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PARAQUAT: OPERATOR EXPOSURE

1 Introduction

The assessment of paraquat using the UK Percent Absorption Model, UK Absorption Rate Model, and the German Model, are given in the *UK Report on Paraquat, Volume 3, B5.14, page 109 - 115, Sept 1996*. The results of the first tier risk assessment conclude that there is a potential concern for operators following the use of paraquat by tractor and knapsack sprayers and therefore further assessment is required. Further assessment of the in-use risk using biomonitoring data, and in-use health studies, demonstrate an acceptable risk (*UK Report on Paraquat, Volume 3, B5.14, page 115 - 131, Sept 1996*).

The SCP Opinion (*SCP/PARAQ/002; January 2002*) on the operator exposure assessment for paraquat, which supported the above conclusion, was discussed at the Working Group Evaluation (WG-E) meeting in June 2002. Some concerns were raised at the WG-E over the operator exposure for amateur use and for negligent users. In order to address these concerns the following request has been recorded: "The main data submitter should provide an analysis of the margins of safety for all use scenarios. In this way the seriousness of the situation could be assessed should the AOEL occasionally be exceeded, for example in the case of spills or other deviations from good working hygiene".

This document is intended to summarise the available data and to demonstrate how this addresses the concerns outlined above.

2 Background Information

2.1 Route of Operator Exposure

When paraquat-containing products are diluted and sprayed, the principal route of occupational exposure is dermal - mainly to the hands but also, during hand-held application, potentially to the lower legs. Inhalation exposure is negligible. During normal occupational exposure, paraquat is poorly absorbed through human skin but any small amounts, which are absorbed, are readily excreted and only reach levels which are significantly below those needed to induce toxic effects in the lung, the most sensitive target organ for paraquat.

The behaviour and properties of paraquat indicate that it will not cause adverse health effects in normal use. Specific health studies, coupled with experience of more than 30 years' use worldwide, have supported this analysis. The simplicity, through ease of use, and reliability, as no need to repeat applications, in the use of paraquat-containing products also contribute to the overall good safety record.

Occasionally, problems of skin irritation or nail damage may be found during occupational exposure, mainly in hand-held applications as a result of unwashed spillages, from unwashed splashes of commercial product or from prolonged dermal contact with spray solution. These local reactions are due to the irritancy of paraquat, as would occur for any irritant product. Such irritation/damage is reversible upon cessation of exposure to paraquat and is indicative of inadequate standards of personal hygiene and serves to highlight the need to generally improve working practices with pesticides and other chemicals. These topical effects should be addressed by labelling requirements (*'Guidance for the setting of an acceptable operator exposure level (AOEL)' 7531/VI/95 rev.6, 10 September 2001*).

2.2 Use Patterns Relevant To Annex I Inclusion

Paraquat is a non-selective contact herbicide, which is primarily used for the treatment of small annual weeds. All applications are directed at the ground, and employ large droplets and targeted spraying, to prevent drift onto non-target areas. The intended supported uses of paraquat are agricultural, by conventional tractor sprayer or knapsack application. It is not appropriate to its use to apply by means of a mist blower, fogging machine or through controlled droplet application equipment. Aerial use is not supported. Other uses are minor and include amateur use using a low strength granular formulation applied with a watering can.

Knapsack application is considered to be the worst-case exposure scenario as the lower limbs of the applicator may be exposed to the downward directed spray drift and also to the freshly sprayed vegetation.

3 Operator Risk Assessment

3.1 Basis For Setting the AOEL for paraquat

According to regulatory guidance an AOEL is based on the lowest NOAEL established over a relevant time period, with a 100 fold safety factor and corrected for oral adsorption, in order to establish a systemic safety level for the operator. In the case of paraquat, the AOEL is derived from the 90-day dog study[1] with an NOAEL of 20 ppm in the diet (mean paraquat intake figures of 0.56 mg paraquat/kg bw/d for males and 0.71 mg paraquat/kg bw/d for females). The AOEL is therefore 0.00056 mg/kg bw/d (equivalent to 560 ng/kg bw/d) with a 100 fold uncertainty factor and corrected for 10% oral absorption. (*Refer to UK Report on Paraquat, Volume 3, B5.10.3, page 97, Sept 1996; UK Report Addendum, Section B.5.10.3, May 2000; Evaluation Table, Section 4.2, Doc 7755/VI/97).*

3.2 First Tier Operator Risk Assessment

The first tier of risk assessment uses 'generic' operator exposure models to assess exposure and compare this with the appropriate acceptable operator exposure level (AOEL). These exposure models are based on a variety of different data which are transposed into a generic exposure database. There is inherent uncertainty to its relevance to specific product use. Risk assessments therefore rely on a number of exposure assumptions and include the use of general uncertainty factors in the extrapolations from animals to man. These limitations in the exposure data are recognised, and have prompted the support for development of a new database to underpin EUROPOEM.

For paraquat, it was concluded that based on the existing models, operator exposure exceeds the AOEL (*Full Report on Paraquat ECCO Peer Review Meetings, July 1997)*. Given the above limitations of first tier risk assessment model, it was considered that this was an unduly conservative assessment of the situation for paraquat. Therefore the next step within a tiered assessment of the risk to the operator is measurement of either exposure or, where possible, of the absorbed dose via biological monitoring (the latter providing the best possible exposure endpoint for an assessment of operator risk).

3.3 Higher Tier In-Use Operator Exposure Data

In the ECCO review, paraquat operator exposure field studies, involving biological monitoring to measure the absorbed dose of paraquat, were considered in the risk assessment. Two studies, a knapsack study in Sri Lanka[2] and a tractor study in Georgia, USA[3] are reviewed in the *UK Report on Paraquat, Volume 3, B5.14, pages 115 - 121, Sept 1996.* During the ECCO review, it was considered that the Sri Lankan study was not appropriate for the EU as there was no personal protective equipment (PPE), minimal clothing (shorts/short sleeved shirts and no footwear) and there were no detects in any 24 hour urine sample. A field study under European conditions was requested. Two new knapsack studies were then submitted, a Spanish study[4] and a Guatemalan[5] study which used a lower level of analytical detection, and these studies were reviewed in the *UK Report Addendum, B5.14, May 2000 and the Evaluation Table, Section 4.5, Doc 7755/VI/97*. The outcome of all of these studies are summarised in the table below, and discussed in detail in Sections 3.3.1-2.

Location	Number Of Workers	Operator	PPE for mixing and loading	PPE for spraying	Exposure (days)	Monitoring (days) excluding pre-treatment baseline	LOD ng/l	Results
USA[3] 1995 (tractor mounted)	17	Loaders / Mixers	Long or short Sleeves Long Trousers Boots Cap 5/17 wore gloves 1/17 rubber apron, 'Tyvek' suit, goggles faceshield 1/17 respirator	Long Sleeves Short Sleeves Long Trousers Boots Cap 2/17 'Tyvek' suit	1	6	5	Detects in 5/17 on day of exposure
Sri Lanka[2] 1987 (knapsack)	2	Mixer / Loaders	Short Sleeves Shorts No Shoes		5	8	30	No detects > LOD
Sri Lanka[2] 1987 (knapsack)	10	Spray Operators		Short Sleeves Shorts No Shoes	5	8	30	No detects > LOD
Spain[4] 1998 (knapsack)	20	Mixer / Loader / Applicators	Long Sleeves Long Trousers Rubber Boots Gloves Face Shield	Long Sleeves Long Trousers Rubber Boots	1	6	0.75	Detects in 18/20 eliminated by day 4 in 16 operators
Guatemala[5] 1997 (diquat) (knapsack)	20	Mixer / Loader / Applicators	Long Sleeves Long Trousers Rubber Boots Long socks Gloves Face Shield	Long Sleeves Long Trousers Rubber Boots Long socks	1	6	0.71	Detects in 20/20 eliminated in 15/20 in 24 hours, Eliminated in all within 48 hours.

3.3.1 Conventional Ground Crop Sprayer (Tractor)

The USA tractor study[3] involved 17 mixer/loader/applicators over one full day of use using a wide range of application equipment. Workers wore long or short-sleeved shirts, long trousers, boots and cap. Only 5 workers wore gloves for mixing/loading. One worker only used full protective clothing. Urine samples were taken for 7 days (the day prior to application, until 5 days after application). Full details of observations of individual worker practices, and associated absorption have been extracted from the study report and are given in Appendix 1. Paraquat was only detected during the first 24 hours and only in 6 of the 17 workers (ranging from 14-88% of the AOEL for those individuals; LOQ 5.0 ng/ml). Paraquat was not detected in any subsequent samples (Days 2-6). The slightly higher absorbed doses of paraquat in specific workers can be attributed to accidental contamination e.g. operator contamination during mixing and loading without gloves, from equipment maintenance, and also handling contaminated equipment without gloves.

For the tractor-mounted application, the bio monitoring study performed in Georgia, USA[3] demonstrated that the AOEL was not exceeded (LOQ: 5μg/ml); and in the majority of the workers there was no detectable absorption of paraquat.

It is concluded by the rapporteur Member State that the bio monitoring study demonstrates that operators handling and using paraquat under the proposed conditions of use for tractor application, will not exceed the AOEL. (*UK Report Addendum, Section 5.14, May 2000 and the Evaluation Table, Section 4. 5, Doc 7755/VI/97)* This is confirmed in the *SCP Opinion for paraquat, SCP/PARAQ/002, January 2002.*

3.3.2 Knapsack Ground Application

The Sri Lankan knapsack study[2] involved 2 mixer/loaders and 10 spray operators over five consecutive day of use. Full details are included in the *UK Report on Paraquat, Volume 3, B5.14.1.4, page 115, Sept 1996*. All workers wore short-sleeved shirts, shorts and no footwear. Complete 24 hour urine samples were taken for 13 days (1 day before first 5 days of use and for 7 days afterwards). Paraquat was not detected in any of the samples (LOQ: 30 ng/ml) collected from the day before spraying until 8 days after the last day of spraying. These data demonstrate that in the worst-case exposure scenario (knapsack, no PPE), paraquat is rapidly excreted and does not accumulate. It should be noted that the risk assessment using this study is based on the assumption that paraquat was present in each urine sample from each operator, on each of the 5 days of exposure, at a concentration equivalent to one half the LOQ. This is a conventional approach established in occupational hygiene as a means of dealing with 'non detects' in exposure samples. Given that the level of clothing and protection represents a 'worst case' as far as typical European practices are concerned, it is reasonable to conclude that exceeding the AOEL by a factor of 2, on the basis of the Sri Lankan data, is acceptable.

The new study carried out in Spain[4] was a realistic assessment of the use of paraquat applied via a knapsack sprayer in an orchard under representative EU conditions. The study involved 20 mixer/loader/applicators applying paraquat product over one full day's use. Workers wore standardised clothing of long sleeved cotton shirt, long cotton trousers and rubber boots. In accordance with the label recommendation, protective (nitrile) gloves and a face shield were worn during mixing and loading. Urine samples were taken for 7 days (the day prior to application, until 5 days after application; LOQ 0.75 ng/ml). Full details of observations of worker practices, and associated absorption are included in the *UK Report Addendum, Section 5.14, May 2000* and are also given in Appendix 2. Paraquat was detected in samples from 18 of the 20 workers, and was totally eliminated within 72 hours (Day 4), except for low levels in 2 workers until Day 5, and 1 worker until Day 7. The slightly higher absorbed doses of paraquat in specific workers can be attributed to accidental contamination of clothing with dilute spray solution e.g. operator contamination from equipment maintenance, tank overflow, and handling contaminated equipment without gloves. The arithmetic mean absorbed dose of paraquat was 149 ng/kg bw/day, which is 30% of the AOEL. The geometric mean absorbed dose of paraquat of 77 ng/kg bw/day, which is 15% of the AOEL. Worker 14, whose shirt was wet due to leakage from the top of the knapsack, had the highest absorbed dose (408 ng/kg/bw/day), which equates to 82% of the AOEL.

An additional study in Guatemala[5] was provided as supporting data for knapsack use, involving 20 mixer/loader/applicators, using the similar compound, diquat, which is almost identical in its physical and chemical behaviour, for one full day's use. Urine samples were taken for 7 days (the day prior to application, until 5 days after application; LOQ: 0.71 ng/ml). Full details of observations of worker practices, and associated absorption are included in the *UK Report Addendum, Section 5.14, May 2000* and are also given in Appendix 3. On the day of exposure, diquat was detected in the urine samples of all 20 workers, and was totally eliminated within 24 hours in 15 workers. No diquat was detected in the urine of any worker after 48 hours. The slightly higher absorbed doses of diquat in specific workers can be attributed to contamination of clothing with dilute spray solution e.g. operator contamination from leaking equipment, lance held at chest and face height, some face to arm contact, and handling contaminated equipment without gloves. The mean absorbed dose of diquat was 125 ng/kg bw/day which is 25% of the AOEL for paraquat. The geometric mean absorbed dose (geometric mean) of 75 ng/kg bw/day which is 15% of the AOEL for paraquat. Worker 11, who sprayed canal areas with lance at head height, had the highest absorbed dose (589 ng/kg/bw/day), which equates to 112% of the AOEL. This is considered to be unrepresentative of applications practised under European conditions.

It is concluded by the rapporteur Member State that these bio monitoring studies demonstrate that operators handling and using paraquat under the proposed conditions of use by knapsack application, will not exceed the AOEL. (*UK Report Addendum, Section 5.14, May 2000 and the Evaluation Table, Section 4. 5, Doc 7755/VI/97*). This is confirmed in the *SCP Opinion for paraquat, January 2002*.

3.3.3 Minor Uses

When the review under Council Directive 91/414/EEC commenced all potential uses of an active substance had to be included in the submission. Therefore all uses of paraquat were included in the original submission including amateur use, which is only registered in UK and Ireland. Using current criteria, this use would not be included in the submission for Annex I inclusion, and would only be considered by competent Authorities, using national use patterns, following inclusion on Annex I. However it is covered here for completeness.

There are no models to estimate exposure from the use of watering cans. Using the German model, the UK Rapporteur estimates the worst case exposure based on the assumption that an amateur spraying for 1 hour/day could spray 67 litres and treat 0.025 ha, applying 15 sachets of Weedol (WG formulation). Using these extreme worst-case assumptions, and assuming repeated use (90 days), the first tier operator exposure assessment marginally exceeds the AOEL (*Refer to UK Report on Paraquat, Volume 3, B5.10.3, page 97, Sept 1996*).

There are no specific bio monitoring data for amateur use of paraquat when applied in small quantities to a limited area, at a concentration of 0.3 g/l via a watering can, on a few occasions per year. However the knapsack biomonitoring studies, demonstrate acceptable safety margins for a full day of exposure, and consecutive use, and on this basis it is considered that the risk assessment for amateurs in the real situation is acceptable.

3.3.4 Worker re-entry

Worker re-entry is discussed in the *UK Report Addendum, Section 5.14, May 2000 and the Evaluation Table, Section 4. 5, Doc 7755/VI/97.* On the basis of a worker re-entry bio monitoring study[6] in which paraquat was not detected in any samples (LOQ 10 ng/ml) for workers re-entering 24 hours post application, and was only detected in 1 sample 4 hours after application. The absorbed dose for this worker was 0.00004 mg/kg bw/day (8% of the AOEL). This is consistent with expectations based on lack of availability once the application has dried onto the vegetation. These data supported the proposed re-entry period of 24 hours.

3.4 Margin of Safety in the Operator Risk Assessment

The US and Sri Lankan studies, conducted with no gloves and/or minimal protective clothing respectively, provide evidence of adequate margin of safety for the operators. Therefore the safety of EU operators will not be compromised if they are negligent and do not adhere to label recommendations for protective clothing.

Furthermore in all the biomonitoring studies, there were incidents of operator contamination from equipment maintenance, tank overflow and from handling contaminated equipment without gloves. As such these studies are representative of the real situation when occasional accidental exposure may occur. Where individual operator practice can be related to bio monitoring results, the occasional misuse, including leaking knapsacks, does not result in an unacceptable margin of safety.

This is not unexpected as the skin provides a very effective barrier to paraquat absorption and this will be the case even in the event of accidental spillage. As indicated in Section 2.1 unwashed spillages, unwashed splashes of commercial product or prolonged skin contact with spray solutions may cause skin irritation. Whilst this is reversible, it provides a good indication of the need for improved working practices and hygiene with all pesticides and other chemicals.

In addition to the adequate margin of safety demonstrated in the bio monitoring studies, it should also be recognised that derivation of the AOEL incorporates some additional conservative elements:

The current EU recommendation is to use an overall assessment, or uncertainty, factor of 100 for inter- and intra-species differences in the setting of an AOEL. This default recommendation is given in the European Commission's *'Guidance for the setting of an acceptable operator exposure level (AOEL)' 7531/VI/95 rev.6, 10 September 2001*. This x100 factor is very conservative. The underlying scientific basis for the use of the 100-fold factor is based on 10 for inter-species differences and 10 for intra-human population differences, including the young and elderly. The previously accepted 25-fold factor (10 for inter-species differences and 2.5 for intra-human working population differences) remains a valid basis for the safety margin for a product used by professional users.

Under EU conditions, the exposure pattern of paraquat is considered to be short-term at specific periods during a year, i.e. 1 application per season, and not involve continuous exposure throughout the year. The AOEL is based on 90 day studies which assume that the farmer applies paraquat every day for 90 days. This is significantly in excess of actual practices. Even in the case of contractors, where the product may be used more frequently, a survey sponsored by ECPA, has demonstrated, for products in France for example, an average application time of < 4 weeks, with an overall application window of 5-6 months (Refer to *Market research of professional field contractors in support of AOEL establishment. A report prepared for ECPA by European Agricultural Services S.A.R.L, 1996*).

4. In-Use Health Monitoring Data

The bio monitoring studies discussed above provide an assessment of actual exposure and therefore the most refined operator risk assessment. In the case of the application of paraquat-containing products by knapsack spray operators, health-monitoring studies are also available to confirm lack of chronic health effects. These were carried out in non-EU situations, where workers apply paraquat daily. These studies were carried out in Malaysia[7] (27 workers; greater than 5 years of daily use), Sri Lanka[8] (85 workers; mean exposure of 12 years) and the Philippines[9] (43 workers; mean exposure 451 days in 3 years, with maximum of 19 years). These long-term health-monitoring studies for paraquat are reviewed in *the UK Report on Paraquat, Volume 3, B5.14, pages 124 - 125, Sept 1996*. In each of these studies application was exclusively by means of knapsack sprayers in plantations in tropical areas where weed control is required throughout the year on a daily basis. In the case of the health monitoring studies performed in Malaysia and the Philippines the workers routinely wore long trousers and long-sleeved shirts, which is most relevant to EU conditions. The fact that the frequency, duration and nature of exposure of the workers assessed in these health-monitoring studies exceed that which might typically occur within the EU provides reassurance of the adequate protection for EU workers.

The health monitoring studies focussed on an assessment of the chronic endpoints based on the known toxicity of paraquat. The health of the spray operators and the control groups were evaluated through full clinical medical examination including lung function.

In all these studies, there were no clinically significant differences in any of the measurements made between the spray operator group and the control group. These studies provide the most definitive assessment of the practical health risk to operators and clearly demonstrate that long-term continuous use of paraquat by plantation workers wearing minimal clothing does not result in long term health effects in human.

These health-monitoring studies also provide further reassurance over the safety margins for operators for application of paraquat-containing products by tractor-mounted sprayers since knapsack application presents a higher potential for operator exposure.

Conclusion

Bio monitoring studies have demonstrated that exposure does not exceed the AOEL, with adequate safety margins even in the event of occasional misuse. This is supported by health monitoring data, which have demonstrated that the use of paraquat has not given rise to any chronic health effects in knapsack spray operators in three studies in Asia Pacific countries.

References

1 [redacted] (1981) 'Paraquat thirteen week (dietary administration) toxicity study in beagles' Hazleton Laboratories Europe Ltd. Report No 2481 – 72/111A, CTL/C/1027 (submitted in the paraquat dossier under Annex II Section 5.9.4; full evaluation in UK Report on Paraquat, Volume 3, B5.3.2, page 59, Sept 1996)

2 [redacted] (1989) 'Paraquat: Dermal Exposure Of, And Absorption By, Sri Lankan Tea Plantation Workers' ICI Agrochemicals Report No. TMF 3189 (submitted in the paraquat dossier under Annex III Section 7.2.1.2; full evaluation in UK Report on Paraquat, Volume 3, B5.14.1.4, page 115, Sept 1996)

3 [redacted] (1995) 'Paraquat: Worker Exposure During Mixing, Loading And Application Of 'Gramoxone Extra' To Pecans Using Vehicle-Mounted, Ground-Boom Equipment (WRC-95-034) (WINO 18627)' Zeneca Ag Products Western Research Center Report No RR 95-019B submitted in the paraquat dossier under Annex III Section 7.2.1.2; full evaluation in UK Report on Paraquat, Volume 3, B5.14.1.4, page 119, Sept 1996)

4 [redacted] (1998) 'Paraquat: Worker Exposure During Mixing Loading And Application Of 'Gramoxone' With Knapsack Sprayers' Zeneca Agrochemicals Report Number WER004 (submitted in Zeneca's comments to the ECCO Report, for inclusion in the paraquat dossier under Annex III Section 7.2.1.2; full evaluation in UK Report Addendum, Section 5.14, May 2000).

5 [redacted] (1997) 'Diquat: Worker Exposure During Mixing Loading And Application Of 'Reglone' With Knapsack Sprayers' Zeneca Agrochemicals Report Number CTL/P/5379 (submitted in Zeneca's comments to the ECCO Report, for inclusion in the paraquat dossier under Annex III Section 7.2.1.2; full evaluation in UK Report Addendum, Section 5.14, May 2000).

6 [redacted] (1995) 'Worker exposure during re-entry into paraquat treated cotton fields: biological monitoring in Georgia in 1994' Zeneca Ag Products Western Research Center Report No RR 95010B (submitted in Zeneca's comments to the ECCO Report, for inclusion in the paraquat dossier under Annex III Section 7.2.2 and 7.2.3; full evaluation in UK Report Addendum, Section 5.14, May 2000).

7 [redacted] (1980) 'A Study Of The Health Of Malaysian Plantation Workers Occupationally Exposed To Paraquat' ICI Plant Protection Division Report No. PSR 80.001B (submitted in the paraquat dossier under Annex III Section 7.2.1.2; full evaluation in UK Report on Paraquat, Volume 3, B5.14.1.4, page 124, Sept 1996)

8 [redacted] (1990) 'The Health Of Sri Lankan Tea Plantation Workers Associated With Long Term Exposure To Paraquat: An Epidemiology Study' ICI Agrochemicals Report No. TMF3589B (submitted in the paraquat dossier under Annex III Section 7.2.1.2; full evaluation in UK Report on Paraquat, Volume 3, B5.14.1.4, page 124, Sept 1996).

9 [redacted] (1992) 'Health Of Paraquat Spraymen In Banana Plantations In The Philippines – An Epidemiology Study' ICI Agrochemicals Report No TMF4180B (submitted in the paraquat dossier under Annex III Section 7.2.1.2; full evaluation in UK Report on Paraquat, Volume 3, B5.14.1.4, page 125, Sept 1996).

APPENDIX 1

PARAQUAT BIOMONITORING STUDY: TRACTOR STUDY IN USA[3] (1995)

Estimate of Absorbed Dose of Paraquat

TRIAL – SUBJECT NUMBER	BODY WEIGHT (lb/kg)	TOTAL TIME SPENT MIXING AND LOADING (min)	TOTAL DURATION OF EXPOSURE (min)	AMOUNT ABSORBED (mg)	AMOUNT ABSORBED (mg/kg bw/day)
1	232/105	31	270	0.0069	0.00007
2	190/86	54	350	-	-
3	188/85	39	330	0.0142	0.00017
4	185/84	49	360	-	-
5	172/78	25	255	-	-
6	161/73	65	230	0.0051	0.00007
7	196/89	80	238	-	-
8	186/84	104	660	0.0273	0.00033
9	205/93	14	397	-	-
10	190/86	54	414	0.0378	0.00044
11	>300/>136	40	397	-	-
12	238/108	53	290	-	-
13	195/89	42	430	-	-
14	210/95	34	404	0.0144	0.00015
15	184/84	44	286	-	-
16	205/93	22	417	-	-
17	203/92	45	311	-	-

Appendix 1 cont.: **Work Practice Observations in Tractor Study in USA**[3]

SUBJECT – TRIAL NO.	OBSERVATIONS AND INCIDENTS
1	1. Hands get contaminated during mixing procedure. Hands are not washed during exposure period. 2. Washes hands, face, arms, and neck after finishing spraying for the day.
2	1. Washes hands after mixing loads 2, 3 and 4. 2. Smokes several cigarettes during exposure period. 3. Rinses out empty containers and measuring devices and pours rinse into spray tank during the mixing and loading operations.
3	1. Calibrates tractor with no gloves on and nozzles are clogged. 2. During mixing of first load, lots of foam in tank when topping off with water, foam gets on subject's hands.
4	1. Rinses out empty containers and measuring devices and pours rinse into spray tank during the mixing and loading operations. Some overflow of foam onto outside of spray tank during each mixing. 2. Washes hands after mixing each load. 3. Some of the rinse from second mixing splashes onto shirt. 4. Washes hands prior to and after urinating.
5	1. Subject wears rubber gloves whilst adding test substance to spray tank. 2. Foam overflows on outside of spray tank. Subject gets foam on bare hands when replacing the lid on the tank.
6	1. Subject rinses out graduated cylinder and pours rinse into spray tank after each mixing. 2. Subject washes hands before eating lunch. 3. After spraying, subject rinses out spray tank and spray system.
7	1. Subject washes hands after mixing load 2. Subject wipes hands off before urinating. 3. Subject washes out spray tank and lines.
8	1. Subject wipes head with shirt. 2. Subject chews gum during exposure period. 3. During the mixing and loading operations there was some foam and water which flowed over the top of the spray tank. Some foam gets on subject's hands. 4. Subject washes face after mixing and loading operations 7, 8, 9, and 10. Subject washes hands after mixing and loading operations 4, 6, 7, 8, 9, 10 and 11. 5. Subject wipes off hands before urinating (2 times during exposure day). 6. Twice during the exposure day, subject works on an irrigation water line on the recently sprayed ground, behind the tractor. 7. Subject removes long-sleeved shirt (worn during the first 3 hr 25 min). 8. Subject checks some spray nozzles, removes them with a wrench and blew into them. No gloves worn (5 min). 9. Subject drops spray tank lid in standing water at pump. Picks up the lid bare handed and washes lid off before replacing. This event occurs during the fifth and eighth mixing and loading operations. 10. Subject removes some branches from under tractor. 11. Subject adjusts spray boom with bare hands three times throughout the exposure day. 12. Subject eats lunch while on tractor spraying. 13. Subject moves tractor to new site to spray. New site water hose has many holes in it. 14. Subject gets a small cut on his arm prior to mixing and applying the last spray tank.
9	1. Subject stops and goes to rear of tractor to check something. 2. Subject washes hands before urinating twice during exposure period. 3. Stops to refuel tractor, then has to jump start the tractor (30 min).

SUBJECT – TRIAL NO.	OBSERVATIONS AND INCIDENTS
10	1. Spray mix splashes out of spray tank during first mixing and loading operation. 2. Subject replaces spray tank lid after picking it up. It blew off because it was not securely fastened. 3. Lots of dew from trees, subject's pants and shirt are damp in early morning hours. 4. Subject gets off tractor to check end nozzles (2 min). 5. Subject stops to urinate. 6. Some foam overflows from spray tank during the third mixing and loading operation. Subject rinses hands after replacing the lid. 7. Subject washes hands after fourth mixing and loading and also washed down end of water pipe. 8. During the fifth and ninth mixing and loading operations, subject opens container with pocket knife and wipes the knife off on right leg of jeans. He does not wash hands after these operations. Observer notes substance is on subject's hands after ninth mixing operation. 9. During the seventh mixing, wipes pocket knife on tissues. He washes off spray tank and rinses hands under running water. 10. Subject drinks coke during spraying load 7. 11. When mixing load 8, subject removes some debris from the measuring cylinder using pocket knife and fingers. There is test substance in cylinder. Subject wipes fingers on jeans.
11	1. Adds 10 gallons of Simitrol (simazine) to tank mix. Triple rinses each container and adds rinse to spray tank. 2. Subject washes rubber gloves and dries them before removing. Then removes face shield, goggles, apron and respirator. 3. Subject stops to talk to someone and gets drink of water (5 min). 4. Subject stops tractor and walks around for 5 minutes, due to cramp in leg. 5. Subject stops spraying and puts on goggles and rubber gloves to rinse out Simitrol containers into spray tank (75 gallons of spray in tank). Takes off goggles and gloves. 6. Subject drives to farm yard (19 min). 7. Subject puts on gloves and goggles to rinse empty containers before puncturing. Rinse is added to spray tank before containers are punctured.
12	1. Subject opens containers with pocket knife. 2. Subject over flows tank when mixing. Washes off gloves and then removes gloves. Proceeds to let some spray substance out of tank in order to add surfactant. Adds surfactant without gloves on. 3. Subject drinks water out of hose which he filled tank with (does twice during exposure period). 4. Subject stops to fix bolt broken on boom, washes hands after repair (5 min). 5. Subject washes out spray tank wearing rubber gloves after finishing spraying.
13	1. Subject removes rubber gloves, face shield and rubber apron after each mixing and loading operation. Subject washes gloves before removing. 2. Subject stops to go to restroom, drinks soda and smokes cigarette (smoking and drinking during spraying). 3. Subject has several small cuts on arms.
14	1. Subject has open cut on back of right hand. 2. Subject takes two drinks of water during exposure period. 3. Subject rinses measuring device and pours rinse into spray tank, then rinses hands and puts lid on spray tank. 4. Subject gets off tractor and opens spray tank lid to check levels three times during exposure period. 5. Subject raises spray boom and ties in upright position so he can stop and take lunch (this prevents nozzles from dripping). 6. Tractor breaks down, leaking fuel. Tractor gets fixed. 7. During last mixing, subject breaks seal on container with pocket knife and pulls off rest of cover with fingers (no gloves). 8. After spraying is completed for day, subject loads empty containers in back of pick-up truck.

SUBJECT – TRIAL NO.	OBSERVATIONS AND INCIDENTS
15	1. During mixing and loading operations, subject uses pocket knife to open seal on test substance containers. Test substance gets on gloves and knife. Puts glove into pocket when returning knife. 2. Subject gets splashes on chest when filling spray tank. 3. Spray tank has some overflow from filling during mixing and loading operations 1 and 3. 4. While adding test product to the spray tank, subject's hat falls off. She stops operation to retrieve and replace hat. Subject wipes her head and takes a drink of water.
16	1. Subject rinses out empty test container and pours rinse into tank during mixing and loading operations. 2. Some splashing and foam overflow when adding water. Subject rinses gloves and washes foam off of tank. He also washes off end of hose that was filling the spray tank. 3. Subject stops to clean pump filter, he puts on glove to open filter. Spray mixture comes out under pressure and spills over gloves. Subject replaces filter cap and then washes down with hose. Removes rubber gloves prior to resuming spraying (15 min). 4. Subject returns from lunch and puts on Tyvek suit, books and gloves. Subject checks spray systems filters and then washes gloves and hands. 5. Subject stops to adjust boom height. 6. Subject starts to spray a portion of the orchard which has been recently mowed, there is a lot of dust.
17	1. During first mixing and loading operation, subject opens test substance container with penknife – no gloves worn. He wipes blade on apron. Subject rinses out first container under running water and pours rinse into tank. He gets some splashes on face shield and apron. After adding more water, subject puts on gloves to pour more test substance into tank. 2. For all mixing operations, the spray tank is filled by overhead water spout approximately 4 ft above spray tank, creates lots of water splashing. 3. Second and third mixing, subject opens containers without gloves. Adds water to tank and puts gloves on before pouring test substance into spray tanks. Rinses out containers and pours rinse into spray tank. Some splashing on apron and face shield. 4. Subject stops and washes hands prior to having lunch. 5. Subject puts on gloves before opening containers for fourth mix and then repeats procedures described in number 3. Subject prepares 250 gal. of solution for final spray. 6. Subject gets a drink from the well.

APPENDIX 2

PARAQUAT BIOMONITORING STUDY: KNAPSACK STUDY IN SRI LANKA[2]
(1989)

Observations on Work Practices

Mixing and loading involved two workers who alternated the handling of "Gramoxone" W formulation and filling of the knapsack tanks. Their equipment consisted of a half oil-drum of nominal 20 gallon (91 litre) capacity, a bucket and a 10 fl oz (283 ml) cut-down baby's feeding bottle. On days 3 to 5, and 6, a second drum was used to increase the efficiency of mixing and loading which resulted in an increase in the amounts of paraquat handled and sprayed compared with days 1 and 2.

The usual source of water for diluting the formulation was a stream as close as possible to the sites of spray application. The mixing drum was placed by the stream and one mixer-loader part-filled it with water using a bucket. He then decanted 5 fl oz (142 ml) "Gramoxone" W into the measuring bottle and poured it into the drum. The drum was filled with water and the resultant spray dilution stirred with a stick. Individual knapsack tanks were then filled to capacity using the bucket. When one drum was in use on days 1 and 2, two drums of spray solution were prepared consecutively by one mixer-loader in order to fill ten knapsack tanks.

The mixer-loaders would often stand in the stream whilst adding water to the drum or handling the formulation. Any spillages on the hands or legs were washed off almost immediately after completion of the task. Overall, the standard of hygiene of the mixer-loaders was very high despite the minimal working clothing and lack of protective equipment.

Owing to the muddy conditions brought about by heavy rainfall, the operators were observed to wash their feet and legs after completion of most spray tanks when they reached the mixing-loading site. Under these conditions, the standard of hygiene of these workers was similarly high.

APPENDIX 3

PARAQUAT BIOMONITORING STUDY: KNAPSACK STUDY IN SPAIN[4] (1998)

Estimate of Absorbed Dose of Paraquat

Worker No. (SP97PQ)	Pre-exposure Day 1	Exposure Day 2A	Day 2B	Day 3	Day 4	Day 5	Day 6	Day 7	Total Estimated Absorbed Dose (ng/kg bw/day)
1	<LLOQ	22.7	111	32.7	<LLOQ	<LLOQ	<LLOQ	<LLOQ	166
2	<LLOQ	9.60	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	9.60
3	<LLOQ	7.90	33.3	24.6	27.4	<LLOQ	<LLOQ	<LLOQ	93.2
4	<LLOQ	<LLOQ	206	35.0	<LLOQ	<LLOQ	<LLOQ	<LLOQ	241
5	<LLOQ	13.3	59.6	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	72.9
6	<LLOQ	51.9	136	39.7	27.2	<LLOQ	<LLOQ	<LLOQ	255
7	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
8	<LLOQ	<LLOQ	68.7	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	68.7
9	<LLOQ	<LLOQ	41.0	36.6	<LLOQ	<LLOQ	<LLOQ	<LLOQ	77.6
10	<LLOQ	<LLOQ	93.6	29.9	<LLOQ	<LLOQ	<LLOQ	<LLOQ	124
11	<LLOQ	<LLOQ	262	41.1	45.7	17.9	<LLOQ	<LLOQ	367
12	<LLOQ	61.4	48.2	42.5	35.9	<LLOQ	29.3	25.1	242
13	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
14	<LLOQ	67.2	181	87.6	38.3	33.5	<LLOQ	<LLOQ	408
15	<LLOQ	<LLOQ	94.7	30.9	32.0	<LLOQ	<LLOQ	<LLOQ	158
16	<LLOQ	18.3	17.8	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	36.1
17	<LLOQ	34.9	26.7	28.0	<LLOQ	<LLOQ	<LLOQ	<LLOQ	89.6
18	<LLOQ	28.6	57.9	42.3	<LLOQ	<LLOQ	<LLOQ	<LLOQ	129
19	<LLOQ	29.4	92.7	51.2	<LLOQ	<LLOQ	<LLOQ	<LLOQ	173
20	<LLOQ	9.49	236	<LLOQ	28.0	<LLOQ	<LLOQ	<LLOQ	273

Appendix 3 cont: **Work Practice Observations in Knapsack Study in Spain**[4]

WORKER NUMBER	NOTIFIER'S OBSERVATIONS
1	There was some spillage of solution on the outside of the spray tank during one mixing. Tended to be a little sloppy with filling the tank with water. Sprayed well. Smoked a cigarette on completion of spraying. No major incidents.
2	On one occasion cleaned the nozzle and washed filter with bare hands. No major incidents.
3	After the 3rd tank some leakage was noted on the left buttock and splashes on the back which were observed to increase. No major incidents.
4	No major incidents.
5	Worker had a problem with a blocked filter which needed cleaning. No major incidents.
6	On one occasion some dilute product was spilt on the back while bending down. No major incidents.
7	Slightly overfilled sprayer on first load. Some problems with leaking sprayer on back and buttocks, resulting in the need to change sprayers. Forgot to wear gloves on two occasions when mixing. No major incidents.
8	On one occasion slightly overfilled sprayer. No major incidents.
9	Workers clothing was observed to be wet, but mainly from the dew and sloppy filling by pouring water over the outside of the tank. No major incidents.
10	Slightly overfilled sprayer on one occasion. Wet clothes from the dew and sloppy filling of spray tank. No major incidents.
11	Forgot to wear face shield on one occasion when mixing. One load was made up by No. 12 while No.11 was returning from breakfast. On another occasion 12 assisted and 11 forgot to wear his face shield again. Observed to have large wet patch on back. No major incidents.
12	Product spillage onto tank lid. Occasionally sprays his feet. Small amount of spray mix noted on shirt. Makes up one load for No. 11 and assists with 2nd load. No major incidents.
13	Some water spilled on outside of knapsack. No major incidents.
14	Shirt wet due to leakage from the top of the sprayer. Lid not tight enough. No major incidents.
15	Shirt noted to be very damp. Smoked on one occasion between loads. Did not wear face shield on one occasion when mixing. Spilt dilute solution over hands while washing sprayer. No major incidents
16	On one occasion only wore one glove during mixing. No major incidents.
17	Back of shirt and shoulder area wet due to leaking from seal around hydraulic pump. No major incidents.
18	Small area of spillage on back and shoulder. No major incidents.
19	Wet patch observed on back and top of trousers. Removed top off bottle without gloves and put finger in the bottle top. No major incidents.
20	Sprayed through area of thick weeds and walked through sprayed area. Encountered problem with pressure in sprayer. Cleaned nozzle with bare hands. Shirt was observed hanging out of his trousers on one occasion. No major incidents

APPENDIX 4

DIQUAT BIOMONITORING STUDY: KNAPSACK STUDY IN GUATEMALA[5] (1997)

Estimate of Absorbed Dose of Diquat

Subject i.d	Body weight (kg)	Amount a.s handled (kg)	Amount diquat absorbed – corrected for 61% excretion (ng/kg bw/day)
1	53.1	3.2	92
2	59	3.2	64
3	59	2.88	26
4	65.8	2.88	54
5	80.8	3.84	77
6	63.6	3.52	111
7	81.3	3.84	126
8	56.3	3.84	195
9	51.8	3.52	15
10	62.7	3.52	52
11	59	3.52	589
12	47.7	3.52	228
13	63.6	2.88	33
14	58.1	2.88	31
15	53.6	2.88	30
16	53.6	2.88	189
17	52.2	3.52	464
18	59	3.52	48
19	65.8	3.84	23
20	81.5	3.84	59

Appendix 4 cont: **Work Practice Observations in Knapsack Study, Guatemala**[5]

WORKER NUMBER	NOTIFIER'S OBSERVATIONS
1	Many banana leaves were observed on the ground making access sometimes difficult. No major incidences.
2	Worker initially held the lance around chest & face height but then generally kept it low. Some glove to hand contamination observed.
3	Knapsack observed to leak slightly from pressure cylinder, leaked on top of trousers and back of left leg. Land very wet and muddy and some tall weeds.
4	Some spraying was done up the sides of banks and spraying tall grass in the canals.
5	Worker was generally fairly careful, on occasions spraying high sided gullies and banks with lance at chest and face height. Occasionally wiped brow with sleeve.
6	Worker often sprayed in deep gullies resulting in nozzle being held at chest and face height. Some arm to face contact. Drank occasionally.
7	Worker sprayed deep steep sided canals. Faceshield and bare hands in contact with gloves. Occasionally wiped forehead with hand. Nozzle often above head height. Tended to work quickly.
8	Sprayed deep-sided ditches with nozzle at head height. Difficult access area necessitated nozzle being held at waist height. Hand to glove contact observed. Wiped brow with sleeve.
9	Worker sprayed in canals a lot, at one stage the nozzle blocked.
10	Workers trousers observed to be very muddy below the knees. Waved lance around frequently and tried to cover the area quickly.
11	Worker sprayed a lot of canal area with the lance held at head height.
12	Worker sprayed a lot of canal area at head height. Shirt and front of trousers observed to be very wet.
13	Worker observed to operate very quickly, on occasions a little careless.
14	Area very muddy. Often sprayed in water filled canals with difficult access. Angle of the nozzle badly directed on one occasion, which caused excessive wetting of trousers.
15	Many tall weeds reaching knee height. Contamination noted on shirt where straps rub. Sprayed in gully at shoulder height.
16	Many tall weeds reaching knee height. Contamination noted on shirt where straps rub. Sprayed in gully at shoulder height.
17	Worker held lance in his left hand and was fairly cautious during the application
18	On the flat areas worker kept the nozzle low. In deep gullies the lance was often held at chest and face height. On occasions worker was observed wiping forehead with sleeve.
19	Worker was thorough, kept nozzle low but often sprayed his trousers.
20	Lance often around face height in deep gullies. Wiped face and brow.