UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAR 1 1988

MAR 1 1988

OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: Exposure Assessment for Lindane Greenhouse Uses

FROM: Laurie Lewis
Special Review Section #2
Exposure Assessment Branch
Hazard Evaluation Division (TS-769C)

TO: Esther Saito, Chemist
Science Integration and Policy Staff
Hazard Evaluation Division (TS-769C)

THRU: Michael Firestone, Chief
Special Review Section #2
Exposure Assessment Branch
Hazard Evaluation Division (TS-769C)

THRU: Paul Schuda, Chief
Exposure Assessment Branch
Hazard Evaluation Division (TS-769C)

1.0 INTRODUCTION

EAB has been requested to provide exposure estimates for workers involved in the greenhouse application of lindane. Because EAB has no data measuring worker exposure to lindane for this use, this exposure assessment was conducted using surrogate data from studies in EAB's data base.

2.0 LINDANE GREENHOUSE USES

Usage information from the Benefits and Use Division indicates that there are currently only eight active registrations for the use of lindane in greenhouses (1). Three separate use patterns were described: smoke fumigation, fog application, and foliar application. For smoke fumigation, workers are present in the greenhouse only to ignite the fumigation device; therefore, exposure to these workers is expected to be minimal. No data are available for fog application scenarios and will need to be provided. For foliar application, EAB has used data from three surrogate studies which are appropriate for assessing the exposure of greenhouse workers applying lindane with backpack

sprayers, and two studies measuring worker exposure to liquid formulations during mixing and loading operations. The following assumptions were required:

1. Foliar greenhouse applications of surrogate chemicals made using backpack sprayers are assumed to generate data representative of exposures received during the foliar application of lindane using other types of hand-held sprayers.

2. An average worker weighs 70 kg.

3. The average size of a commercial greenhouse is 21,000 ft^2 with 15,000 ft^2 of bench space. It is assumed that one greenhouse is treated per day.

4. At an application rate of 3 gallons of finished spray per 1000 ft^2 of bench area, approximately 45 gallons of finished spray (0.05-0.1 lb ai) is required to treat a commercial greenhouse.

5. Exposure values are not adjusted for dermal absorption.

6. According to label instructions, applicators must wear a lightweight protective suit or coveralls, water resistant hat, unlined waterproof gloves, and unlined lightweight boots. Mixer/loaders must also wear goggles or a face shield and a waterproof apron.

7. An open loading system is assumed.

8. Mixing/loading and application operations are performed by the same individual.

9. No data are available regarding the application frequency of lindane in greenhouses. Similar insecticides are applied 8-16 times per year; however, BUD believes that lindane would be applied less frequently. Due to this uncertainty, EAB has provided exposure estimates based on 4, 8, and 16 applications per year.

3.0 REVIEW OF SURROGATE STUDIES

3.1 Mixer/loader Exposure

Two studies were reviewed that provided useful information for evaluating the exposure of mixer/loaders handling liquid formulations. Exposure was estimated assuming that workers wear chemical resistant protective suits that completely eliminate exposure to the torso and limbs. Protective gloves that reduced exposure to the hands by 90% were also assumed, as was the use of an open loading system.

Abbott (2) investigated the dermal exposure to mixer/loaders open pour loading 2,4-D liquid formulations. A total of six replicates for each of three mixer/loaders was studied. The mixer/loaders measured appropriate quantities of the 2,4-D into the spray tanks which ranged from 400 to 1600 L in size.

Dermal exposure was measured by sectioning disposable clothing into representative body areas and analyzing the sectioned clothing for 2,4-D residues. Hand exposure was measured by analyzing gloves for 2,4-D residues. Exposure values for the 18 replicates are shown in Table 1. Based on these data, the mean exposure for these workers is 0.48 mg/lb ai, assuming that only the hands are exposed and that the use of protective gloves has reduced hand exposure by 90%.

Dermal exposure to three mixer/loaders was measured by Lavy (3), using denim patches attached to exposed skin areas (hands, neck, and face). Mixer/loaders 1 and 2 used pumping systems to load 1000 gallons each of 2,4-D spray into aircraft from batch trucks. Mixer/loader 3 transferred the spray via 2 gallon pails. Actual mixing of the concentrate was not performed by the mixer/loaders in this study. The spray mixture contained 5% Esteron 99 Concentrate; each mixer/loader handled 200 lbs of active ingredient. Based on the data from this study (Table 2), an individual involved in transferring the spray solution from a batch truck to a spray tank while wearing clothing that provides 100% protection to the limbs and torso, and protective gloves that reduce hand exposure by 90% will receive an average exposure of 0.02 mg/lb ai.

The weighted average for mixer/loader exposure based on the 18 Abbott replicates (0.48 mg/lb ai) and the one Lavy replicate in which an open loading system was used (0.02 mg/lb ai) is 0.46 mg/lb ai.

3.2 Applicator Exposure to Fosetyl-Al

Exposure of workers was measured during application of Aliette (Fosetyl-Al, 80% wettable powder) to greenhouse ornamentals at Columbus, New Jersey (3). Mixer/loader and applicator exposures were measured separately for four different workers. The tasks were changed so that no worker performed the same one twice, yielding a total of four replicates each for the mixing/loading and application functions. All workers wore the label required long-sleeved shirts, long trousers and impermeable gloves. Workers also wore baseball hats and respirators which are not required by the label.

Each replicate consisted of either mixing/loading or application of 12 tanks of spray mixture. The tanks contained 57 grams of formulated material (45.6 grams of active ingredient) in 2.5

gallons of water. This concentration matches the maximum application rate of 5 pounds of formulation per 100 gallons. The mixer/loader weighed the material from a bag of bulk material on a top loading balance and transferred the required amount into the tank. The tank was then filled with 2.5 gallons of water, capped, pressurized with carbon dioxide, and shaken to mix the contents. Each mixer/loader handled a total of 684 grams of formulation (547 grams or 1.2 pounds of active ingredient) during each replicate. The applicator then sprayed the diluted material onto the foliage until runoff. Power for the spray was provided by a carbon dioxide cylinder strapped to the worker's back. Application took 53-65 minutes, with an average time of 58 minutes.

Respiratory exposure was measured by drawing air at a known rate through a cassette containing a fiberglass filter. The cassette was attached to the worker's collar in the breathing zone. Pump flow rates were determined before and after the sampling interval.

Dermal exposure was measured using gauze pads attached to the hat, shoulders, chest, upper arms, forearms, thighs, and lower legs. In order to estimate the effectiveness of protective clothing, duplicate sets of pads (except hat pad) were used, one located on the outside of the clothing and the other inside of the garments. The pads consisted of a 3-inch square gauze pad in an aluminum lined paper envelope. A 25 cm^2 circular area was exposed to the environment. Exposure of the hands was measured by hand washes with 10 percent isopropyl alcohol. The hands were washed 3 times before and after exposure. The washes for each hand were pooled prior to analysis.

Samples were stored frozen prior to analysis. A 10 percent aliquot of the hand wash was mixed with an equal volume of methanol and 5 ml of methoxyethanol. The water was evaporated under vacuum using a rotary evaporator. The residue was then methylated with diazomethane, reduced in volume, and brought to a final volume of 5 ml with methoxyethanol:acetonitrile (50:50). Gauze pads and fiberglass filters were extracted twice with methanol:deionized water (50:50), followed by evaporation and methylation. The methylated derivatives were quantified by gas chromatography using a phosphorous specific flame photometric detector. The limit of detection for the dosimeters was 0.2 ug for patches and 2.0 ug for hand washes. The recoveries of spiked samples are presented in Appendix A.

The average exposures of applicators are summarized in Table 3; mixer/loader exposure to the wettable powder formulation investigated in this study is not applicable to lindane greenhouse uses and will not be covered in this review.

3.3 Applicator Exposure to 2,4-D

Abbott et al. (2) measured dermal exposure to two individuals involved in the backpack spray application of 2,4-D to grassland. 2,4-D was applied at a rate of 0.3 gal/A (spray concentration of 0.7% w/v) using backpack sprayers equipped with either a 1-m boom or a single lance. A total of six replicates was measured for each applicator. Each replicate took 58-78 minutes to complete and included time spent loading premixed 2,4-D from a barrel into the backpack spray tank and changing blocked nozzles.

Dermal exposure was measured by sectioning disposable clothing worn by the workers into representative body areas, and then analyzing the sections for 2,4-D residues. Each worker wore disposable Corovin coveralls, Tyvek hoods and gauntlets, and nylon socks. The coveralls were sectioned into the following portions: arms, front and back torso, and upper and lower legs. Respiratory exposure was measured in the breathing zone of the workers, using personal air samplers equipped with glass fiber filters and operating at a flow rate of 4 L/min.

Samples were shredded and extracted with methanol. Aliquots of the extract were evaporated to dryness, redissolved in a small volume of methanol, and quantified using HPLC. Recovery of 2,4-D from laboratory spiked samples averaged 97, 96, 100, and 83% for coveralls, filters, socks, and hood/gauntlet materials, respectively. Corresponding values for field spike recoveries were 101, 75, 111, and 106%, respectively.

Dermal exposure values for the two applicators (six replicates per worker) are shown in Table 4. Based on these data, the backpack sprayers averaged exposures of 112 and 137 ug/g ai sprayed. These exposures are equivalent to 51 and 62 mg/lb ai. The mean exposure for the 12 total replicates is 57 mg/lb ai. Assuming that workers wear clothing that provides 100% protection to their torso and limbs, and protective gloves providing 90% protection to their hands, mean exposure to these workers is 3.1 mg/lb ai.

3.4 Applicator Exposure to Dimethoate

Copplestone et al. (5) measured the dermal exposure of eight sprayers applying dimethoate using a backpack mist blower and duster. Exposure was measured by placing alpha-cellulose patches on one forearm, one shin, one thigh, and the chest, back and head. The six patches were placed on top of the worker's clothing. A seventh patch was placed on the stomach underneath the clothing. Hand exposure was not measured; forearm patches were used to extrapolate to hand exposure.

Dermal patches were extracted with benzene, and aliquots of the extract were quantified using GC with flame-photometric

detection. The detection limit was 0.01 ug/sample.

Dermal exposure for these workers is shown in Table 5. Assuming no exposure to the worker's torso and limbs, and that 90% hand protection is provided by gloves, the weighted mean exposure for these workers is 0.023 mg/lb ai.

4.0 CALCULATION OF EXPOSURES

The 19 replicates for the open-pour loading of liquid formulations provide a dermal exposure estimate of 0.46 mg/lb ai when a chemical resistant suit and protective gloves are worn:

Abbott	18 replicates	0.48 mg/lb ai
Lavy	1 replicate	0.02 mg/lb ai
Weighted mean	19 replicates	0.46 mg/lb ai

Exposure estimates for workers handling lindane for greenhouse application, adjusted for 70 kg workers and for the amount of lindane handled are:

$$\frac{0.46\ \text{mg}}{\text{lb ai}} \times \frac{1}{70\ \text{kg}} \times \frac{0.1\ \text{lb ai}}{\text{day}} = 6.6 \times 10^{-4}\ \text{mg/kg/day}$$

$$\frac{0.46\ \text{mg}}{\text{lb ai}} \times \frac{1}{70\ \text{kg}} \times \frac{0.1\ \text{lb ai}}{\text{day}} \times \frac{4\ \text{days}}{\text{year}} = 2.6 \times 10^{-3}\ \text{mg/kg/year}$$

$$\frac{0.46\ \text{mg}}{\text{lb ai}} \times \frac{1}{70\ \text{kg}} \times \frac{0.1\ \text{lb ai}}{\text{day}} \times \frac{8\ \text{days}}{\text{year}} = 5.3 \times 10^{-3}\ \text{mg/kg/year}$$

$$\frac{0.46\ \text{mg}}{\text{lb ai}} \times \frac{1}{70\ \text{kg}} \times \frac{0.1\ \text{lb ai}}{\text{day}} \times \frac{16\ \text{days}}{\text{year}} = 1.1 \times 10^{-2}\ \text{mg/kg/year}$$

The applicator exposure estimate of 0.80 mg/lb ai has been based on 48 replicates from surrogate studies:

Abbott	12 replicates	3.1 mg/lb ai
Coppleстone	38 replicates	0.023 mg/lb ai
Fenske	4 replicates	0.097 mg/lb ai
Weighted mean	48 replicates	0.80 mg/lb ai

Based on these data, applicator exposure to lindane is estimated to be:

$$\frac{0.80\ \text{mg}}{\text{lb ai}} \times \frac{1}{70\ \text{kg}} \times \frac{0.1\ \text{lb ai}}{\text{day}} = 1.1 \times 10^{-3}\ \text{mg/kg/day}$$

$$\frac{0.80\ \text{mg}}{\text{lb ai}} \times \frac{1}{70\ \text{kg}} \times \frac{0.1\ \text{lb ai}}{\text{day}} \times \frac{4\ \text{days}}{\text{year}} = 4.4 \times 10^{-3}\ \text{mg/kg/year}$$

$$\frac{0.80\ mg}{lb\ ai} \times \frac{1}{70\ kg} \times \frac{0.1\ lb\ ai}{day} \times \frac{8\ days}{year} = 8.8 \times 10^{-3}\ mg/kg/year$$

$$\frac{0.80\ mg}{lb\ ai} \times \frac{1}{70\ kg} \times \frac{0.1\ lb\ ai}{day} \times \frac{16\ days}{year} = 1.8 \times 10^{-2}\ mg/kg/year$$

Assuming that mixing/loading and application operations are performed by the same individual, exposure estimates are 1.8×10^{-3} mg/kg/day, 7.0×10^{-3} mg/kg/year (4 applications per year), 1.4×10^{-2} mg/kg/year (8 applications per year), and 2.9×10^{-2} mg/kg/year (16 applications per year).

5.0 CONCLUSIONS

Based on data from surrogate studies and on usage information provided by the Benefits and Use Division, dermal exposure estimates for mixer/loader/applicators handling lindane for greenhouse use are 1.8×10^{-3} mg/kg/day, 7.0×10^{-3} mg/kg/year (4 applications per year), 1.4×10^{-2} mg/kg/year (8 applications per year), and 2.9×10^{-2} mg/kg/year (16 applications per year).

These exposure estimates assume that the limbs and torso of the worker are completely protected and that 90% hand protection is provided by protective gloves. No adjustments have been made for dermal absorption.

REFERENCES

1) Memorandum from David W. Brassard (BUD) to Mike Firestone (EAB) entitled "Exposure Parameters for the Use of Lindane in Greenhouses," dated February 3, 1988.

2) Abbott, I.M. et al. 1987. Worker Exposure to a Herbicide Applied With Ground Sprayers in the United Kingdom. Am. Ind. Hyg. Assoc. J. 48(2):167-175.

3) Lavy, T.L. et al. 1982. 2,4-D Exposure Received by Aerial Application Crews During Forest Spray Operations. J. Agric. Food Chem. 30:375-381.

4) Fenske, R.A. et al. 1987. Occupational Exposure to Fosetyl-Al Fungicide During Spraying of Ornamentals in Greenhouses. Arch. Env. Contam. Toxicol. 16(5):615-621.

5) Copplestone, J.F. et al. 1976. Exposure to Pesticides in Agriculture: A Survey of Spraymen Using Dimethoate in the Sudan. Bull. World Health Organ. 54:217-223.

Table 1. Dermal Exposure to Workers Open-Pour Loading 2,4-D.

Body Area	Exposure (mg/lb ai) M/L 1	M/L 2	M/L 3
Front torso	0.036	0.140	0.007
Back torso	0.005	0.009	0.003
Left arm	0.016	0.126	0.051
Right arm	0.103	0.095	0.024
Left hand[a]	0.111	0.315	0.215
Right hand	0.258	0.339	0.188
Left thigh	0.027	0.074	0.009
Right thigh	0.005	0.123	0.008
Left shin	0.007	0.045	0.016
Right shin	0.002	0.407	0.013
Total dermal	0.557	1.67	0.534
Total hands	0.369	0.654	0.403

[a] Hand exposure values have been adjusted for the wearing of protective gloves, assuming a 90% reduction in hand exposure.

Table 2. Dermal Exposure to Workers Loading 2,4-D.

Body Area	Dermal Exposure (mg) M/L 1 Closed loading	M/L 2 Closed loading	M/L 3 Open pour
Hands	0.01	0.07	0.80
Neck	0.03	0.02	0.01
Face	0.30	16	2.5
Total (mg)	0.34	16	3.3
Total (mg/lb ai)[a]	0.002	0.08	0.02

[a] Each worker handled 200 lb ai during the exposure period.

Table 3. Average Exposure of Applicators to Fosetyl-Al during Application of Aliette to Greenhouse Ornamentals.

Body Part	Exposure (ug/body part)
Face	76
Front of Neck	18
Back of Neck	17
Chest	1.5×10^2
Back	1.0×10^3
Left Upper Arm	1.5×10^2
Right Upper Arm	53
Left Forearm	1.5×10^2
Right Forearm	6.0×10^3
Left Thigh	1.6×10^3
Right Thigh	8.5×10^2
Left Lower Leg	1.3×10^3
Right Lower Leg	3.9×10^3
Left Hand	12
Right Hand	12
Total Dermal (ug)	1.5×10^4
Time (minutes)	58
Total Dermal (ug/hr)	1.6×10^4
Pounds of ai handled	1.2
Total Dermal (ug/lb ai)	1.3×10^4
Respiratory (ug)	3.2
Respiratory (ug/hr)	28
Respiratory (ug/lb ai)	2.7

[a]Assuming that the torso and limbs are completely protected, and that protective gloves provide 90% hand protection, worker exposure is:

Face	76 ug
Neck	35 ug
Hands (90% protection)	2.4 ug
Total (ug)	113 ug
Total (ug/hr)	117 ug/hr
Total (mg/lb ai)	0.097 mg/lb ai

11

Table 4. Dermal Exposure to Backpack Applicators Spraying 2,4-D.

Body area	Dermal Exposure (ug/g ai) Sprayer 1	Sprayer 2
Head	0.22	4.4
Body front	0.67	2.2
Body back	2.37	2.1
Left arm	0.44	0.62
Right arm	0.33	0.62
Left hand	4.43	57
Right hand	5.3	25
Left thigh	4.6	4.8
Right thigh	3.8	6.7
Left shin	43	30
Right shin	47	34
Total (ug/g ai)	112	137
Total (mg/lb ai)	51	62

[a]Assuming that the torso and limbs are completely protected, and that protective gloves provide 90% hand protection, mean worker exposure is:

Head	0.22	4.4
Hands (90% protection)	0.97	8.2
Total (ug/g ai)	1.19	12.6
Average (ug/g ai)	6.9	
Average (mg/lb ai)	3.1	

Table 5. Dermal Exposure to Workers Applying Dimethoate.

Body area	Mean Dermal Exposure (mg) Wkr 1	Wkr 2	Wkr 3	Wkr 4	Wkr 5	Wkr 6	Wkr 7	Wkr 8
Arms	0.018	0.029	0.110	0.015	0.008	0.029	0.025	0.528
Thighs	0.150	0.105	1.10	0.219	0.027	0.112	0.195	1.99
Shins	0.272	0.183	3.16	0.457	0.377	0.036	3.14	2.30
Chest	0.006	0.025	0.028	0.021	0.019	0.039	0.005	0.013
Back	0.016	0.132	0.209	0.197	0.012	0.022	0.130	0.010
Head	0.003	0.005	0.003	0.004	0.003	0.001	0.003	0.009
Hands	0.009	0.015	0.058	0.008	0.004	0.015	0.013	0.276
# Reps	4	5	5	6	4	4	5	5
Total	0.472	0.683	4.67	0.921	0.450	0.254	3.51	5.13
ai handled (g/day)	153	210	193	175	263	263	210	175
Exposure (mg/g ai)	0.003	0.003	0.024	0.005	0.002	0.001	0.017	0.029
Exposure (mg/lb ai)	1.4	1.5	11	2.4	0.78	0.44	7.6	13

APPENDIX A. Recovery of Fosetyl Al from Sampling Media

Sampling Medium	Type	Spike Level (ug)	Percent Recovery
Gauze Pad	Method Dev.	0.50	117
		5.00	106
		50.00	130
	Field[1]	24.0	96
		240.0	98
	Laboratory[2]		98
	Storage (6 wk)	0.5	80
		5.0	120
		50.0	91
	Storage (9 wk)	0.5	120
		5.0	166
		50.0	110
Fiberglass filter	Method Dev.	0.50	117
		2.00	106
		10.00	119
	Field[1]	1.0	108
		10.0	102
	Laboratory[3]		119
	Storage (6 wk)	1.0	120
		10.0	70
	Storage (9 wk)	1.0	70
		10.0	106
Hand Wash	Method Dev.	10	85
		100	88
		1000	81
		10000	104
	Field[1]	100	83
		1000	95
	Laboratory[4]		85
	Storage (4 wk)	10	130
		100	86
		1000	84
		10000	126

[1] Average of daily spikes.

[2] Spikes ranged from 0.5 to 50 ug.

[3] Spikes ranged from 1.0 to 10.0 ug.

[4] Spikes ranged from 10 to 1000 ug.