A	N/A	This swath was not evaluated as no field measurements were taken past 30 feet.
Gilbert, IA Swath 2	35	15	5	14 & 28 DAT and Yield controls had n=4. For yield, no distance had lower mean yield compared to controls.

*** Distance based on Plant Height after 14 and 28 days after treatment (DAT) and Yield ($\alpha = 0.10$). No effect" indicates no reduction in plant height or biomass relative to controls. In controls, the sample size (n) is considered 6 (or 10 for Brooksville, MS and Scott, MS trial sites) unless otherwise noted in the comments section where fewer controls may affect the power of the test.**

Weight of Evidence Conclusions

After reviewing the field trial data submitted to EPA, EFED finds that there is considerable uncertainty around the use of a 70 foot in-field buffer with the intent to keep any adverse effects (related to our apical endpoints of plant height and biomass) on the field, as the majority of the sites appeared to have effects on plant height at distances past this. Though the quality of this field trial data is not suitable for the purpose of establishing an appropriate buffer distance (especially as the lack of true controls may mean that the magnitude of effects to true control plants could be greater than indicated here), EFED believes this data provides a line of evidence that an in-field buffer greater than 70 feet is warranted to ensure protection of listed species, such as that determined in our previous risk assessment addendum (D404138, 5/20/14) which used a refined modeling approach extracting out the coarse, extra-coarse and ultra-coarse droplet spectra to determine an average 124 foot buffer (rounded up to 125 feet) or **solely the extra-coarse and ultra-coarse droplet spectra for an estimated average distance of 107 feet (rounded up to 110 feet) for a 0.5 lbs a.e./A application.** The draft label only supports the use of one nozzle (Tee Jet® TTI11004) with a maximum operating pressure of 63 psi which restricts droplet spectra to ultra-coarse and extremely coarse.

Using a weight of evidence approach (covering the refined modeling analysis conducted in the previous risk assessment addendum, the spray drift deposition study submitted by BASF (MRID 49067704) and the submitted field trial data discussed here), EFED concluded that **the label should be modified to include language to maintain a 100 to 110 foot downwind buffer when applying at the 0.5 lbs a.e./A application rate and with the described nozzles restricting the droplet spectra extra-coarse and ultra-coarse. The July 2015 amended labels subsequently submitted by Monsanto included a 110 foot buffer and 220 foot buffer for 0.5 and 1.0 lbs a.e./A application rates, respectively.**

Further data that may help refine this estimate would be field trial data with actual controls (and/or residue analysis to indicate a lack of dicamba or other herbicide treatments), larger control sample sizes and transect replication, field measurements provided regardless of whether plant visual response (damage) was observed or not, a greater number of swaths at each trial site (reflective of typical practices in soybean agriculture) and using the maximum labeled nozzle operating pressure.

2. Incidents

Incident Reports Submitted by Monsanto (2012-2014)

Monsanto provided information for 73 incidents involving the M1691 formulation from 2012 to 2014. In their response document (MRID 49612701 pg. 68), Monsanto notes that observations were solely qualitative visual estimates and that no measurements of apical endpoints such as plant height or yield were taken. Monsanto further noted that the incidents related either to seed production activities or to activities performed as part of the product development process relating to product stewardship. They stated that current proposed label requirements were not in place in 2012, that all of these incidents either did not follow all of the current draft label requirements (including tank mixtures with additional pesticide active ingredients such as glyphosate, nozzle type, wind-speed, wind direction, spray volume, etc.) or they were a result of other factors (*e.g.* burndown application, heavy rainfall, equipment contamination, spillage, etc.) and that the percentage of incidents as a function of the number of applications made has decreased in each subsequent year since 2012.

EFED has conducted an initial review of these incidents and generally agrees with Monsanto that the incidents resulted from applications not in accordance with currently proposed draft label language or were attributed to other (non-dicamba) factors. However, four incidents (Inquiries 19, 20, 24, and 30) from 2014 lacked sufficient information in the report (such as on tank mixture, application rates, nozzles, wind direction & speed, equipment speed, buffer distance, spray volume & pressure or boom height) to determine whether their occurrence followed applications that were in accordance with the current proposed draft label requirements. Although, as Monsanto notes, much of this data arises from seed production activities or activities related to the product development process and were not generated for purposes of risk assessment, EFED does not discount that they could be suggestive of potential incidents in the field and they could provide useful information to that end.

EFED also acknowledges that the incident observations are qualitative measures of visual injury (*e.g.* leaf spotting or curling). Nonetheless, the information presented in these incidents may be useful if future labels incorporate changes such as potential tank mixes with additional active ingredients or additional nozzle types, since some of these incidents include information on tank mixes and nozzle types which would be relevant in the case where those changes are made to the label.

Missouri and Arkansas Case files

The Missouri Department of Agriculture (MDA) has submitted information for incidents occurring from 2013 to 2015 and the Arkansas Plant Board (APB) has submitted information for incidents occurring in 2015, regarding observations of dicamba-type damage to non-tolerant plants following either preemergence or postemergence applications to dicamba-tolerant (DT) soybeans or cotton. Similar to the incidents reported by Monsanto for 2012-2014, all of the incidents were qualitative visual estimates and no observations or measurements of apical endpoints such as plant height or yield were taken.

2013-2014 Incidents

MDA has notified EPA of two incidents following potential dicamba applications that occurred in 2013 and 2014. In 2013, dicamba-type damage was observed in a non-DT soybean field (MO Case File #81513M00701, EIIS Incident report number I026579-001). The only dicamba application in the area was reported to be a Clarity herbicide application on DT-soybeans 2,800 feet from the damaged field. The air temperature and humidity at the time of dicamba application were reported to be 82^0F and 55%, respectively. Dicamba residues were found in one foliage sample taken from the affected field at 42 µg/kg. In the other two samples, dicamba residues were not detected (limit of detection not reported, but a limit of quantification of 3.8

µg/kg). The case file submitted to the agency did not originally determine the cause of the dicamba damage. In subsequent communication with the Agency (2015 letter from D. Slade, MDA to Grant Rowland, EPA), MDA concluded that the application of Clarity herbicide was not transported to the affected site by spray drift, but by later volatilization.

In their response document (MRID 49612701 pg. 1, submitted prior to MDA's December, 2015 letter), Monsanto noted that it has reviewed the complete incident report from the Missouri Department of Agriculture (MRID 49612701 pg. 75). Monsanto stated that the report indicated that 1) there was potential the crop visual injury response was observed prior to the dicamba application, 2) MO Department of Agriculture did not come to a definitive conclusion on the primary cause of the incident and 3) other plausible explanations were not investigated, such as temperature inversion, alternative sources of dicamba, such as leaking equipment or damage from other herbicides. Therefore, Monsanto concluded that the incident did not provide evidence that the observed plant response was a result of exposure to vapor drift of dicamba residues. Monsanto also included this incident in their description of the 73 incidents from 2012-2014 discussed previously in this section and noted that this incident would not comply with the current proposed label requirements, as M1691 was tank mixed with glyphosate and other adjuvants.

EPA notes that MDA has now completed their investigation of this incident, measured residues indicating the presence of dicamba residues on the affected site, concluded that dicamba volatilization rather than drift was the likely cause of the damage and initiated enforcement action against the applicator for allowing the product to move from the target field. The climatic conditions at the time of application were slightly outside of the range of conditions from the available laboratory studies on dicamba DGA salt's volatility. Given that effects to EPA's apical endpoints of plant height and biomass were not measured, there is uncertainty whether this incident indicates that volatilization following dicamba applications may result in impacts to apical endpoints beyond the proposed spray drift buffer of 110 feet for a 0.5 lb/A application. However, based on the available data, a volatilization buffer equal to the spray drift buffers, and extending in all directions from the treated field, is justified. The current proposed labels only apply a unidirectional spray drift buffer in the direction wind is blowing. Further discussion of volatility is provided in **Section 3** below.

MDA also notified EPA of an incident in 2014 (MO Case File #072214MO0701) where "dicamba type" damage was observed on a non-DT cotton field where the only nearby dicamba application would have been a Clarity herbicide application on DT-soybeans, 2.2 miles from the affected site. As with the other incidents, the provided information only indicated observations of visual injury and not effects to apical endpoints such as plant height and yield. Residue samples taken from the affected site failed to detect dicamba residues. It is unclear whether this incident was also included in Monsanto's submitted information on the 73 incidents from 2012-2014 (discussed previously in this section). With the current information available, and due to the lack of identified dicamba residues, it is uncertain whether the damage observed in the incident was a result of dicamba applications or due to some other unidentified cause. If the observed damage was caused by dicamba, then given the large distance between the affected site and the nearest known dicamba application, it would likely have been a result of volatilization, rather than spray drift.

2015 Incidents

Missouri and Arkansas recently submitted to EPA a total of 15 incidents in 2015 that might be attributed to dicamba use (12 in Arkansas and 3 in Missouri). The information indicates that these incidents resulted from 6 separate instances of applications of dicamba, with 8 of the incidents (7 from Arkansas and 1 from Missouri) being a result of a single instance of a post-emergent dicamba application to DT-cotton of Strut herbicide (active ingredient Dicamba DGA), tank-mixed with glyphosate and applied at two times the labeled rate for the proposed Clarity/M1691 post-emergent use. Visual observations of plant damage extended to 1320 feet (1/4 mile) from the application site. The remaining incidents were pre-emergent applications of dicamba or at this time remain uncertain as to whether any application of dicamba was made.

Conclusions Regarding Incident Information 2012—2015

For the purposes of the registration of dicamba on dicamba-tolerant soybean, the incident information available at this time indicates that the vast majority of incidents occurred following applications that were not made according to the current draft label requirements. Label requirements that were not followed included tank mixes with other active ingredients and adjuvants, higher application rates, and applications with different nozzle types and climatic conditions than permitted according to the draft label. Quantitative measurements of yield loss or decreased plant height were not made in any of the incident descriptions. Currently, EPA has no methodology for relating qualitative estimates of visual damage to quantitative effects to apical endpoints.

Most of these incidents were likely caused by spray drift off the field following the application. The only incident where volatility of dicamba residues has been concluded to be the cause of the incident by a regulatory agency (MDA for MO Case File #81513M00701, EIIS Incident report number I026579-001) was an incident where the application was also made as a tank mix of glyphosate, additional adjuvants, and dicamba. However, EFED believes that this difference from the draft label is unlikely to have impacted the ability of dicamba residues to volatilize since the different active ingredients and adjuvants are generally presumed to have disassociated from each other by the time any volatilization would occur. Rather, the volatilization may have been more likely impacted by the climatic conditions (temperature and humidity) in the days following the application which fall outside of the range of submitted laboratory data conditions. Additional discussion and characterization of volatility is provided in the next section.

3. Volatility

After reviewing data submitted to EPA relating to the volatility of dicamba, EFED had concerns regarding the volatility of dicamba, and possible post-application, vapor-phase off-site transport that might damage non-target plants. Monsanto responded to these concerns with a submission (MRID 49612701 pg. 143) that acknowledged the long-recognized volatility of dicamba and described measurements of the volatilization in the different formulations.

The information submitted to address EFED's concerns was helpful, but the submission did not include enough detail to verify the measurements in the studies. EFED determined that it would be useful also to perform volatility experiments under varied conditions of temperature and relative humidity, because these factors seem to be important in field conditions.

The registrant has agreed to place directional, in-field spray drift buffers of 110 feet for the 0.5 lb a.e./A application rate and 220 feet for the 1.0 lb a.e./A application rate. One open literature study (Egan and Mortensen 2012), directly addresses the potential for volatilization and transport of dicamba, and the potential for damage to the most sensitive tested species, soybean (non dicamba-tolerant). Based on damage assessments of non dicamba-tolerant soybean plants placed near treated fields after spray drift from a 0.5 lb/A DGA salt application had dissipated, the authors estimated the exposure at distance by correlation to known dose-damage correlations. They estimated that the 95% upper bound vapor exposure would drop below the soybean NOAEC at approximately a distance of 25 meters (82 feet). This is well within the 110-foot spray drift buffer proposed for the 0.5-lb/A rate. Thus, based on at least one study, this buffer distance should be adequate to protect against volatilization exposure for EPA's apical endpoints of plant height and yield. However, consideration should be made as to whether this buffer distance should be applied on all sides of the field, rather than the currently labeled uni-directional buffer according to wind direction.

The incident described by MDA in the previous section (MO Case File #81513M00701, EIIS Incident report number I026579-001) provides limited information that the proposed 110 to 220-foot spray drift buffers would not be adequate to limit off-site plant damage due to post-application volatilization. However, since the incident only qualitatively describes visual damage, while the buffer is intended to be protective of apical endpoints of height and yield, this remains an uncertainty, and would benefit from additional field trial data under varied conditions of temperature and relative humidity. Based on the best available data for dicamba residues from vapor drift compared to effects on apical endpoints, EFED believes that a 110 foot buffer for the 0.5 lb ae/A application rate should be adequate to protect against effects on non-target plants from volatilization of dicamba residues. This analysis similarly suggests that a 220-foot buffer is protective for the 1.0 lb ae/A application rate, though this may be overly conservative since the 1.0 lb ae/A rate is for pre-emergent applications that may be applied under conditions less conducive to vapor drift (*e.g.* cooler temperatures)

4. Potential Effects on Terrestrial Plant Reproduction

EFED is aware of published literature associating dicamba applications with effects to soybean progeny. These studies indicate potential effects to the quantity and reproductive quality of future soybean generations following dicamba applications that would not be observed in the guideline vegetative vigor and seedling emergence studies EFED typically uses to assess risk to terrestrial plants. Therefore, these data raise a potential concern that has not been directly addressed in OPP assessments, should these effects occur at lower exposures than the effects observed in the guideline terrestrial plant studies. In meetings and email correspondence in January/February, 2015, OPP asked whether Monsanto was aware of this issue. Monsanto requested the references that OPP was aware of, so that they could independently review them.

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A Meta-Analysis on the Effects of 2,4-D and Dicamba Drift on Soybean and Cotton

J. Franklin Egan, Kathryn M. Barlow, and David A. Mortensen*

Commercial introduction of cultivars of soybean and cotton genetically modified with resistance to the synthetic auxin herbicides dicamba and 2,4-D will allow these compounds to be used with greater flexibility but may expose susceptible soybean and cotton cultivars to nontarget herbicide drift. From past experience, it is well known that soybean and cotton are both highly sensitive to low-dose exposures of dicamba and 2,4-D. In this study, a meta-analysis approach was used to synthesize data from over seven decades of simulated drift experiments in which investigators treated soybean and cotton with low doses of dicamba and 2,4-D and measured the resulting yields. These data were used to produce global dose–response curves for each crop and herbicide, with crop yield plotted against herbicide dose. The meta-analysis showed that soybean is more susceptible to dicamba in the flowering stage and relatively tolerant to 2,4-D at all growth stages. Conversely, cotton is tolerant to dicamba but extremely sensitive to 2,4-D, especially in the vegetative and preflowering squaring stages. Both crops are highly variable in their responses to synthetic auxin herbicide exposure, with soil moisture and air temperature at the time of exposure identified as key factors. Visual injury symptoms, especially during vegetative stages, are not predictive of final yield loss. Global dose–response curves generated by this meta-analysis can inform guidelines for herbicide applications and provide producers and agricultural professionals with a benchmark of the mean and range of crop yield loss that can be expected from drift or other nontarget exposures to 2,4-D or dicamba.

Nomenclature: 2,4-D (2,4-dichlorophenoxyacetic acid); dicamba (3,6-dichloro-2-methoxy benzoic acid); glyphosate; soybean, *Glycine max* (L.) Merr.; cotton, *Gossypium hirsutum* L.
Key words: Dose–response curves, *Glycine max*, *Gossypium hirsutum*, herbicide drift, herbicide-resistant crops, meta-analysis.

Biotechnology companies are currently developing cultivars of corn, soybean, and cotton engineered with transgenic resistance to the synthetic-auxin herbicides 2,4-D and dicamba (Behrens et al. 2007; Waltz 2010; Wright et al. 2010). Dow AgroSciences is currently developing corn (*Zea mays* L.), soybean, and cotton cultivars resistant to 2,4-D, and the Monsanto Company in collaboration with BASF is developing cultivars of soybean and cotton resistant to dicamba. Dicamba and 2,4-D have been widely used for decades for selective weed control of broadleaf plants in grass and cereal crops (Monaco et al. 2002). However, the new resistant cultivars will enable these compounds to be applied in new crops, at new times during the growing season (including more POST applications), and over greatly expanded areas, potentially leading to increased problems with nontarget drift onto susceptible crops, including non-transgenic soybean and cotton (Mortensen et al. 2012).

Soon after the commercialization of 2,4-D in the 1940s and dicamba in the 1960s, recurrent problems of nontarget exposures to susceptible crops began to occur (Staten 1946; Wax et al. 1969). Continuing to the present, the Association of American Pesticide Control Officers (AAPCO) consistently ranks 2,4-D and dicamba at or near the top of herbicide active ingredients implicated in crop injury complaints (AAPCO 2005), and several states and municipalities have special restrictions on the use of these compounds to help prevent crop injury problems (Louisiana Department of Agriculture and Forestry 2011; Texas Department of Agriculture 2012). This high frequency of crop injury complaints relative to other herbicides is likely due to several factors specific to 2,4-D and dicamba. First, synthetic auxin herbicides can cause distinctive injury symptoms on many broadleaf crops, including twisting or epinasty of stems and cupping of leaves, such that even slight injury can be readily recognized by growers and land owners.

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Secondly, several broadleaf crops, including soybean and cotton, are very sensitive to these compounds, creating the potential for noticeable injury and potential yield loss following very low-dose exposures. Finally, several commercially available 2,4-D and dicamba products include moderately volatile herbicide formulations that can travel away from treated fields as vapor drift (Behrens and Lueschen 1979; Egan and Mortensen 2012; Grover et al. 1972).

In regions where synthetic auxin–resistant cultivars of cotton and soybean will be widely adopted, the use of 2,4-D and dicamba is likely to increase substantially over the next 5 to 10 years (Mortensen et al. 2012). These trends could increase the risk of injury and yield loss to susceptible crops, including non-transgenic soybean and cotton through a variety of mechanisms. First, as with all herbicides, 2,4-D and dicamba can move as particle drift from ground or aerial application equipment, especially when herbicides are applied under windy conditions or when spray equipment not designed to reduce particle drift is used (Wang and Rautman 2008). Secondly, as previously mentioned, if volatile formulations are used under high temperature conditions, 2,4-D and dicamba can move from treated fields onto susceptible fields. Third, 2,4-D and dicamba residues are known to be difficult to clean from equipment, and small amounts of these compounds could be inadvertently applied to susceptible crops if the same equipment was recently used to treat dicamba or 2,4-D resistant or tolerant crops (Boerboom 2004). Finally, in regions where 2,4-D or dicamba are used frequently and over large areas, such as the wheat (*Triticum aestivum* L.) cropping systems of the Canadian prairie provinces, herbicide residues can accumulate in the atmosphere and return to fields as precipitation at concentrations high enough to cause injury to susceptible crops (Hill et al. 2002; Tuduri et al. 2006).

Anticipating potential problems, Dow AgroSciences, BASF, and Monsanto Company have been working with growers, agricultural service providers, and university extension to develop stewardship practices for these technologies. These practices will include the development of extremely low volatility formulations of 2,4-D and dicamba, adjuvants and herbicide premixes that reduce particle drift, and advanced spray nozzle designs that limit fine spray droplets (Dow AgroSciences 2011a, 2011b; Thomas et al. 2012). However, due to the combination of exposure routes, it remains likely that nontarget drift to susceptible crops will be a significant concern for growers, especially during the early phase of commercialization of these technologies. Because soybean and cotton are among the crop species most susceptible to these compounds, the risk of crop injury and potential yield loss will perhaps be greatest to soybean and cotton growers who choose not to use resistant cultivars in regions where the transgenic cultivars and associated herbicide programs are widely adopted by neighboring farmers. Importantly, because 2,4-D resistant crops will be susceptible to dicamba (and vice versa), crop injury risk could extend to growers that choose 2,4-D resistant cultivars in regions where dicamba resistant cultivars are more popular (and vice versa). In order to prepare for crop injury incidents and potential yield loss, growers and agricultural professionals may find it helpful to be equipped with a detailed understanding of the likely responses of cotton and soybean to low-dose exposures of 2,4-D and dicamba.

Fortunately, the dose–response patterns of crop injury and yield loss in cotton and soybean to 2,4-D and dicamba have already been extensively researched. Beginning in the 1950s with cotton, weed scientists in the United States and internationally began conducting simulated drift bioassay experiments to determine the herbicide doses that are likely to cause noticeable injury symptoms and the doses that are likely to cause significant yield loss. In this paper, a meta-analysis approach was used to review and synthesize the results from many of these previously published simulated drift experiments. After conducting an exhaustive search of the literature, an extensive dataset on the response of cotton and soybean to simulated drift was used to answer four key interrelated questions. First, what is the dose–response pattern of herbicide exposure dose (in g ha^{-1}) and crop yield? Second, how is the dose–response pattern affected by crop phenology at the time of exposure? Third, what other environmental and agronomic factors may influence crop dose–response? Finally, how do visual injury symptoms in soybean and cotton from 2,4-D and dicamba exposure correlate with yield loss?

Material and Methods

Literature Search. Literature searches were performed using the CAB Direct database in October and November of 2011 (Centre for Agriculture and Biosciences International 2012). CAB Direct spe-cializes in agricultural research and indexes many materials that would be missed by more general literature search engines such as Web of Science or Google Scholar, including conference proceedings and research reports from state agricultural experiment stations. The search was defined using the terms (cotton or soy*) and (2,4-D or dicamba) and (drift or injury or sensitiv* or toleran*). Several pilot searches using broader search terms such as "yield" were also conducted, but it was found that the more specific search terms captured all of the relevant material. Studies were classified as relevant based on the following criteria:

1. The study must have employed a replicated field experiment in which cotton or soybean was exposed to at least one dose of dicamba or 2,4-D and a water or untreated control. Studies in which dicamba or 2,4-D was applied in mixtures with other herbicidal compounds were not included. Herbicide treatment doses must have been applied as a foliar spray and presented in grams per hectare or in units that could be converted into grams per hectare doses.
2. Because 2,4-D or dicamba applications could affect crop performance by influencing weed–crop competition in addition to having direct phytotoxic effects, studies were selected that eliminated background weed communities with appropriate herbicides or cultivation. In some instances, studies selected as relevant did not specifically describe background weed control practices, but based on their methodologies and stated objectives, it could be safely inferred that weeds were effectively managed.
3. Studies must have collected and reported data on grain yield for soybean and seed cotton or lint yield for cotton. Data on visual injury ratings from studies that reported yield were also included.

CAB Direct indexes international publications and proceedings, but it reports all abstracts in English. For studies not published in English, the abstract, tables, and figures were reviewed to determine if the paper was likely to fit the criteria defined above. For these likely papers, international colleagues at The Pennsylvania State University were recruited to assist with interpretation. One study originally published in Portuguese (Constantin et al. 2007) was fully translated.

For each study that was selected as relevant, the bibliography was also reviewed and a backward search was then performed using the same criteria.

Data Coding. For each relevant study, information was gathered from tables and figures, and the available data on the dose of dicamba or 2,4-D exposure in each treatment and the resulting yield and visual injury (most commonly reported on a 0 to 100 scale) was coded. Yield response and injury data were coded as the mean value for a given dose as presented in each study's tables or figures. All yield data were normalized as the proportion of the respective control dose. Data presented in figures were extracted using the software program EnGauge (M. Mitchell 2007, Engauge Digitizing Software).

The crop growth stage at the time of exposure was coded by grouping the phenology described by the authors into either vegetative, flowering, or pod formation stages for soybean and into vegetative, preflower squaring (flower buds are first forming), early flowering, or mature flowering/boll formation stages for cotton. Several studies did not clearly describe the crop's growth stage, but instead listed the crop's height or number of leaves or nodes at the time of herbicide treatment. In these cases, the crop's phenology was inferred based on other studies in the dataset that reported height, leaf number, and phenology from similar locations and using similar cultivars or using information presented in Barker et al. (1985), Oosterhuis and Jernstedt (1999), and Pedersen (2004).

Many studies quantified yield response under several unique experimental conditions, for instance crop response may have been measured to both dicamba and 2,4-D or to different 2,4-D doses at multiple phenological timings of herbicide exposure. Within a study, a unique set of experimental conditions was classified as a unique "sequence." For instance Kelley et al. (2005) present data from an experiment in which soybean were exposed to dicamba at the V3, V7, and R2 growth stages, providing three unique dose–response sequences. They also report on a separate experiment in which soybean were exposed to dicamba at the V3 and V7 stages in two different years, with each year reported separately. In total, this reference therefore contributed seven different dicamba dose–response sequences to the dataset. Because each sequence contained either one or two different doses of dicamba exposure, Kelley et al. (2005) contributed 10 data points to this meta-analysis for dicamba and soybean.

Statistical Analysis. The dose–response patterns of dicamba or 2,4-D simulated drift on soybean and cotton yield were analyzed by fitting log-logistic curves to the data using the nls package in R (R Core Team 2011; Ritz and Streibig 2008). Because the untreated control yields were defined as 1.0, and because label rates of dicamba and 2,4-D are obviously fatal to both cotton and soybean, a two-parameter log-logistic function with the upper asymptote set to 1 and the lower asymptote set to zero was used (Equation 1).

$$\text{Yield}_i = 1/(1 + \exp\{b \times [\log(\text{Dose}_i) - \log(e)]\}) + e_i,\ e_i \sim N(0, \sigma^2) \qquad [1]$$

where e is the dose that causes a 50% yield loss and b is the slope of the curve at the e-parameter dose (Ritz and Streibig 2005). Because all yields were normalized as a proportion of the control, the untreated control yields were removed from the data set before fitting the models to avoid heteroscedasticity and nonnormality of residuals. To quantify the influence of crop phenology at the time of exposure, separate models were fitted for each combination of crop growth stage and herbicide active ingredient (dicamba or 2,4-D).

For cotton, a fraction of studies reported yield in terms of both raw seed cotton yield and ginned lint yield. To test for any potential interaction of herbicide dose and lint yield as a percentage of seed cotton yield (ginning percentage), the correlation between normalized seed cotton and lint yield was assessed for this subset of studies. Linear regression results indicated a near perfect correlation (0.999) with a slope nearly equal to one (0.993), implying no influence of either herbicide on ginning percentage. Studies that reported seed cotton or lint cotton yields were therefore pooled into the same dose–response curves.

In this meta-analysis, the effect size or response statistic is the ratio of treatment yield to control yield. Meta-analysis requires estimating the within-study variation in effect size as a measure of the precision with which the authors of a given study were able to estimate an effect or response in their experiments (Cooper et al. 2009). Within-study variation statistics can then be used to weight more precise studies more heavily than less precise studies in the meta-analysis. For response ratio data, Hedges et al. (1999) suggested that the variance of response ratios provides a good estimate of within-study variation. Hedges et al. (1999) further suggested that the natural logarithm of response ratios and its associated variance are better effect size statistics because they weight changes in control and treatment response equally and tend to be more normally distributed than the untransformed response ratio statistic. But, for log-logistic models, log-transforming the y-axis and using log response ratios would lose the biological meaning of the model's asymptotes, because log(1) equals zero and log(0) equals negative infinity. Therefore the more interpretable untransformed response ratio statistic and its associated variance were used in this analysis, as defined in Equation 2 and in Appendix A of Hedges et al. (1999).

$$\text{Variance of Response Ratio} = (X_T/X_C)^2 \times \left[\left(SE_T^2/n_T X_T^2\right) + \left(SE_C^2/n_C X_C^2\right)\right] \qquad [2]$$

where, X_T is the mean from a treatment group, SE_T is the standard error of that mean, n_T is the sample size of the treatment group, and X_C, SE_C, and n_C are the analogous quantities for the control group.

For several studies in this meta-analysis, the values for the standard error of the mean that were needed to calculate Equation 2 were either reported directly or could be back-calculated using summary statistics reported by the authors, such as the Fisher's Least Significant Difference (Kuehl 2000; Zar 1998). Using reported values or back-calculations, Equation 2 could be calculated for four studies and 35 sequences for soybean and eight studies and 57 sequences for cotton. Unfortunately, in many cases authors did not report sufficient information to calculate standard errors of the means but instead only reported sample size or the number of replications. Rather than simply exclude studies that did not report variance statistics from this meta-analysis, the subset of studies for which Equation 2 could be calculated was used to exploit a correlation between within-study variance and sample size. The pattern evident in this correlation was then applied to the entire dataset using the following bootstrap procedure.

For the subset of studies for which Equation 2 could be calculated, the variance of the response ratio statistics were binned into three replicate size classes (three, four or five, and more than six replicates). Figure 1 indicates a clear pattern of decreasing variation with increasing sample size, as is expected from basic statistical theory (Crawley 2005). Next, the subset for which Equation 2 could be calculated was separated by crop and the variance statistics were then randomly sampled with replacement from each replicate size class. These randomly sampled values were then assigned to data points with corresponding sampling sizes in the full dataset. A two-parameter log-logistic model was then fit using the randomly

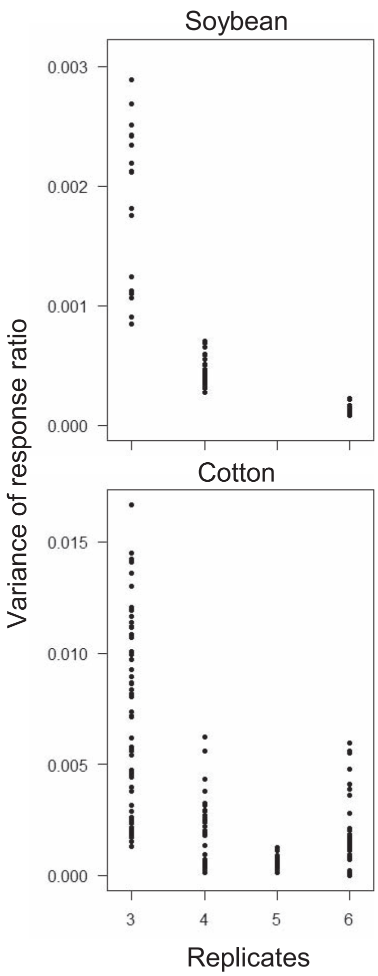

Figure 1. Relationship between the number of replications and the variance of the response ratio of yields in treated to untreated control plots. Data are compiled from previously published experiments that measured the effect of simulated dicamba and 2,4-D drift on yields of soybean and cotton.

assigned variance statistics as weights (Equation 3; Ritz and Streibig 2008).

$$\text{Yield}_i = 1/(1 + \exp\{b \times [\log(\text{Dose}_i) - \log(e)]\}) + e_i/\sqrt{w_i},\ e_i \sim N(0,\sigma^2) \quad [3]$$

where w_i is the variance of response ratio randomly assigned based on sample size. For each combination of crop growth stage and herbicide, this procedure was repeated 100 times, and results are reported as the median from this bootstrapped distribution of fitted models. R code for this procedure is available from the authors upon request.

Synthetic auxin herbicides are widely reported to cause stimulatory effects to crops at low doses, also known as hormesis. To test for the possibility of hormesis, the log-logistic model was compared to the Cedergreen hormesis model (Cedergreen et al. 2005) using Akaike's Information Criterion (Burnham and Anderson 2002) and *t*-tests of the Cedergreen f parameter (Cedergreen et al. 2005). For all combinations of crop growth stage and herbicide, the log-logistic model showed a substantially better fit to the data, indicating no evidence for a hormesis effect (data not presented).

To assess potential yield loss from herbicide drift, the predicted yield loss for each crop growth stage and herbicide combination was calculated at doses of 0.56, 5.6, and 56 g ha^{-1}. Assuming a field application rate of 560 g ha^{-1}, these doses roughly correspond to a vapor drift exposure in an adjacent field (Egan and Mortensen 2012; Grover et al. 1972), a particle drift exposure in an adjacent field (Brown et al. 2004; Carlsen et al. 2006; de Jong et al. 2008; United States Environmental Protection Agency 2006; Wang and Rautman 2008), or a serious application error, respectively. For each bootstrapped model fit, 95% confidence intervals were calculated around these yield loss estimates using the delta method in the R package car (Fox and Weiseberg 2010). The median intervals from the bootstrapped distribution of 100 models are reported.

For the subset of studies that reported data on both yield and visual injury for the same treatments, simple linear models of the relationship between yield and injury rating were calculated. Multiple linear (including a quadratic term for injury) and logistic regression models for the relationship between yield and injury were also calculated. For soybean, logistic models provided a better fit, but for cotton, linear, multiple linear, and logistic models all produced similar fits. However, for both soybean and cotton, all models led to a similar interpretation of the results, therefore results will only be presented for the simple linear models. Injury ratings 12 to 16 d after treatment (DAT) were used because this was the most commonly reported injury rating interval. For one cotton 2,4-D study (Goodman et al. 1955), injury 3 DAT was used, since this was the closest reported interval.

Mitigating Environmental and Agronomic Factors. Many authors conducted experiments over multiple years and sites or crossed herbicide dose with another potentially important factor such as herbicide formulation or crop genetics. Because data on these potentially important factors was not collected or reported consistently across the family of studies in the dataset, their significance could not be statistically assessed. Instead each author's explanation and discussion of potentially important factors that could influence dose–response patterns was carefully examined, and these findings are presented here as a narrative review.

Table 1. Summary of the number of studies, dose–response sequences, and unique mean data points excluding controls (*n*). collected from a literature search of studies that measured the yield response of soybean and cotton to simulated dicamba and 2,4-D drift at different crop growth stages.

Crop, herbicide	Growth stage	Studies	Sequences	*n*	Citations
Soybean, dicamba	Vegetative	6	20	61	Al-Khatib and Peterson 1999; Andersen et al. 2004; Auch and Arnold 1978; Johnson et al. 2012; Kelley et al. 2005; Wax et al. 1969
	Flowering	4	22	80	Auch and Arnold 1978; Kelley et al. 2005; Wax et al. 1969; Weidenhamer et al. 1989
	Pod	2	9	26	Auch and Arnold 1978; Weidenhamer et al. 1989
Soybean, 2,4-D	Vegetative	9	25	81	Andersen et al. 2004; Johnson et al. 2012; Kelley et al. 2005; Merotto et al. 1999; Robinson et al. 2013; Slife 1956; Smith 1965; Wax et al. 1969; Wiese and Martin 1963
	Flowering	5	13	35	Kelley et al. 2005; Slife 1956; Smith 1965; Wax et al. 1969; Wiese and Martin 1963
Cotton, dicamba	Vegetative	6	11	42	Everitt and Keeling 2009; Johnson et al. 2012; Lanini 1999; Marple et al. 2007, 2008; Smith and Wiese 1972
	Squaring	4	6	18	Everitt and Keeling 2009; Hamilton and Arle 1979; Marple et al. 2008; Smith 1972
	Flowering	5	7	19	Everitt and Keeling 2009; Hamilton and Arle 1979; Lanini 1999; Marple et al. 2008; Smith 1972
Cotton, 2,4-D	Vegetative	15	44	117	Behrens et al. 1955; Carns and Goodman 1956; Charles et al. 2007; Epps 1953; Everitt and Keeling 2009; Goodman et al. 1955; Goodman 1953; Johnson et al. 2012; Lanini 2000; Marple et al. 2007, 2008; Miller et al. 1963; Smith 1972; Watson 1955; Wiese and Martin 1963
	Squaring	11	28	76	Arle 1954; Banks and Schroeder 2002; Behrens et al. 1955; Carns and Goodman 1956; Charles et al. 2007; Everitt and Keeling 2009; Goodman et al. 1955; Marple et al. 2008; Miller et al. 1963; Smith 1972; Wiese and Martin 1963
	Flowering	12	34	75	Arle 1954; Behrens et al. 1955; Carns and Goodman 1956; Charles et al. 2007; Constantin et al. 2007; Everitt and Keeling 2009; Goodman et al. 1955; Lanini 1999; Marple et al. 2008; Miller et al. 1963; Smith 1972; Watson et al. 1955
	Boll	10	33	64	Arle 1954; Behrens et al. 1955; Carns and Goodman 1956; Charles et al. 2007; Constantin et al. 2007; Epps 1953; Goodman et al. 1955; Kittock and Arle 1977; Kittock et al. 1973; Miller et al. 1963

Results and Discussion

Search Results. The literature searches retrieved 512 unique studies, of which 23 were classified as relevant. Backward searches produced an additional five relevant studies. Two recent papers (Johnson et al. 2012; Robinson et al. 2013) that were published after the conclusion of the literature review were added. In total, the dataset includes 30 studies and a total number of 252 sequences. The number of studies, sequences, and unique dose-response data points (excluding control points) for each crop growth stage and herbicide combination is summarized in Table 1.

Dose–Response Curves. *Soybean*. Soybean was far more sensitive to dicamba than to 2,4-D and was more sensitive to both herbicides in the flowering growth stage than in other stages (Tables 2 and 3, Figure 2). During the flowering stage, the dose–response curves indicate a mean yield loss of ~1.0% from dicamba vapor drift exposures (0.56 g ha^{-1}) and 8.7% from dicamba particle drift exposures (5.6 g ha^{-1}). Yield losses were basically zero for 0.56 g ha^{-1} exposures during vegetative and pod formation stages, and slight (3.7%) for 5.6 g ha^{-1} exposures during vegetative stages. For serious misapplication exposures (56.1 g ha^{-1}), all soybean growth stages showed drastic yield losses of 48% or greater.

The dose–response curves suggest that soybean has surprisingly high tolerance to 2,4-D. During both vegetative and flowering stages, soybean showed essentially no yield loss to vapor or particle drift level exposures and only slight yield losses (1.5 to 3.0%) to even serious misapplication exposures. There were no data available for pod formation stage exposures to 2,4-D.

These data suggest that yield loss from synthetic auxin drift to soybean is more likely to be an issue when soybean is exposed to dicamba during the flowering stage. Because soybean may be planted

Table 2. Summary of log-logistic dose–response models for the effects of dicamba and 2,4-D exposure on yields of soybean and cotton at different crop growth stages. Values reflect the median parameter estimates across 100 bootstrapped model fits.[a]

Crop, herbicide	Growth stage	e^{b}	b^{c}	r^{2d}
Soybean, dicamba	Vegetative	58	1.40	0.60
	Flowering	60	0.99	0.58
	Pod	51	3.41	0.84
Soybean, 2,4-D	Vegetative	651	1.42	0.47
	Flowering	461	2.00	0.63
Cotton, dicamba	Vegetative	6730	0.46	0.22
	Squaring	109	1.46	0.63
	Flowering	92	1.15	0.60
Cotton, 2,4-D	Vegetative	61	0.33	0.28
	Squaring	15	0.70	0.48
	Flowering	72	0.63	0.44
	Boll	328	0.66	0.38

[a] Yield = 1/(1 + exp{b × [log(Dose) − log(e)]}), with yield normalized as proportion of untreated control.
[b] The *e* parameter is the herbicide dose causing a 50% loss in yield (in units of g ha^{-1}).
[c] The *b* parameter describes the slope of the curve at the *e* parameter dose.
[d] The r^2 statistic is the squared Pearson correlation of predicted and observed values for each curve.

over a long period (6 wk or longer, particularly in the southern United States), such a scenario is more likely to occur if POST applications of dicamba herbicides become more common in soybean production areas. The new resistant traits will make later POST applications of dicamba in soybean and corn a weed control option that may be very attractive to growers where glyphosate-resistant and tolerant weeds are a serious problem. Thus, it will remain important to use appropriate application techniques and stewardship practices when using dicamba near susceptible soybean and other crops.

Cotton. Cotton was far more sensitive to 2,4-D than dicamba (Tables 2 and 3, Figure 2), and for 2,4-D, cotton showed the most sensitivity relative to all of the other three crop–herbicide combinations. Cotton was most sensitive to dicamba during early flowering, with slight losses (1.3%) predicted from vapor drift exposures and slightly more substantial (3.9%) losses predicted from particle drift exposures. During vegetative and squaring stages, basically no yield loss is predicted from vapor drift exposures of dicamba, but more substantial yield losses are possible from particle drift exposures. Serious misapplication doses (56.1 g ha^{-1}) indicated yield losses of 10% or more from all growth stages (no data were available for dicamba exposures in the boll stage).

As has been widely appreciated nearly since the discovery of 2,4-D, cotton is extremely sensitive to this herbicide, especially during vegetative and preflowering squaring stages. During vegetative stages, average yield losses of more than 19% are predicted just from vapor drift exposures, and 32% and 49% yield losses are possible from particle drift or misapplication exposures. During preflowering squaring stages, cotton showed less sensitivity to vapor drift exposures (9% yield loss), but greater sensitivity to particle drift (33% loss) and misapplication (71% loss) doses. Cotton sensitivity declines somewhat as plants mature and begin

Table 3. Predicted yield of soybean or cotton exposed to three doses of dicamba or 2,4-D at different crop growth stages. Yield is presented as the proportion of untreated or control yield, and doses represent probable exposures to vapor drift, particle drift, or herbicide misapplication onto a sensitive crop adjacent to a field treated at 560 g ha^{-1} with either herbicide. Predictions are derived from log-logistic dose–response[a] curves fit to data from previously published simulated drift experiments. Values reflect the median estimates across 100 bootstrapped model fits with 95% confidence intervals displayed in parentheses.

		Yield		
Crop, herbicide	Growth stage	0.56 g ha^{-1} vapor drift	5.6 g ha^{-1} particle drift	56 g ha^{-1} misapplication
Soybean, dicamba	Vegetative	0.998 (0.995, 1.002)	0.963 (0.920, 1.006)	0.511 (0.414, 0.607)
	Flowering	0.990 (0.979, 1.002)	0.913 (0.873, 0.953)	0.515 (0.455, 0.576)
	Pod	1.000 (1.000, 1.000)	0.999 (0.998, 1.001)	0.414 (0.278, 0.550)
Soybean, 2,4-D	Vegetative	1.000 (1.000, 1.000)	0.999 (0.997, 1.001)	0.970 (0.945, 0.996)
	Flowering	1.000 (1.000, 1.000)	1.000 (0.999, 1.000)	0.985 (0.965, 1.006)
Cotton, dicamba	Vegetative	0.989 (0.966, 1.015)	0.969 (0.923, 1.008)	0.904 (0.858, 0.955)
	Squaring	1.000 (0.998, 1.001)	0.986 (0.959, 1.012)	0.727 (0.624, 0.823)
	Flowering	0.997 (0.989, 1.005)	0.961 (0.903, 1.017)	0.642 (0.520, 0.751)
Cotton, 2,4-D	Vegetative	0.805 (0.712, 0.900)	0.680 (0.601, 0.756)	0.509 (0.412, 0.605)
	Squaring	0.912 (0.844, 0.978)	0.670 (0.577, 0.763)	0.293 (0.223, 0.361)
	Flowering	0.956 (0.906, 1.001)	0.835 (0.747, 0.914)	0.545 (0.456, 0.626)
	Boll	0.985 (0.963, 1.005)	0.937 (0.890, 0.983)	0.761 (0.704, 0.817)

[a] Yield = 1/(1 + exp{b × [log(Dose) − log(e)]}).

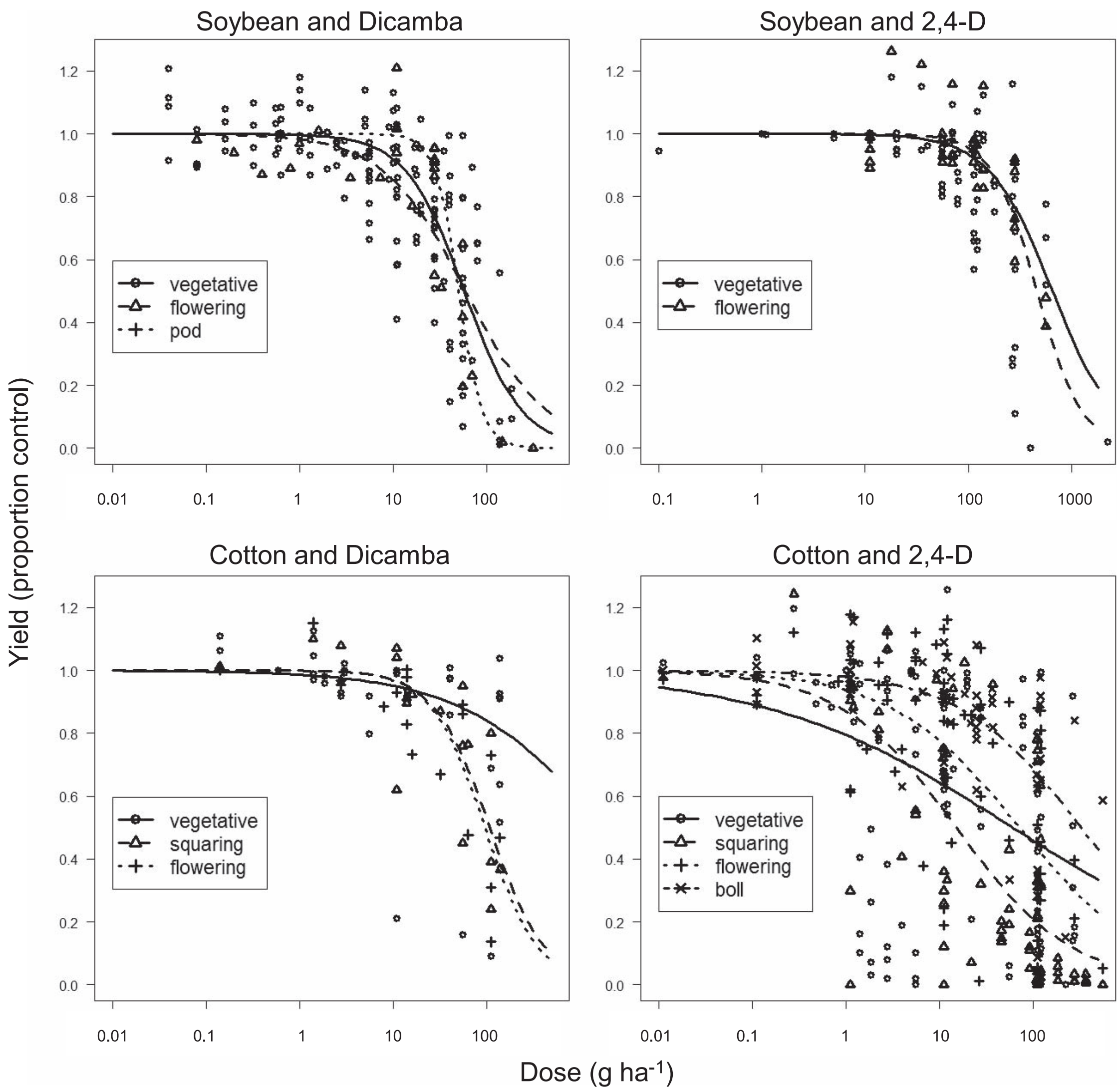

Figure 2. Yield response of soybean and cotton to dicamba or 2,4-D exposure across different crop growth stages. Data are compiled from previously published simulated drift experiments. Dose–response curve lines reflect the log-logistic models defined in Table 2.

developing bolls, but small yield losses are still possible from vapor drift (1.5%) or particle drift exposures (6.3%) during boll stages. Interestingly, cotton was also far more variable in its response to 2,4-D as compared with soybean's response to either herbicide (Table 3, Figure 2). This variability may reflect inherent variation in the uptake and biochemical response of cotton to 2,4-D, or it may reflect the fact that this dataset contains a greater number of studies, locations, and environmental conditions for cotton and 2,4-D as compared with the other herbicide–crop combinations in this meta-analysis (Table 1).

These data suggest that yield losses from 2,4-D drift to cotton may be a substantial problem if new resistant crops make postemergence 2,4-D applications common when susceptible cotton is growing nearby. Such a scenario is probable, because in much of the southern United States cotton is planted before soybean. The observed variability in response indicates it will be very difficult to anticipate yield loss following crop injury, but that yield losses could potentially be high. It will be critically important to use low volatility formulations, state-of-the-art application equipment, and perform applications under appropriate environmental conditions. Dicamba may be a safer option than 2,4-D if susceptible cotton is nearby, and it may be more appropriate to avoid synthetic auxins all together and integrate alternative weed management practices instead.

Mitigating Environmental and Agronomic Factors. The studies in this dataset reflect broad heterogeneity with regard to many factors that are well known to influence crop response to herbicides,

Table 4. Summary of environmental and agronomic factors found to influence soybean and cotton sensitivity to yield loss and injury from simulated dicamba or 2,4-D drift.

Crop	Herbicide	Factor	Effect on sensitivity	Citations
Soybean	Dicamba	Crop oil adjuvants in spray solution	Increased	Andersen et al. 2004
	Dicamba, 2,4-D	Dry conditions around exposure	Increased	Andersen et al. 2004; Auch and Arnold 1978; Kelley et al. 2005; Weidenhamer et al. 1989
	Dicamba	Higher temperatures around exposure	Increased	Al-Khatib and Peterson 1999
	Dicamba, 2,4-D	Crop cultivar	Variable	Auch and Arnold 1978; Wax et al 1969; Weidenhamer et al. 1989
	2,4-D	Formulation (ester vs. amine)	Increased	Smith 1965; Weise and Martin 1963
	Dicamba, 2,4-D	"Thickening agent" (Norbak) added to spray solution	No effect	Wax et al. 1969
	Dicamba	Narrower row spacing	Increased	Weidenhamer et al. 1989
	Dicamba	Formulation (DMA vs. Na)	No effect	Weidenhamer et al. 1989
Cotton	2,4-D	Favorable fall weather facilitates recovery	Decreased	Arle 1954; Behrens 1955; Carns and Goodman 1956; Miller et al. 1963
	2,4-D	Higher carrier volume in simulated drift studies	Decreased	Banks and Schroeder 2002
	Dicamba, 2,4-D	Dry conditions around exposure	Increased	Behrens 1955; Carns and Goodman 1956; Marple et al. 2007; Marple et al. 2008
	Dicamba, 2,4-D	Moist conditions around exposure	Increased	Carns and Goodman 1956; Goodman 1953; Marple et al. 2007
	2,4-D	Higher temperatures around exposure	Increased	Kittock and Arle 1953
	2,4-D	Formulation (ester vs. amine)	Increased	Marple et al. 2007; Wiese and Martin 1963
	2,4-D	Soil quality facilitates recovery	Decreased	Miller et al. 1963

including meteorological and edaphic conditions at the time of spraying, crop cultivar and genetics, herbicide formulation, and herbicide carrier volume. Because these factors were generally not balanced in this dataset in a way that permitted a rigorous statistical analysis, the dose–response curves reflect the mean or expected yield loss across this broad heterogeneity. The often substantial variability around these mean curves (Table 3, Figure 2) reflects the combined contributions of these mitigating factors. Nevertheless, many authors explored crop herbicide response over multiple site years or over different experimental conditions and offered some explanations for the variation they observed in crop response. These factors are summarized in Table 4, and a few consistent themes emerge.

First, environmental conditions before, during, and following herbicide exposure play a very important role determining crop sensitivity to herbicide drift. Soil moisture level and air temperature were identified by several authors as key factors. For soybean, dry conditions were consistently associated with increased dicamba and 2,4-D sensitivity relative to conditions with less water stress. For cotton, the effect of soil moisture was more nuanced. For vegetative and squaring stage exposures, several authors noted that sufficient soil moisture and humid conditions led to plants that were actively growing and therefore absorbed and translocated more herbicide, leading to greater sensitivity. However, for late flowering or boll stage exposures, dry conditions were found to affect the floral abscission and boll development process negatively, such that sensitivity to 2,4-D was increased. For vegetative growth stages, Marple et al. (2007) found that dry conditions increased sensitivity, especially with ester formulations of 2,4-D. Marple et al. (2007) suggested this occurred because esters are less polar molecules relative to amine formulations and therefore may be more likely to cross the waxy cuticle of cotton leaves under dry conditions. Several authors also concluded that higher air temperatures increased herbicide uptake and resulted in greater injury and yield loss in both cotton and soybean.

As an indeterminate species, cotton produces squares and flowers continuously until arrested by low night temperatures (~5 C) or by "cut-out," a physiological end of a flowering cycle that depends on latitude, night temperatures, cultivar, and fruit load (Bednarz and Nichols 2005). Consequently, cotton plants injured by 2,4-D or dicamba early in development can often resume flowering and compensate with later fruit set. However, depending on latitude, climate, and weather patterns during a particular season, injured plants may hit the end of the growing season before they are able to fully recover. Several authors (Arle 1954; Behrens 1955; Carns and Goodman 1956; Miller et al. 1963) documented that in seasons with delayed frosts and extended growing seasons, yield losses from 2,4-D exposures during vegetative, preflowering squaring, and flowering stages were substantially reduced from losses observed during shorter growing seasons.

Cultivars and crop genetics are also likely key factors, but the effect of crop cultivar on sensitivity was only well explored for soybean. Weidenhamer et al. (1989) found that for flowering stage exposures to dicamba, a determinate soybean cultivar that ceases vegetative growth at the onset of flowering was less sensitive than an indeterminate cultivar. Wax et al. (1969) also commented that indeterminate cultivars were likely to be more sensitive to dicamba during flowering stages than determinate cultivars, but that determinate cultivars may be more sensitive during vegetative stages. Auch and Arnold (1978) observed variation for dicamba sensitivity across cultivars, but did not find that any cultivars were especially tolerant. Several authors working with cotton discussed the possibility of selecting cotton cultivars with increased tolerance to 2,4-D (Charles et al. 2007; Marple et al. 2008), but none compared different cultivars statistically.

Particularly with 2,4-D, the specific active ingredient and formulation of the herbicide was also identified as an important factor. Both cotton and soybean were consistently shown to be more sensitive to esters vs. amine simulated drift of 2,4-D. As part of their resistant crop cultivar technology packages, Dow AgroSciences and Monsanto/BASF are both promoting new low volatility formulations (Dow AgroSciences 2011a; Thomas et al. 2012). Dow is promoting Cholex-D, a quaternary choline salt of 2,4-D, and BASF (the primary manufacturer of dicamba and business partner of Monsanto) has developed EnGenia, an aminopropyl methylamine salt of dicamba. However, there are currently no published data on how susceptible crops will respond to these formulations. Only one study in this dataset systematically compared dicamba formulations (Weidenhamer et al. 1989) and found no difference in soybean susceptibility to dimethlylamine vs. sodium salt dicamba treatments. Depending on the nature of the adjuvant, incorporating adjuvants were observed to either increase or have no effect on the sensitivity of soybean to simulated dicamba or 2,4-D drift (Table 4).

Herbicide carrier volume was addressed in one study as an important factor influencing crop sensitivity (Banks and Schroeder 2002) and has also been highlighted by authors conducting simulated drift studies on other crop–herbicide combinations (Ellis et al. 2002; Roider et al. 2008). In simulated drift studies, experimenters typically hold the carrier volume constant while reducing the grams per hectare dose, thus effectively also reducing the grams per liter herbicide concentration of the treatment. When carrier volume is reduced across a dose gradient, such that grams per liter concentrations are kept constant, the crop response is often more severe. Most of the studies in this dataset used field application rate carrier volumes ($\sim$187 L ha^{-1}). Thus, the dose–response curves presented here may in fact underestimate the real yield losses that can occur from particle or vapor drift exposures.

Considering the range of factors affecting crop sensitivity to herbicide drift, it is important to consider that these dose–response curves are not meant to predict yield loss in any specific field event. Instead, global dose–response curves can provide a statistically valid estimate of the mean and variation of potential yield loss and also highlight the important differences between crops, herbicides, and growth stages at the time of exposure.

Visual Injury and Yield Loss. From the subset of studies that measured both yield loss and visual injury symptoms $\sim$14 DAT, linear models with visual injury symptoms generally overestimated yield loss (Figure 3). For both cotton and soybean, data was mainly available only for vegetative growth stages, so it remains unclear how well the patterns documented in Figure 3 translate across growth stages, or to other circumstances beyond this sample of studies.

For soybean, injury seemed to correlate fairly closely with yield loss for both dicamba ($r^2 = 0.62$) and 2,4-D ($r^2 = 0.61$). However, for both herbicides the slope was somewhat above unity, indicating that a linear model for injury will overestimate yield loss and that plants exposed in vegetative stages can generally grow out of low to moderate injury symptoms. For cotton and dicamba, injury appeared to greatly overestimate yield loss, indicating that plants may sometimes express severe synthetic auxin injury symptoms but will generally grow out of the injury without suffering

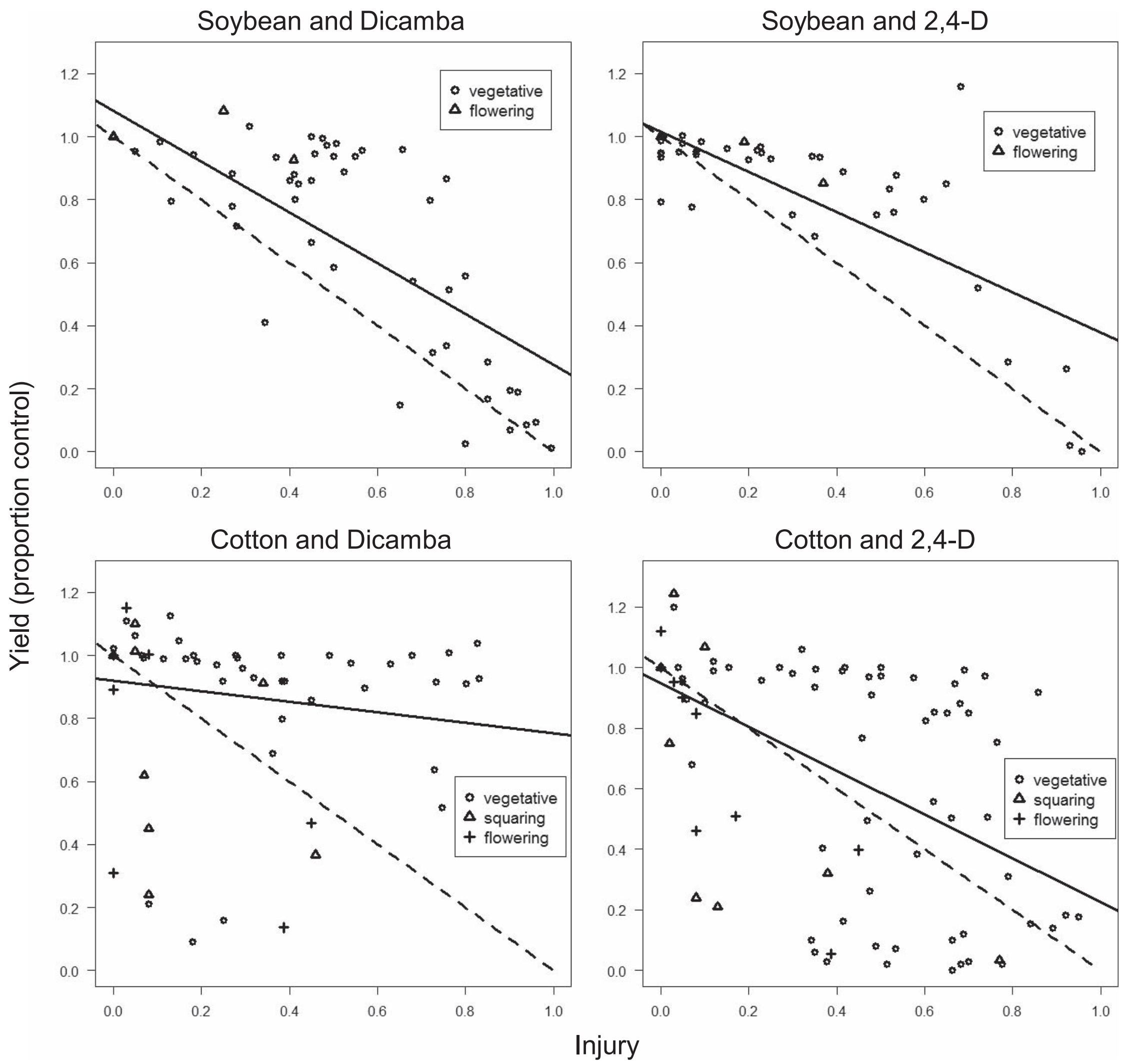

Figure 3. Correlations between yields of soybean and cotton and visual ratings of dicamba or 2,4-D 14 d after treatment. Data are compiled from previously published experiments evaluating the response of soybean or cotton to simulated dicamba and 2,4-D drift. Solid lines reflect the fit of linear regression models and dashed lines reflect an idealized 1:1 exact correlation. Symbols reflect different crop growth stages, but regressions for each crop and herbicide were calculated with all growth stages combined. Regression equations for each panel are as follows: soybean and dicamba, Yield = 1.08 − 0.81 × Injury ($r^2 = 0.62$); soybean and 2,4-D, Yield = 1.02 − 0.64 × Injury ($r^2 = 0.61$); cotton and dicamba, Yield = 0.92 − 0.17 × Injury ($r^2 = 0.01$); cotton and 2,4-D, Yield = 0.95 − 0.72 × Injury ($r^2 = 0.32$).

substantial yield loss. For cotton and 2,4-D the slope of the trend line was close to unity, indicating broad agreement between injury symptoms and yield loss. However, there was large variation around the trend line indicating that in specific circumstances, injury can only serve as a rough predictor of final yield loss.

Utility of Meta-Analysis. Meta-analysis has long been a standard research tool in the biomedical sciences (Cooper et al. 2009) but has been seldom applied in weed science research. For instance, a recent Web of Science search on the topic "meta-analysis" in the journals *Weed Science* and *Weed Technology* retrieved only three publications (Rinella and Sheley 2005; Schutte et al. 2010; Wagner et al. 2007). Statistical approaches for the meta-analysis of dose–response curves continue to be developed (Bagnardi et al. 2004; Paul et al. 2006; Ritz and Streibig 2008; Thompson and Higgins 2002). As has been demonstrated in this paper, these approaches can readily be adapted to the synthesis of data on dose–response patterns of crops and weeds to herbicides. As weed science continues to address changes in weed communities across cropping systems, the evolution of new resistant weed species, and the commercialization of new herbicide-resistance traits, carefully synthesized information describing the sensitivity of crops to herbicide active ingredients will continue to be useful. During the time work was progressing on this meta-analysis, other research groups interested in synthetic auxin drift from herbicide-resistant cropping systems published results from new field experiments assessing the response of cotton and soybean to simulated dicamba and 2,4-D drift (Johnson et al. 2012; Robinson et al. 2013). While these studies added several valuable data points to this meta-analysis, the multiple site-year experiments described in these papers were no doubt very costly and time-consuming to conduct, and on their own, they provide an understanding of cotton and soybean sensitivity to herbicide drift that is limited to their site and experimental conditions. When an opportunity arises to use existing chemistries in new contexts, meta-analysis approaches can provide a supplement to new experiments and can be a powerful and cost-effective approach towards understanding the dose–response patterns of weeds and crops.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C., 20460

OFFICE OF
CHEMICAL SAFETY AND
POLLUTION PREVENTION

PC Code: **128931**
DP Barcode: **D378444**

MEMORANDUM

DATE: March 8, 2011

SUBJECT: Ecological Risk Assessment for Dicamba and its Degradate, 3,6-dichlorosalicylic acid (DCSA), for the Proposed New Use on Dicamba-Tolerant Soybean (MON 87708).

TO: Michael Walsh, Risk Manager Reviewer
Kathryn Montague, Risk Manager, RM 23
Registration Division (7505P)

FROM: Iwona L. Maher, Chemist, ERB6
Michael Wagman, Biologist, ERB6
Environmental Fate and Effects Division (7507P)

THROUGH: Mark Corbin, Branch Chief, ERB6
Environmental Fate and Effects Division (7507P)

The Environmental Fate and Effects Division (EFED) has completed a review of the new use request for the herbicide dicamba [M1691 Herbicide, EPA Reg. No. 524-582 (56.8% diglycolamine salt of dicamba (DGA); PC code 128931)] for use on dicamba-tolerant soybeans (MON 87708). Dicamba is currently registered for use on soybeans at applications rates similar to those proposed for the new use. The use of dicamba on soybeans was assessed by the Environmental Fate and Effects Division (EFED) in 2005 (USEPA, 2005, D317696). The primary difference between the proposed new use on soybeans and the previous soybean use assessed is the timing of the applications. The current registration for dicamba use on soybeans is limited to pre-emergence applications; however, for the proposed new use on dicamba-tolerant soybeans, dicamba could be applied pre-emergence and/or post-emergence. Therefore, an abbreviated ecological risk assessment is provided. Details on the fate and transport properties and effects data for dicamba can be found in the attached assessments.

Based on the proposed maximum application rates, there is a potential for direct adverse effects to listed and non-listed birds (acute exposure), listed and non-listed mammals (chronic exposure), listed vascular aquatic plants, and listed and non-listed terrestrial dicots from the proposed new use. This assessment uses new submitted information on the toxicity of diglycolamine salt of dicamba (DGA) to terrestrial plants. Although for monocots toxicity of the DGA salt formuation is decreased compared to TGAI dicamba acid, the vegetative vigor data indicate that toxicity in the DGA salt formulation is enhanced for dicots. It is unclear if the enhanced toxicity to dicots is due to synergistic effects with surfactants and adjuvants in the formulation used (Clarity Herbicide, EPA Reg No. 7969-137, 56.8% DGA salt) or due to the DGA salt itself. The study with TGAI dicamba acid did not use surfactants or adjuvants. Although levels of concern were not exceeded for listed and non-listed species of monocots, exceedances for monocots would occur if toxicity data for dicamba acid was used in place of the data for the DGA salt. Risks to aquatic animals from chronic exposure to dicamba could not be assessed at this time because of a lack of data; therefore, since risk to these taxa cannot be precluded, it is assumed.

At this time, no federally-listed taxa can be excluded from the potential for direct and/or indirect effects from the proposed new use of dicamba, since there is a potential for indirect effects to taxa that might rely on plants, birds, aquatic animals, and/or mammals for some stage of their life-cycle. A complete co-occurrence analysis could not be completed for listed species at this time, since the specific use site associated with the proposed new use of dicamba (dicamba-tolerant soybeans) is not available for analysis in LOCATES. Therefore, without further refinement, no species currently listed as federally threatened or endangered can be excluded from the potential for adverse effects from the proposed new use of dicamba. Details regarding the environmental fate, ecological effects and ecological risks associated with the proposed new uses of dicamba are discussed in the sections that follow.

The following studies are identified as data gaps for dicamba and should be required to address the uncertainties described in this assessment:

850.1400	Chronic freshwater fish toxicity (TGAI)
850.1300	Chronic freshwater invertebrate toxicity (TGAI)
850.1400	Chronic estuarine/marine fish toxicity (TGAI)
850.1350	Chronic estuarine/marine invertebrate toxicity(TGAI)
850.2200	Avian acute oral toxicity (with a passerine species)
850.4250	Terrestrial plant toxicity (Tier II vegetative vigor, with lettuce using TEP)
850.5400	Green algae toxicity (TGAI)

Bridging data were submitted indicating that the dicamba salts will be rapidly converted to the free acid of dicamba (MRID 43288001). Additionally, effects data provided indicate equatoxicity of the acid and salts (based on acid equivalents). EFED determined that fate studies conducted with dicamba acid provide "surrogate data" for the dicamba salts and that toxicity data across the acid and salts could generally be combined.

Although the risks, based on standard risk assessment methods used by the Environmental Fate and Effects Division (EFED), are not expected to differ from the previous assessment done for dicamba use on soybeans (because the rates are similar to those already assessed), there is potential for other ecological concerns that would not normally be captured using our standard risk assessment methods. These concerns are related to a potential increase in usage of dicamba products and the proposed changes in the timing of applications. In general, there is also a potential for increased susceptibility of late season plants to direct impact from off-site transport. Thus, unlike previous assessments of dicamba the risk conclusions in this assessment have increased uncertainty.

PROBLEM FORMULATION

Dicamba was first registered in the United States in 1967 and is widely used in agricultural, industrial and residential settings. Dicamba is a benzoic acid herbicide similar in structure and mode of action to phenoxy herbicides. Dicamba controls annual, biennial and perennial broadleaf weeds in crops and grasslands, and it is used to control brush and bracken in pastures. Dicamba is formulated primarily as a salt in an aqueous solution. Supported forms are: dicamba acid (29801), dicamba dimethylamine salt - DMA (29802), dicamba sodium salt (29806), dicamba diglycoamine salt - DGA (128931), dicamba isopropylamine salt (128944) and dicamba potassium salt (129043).

This assessment is for the new use request for the herbicide dicamba [M1691 Herbicide, EPA Reg. No. 524-582 (56.8% diglycolamine salt of dicamba (DGA); PC code 128931)] for use on dicamba-tolerant soybeans (MON 87708). Dicamba is currently registered for use on soybeans at applications rates similar to those proposed for the new use. The primary difference between the proposed new use on soybeans and the one proposed here is the timing of the applications. The current registration for dicamba use on soybeans is limited to pre-emergence applications. For the proposed new use on dicamba-tolerant soybeans, dicamba could be applied pre-emergence and/or post-emergence. Additionally, the maximum current application rate for soybeans (single application and maximum yearly applications) is 2.0 lb acid equivalent (a.e.)/acre. For the proposed new use on dicamba-tolerant soybeans, the maximum single application rate is 1 lb a.e./acre and the maximum yearly application rate is 2.0 lb a.e./acre.

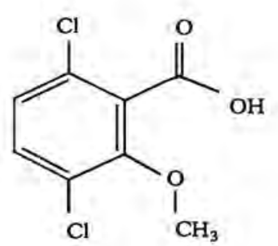
The major degradate under anaerobic conditions is 3,6-dichlorosalicylic acid (DCSA) which is persistent, comprising > 60% of the applied after 365 days of anaerobic incubation in sediment:pond water system (Stable, MRID 43245208). DCSA is formed in aerobic soil under laboratory conditions at the maximum of 17.4 % of the applied parent. Toxicity data for DCSA and mammals have been submitted to the Agency. Based on available data, DCSA appears to be less toxic or equally toxic as the parent (see **Table 1**). Therefore, this assessment will consider the parent and its degradate DCSA (with the assumption that dicamba and DCSA are equatoxic).

TABLE 1. Toxicity Data for the Dicamba Degradate DCSA (no registrant-submitted toxicity data are available for the degradate).

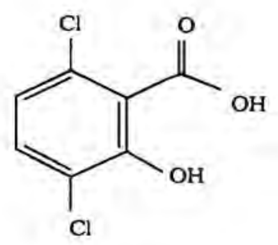
SOURCE	DICAMBA	DCSA
SUBMITTED DATA (Most Sensitive)		
Acute oral Rat (LD_{50}; mg/kg-bw)	2,740	2,641 (MRID 47899504)
Chronic rat (NOAEC; mg/kg-bw)	45 (based on decreased pup weight at 136 mg a.e./kg-bw)	37 (based on decreased parental body weight) (MRID 47899517)
Acute oral Avian (LD_{50}; mg/kg-bw)	188	--
Acute Fish (LC_{50}; mg/L)	28	--
Chronic Fish (NOAEC; mg/L)	--	--
Acute FW Invertebrate (EC_{50}; mg/L)	34.6	--
Chronic FW Invertebrate (NOAEC; mg/L)	--	--
NV Aquatic Plant (EC_{50}; mg/L)	0.061	--
V Aquatic Plant (EC_{50}; mg/L)	>3.25	--
Acute Honeybees (LD_{50}; µg/bee)	>90.65	--
PPDB (EU) WEBSITE[1]		
Acute oral Rat (LD_{50}; mg/kg-bw)	1,581	>1,560
Acute oral Avian (LD_{50}; mg/kg-bw)	1,373	--
Acute Fish (LC_{50}; mg/L)	>100	>100
Chronic Fish (NOAEC; mg/L)	--	--
Acute FW Invertebrate (EC_{50}; mg/L)	>110.7	89
Chronic FW Invertebrate (NOAEC; mg/L)	97	--
NV Aquatic Plant (EC_{50}; mg/L)	1.8	138
V Aquatic Plant (EC_{50}; mg/L)	>3.25	>73
Acute Honeybees (LD_{50}; µg/bee)	>100	--
Acute Earthworms (LC_{50}; mg/kg)	>1,000	>1,000

1 Pesticide Properties Database (PPDB) (http://sitem.herts.ac.uk/aeru/footprint/en/index.htm)

Figure 1: Chemical Structures for Dicamba and its Degradate DCSA



Dicamba
3,6-dichloro-o-anisic acid



DCSA
3,6-dichlorosalicylic acid

BACKGROUND

The most recent regulatory actions for dicamba include the following:

- US EPA/EFED (2010) Reduced Risk Request for Dicamba Herbicide Over-The-Top of Dicamba-Tolerant Soybean. May 27, 2010.

- US EPA. (2010) EFED Response to a FIFRA Section 18 Emergency Exemption for Dicamba co-formulated with 2,4-D (Latigo™) Use on Teff grown for grain, seed, and hay to control broadleaf weeds. Requested by the Oregon Department of Agriculture. May 24, 2010. D377095

- US EPA (2006) Reregistration Eligibility Decision for Dicamba and Dicamba Salts. June 8, 2006.

- US EPA (2005) Drinking water assessment for dicamba on sugarcane. May 31, 2005. D317705

- US EPA (2005) EFED Reregistration Chapter for Dicamba/Dicamba Salts. August 31, 2005. D317696

Consistent with the previous assessments, the environmental fate and effects data used in this assessment will be bridged across the dicamba acid and all of the supported dicamba salts (MRID 43288001). EFED established a strategy for bridging the environmental fate and effects data requirements for the dicamba sodium and potassium salts, dimethylamine salt (DMA), isopropylamine salt and diglycoamine salt (DGA) to the dicamba acid. Bridging data were submitted indicating that the dicamba salts will be rapidly converted to the free acid of dicamba. Additionally, effects data provided indicate equatoxicity of the acid and salts (based on acid equivalents). EFED determined that fate studies conducted with dicamba acid provide "surrogate data" for the dicamba salts and that toxicity data across the acid and salts could generally be combined.

MODE OF ACTION

Dicamba is a benzoic acid herbicide similar in structure and mode of action to phenoxy herbicides. Like the phenoxy herbicides, dicamba mimics auxins, a type of plant hormone and causes abnormal cell growth by affecting cell division. Dicamba acts systematically in plants after it is absorbed through leaves and roots. It is easily transported throughout the plant and accumulates in new leaves.

USE CHARACTERIZATION

Monsanto Company submitted a new use request for the herbicide dicamba [M1691 Herbicide, EPA Reg. No. 524-582 (56.8% diglycolamine salt of dicamba)] for use on dicamba-tolerant soybeans (MON 87708). M1691 Herbicide is a water-soluble formulation intended for control and suppression of many broadleaf weeds, woody brush and vines. **Table 2** presents the proposed application rates to the dicamba-tolerant soybean. Rates for dicamba salts are normalized to dicamba acid equivalent per acre (a.e./A).

Product Information
Product Name: M1691 Herbicide
Active Ingredient: Diglycolamine salt of dicamba (3,4-dichloro-o-anisic acid)*............56.8%
Other Ingredients..43.2%
Total...100.0%
*Contains 38.5%, 3,6-dichloro-o-anisic acid (4 pounds acid equivalent per US gallon or 480 grams per liter).

TABLE 2. Dicamba DGA Proposed[1] Use Pattern for Dicamba-Tolerant Soybean.

Crop	Maximum Individual Application Rate[3] lbs dicamba a.e./A		Number of Applications	Minimum Application Interval (days)	Max Annual Application Rate in lbs dicamba a.e./A/year		Application Method
Dicamba-tolerant soybean MON 87708	Pre-emergence (pre-plant, at planting, or prior to crop emergence)[2]	1.0	NS	Pre-plant, at planting or prior to crop emergence	1.0	2.0	Ground spray
	Post-emergence[1] (Preharvest)	0.5	2[4]	From V3 (emergence) to before R1 (early flower) reproductive stage of soybean	1.0		

[1]- M1691 Herbicide
[2]- Registered uses
[3]- "Acid equivalent"
[4]- Calculated by dividing the max application rate by the max individual application rate.

Proposed preharvest interval for soybean forage and hay are 7 and 14 days, respectively. The herbicide can be tank mixed with other products. According to the proposed label, aerial applications of dicamba to dicamba-tolerant soybeans is not allowed (*i.e.*, it is limited to ground applications).

Currently, BASF maintains registration for dicamba as the dimethylamine (DMA), diglycolamine (DGA), isopropylamine (IPA), sodium (NA) and potassium (K) salts. To date dicamba salts have registered uses on right-of-way areas, asparagus, barley, corn, grasses grown in pasture and regland, oats, proso millet, rye, sorghum, soybeans (preemergent), sugarcane, wheat, and uses on golf courses and residential loans. Chemical structures of dicamba salts are provided in Table 1, Attachment I.

The proposed dicamba registration is for use on dicamba-tolerant soybean (MON 87708). Dicamba-tolerant soybeans (MON 87708) are not currently available for sale in the United States, therefore, maps of specific use-sites are not available. However, maps for soybean acreage can be used as a proxy under the assumption that dicamba-tolerant soybeans could be grown wherever soybeans are grown. Based on National Agricultural Statistics Service (NASS) 2009 data, soybeans are grown primarily in the central portions of the United States (see **Fig. 2**). These represent potential use sites for use of dicamba on dicamba-tolerant soybeans.

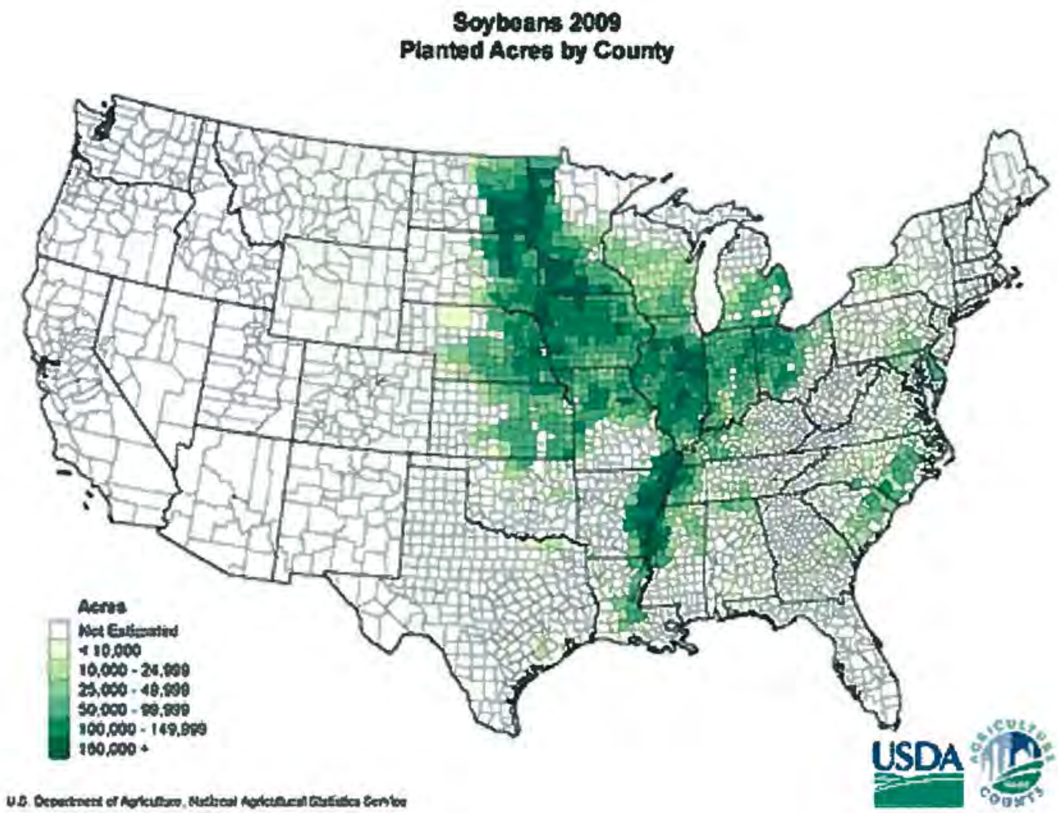


FIGURE 2. Acres of Soybeans Grown By County in the United Stated in 2009 (based on information from USDA-NASS) (http://www.nass.usda.gov/Charts_and_Maps/Crops_County/sb-pl.asp).

ENVIRONMENTAL FATE CHARACTERISTIC

Dicamba is a benzoic acid herbicide applied to leaves or to soil as a growth regulator, and is absorbed by leaves and roots moving throughout the plant. In some plants, it may accumulate in the tips of leaves. Some plants can metabolize or break down dicamba.

Dicamba is very soluble (6,100 ppm) and very mobile (K_{oc} = 13.4) in the laboratory, and is not expected to bioaccumulate in aquatic organisms because it is an anion at environmental pHs (pKa = 1.9). The active ingredient can reach surface water via run-off, spray drift during application, and vapor drift/volatilization. Multiple literature studies show that there is a high vapor drift from soybean fields resulting in non-target plant injury[1]. Since dicamba is not persistent under aerobic conditions, very little dicamba is expected to leach to groundwater. In two acceptable field dissipation studies conducted with dimethylamine salt of dicamba, dicamba was found in soil segments deeper than 10 cm (half-life range = 4.4 to 19.8 days, MRID 43651405, MRID 43651407). Any dicamba reaching anaerobic ground water would be

[1] Al-Khatib and Tamhane, 1999; Auch and Arnold, 1978; Everitt and Keeling, 2009; Kelley et al., 2005; Hamilton and Arle, 1979; Lanini, 2000; Marple et al., 2008; Wall, 1994; Weidenhamer et al., 1989; Wax et al., 1969.

somewhat persistent (due to its anaerobic half-life of 141 days).

Aerobic soil metabolism is the main degradative process for dicamba (6 days, MRID 43245207). Dicamba is stable to abiotic hydrolysis at all pH's and photodegrades slowly in water and on soil and is more persistent under anaerobic conditions in soil:water systems in the laboratory (141 days, MRID 43245208). A supplemental aerobic aquatic metabolism study of dicamba indicates that dicamba degrades more rapidly in aquatic systems when sediment is present. Its aerobic soil metabolism half-life in sediment:water system is about 24 days.

The major degradate under anaerobic conditions is 3,6-dichlorosalicylic acid (DCSA) which is persistent, comprising > 60% of the applied after 365 days of anaerobic incubation in sediment:pond water system (Stable, MRID# 43245208). DCSA is non-persistent when formed under aerobic conditions and degrades roughly at the same rate as the parent (8.2 days, MRID 43245207). DCSA was also found in the two acceptable field studies in soil segments deeper than 10 cm, and is believed to be persistent if it was to reach anaerobic ground water. The degradate is formed in aerobic soil under laboratory conditions at the maximum of 17.4 % of the applied parent. Other minor dicamba degradates of concern are DCGA and 5-OH-dicamba, and both are less toxic than the parent and DCSA. The formation of DCGA in the laboratory studies did not exceed 3.64%, and the formation of 5-OH dicamba did not exceed 1.9 % in soil/water system during anaerobic aquatic degradation of dicamba under laboratory condition.

Dicamba nomenclature including selected physical-chemical and fate properties for dicamba are provided below in Table 3. Chemical structures of dicamba and dicamba salts are presented in Table 1, Attachment I. The maximum percent formations of dicamba's metabolites are provided in Table 2, Appendix I. Further details regarding fate and transport laboratory and field studies submitted for dicamba can be found in the EFED Reregistration Chapter (US EPA, 2005).

TABLE 3. Selected Physical-Chemical and Fate Properties of Dicamba Acid.

CAS Name	3,6-dichloro-2-methoxybenzoic acid
IUPAC Name	3,6-dichloro-o-anisic acid
CAS No	1918-00-9
PC Code	029801
Empirical Formula	$C_8H_6Cl_2O_3$
Molecular Weight	221.04
Common Name	Dicamba
Formulated Product	Banex; Banlen; Banval; Banvel; Banvel 10G; Banvel 4E; Banvel 5G; Banvel CST; Banvel D; Banvel XG; dianat; Dicambe; Dicamba; Dicamba ; dicamba + 2,4-D; dicamba + atrazine; dicamba (amine); Clarity; Marksman; MDBA; Mediben; Velsicol 58-CS-11; Velsicol compound "R"
Pesticide Type	Herbicide
Chemical Family	Benzoic acid
Color/Form	Colorless crystals
Odor	Odorless
Melting Point	114 - 116°C (Kidd and James, 1991))

Flash Point	199°C (Gosselin, 1984)
Relative Density	1.57 g/ml at 25°C (Spectrum Laboratories: Chemical Fact Sheet)
Water Solubility	6100 mg/L SANDOZE Safety Data Sheet (Nov, 1989) 8240 mg/L at 25°C (Toxicology and Regulatory Affairs Flemington, NJ) 6500 mg/L at 25°C (Kidd and James, 1991)
Solubility in other solvents	Acetone 810 g/L at 25°C Dichloromethane 260 g/L at 25°C Dioxane 1.18 kg/L at 25°C Ethanol 922 g/L at 25°C Toluene 130 g/L at 25°C Xylene 8 g/L at 25°C (Worthing 1987)
Vapor Pressure	3.41 E-05 torr (25°C) SANDOZE Safety Data Sheet (Nov, 1989) 3.4 E-05 torr (25°C) (Kidd and James, 1991))
Henry's Law Constant	1.79 E-08 (ARS Pesticide Properties Database)
pKa	1.87 (MRID 43288001)
K_d(Freundlich) K_{oc}	0.07 - 0.53 mL/g (MRID 42774101) 3.45 - 21.1 mL/g (MRID 42774101)

Aquatic Exposure Estimates

The Tier II modeling was performed for dicamba acid and its major degradate DCSA using PRZM (v3.12.2; May 12, 2005)/EXAMS (v. 2.98.04.06; April 25, 2005) coupled with the standard pond scenario. Standard Mississippi soybean scenario was selected to assess runoff potential from vulnerable use sites. The modeling scenario for DCSA was based on the following: (1) assuming 17.4% conversion from parent DCSA and (2) using molecular weight conversion to adjust from parent application rate to DCSA application rate. **Tables 4** and **5** list the input parameters used for the PRZM/EXAMS modeling of dicamba acid and DCSA degradate.

TABLE 4. PRZM/EXAMS Input Parameters for Dicamba.

Model Input Variable	Input Value	Source and Comments
Application rate (kg ai/hectare)	Soybean: 1.12; 0.56; 0.56	M1691; EPA Reg. No. 524-582
Number of appl./season	Soybean: 3	M1691; EPA Reg. No. 524-582
Interval between appl. (d)	3 days	M1691; EPA Reg. No. 524-582
Application Method	Soybean: Ground	M1691; EPA Reg. No. 524-582
Scenario modeled (Metfile) - Initial Application Date	MSsoybeanSTD (W03940.dvf) - 16 April	Dates based on the crop profile, date of planting, & precipitation data.
Henry's Law Constant (atm m^3/mol)	1.6×10^{-9}	Estimated (VP x MW)/(760 torr/1 atm * solubility)
Molecular Weight (g/mol)	221	SANDOZE Safety Data Sheet (Nov, 1989).
Solubility @ 25°C (mg/L)	6100	SANDOZE Safety Data Sheet (Nov, 1989).
Vapor Pressure (torr)	3.41×10^{-5}	SANDOZE Safety Data Sheet (Nov, 1989).

K_{oc} (mL/g)	13.4 (average)	MRID 42774101; Input parameters guidance (10/22/2009).
Aerobic Soil Metabolic Half-life (days)	18	MRID 43245207; (6d x 3) input parameters guidance (10/22/2009).
Is the pesticide wetted-in?	No	EPA Reg. No. 5905-564
Spray Drift Fraction	0.01 ground	Input guidance, 2009
Application Efficiency	0.99 ground	Input guidance, 2009
Aerobic Aquatic Metabolic Half-life (days)	72.9	MRID 43758509; 3x a single half-life value of 24.3 days was used per guidance (Input guidance, 2009).
Anaerobic Aquatic Metabolic Half-life (days)	423	A single half-life value was available (MRID 43245208); 3x the half-life value (141 x 3 = 423) was used per Input Parameter Guidance 2009.
Hydrolysis (pH 7) half-life (days)	0	Stable. MRID 40547902
Aquatic Photolysis Half-life (days)	105	MRID 42774102. Input Parameter Guidance 2009. Adjusted half-life to represent sun intensity and 12 hours of sunlight per day. 38.1 day value represented continuous sun exposure at an intensity of 1.38 times natural sunlight. Degradate not present.

Table 5. PRZM/EXAMS Input Parameters for DCSA.

Model Input Variable	Input Value	Source and Comments
Application rate (kg ai/hectare)	Soybean: 0.18; 0.09; and 0.09	(degradate molecular weight)/(parent molecular weight) x max%formation x application rate = (207/221)x 0.174 x 1.12
Number of appl./season	Soybean: 3	EPA Reg. No. 524-582
Interval between appl. (d)	3 days	EPA Reg. No. 524-582
Scenario modeled (Metfile) -Initial Application Date	MSsoybeanSTD (W03940.dvf) - 16 April	Dates based on the crop profile, date of planting, & precipitation data.
Henry's Law Constant (atm m^3/mol)	1.6×10^{-9}	Estimated for dicamba and used for DCSA (VP x MW)/(760 torr/1 atm * solubility)
Molecular Weight (g/mol)	207	Product Chemistry
Solubility @ 25°C (mg/L)	2112	MRID 43095301
Vapor Pressure (torr)	3.41×10^{-5}	For Dicamba. SANDOZE Safety Data Sheet (Nov, 1989).
K_{oc} (mL/g)	1208 (average)	MRID 43095301; Input parameters guidance (10/22/2009).
Aerobic Soil Metabolic Half-life (days)	24.6	MRID 43245207; (8.2 d x 3) (Input Parameters Guidance; 10/22/2009).
Is the pesticide wetted-in?	No	EPA Reg. No. 524-582
CAM	1	DCSA formed from parent in the top soil layer
Spray Drift Fraction	0	Assumed formed in the soil
Application Efficiency	1.0	Assumed formed in the soil
Aerobic Aquatic	49.2	No acceptable data were available; 2x the half-life corresponding to the PRZM aerobic soil metabolism rate

Metabolic Half-life (days)		input value (2x 24.6d) was used per guidance (Input guidance, 2009).
Anaerobic Aquatic Metabolic Half-life (days)	0	Stable. MRID 43245208. Input Parameter Guidance 2009.
Hydrolysis (pH 7) Half-life (days)	0	Stable. MRID# 43245208
Aquatic Photolysis Half-life (days)	105	No data for DCSA; therefore, used value for dicamba: MRID 42774102. Input Parameter Guidance 2009. Adjusted half-life to represent sun intensity and 12 hours of sunlight per day. 38.1 day value represented continuous sun exposure at an intensity of 1.38 times natural sunlight.

PRZM-EXAMS Modeling Output

Table 6 presents combined PRZM/EXAMS estimated environmental concentrations in surface water for dicamba acid and the DCSA degradate for the proposed use on dicamba-tolerant soybean. These estimated environmental concentrations (EECs) were used to calculate risk to aquatic animals and plants.

The 1-in-10-year peak concentration for dicamba acid for modeled soybean scenario is 38 μg/L, the 21-day average concentration is 36 μg/L, and the 60-day average concentration is 31 μg/L. Table 6 provides combined EECs for dicamba parent and DCSA degradate. The PRZM/EXAMS output files are provided in the **APPENDIX II.**

TABLE 6. Combined PRZM/EXAMS Estimated Environmental Concentrations (EECs) for Dicamba Acid and DCSA Degradate.

Scenario	Estimated Water Concentrations (μg/L)		
	1-in-10-year Peak EEC	1-in-10-year 21-day mean EEC	1-in-10-year 60-day mean EEC
Dicamba and DCSA[1]			
MS Soybean – water column	40.3	37.9	33.1

[1] The EEC presents a combined value for the parent and degradate

ASSUMPTIONS AND UNCERTAINTIES

The following uncertainties have been identified in the environmental fate properties and aquatic assessment for dicamba and its degradate DCSA:

- The proposed label does not specify the minimum application interval between the consecutive applications, but the approximate growth stage of the plant. Therefore, for this assessment, it was assumed that the minimum application interval between the consecutive applications is 3 days.

- DCSA percent formation used for the modeling "application rate" calculation was based on the amount of degradate formed in the aerobic soil metabolism conducted on silt loam soil. It is possible that DCSA maybe formed in different amounts in different soil types, and result in DCSA EECs being underestimated. The use of 100% conversion from the parent to DCSA, however, was not pursued herein as this approach would be overly conservative.

- The PRZM/EXAMS aerobic aquatic metabolism input parameter is based on a supplemental study, although there are uncertainties associated with the aerobic aquatic metabolism half-life (MRID 43758509), the input parameter is more conservative than the one previously used in the aquatic assessments (US EPA, 2010).

MONITORING DATA

Surface water and groundwater monitoring data from the United States Geological Survey (USGS) NAWQA program was accessed on November 16, 2010 and all filtered water data (.7 micron glass fiber filter) were downloaded. A total of 14163 water samples from 6243 sites were analyzed for dicamba. Of these samples, 268 (3.4%) out of 7822 samples had positive detections of dicamba in surface water, and five out of 6341 samples in groundwater. The maximum concentration detected in filtered water from surface water was 1.76 µg/L in the Rocky Creek at State Hwy 587 at Citrus Park, Hillsborough County, Florida. Dicamba was detected in the Zollner Creek near Mt Angel, Oregon (agricultural area), in 19 samples with concentrations ranging 0.0097 -0.3775 µg/L and in the White Rock Creek at Greenville Ave, Dallas, Texas (urban area), in 16 samples with concentrations ranging from 0.0113 -0.3175 µg/L. The maximum estimated concentration detected in the filter groundwater was 4.03 µg/L in urban area (SH:UR-18) in Shelby, Tennessee. Overall the filtered surface water samples were detected at various areas with concentrations ranging 0.0094 -1.76µg/L, while groundwater filtered samples with concentration ranging 4.03 (estimated value)-0.14 µg/L. No clear pattern in dicamba detections from different use sites is evident because dicamba was detected in a number of different types of watersheds (agricultural, urban, mixed and other) as classified by the USGS land use information. Most of this data is non-targeted (*i.e.*, study was not specifically designed to capture dicamba concentrations in high use areas). Typically, sampling frequencies employed in monitoring studies are insufficient to document peak exposure values. This coupled with the fact that these data are not temporally or spatially correlated with dicamba application times and/or areas limit the utility of these data in estimating exposure concentrations for risk assessment.

Monitoring data are available in the Pesticides in Ground Water Database [Hoheisel *et al.* 1991] for dicamba (3,172 wells sampled) and 5-hydroxy dicamba (87 wells sampled). Out of the wells sampled, there were no reports of residues greater than the stated MCL (200 µg/L lifetime). However, the detection limits are unknown, and it is not known if wells were sampled in areas where dicamba was used. STORET contains records for sampling for dicamba in samples from lakes, ocean, estuary, canal, or reservoir sites. The data have not been extensively evaluated; in addition, it is uncertain what the actual detection limits were for the samples and whether samples were taken from areas where dicamba was not in use.

ENVIRONMENTAL EFFECTS DATA

Assessment of risk is based on the most sensitive species tested for terrestrial and aquatic organisms. The acute and chronic toxicity values for the most sensitive terrestrial and aquatic organisms tested are presented in **Table 7**. These endpoints are based on those presented in the most recent assessment conducted for dicamba, except for the terrestrial plant endpoints (USEPA 2010, D029801). The risks to terrestrial plants were evaluated using new toxicity information from a seedling emergence (MRID 47815101) and vegetative vigor (MRID 47815102) terrestrial plant studies conducted with a typical end-use product (TEP) representative of the product being proposed here for use on dicamba-tolerant soybean. The new vegetative vigor study was determined to be supplemental due to a decrease in plant height in lettuce controls. Quantitative data for the other nine species in the study may be used in risk assessment, but the endpoints for lettuce may not be used in risk assessment. The new data indicates that the DGA salt may be less toxic to monocots, but has an EC_{25} approximately 13 times more toxic to the vegetative vigor of dicots than dicamba acid. It is unclear if the enhanced toxicity to dicots is due to synergistic effects with surfactants and adjuvants in the formulation used (Clarity Herbicide, EPA Reg No. 7969-137, 56.8% DGA salt) or due to the DGA salt itself.

TABLE 7. Toxicity Values Used to Assess Risks from Use of Dicamba.

SPECIES	ACUTE ENDPOINT	NOAEC	MRID
Rainbow trout (*Oncorhynchus mykiss*)	LC_{50} = 28 mg a.e./L	No data available	40098001[1]
Sheepshead minnow (*Cyprinodon variegates*)	LC_{50} > 180 mg a.e./L	No data available	000253901
Water flea (*Daphnia magna*)	EC_{50} > 100 mg a.e./L	No data available	40094602
Grass shrimp (*Palaemonetes purgio*)	EC_{50} > 100 mg a.e./L	No data available	00034702
Duckweed (*Lemna gibba*)	IC_{50} > 3.25 mg a.e./L	NOAEC = 0.20 mg a.e../L	42774111
Blue-green algae (*Anabaena flos-aquae*)	IC_{50} = 0.061 mg a.e./L	NOAEC = 0.005 mg a.e./L	42774109
Bobwhite quail (*Colinus virginianus*) or Mallard duck (*Anas platyrhynchos*)	LD_{50} = 188 mg a.e./kg-bw (quail) LC_{50} > 10,000 mg a.e./kg-diet (quail)	NOAEC = 800 mg a.e./kg-diet (duck) (based on a reduction in hatchability at 1,600 mg a.e./kg-diet)	42918001, 00025391, 43814003
Rat (*Rattus norvegicus*)	LD_{50} = 2,740 mg a.e./kg-bw	NOAEL = 45 mg a.e./kg-bw (based on decreased pup weight at 136 mg a.e./kg-bw)	00078444, 43137101
Honey bee (*Apis mellifera*)	LD_{50} > 91 µg a.e./bee	No data available	00036935
Dicot (Tomato, *Lycopersicon esculentum*) – seedling emergence	EC_{25} = 0.123 lbs ae/A	NOAEC = 0.0673 lbs ae/A	47815101
Monocot (Onion, *Allium cepa*) – Seedling Emergence	EC_{25} = 1.68 lbs ae/A	NOAEC = 0.64 lbs ae/A	47815101
Dicot (Soybean, *Glycine max*) – Vegetative Vigor	EC_{25} = 0.000513 lbs ae/A	EC_{05} = 0.000013 lbs ae/A	47815102[2]
Monocot (Onion, *Allium cepa*) – Vegetative Vigor	EC_{25} = 0.472 lbs ae/A	EC_{05} = 0.137 lbs ae/A	47815102[2]

[1] The raw data from this study (Mayer and Ellersieck, 1986; MRID 40098001) were not available for review. Therefore, per current EFED policy regarding the results from this study, the study was classified as 'supplemental'.
[2] Currently in review.
"a.e." = acid equivalent.

RISK ESTIMATION & CHARACTERIZATION

Aquatic Organisms

The only acute RQ that could be calculated for aquatic animals based on available data is for freshwater fish [specifically rainbow trout (*Oncorhynchus mykiss*) (MRID 40098001)]. The acute RQ for freshwater fish is <0.01 for both dicamba (37.9 µg a.e./L divided by 28,000 µg a.e./L) and DCSA (2.4 µg a.e./L divided by 28,000 µg a.e./L). The results from the remaining acute aquatic animal studies are from limit tests and are non-definitive (*i.e.*, the LC_{50}/EC_{50}'s are 'greater than' values); therefore, acute RQs cannot be calculated using these data.

In order to gain a better understanding of how the EECs for the maximum proposed dicamba application rate for soybeans relate to the toxicity data currently available for aquatic animals, we compared the EECs to the toxicity endpoints using the conservative assumption that the highest concentrations tested in the acute aquatic animal studies represent endpoints (*e.g.*, acute: LC_{50} = 100 mg a.e./L). In this exercise, none of the acute RQs for estuarine/marine fish or aquatic invertebrates (freshwater and estuarine/marine) would exceed an Agency level of concern (LOC) for dicamba or DCSA (they are all <0.01).

Risks to aquatic animals from chronic exposure to dicamba could not be assessed at this time because of a lack of data. Since risk cannot be precluded, it is assumed.

For aquatic plants the only RQ that exceeds an Agency LOC is for listed non-vascular aquatic plants and dicamba (RQ = 7.6) (see **Table 8**). The results from the available vascular aquatic plant study are non-definitive (*i.e.*, the IC_{50}' is a 'greater than' value); therefore, a non-listed species RQ cannot be calculated using these data. In order to gain a better understanding of how the EECs for the maximum proposed dicamba application rate for soybeans relate to the toxicity data currently available for aquatic vascular plants, we compared the EECs to the toxicity endpoints using the conservative assumption that the highest concentration tested in the vascular aquatic plant study represents the endpoint (*i.e.*, IC_{50} = 3.25 mg a.e./L). In this exercise, the RQ would not exceed the Agency's level of concern (LOC) for dicamba or DCSA (they are <0.01).

TABLE 8. RQs for Aquatic Plants and the Use of Dicamba on Soybeans.

TAXON	LISTED/NON-LISTED	ENDPOINT (µg a.e./L)	MS -SOYBEANS			
			DICAMBA		DCSA	
			EEC (µg a.e./L)	RQ	EEC (µg a.e./L)	RQ
Vascular Aquatic Plant	Non-listed species	Non-definitive	37.9 (peak)	N/A	2.4 (peak)	N/A
	Listed species	NOAEC = 200	37.9 (peak)	0.2	2.4 (peak)	0.01
Non-Vascular Aquatic Plant	Non-listed species	IC_{50} = 61	37.9 (peak)	0.6	2.4 (peak)	0.04
	Listed species	NOAEC = 5	37.9 (peak)	**7.6**	2.4 (peak)	0.5

Bolded numbers exceed the Agency LOC of '1'.
"a.e." = acid equivalent.
"N/A" = not applicable

Terrestrial Organisms

In the EFED Reregistration Chapter for Dicamba/Dicamba Salts (USEPA 2005; DP 317696), the maximum single application rate assessed was 2.0 lb a.e./acre. The maximum single application rate for the proposed new use of dicamba on dicamba-tolerant soybeans is 1.0 lb a.e./acre, with a maximum yearly application rate of 2.0 lb a.e./acre. The maximum single application rate of 1.0 lb a.e./acre can only be used once; the maximum application rate for subsequent applications is limited to 0.5 lb a.e./acre. T-REX does not currently model RQs for multiple applications that have different single application rates (*i.e.*, when entering the application rate for multiple applications into the model, the application rates must be the same for the RQs to be automatically calculated).

In the previous assessments conducted by EFED (USEPA, 2005, 2010), there were risks to birds (acute - listed and non-listed) and mammals (acute – listed; chronic – listed and non-listed) identified based on LOC exceedences from RQs calculated in T-REX using the 2.0 lb a.e./acre application rate. We re-ran T-REX using the 1.0 lb a.e./acre application rate. At the 1.0 lb a.e./acre application rate, the Agency's acute LOCs are exceeded for listed and non-listed birds [acute dose-based RQs range from <0.01 (1,000 g bird that eats seeds) to 2.0 (20 g bird that eats short grass)] (see **Table 9** and **APPENDIX IV**). No chronic RQs exceed the Agency's LOC for chronic risk (chronic dietary-based RQs range from 0.02 to 0.30).

TABLE 9. Acute Dose-Based RQs for Birds from T-REX for Dicamba Use on Dicamba-Tolerant Soybeans[1].

Dose-based RQs (Dose-based EEC/adjusted LD50)	Avian Acute RQs Size Class (grams)		
	20	100	1000
Short Grass	**2.02**	**0.90**	**0.29**
Tall Grass	**0.92**	**0.41**	**0.13**
Broadleaf plants/sm insects	**1.14**	**0.51**	**0.16**
Fruits/pods/seeds/lg insects	**0.13**	0.06	0.02
Seeds (granivore)	0.03	0.01	0.00

[1] One application at 1.0 lb a.e./acre was modeled
Bolded numbers exceed the Agency's acute risk LOC for non-listed species (RQ > 0.5) and/or the acute risk LOC for listed species (RQ > 0.1).

For mammals, none of the acute RQs exceed any of the Agency's LOCs (acute dose-based RQs range from <0.01 to 0.04). Additionally, none of the dietary-based chronic RQs exceed the Agency's LOCs for chronic risk (chronic dietary-based RQs range from 0.02 to 0.27). Chronic dose-based RQs, however, do exceed the Agency's LOC for chronic risk (chronic dose-based RQs range from 0.01 to 2.3) (see **Table 10** and **APPENDIX IV**).

TABLE 10. Chronic Dose-Based RQs for Mammals from T-REX for Dicamba Use on Dicamba-Tolerant Soybeans[1].

Dose-based RQs (Dose-based NOAEL)	Small mammal 15 grams	Medium mammal 35 grams	Large mammal 1000 grams
Short Grass	**2.31**	**1.98**	**1.06**
Tall Grass	**1.06**	0.91	0.49

Broadleaf plants/sm insects	**1.30**	**1.11**	0.60
Fruits/pods/lg insects	0.14	0.12	0.07
Seeds (granivore)	0.03	0.03	0.01

[1] One application at 1.0 lb a.e./acre was modeled
Bolded numbers exceed the Agency's chronic risk LOC for listed and non-listed species (RQ > 1).

Therefore, there are still risks to birds (acute - listed and non-listed) and mammals (acute – listed; chronic – listed and non-listed) with the single maximum application rate of 1.0 lb a.e./acre.

Based on the available acute toxicity data available for honey bees, dicamba is classified as practically non-toxic to beneficial terrestrial invertebrates.

Terrestrial Plants

Dicamba exposure to terrestrial and semi-aquatic plants is estimated using the TerrPlant (version 1.2.2) model. The model generates EECs for plants residing near a use area that may be exposed via runoff and/or spray drift. The EECs are generated from one application at the maximum rate for a particular use and compound-specific solubility information. Only a single application is considered because it is assumed that for plants, toxic effects are likely to manifest shortly after the initial exposure and that subsequent exposures do not contribute to the response. Hence, the model estimates EECs based on application rate, the solubility factor, and default assumptions of drift. Parameter values for application rate, drift assumption and incorporation depth are based upon the use and related application method and can be found in Appendix V.

The EECs and resulting RQs for terrestrial and semi-aquatic plants for a single application of dicamba DGA at the maximum label rate for the proposed use on dicamba-tolerant soybeans are presented in **Tables 11 and 12.** RQs were exceeded for listed and non-listed dicots due to spray drift or in semi-aquatic areas due to runoff and spray drift.

Table 11. EECs for Terrestrial and Semi-Aquatic Plants Near Dicamba Use on Dicamba-Tolerant Soybeans.

Crop	Single Max. Application Rate (lbs a.e./A)	EECs (lbs a.e./A) Ground Spray		
		Total Loading to Adjacent Dry Areas (sheet runoff + drift)	Total Loading to Semi-Aquatic Areas (Channelzed runoff + drift)	Drift EEC
Dicamba-Tolerant Soybeans	1.0	0.06	0.51	0.01

Table 12. RQ values for plants in dry and semi-aquatic areas exposed to Diglycolamine Salt (DGA) through runoff and/or spray drift.*

Plant Type	Listed Status	Dry	Semi-Aquatic	Spray Drift
Monocot	non-listed	<0.1	0.30	<0.1
Monocot	listed	<0.1	0.80	<0.1

Dicot	non-listed	0.49	**4.15**	**19.49**
Dicot	listed	0.89	**7.58**	**769.23**
*If RQ > 1.0, the LOC is exceeded, resulting in potential for risk to that plant group.				

EFED's current screening tool TerrPlant results in a RQ of 0.89 for listed species and 0.49 for non-listed species of dicots in dry areas, which is less than the LOC for plants of 1.0. However, using AgDrift, with standard default assumptions, the RQ exceeds the listed species LOC at ≤142 feet from the application site. At 100' from the application area, the RQ=1.45 and at 50' from the application area the RQ=2.54. Similarly, using AgDrift, the RQ for non-listed species exceeds the LOC at ≤ 77 feet from the application site. For ground application in dry areas, listed dicot populations must be > 142 feet from the application area to be protected and non-listed dicot populations must be > 77 feet from the application area to be protected. **Table 13** shows the distance from the edge of field (as calculated by AgDrift) where the RQ falls below the risk to terrestrial plant LOCs. Listed plant species that may be similar to tomatoes or soybeans would exceed the LOC even if a 1000' buffer was applied to the application site. These calculations used a default droplet size distribution of fine to medium. Different droplet spectra (e.g. coarser drop size distributions) would yield less spray drift and lower RQs.

The aforementioned RQ values are for the DGA salt of dicamba. For dicamba acid, which DGA salt may dissociate to and which has more sensitive seedling emergence values, RQ values would exceed the LOC of 1.0 for all listed and non-listed monocots and dicots in semi-aquatic areas and for listed monocots and listed and non-listed dicots in dry areas. It is unclear what the differences in observed toxicities of the seedling emergence and vegetative vigor studies between the DGA salt and dicamba acid is due to.

Table 13 Distance (feet) from the edge of field where the RQ falls below the risk to terrestrial plant LOC for seedling emergence and vegetative vigor endpoints for ground application, based on AgDRIFT EECs.

Plant Species	Seedling Emergence		Vegetative vigor	
	Listed	Nonlisted	Listed	Nonlisted
Corn	30	<3.3	<3.3	<3.3
Ryegrass	<3.3	<3.3	<3.3	<3.3
Wheat	<3.3	<3.3	3.3	<3.3
Onion	<3.3	<3.3	7	<3.3
Oilseed rape	233	<3.3	10	<3.3
Soybean	10	3.3	>997	784
Cabbage	<3.3	<3.3	30	<3.3
Carrot	3.3	<3.3	171	13

Plant Species	Seedling Emergence		Vegetative vigor	
	Listed	Nonlisted	Listed	Nonlisted
Lettuce	3.3	<3.3	259	36
Tomato	10	7	>997	538

Incident Data

A preliminary review on February 23, 2011, of the Ecological Incident Information System (EIIS, version 2.1), which is maintained by the Agency's Office of Pesticide Programs, and the Avian Monitoring Information System (AIMS), which is maintained by the American Bird Conservancy, indicates a total of 2 reported ecological incidents associated with the use of DGA salt. This total excludes incidents classified as 'unlikely' or 'unrelated' and only includes those incidents with certainty categories of 'possible', 'probable', and 'highly probable' (for EIIS) and 'possible', 'probable', 'likely', 'highly likely' and 'certain' (for AIMS). Incidents classified as 'unlikely' the result of or 'unrelated' to DGA salt will not be included in this ecological risk assessment.

In 1998, in Lyon County, Minnesota, 120 acres of soybeans were adversely affected after dicamba DGA and clopyralid were applied. The type of injurty was not reported. The incident was classified as probable for both dicamba DGA salt and clopyralid and the incident was considered as an accidental misuse. In 2007, in Imperial County, California, a complaint was received that alfalfa fields were damaged, with dead and stunted plants, and leaves curled and cupped. An application of dicamba DGA salt and 2,4-D DMA salt by air to adjacent fields was conducted, however, samples taken from the affected field were found negative for both dicamba and 2,4-D. This incident was classified possible for Dicamba DGA salt and 2,4-D DMA salt and was considered a registered use.

A review was also briefly conducted on the incident data for dicamba acid. The 2006 RED recorded thirty-five ecological incidents attributed to dicamba acid use having been recorded in the Ecological Incident Information System (EIIS) as of June l, 2005. Since the RED, two additional incidents have been reported. In 2006, in St. Landry County, LA, 1500 acres of soybean were damaged by a combination of glyphosate, dicamba and 2,4-D. The type of injury was not reported. This incident was classified as probable for dicamba and 2,4-D and possible for glyphosate and the incident was considered as an intentional misuse. In 2007, in Lancaster County, PA, 4 rabbits were killed after a homeowner applied product with MCPP, Dicamba, and 2-4 D ingredients to the house lawn. This incident was classified as possible for all three active ingredients and the legality was undetermined. The earlier incidents reported include terrestrial, plant, and aquatic impacts. 19 of the incidents involve 2,4-D in addition to dicamba and sometimes other active ingredients. Although the database lists a terrestrial mammalian incident in Utah where dicamba was applied, the database states that dicamba is "unlikely" to have caused the incident. Impacts to plants included a wide range of crops (soybeans, corn, wheat) as well as non-agricultural applications. The specific impacts varied from browning and plant damage to mortality of all plants within the treated area. Aquatic impacts consist of two fish kill incidents associated with agricultural and residential turf application.

FEDERALLY-LISTED SPECIES

Potential effects to federally-listed endangered and threatened species (listed species) based on LOC exceedances require an in-depth listed species evaluation. Identified potential risks to listed species are summarized in **Table 14.**

TABLE 14. Listed Species Risks Associated with Potential Direct or Indirect Effects Due to the Proposed Applications of Dicamba on Dicamba-Tolerant Soybeans.

LISTED TAXON	DIRECT EFFECTS	INDIRECT EFFECTS
Terrestrial and semi-aquatic plants – monocots	No[1]	Yes[3]
Terrestrial and semi-aquatic plants - dicots	Yes	Yes[3]
Insects	No	Yes[3]
Birds	Yes (Acute)	Yes[3]
Terrestrial phase amphibians	Yes (Acute)	Yes[3]
Reptiles	Yes (Acute)	Yes[3]
Mammals	Yes (Chronic)	Yes[3]
Aquatic plants	Yes (Non-vascular)	Yes[3]
Freshwater fish	Yes (Chronic)[2]	Yes[3]
Aquatic phase amphibians	Yes (Chronic)[2]	Yes[3]
Freshwater crustaceans	Yes (Chronic)[2]	Yes[3]
Mollusks	No	Yes[3]
Marine/estuarine fish	Yes (Chronic)[2]	Yes[3]
Marine/estuarine crustaceans	Yes (Chronic)[2]	Yes[3]

[1]Listed species of monocots RQ values did not indicate risk from DGA salt, but risk was indicated for dicamba acid. DGA salt rapidly disassociates into dicamba acid.
[2] Risks could not be precluded due to a lack of data; therefore, risk is assumed.
[3]The listed chronic LOC was exceeded for fish and mammals. Therefore, the potential for adverse effects to those species that rely on a specific animal species (specifically fish and/or mammals) or multiple animal species (specifically fish and/or mammals) cannot be precluded. Indirect effects may include general habitat modification,

loss of pollinators/seed dispersers, and food supply disruption.

At this time, no federally-listed taxa can be excluded from the potential for direct and/or indirect effects from the proposed new uses of dicamba, since there is a potential for indirect effects to taxa that might rely on plants, birds, aquatic animals, and/or mammals for some stage of their life-cycle. A complete co-occurrence analysis could not be completed for listed species at this time, since the specific use site associated with the proposed new use of dicamba (dicamba-tolerant soybeans). Therefore, without further refinement, no species currently listed as federally threatened or endangered can be excluded from the potential for adverse effects from the proposed new use of dicamba. Details regarding the environmental fate, ecological effects and ecological risks associated with the proposed new uses of dicamba are discussed in the sections that follow.

UNCERTAINTIES

There is a lack of data on the effect of dicamba to green algae as well as a lack of data on chronic effects of dicamba to freshwater and saltwater fish and invertebrates. In the absence of data, risk to these taxa has been assumed.

Based on the usage of other herbicides associated with genetically modified crops that are tolerant to a specific herbicide (*e.g.,* glyphosate-tolerant soybean), the use of dicamba on soybeans [lbs acid equivalent (a.e.)/year] could potentially increase when compared to past usage data from this new use. This is due to a variety of factors including the fact that once a tolerant crop is grown in a particular area, the use of the tolerant crop is often adopted by neighbors (to minimize the potential risk from spray drift). Additionally, dicamba use on tolerant soybeans is predicted to increase given the recent resistance issues identified in glyphosate-tolerant soybean (J. Tooker, D. Mortensen, and F. Egan, pers. comm., Nov. 2010; Mortensen 2010). Although EFED does not typically address specific concerns related to the increased usage of a chemical, the potential for ecological risks likely increases with increased usage. BEAD should be consulted on the potential for increase use.

Additionally, applications during a warmer time (*i.e.*, post-emergence) may increase off-site transport (via volatility) during a time when many plants have leafed out (J. Tooker, D. Mortensen, and F. Egan, pers. comm., Nov. 2010; Mortensen 2010). Therefore, a post-emergence application may increase the likelihood of effects to non-target plants through habitat loss. This could indirectly affect those organisms which rely on those plants, including pollinators, through this is uncertain and requires additional evaluation.

It is also possible that the proposed new use of dicamba on dicamba-tolerant soybeans may increase the occurrence of weeds that are resistant to dicamba. The occurrence of weed resistance to glyphosate has increased significantly since the adoption of transgenic glyphosate-resistant crops (Powles, 2008). Prior to development of glyphosate-resistant crops, there were no known cases of evolved glyphosate-resistant weeds (Dyer, 1994). There exists potential that a similar pattern of rapidly evolving weed resistance to dicamba could occur where transgenic dicamba-resistant crops are used.

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APPENDIX I

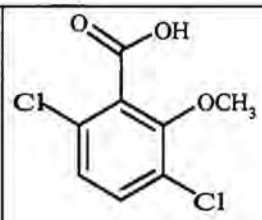
Table 1: Chemical Structures for Dicamba and its Salts	
PC Code 029801	
Chemical structure	
Common name	Dicamba acid
Molecular Formula	$C_8H_6Cl_2O_3$
Molecular Weight	221.04
IUPAC name	3,6-dichloro-*o*-anisic acid
CAS name	3,6-dichloro-2-methoxybenzoic acid or 2-methoxy-3,6-dichlorobenzoic acid
CAS #	1918-00-9
PC Code 029802	
Chemical structure	
Common name	Dicamba dimethylamine salt (DMA salt)
Molecular Formula	$C_{10}H_{13}Cl_2NO_3$
Molecular Weight	266.1
CAS #	2300-66-5
PC Code 029806	
Chemical structure	
Common name	Dicamba sodium salt (Na salt)
Molecular Formula	$C_8H_5Cl_2NaO_3$
Molecular Weight	243.0
CAS #	1982-69-0
PC Code 128931	

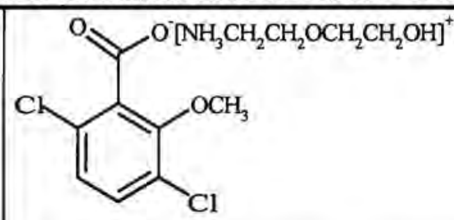
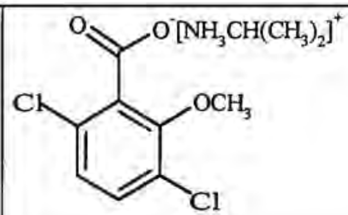
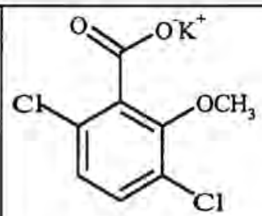
Table 1: Chemical Structures for Dicamba and its Salts	
Chemical structure	
Common name	Dicamba diglycolamine salt (DGA salt)
Molecular Formula	$C_{12}H_{17}Cl_2NO_5$
Molecular Weight	326.18
CAS #	104040-79-1
PC Code 128944	
Chemical structure	
Common name	Dicamba isopropylamine salt (IPA salt)
Molecular Formula	$C_{11}H_{15}Cl_2NO_3$
Molecular Weight	280.15
CAS #	55871-02-8
PC Code 129043	
Chemical structure	
Common name	Dicamba potassium salt (K salt)
Molecular Formula	$C_8H_5Cl_2KO_3$
Molecular Weight	259.1
CAS #	10007-85-9

Table 2. Maximum Percent Formation of Dicamba Degradates Observed in the Laboratory and Field Studies

Degradate	***Max Degradate Concentration (% of applied)***						
	Hydrolysis	***Aqueous Photolysis***	***Soil Photolysis***	***Aerobic Soil Metabolism***	***Anaerobic Aquatic Degradation***	***Aerobic Aquatic Degradation***	***TFD***
DCSA				17.4% (7 days) (MRID 43245207)	61.6% in soil/water system (MRID 43245208)	8.6% (30 days) water 26% (41 days) soil (MRID 43758509)	present
DCGA					3.64% in soil/water system		not detected
5-OH-Dicamba				0.8%	1.9%in soil/water system		not detected
2,5-DiOH-Dicamba				2.7%			not detected

APPENDIX II

Modeling Dicamba applied aerially on MS Soybean

stored as DicamMSsoybeanPDgr.out
Chemical: Dicamba
PRZM environment: MSsoybeanSTD.txt modified Tueday, 26 August 2008 at 06:16:40
EXAMS environment: pond298.exv modified Tueday, 26 August 2008 at 06:14:08
Metfile: w03940.dvf modified Tueday, 26 August 2008 at 06:14:14
Water segment concentrations (ppb)

Year	Peak	96 hr	21 Day	60 Day	90 Day	Yearly
1961	3.195	3.145	2.943	2.516	2.225	0.9442
1962	5.396	5.332	5.01	4.23	3.702	1.587
1963	12.08	11.87	11.58	10.37	9.189	3.823
1964	5.363	5.289	4.962	4.226	3.711	1.944
1965	1.591	1.57	1.474	1.29	1.159	0.66
1966	12.54	12.38	11.79	10.4	9.286	3.859
1967	16.2	15.97	15.01	13.07	11.6	5.425
1968	7.467	7.396	6.957	5.96	5.242	2.977
1969	48.76	48.28	45.97	39.81	35.09	14.15
1970	11.28	11.1	10.43	9.477	8.454	5.163
1971	38.87	38.42	36.97	32.31	28.59	11.79
1972	6.122	6.027	5.675	5.185	4.781	3.216
1973	51.33	50.79	49.22	43.39	38.3	15.18
1974	21.51	21.25	20.05	17.24	15.32	7.924
1975	7.27	7.187	6.761	5.757	5.074	2.986
1976	4.089	4.033	3.884	3.537	3.171	1.621
1977	15.79	15.62	14.78	12.57	11.01	4.514
1978	8.735	8.624	8.323	7.436	6.6	3.148
1979	9.771	9.625	9.314	8.364	7.481	3.405
1980	28.71	28.38	26.91	22.96	20.02	8.069
1981	3.741	3.725	3.654	3.479	3.32	2.006
1982	16.96	16.75	16.25	14.06	12.41	5.057
1983	3.7	3.645	3.438	2.989	2.802	1.812
1984	8.018	7.894	7.713	6.93	6.174	2.653
1985	6.5	6.417	6.104	5.255	4.64	2.184
1986	1.813	1.783	1.682	1.591	1.459	0.8394
1987	3.864	3.806	3.625	3.072	2.692	1.175
1988	24.89	24.58	23.15	19.85	17.43	6.966
1989	14.08	13.9	13.02	11.09	9.77	4.864
1990	19.66	19.43	18.39	15.9	13.94	6.067

Sorted results

Prob.	Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.032258064516129	51.33	50.79	49.22	43.39	38.3	15.18
0.0645161290322581	48.76	48.28	45.97	39.81	35.09	14.15
0.0967741935483871	38.87	38.42	36.97	32.31	28.59	11.79
0.129032258064516	28.71	28.38	26.91	22.96	20.02	8.069
0.161290322580645	24.89	24.58	23.15	19.85	17.43	7.924
0.193548387096774	21.51	21.25	20.05	17.24	15.32	6.966
0.225806451612903	19.66	19.43	18.39	15.9	13.94	6.067
0.258064516129032	16.96	16.75	16.25	14.06	12.41	5.425
0.290322580645161	16.2	15.97	15.01	13.07	11.6	5.163
0.32258064516129	15.79	15.62	14.78	12.57	11.01	5.057
0.354838709677419	14.08	13.9	13.02	11.09	9.77	4.864
0.387096774193548	12.54	12.38	11.79	10.4	9.286	4.514
0.419354838709677	12.08	11.87	11.58	10.37	9.189	3.859
0.451612903225806	11.28	11.1	10.43	9.477	8.454	3.823
0.483870967741936	9.771	9.625	9.314	8.364	7.481	3.405
0.516129032258065	8.735	8.624	8.323	7.436	6.6	3.216
0.548387096774194	8.018	7.894	7.713	6.93	6.174	3.148
0.580645161290323	7.467	7.396	6.957	5.96	5.242	2.986
0.612903225806452	7.27	7.187	6.761	5.757	5.074	2.977
0.645161290322581	6.5	6.417	6.104	5.255	4.781	2.653
0.67741935483871	6.122	6.027	5.675	5.185	4.64	2.184
0.709677419354839	5.396	5.332	5.01	4.23	3.711	2.006
0.741935483870968	5.363	5.289	4.962	4.226	3.702	1.944
0.774193548387097	4.089	4.033	3.884	3.537	3.32	1.812

0.806451612903226	3.864	3.806	3.654	3.479	3.171	1.621	
0.838709677419355	3.741	3.725	3.625	3.072	2.802	1.587	
0.870967741935484	3.7	3.645	3.438	2.989	2.692	1.175	
0.903225806451613	3.195	3.145	2.943	2.516	2.225	0.9442	
0.935483870967742	1.813	1.783	1.682	1.591	1.459	0.8394	
0.967741935483871	1.591	1.57	1.474	1.29	1.159	0.66	
0.1	37.854	37.416	35.964	31.375	27.733	11.4179	
				Average of yearly averages:			4.53362

Inputs generated by pe5.pl - Novemeber 2006

Data used for this run:
Output File: DicamMSsoybeanPDgr
Metfile: w03940.dvf
PRZM scenario: MSsoybeanSTD.txt
EXAMS environment file: pond298.exv
Chemical Name: Dicamba

Description	Variable Name	Value	Units	Comments
Molecular weight	mwt	221	g/mol	
Henry's Law Const.	henry	1.6E-9	atm-m^3/mol	
Vapor Pressure	vapr	3.41E-5	torr	
Solubility	sol	6100	mg/L	
Kd	Kd		mg/L	
Koc	Koc	13.4	mg/L	
Photolysis half-life	kdp	105	days	Half-life
Aerobic Aquatic Metabolism	kbacw	72.9	days	Halfife
Anaerobic Aquatic Metabolism	kbacs	423	days	Halfife
Aerobic Soil Metabolism	asm	18	days	Halfife
Hydrolysis:	pH 5	0	days	Half-life
Hydrolysis:	pH 7	0	days	Half-life
Hydrolysis:	pH 9	0	days	Half-life
Method:	CAM	2	integer	See PRZM manual
Incorporation Depth:	DEPI		cm	
Application Rate:	TAPP	1.12	kg/ha	
Application Efficiency:	APPEFF	0.99	fraction	
Spray Drift	DRFT	0.01	fraction of application rate applied to pond	
Application Date	Date	16-04	dd/mm or dd/mmm or dd-mm or dd-mmm	
Interval 1	interval	3	days	Set to 0 or delete line for single app.
app. rate 1	apprate	0.56	kg/ha	
Interval 2	interval	3	days	Set to 0 or delete line for single app.
app. rate 2	apprate	0.56	kg/ha	
Record 17:	FILTRA			
	IPSCND	1		
	UPTKF			
Record 18:	PLVKRT			
	PLDKRT			
	FEXTRC	0.5		
Flag for Index Res. Run	IR		EPA Pond	
Flag for runoff calc.	RUNOFF	none	none, monthly or total(average of entire run)	

Modeling DCSA from Dicamba applied via ground on MS Soybean

stored as DCSAMSsoybeanPD.out
Chemical: DCSA
PRZM environment: MSsoybeanSTD.txt modified Tueday, 26 August 2008 at 06:16:40
EXAMS environment: pond298.exv modified Tueday, 26 August 2008 at 06:14:08
Metfile: w03940.dvf modified Tueday, 26 August 2008 at 06:14:14
Water segment concentrations (ppb)

Year	Peak	96 hr	21 Day	60 Day	90 Day	Yearly
1961	0.4857	0.456	0.3607	0.2974	0.2768	0.1214
1962	0.4204	0.3977	0.3476	0.26	0.2205	0.1292
1963	0.4554	0.4319	0.3631	0.3058	0.2959	0.1733
1964	1.794	1.691	1.339	0.9315	0.7746	0.3625
1965	0.2641	0.2637	0.2613	0.2549	0.2493	0.1673
1966	1.569	1.516	1.312	1.104	0.9609	0.4516
1967	2.399	2.281	1.973	1.573	1.345	0.6988
1968	1.263	1.218	1.119	0.9311	0.811	0.5318
1969	2.197	2.086	1.722	1.258	1.057	0.5596

1970	0.7601	0.728	0.6233	0.5022	0.451	0.3258
1971	2.736	2.601	2.353	1.972	1.657	0.7538
1972	1.099	1.052	1	0.7875	0.6824	0.4672
1973	2.711	2.611	2.242	1.775	1.486	0.7053
1974	0.9504	0.915	0.7939	0.69	0.6292	0.4341
1975	1.589	1.503	1.298	1.012	0.8664	0.4646
1976	1.438	1.367	1.228	0.9746	0.8417	0.4763
1977	1.088	1.039	0.8804	0.6684	0.5829	0.3699
1978	1.36	1.291	1.196	0.9029	0.7588	0.4023
1979	1.502	1.423	1.288	1.046	0.9341	0.5168
1980	1.899	1.81	1.648	1.408	1.19	0.619
1981	1.072	1.024	0.9449	0.7578	0.6585	0.4295
1982	2.189	2.075	1.823	1.319	1.159	0.5977
1983	2.088	1.993	1.646	1.207	1.01	0.5655
1984	1.153	1.099	0.9339	0.7359	0.6511	0.4228
1985	0.3574	0.3475	0.317	0.27	0.2617	0.2047
1986	1.158	1.089	0.8878	0.6305	0.5289	0.2581
1987	0.5557	0.5283	0.4466	0.3983	0.3662	0.2322
1988	1.379	1.307	1.064	0.7544	0.6282	0.3171
1989	1.823	1.729	1.541	1.297	1.111	0.5428
1990	1.513	1.439	1.221	1.001	0.8629	0.5036

Sorted results

Prob.	Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.032258064516129	2.736	2.611	2.353	1.972	1.657	0.7538
0.0645161290322581	2.711	2.601	2.242	1.775	1.486	0.7053
0.0967741935483871	2.399	2.281	1.973	1.573	1.345	0.6988
0.129032258064516	2.197	2.086	1.823	1.408	1.19	0.619
0.161290322580645	2.189	2.075	1.722	1.319	1.159	0.5977
0.193548387096774	2.088	1.993	1.648	1.297	1.111	0.5655
0.225806451612903	1.899	1.81	1.646	1.258	1.057	0.5596
0.258064516129032	1.823	1.729	1.541	1.207	1.01	0.5428
0.290322580645161	1.794	1.691	1.339	1.104	0.9609	0.5318
0.32258064516129	1.589	1.516	1.312	1.046	0.9341	0.5168
0.354838709677419	1.569	1.503	1.298	1.012	0.8664	0.5036
0.387096774193548	1.513	1.439	1.288	1.001	0.8629	0.4763
0.419354838709677	1.502	1.423	1.228	0.9746	0.8417	0.4672
0.451612903225806	1.438	1.367	1.221	0.9315	0.811	0.4646
0.483870967741936	1.379	1.307	1.196	0.9311	0.7746	0.4516
0.516129032258065	1.36	1.291	1.119	0.9029	0.7588	0.4341
0.548387096774194	1.263	1.218	1.064	0.7875	0.6824	0.4295
0.580645161290323	1.158	1.099	1	0.7578	0.6585	0.4228
0.612903225806452	1.153	1.089	0.9449	0.7544	0.6511	0.4023
0.645161290322581	1.099	1.052	0.9339	0.7359	0.6292	0.3699
0.67741935483871	1.088	1.039	0.8878	0.69	0.6282	0.3625
0.709677419354839	1.072	1.024	0.8804	0.6684	0.5829	0.3258
0.741935483870968	0.9504	0.915	0.7939	0.6305	0.5289	0.3171
0.774193548387097	0.7601	0.728	0.6233	0.5022	0.451	0.2581
0.806451612903226	0.5557	0.5283	0.4466	0.3983	0.3662	0.2322
0.838709677419355	0.4857	0.456	0.3631	0.3058	0.2959	0.2047
0.870967741935484	0.4554	0.4319	0.3607	0.2974	0.2768	0.1733
0.903225806451613	0.4204	0.3977	0.3476	0.27	0.2617	0.1673
0.935483870967742	0.3574	0.3475	0.317	0.26	0.2493	0.1292
0.967741935483871	0.2641	0.2637	0.2613	0.2549	0.2205	0.1214
0.1	2.3788	2.2615	1.958	1.5565	1.3295	0.69082

Average of yearly averages: 0.42682

Inputs generated by pe5.pl - Novemeber 2006

Data used for this run:
Output File: DCSAMSsoybeanPD
Metfile: w03940.dvf
PRZM scenario: MSsoybeanSTD.txt
EXAMS environment file: pond298.exv
Chemical Name: DCSA

Description	Variable Name	Value	Units	Comments
Molecular weight	mwt	207	g/mol	
Henry's Law Const.	henry	1.6E-9	atm-m^3/mol	
Vapor Pressure	vapr	3.41E-5	torr	

Solubility	sol	2112	mg/L		
Kd	Kd		mg/L		
Koc	Koc	1208	mg/L		
Photolysis half-life	kdp	105	days	Half-life	
Aerobic Aquatic Metabolism		kbacw	49.2	days	Halfife
Anaerobic Aquatic Metabolism		kbacs	0	days	Halfife
Aerobic Soil Metabolism		asm	24.6	days	Halfife
Hydrolysis:	pH 5	0	days	Half-life	
Hydrolysis:	pH 7	0	days	Half-life	
Hydrolysis:	pH 9	0	days	Half-life	
Method: CAM	1	integer	See PRZM manual		
Incorporation Depth:	DEPI		cm		
Application Rate:	TAPP	0.18	kg/ha		
Application Efficiency:		APPEFF	1.0	fraction	
Spray Drift	DRFT	0	fraction of application rate applied to pond		
Application Date	Date	16-04	dd/mm or dd/mmm or dd-mm or dd-mmm		
Interval 1 interval	3	days	Set to 0 or delete line for single app.		
app. rate 1 apprate	0.09	kg/ha			
Interval 2 interval	3	days	Set to 0 or delete line for single app.		
app. rate 2 apprate	0.09	kg/ha			
Record 17: FILTRA					
IPSCND	1				
UPTKF					
Record 18: PLVKRT					
PLDKRT					
FEXTRC	0.5				
Flag for Index Res. Run		IR	EPA Pond		
Flag for runoff calc.	RUNOFF	none	none, monthly or total(average of entire run)		

APPENDIX III: Environmental Fate and Transport Database Dicamba Acid (and its Salts):

GUIDELINE NUMBER	DESCRIPTION	ACTIVE INGREDIENT	CITATION	CLASSIFICATION
835.2120	Hydrolysis	Dicamba acid	40335501	Acceptable
835.2240	Photodegradation in Water	Dicamba acid	42774102	Acceptable
835.2410	Photodegradation on Soil	Dicamba acid	42774103	Acceptable
835.2370	Photodegradation in Air	No data available	N/A	N/A
835.4100	Aerobic Soil Metabolism	Dicamba aicd	43245207	Acceptable
835.4200	Anaerobic Soil Metabolism	Dicamba acid	43245208	Acceptable
835.4400	Anaerobic Aquatic Metabolism	Dicamba acid	43245208	Acceptable
835.4300	Aerobic Aquatic Metabolism	Dicamba acid	43758509	Supplemental
835.1230	Leaching Adsorption/Desorption	Dicamba acid Dicamba acid	42774101 43095301	Acceptable Supplemental
835.1410	Laboratory Volatility	K and DMA salts	41966602	Acceptable
835.8100	Field Volatility	No data available	N/A	N/A
835.6100	Terrestrial Field Dissipation	Sodium and Diglycoamine salts Diglycoamine salt Dimethylamine salt Diglycoamine salt Sodium salt Potassium salt Potassium salt	43361506 43361507 43651405 43651407 43651408 42754101 42754102	Supplemental Supplemental Supplemental Supplemental Supplemental Supplemental Supplemental
835.6200	Aquatic Field Dissipation	No data available	N/A	N/A
835.6300	Forestry Dissipation	No data available	N/A	N/A
850.1730	Accumulation in Fish	Study waived	N/A	N/A
850.1950	Accumulation Aquatic non-target organisms	No data available	N/A	N/A
835.7100	Ground Water- small prospective	No data available	N/A	N/A
166-2	Groundwater-small retrospective	No data available	N/A	N/A
201-1	Droplet Size Spectrum	No data available	N/A	N/A
202-1	Drift Field Evaluation	No data available	N/A	N/A

APPENDIX IV: T-REX Inputs and Outputs for Dicamba Use on Dicamba-Tolerant Soybeans.

Upper Bound Kenaga Residues For RQ Calculation

Chemical Name:	0	
Use	0	
Formulation	0	
Application Rate	1	lbs a.i./acre
Half-life	35	days
Application Interval	0	days
Maximum # Apps./Year	1	
Length of Simulation	1	year

Endpoints			
Avian	Bobwhite quail	LD50 (mg/kg-bw)	188.00
	Bobwhite quail	LC50 (mg/kg-diet)	0.00
	Mallard duck	NOAEL(mg/kg-bw)	0.00
	Mallard duck	NOAEC (mg/kg-diet)	800.00
Mammals		LD50 (mg/kg-bw)	2740.00
		LC50 (mg/kg-diet)	0.00
		NOAEL (mg/kg-bw)	45.00
		NOAEC (mg/kg-diet)	900.00

Dietary-based EECs (ppm)	Kenaga Values
Short Grass	240.00
Tall Grass	110.00
Broadleaf plants/sm Insects	135.00
Fruits/pods/seeds/lg insects	15.00

Summary of Risk Quotient Calculations Based on Upper Bound Kenaga EECs

Upper Bound Kenaga, Acute Avian Dose-Based Risk Quotients											
Size Class (grams)	Adjusted LD50	EECs and RQs									
		Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
20	135.44	273.34	2.02	125.28	0.92	153.75	1.14	17.08	0.13	3.80	0.03
100	172.42	155.87	0.90	71.44	0.41	87.68	0.51	9.74	0.06	2.16	0.01
1000	243.55	69.78	0.29	31.98	0.13	39.25	0.16	4.36	0.02	0.97	0.00

Upper Bound Kenaga, Chronic Avian Dietary Based Risk Quotients

NOAEC (ppm)	EECs and RQs							
	Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
800	240.00	0.30	110.00	0.14	135.00	0.17	15.00	0.02

Size class not used for dietary risk quotients

Upper Bound Kenaga, Acute Mammalian Dose-Based Risk Quotients												
Size Class (grams)	Adjusted LD50	EECs and RQs										
		Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	6022.06	228.82	0.04	104.88	0.02	128.71	0.02	14.30	0.00	3.18	0.00
35	4872.49	158.15	0.03	72.48	0.01	88.96	0.02	9.88	0.00	2.20	0.00
1000	2107.50	36.67	0.02	16.81	0.01	20.63	0.01	2.29	0.00	0.51	0.00

Upper Bound Kenaga, Chronic Mammalian Dietary Based Risk Quotients								
NOAEC (ppm)	EECs and RQs							
	Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
900	240.00	0.27	110.00	0.12	135.00	0.15	15.00	0.02

Size class not used for dietary risk quotients

Table X. Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients											
Size Class (grams)	Adjusted NOAEL	EECs and RQs									
		Short Grass		Tall Grass		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	98.90	228.82	2.31	104.88	1.06	128.71	1.30	14.30	0.14	3.18	0.03
35	80.02	158.15	1.98	72.48	0.91	88.96	1.11	9.88	0.12	2.20	0.03
1000	34.61	36.67	1.06	16.81	0.49	20.63	0.60	2.29	0.07	0.51	0.01

APPENDIX V: TerrPlant Inputs and Outputs for Dicamba Use on Dicamba-Tolerant Soybeans.

Table 1. Chemical Identity.	
Chemical Name	Diglycolamine salt (DGA) of Dicamba
PC code	128931
Use	Dicamba-Tolerant Soybeans
Application Method	Foliar
Application Form	Liquid
Solubility in Water (ppm)	6100

Table 2. Input parameters used to derive EECs.			
Input Parameter	Symbol	Value	Units
Application Rate	A	1	
Incorporation	I	1	none
Runoff Fraction	R	0.05	none
Drift Fraction	D	0.01	none

Table 3. EECs for Diglycolamine salt (DGA) of Dicamba. Units in .		
Description	Equation	EEC
Runoff to dry areas	(A/I)*R	0.05
Runoff to semi-aquatic areas	(A/I)*R*10	0.5
Spray drift	A*D	0.01
Total for dry areas	((A/I)*R)+(A*D)	0.06
Total for semi-aquatic areas	((A/I)*R*10)+(A*D)	0.51

Table 4. Plant survival and growth data used for RQ derivation. Units are in .				
	Seedling Emergence		Vegetative Vigor	
Plant type	EC_{25}	NOAEC	EC_{25}	NOAEC
Monocot	1.68	0.64	0.472	0.137
Dicot	0.123	0.0673	0.000513	0.000013

Table 5. RQ values for plants in dry and semi-aquatic areas exposed to Diglycolamine salt (DGA) of Dicamba through runoff and/or spray drift.*				
Plant Type	Listed Status	Dry	Semi-Aquatic	Spray Drift
Monocot	non-listed	<0.1	0.30	<0.1
Monocot	listed	<0.1	0.80	<0.1
Dicot	non-listed	0.49	4.15	19.49
Dicot	listed	0.89	7.58	769.23
*If RQ > 1.0, the LOC is exceeded, resulting in potential for risk to that plant group.				

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September 17, 2010

Environmental Protection Agency
Office of Pesticide Programs
Regulatory Public Docket (7502P)
1200 Pennsylvania Ave., NW
Washington, DC 20460

RE: Docket No.: EPA-HQ-OPP-2010-0496

Monsanto's petition seeking registration of the use of dicamba on dicamba-resistant soybeans raises a number of important issues, some specific to dicamba and dicamba-resistant crops, and others pertaining to the use of herbicide-resistant (HR) crop systems in general, and how they are regulated by USDA and EPA. We will first address the more general concerns with HR crop systems, followed by a discussion of issues specific to dicamba and dicamba-resistant soybeans.

I. Need for coordinated regulation of herbicide-resistant crop systems

Herbicide-resistant crops (when developed via genetic engineering) are the purview of the USDA, while the application to them of the crop-associated herbicide(s) is the purview of the EPA. The fundamental problem with this regulatory framework is that it fails to address significant issues and problems that arise from the combination.

Below, we argue that herbicide-resistant crops and their associated herbicides must be understood as ***herbicide-resistant crop systems (HRCSs)***, and that the Coordinated Framework must be adapted to regulate them as such. As things now stand, unregulated use of HRCSs have triggered and will continue to cause huge and costly agronomic problems for U.S. agriculture.

a) Distinctive features of HRCSs:

Herbicide-resistant crop systems have dramatically altered the way American farmers control weeds, and it is important to understand why this is so. We discern four distinctive features. With respect to the HR crop-associated herbicide(s), HRSCs facilitate:

1) A great expansion in treated acreage;

2) A dramatic widening of the temporal "application window" or period of the crop's life when the herbicide(s) can be applied;
3) Increased rate of application; and
4) Increased reliance, to the exclusion of other methods of weed control.

The discussion below relies heavily on empirical evidence from glyphosate-resistant, Roundup Ready crop systems, which at present represent nearly the entire universe of HRCSs. Lessons learned from analysis of glyphosate-resistant crop systems should be applied to better anticipate and manage problems created by future HRCSs, including dicamba-resistant soybeans.

Expanded acreage
Herbicide-resistance by definition permits direct application of the associated (usually broad-spectrum) herbicide(s) to a crop that was previously susceptible (or only slightly tolerant) to it. Widespread adoption of the HR crop thus triggers greatly expanded use. Glyphosate-resistant (GR), Roundup Ready crops are instructive in this regard. Prior to GR crop introduction, glyphosate was little used in field crops because it is extremely toxic to both cereal and broadleaf crops. Since their introduction in 1996, GR crops have been grown on roughly 1 billion acres. In 2008, GR soybeans, corn and cotton were planted on at least 130 million acres in the U.S. – over 90% of soybean and cotton acreage, roughly 60% of corn acreage. Thus, it is not surprising to learn that glyphosate use on soybeans, cotton and corn has increased by 15-fold in the U.S. from 1994, shortly before their introduction, to 2005. Thus far, biotech-pesticide firms have targeted HR crop development to the nation's highest acreage crops – corn, soybeans, wheat, alfalfa[1] and cotton – maximizing the expansion in acreage treated with HR crop-associated herbicides.

Widened application window
HR crops are designed to facilitate complete or primary reliance on post-emergence weed control. This means that a broad-spectrum herbicide whose use was previously limited to the beginning (burndown, pre-plant, pre-emergence) or end (burndown) of a crop season may now be applied one or more times through much or all of the crop's growing season. The widespread adoption of GR crops has greatly expanded the post-emergence use of glyphosate. In 1996, glyphosate was applied to soybean and cotton fields on average 1.1 and 1.0 times per season, reflecting the one-time burndown usage of glyphosate by some growers prior to GR crop introduction. In 2006 and 2007, glyphosate was used on average 1.7 and 2.4 times per season on soybeans and cotton, respectively, reflecting a shift to one or more post-emergent applications to GR versions of these crops. This greatly expanded temporal scope of application has many important impacts that will be discussed below.

Increased intensity

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[1] Glyphosate-resistant, Roundup Ready wheat was developed by Monsanto, though never introduced due to market rejection. USDA's decision to approve Roundup Ready alfalfa for commercial use was reversed by a U.S. district court due to inadequate environmental assessment by USDA.

HR traits eliminate the obstacles that previously attached to use of HR crop-associated herbicides. Yield-robbing crop injury is no longer a concern. The herbicide can be used through much or all of the crop's growing season. Thus, it is not surprising to find these herbicides used at greater annual rates. From 1996 to 2006 (soybeans) and 2007 (cotton), average one-time glyphosate application rates rose by approximately 25% for both crops, while ***annual per acre use*** of glyphosate approximately doubled for soybeans and tripled for cotton. These dramatically increased herbicide intensities reflect GR crop adoption rates that rose from 0% to over 90% for both soybeans and cotton over this period, as well as increased use to control glyphosate-resistant and glyphosate-tolerant weeds.

Increased reliance

Growers appreciate the flexibility and convenience of the post-emergence weed control regimes associated with HR crops. Effective pre-emergence weed control can be dependent on timely rainfall to activate a residual herbicide. Pre-emergence weed control is also of more limited effectiveness for slow-growing crops, and does not control weeds sprouting later in the season. In contrast, HR crops permit flexible post-emergence timing of herbicide application to more efficiently kill weeds. Thus, it is not surprising that HR crop systems foster exclusive or near-exclusive reliance on the associated herbicide(s). This same overreliance, however, is also a major downside of HRCSs, in that it leads to adverse consequences such as accelerated evolution of HR weeds. As discussed further below, unregulated use of GR crop systems has triggered massive emergence of GR weeds, which are imposing huge and growing costs on U.S. agriculture.

b) Adverse impacts of HRCSs

The distinctive features of HRCSs – including many of their real and perceived advantages – generate adverse consequences both for the growers of these crops, as well as farmers who choose not to grow them. In some cases, HRCSs impair common agricultural resources that are shared by all farmers. In some cases, these adverse impacts are novel. In others, HRCSs exacerbate negative impacts that have long been problems in farm country. Our focus below is on those negative impacts of HRCSs that affect growers of other crops.

Collateral damage

HR crops are usually high-acreage crops engineered for resistance to powerful, broad-spectrum herbicides, the premier example being GR crops and glyphosate. As HR crop adoption and use of the associated herbicide grows, so does the potential for injury to crops that don't carry the herbicide-resistance trait. Collateral damage of this sort is fostered by the large acreage treated with HR crop-associated herbicides, and even more by the expanded application window of the herbicide. Herbicides that were formerly restricted to use at the beginning or end of the agricultural season, when the potential for collateral damage was minimal, are now used throughout the season, with correspondingly greater opportunity to inadvertently harm other (non-HR) crops through drift, misapplication, or volatilization.

Spray drift is a problem that pre-dates, but has been greatly exacerbated by, HR crop adoption. The large acreage planted to GR crops mean that non-GR crop growers are often within "drift range" of a neighboring GR crop grower. Aerial application of glyphosate to GR crops in Arkansas has led to many episodes of injury to non-GR crops like rice. Simulated drift studies show that doses of glyphosate as low as 6.25% of the normal application rate can cause visible injury to conventional cotton, while 12.5% of the same reduces yield (Thomas et al 2005). Since drift incidents often go unreported, it is difficult to estimate the extent of crop injury they cause, but it is likely substantial.

Misapplication is another problem exacerbated by HR crops, as well as the growing trend for farmers to use contract pesticide applicators. These commercial operators, unfamiliar with an HR crop grower's fields, sometimes mistakenly apply an herbicide to an adjoining neighbor's field, causing severe crop injury if the crop is not HR.

Volatilization is another avenue for collateral damage, and is a particular problem in the case of highly volatile dicamba. Behrens and Lueschen (1979) report that post-emergence dicamba sprays used on 250,000 ha of corn in Minnesota in 1974 resulted in 68 reports of dicamba drift effects on soybeans. In contrast, post-emergence use of 2,4-D on 800,000 ha hectares of corn yielded just seven reports. In a series of field and glasshouse experiments, Behrens and Lueschen established that dicamba, volatilizing after application to corn, caused symptoms on soybean plants placed up to 60 meters downwind of the treated corn; that dicamba volatilizing from treated corn could be detected via effects on soybeans for three days after the application; and that dicamba volatilization was enhanced by higher temperatures and lower humidity, and extinguished by rainfall.

Interestingly, this team determined that dicamba acid and various salt forms had widely varying volatilization rates from glass surfaces, and that the vapors of more volatile salts (after application to corn) caused much greater damage to nearby soybeans in closed jars than did the less volatile salts. However, in field experiments, these differences largely disappeared. That is, less volatile salts applied to corn vaporized to damage downwind soybeans almost as much as the highly volatile (e.g. dimethylamine) salts. The diglycolamine salt is apparently less volatile than the widely used dimethylamine salt. However, this may not translate into lesser injury to crops from volatilization.

In tests involving the diglycolamine salt of dicamba, Andersen et al (2004) simulated dicamba drift injury by directly treating soybeans with 5.6 to 56 g a.e./ha dicamba (1% to 10% of the label rate for corn). These treatments reduced soybean yields by 14% to 93%. Andersen et al found greater soybean injury in the drier of the two years of their experiment, in line with the findings of Behren and Lueschen that rainfall extinguished dicamba's volatilization, and that lower humidity enhanced volatilization. Finally, it was found that dicamba applied in a mixture with crop oil concentrate, which enhances absorption of the active ingredient by crop tissues, resulted in slightly higher levels of injury. This highlights the importance of considering dicamba's activity in the forms in which it is actually used by farmers.

Kelly et al (2005) examined the impact of low-level dicamba in combination with other post-emergent herbicides on soybeans, to simulate the effect of dicamba vapor drift in a realistic soybean production setting. Similar to Andersen et al, this team found yield reductions from application of 5.6 g a.e./ha dicamba (1% the label rate for corn) either alone or in combination with each of several post-emergent soybean herbicides (glyphosate, imazethapyr, imazamox, or fomesafen) of from 7% to 41%, with the dicamba/fomesafen combination lowering soybean yield more than any of the other combinations. This study is important in establishing yield losses from soybean exposure to realistic volatilization drift rates (e.g. 1%) under field conditions where such exposure is accompanied by application of common post-emergent soybean herbicides.

Pesticide mixing tanks that harbor residues of dicamba also pose a substantial risk of crop injury to non-dicamba resistant crops that are sprayed from them, in particular soybeans, given their extreme sensitivity to damage from this herbicide. Other crops that are very sensitive to dicamba damage are tomatoes and grapes.

At present, dicamba is applied primarily to corn, which as a monocot (cereal) is naturally tolerant of the herbicide. But at present, the many farmers who utilize the common corn-soybean rotation are less likely to use dicamba on their corn if they are also growing soybeans, from fear of dicamba vapors harming their soybeans. This constitutes a substantial barrier to wider use of this herbicide, which is quite effective and cheap, and helps explain why it was applied to only 12% of U.S. corn acres in 2005, the last year for which USDA NASS data are available. Introduction of dicamba-resistant soybeans would increase dicamba use in two ways. First, it would facilitate dicamba use on tens of millions of acres of soybeans that had previously not been treated at all with this herbicide. Second, it would expand dicamba use on corn, since adoption of dicamba-resistant (DR) soybeans would eliminate the fear of vapor damage in those (many) cases where corn would be grown near DR soybeans.

Pennsylvania State University weed scientist Dave Mortensen estimates that dicamba-resistant soybeans and 2,4-D resistant soybeans will increase herbicide use on soybeans by approximately 70% within a few years of their introduction (Mortensen 2010).

Defensive adoption and its costs

Clearly, the highly volatile nature of dicamba; its ability to injure broadleaf crops like soybeans, tomatoes and grapes at extremely low levels; and the substantial increase in usage expected in consequence of DR soybean adoption, all add up to a significant threat to any farmer growing a non-cereal crop that does not carry a dicamba-resistance trait.

A substantial but undetermined proportion of Roundup Ready corn adoption is attributable to defense – that is, protection from the hazards of spray drift and misapplication in a Roundup Ready world. According to Ford L. Baldwin, of Arkansas-based Practical Weed Consultants, Inc.:

> "A lot of growers planted Roundup Ready corn in the beginning out of self defense. I looked at enough glyphosate drift on conventional corn to understand why."[2]

With the still greater hazards of dicamba volatility, any substantial adoption of DR soybeans would certainly drive many other soybean growers to purchase DR seeds for purposes of "self-defense." Thus, there would likely be a stampede from Roundup Ready soybeans to those conferring resistance to dicamba (perhaps stacked with glyphosate), even by those growers who had no interest in using the DR trait through post-emergence application of dicamba. This would mean, first of all, that farmers would take an economic hit by purchasing a costly DR trait that they do not want to use, and wouldn't need to purchase in a world without that DR trait. Second, it would encourage these very same involuntary adopter farmers to make use of the DR trait that they had purchased initially only for "self-defense." Paying a royalty for a biotech trait constitutes an inducement to make use of it, especially since dicamba is off-patent and cheap, and glyphosate-resistant weeds are legion (note that Baldwin, quoted above, states that growers purchased Roundup Ready corn seed out of self defense ***in the beginning***, implying that they later made use of the trait through reliance on glyphosate).

This additional spur to usage of dicamba (beyond that from growers who actually do want to use the DR trait) would of course redouble selection pressure for evolution of dicamba-resistant weeds. At present, www.weedscience.com lists eight reports of weeds resistant to dicamba, four of them in the U.S.: dicamba-resistant kochia in North Dakota, Idaho and Montana (all 1990s); and dicamba-resistant prickly lettuce in Washington State (2007). While this might be interpreted as indicating a low propensity for weed evolution of resistance to dicamba, it must be recalled that glyphosate-resistant weeds were practically unknown prior to the advent of GR crops. It was only 3-4 years after the introduction of GR soybeans that the decade-long epidemic of GR weeds began. In that short time, GR weeds have expanded from a few thousand acres to infest over 10 million acres in the U.S. alone, a larger acreage than that infested by weeds resistant to any other class of herbicides (ALS inhibitor-resistant weeds come in second). Clearly, a substantial increase in the use of, and reliance on, dicamba, could drive a similar dramatic increase in weeds resistant to this herbicide.

Dicamba-resistant soybeans will likely be introduced in versions stacked with glyphosate resistance. The conventional wisdom holds that dicamba will eliminate GR weeds, while glyphosate will prevent the emergence of any DR weeds. This facile theorizing ignores a basic fact – namely, that over ten million acres are ***already*** infested with weeds that are resistant to glyphosate. Use of dicamba on even a portion (that planted to DR/GR crops) of this huge expanse of land, harboring enormous populations of GR biotypes, will certainly select for the dicamba-resistant biotypes that exist among the innumerable glyphosate-resistant weeds. The result will be biotypes that are resistant to both glyphosate and dicamba. Multiple herbicide-

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[2] Baldwin, F.L. (2010). "Herbicide drift damaging rice," Delta Farm Press, June 7, 2010. Baldwin is drawing an analogy between defensive adoption of Clearfield rice and Roundup Ready corn.

resistant weeds, already expanding rapidly, will be spurred on to propagate still more by the adoption of multiple-herbicide-resistant crops such as dicamba/glyphosate-resistant soybeans.

Conclusion

Monsanto has only recently submitted its petition for deregulation of DR soybeans to the USDA, which will not take action for a year or more. EPA is urged to postpone consideration of Monsanto's request to register the diglycolamine salt of glyphosate for use on soybeans until a thorough and coordinated analysis of the ***dicamba-resistant soybean system*** has been carried out jointly by EPA together with USDA. Without such coordinated assessment and regulation of HR crop systems, American agriculture will be pushed willy nilly, without forethought or consideration, into a new age of agriculture that is still more pesticide-intensive, environmentally damaging, and unsustainable as the current one.

Bill Freese, Science Policy Analyst
Center for Food Safety

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JUNE 4, 2010

Superweed Outbreak Triggers Arms Race

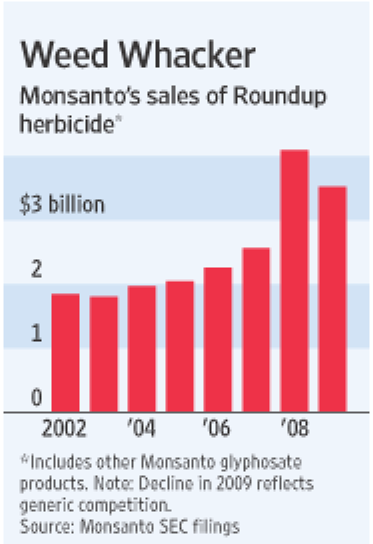
By SCOTT KILMAN

Associated Press

Hardy superweeds immune to the Farm Belt's most effective weedkiller are invading fields, prompting a counterattack from agribusiness that could leave farmers using greater amounts of harsh old-line herbicides.

The flagging weedkiller is Roundup. Its developer, Monsanto Co., also sells seeds for corn, soybean and cotton plants unaffected by the chemical, enabling farmers to spray it on freely without fear of harming their crops. Farmers now do so en masse, using "Roundup Ready" crop varieties for 90% of the soybeans and 80% of the corn grown across the U.S.

The rise of Roundup, more than a decade ago, sent older herbicides that damage both weeds and crops into deep eclipse. But now, as nasty invaders with names like pigweed, horseweed and Johnsongrass develop immunity to the mighty Roundup, chemical companies are dusting off the potent herbicides of old for an attack on the new superweeds.



And big chemical companies—taking a page from Monsanto's book—are engineering crop varieties that will enable farmers to spray on the tough old weedkillers freely, instead of having to apply them surgically in order to spare crops.

Dow Chemical Co., DuPont Co., Bayer AG, BASF SE and Syngenta AG are together spending hundreds of millions of dollars to develop genetically modified soybean, corn and cotton seeds that can survive a dousing by their herbicides, many decades old.

"It will be a very significant opportunity" for chemical companies, says John Jachetta, a scientist at Dow Chemical's Dow AgroSciences and president of the Weed Science Society of America. "It is a new era."

The bioengineering push is causing controversy, though. Some of the old pesticides—in particular, those called 2,4-D and dicamba—have a history of posing more risks for the environment than the chemical in Roundup. That's partly because they have more of a tendency to drift on the wind onto neighboring farms or wild vegetation. Roundup tends to adhere better to the ground.

The chemical companies are betting their biotech investments will pay off in two ways: Farmers will buy more of their herbicides, and will pay big premiums for the new seeds.

Some 40% of U.S. land planted to corn and soybeans is likely to harbor at least some Roundup-resistant superweeds by the middle of this decade, executives at DuPont estimate. That could create big demand for the herbicides that can kill the evolved weeds—and for the seeds of crops that permit free use of those herbicides.

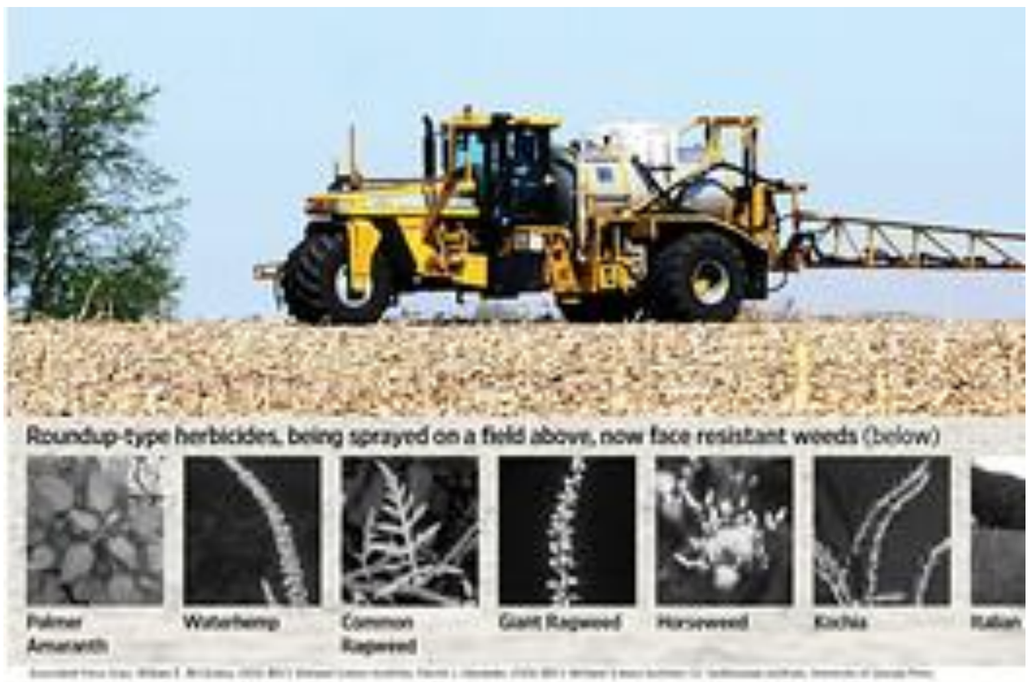
The new herbicide-tolerant seeds "would make controlling weeds very easy for farmers," says David Mortensen, a weed scientist at Pennsylvania State University. As a result, he says, the amount of herbicide sprayed on just one major crop, soybeans, could climb roughly 70%.

The burst of efforts by rivals isn't necessarily bad for Monsanto's crop-biotech business, at least in the short term. The chemical in Roundup remains able to kill hundreds of kinds of weeds and will remain a central part of the farmer's arsenal. Most companies developing crops tolerant of other herbicides want to build them on a Roundup Ready platform, so to speak—putting their new herbicide-tolerant genes into crops that already carry tolerance for Roundup.

Yet the developments portend further turmoil in the $12 billion U.S. pesticide industry. Monsanto already is cutting prices for Roundup to compete with a flood of cheap Chinese-made generics. The patent for Roundup expired years ago. The St. Louis company has cut its earnings outlook recently to reflect both generic competition and a backlash by farmers against the steep prices it charges for genetically modified seeds. Its stock has dropped 39% this year.

Monsanto also is facing the 2014 expiration of the patent on the key gene in seeds for soybeans tolerant of the weedkiller.

Round-type herbicides, being sprayed on a field above, now face resistant weeds.

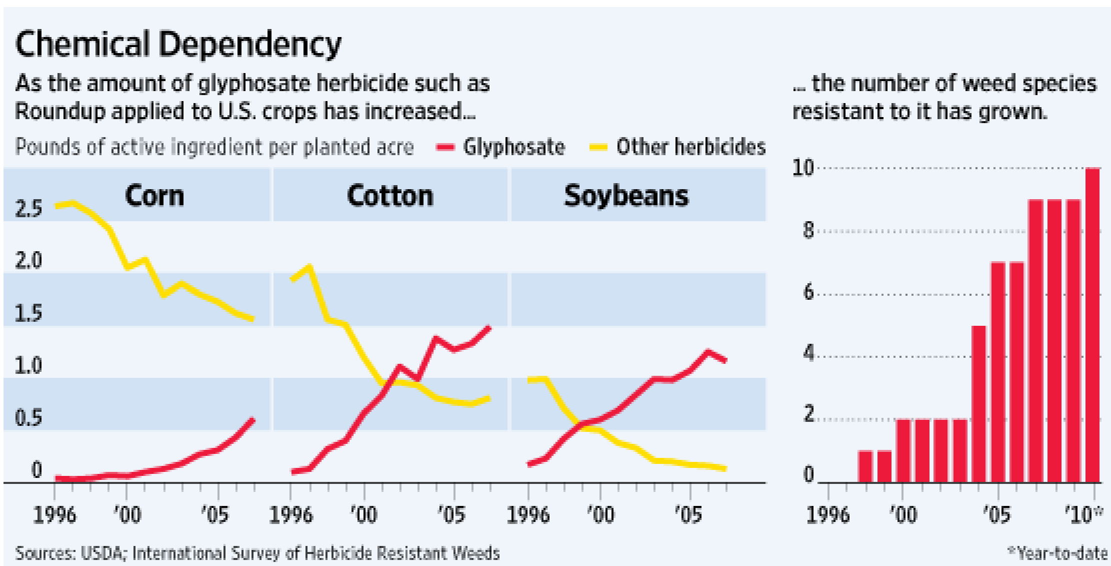


It was back in the 1990s that Monsanto upended the herbicide industry and farming practices by offering its first genetically modified product—soybean seeds into which scientists had transplanted genetic material from microorganisms and petunias. The seeds sprouted soybean plants that could survive exposure to Roundup. Chemically known as glyphosate, Roundup was known for its ability to kill almost anything green yet leave a relatively small environmental footprint, being less toxic to wildlife and people than most weedkillers. "If glyphosate isn't the safest herbicide, it is damn close," says Charles Benbrook, chief scientist of the Organic Center, a nonprofit organic advocacy group.

The new seeds meant farmers could leave behind the risk and guesswork of choosing the right herbicides to spray, at exactly the right time, on the right weeds. Weed control became so easy that many farmers sold off their weed-tilling implements and stopped buying other pesticides.

The chemical weed control even had some environmental pluses because it left the soil undisturbed, reducing erosion. Farmers burned less fuel, no longer needing to crisscross fields with implements that root out weeds. The Roundup revolution, as some called it, freed up time for growers to plant more land, helping spur bigger farms.

Monsanto's sales and profits soared while other herbicide makers suffered. DuPont's leading herbicide for soybean farmers, called Classic, lost about 90% of its business. Some industry players were swept into mergers, and research spending wilted. Today, Roundup and its generic competitors are used on nearly four times as many U.S. acres as any other herbicide.



But weeds are adapting. At least nine species have developed immunity to it. They've spread to millions of acres in more than 20 states in the Midwest and South.

Ron Holthouse, a farmer who grows cotton and soybeans on 8,600 acres near Osceola, Ark., says he spends hundreds of thousands of dollars annually on the herbicide. But after 10 years of use on his land, Roundup no longer controls pigweed, which ran rampant in his fields last year.

The weed, which can grow six feet high on a stalk like a baseball bat, is tough enough to damage delicate parts of his cotton-picking equipment. Mr. Holthouse had to hire a crew of 20 laborers to attack the weeds with hoes, resorting to a practice from his father's generation. For the first time in years, Mr. Holthouse used some of an older, highly poisonous weedkiller called paraquat.

Many Southern farmers are spending twice as much on killing weeds as it typically cost them just a few years ago. "It is getting a lot harder and expensive to run a big farm," says Mr. Holthouse. "This is nerve-racking."

Farmers have no wish to return to labor-intensive methods. The success of expensive seeds that are Roundup-tolerant shows growers will pay a steep premium to control weeds chemically.

Chemical companies are tight-lipped about their development of crops that can tolerate the spraying of herbicides other than Roundup. BASF and Bayer filed petitions last year with biotech regulators at the U.S. Department of Agriculture, seeking permission to market new herbicide-tolerant seeds. The USDA hasn't yet released its environmental assessments. Several of the genetically modified plants are still in field trials or in the laboratory.

Dow AgroSciences manufactures 2,4-D, a powerful herbicide introduced nearly 65 years ago. The company hopes by 2013 to be selling seeds for corn crops that will be unaffected if farmers splash 2,4-D on their fields. The company hopes to have seeds for soybeans tolerant of the herbicide a year later, and is also working on a herbicide-tolerant cotton variety.

It won't predict how the new seeds might help its sales of 2,4-D, but it's optimistic enough that it's developing a new form of the herbicide.

Some winery owners are concerned that such efforts will renew farmer demand for 2,4-D, to which grapes are highly sensitive if the herbicide drifts from a farm sprayer onto vines. "I couldn't survive in this business if 2,4-D resistant seed catches on in cotton country," says Neal Newsom, whose 100-acre vineyard in Plains, Texas, is surrounded by cotton fields. "A neighbor could take me out in one night."

The Natural Resources Defense Council petitioned the Environmental Protection Agency in 2008 to ban 2,4-D, citing research that suggests it disrupts hormones in trout, rodents and sheep. Dow says it is providing rebuttal data to the agency. A spokesman for the EPA said it anticipates responding to the petition this fall.

Both 2,4-D and dicamba, another older herbicide, are common ingredients in weedkillers at lawn-and-garden stores, which homeowners are careful to keep away from flowers and vegetables. Chemical companies say both are safe in larger amounts if farmers follow usage instructions cleared years ago by the EPA.

Allthough dicamba could kill superweeds such as Mr. Holthouse's pigweed, soybean farmers haven't sprayed it because it kills soybeans, too. A dicamba-tolerant soybean variety would change that. Monsanto itself is developing one.

Bayer is developing soybeans that can survive exposure to a herbicide that disables weeds' defense to ultraviolet rays, setting them up for a fatal sunburn. Bayer hopes to have those soybean seeds on the market in 2015 and later give corn and cotton plants immunity to the same herbicide, called isoxaflutole.

As for Monsanto, its chairman and chief executive, Hugh Grant, hinted in a call with analysts last week that the company is considering whether to begin selling farmers cheap, off-patent weedkillers that can kill Roundup-tolerant weeds. On Thursday a Monsanto spokeswoman, Kelli Powers, said, "We remain committed to working with farmers to manage weed resistance," adding, "We have a shared interest with farmers in continuing to deliver environmental and production benefits on the farm with glyphosate."

Monsanto, in fact, is launching a second generation of Roundup Ready seeds. Competitors continue to try to develop their own plant varieties tolerant of the chemical in Roundup. DuPont's big Pioneer Hi-Bred seed business, for example, plans to begin selling seed for soybean and corn plants that can tolerate exposure to both the Roundup chemical and other herbicides.

Swiss-based Syngenta, meanwhile, is field-testing soybeans genetically engineered to tolerate exposure to a relatively new herbicide Syngenta makes called Callisto.

"The herbicide business used to be good before Roundup nearly wiped it out," says Dan Dyer, head of soybean research and development at Syngenta. "Now it is getting fun again."

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

PC Codes: 029801, 029802, 029806, 128931,
128944, 129043
DP Barcode: 317696

August 31, 2005

MEMORANDUM

Subject: EFED Reregistration Chapter For Dicamba/Dicamba Salts

To: Susan Lewis, Branch Chief
Reregistration Branch 1
Special Review and Reregistration Division

From: William Erickson, Biologist
Ibrahim Abdel-Saheb, Environmental Scientist
Shannon Borges, Biologist
Environmental Risk Branch 2, Environmental Fate and Effects Division

Through: Thomas Bailey, Branch Chief,
Environmental Risk Branch 2, Environmental Fate and Effects Division

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EFED has completed a screening-level ecological risk assessment for the proposed reregistration of dicamba and its salts. Dicamba is a benzoic acid herbicide formulated for use in agricultural and residential settings. Its major use is weed control in corn, with other major use sites including wheat, barley, pastures, and lawn and turf. The risk assessment is based on toxicity and environmental fate studies submitted to support the registration of dicamba and its salts and on ecological modeling to estimate environmental concentrations. EFED's risk conclusions are summarized below.

- listed and non-listed terrestrial plants are at risk from runoff and drift from all use sites
- risk exists to non-vascular aquatic plants but is minimal for listed and non-listed vascular aquatic plants
- acute risk exists to listed and non-listed birds
- acute risk exists to small, listed mammals exposed to maximum residues from application to sugarcane
- chronic risk exists for listed and non-listed mammals
- minimal risk is expected to listed and non-listed vascular aquatic plants

- no adverse effects are expected for listed and non-listed freshwater and estuarine fish and aquatic invertebrates

The following data gaps have been identified (see Appendix E for further details):

- seedling emergence and vegetative vigor studies (123-1a,b); dicamba acid, TEP
- seedling emergence and vegetative vigor studies (123-1a,b); dimethylamine salt, TEP
- seedling emergence and vegetative vigor studies (123-1a,b); diglycoamine salt, TEP
- seedling emergence and vegetative vigor studies (123-1a,b); isopropylamine salt, TEP
- seedling emergence and vegetative vigor studies (123-1a,b); sodium salt, TEP
- seedling emergence and vegetative vigor studies (123-1a,b); potassium salt, TEP

Note: These seedling emergence and vegetative vigor tests can each be limited to the five most sensitive species determined in previous testing with the technical grade of dicamba acid (MRID no. 42846301). Those species are soybean, onion, turnip, tomato, and lettuce.

EFED plans on conducting further refinements to this assessment after registrant comments have been received. These refinements include the following:

- An AgDrift analysis will be completed.
- An assessment of exposure and risk from granular formulations will be conducted.
- RQs for listed terrestrial plants will be recalculated.
- Available incident data will be more fully evaluated.
- ECOTOX literature references will be examined for relevant information.

Environmental Fate and Ecological Risk Assessment for the Reregistration of Dicamba and Dicamba Sodium, Potassium, Diglycoamine, Dimethylamine and Isopropylamine Salts

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I. EXECUTIVE SUMMARY

A. Nature of Chemical Stressor

Dicamba was first registered in the United States in 1967 and is widely used in agricultural, industrial and residential settings. Dicamba is used as an ingredient in agricultural and home use products, as a sole active ingredient and in conjunction with other active ingredients. Dicamba is a benzoic acid herbicide similar in structure and mode of action to phenoxy herbicides. Typical terrestrial application methods consist of ground and aerial spray to the leaves or to the soil. Dicamba controls annual, biennial and perennial broadleaf weeds in crops and grasslands, and it is used to control brush and bracken in pastures. In combination with a phenoxyalkanoic acid or other herbicide, dicamba is used in pastures, rangeland, and non-crop areas such as fence-rows and roadways to control weeds. Dicamba is absorbed by leaves and roots, and moves throughout the plant acting at multiple sites to disrupt hormone (auxin) balance and protein synthesis, resulting in plant growth abnormalities. Dicamba is formulated primarily as a salt in an aqueous solution. Supported forms are; dicamba acid (29801), dicamba dimethylamine salt - DMA (29802), dicamba sodium salt (29806), dicamba diglycoamine salt - DGA (128931), dicamba isopropylamine salt (128944) and dicamba potassium salt (129043).

B. Potential Risks to Non-target Organisms

For this screening risk assessment, the potential exposure of dicamba and its salts to aquatic and terrestrial endpoints was modeled. The Tier II PRZM(3.12)/EXAMS(2.98) models were used to estimate exposure concentrations for aquatic animals and plants in surface water. The potential levels of dicamba residues on various food items for birds and terrestrial mammals was modeled using the T-REX 1.2.3. Likewise, the TerrPlant 1.0 model estimated exposure to nontarget plants. The risk assessment indicates risk to non-target terrestrial plants and freshwater non-vascular plants; acute sublethal risk to birds; chronic (developmental/reproductive) risk to mammals; and potential risks to listed species (birds, small mammals, terrestrial and semi-aquatic monocots and dicots) from dicamba use based on the maximum application rates of 2.8 lbs ae/acre for sugarcane, 2.0 lbs ae/acre for hay, pasture/rangeland, soybean and turf, 1.0 lbs ae/acre for wheat and 0.75 lbs ae/acre for corn.

The results of this screening risk assessment indicate that dicamba applied at the maximum rates according to label directions as a liquid spray for ground or aerial applications will impact non-target plants for some distance from the application site. Results of Tier I and II toxicity studies with monocots and dicots indicate that seed germination, seedling emergence, and vegetative vigor are impacted by exposure to dicamba. For the modeled scenarios at the label maximum application rates of 2.8, 2.0, 1.0 and 0.75 lbs ae/acre, Acute Risk LOCs for non-listed monocots and dicots located adjacent to treated areas, in semi-aquatic areas, and as a result of spray drift were exceeded. Spray drift from coarse sprays would be expected to damage non-target plants that are closer to the target site; whereas, finer sprays have the potential to travel greater distances. Exposure will depend on droplet size, wind speed, and other factors. Highly active herbicides, such as the growth regulators, present the greatest drift hazard because small amounts can cause severe problems. Even if only a small surface area of the plant is exposed to dicamba, or a seedling is exposed to dicamba as it breaks through the soil surface, there is a possibility that the plant may be severely damaged or die as a result. The resulting damage, even if only minor, may be sufficient to prevent the plant from competing successfully with other plants for resources and water. Currently, some labels for the registered dicamba herbicides place restrictions on droplet size, wind speed or ambient temperatures during application. These specific requirements are intended to reduce the potential exposure of spray drift to susceptible non-target plants.

The results of this screening risk assessment indicate that dicamba applied at the maximum rates according to label directions as a liquid spray for ground or aerial applications will impact freshwater non-vascular plants. The non-listed Acute Risk LOC for the non-vascular aquatic plant (blue green algae) was exceeded; consequently, direct effects to growth, development, and reproduction of aquatic non-vascular plants inhabiting surface waters adjacent to a treated field may occur when exposed to dicamba as the result of the labeled use of the herbicide.

The results of this screening risk assessment indicate that dicamba applied at the maximum rates according to label directions as a liquid spray for ground or aerial applications will impact avian species. The Acute Use and Acute Restricted Use LOCs were exceeded for all weight-classes of birds (20, 100, 1000 g) consuming short grasses, tall grasses and broadleaf forage/small insects and for small birds (20 g) consuming fruit, pods, seeds, and large insects at the higher application rates (2.8 and 2.0 lbs ae/acre) and maximum predicted residues. In addition, the Acute Use and Acute Restricted Use LOCs were exceeded for 20 and 100 g birds consuming short grasses, tall grasses and broadleaf forage/small insects and for large birds (1000 g) consuming short grasses at the lower application rates (1.0 and 0.75 lbs ae/acre) and maximum predicted residues. For mean predicted residues, the Acute Use and Acute Restricted Use LOCs were exceeded for small birds (20 and 100 g) consuming short grasses, tall grasses and broadleaf forage/small insects and for large birds (1000 g) consuming short grasses at the higher application rates (2.8 and 2.0 lbs ae/acre). In addition for mean predicted residues, the Acute Use and/or Acute Restricted Use LOCs were exceeded for 20 g birds consuming short grasses, tall grasses and broadleaf forage/small insects and for100 g birds consuming short grasses at the lower application rates (1.0 and 0.75 lbs ae/acre). Consequently, there may be a concern for potential indirect effects to listed species dependent upon birds for food, pollination or seed dispersal, or habitat. Consequently, based on these results, birds may be subject to sublethal effects and indirect effects on foraging behavior when acutely exposed to dicamba as a result of the labeled use of the herbicide.

Assuming maximum residue levels at the maximum application rates of 2.8, 2.0, 1.0 and 0.75 lbs ae/acre, Chronic Risk LOCs were exceeded for mammals consuming short grass, tall grass and broadleaf forage/small insects. There were no exceedances of Chronic Risk LOC for mammals consuming fruit, seeds, pods and large insects. The risk assessment and calculated RQs assume 100% of the diet is relegated to single food types foraged only from treated fields. These assumptions may overestimate risk, especially considering that contaminated food items might be avoided for more preferred items and diets would likely be more variable over longer periods of time. Other exposure routes are possible for animals residing in or moving through treated areas. Consumption of drinking water would appear to be inconsequential if water concentrations were equivalent to the concentrations from PRZM/EXAMS; however, concentrations in puddled water sources on treated fields may be higher than concentrations in modeled ponds. Preening and grooming exposures, involving the oral ingestion of material from the feathers or fur remains an unquantified, but potentially important, exposure route. Consequently; based on these results, mammals may be subject to developmental/ reproductive effects and direct effects on foraging behavior when chronically exposed to dicamba as a result of the labeled use of the herbicide.

Exposure to dicamba results in direct effects to plant species that could result in indirect effects at the higher levels of organization (i.e. population, trophic level, community, ecosystem). The guideline terrestrial plant studies indicate direct adverse effects to seedling emergence and vegetative vigor, as well as non-lethal effects including brown leaf tips, necrosis, chlorosis, stem tumors, leaf curl, and decrease in size. In terrestrial and shallow-water aquatic communities, plants are the primary producers upon which the succeeding trophic levels depend. If the available plant material is impacted due to the effects of dicamba, this may have negative effects not only on the herbivores, but throughout the food chain. Also, depending on the severity of impacts to the plant communities (edge and riparian vegetation), community assemblages and ecosystem stability may be altered (i.e. reduced bird populations in edge habitats; reduced riparian vegetation resulting in increased light penetration and temperature in aquatic habitats). In addition, allochthonous input from riparian vegetation is not only a significant component of the food supply for aquatic herbivores and detritivores but also provides habitat (i.e. leaf packs, materials for case-building for invertebrates).

The screening risk assessment for listed species indicates potential risk to the following taxonomic groups for the dicamba use scenarios as specified below:

- small birds (20g) feeding on short grasses, tall grasses, broadleaf forage/small insects, and fruit/pods/seeds/large insects at all application rates
- small birds (100 g) feeding on short grasses, tall grasses, and broadleaf forage/small insects at 0.75 and 1.0 lbs ae/acre
- small birds (100 g) feeding on short grasses, tall grasses, broadleaf forage/small insects, and fruit/pods/seeds/large insects at 2.8 and 2.0 lbs ae/acre
- large birds (1000 g) feeding on short grasses, tall grasses, and broadleaf forage/small insects at all application rates
- small (15 g) mammals feeding on short grasses at 2.8 lbs ae/acre
- non-target terrestrial plants - monocots and dicots adjacent to treated areas and in semi-aquatic areas at all application rates (all uses modeled) by ground and aerial spray application.

Although exceedances occurred with comparisons of RQs calculated from mean Kenaga EECs to listed species LOCs, screening level risk assessments rely on maximum residues. Mean Kenaga EECs may be considered more closely in future refined risk assessments.

Since the Listed Species LOCs for birds, small mammals, and terrestrial monocots and dicots are exceeded for the use of dicamba, the LOCATES was run for all taxonomic groups. For terrestrial monocots and dicots, both the Acute Risk LOCs for non-listed species and the Listed Species LOCs were exceeded; consequently a potential concern arises for species with both narrow (i.e., species that are obligates or have very specific habitat or feeding requirements) and general dependencies (i.e., cover type requirements). Information from LOCATES indicates that for the corn, wheat, sugarcane and pasture/grazing uses, several potentially affected species of birds, mammals, reptiles and plants appear to be co-located with pesticide use areas. Consequently, there may be a concern for potential indirect effects to listed species dependent upon birds that consume feed items (short and tall grasses; broadleaf plants; small and/or large insects; and fruits, seeds, and pods) contaminated with dicamba residues; such as predatory birds and mammals. In addition, there may be a potential concern for indirect effects related to plants that require birds and/or mammals for pollination or seed dispersal and for animals that use burrows for shelter or breeding habitat.

This screening risk assessment indicates that there are no acute risks to fish, aquatic invertebrates, aquatic vascular plants and mammals at maximum application rates of 2.8, 2.0, 1.0 and 0.75 lbs ae/acre. In addition, there are no chronic risks to birds at the maximum application rates. Consequently, fish, aquatic invertebrates and aquatic vascular plants inhabiting surface waters adjacent to a dicamba treated field would not be at risk for adverse acute effects on reproduction, growth and survival when exposed to residues in surface runoff and spray drift as a result of ground and/or aerial spray application. Likewise, acute risks to mammals and chronic risks to birds consuming food types containing dicamba residues are not expected from the labeled uses of the herbicide. EFED currently does not quantify risks to terrestrial non-target insects.

C. Conclusions - Exposure Characterization

EFED established a strategy for bridging the environmental fate data requirements for the dicamba sodium and potassium salts, dimethylamine salt (DMA), isopropylamine salt and diglycoamine salt (DGA) to the dicamba acid. Bridging data were submitted indicating that the dicamba salts will be rapidly converted to the free acid of dicamba. A laboratory dissociation study showed that each dicamba salt (tested at >99% purity) completely dissociated to dicamba acid within 75 seconds in pure water. EFED determined that fate studies conducted with dicamba acid provide “surrogate data" for the dicamba salts. However, there is uncertainty regarding the fate of formulated typical end use products (TEPs) containing the dicamba salts in the environment. The influence of inert ingredients and additives, in formulated TEPs, on the degradation potential are unknown.

Based on the physical and chemical properties as well as the laboratory fate studies, dicamba acid is very soluble (6100 mg/L) and very mobile in laboratory soil studies thus it is expected to mobile in environmental settings. Aerobic soil metabolism is the main degradative process for dicamba acid. A single observed half-life for dicamba acid was six days, with formation of the intermediate non-persistent degradate 3,6-dichlorosalicylic acid (DCSA). DCSA degraded at approximately the same rate as dicamba with the final metabolites being carbon dioxide and microbial biomass. Dicamba is stable to abiotic hydrolysis at all pH's and photodegrades slowly in water and on soil. Dicamba is more persistent under anaerobic soil:water systems in the laboratory, with a half-life of 141 days. The major degradate under anaerobic conditions was DCSA, which was persistent, comprising > 60% of the applied after 365 days of anaerobic incubation. There are no acceptable data for the aerobic aquatic metabolism of dicamba; supplemental information indicates that dicamba degrades more rapidly in aquatic systems when sediment is present. Dicamba is not expected to bioaccumulate in aquatic organisms because it is an anion at environmental pHs (pKa = 1.9).

Routes of exposure evaluated in this screening risk assessment focused on deposition, runoff and spray drift from ground and aerial spray applications of dicamba. The dicamba exposure characterization combined the environmental fate data with Tier II exposure models to estimate environmental exposure concentrations (EECs). EECs for aquatic endpoints were developed using the Tier II surface water models PRZM/EXAMS. These models are more comprehensive and determine EECs based on geographic areas nationwide and product use sites in close proximity to water bodies. Likewise, EECs for birds and terrestrial mammals were estimated using the T-REX 1.2.3 model and EECs for non-target terrestrial plants are estimated by the TerrPlant 1.0 model. A review of ground water and surface water monitoring data indicate historical detections of dicamba at low concentrations (<1.14 µg/L). Approximately, 100 incidents have been reported associated with dicamba usage. Incidents reported include impacts to terrestrial and aquatic non-target plants and animals. The majority of reported incidents are damage to plants including a wide range of crops (corn, sorghum, soybeans, sugar beets and wheat) as well as impacts to non-crop plants. The specific impacts varied from browning and plant damage to mortality of all plants within the treated area. Aquatic impacts reported consist of three fish kill incidents associated with pasture and residential turf application.

D. Conclusions - Effects Characterization

Spray drift and runoff to adjacent bodies of water are the most likely sources of dicamba and dicamba salts exposure to nontarget aquatic organisms. Available acute toxicity data indicate that dicamba acid appears to be slightly toxic to freshwater fishes (rainbow trout and bluegill sunfish) and the sodium salt of dicamba is slightly toxic to daphnids. No toxicity studies have been conducted to determine potential chronic effects to fish and aquatic invertebrates. Toxicity studies with non-vascular aquatic plants exposed to dicamba acid indicate that cell densities were significantly reduced in blue-green algae. However, aquatic vascular plant species were not sensitive to dicamba acid. Data are currently unavailable to determine potential impacts to sediment-dwelling benthic organisms and to riparian habitats.

Ground deposition and spray drift with resulting residues on foliage and on insects and seeds are the most likely sources of dicamba exposure to nontarget terrestrial birds and mammals, including listed species. In addition, uptake in plant roots could occur through ground spray application. Available acute toxicity data indicate that the s dicamba salts are practically non-toxic to bobwhite quail and mallard ducklings in the diet; however, oral gavage studies indicate that dicamba acid was moderately toxic to bobwhite quail and slightly toxic to mallard ducks. In chronic studies with dicamba acid, a reduction in hatchability was observed in mallard ducks. No treatment-related mortality, signs of toxicity, or effects on reproduction were observed in bobwhite quail. Dicamba acid is classified as practically non-toxic to small mammals on an acute oral basis. In a 2-generation rat reproduction study, maternal neurotoxicity was observed as well as decreased pup growth. Developmental studies with rabbits reported irregular ossification of internasal bones and maternal toxicity. Mortality, clinical signs of toxicity, body weight changes, and decreased food consumption, was also observed in rats. In addition, sublethal effects were reported in subchronic feeding studies. The reproductive and developmental effects observed in these studies may lead to a potential concern for impacts to populations of mammals consuming feed items contaminated with dicamba and to the predators that feed on them. Since, dicamba is classified as practically non-toxic to bees on a contact exposure basis (LD_{50} > 90.65 µg/bee); the potential for dicamba to have adverse effects on pollinators and other beneficial insects is low. Therefore, the label does not need a warning for honey bees.

Terrestrial plant toxicity studies indicate that dicamba acid negatively impacts seed germination (radicle length; soybean EC_{25} = 0.036 lb ai/A), seedling emergence (shoot length;

soybean EC_{25} = 0.0027 lb ai/A), and vegetative vigor (shoot length; soybean EC_{25} = 0.0068 lb ai/A) in monocots and dicots. The most sensitive monocot tested was onion (EC_{25} = 0.071 lb ai/A - seed germination; EC_{25} = 0.0044 lb ai/A - seedling emergence; and EC_{25} = 0.1507 lb ai/A - vegetative vigor). Non-lethal effects included brown leaf tips, necrosis, decrease in size, leaf curling, chlorosis, and stem tumors. Consequently, spray drift presents a potential risk to non-target plants inhabiting edge habitats adjacent to target fields and riparian vegetation along streams and/or ponds in close proximity to sprayed fields.

E. Uncertainties and Data Gaps

There are a number of areas of uncertainty in the terrestrial and the aquatic organism risk assessments that could potentially cause an underestimation of risk. First, this assessment accounts only for exposure of non-target organisms to dicamba, but not to its degradates. The risks presented in this assessment could be underestimated if degradates also exhibit toxicity under the conditions of use proposed on the label. Data are not available concerning the fate and toxicity of the degradation products of dicamba. Second, the risk assessment only considers the most sensitive species tested and only considers a subset of possible use scenarios. For the aquatic organism risk assessment, there are uncertainties associated with the PRZM/EXAMS model, input values, and scenarios including the use of surrogate scenarios, however these uncertainties cannot be quantified. The potential impacts of these uncertainties are outlined in the Aquatic Exposure and Risk Assessment and the Terrestrial Exposure and Risk Assessment sections of this document.

There is uncertainty in the environmental fate of the typical end use products (TEPs) which contain the sodium, DMA or DGA salts. Dissociation rates, adsorption/desorption rates and field dissipation information are needed for TEPs to determine the persistence and mobility of the salts and their associated inert ingredients found in the TEPs.

Additional uncertainty results from lack of information in components of this ecological risk assessment. For example, actual residue levels in foliage, insects, and seeds are not available to accurately predict risks to terrestrial organisms (birds, mammals, pollinators) which may contact dicamba residues after application. Therefore, model estimates are used in risk quotient calculations. Additionally, little field information is not available to help characterize risks. An AgDrift analysis also will be completed in further refinements to the chapter.

II. PROBLEM FORMULATION

The purpose of the ecological risk assessment (ERA) is to assist the Agency in evaluating the actions needed, if any, to address ecological risks associated with the reregistration of the herbicide dicamba (3,6-Dichloro-o-anisic acid). Dicamba is formulated in aqueous solutions as a salt and has herbicidal activity against annual, biennial and perennial broadleaf weed species and other plants in terrestrial settings.

A. Stressor Source and Distribution

1. Source and Intensity: Dicamba is a benzoic acid herbicide similar in structure and mode of action to phenoxy herbicides. Typical terrestrial application methods consist of ground and aerial spray to the leaves or to the soil. Dicamba controls annual, biennial and perennial broadleaf weeds in grain crops and grasslands, and it is used to control brush and bracken in

2. **Physical/Chemical/Fate and Transport Properties:** A summary of selected physical and chemical properties for dicamba acid are presented in Table II.b.

EFED established a strategy for bridging the environmental fate data requirements for the dicamba sodium and potassium salts, dimethylamine salt (DMA), isopropylamine salt and diglycoamine salt (DGA) to the dicamba acid. Bridging data were submitted indicating that the dicamba salts will be rapidly converted to the free acid of dicamba. A laboratory dissociation study showed that each dicamba salt (tested at >99% purity) completely dissociated to dicamba acid within 75 seconds in pure water (MRID 43288001). EFED determined that fate studies conducted with dicamba acid provide “surrogate data" for the dicamba salts.

Dicamba acid is very soluble (6100 mg/L) and very mobile in laboratory soil studies. In batch equilibrium experiments, dicamba acid was determined to be very mobile in loam, clay loam, silt loam, and sandy loam soils and a loam sediment, with Freundlich K_d values of 0.16, 0.10, 0.53. 0.07 and 0.21, respectively. Corresponding K_{oc} values were 7.27, 3.45, 21.1, 17.5 and 17.5, respectively.

Aerobic soil metabolism is the main degradative process for dicamba acid. A single observed half-life for dicamba acid was six days, with formation of the intermediate non-persistent degradate 3,6-dichlorosalicylic acid (DCSA). DCSA degraded at approximately the same rate as dicamba with the final metabolites being carbon dioxide and microbial biomass. Aerobic degradation of dicamba is slower at lower temperatures and low soil moisture and rainfall. Dicamba is stable to abiotic hydrolysis at all pH's and photodegrades slowly in water and on soil. Dicamba is more persistent under anaerobic soil:water systems in the laboratory, with a half-life of 141 days. The major degradate under anaerobic conditions was DCSA, which was persistent, comprising > 60% of the applied after 365 days of anaerobic incubation. No other anaerobic degradates were present at > 10% during the incubation. There are no acceptable data for the aerobic aquatic metabolism of dicamba; supplemental information indicates that dicamba degrades more rapidly in aquatic systems when sediment is present.

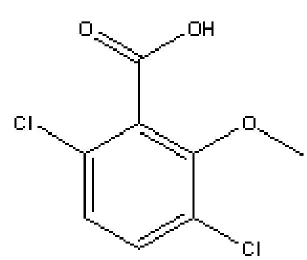
Provided retention times of dicamba in aerobic soils are sufficient and conditions are amenable to allow degradation, dicamba can be biodegraded thus reducing the potential to leach to groundwater. Biodegradation in aerobic soils is reduced at lower temperatures and dry conditions. If dicamba did reach anaerobic soil or anaerobic groundwater zones, it would be somewhat persistent (due to its anaerobic half-life of 141 days); any DCSA that reached groundwater would also be expected to persist.

Results from field dissipation studies conducted with the dimethylamine salt of dicamba, indicated that dicamba dissipated with reviewer calculated half-lifes ranging from 4.4 to 19.8 days with DCSA was the major degradate. Both, dicamba and its primary degradate were found at low concentrations (<20 ppb) in soil segments deeper than 10 cm. Supplementary data in other field dissipation studies indicate that the sodium and diglycoamine salts of dicamba dissipated similar to the dimethylamine salt with half-lifes ranging from 3 to 12.9 days.

Based on the vapor pressure of $3.4e^{-5}$ torr, when released in the atmosphere dicamba will exist in both the vapor phase as well as the adsorbed to particulate phase. Soil volatilization rates for potassium salt and DMA ranged from 2.91 to 4.97×10^{-4} $\mu g/cm^2/hr$ when dicamba was applied at rate of 0.5 lb a.i./A (MRID 41966602). There are numerous label restrictions for ground and aerial spray applications. Spraying is not recommended if wind is gusty or in excess of 5 mph and moving in the direction of adjacent sensitive crops. Recommendations on spray systems for coarse spray application are included on the labels as well as directions for keeping the spray pressure at or below 20 psi and spray volume at or above 20 gpa. Finally, dicamba should not be applied adjacent to sensitive crops when temperature on the day of application is expected to exceed 85°C as drift is more likely to occur.

Dicamba is not expected to bioaccumulate in aquatic organisms because it is an anion at environmental pHs (pKa = 1.9).

Figure II.a. Chemical Structure of 3,6-Dichloro-o-anisic acid (Dicamba)
(CAS No. 1918-00-9)



Form	Molecular Weight	ae Conversion Factor
dicamba acid	221.0	----
dimethylamine salt of dicamba	226.1	0.977
sodium salt of dicamba	243.0	0.909
potassium salt of dicamba	259.1	0.853

The emphasis of this preliminary screening risk assessment is to address risk to non-target aquatic and terrestrial species that may be exposed to dicamba and its salts. The labeled uses of dicamba (Table II.c.) could result in exposure to aquatic and terrestrial organisms inhabiting flowing, non-flowing or transient freshwater waterbodies and wildlands (forests, wetlands and ecotones, such as edge and riparian habitats).

a. Aquatic Effects

Spray drift and surface runoff/leaching to adjacent bodies of water are the most likely sources of dicamba exposure to nontarget aquatic organisms, including listed species. Available acute toxicity data indicates that the toxicity of dicamba varies with the salt forms tested. Study results show that the salt forms appeared to be practically non-toxic to freshwater fishes (LC_{50} >100 mg/L); however, dicamba acid (LC_{50} = 28 mg a.e./L; 88% a.i.) was slightly toxic to rainbow trout. Toxicity to bluegill was similar. The sodium salt of dicamba (26.5% a.i.) was slightly toxic to daphnids with an EC_{50} of 34.6 mg a.e./L. Dicamba acid and the other salts were not toxic to daphnids, with EC_{50}'s >100 mg/L. Results of acute aquatic toxicity studies with the potassium salt of dicamba are questionable due to the precipitation of the test material during testing. Toxicity test results with marine/estuarine species indicate that dicamba acid is practically non-toxic to fish (96-hr LC_{50} >180 mg a.i./L - sheepshead minnow) and invertebrates (96-hr LC_{50} >100 mg a.i./L - grass shrimp; 96-hr LC_{50} >180 mg a.i./L - fiddler crab). No toxicity studies have been conducted to determine potential chronic effects to freshwater and marine/estuarine fish and aquatic invertebrates. Toxicity studies with algae exposed to dicamba acid indicate that cell densities were significantly reduced in blue-green algae at test concentrations as low as 0.061 mg a.i./L. Aquatic vascular plant species were not as sensitive to dicamba acid with 14-day EC_{50} values of >3.25 mg a.i./L, which is greater than the equivalency of the maximum application rate [2.9 mg a.i./L (4 lb ai/ac)]. However, duckweed frond chlorosis occurred at mean measured concentrations as low as 0.39 mg a.i./L. Laboratory studies indicate that dicamba should not bioaccumulate in aquatic organisms; however, it may persist in sediments with an estimated half-life of 141 days (MRID 43245208). Data are currently unavailable to determine potential impacts to sediment-dwelling benthic organisms and to semi-aquatic/transitional habitats (wetlands, riparian habitats).

b. Terrestrial Effects

Ground deposition, spray drift, and wind erosion of soil particles with resulting residues on foliage and on insects and seeds are the most likely sources of dicamba exposure to nontarget terrestrial organisms, including listed species. In addition, uptake in plant roots and foliage would be expected to occur. Current data were not provided to determine the potential exposure to birds, mammals, and pollinators from residues on foliage, insects, and seeds. Available acute toxicity data indicate that the salt forms of dicamba are practically non-toxic to bobwhite quail and mallard ducklings in the diet; however, oral gavage studies indicate that dicamba acid (86.9% a.i.) was moderately toxic (LD_{50} = 188 mg ai/kg) to bobwhite quail and slightly toxic to mallard ducks (NOEL could not be determined due to signs of toxicity at all test levels). In chronic studies with dicamba acid (86.9% a.i.), a reduction in hatchability was observed in mallard ducks at 1390 ppm a.e. (NOEC = 695 ppm a.e.). No treatment-related mortality, signs of toxicity, or effects on reproduction were observed in bobwhite quail. Dicamba acid is classified as practically non-toxic to small mammals on an acute oral basis. A 13-week subchronic oral study in Charles River CD rats reported body weight changes and liver effects at 1000 mg a.i./kg/day. Developmental studies with New Zealand white rabbits reported irregular ossification of internasal bones at 300 mg a.i./kg/day (dicamba acid, 90.5% a.i.) and maternal toxicity (abortion and clinical signs of toxicity, including ataxia, rales, and decreased motor activity) was reported at 150 mg a.i./kg/day. Maternal toxicity; including mortality, clinical signs of toxicity, body weight changes, and decreased food consumption, was also observed in Charles River CD rats at 400 mg a.i./kg/day (dicamba acid, 85.8% a.i.). In a 2-generation reproduction study with Sprague-Dawley rats (dicamba acid, 86.5% a.i.), maternal neurotoxicity was observed at doses of 419 mg a.i./kg/day in males and at 450 mg a.i./kg/day in females and developmental effects, decreased pup growth, were observed in rats at a dose of 136 mg a.i./kg/day. No toxicity studies have been conducted to determine the potential effect of residues to pollinators. An additional source of exposure to dicamba could be in puddled water on treated fields through preening and grooming, involving the oral ingestion of material from the feathers or fur.

Terrestrial plant toxicity studies indicate that dicamba acid negatively impacts seed germination (radicle length; soybean EC_{25} = 0.036 lb ai/A), seedling emergence (shoot length; soybean EC_{25} = 0.0027 lb ai/A), and vegetative vigor (shoot length; soybean EC_{25} = 0.0068 lb ai/A) in monocots and dicots. The most sensitive monocot tested was onion (EC_{25} = 0.071 lb ai/A - seed germination; EC_{25} = 0.0044 lb ai/A - seedling emergence; and EC_{25} = 0.1507 lb ai/A - vegetative vigor). Consequently, spray drift presents a potential risk to non-target plants inhabiting edge habitats adjacent to target fields and riparian vegetation along streams and/or ponds in close proximity to sprayed fields.

Dicamba is readily absorbed through the foliage and roots of plants; consequently, it could be injurious to non-target plant species by drift, runoff, or leaching to roots. Dicamba may accumulate in the soil with frequent or extensive use which may result in damage to trees, shrubs, or other ornamentals. Residuals of dicamba in soil have been shown to reduce emergence in sugarbeet and cause petiole epinasty, severe stunting of seedlings, and trumpeting (Dexter et al, 1994). Dicamba applied according to label directions as a liquid spray for ground or aerial applications may impact non-target plants for some distance from the application site depending on droplet size, wind speed, and other factors. Numerous cases of soybean injury are reported yearly from the use of dicamba on corn that results in the exposure of adjacent fields of soybean to dicamba through spray drift and volatilization (Proost and Boerboom 2004; Hartzler 2003). Injury includes leaf malformations, terminal bud kill, and delayed maturity. Yield loss can occur if soybeans are exposed to dicamba after they bloom (in the reproductive stage).

Since the dicamba salts rapidly dissociate to dicamba acid and it rapidly degrades under aerobic conditions, it would not be expected to persist in surface soils. Thus, risks from exposure to birds, small mammals, and soil invertebrates through dermal contact or ingestion of soils should be minimal.

2. Ecosystems at Risk

In terrestrial and shallow-water aquatic communities, plants are the primary producers upon which the succeeding trophic levels depend. If the available plant material is impacted due to the effects of dicamba, this may have negative effects not only on the herbivores, but throughout the food chain. Also, depending on the severity of impacts to the plant communities [i.e., forests, wetlands, ecotones (edge and riparian habitats)], community assemblages and ecosystem stability may be altered (i.e. reduced bird and mammal populations in edge habitats; reduced riparian vegetation resulting in increased light penetration and temperature in aquatic habitats; reductions in algal biomass). In addition, allochthonous input from riparian vegetation is not only a significant component of the food supply for aquatic herbivores and detritivores but also provides habitat (i.e. leaf packs, materials for case-building for invertebrates).

C. Assessment Endpoints

The portion of the problem formulation which is an explicit statement of the characteristic of the environment to be protected is encompassed in a delineation of endpoints. These endpoints can include a particular species, a functional group of species, a community, or an ecosystem.

Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs, U.S. Environmental Protection Agency

Endangered and Threatened Species Effects Determinations

Office of Prevention, Pesticides and Toxic Substances
Office of Pesticide Programs
Washington, D.C.

January 23, 2004

In situations where available toxicity data indicate that a pesticide formulation for registration in the United States may be more toxic to terrestrial wildlife than indicated by active ingredient effects testing, it may be necessary to consider exposure to the formulation. Exposure modeling in these instances is limited to dietary exposure to residues for a time period immediately following pesticide product application.

The limitation on the quantitative exposure modeling for formulations is based on the expectation that the varying physical-chemical properties of individual components of pesticide formulations will result in progressively different formulation constituents in environmental media over time. Because the proportions of formulation components in environmental media differ from the proportions in the tested formulation, the assumption that environmental residues are toxicologically equivalent to tested formulations cannot be supported beyond the time period immediately following product application.

The Agency's methods for considering formulated product exposure in the screening-level terrestrial organism risk assessment follows approaches developed by the European Union for evaluating pesticide formulation risks (see Support Document #80 - EU Council Directive 91/414/EEC).

d. Non-Target Plant Exposure Modeling

As discussed previously in the aquatic organism exposure section, exposure for non-target aquatic plants is assessed in a manner consistent with exposure for other aquatic organisms.

Terrestrial and semi-aquatic plant exposure characterization employs runoff and spray drift scenarios contained in OPP's Terrplant model (Support Document #18). Exposure calculations are based on a pesticide's water solubility and the amount of pesticide present on the soil surface within the first inch of depth. For dry areas, the loading of pesticide active ingredient from runoff to an adjacent non-target area is assumed to occur from one acre of treatment to one acre of non-target area; for semi-aquatic (wetland) areas, runoff is considered to occur from a larger source area with active ingredient loading originating from 10 acres of treated area to a single acre of non-target wetland. Default spray drift assumptions are 1% for ground applications and 5% for aerial, airblast, forced air, and chemigation applications. Drift is not considered for formulations of herbicides that are not spray-applied (e.g., granules); however, runoff is still considered and expressed on a percent of applied mass basis. A discussion of the uncertainties associated with the drift assumptions is included in section VI.C.6 .b.10 and are included in the risk characterizations for screening-level risk assessments.

2. Effects Characterization

In screening-level ecological risk assessments, effects characterization describes the types of effects a pesticide can produce in an organism and how those effects change with varying pesticide exposure levels. This characterization is based on an effects profile that describes the available effects (toxicity) information for various plants and animals and an interpretation of available incidents information and effects monitoring data. Environmental fate data, monitoring data, and computer models are used to estimate the exposure of non-target animals and plants to pesticide residues in the environment.

40 *CFR* Parts 158.490, 158.540, and 158.590 specify the types and amounts of data that the Agency needs to determine the risks of a pesticide to wildlife, aquatic organisms, and plants. The types of data needed can vary depending on how and where the pesticide is used. A list of the studies that the Agency may require in support of the registration or approval of certain pesticides is provided in Support Document #29.

In these tests, organisms are exposed to different amounts of pesticide active ingredient (and under certain conditions formulated product and degradates) and their responses to these varying concentrations are measured. Study endpoints are used to estimate the toxicity or hazard of a pesticide. (See Support Documents #45, #47-49, #52-53, #57, and #63 for toxicity categories.) The toxicity testing scheme is tiered, such that results from a lower level study are used to determine potential harmful effects to non-target organisms and whether further testing is required. Testing can progress from basic laboratory tests at the lowest level to applied field tests at the highest level.

For screening risk assessments, the following toxicity endpoints are used as inputs to the Risk Quotient (RQ) method for expressing risk (see Section V. C.1) :

Aquatic Animals	
Acute assessment	Lowest tested EC_{50} or LC_{50} for freshwater fish and invertebrates and estuarine/marine fish and invertebrates acute toxicity tests.
Chronic assessment	Lowest NOEC for freshwater fish and invertebrates and estuarine/marine fish and invertebrates early life-stage or full life-cycle tests.
Terrestrial Animals	
Acute avian assessment	Lowest LD_{50} (single oral dose) and LC_{50} (subacute dietary).
Chronic avian assessment	Lowest NOEC for 21-week avian reproduction test.
Acute mammalian assessment	Lowest LD_{50} from single oral dose test.
Chronic mammalian assessment	Lowest NOEC for two-generation reproduction test.
Plants	
Terrestrial non-endangered	Lowest EC_{25} values from both seedling emergence and vegetative vigor for both monocots and dicots.
Aquatic vascular and algae	Lowest EC_{50} for both vascular and algae.
Terrestrial endangered	Lowest EC_5 or NOEC for both seedling emergence and vegetative vigor for both monocots and dicots.

While the above toxicity endpoints are routinely used to calculate screening-level risk assessment RQs, they do not represent a limitation on the types of toxicity endpoints that may be considered in the risk assessment. Over the course of evaluation of available toxicity data (see Section V.B.2 for a discussion of OPP's use of ECOTOX database for effects data searches), the risk assessment team may encounter other effects data that provide: (1) additional information on existing toxicity endpoints commonly used in the screening risk assessment, (2) insight on endpoints not routinely considered for RQ calculation, and/or (3) effects data on specific additional taxonomic groups (e.g., amphibian and freshwater mussel tests). Professional judgment is used and documented by the risk assessment team to determine whether and how available data on other toxicological endpoints are included in the risk assessment. This evaluation may include (1) reference to data quality objectives for specific types of studies, (2) the degree to which adequate documentation is available to evaluate the technical merit of the data, and (3) whether the data are applicable to the assessment endpoints established for the risk assessment. To decide if data are applicable to assessment endpoints, the risk assessment team uses professional judgment and available lines of evidence to determine if the toxicological endpoints can be linked to assessment endpoints in a reasonable and plausible manner.

As stated earlier in this section, the Agency routinely conducts screening-level risk assessments on an active ingredient basis. The only routine exception to this is for terrestrial plant effects analysis, where toxicity studies are conducted on the formulated product. Consequently, the majority of toxicity data received by the Agency relates to the active ingredient. However, Agency regulations have provisions for the request of additional data on formulated products. 40 *CFR* 158.75 allows the Agency to request additional data if routinely required data are not sufficient to evaluate the potential of a pesticide product to cause unreasonable adverse effects on man or the environment. In addition., 40 *CFR* 158.202 indicates that acute aquatic animal toxicity testing may be required if any of the following conditions are met:

- The end-use product is applied directly to water when used as directed;
- Active ingredient LC_{50}/EC_{50} values are equal to or less than the maximum expected environmental concentration or the estimated environmental concentration in aquatic systems when the product is used as directed; or
- An ingredient in the end-use product is expected to enhance the toxicity of the active ingredient or is toxic itself to aquatic organisms.

Support Document #78 presents the Agency's process for the identification of degradates of potential toxicological concern. This information, in conjunction with any available toxicity data and data regarding the extent to which degradates are produced in laboratory and field environmental fate studies, will be considered by the Agency to determine the need for incorporating active ingredient degradates in a risk assessment. This evaluation, which is conducted by the Metabolism Assessment Review Committee, may be based upon information relating to (1) biologically reactive chemical moieties on both the active and degradates, (2) past experience with close chemical analogues, (3) consultation with Agency human health toxicologists, and (4) publically available literature. If degradates are considered by the Agency to be of toxicological significance as determined by the process outlined in Support Document # 78, the Agency evaluates the available information to determine if quantitative or qualitative consideration of degradate risks is warranted. The rationale supporting such decisions are documented in the risk assessment document. To be consistent with Agency risk assessment guidance, risk assessors must clearly and concisely describe this evaluation in the risk assessment.

Formulated product effects data are evaluated and included in the risk assessment when available. (See Section V.A.2 for sources of such information). Acute mammalian effects testing for formulated products is commonly submitted to the Agency. In addition, effects testing for formulations is required for registrations in other nations (EU Directive 91/414/EEC). The Agency provisions for submission of effects data under 40 *CFR* 159.165(b) suggest that formulation effects information conducted for other nations would be submitted to the Agency when it indicates that the formulation may be more toxic than the active ingredient. In addition, searches of the publicly available literature may identify additional effects data for formulations.

Before formulated product effects data can be considered quantitatively in the risk assessment, it must be evaluated for its applicability to formulations under consideration for registration. This evaluation includes a comparison of the confidential statement of formulation for the product proposed for registration with any available information on the constituents of the tested formulation. If the comparison suggests that the tested and proposed registration formulations are similar, the test data are used quantitatively in the risk assessment process. However, if a similarity is not supported by the available formulation information, the toxicity data on formulated products is documented, and the risk characterization qualitatively discusses the potential implications the formulated toxicity may have on the confidence of the risk assessment conclusions.

a. Registrant-Submitted Studies for Direct Effects of Pesticides

Support Documents #45 - #57 and #63 list the universe of toxicity studies commonly submitted by pesticide registrants in support of registration proposals. 40 *CFR* Section 158 describes the criteria that serve as the basis for the requirements for each type of study. The Agency has determined, that under most situations, these effects data are sufficient for risk assessment purposes.

b. Open Literature Studies for Direct Effects of Pesticides

In addition to registrant-submitted data, the Agency also consults publicly available literature for additional toxicity information to be used in screening risk assessments, such as studies on additional taxa, toxicity endpoints, routes of exposure, or test materials. (See Section V.B.2.)

To ensure consistent consideration and use of information in the open literature for ecological risk assessments, OPP has developed guidance for its scientists (Support Document #71) and steps to implement the guidance have been initiated.

(1). ECOTOX

OPP uses the ECOTOX (ECOTOXicology) database as a search engine to identify open literature studies that may potentially be used in ecological risk assessments (http://www.epa.gov/ecotox). The ECOTOX database was selected because it is a user-friendly, publicly-available, quality-assured, comprehensive tool for locating open literature chemical toxicity data for aquatic life, terrestrial plants, and wildlife. Relevant literature for ECOTOX is retrieved using a comprehensive search strategy designed to locate worldwide aquatic and terrestrial ecological effects literature. This strategy is expected to capture the data from research that evaluates species and/or toxic effects, which fall outside the standard battery of required ecotoxicity tests.

The ECOTOX database is developed and maintained by EPA's National Health and Environmental Effects Research Laboratory, Mid-Continent Ecology Division (MED) in Duluth, Minnesota. ECOTOX includes unique toxicity data for aquatic life, terrestrial plants, and terrestrial wildlife and contains information on lethal, sublethal and residue effects. With regard to terrestrial animals, ECOTOX's primary focus is wildlife species, but the database does include some information on domestic species. Sources routinely used for ECOTOX searches are AGRICOLA, Cambridge Scientific Abstracts (CSA), BIOSIS and CAB Abstracts, Current Contents, ScienceDirect, and MED library journal holdings. Relevant sources are also identified from benchmark documents and review papers, and online ecotoxicology databases such as the U.S. Geological Survey's "Wildlife and Contaminants Online" website http://www.pwrc.usgs.gov/contaminants-online/ and the Canadian Wildlife Service's "Reptile and Amphibian Toxicology Literature" website http://www.cws-scf.ec.gc.ca/nwrc-cnrf/ratl/index_e.cfm.

The ECOTOX database can issue two types of reports. The aquatic organism report includes toxic effects data on all aquatic species including plants and animals and freshwater and saltwater species, while the terrestrial organism report contains toxicity data for terrestrial animals and terrestrial plants.

The high level of quality assurance of the ECOTOX database makes it an important primary source for consistently searching open literature data. Extensive documentation for this database, ranging from Standard Operating Procedures, Coding Guidelines, Chemical Verification, and various procedures, are described in Support Documents #72 - #77.

Quality assurance procedures begin with literature acquisition and cataloging and continue through the chemical and species verification, the literature review process, data entry, and data retrieval. The ECOTOX literature is encoded by trained document abstractors. An intensive training period, a well-documented manual, and close interaction with the data coordinator help to ensure a high level of accuracy and consistency in the review process. Ten percent of the publications are independently reviewed by two different reviewers. These reviews are compared, and differences (if any) are documented, discussed, and resolved by the data coordinator.

This procedure provides a consistent attempt at finding data. Since there is a lag time of three months between literature acquisition and data availability in ECOTOX, OPP may request MED to search their reference files for any unreviewed studies on a chemical of concern. In addition, OPP will work with MED to identify citations and papers in their holdings that were not encoded in ECOTOX, including studies conducted on chemical mixtures, formulations, inert ingredients and surfactants, and survey and incident data.

(2). OPP Strategy for Conducting Literature Searches

OPP is refining a search strategy that it will follow for finding and filtering pesticide data in ECOTOX and is establishing guidance that describes how to evaluate the data output from ECOTOX. After identifying pesticide toxicity data in ECOTOX that may be useful in a pesticide risk assessment, copies of the journal articles and study reports will be retrieved so that the risk assessor may more closely critique the study. MED holds paper copies of all studies cited in the ECOTOX database and copies of applicable papers can be provided to OPP upon request.

This guidance, which will help maintain consistency concerning when and how data from open literature can be used, will help the risk assessor determine if an open literature study can be used in a pesticide risk assessment. Development of this guidance is being coordinated with other OPP quality assurance guidance. In addition, EPA science policy documents will be used as a base in developing the guidance (http://www.epa.gov/osp/spc/2polprog.htm and http://www.epa.gov/oei/qualityguidelines), and the guidance will be similar to previous work by OPP (U.S. Environmental Protection Agency, 2003), Superfund (http://www.epa.gov/ecotox/ecossl/), Office of Water (U.S. Environmental Protection Agency, 2002a), and EVISTRA (U.S. Environmental Protection Agency, 2002b).

In accordance with established risk assessment guidance, the Agency will identify in the risk assessment (1) the effects data from the literature that were considered in the risk assessment, (2) the basis for decisions on the manner in which such data were incorporated in the risk assessment, and (3) the rationale for not including data obtained from the literature.

c. Open Literature Studies for Indirect Effects of Pesticides

To obtain best available information for interpreting the potential for indirect effects at the screening level, the Agency will utilize "species profiles", when available, prepared by the Services for other Federal action agencies (e.g., EPA's Office of Water). These summaries, or profiles, are considered current best available information concerning species' life history, ecology, population demographics, etc., and will be provided to the Agency by the Services. The Agency anticipates that the Services will provide the Agency with similar summary information for listed species not covered by existing "species profiles."

d. Open Literature Studies for Critical Habitat Evaluations

To obtain best available information for interpreting the potential for critical habitat evaluations at the screening level the Agency may utilize "critical habitat profiles", when available, prepared by the Services. These summaries, or profiles, are considered current best available information concerning principle constituent elements for specific species and will be provided to the Agency by the Services. Critical habitat profiles provide the Agency with an identification of the principle constituent elements or equivalent (e.g., lists of biological resource requirements for the listed species associated with the critical habitat).

C. Risk Characterization

Risk characterization is the integration of effects and exposure characterization to determine the ecological risk from the use of the pesticide and the likelihood of effects on aquatic life, wildlife, and plants based on varying pesticide-use scenarios. The Agency's policy and guidance (Support Document #28) requires that risk characterizations be prepared in a manner that is clear, transparent, reasonable, and consistent with other risk characterizations of similar scope.

1. Integration of Exposure and Effects Data - The Risk Quotient for Direct Effects

Risk characterization integrates the results of exposure and toxicity data to evaluate the likelihood of adverse ecological effects on non-target species. For most chemicals, the effects characterization is based on a deterministic approach using one point on a concentration-response curve (e.g., LC50). In this approach, OPP uses the risk quotient (RQ) method to compare exposure over toxicity. Estimated environmental concentrations (EECs) based on maximum application rates are divided by acute and chronic toxicity values. (Equations are provided in Support Document #8.)

2. Levels of Concern for Direct Effects - The Policy Tool for Interpreting Risk Quotients for Direct Effects

After risk quotients are calculated, they are compared to the Agency's LOCs. These LOCs are the Agency's interpretative policy and are used to analyze potential risk to non-target organisms and the need to consider regulatory action. These criteria are used to indicate when a pesticide use as directed on the label has the potential to cause adverse effects on non-target organisms. A discussion of the developmental history is provided in support document # 70. LOCs currently address the following risk presumption categories:

- Acute - Potential for acute risk to non-target organisms which may warrant regulatory action in addition to restricted use classification (acute RQ > 0.5 for aquatic animals, mammals, birds);

- Acute Restricted Use - Potential for acute risk to non-target organisms, but may be mitigated through restricted use classification (acute RQ > 0.1 for aquatic animals or 0.2 for mammals and birds);

- Acute Endangered Species - Endangered species may be potentially affected by use (acute RQ > 0.05 for aquatic animals or 0.1 for mammals and birds);

- Chronic Risk - Potential for chronic risk may warrant regulatory action, endangered species may potentially be affected through chronic exposure (chronic RQ > 1 for all animals);

- Non-endangered Plant Risk - RQ >1; and

- Endangered Plant Risk - Potential for effects in endangered plants (RQ>1).

It should be noted that both acute endangered species and chronic risk LOCs are considered in the screening-level risk assessment of pesticide risks to listed species. Endangered species acute LOCs are a fraction of the non-endangered species LOCs or, in the case of endangered plants, RQs are derived using lower toxicity endpoints than non-endangered plants. Therefore, concerns regarding listed species within a taxonomic group are triggered in exposure situations where restricted use or acute risk LOCs are triggered for the same taxonomic group. The Agency risk assessment also includes, both in the risk characterization and the endangered species sections, an evaluation of the potential probability of individual effects for exposures that may occur at the established endangered species LOC. This probability is calculated using the established dose/response relationship and the median lethal dose estimate for the study used to establish the toxicity endpoint for the endangered taxa.

As discussed earlier in this document, the Agency is not limited to a base set of surrogate toxicity information in establishing risk assessment conclusions. The Agency also considers toxicity data on non-standard test species (e.g., amphibian data) when available. (See Section V.B.2.b.on searches for publically available effects information.) To the extent that such data meet data quality requirements, it is used to interpret the relevance of risk assessment LOCs in the context of other tested taxa.

3. Comparison of Field and Laboratory Data for Direct Effects

Given the general widespread nature of pesticide uses and the variability in the physical, chemical, and biological conditions associated with pesticide use sites, validation of the results of the existing screening risk assessment process would be impractical. However, OPP does consider data on exposure and effects collected under field conditions to make determinations on the predictive utility of the screening assessment.

After the 1992 Ecological, Fate, and Effects Task Force review of the testing requirements for environmental fate and ecological effects, the Agency decided to not require avian and aquatic guidelines field testing, except in unusual circumstances (Support Document #25). However, when field studies along with incident data reports and compliance monitoring studies are available, they are used to help elucidate the potential sources and magnitude of uncertainties when extrapolating from effects predictions based on laboratory toxicity data to effects occurrence in the field. As pointed out in the Agency's Guidelines for Ecological Risk Assessment (Support Document #7), developing solid relationships between cause and observed field effects adds to the certainty of the assessment. The criteria presented in these guidelines adopted from Fox (1991) and similar to other criteria reviewed by Fox (U.S. Department of Health, Education, and Welfare, 1964; Hill, 1965; and Susser, 1986a and 1986b) stressed the importance of the strength of association between the causative agent and the observed effect.

OPP routinely receives information on the field dissipation of pesticides under actual use conditions. These data provide the Agency with information on the persistence of the parent compound and the rate of production of degradates. Incorporation of the results of field dissipation data into the quantitative exposure modeling is problematic because of the nature of the model input requirements. However, overall rates and routes of pesticide decline as predicted by the fate models can be examined and compared with the results of the field dissipation models to determine the degree to which the risk assessment fate modeling may overstate exposure.

In addition to field dissipation measurements, scientists often consider available data on environmental media monitoring for pesticides. For example, the results of the screening environmental models are compared with monitoring data for surface waters. As previously mentioned, though, there are practical limitations to surface water monitoring efforts. For example, non-targeted routine monitoring programs, such as the U.S. Geological Survey's National Water-Quality Assessment Program, are more useful for tracking trends than they are for establishing true peak concentrations. However, comparison of the Agency modeling results with such monitoring programs can provide some insight into the degree to which modeling results reflect realistic conditions in the field.

As discussed for surface water monitoring, field effects data are limited in the ability to account for the myriad combinations of physical, chemical, and biological variables that may affect organism response to pesticides in the environment. Consequently, field studies or incident reports cannot conclusively validate screening risk assessment predictions, but they can allow inferences on the reasonableness of the assessment predictions.

Incident information can add lines of evidence to provide context to the risk predictions from the screening level assessment. Sometimes this reporting provides limited information for an ecological assessment because most incidents are not reported, and those that are reported, often do not have enough information to assess cause and effect. Generally, it is assumed that the application was from normal use and was applied within the rates allowed on the labeling, unless otherwise indicated. On occasion, the use rates are reported in incident investigations, but actual documentation with scientific rigor is rare. Therefore, incident reports often provide limited information about the correlation between use rates and effect levels. However, consistent with components of the criteria described by Fox (1991), the greater the number of wildlife mortality incidents following application of a specific pesticide for a specific use, and the greater the number of individuals involved, the higher the confidence in the strength of the association. The more confidence in the association between incident and pesticide exposure, the more useful the information when evaluating risk conclusions derived from laboratory-based screening assessment methods. The Agency maintains a database, which is described in Section IV.C.2.c, of incident information to support risk assessment.

4. Indirect Effects Characterization for Listed Species

The Agency acknowledges that pesticides have the potential to exert indirect effects upon the listed organisms by, for example, perturbing forage or prey availability, altering the extent and nature of nesting habitat, etc.

In conducting a screen for indirect effects, the Agency uses the direct effects LOCs for each taxonomic group to make inferences concerning the potential for indirect effects upon listed species that rely upon non-endangered organisms in these taxonomic groups as resources critical to their life cycle. The Agency considers pesticide-use scenarios, resulting in RQs that are below all direct effect endangered species LOCs for all taxonomic groups assessed to be of no concern for risks to listed species either by direct or indirect effects.

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Wildlife Exposure Factors Handbook

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WILDLIFE EXPOSURE FACTORS HANDBOOK

Volume I of II

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1. INTRODUCTION

The Wildlife Exposure Factors Handbook (hereafter referred to as the Handbook) provides data, references, and guidance for conducting exposure assessments for wildlife species exposed to toxic chemicals in their environment. It is the product of a joint effort by EPA's Office of Research and Development (ORD), Office of Solid Waste and Emergency Response (OSWER), and Office of Water (OW). The goals of this Handbook are (1) to promote the application of risk assessment methods to wildlife species, (2) to foster a consistent approach to wildlife exposure and risk assessments, and (3) to increase the accessibility of the literature applicable to these assessments.

1.1. PURPOSE AND SCOPE

The purpose of the Handbook is to provide a convenient source of information and an analytic framework for screening-level risk assessments for common wildlife species. These screening-level risk assessments may be used for several purposes, including: to assess potential effects of environmental contamination on wildlife species and to support site-specific decisions (e.g., for hazardous waste sites); to support the development of water-quality or other media-specific criteria for limiting environmental levels of toxic substances to protect wildlife species; or to focus research and monitoring efforts. The Handbook provides data (analogous to EPA's *Exposure Factors Handbook* for humans, USEPA, 1989c) and methods for estimating wildlife intakes or doses of environmental contaminants. Although the data presented in the Handbook can be used for screening analyses, we recommend that anyone establishing a cleanup goal or criterion on the basis of values contained herein *obtain the original literature on which the values are based to confirm that the study quality is sufficient to support the criterion.* This Handbook does not include data or extrapolation methods required to assess the toxicity of substances to wildlife species, nor does it include any chemical-specific data (e.g., bioavailability factors).

For the Office of Water, data gathered for the Handbook were used to identify wildlife species that are likely to be at greater risk from bioaccumulative pollutants in surface waters and to estimate likely exposures for these species. Data on diets and on

food and water ingestion rates can be used with chemical-specific information, such as bioaccumulation potential and wildlife toxicity, to calculate site- or region-specific concentrations of a chemical in water (or soil or sediment) that are unlikely to cause adverse effects.

For the Superfund program, this Handbook supplements the existing environmental evaluation guidance. EPA's *Risk Assessment Guidance for Superfund: Volume II--Environmental Evaluation Manual* (U.S. EPA, 1989a) provides an overview of ecological assessment in the Superfund process. It includes a description of the statutory and regulatory bases for ecological assessments in Superfund and fundamental concepts for understanding ecological effects of environmental contaminants. The *Environmental Evaluation Manual* also reviews elements of planning an ecological assessment and how to organize and present the results of the assessment. EPA's *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference* (U.S. EPA, 1989b) and *Evaluation of Terrestrial Indicators for Use in Ecological Assessments at Hazardous Waste Sites* (U.S. EPA, 1992) are companion documents that describe biological assessment strategies, field sampling designs, toxicity tests, biomarkers, biological field assessments, and data interpretation. The *ECO Update* intermittent bulletin series (published by EPA's Office of Solid Waste and Emergency Response, publication no. 9345.0-05I, available from the National Technical Information Service, Springfield, Virginia) provides supplemental guidance for Superfund on selected issues. Although these documents have identified decreases in wildlife populations as potential endpoints for ecological assessments, they do not provide guidance on how to conduct a wildlife exposure assessment that is comparable to the guidance provided by the Superfund program for human health exposure assessments. This Handbook provides both guidance and data to facilitate estimating wildlife exposure to contaminants in the environment.

Exposure assessments for wildlife and humans differ in several important ways. One key distinction is that many different wildlife species may be exposed, as compared with a single species of concern for a human health assessment. Exposure varies between different species and even between different populations of the same species; behavioral attributes and diet and habitat preferences influence this variation. Second, whereas it is

seldom possible to confirm estimated levels of human exposure without invasive sampling of human tissues, confirmatory sampling for many chemicals can be done in wildlife species (protected species excepted). However, the tissue sampling required to quantify actual exposure levels can be costly, and interpretation of tissue concentrations can be complex.

For both human health and wildlife exposure assessments, the most cost-effective approach is often to first screen for potentially significant exposures using measures (or estimates) of environmental contamination (e.g., in soils, water, prey species) to estimate contaminant intakes or doses by significant routes of exposure. If estimated doses fall far below the toxicity values associated with adverse effects, especially from chronic exposures, further assessment may be unnecessary. If estimated doses far exceed reference toxicity values, it may be possible to determine appropriate actions on the basis of these estimates alone. When a screening-level exposure assessment indicates that adverse effects are likely, additional confirmatory data may be needed in the decision-making process. For humans, it is usually not practicable to obtain additional types of data (e.g., tissue concentrations, biomarkers), and human exposure estimates are often refined by using more site-specific data for exposure parameters. For wildlife, confirmatory data may be obtained from chemical analyses of tissue samples from potentially exposed wildlife or their prey and from observed incidence of disease, reproductive failure, or death in exposed wildlife. These are reviewed in EPA's field and laboratory reference and terrestrial indicators documents described above (EPA, 1989b, 1992). If this more direct approach is not possible, the exposure analysis can be refined on the basis of more site-specific data for the species of concern.

Wildlife can be exposed to environmental contaminants through inhalation, dermal contact with contaminated water or soil, or ingestion of contaminated food, water, or soil. Exposure assessment seeks to answer several questions, including:

- **What organisms are actually or potentially exposed to contaminants?**

- **Which organisms or life stages might be most vulnerable to environmental contaminants (e.g., ingest the largest quantities of contaminated media relative to body size)?**
- **What are the significant routes of exposure?**
- **To what amounts of each contaminant are organisms actually or potentially exposed?**
- **How long is each exposure?**
- **How often does or will exposure to the environmental contaminants take place?**
- **What seasonal and climatic variations in conditions are likely to affect exposure?**
- **What are the site-specific geophysical, physical, and chemical conditions affecting exposure?**

The parameters for which data are presented in the Handbook are intended to help a risk assessor answer these questions. The population parameter data (e.g., birth and death rates) may be useful for placing estimates of risks to wildlife populations in a broader ecological context and for planning monitoring activities.

This Handbook focuses on selected groups of mammals, birds, amphibians, and reptiles. Fish and aquatic or terrestrial invertebrates were not included in this effort. The profiles on amphibians and reptiles are, in general, less developed than those for birds and mammals. We emphasized birds and mammals because methods for assessing their exposure are more common and well developed. As more assessments are done for amphibians and reptiles, we anticipate that additional methods and supporting factors will be necessary. Until then, we hope the information presented here will encourage assessors to begin considering and quantifying their exposure.

For all exposure parameters and species in the Handbook, we try to present data indicative of the range of values that different populations of a species may assume across North America. For site-specific ecological risk assessments, it is important to note that the values for exposure factors presented in this Handbook may not accurately represent

specific local populations. The species included in the Handbook have broad geographic ranges, and they may exhibit different values for many of the exposure factors in different portions of their range. Some species exhibit geographic variation in body size, survival, and reproduction. Breeding and migration also influence exposure. Site-specific values for these parameters can be determined more accurately using published studies of local populations and assistance from the U.S. Fish and Wildlife Service, state departments of fish and game, and organizations such as local Audubon Society chapters. In addition, The Nature Conservancy develops and maintains wildlife databases (including endangered species) in cooperation with all 50 states. Local information increases the certainty of a risk assessment. Thus, for site-specific assessments, we strongly recommend contacting local wildlife experts to determine the presence and characteristics of species of concern.

Finally, we do not intend to imply that risk assessments for wildlife should be restricted to the species described in this Handbook, or should always be conducted for these species. We emphasize that locally important or rare species not included in this Handbook may still be very important for site-specific risk assessments. To assist users who wish to evaluate other species, we list general references for birds, mammals, reptiles, and amphibians in North America. The Handbook also provides allometric equations to assist in extrapolating exposure factors (e.g., water ingestion rate, surface area) to closely related species on the basis of body size.

1.2. ORGANIZATION OF THE HANDBOOK

The Handbook is organized into four chapters. The remainder of this chapter provides an overview of the species and exposure factors included in the Handbook and discusses the literature search strategy used to identify factors. Chapter 2 presents exposure profiles for the selected species (described in greater detail below). Chapter 3 provides allometric models that may be used to estimate food and water ingestion rates, inhalation rates, surface areas, and metabolic rates for wildlife species on the basis of body size. Chapter 4 describes common equations used to estimate wildlife exposure to environmental contaminants. Included are methods for estimating diet-specific food

ingestion rates on the basis of metabolic rate and for estimating exposure to chemicals in soil and sediment.

Chapter 2 is the core of the Handbook; it presents exposure profiles for selected birds (Section 2.1), mammals (Section 2.2), and reptiles and amphibians (Section 2.3), along with brief descriptions of their natural history. Each species profile includes an introduction to the species' general taxonomic group, qualitative description of the species, list of similar species, table of exposure factors, and reference list (which also covers that species' section in Volume II, the Appendix). The values included in the exposure factors tables are a subset of those we found in the literature and also include values that we estimated using the allometric equations presented in Chapter 3. We selected values for the tables in Chapter 2 based on a variety of factors including sample size, quantification of variability (e.g., standard deviations, standard errors, ranges), relevance of the measurement technique for exposure assessment, and coverage of habitats, subspecies, and the variability seen in the literature. A complete listing of the parameter values identified in our literature survey is provided in the Appendix. The Appendix also includes more details concerning sample size, methods, and qualifying information than the species profiles. Users are encouraged to consult the Appendix to select the most appropriate values for their particular assessment.

The remainder of this introductory chapter describes the species and exposure factors covered in the Handbook in greater detail. The literature search strategy is discussed in Section 1.6.

1.3. LIST OF SELECTED SPECIES

Wildlife species were selected for the Handbook to provide several types of coverage:

- **Major taxonomic groups (major vertebrate groups, orders, and families);**
- **A range of diets (e.g., piscivore, probing insectivore) likely to result in contact with contaminated environmental media;**

- A variety of habitat types (e.g., fields, marshes, woodlands, coastal areas); and
- Small to large body sizes.

Other attributes also were considered when selecting species for the Handbook, including:

- Species with wide geographic distribution within the United States (or replaced regionally by similar species);
- Species of concern to EPA or other regulatory agencies (managed by state or Federal agencies); and
- Species of societal significance (familiar or of concern to most people).

Tables 1-1, 1-2, and 1-3 list the birds, mammals, and reptiles and amphibians, respectively, included in the Handbook. The species are listed according to diet, general foraging habitat, and relative body size.

The species included in this Handbook were necessarily limited; *however, we do not recommend limiting wildlife exposure assessments to the species or similar species identified in the Handbook.* Instead, the Handbook should be used as a framework to guide development of exposure factors and assessments for species of concern in a risk assessment. Species selection criteria for site-specific risk assessments might include the following considerations:

- Species that play important roles in community structure or function (e.g., top predators or major herbivores);
- Diet, habitat preferences, and behaviors that make the species likely to contact the stressor;
- Species from different taxa that might exhibit different toxic effects from contaminants;
- Local species that are of concern to Federal and state regulatory agencies (e.g., endangered and threatened species);

Table 1-1. Characteristics of Selected Birds

Diet	General Foraging Habitat	Body Size	Selected Bird Species
Insectivore[a] probing/soil-dwelling invertebrates gleaning/insects	woodlands, marshes marshes	medium small	American woodcock marsh wren
Herbivore gleaning/seeds grazing/shoots	woodlands, fields and brush open fields	medium large	northern bobwhite Canada goose
Omnivore	open woodland, suburbs	small	American robin
Carnivore[b]	open fields, forest edge most open areas	medium medium	American kestrel red-tailed hawk
Carnivore/Piscivore/Scavenger small birds & mammals/fish/dead fish fish/invertebrates/small birds/garbage	open water bodies Great Lakes and coastal	large medium	bald eagle herring gull
Piscivore[c]	most streams, rivers, small lakes most freshwater and saltwater bodies large water bodies	medium large large	belted kingfisher great blue heron osprey
Aquatic Insectivore[d] probing/soil-dwelling invertebrates diving/aquatic invertebrates	most rivers and streams oceans and coastal areas	small medium	spotted sandpiper lesser scaup
Aquatic Herbivore/Insectivore	most wetlands, ponds	medium	mallard

[a]Includes consumption of insects, other arthropods, worms, and other terrestrial invertebrates.
[b]Includes consumption of terrestrial vertebrates and large invertebrates.
[c]Includes consumption of fish, amphibians, crustaceans, and other larger aquatic animals.
[d]Includes consumption of aquatic invertebrates and amphibian larvae by gleaning or probing.

Table 1-2. Characteristics of Selected Mammals

Diet	General Foraging Habitat	Body Size	Selected Mammal Species
Insectivore[a] gleaning/surface-dwelling invertebrates	most habitat types	small	short-tailed shrew
Herbivore gleaning/seeds grazing or browsing/shoots, roots, or leaves	most dry-land habitats grassy fields, marshes, bogs prairie grass communities most habitat types	small small small medium	deer mouse meadow vole prairie vole eastern cottontail
Omnivore	woodlands, suburbs mixed woodlands and open areas	medium medium	raccoon red fox
Carnivore[b]	most areas near water	medium	mink
Piscivore[c]	rivers coastal, estuaries, lakes	medium medium	river otter harbor seal
Aquatic Herbivore	most aquatic habitats	medium	muskrat

[a]Includes consumption of insects, other arthropods, worms, and other terrestrial invertebrates.
[b]Includes consumption of aquatic and terrestrial vertebrates and large invertebrates.
[c]Includes consumption of fish, amphibians, crustaceans, molluscs, and other large aquatic animals.

Table 1-3. Characteristics of Selected Reptiles and Amphibians

Adult Diet	General Foraging Habitat for Adults	Body Size	Selected Reptile or Amphibian Species
REPTILES			
Terrestrial Carnivore[a]	open woods, fields and brush	medium	racer
Aquatic Piscivore[b]	most types of water bodies	medium	northern water snake
Omnivore	open fields, forest edge, marshes most freshwater bodies	medium large	eastern box turtle snapping turtle
Aquatic Herbivore	most wetlands, ponds	medium	painted turtle
AMPHIBIANS			
Insectivore[c]	shallow freshwater bodies	small	green frog
Aquatic Piscivore/Insectivore[d]	lakes, ponds, bogs, streams small lakes, ponds, streams	medium small	bullfrog eastern newt

[a]Includes consumption of terrestrial vertebrates and invertebrates, insects, other arthropods, worms, and other terrestrial invertebrates.
[b]Includes consumption of fish, amphibians, and crustaceans.
[c]Includes consumption of insects, other arthropods, worms, and other terrestrial invertebrates.
[d]Includes consumption of fish, amphibians, crustaceans, molluscs, other aquatic animals, and terrestrial insects and other invertebrates.

No. 17-70196

UNITED STATES COURT OF APPEALS
FOR THE NINTH CIRCUIT

NATIONAL FAMILY FARM COALITION, *et al*.,

Petitioners,

v.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, *et al*.,

Respondents,

and

MONSANTO COMPANY,

Intervenor-Respondent.

ON PETITION FOR REVIEW FROM THE UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

PETITIONERS' EXCERPTS OF RECORD VOLUME V (REDACTED)

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INDEX TO PETITIONERS' EXCERPTS OF RECORD

[1] Unless otherwise specified, the document identifier numbers record to their document numbers as listed in the Certified Amended Index, ECF No. 63-3.

[2] Respondent United States Environmental Protection Agency (EPA) did not produce, but only provided hyperlinks to, publicly available documents. *See* ECF No. 63-3. For the Court's convenience, Petitioners have produced those hyperlinked documents in their entirety in the Excerpts of Record.

VOLUME II			
Date	**Admin. R. Doc. No.**	**Document Description**	**ER Page No.**
10/10/2017	K.36	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: FW: New Dicamba non-crop complaints	ER 122
10/10/2017	K.53	E-mail from Reuben Baris (EPA) to Thomas Marvin (Monsanto) re: Label comments	ER 123
10/10/2017	K.90	E-mail from Philip Perry (Monsanto) to Michele Knorr (EPA), others, re: Response to Terms and conditions Page 1 - EPA comments	ER 165
10/10/2017	K.94	E-mail from Reuben Baris (EPA) to Tom Marvin (Monsanto) with markup of EPA's response to terms and conditions	ER 167
10/9/2017	K.52	E-mail from Phil Perry (Monsanto) to Michele Knorr (EPA) re: Implementation Terms and Conditions	ER 170
10/5/2017	K.16	E-mail from R. Baris (EPA) to T. Marvin (Monsanto) re: dicamba proposed registration conditions	ER 172
9/27/2017	K.11	E-mail from Jamie Green (EPA) to Anne Overstreet (EPA) re: correspondence received from seed company owner regarding Dicamba Control	ER 175
9/27/2017	K.42	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: article on Dicamba from Delta Farm Press[3]	ER 182

[3] This e-mail contains a hyperlink to an online article. *See* David Bennett, *Might Dicamba be Affecting Pollinators*?, Delta Farm Press, Sept. 26, 2017. For the Court's convenience, Petitioners have produced this and other similarly hyperlinked articles in the Excerpts of Record.

9/27/2017	K.32	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: FW: Many U.S. Scientists to skip Monsanto summit on dicamba	ER 188
9/27/2017	K.93	E-mail from Nicholas Sorokin (EPA) to EPA recipients of Office of Public Affairs media clips re: Reuters: Exclusive: U.S. scientists to skip Monsanto summit on controversial weed killer	ER 189
9/26/2017	K.46	E-mail from Reuben Baris (EPA) to Jonathan Becker (EPA) re: FW: yield data forwarded 10 journal articles on yield impact resulting from dicamba exposure	ER 192
9/21/2017	K.19	E-mail from Pesticide Action Network to Rick Keigwin (EPA) re: EPA: Pull Monsanto's crop-killing dicamba now	ER 278
9/21/2017	K.80	E-mail from Caleb Hawkins (EPA) to Jonathan Becker and others at EPA forwarding Reuters article on dicamba[4]	ER 280
9/13/2017	K.39	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Record number of pesticide misuse claims by Iowa farmers due to dicamba drift problems[5]	ER 285
9/12/2017	K.35	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: More Dicamba = Monsanto Petition to Arkansas State Plant Board	ER 291

[4] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* Tom Polansek, *U.S. Regulator Aiming to Allow Controversial Herbicide Use with Safeguards*, Reuters, Sept. 20, 2017.

[5] This e-mail contains a hyperlink to an online article that Petitioners have reproduced in its entirety. *See* Donnelle Eller, *Iowa Farmer Makes Record Number of Pesticide Misuse Claims*, The Des Moines Register, Sept. 12, 2017.

[6] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* David Bennett, *Dicamba Tests Showing Similar Results from Scattered Locations*, Delta Farm Press, Sept. 6, 2017.

8/29/2017	K.51	Ten articles on Dicamba send as a Google Alert to Reuben Baris (EPA)[7]	ER 364
8/23/2017	K.101 (Second Am. Certified Index, ECF No. 69-3)	Notes from 8/23/2017 EPA meeting with various state officials	ER 369
8/22/2017	K.31	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Letter to Topeka paper	ER 372
8/22/2017	K.38	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Off-target Movement of Dicamba in Missouri. Where Do We Go From Here?[8]	ER 374
8/21/2017	K.92	E-mail from Nicholas Sorokin (EPA) to EPA recipients of Office of Public Affairs media clips re: Reuters: Exclusive: U.S. farmers confused by Monsanto's weed killer's complex instructions	ER 379
8/20/2017	K.27	E-mail from Jamie Green (EPA) to Dan Kenny (EPA) re: FW: Dicamba update	ER 382
8/18/2017	K.88	E-mail from Kevin Bradley (University of Missouri) to R. Baris (EPA) regarding WSSA committee	ER 390

[7] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See EPA Responds to Dicamba Complaints*, Ag. Professional, Aug. 29, 2017.

[8] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* Kevin Bradley, *Off-target Movement of Dicamba in Missouri: Where Do We Go from Here?*, Integrated Pest Mgmt., Univ. Mo., Aug. 21, 2017.

8/17/2017	K.12	E-mail from Reuben Baris (EPA) to Dicamba registrants regarding next steps on dicamba	ER 394
8/10/2017	K.21	E-mail from Jamie Green (EPA) to Reuben Baris (EPA) re: FW Article from Arkansas times[9]	ER 395
8/3/2017	K.49	E-mail from Reuben Baris (EPA) to Mark Corbin (EPA) re: Fwd: TN data Effect of adding Roundup PowerMax to Engenia on vapor losses under field conditions	ER 406
8/2/2017	K.20	E-mail-calendar invite from Emily Ryan (EPA) to Reuben Baris (EPA) and other internal and external parties re: follow-up on Dicamba with AAPCO/SFIREG and agenda for 8/2/17	ER 417
8/2/2017	K.100 (Second Am. Certified Index, ECF No. 69-3)	Notes from 8/2/2017 EPA meeting with various state officials	ER 420
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8/1/2017	K.14	E-mail from Shanta Adeeb (EPA) to Dan Kenny (EPA) re: Dicamba Notes from July 28th meeting with states on dicamba incidents	ER 435
7/28/2017	K.66	E-mail from Reuben Baris (EPA) to Dan Rosenblatt (RPA) re: EPA notes taken during dicamba teleconference with state extension representatives on 7/28/17	ER 441

[9] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. *See* David Koon, *Farmer vs. Farmer*, Ark. Times, Aug. 10, 2017.

7/25/2017	K.22	E-mail from Dan Kenny (EPA) to Reuben Baris (EPA) re: FW Conference Call with EPA on Dicamba 7/25/17 (conference call information will be redacted)	ER 445
7/25/2017	K.59	E-mail from Sarah Meadows (EPA) to Dan Kenny (EPA) re: Notes from Dicamba meeting with states on 7/13/17	ER 447
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6/20/2016	A.863	Comment submitted by National Family Farm Coalition	ER 473
6/15/2016	A.57	Mortensen *et al.*, *Navigating a Critical Juncture for Sustainable Weed Management*, BioScience, Jan. 2012, at 75-84 (submitted as an attachment to comment submitted by Sylvia Wu, Center for Food Safety)	ER 474
6/15/2016	A.473	Comments submitted by The Center for Food Safety, including Excerpts from Exhibits A and F.	ER 485
6/10/2016	A.304	Comment submitted by J. R. Paarlberg	ER 554

6/10/2016	A.526	Anonymous Public Comment	ER 556
5/31/2016	A.581	Comment submitted by Steve Smith, Chairman, Save Our Crops Coalition (SOCC)	ER 558
5/31/2016	A.703	Comment submitted by Marcia Ishii-Eiteman, PhD, Senior Scientist, Pesticide Action Network	ER 572
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5/27/2016	A.34	Comment submitted by P. Douglas Williams, Director, Regulatory Affairs and Donald R. Berdahl, Executive Vice President/ CTO, Kalsec, Inc.	ER 603
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5/25/2016	A.840	Anonymous Public Comment	ER 612
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4/28/2016	A.838	Comment submitted by D. Dolliver	ER 625
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3/24/2016	A.285	Excerpt of Addendum to Dicamba Diglycolamine Salt (DOA) and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in in 11 U.S. States: (Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia). Phases 3 and 4	ER 702
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3/24/2016	A.45	Excerpt of Dicamba DGA: Second Addendum to the Environmental Fate and Ecological Risk Assessment for Dicamba DGA salt and its Degradate	ER 716
2014	I.28	Egan, J. F., Barlow, K. M., and Mortensen, D. A. 2014. A meta-analysis on the effects of 2,4-D and dicamba drift on soybean and cotton. Weed Science 62:193-206.	ER 724
3/8/2011	A.91	Excerpt of Ecological Risk Assessment for Dicamba and its Degradate	ER 740
9/17/2010	B.12	Comment submitted by Bill Freese, The Center for Food Safety	ER 774
6/4/2010	B.0024	Scott Kilman, *Superweed Outbreak Triggers Arms Race*, Wall St. J. (submitted as an attachment to the comment submitted by Ryan Crumley, The Center for Food Safety)	ER 782

THIS ENTIRE VOLUME IS FILED UNDER SEAL.

9th Circuit Case Number(s) 17-70196

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