Section 5
OCCUPATIONAL HEALTH AND SAFETY ASSESSMENT

LIST OF TABLES

1. INTRODUCTION

Monocrotophos is an organophosphate (OP) compound used in agriculture to control a range of insect pests in horticultural and agricultural crops. It has been in use in Australia and other countries for nearly 30 years. Monocrotophos is one of 80 agricultural and veterinary chemicals identified as candidates for priority review under the Existing Chemicals Review Program. Following data call in process, additional occupational health and safety (OHS) data has been submitted and is assessed in this report below. The sources of information used in the report include industry registrants, NRA Performance Questionnaires, Agricultural Assessment, Toxicological Assessment, Environmental Assessment and the published literature.

2 TOXICOLOGY

2.1 Toxic end points

A detailed review of the mammalian toxicology and toxicokinetic/metabolism data on monocrotophos is available in the separate toxicology report (Department of Health & Family Services (DHFS), June 1998). A summary of the main toxicology findings relevant to assigning the toxic end points for the OHS risk assessment is included in this report.

Technical monocrotophos is of high acute toxicity. The lowest oral LD_{50} is 8.4 mg/kg bw in rats (10 mg/kg bw in mice) and lowest inhalation LC_{50} is 80 mg/m^3 (4h) in rats. The acute dermal toxicity of monocrotophos is variable and dependent on the solvent, the lowest LD_{50} is 123 mg/kg (rats). It is a slight skin and eye irritant in rabbits. Monocrotophos is not a skin sensitiser in guinea pigs.

Based on a study using rats injected with intraperitoneal (IP) radiolabelled monocrotophos, major metabolites were dimethyl phosphate (DMP) (40%), N-hydroxymethyl monocrotophos (19%), O-demethyl monocrotophos (10%) and phosphoric acid (3%). Sixty-one percent of radioactivity was found in urine over 48 hours.

In rats administered with radiolabelled monocrotophos by oral gavage at 2 mg/kg bw. Monocrotophos was excreted mainly in the urine (82% excreted in 96 hrs). Radiolabelled monocrotophos fed to goats and cows was excreted mainly in urine and some in milk with little evidence of accumulation in tissues.

Studies in experimental animals indicate that cholinesterase (ChE) inhibition is the major toxic effect of monocrotophos. The chemical did not demonstrate a clear difference in binding affinity between plasma, red blood cell (RBC) and brain ChE. Some animal studies indicated no difference in sensitivity between different ChE activities.

Monocrotophos was not found to be carcinogenic. It did not have an adverse effect in reproductive parameters in rodent studies. Developmental toxicity was noted only at or near maternotoxic doses in rats and rabbits, however, no teratogenic findings were observed.

Monocrotophos appears to be a weak mutagen at high doses. Metabolic activation was not required for genotoxic effects of monocrotophos.

Single or repeat dose studies (up to 78 days) in hens did not demonstrate delayed neurotoxicity. Two year dietary administration of the chemical in rats did not indicate nerve damage or acceleration of normal age related changes.

The most conservative no-observed effect level (NOEL) for monocrotophos established for animal studies was 0.004 mg/kg/d in 1 and 2 year dog dietary studies for brain ChE depression.

A number of trials were carried out in male volunteers. The first two trials were considered inadequate as no controls were used. In the third trial, 3 groups of 6 volunteers were given 0.0036 and 0.0059 mg/kg/d monocrotophos in gelatin capsules. Controls were used. Baseline ChE levels were measured. A NOEL of 0.0036 mg/kg/d was established based on plasma ChE depression at the high dose. RBC ChE was not affected (Verberk, 1972).

In a subsequent trial, six male volunteers were given 0.0036 and 0.0057 mg/kg/d monocrotophos in capsule form for 28 days. No adverse clinical signs were observed. RBC ChE activity was not affected at either dose. Plasma ChE was significantly decreased at 0.0057 mg/kg/d. A decrease was seen with 0.0036 mg/kg/d in plasma ChE but was not significant. The NOEL was established at 0.0036 mg/kg/d (Verberk, 1977).

The NOELs established in short-term human studies (0.0036 mg/kg bw/d) are similar to the NOELs for long term animal studies (0.004 mg/kg bw/d).

In reports of human poisonings, there were three cases of 'intermediate syndrome', involving muscular weakness and paralysis which is manifested, 1-4 days after exposure (short-term effects). The DHFS concluded that monocrotophos does not produce chronic neurological changes.

Acute reference dose

The acute reference dose (RfD) reflects a safe or acceptable exposure from a single or short exposure. No single dose human studies were available for monocrotophos. Use of a NOEL from short-term animal studies would result in a RfD below the Acceptable Daily Intake (ADI). Consequently the DHFS selected the RfD of 0.0003 mg/kg/d, based on a human NOEL of 0.0036 mg/kg/d with a safety factor of 10.

Dermal absorption

Feldmann and Maibach (1974) studied the penetration of 12 radiolabelled pesticides and herbicides including monocrotophos in male volunteers (6 subjects per compound). Urinary excretion of radiolabelled monocrotophos was measured over a five day period following either intravenous (IV) injection or topical application of monocrotophos to either one or both forearms. Excretion was calculated as a percentage of administered/applied doses. Over this period, 68% of the IV dose was excreted, and the half-life for urinary excretion was determined to be 20 hrs. Following dermal application the skin was allowed to air dry and not washed for 24 hrs. In the topical studies, the results were corrected for incomplete urinary excretion. Over the 5-day period, 15% of the administered dose of monocrotophos was excreted in the urine. It was calculated that a maximum of 22% of the applied dose was absorbed. This value is used in the risk assessment.

2.2 Hazard classification

Active constituent

Monocrotophos is listed in the National Occupational Health and Safety Commission (NOHSC) List of Designated Hazardous Substances (NOHSC, 1994a). Concentration cut-off for monocrotophos is:

0.1%	Harmful
1.0%	Toxic
7.0%	Very toxic

The following risk and safety phrases have been allocated to monocrotophos:

R24	Toxic in contact with skin
R28	Very toxic if swallowed
S1/2	Keep locked up and out of reach of children
S23	Do not breathe gas/fumes/vapour/spray *[appropriate wording to be specified by the manufacturer]*.
S36/37	Wear suitable protective clothing and gloves
S45	In case of accident or if you feel unwell, contact a doctor or Poisons Information Centre immediately (show the label where possible)

Products

All monocrotophos products under review are determined to be hazardous substances because they contain monocrotophos at 40% (w/v), exceeding the cut-off concentrations for hazardous substances.

3 OCCUPATIONAL EXPOSURE

Monocrotophos products currently registered in Australia are:

- Azodrin 400 Systemic Insecticide/Miticide (Azodrin Insecticide) (Cyanamid Agriculture Pty Ltd)
- Farmoz Monocron 400 Systemic Insecticide, Farmoz Monocron 400 Systemic Miticide/Insecticide (Farmoz Pty Ltd)
- Phoskill 400 Systemic and Contact Insecticide (Phoskill) (United Phosphorus Ltd).

3.1 Handling prior to end use

Technical grade monocrotophos is imported from various sources. All the products are formulated in Australia. Chemical industry workers will be potentially exposed to monocrotophos and monocrotophos products. Retail, transport and storage workers will handle the packaged active constituent or products. There is no exposure information available on formulation workers.

3.2 Use pattern of the end use products

Monocrotophos is an OP compound for use as a broad spectrum insecticide/miticide on various crops including fruit (apples, pears and bananas) and vegetables (tomatoes sweetcorn, potatoes and beans), cotton, tobacco, cereals, oilseeds, and for treatment of non-fruit bearing tree trunks by local injection.

3.2.1 Label information

The products are formulated as aqueous concentrates (AC) or emulsifiable concentrates (EC) containing 400 g/L monocrotophos. They contain solvents such as cyclohexanone or ethylene glycol monomethyl ether (540 to 567 g/L). Container size of the products is 5L and 200L.

The use patterns of all the products are similar. Both ground and aerial spraying is possible. In Tasmania, the products must not be applied by aircraft without the specific approval of the Registrar of Pesticides.

The Azodrin Insecticide label includes the following restraints:

Do not use for the control of pests that are suspected to be resistant to organophosphate insecticides.
Do not apply with fogging machines.
Do not apply with a back mounted knapsack.

Monocron 400 Systemic Insecticide, Monocron 400 Systemic Miticide and Phoskill labels includes the following restraints:

Do not spray during night hours.
Do not spray if birds are active in the orchard or the field.
Do not spray into flocks of birds.

The products are not registered for home garden use.

Application rates are specified as mL product/100 L water or L product/ha. The ranges are 85 mL-300 mL/100 L (0.03-0.12% monocrotophos) and 250 mL - 4.0 L/ha (100 g-1600 g monocrotophos/ha).

A summary of composite information across the labels is given in Table 1.

Table 1: Monocrotophos products: use rate by crop

Crop	**Use rate**	
	per 100 L (g ai)	**per ha (g ai)**
Fruits		
Apples and pears	100 mL/100 L (40 g)	
Bananas		1 or 2 L/ha (400-800 g)
Vegetables		
French beans	85 mL/100 L (34 g)	650 mL/ha (260 g)
Potatoes		350 mL-1 L/ha (140 g)
Tomatoes	150-250 mL/100 L (60-100 g)	1.5-2 L/ha (600-800 g)
Sweet corn	125 ml/100 L (50 g)	1L/ha (400 g)
Broadacre		
Tobacco	150-300 mL/100 L (60-120g) as a directed spray	350-700 mL/ha (140-280 g)
Cereals, wheat, oilseeds and cotton		250 mL-4.0 L/ha (100-1600 g)
Non-fruit bearing trees	0.5 or 1 mL per 1 cm of trunk diameter (excluding the bark) at chest height (same amount of water)	

Final ground spray volumes are not provided on the labels. High volume and low volume specifications are given for vegetables (tomatoes, French beans and sweet corn). High volume specifications are given for fruit and tobacco. Where necessary, the high volumes of > 2000 L/ha (trees and bushes) and > 1000 L/ha (row and field crops) (Banks et al., 1994) are used in the exposure assessment. Low volume specifications are given for broadacre crops and potatoes. Where necessary, the low volume range of 100-400 L/ha for row and field crops (Banks et al. 1994) is used in the exposure assessment.

The labels recommend application by standard equipment; indicating ground boom, airblast and hand directed sprayers for ground application. Greenhouse applications are not excluded by label restraints concerning foggers and knapsacks.

Repeated applications of monocrotophos products are permissible according to label directions for use. They may be given as necessary or within particular intervals as stated on the labels.

Withholding periods (WHP) fall within the following categories:

Potatoes	3 days before harvest
Tomatoes	4 days before harvest
Soybeans, sunflower, sweet corn, tobacco	5 days before harvest
Bananas	10 days before harvest
Cotton, French beans	21 days before harvest
Apples, pears	4 weeks before harvest
Maize, millet, panicum, sorghum, wheat	6 weeks before harvest

Labels instruct not to graze or cut for stockfood for 7 days after application on lucerne, pasture, maize, millet, panicum, sorghum and wheat.

Re-entry Interval

Only the Azodrin Insecticide label states following cautionary statement on re-entry interval:

"Workers should not handle crops for 5 days after spraying unless wearing protective clothing."

3.2.2 User survey information

User survey information was provided through the Existing Chemicals Review Program 1997 NRA Performance Questionnaire No. 1 Large Scale Users Survey, No. 5 Chemical Industry Survey and No. 6 Commodity/Grower Group Survey. Relevant information is summarised in Tables 2, 3 and 4.

The information on use relevant to the exposure assessment is derived from the NRA Agricultural Assessment Report, Performance Questionnaire No 1, 5 and 6 and product labels (Section 3.2.1). The NRA report states that monocrotophos is applied by aerial spraying on bananas in preference to ground spraying.

There are currently two permits issued for monocrotophos use, one in Queensland to control budworm in commercial flower crop and the other in NSW for the control of western flower thrips on ornamentals. The method of application (for both permits) will be high volume boomspray using 0.18-0.25 L/100 L of the registered product (same as tomatoes).

Table 2: Summarised information from Large Scale Users survey; NRA Performance Questionnaire No. 1

Crop	Area treated ha/hr	Application rate	No of applications per season	Method of application	Region	Comments relevant to OHS
Tomatoes	not provided	2 L/ha	4	boomspray mister	Helidon, Qld	Alternatives-Lannate, pyrethroids & endosulfan.
Tomatoes	not provided	2 L/ha	4	boomspray	Burdekin, Qld	Pourers should be compulsory. Alternatives-diazinon and methomyl.
Tomatoes	not provided	as per label (20 L/season/year)	3	boomspray	Stanthorpe, Qld	Alternatives-azinphos and Clor; mix with fungicides.
Tomatoes	4 ha	2000 mL/100 L as per label (8 L/ha, per crop season)	4	ground rig, hollow cone	Bundaberg, Qld	Alternatives-dimethoate mix with Lannate
Green beans	4 ha	85 mL/100 L (3 L/ha, per crop season)	4	ground rig, hollow cone	Bundaberg, Qld	Alternatives-dimethoate mix with Lannate.
Sweet corn	not provided	1 L/ha	In a program	boomspray	Burdekin, Qld	Pourers should be compulsory. Alternative-diazinon and methomyl.
Apples	not provided	as per label (20 L/season/year)	2	air blast sprayer	Stanthorpe, Qld	Alternatives-azinphos and Clor; mix with fungicides.
Tobacco	3-4 ha	as recommended (60 to 100 L use/season/year)	3 (10 days interval)	boomspray	Mareeba, Qld	Alternatives-Orthene, Lannate & Heliothion; Mix with Ridomil (metalaxyl).
Tobacco	3-4 ha (8 acres)	1 mL to 1L (20-30L/season)	as needed	boomspray	Mareeba, Qld	No alternatives.

Crop	Area treated ha/hr	Application rate	No of applications per season	Method of application	Region	Comments relevant to OHS
Potatoes	1.5	as recommended	1-2	boomspray	Marybrook, WA	20 L containers difficult to handle. May combine with fungicide like Rovral or Bravo or Dithane; Alternative-chlorpyrifos.
Potatoes	10	1L/ha (440 L/year)	2-3	boomspray	Mt Gambier, SA	Alternatives-Hymal & Nitofol; Mix with Diquat, Bravo & Sumisclex.
Celery seedbeds	not provided	700 mL/ha	1	boomspray	Virginia, SA	Only used for Bean fly Maggot; mix with Bravo.
Cotton	not provided	as recommended	1 in December or January for tipworm (if used at all)	boomspray and aerial	Macquarie, NSW	Alternatives-endosulfan, Comite, Folimat (omethoate) and Rogor (dimethoate).
Not provided	not provided	-	-	-	Martindale, NSW	Alternatives-Metasystox and Lorsban.
Not provided	not provided	-	-	-	Victoria	Alternatives-methomyl and fenvalarate.

Queensland Tully Banana Growers and Innisfail Banana Growers submitted Performance Questionnaire No. 1 indicating that monocrotophos is not used on bananas in Queensland.

Table 3: Summarised information from Chemical Industry Survey; NRA Performance Questionnaire No. 5 (1)

Crop	Area treated ha/hr	Application Rates	Method of application	Region
Sweet corn	5-10	1 L/ha (1 application/ season)	Boomspray	Bundaberg Burdekin Bowen
Field crops	5-10 (boomspray) 65 (aerial)	as per label (1 application/ season)	Aerial spraying or boomspraying	Darling Downs
Tomatoes	5-10	250 mL/100 L (2 application/ crop)		Bundaberg Gatton Bowen
Beans	5-10	85 mL/100 L (1 application/ season)	Boomspray	Bundaberg Gatton Gympie Bowen
Non crop areas or sorghum or soybeans	65	500-700 mL/ha (1 application/ season)	Aerial	Central Highlands of Queensland
Cotton	5-10 (boomspray) 65 (aerial)	as per label (1 application)	Air/ground	Darling Downs

As provided by Cyanamid Agriculture Pty Ltd.

Table 4: Summarised information from Commodity/Grower Group Survey; NRA Performance Questionnaire No. 6

Crop	Area treated ha/hr	Application Rates	Method of application	Region
Tobacco	3	700 mL/ha (3 application/season)	Boomspray	Victoria
Tobacco	2	-	Boomspray or aircraft	Mareeba, Qld

Nicol Nominees Pty Ltd Virginia, SA reported about using monocrotophos, details not provided.

3.3. Exposure information

Various sources of monocrotophos exposure information are of relevance to the OHS risk assessment. Reports include poisoning incidents resulting from possible deliberate ingestion, health effects resulting from occupational exposure, measured worker exposure studies and re-entry exposure. Adverse health effects from possible deliberate poisoning incidents and occupational accidents provide useful information on the magnitude of acute and long term monocrotophos toxicity in humans and may help define the likely causes of poisoning incidents. Relevant information is described below.

The industry data did not contain any exposure information on formulation workers. Public submissions to the NRA did not contain any specific information concerning occupational exposure to monocrotophos.

3.3.1 Poisoning incidents involving monocrotophos

Non-occupational incidents

The DHFS assessed overseas literature reports submitted by Cyanamid Agriculture Pty Ltd on deliberate or accidental monocrotophos ingestion by humans, Przezdiak & Wisniewsa (1975), Gelbke & Schlicht (1978) and Mani et al. (1992). These reports did not have any relevance to occupational exposure. The human lethal dose of 23 mg/kg in an attempted suicide case (Gelbke & Schlicht, 1978) is similar to the oral LD_{50} of 8 mg/kg in rats. One man suffered severe intoxication after accidentally swallowing half a teaspoon of monocrotophos (Przezdiak & Wisniewsa, 1975). He was unconscious for 4 days, suffered bronchopneumonia and thrombophlebitis, but recovered after 33 days.

Senanayake & Karalliedde (1987) have reported ten cases of neurotoxic effects of OP insecticides over a 3-year period in Sri Lanka. Ingestion of monocrotophos with suicidal intent accounted for one case. The person showed a well defined cholinergic phase followed by an acute attack of "Intermediate Syndrome" (muscular weakness, cranial nerve palsies and respiratory difficulty), 24-96 hrs after poisoning. The muscular weakness lasted for 16-18 days. This person did not develop delayed polyneuropathy.

Peiris et al. (1988) investigated a case of accidental poisoning with monocrotophos in Sri Lanka. A 32 year-old man was assaulted with a 100 mL bottle of monocrotophos. The impact resulted in a 2-inch long laceration just above the left eyebrow and spilling of the liquid over the head and face. The liquid was wiped off (not washed) and the wound sutured. The patient had a meal 3-4 hrs later without washing his hands. He developed the characteristic symptoms of OP poisoning a few hours after his meal. On the third day he had severe weakness of limbs and respiratory distress requiring assisted ventilation. Blood ChE levels were 37.5%-50% of normal as late as 21 days post-exposure.

Occupational incidents - case study of monocrotophos poisoning

In the ten cases of neurotoxic effects of OP insecticides reported by Senanayake et al. (1987), one related to contamination after spraying monocrotophos. The person showed a well defined cholinergic phase followed by an acute attack of "Intermediate Syndrome" 24-96 hrs after poisoning. The muscular weakness lasted as long as that cited in the attempted suicide case (16-18 days). The person did not develop delayed polyneuropathy.

3.3.2 Health effects and urinary excretion involving agricultural workers using monocrotophos

Some studies on health effects, health surveillance and urinary monocrotophos metabolites excretion have been previously published and were submitted by Cyanamid Agriculture Pty Ltd. Many studies

were conducted in developing countries using knapsack (on rice) or hand held equipment and an ultra low volume (ULV) formulation on cotton. ULV formulations are not registered in Australia and hand held uses in field crop are not anticipated. Back mounted knapsack application is prohibited in registered Australian labels for monocrotophos products.

Each study is briefly described below:

In Australia

Simpson (1973) conducted a survey in Australia on the use of monocrotophos and other OPs by aerial spraying. During February and March 1972, blood ChE surveys were conducted on volunteers from aerial spray crews (pilots, loaders, markers, cleaners and engineers). The first survey in February indicated that at least 50% of the workers had blood ChE values below normal and the author believed, some of them should not have been exposed further. In the second survey in March, 24 out of 30 subjects had blood ChE below normal, with 11 at a level not specified, where the author believed they should not have been exposed further. In general, protective clothing was not provided and washing facilities were poor.

A survey was conducted by the Division of Occupational Health and Pollution Control of the Health Commission of New South Wales (Simpson, 1974) on 952 workers associated with aerial spraying of OPs (mainly monocrotophos and parathion) in cotton. Five workers demonstrated 40% blood ChE depression (4 loaders and mixers and 1 market gardener), and a further 15 demonstrated 60% blood ChE depression (14 markers, loaders, mixers and drivers and 1 market gardener). Fewer workers were affected in the second survey as occupational hygiene measures in the aerial spraying industry improved as a result of the investigation (protective clothing and washing facilities provided).

Overseas

Gaeta et al. (1975) reported on monocrotophos application on cotton using knapsack sprayers in Portugal. Two groups consisting of 46 (working on immature plants) and 26 (working on mature plants) sprayers were monitored for approximately 5 days. Workers did not use protective clothing and personal hygiene was poor. Blood samples were taken one day before and one day after each spray application to estimate whole blood and plasma ChE. Workers were observed over a period of three and half months after spraying monocrotophos. Whole blood ChE was more significantly depressed than plasma ChE in all sprayers.

Blok et al. (1977a & 1977b) monitored ChE activity in workers applying Azodrin (monocrotophos, 40% water soluble formulation), Bidrin (dicrotophos) and Birlane (chlorfenvinphos) on rice using back mounted knapsack sprayers and high volume nozzles in India. Whole blood and plasma ChE (pre-exposure and post-exposure) were measured but not under controlled laboratory conditions. Depression of ChE was seen on the first two days in workers and control group. No inhibition of ChE was seen for the rest of the trial. It was concluded that there was little effect from applying monocrotophos from a knapsack sprayer, however the quality of the assay method may have obscured any real effects.

Ullmann et al. (1979) investigated ChE levels in aerial applicators and allied workers in three regions of the Democratic Republic of Sudan over a period of 4 weeks. Four categories of workers were examined including pilots, aircraft engineers, ground personnel and entomologists. Personal protective equipment was available but not always worn. Only ground workers demonstrated depression of ChE. This improved as more stringent hygiene measures were introduced (overalls, goggles, gloves and gas masks). None of the study subjects showed signs or symptoms of OP poisoning.

Two trials were carried out in India, on human volunteers to investigate the health effects of aerial spraying of cotton with Nuvacron 40 (monocrotophos) (Rao et al., 1979, 1980). In the first trial, 17

volunteers (12 males and 5 females) were exposed to a single 2.2% monocrotophos spray applied by helicopter. In the second trial, 12 male volunteers (3 groups of 4 each) were exposed to a 1.7% aerial spray of monocrotophos for 3 consecutive days. All subjects remained in the cotton field during spray application and for the next 1 hour. In both trials, the males wore no shirts and the females wore light clothing (no description provided). Clinical examination and ChE values (whole blood, plasma and RBC) were determined pre-exposure (both trials) and at 2, 24, 48 and 72 hrs post exposure (trial 1) and up to 15 days post-exposure (trial 2). All study subjects wore finger gloves on fingers from which blood was to be taken for testing. In both trials, there was no significant difference in post-exposure ChE levels compared to pre-exposure values. No adverse health effects were noted soon after exposure or at any time during the 2-week post-exposure period.

Coveney and Eadsforth (1981) conducted a urine monitoring study of 8 workers at three different cotton farms in the Natal province of South Africa. The workers were involved in hand-held ULV spraying of the monocrotophos/DDT formulations, Azodrin/DDT/Shellsol (Shellsol) and Azodrin/DDT/Dioxitol (Dioxitol). There was a significant increase in urinary DMP in workers applying both formulations compared with pre-exposure controls. However average urinary DMP was approximately 3 times higher in those spraying Shellsol than Dioxitol formulation, a fact attributed by study authors to the higher skin penetration of Shellsol.

van Sittert and Tordoir (1981) investigated workers involved in the hand held ULV application of Azodrin Insecticide on cotton, in South Africa. Mean pre- and post-exposure ChE levels (whole blood, plasma and RBC) and post exposure urinary DMP levels were measured. Relevant results are presented below.

Kummer and van Sittert (1985) carried out a study in South-East Celebes in Indonesia in 1984, monitoring farmers applying a 20% Azodrin formulation to cotton, using hand-held ULV equipment. Pre- and post-exposure urinary DMP and ChE activity in whole blood, RBC and plasma were measured. Relevant results are presented below.

Rastogi et al. (1989) investigated respiratory impairment among 489 pesticide sprayers in mango plantations and 208 unexposed controls, in the period 1986-1987 in India. These workers applied organochlorines and OP pesticides, including monocrotophos, by foot operated hand held equipment. No protective clothing was worn. The study authors found a direct but non-statistical correlation between occupational exposure to pesticides and prevalence of respiratory impairment.

Brocklehurst et al. (1990) investigated monocrotophos application on rice in the Philippines by workers using semi-automatic knapsack sprayers. The study subjects performed all tasks of mixing, loading, spraying and cleaning up over three consecutive days. They wore various protective or normal clothing. Pre- and post-exposure (2 hrs post exposure after each spraying day and 20 hrs after last spray application) venous blood and 24 hr urine samples were collected from subjects and controls to determine whole blood, plasma and RBC ChE and urine DMP levels. Relevant results are presented below.

Chromosomal aberrations in peripheral lymphocytes of cotton field workers exposed to a mixture of pesticides, including monocrotophos were investigated (Rupa et al., 1989, 1991a, 1991b). There was a significant increase in chromosomal aberrations in the exposed population compared to controls but the particular contribution of monocrotophos could not be defined.

Only the findings applicable to the Australian use of monocrotophos are summarised below (van Sittert and Tordoir (1981), Kummer and van Sittert (1985) and Brocklehurst et al. (1990)).

- Recovery of whole blood and plasma ChE was not seen up to 40-hrs post-exposure (Kummer and van Sittert, 1985).

- Hand contamination was noted during open mixing/loading operations (Kummer and van Sittert, 1985) which included the use of a 1 L container with a special dispenser (Brocklehurst et al., 1990). One mixer/loader demonstrated a 47% ChE depression (from individual baseline level) despite wearing gloves (van Sittert and Tordoir, 1981).

- During hand-held spraying operations, greatest exposure was noted on the forearms and hands (van Sittert and Tordoir, 1981).

- Cleaning up application equipment without gloves resulted in worker exposure and depression of ChE (Kummer and van Sittert, 1985). Clean up activities are not covered by the safety directions on Australian labels.

- Urinary DMP excretion corresponded with handling and application practices (Kummer and van Sittert and 1985 Brocklehurst et al., 1990). DMP excretion was incomplete 20 hrs after last exposure (Brocklehurst et al., 1990).

- The degree of ChE depression correlated well with urinary DMP levels (Brocklehurst et al., 1990). Greater absorption was noted when using monocrotophos products containing aromatic hydrocarbon solvents than glycol ether solvents, as indicated by urinary DMP levels and blood ChE depression (van Sittert and Tordoir, 1981).

3.4 Measured worker exposure studies

There are no measured worker exposure studies for mixer/loader/applicators (M/L/A) of monocrotophos products.

3.5 Predicted worker exposure

UK POEM was used to predict exposure during ground spraying with the 40% EC (worst case scenario), under the Australian use situation. Since monocrotophos is used on a wide variety of crops, the POEM scenarios tested are grouped around similar crop types and similar application methods. The scenarios aim to derive exposures for users treating small and large areas with application times lasting the full or partial day. Where possible, high volume and low volume scenarios are included.

Scenarios were derived from use pattern information detailed in the labels, NRA PQ No.1, 5 and 6, the NRA Agricultural Report and Banks et al. (1994).

POEM can only test containers sizes of up to 20 L. Bulk handling with the 200 L container for mixing/loading is not covered in the POEM estimates.

The application equipment used in the Model follows:

Vehicle mounted with cab (boomspray) with hydraulic nozzles (V-Nozzle);

Vehicle mounted (without cab) Air-Assisted (Air-Blast) both high (V-500) and low volume (V-100); and

The following parameters were entered *:

Concentration of product:	400 g/L

Formulation type:	EC
Container size:	5 L (most commonly used)
Percent absorbed (dermal):	22%
Human NOEL (oral):	0.0036 mg/kg/day
Average body weight:	60 kg
Transfer through gloves and one layer of clothing:	POEM default values
Other parameters:	POEM default values (75th percentile)

* Details of product rates, application area, spray volumes and duration of exposure are available in Table 5.

Table 5: Predicted exposure obtained from POEM for ground application using use pattern described on product labels, NRA use pattern information and NRA Performance Questionnaire No. 1

Crop	Estimate Number (equipment)	Spray volume (L/ha)	Product rate (L/ha)	Application area/time in hours (ha/h)	Active handled (kg/day)	Mixer/loader absorbed dose dermal (mg/kg bw/day)	Applicator absorbed dose dermal (mg/kg bw/day)	M/L/A [2] Absorbed dose [3] dermal + inhalation (mg/kg bw/day)
						Gloves	Gloves [1]	Gloves
Apple+pears High volume (HV)	I air-blast-no-cab	2000	2	30/6	24	0.352	0.125	0.479
Apple+pears HV	II air-blast-no-cab	2000	2	2/2	1.6	0.029	0.042	0.072
French beans HV	III boomspray+cab	1000	0.85	24/6	8.16	0.220	0.008	0.228
French beans (Low volume) LV	IV boomspray+cab	100	0.65	24/6	6.24	0.147	0.061	0.211
Potatoes LV	V boomspray+cab	100	1	50/6	20	0.367	0.095	0.465
Tomatoes HV	VI boomspray+cab	1000	2.5	30/6	30	0.587	0.024	0.611
Tomatoes LV	VII boomspray+cab	100	2	30/6	24	0.440	0.189	0.637
Sweet corn HV	VIII boomspray+cab	1000	1.25	30/6	15	0.293	0.012	0.306
Sweet corn LV	IX boomspray+cab	100	1	30/6	12	0.220	0.095	0.319

Table 5: continued

Crop	Estimate Number (equipment)	Spray volume (L/ha)	Product rate (L/ha)	Application area/time in hours (ha/h)	Active handled (kg/day)	Mixer/loader absorbed dose dermal (mg/kg bw/day)	Applicator absorbed dose dermal (mg/kg bw/day)	M/L/A (2) absorbed dose (3) dermal + inhalation (mg/kg bw/day)
						Gloves	Gloves (1)	Gloves
Tobacco HV	X boomspray+cab	1000	0.7	24/6	6.72	0.147	0.007	0.154
Broadacre LV	XI boomspray+cab	100	4	50/6	80	1.467	0.378	1.861
Broadacre LV	XII boomspray+cab	100	1.8	50/6	36	0.660	0.170	0.837
Broadacre LV	XIII boomspray+cab	100	0.25	50/6	5	0.147	0.024	0.171

(1) Absorbed dose for applicators wearing gloves and one layer of clothing
(2) M/L/A = mixer/loader/applicator
(3) Combined dermal and inhalation absorbed dose incorporating dermal absorption (22%), inhalation retention and absorption during application (100%) and an average worker weight of 60 kg

3.6. Measured worker exposure during re-entry

Dermal exposure was estimated on swampers (n = 1) (loaders), flagmen (n = 2) and field checkers (n = 2) from aerial application of Azodrin Insecticide in cotton (Anonymous, 1968). Azodrin was applied at a rate of 1.5 pints in 5 gallons of water (1.2 L/ha). The field had received a similar treatment ten days before. All subjects were dressed in short sleeve shirts, washable pants and low cut shoes. None of them wore protective clothing. All study subjects were exposed for a period of 1 hour only. Pre-exposure plasma and RBC ChE values were measured and post-exposure blood samples were collected at four hours, three days and seven days after exposure. Gauze patches were taped to the clothes of each subject at the following sites: right and left shoulders, right and left lower legs, right and left thighs, right and left wrists, middle of chest and middle of back (one swamper and two flagmen only). Greatest dermal exposure occurred in the field checkers, particularly on the wrists, thighs and legs. ChE values were reasonably unchanged in all five volunteers although 3/5 subjects had prior exposure to OPs and carbamates.

The following studies were obtained from the scientific literature and are summarised in Table 6:

Establishment of re-entry period for OP treated cotton fields based on human monitoring data: Ware et al. (1974 a) and Ware et al. (1975).

Establishment of a re-entry period for monocrotophos treated tobacco (Guthrie et al., 1976).

Table 6 Summary of Re-entry studies in cotton and tobacco

Study reference	Ware et al. (1974a)	Ware et al. (1975)	Guthrie et al. (1976)
Chemical. crop, No. of subjects, activity, application method and rate	Azodrin, cotton fields, six volunteers (4 for each re-entry), ground spray, 1.43 kg ai/ha.	Monocrotophos, cotton fields, 14 volunteers (5 for each re-entry), ground spray, 1.12 kg ai/ha.	Monocrotophos, tobacco fields, 13-15 volunteers, ground spraying, 0.56 kg ai/ha.
Personal protective equipment	T-shirts, jeans, head covering (optional)	T-shirts, jeans, head covering (optional)	Long pants and short sleeved shirts.
Re-entry period observed and duration of exposure	Five hour exposures at 24 hrs post-application	Five hour exposure periods, at 24, 48 and 72 hrs. (post-application)	Eight-hour exposure period at 48, 72 and 96 hrs post application.
OP related illness	None observed	None observed	None reported
ChE effects	Consistent depression of RBC ChE during and after field exposure. Some recovery evident the next morning. No apparent effect on plasma ChE.	Slight but consistent depression of plasma ChE in subjects at 48 & 72 hrs post application and depression of RBC ChE at 48 hrs post application.	No significant depression of plasma and RBC ChE values.
Urinary metabolites	Not measured.	Not measured.	No significant difference in pre and post exposure DMP at all re-entry times.
Sampling method and dermal exposure	Extracted from clothing and hand washes (average from 4 subjects), after 5 hrs exposure: Hands - 5.7 mg Shorts - 16.5 mg Pants - 70.8 mg	Extracted from clothing and hand washes (average from 5 subjects), after 5 hr exposure: Source 48 hrs mg 72 hrs mg Hands 2.08 3.03 Shirts 13.5 13.4 Pants 20.2 28.7	Not measured
Sampling method, inhalation exposure and comparison with NOHSC TWA[(a)]	Portable air samplers (2/4 subjects) – respiratory exposure not significant, max. of 27 µg/5 hours < NOHSC TWA	Portable air samplers - respiratory exposure not significant, < 0.6 µg/5 hr, at 48 & 72 hrs post application < NOHSC TWA	Not measured
Foliar/soil residues	Foliar residues: DFR (mg/m^2) At application 4.5 30 hours 5.2	Dislodgeable leaf residues refer to Section 3.3.6 for details	Dislodgeable foliar residues: Hrs DFR (mg/m^2) 48 314 (no rain) 72 26 (rain +) 96 27 (rain+)
Conclusions of authors	Degree of contamination, absorption and effects on blood enzymes correspond qualitatively with foliar residue levels. A 24-hr REP is inadequate for Azodrin.	Respiratory exposure was not significant. Clear effect on blood ChE at 48 hrs but not at 72 hrs post application. High residue levels 48 hrs after application and residues easily transferable to other surfaces.	Rainfall caused a significant reduction in dislodgeable foliar residue levels. A 72 hrs REP appears tenable under dry conditions based on low ChE depression at 48 hrs.

(a) NOHSC TWA Exposure Standard for monocrotophos of 0.25 mg/m^3.

3.7 Health effects involving re-entry workers

Wicker et al. (1979) monitored plasma and RBC ChE levels and clinical signs of toxicity, in cotton scouts from several locations throughout North Carolina, USA over 8 years (1971-1978). Cotton crops were treated with various OP insecticides 3-15 times/season at 5-7 day intervals. Most scouts wore long pants, short sleeved shirts and boots or tennis shoes and a few scouts wore hats and gloves. Many changed work clothes daily but seldom washed their hands after the exposure period. Although a minimum re-entry period of 48 hrs was recommended, it was not strictly adhered to. Individual exposures were not determined because the spray application rate and time depended on pest pressure (monocrotophos applied at 0.6-0.9 lb ai/acre or 0.67-1.01 kg ai/ha), the number of fields scouted by each subject varied and the weathering of residues was variable. Scouts with no known exposure to OP or carbamate insecticides served as controls. The following shortcomings are noted in the study:

- The number of controls was variable and did not match study subjects.
- Sample collection could not be related to time from most recent application.
- The sampling method was either venipuncture or finger stick sampling (which is more prone to contamination from skin deposits). Results could not be disaggregated.
- ChE analysis was carried out using different methods.

However the following findings were important:

- Two workers who showed 50% depression of plasma ChE demonstrated poor work practices, such as not changing work clothes daily and a disregard for re-entry restrictions especially in dew-wet fields.
- The depressed ChE activity noted in subjects in one County in the latter part of the season correlated with increase of OP use during this period.
- Three scouts who inadvertently entered a field within 48 hrs of treatment showed significant plasma depression but no change in RBC ChE levels.
- Many highly exposed scouts complained of feeling ‘unwell’ the evening after exposure. No other symptoms were noted.

The study authors conclude that no adverse health effects would be likely in cotton scouts exposed to OPs if the recommended procedures were followed. These would include a 48 hr re-entry interval, daily change of clothes, avoidance of dew-wet fields, frequent check for eye changes (miosis), forced absence from further exposure when ChE depression exceeds 25% (determined by regular monitoring).

3.7.1 Studies on dislodgeable residues

Ware et al. (1974a, 1974b, and 1975) and Cahill et al. (1975) conducted consecutive studies to investigate the dissipation of leaf-surface residues of commonly used OPs (including monocrotophos) in cotton. Similar quantities of active ingredient were applied in all trials (1.12 kg ai/ha).

Table 7: Monocrotophos residues on cotton plants after application by ground equipment

Time post application (hours)	Residues (µg/cm^2)		
	La Palma[(1)], Arizona	La Palma[(2)], Arizona	Coolidge, Arizona[(3)]
0	1.42	2.51	1.28
24	1.48	1.39	1.06
48	1.1	0.84	0.63
72	0.77	0.43	0.43
96	0.7	0.3	-

(1) Ware et al. (1974b)
(2) Cahill et al. (1975)
(3) Ware et al. (1975)

Residues were seen at 96 hours (after 4 days) in Ware et al. (1974b) and Cahill et al. (1975). They were at very low levels of 0.7 µg/cm^2 and 0.3 µg/cm^2 respectively.

Toshniwal et al. (1989) conducted a study to measure worker exposure to residues in OP treated cotton fields in India. Monocrotophos (among other OPs) was applied at 0.03% ai and 0.05% ai at 20-day intervals. Dislodgeable foliar residues (DFR) were estimated at 0 hour and 3, 7 and 15 days after spraying. Surface soil was collected immediately after completion of spraying. Butter paper pads were placed on shoulder, chest, thigh and back of workers spraying the pesticides (number of subjects not available). Hand rinse samples were collected after spraying. DFR, surface soil residues and dermal exposures were provided as ppm. Details were not provided on the collection or analysis, therefore results are not presented in this report. DFR of monocrotophos declined to less than 15-18% of original values after 15 days post application. Maximum worker contamination after re-entry was as follows: thighs > shoulders > hands > chest.

Baugher DG (1987) conducted risk assessments for workers re-entering cotton treated with monocrotophos, based on published exposure data in a variety of crops and DFR. Details of exposure data are not available.

The DFR studies for monocrotophos were conducted by Du Pont de Nemours and Company, Inc., at 4 sites in the USA. Monocrotophos was applied to cotton by ground equipment in Arkansas or California and by aircraft in Mississippi and Texas. Treated leaf disks were collected for analysis.

A linear regression analysis was carried out by plotting the logarithm of the DFR (µg/cm^2) versus post-application time. The regression equations were used to predict DFRs from 0 to 14 days post-treatment. These DFRs predicted by the regression equation were used in the re-entry models to calculate exposures at equivalent times.

Margins of safety (MOS) were calculated for all exposures. Based on a rat study, dermal absorption was estimated at 11%. MOS approached or exceeded 200 at all sites on the day of application, using a NOEL of 39.6 mg/kg/d based on a rat subchronic study. Using a NOEL of 0.135 mg/kg/d based on a rat reproduction study, MOS exceeded 100 at all sites, 24 hours post-application.

4 RISK ASSESSMENT

Workers may be exposed to monocrotophos when mixing/loading, applying spray, cleaning up spills and maintaining equipment. In addition re-entry workers may come in contact monocrotophos residues on treated foliage. Re-entry tasks would include crop checking and maintenance, manual weeding (eg in cotton crops) and harvesting.

The vapour pressure of monocrotophos is low ($7x10^{-5}$ mm Hg at 20^oC), indicating that inhalation of vapours from the concentrate is unlikely and would be dependant on the formulation.

The main route of occupational exposure will be through skin contamination while performing any routine tasks. Sprayers may inhale spray mist.

Agricultural workers such as farm-based operators and contract sprayers, may be repeatedly exposed to monocrotophos over the application season. The frequency and duration of exposure would depend on the crop type and area to be treated. The NRA PQ No. 1 Large Scale User Survey indicated that crops such as French beans, tomatoes, sweet corn and tobacco may receive more than two treatments in a season and cotton only one treatment per season (tipworm treatment). Other crops including apples and potatoes may need 1-3 treatments per season. The spraying period may span a number of days.

4.1 Acute toxic potential

The dermal LD_{50} of monocrotophos is 123 mg/kg. An average 60-kg worker would need to become contaminated on the skin with 7.38 g of monocrotophos or 18.5 mL of the formulation at 400 g/L, to reach the dermal LD_{50}. The amount of working strength solution needed to reach the dermal LD_{50} will be 6.15 L of the spray solution at the maximum high volume concentration of 0.12% monocrotophos (tobacco). Low volume spraying can result in high end use concentration of monocrotophos. A concentration of 0.4% monocrotophos is possible with low volume (100L/ha) spraying to vegetables. In this case the amount of working strength solution needed to reach the dermal LD_{50} is 1.8 L. The maximum concentration of monocrotophos in aerial spraying solution is 8% (1600 g ai, 20 L/ha (bananas)). The volume of working strength solution needed to reach the dermal LD_{50} is 92 mL. These calculations do not include a safety factor.

A fatal case of human poisoning after ingestion of monocrotophos at dose equivalent to 23 mg/kg bw was reported (Section 3.3.1). Assuming 60-kg body weight and 22% dermal absorption, this equates to a dermal dose of 6.3 g monocrotophos or 15.8 mL of Azodrin Insecticide at 40%.

Monocrotophos is a slight eye and skin irritant in experimental animals and may cause these effects in exposed workers.

4.2 Repeat dose toxic potential

The human oral NOEL of 0.0036 mg/kg and percutaneous absorption of 22% is used to assess the risk to workers repeatedly exposed to monocrotophos. In order to exceed this dose, skin would need to be contaminated with more than 0.98 mg monocrotophos or 0.002 mL of 40% formulation for an average 60-kg worker. This calculation does not include a safety factor.

4.3 Assessment of end-use exposure

Monocrotophos is used on a variety of crops using different application equipment.

The end use exposure data available for assessment by crop group is given in Table 8.

Table 8: End use and re-entry exposure data by crop groups

Crop	Mixer/loader/applicator measured worker exposure data	POEM Estimates	Re-entry measured worker exposure data
Apples & pears	None	high volume air-blast	
Bananas	None	None (only aerial spraying)	
French beans	None	high volume and low volume boomspray	
Potatoes	None	low volume boomspray	
Tomatoes	None	high and low volume boomspray	
Sweet corn	None	low volume boomspray (like broadacre) high volume boomspray (NRA report)	
Tobacco (broadacre)	None	high volume boomspray (NRA report)	Guthrie
Broadacre including cereals, wheat, oilseeds and cotton	None	low volume boomspray	Ware (cotton) Burger (cotton)

4.3.1 Margin of exposure for measured worker exposure

Margins of exposure (MOE) based on measured data could not be determined due to lack of worker exposure studies for mixer/loader/applicators of monocrotophos.

4.3.2 Margin of exposure for predicted worker exposure

MOE are calculated by comparing the most appropriate NOEL with exposure data obtained from predicted exposure modeling (Table 9). The NOEL of 0.0036 mg/kg/d from a human study is used. Considering the inter-species variability, MOE of 10 or above are considered to be acceptable. POEM scenarios, use patterns and MOE are provided in Table 9.

Table 9: Margins of exposure (MOE) using exposure estimates from POEM, use patterns described on monocrotophos labels, NRA use pattern information and NRA Performance Questionnaire No. 1

Crop	Estimate Number (equipment)	Product rate (L/ha)	Active handled (kg/day)	MOE [(1)] mixer/ loader	MOE Applicator	MOE M/L/A
				Gloves	Gloves[(2)]	Gloves
Apple+pears High volume (HV)	I air-blast-no-cab	2	24	< 1	< 1	< 1
Apple+pears HV	II air-blast-no-cab	2	1.6	< 1	< 1	< 1
French beans HV	III boomspray+cab	0.85	8.16	< 1	< 1	< 1
French beans LV	IV boomspray+cab	0.65	6.24	< 1	< 1	< 1
Potatoes LV	V boomspray+cab	1	20	< 1	< 1	< 1
Tomatoes HV	VI boomspray+cab	2.5	30	< 1	< 1	< 1
Tomatoes LV	VII boomspray+cab	2	24	< 1	< 1	< 1
Sweet corn HV	VIII boomspray+cab	1.25	15	< 1	< 1	< 1
Sweet corn LV	IX boomspray+cab	1	12	< 1	< 1	< 1
Tobacco HV	X boomspray+cab	0.7	6.72	< 1	< 1	< 1
Broadacre LV	XI boomspray+cab	4	80	< 1	< 1	< 1
Broadacre LV	XII boomspray+cab	1.8	36	< 1	< 1	< 1
Broadacre LV	XIII boomspray+cab	0.25	5	< 1	< 1	< 1

MOE = Margin of exposure, derived using the oral NOEL of 0.0036 mg/kg/day
Absorbed dose for applicators wearing gloves and one layer of clothing

Results

For uses in fruit trees, beans, tomatoes, sweet corn, tobacco and broadacre crops, all MOE for M/L/A are below 1.

4.3.3 End use exposure and qualitative risk assessment

There are numerous reports on the acute toxic effects of monocrotophos and biomonitoring studies on exposed workers and other reports where exposure to monocrotophos has resulted in depressed ChE without accompanying symptoms of over-exposure. The extent to which either symptoms or depressed ChE result from monocrotophos use in Australia is unknown. Reports of ChE measurements during routine use of monocrotophos along with other OPs indicated that ChE inhibition could occur in some

individuals without clinical symptoms. In Australia, reports include Simpson (1973) and Simpson (1974) both for aerial spraying.

Many studies were available for monocrotophos (ULV formulation) use by hand held application using knapsack (on rice, Section 3.3.2). The studies are not directly relevant to the Australian use pattern. However some conclusions are relevant for general monocrotophos use. They include:

- Plasma ChE is more sensitive to inhibition by monocrotophos than RBC ChE and urinary DMP excretion correlated with the degree of ChE depression.

- Recovery of RBC and plasma ChE was not seen up to 40 hrs post exposure.

Ground spraying

There are no measured worker exposure studies for M/L/A of monocrotophos. The UK POEM is used to calculate exposure and MOE for the Australian use pattern wherever possible. The end use scenarios listed in the model are derived from the ECRP Questionnaire, NRA Agricultural Report and registered labels. For other use patterns where POEM estimations were not possible, a qualitative risk assessment is carried out.

Fruit trees (apple and pears)

Predicted exposure for M/L/A from POEM for high volume airblast spraying without cabs at 2000 L/ha spraying for 2 hours (2 ha) or 6 hours (30 ha) results in low and unacceptable MOE for workers using gloves and overalls. Elimination of mixer/loader exposure will not substantially reduce the risk. An additional layer of protective clothing will not substantially reduce the risk.

Vegetables including potatoes, French beans, tomatoes and sweet corn

Predicted exposure using POEM for both high and low volume application, results in low and unacceptable MOE for mixer/loader and applicators using gloves and overalls. The elimination of worker exposure during mixing is unlikely to substantially influence the MOE. The addition of respiratory protection in unlikely to substantially influence the MOE.

Broadacre (tobacco, cereals, wheat, oilseeds and cotton)

Predicted exposure using POEM results in low and unacceptable MOE for workers using gloves and overalls. The elimination of worker exposure during mixing is unlikely to substantially influence the MOE. The addition of respiratory protection is unlikely to substantially influence the MOE.

Non-fruit bearing trees

There are no measured exposure studies available for workers involved in treating trees by standard syringe or eyedropper and it is not possible to predict exposure using POEM. Details of work practices are not available for this registered use. Exposure and risk for these workers could not be quantified.

Flowers-control of budworms (permit use in Queensland)

Monocrotophos is used under permit conditions in Queensland and NSW. The application rate and method are very similar to high volume boomspraying of tomatoes. POEM Estimate VI is applicable to this use pattern. Predicted exposure using POEM for high volume application, results in low and

unacceptable MOE for workers using gloves and overalls. The elimination of worker exposure during mixing is unlikely to substantially influence the MOE. The addition of respiratory protection in unlikely to substantially influence the MOE.

Aerial spraying

There are no measured exposure studies available for workers involved in the aerial spraying of monocrotophos and it is not possible to predict exposure using POEM. Aerial spraying is the common method of applying monocrotophos in bananas, various broadacre crops including cotton, potatoes, non-crop areas (locust control) and tobacco.

The operators may be involved in multiple applications. The container sizes available are 5 L or 200 L. However considering the large amounts of monocrotophos needed, the 200 L bulk handling containers would be most frequently used. Mixer/loaders using bulk containers are likely to receive special training in chemical handling and should be able to exercise more effective control over exposure. This is essential as more concentrated sprays will be used and more areas covered (65 ha/hr using not less than 10 L water/ha). Spray pilots are protected from direct contamination with spray mist (when located inside the plane). On balance, the risks to mixer/loaders and spray pilots is considered acceptable.

Flaggers involved in aerial spraying may become contaminated with spray mist. Likelihood of exposure is high and cannot be quantified. Therefore the potential risk to human flaggers is considered unacceptable, unless they are protected by engineering controls such as cabs.

Tank mixing

Registered monocrotophos labels include tank mixing or compatibility statements using other anticholinesterase agricultural chemicals.

The risk assessment indicates unacceptable risk to workers handling monocrotophos alone. Therefore, the additional (unquantified) risk of mixing monocrotophos and other anticholinesterase chemicals is not acceptable on occupational health and safety grounds.

4.4 Re-entry Assessment

There is a re-entry period of 5 days on the registered label for Azodrin 400 Systemic Insecticide/Miticide cautioning workers not to handle treated crops after spraying unless wearing protective clothing.

There is no information available on re-entry periods for orchard and vegetable use. Some information is available for broadacre use. The information includes studies on re-entry exposure and on dislodgeable residues (Section 3.3.5 and 3.3.7). Studies conducted for cotton and tobacco demonstrated that ChE depression was low at 48 hours and concluded that a 72 hour re-entry period was adequate for monocrotophos [Ware et al., (1974a and 1975), Wicker et al. (1979) and Guthrie et al. (1976)].

Baugher DG (1987) concluded a re-entry period of 24 hours to be safe based on the DFR studies conducted by Du Pont de Nemours and Company Inc. This is not relevant for the Australian use situation as details (Section 3.3.7) of exposure data used are not available and NOELs and dermal absorption used in the risk assessment are different to those used in this assessment. Therefore this

study will not be considered. Other studies on DFR indicated very low levels of residues at 96 hours [Ware et al. (1974a, 1974b and 1975) and Cahill et al. (1975)].

The degradation of monocrotophos under aerobic conditions in soil is fast, with a half-life of between 1 and 7 days. It is unlikely to persist beyond one week following application in soil. Bioaccumulation is not expected (Environment Australia, June 1998).

Based on currently available data a re-entry period of 5 days is acceptable.

5 OCCUPATIONAL CONTROLS

5.1 Statement of hazardous nature

Monocrotophos and formulated products containing monocrotophos are classified as hazardous substances according to NOHSC criteria. Hazardous substances are subject to the workplace controls outlined in the NOHSC Control of Workplace Hazardous Substances (NOHSC, 1994b).

5.2 Safety Directions

The existing safety directions are (Handbook of First Aid and Safety Directions, 1998) :

AC 400 g/L or less

100 101	Very dangerous, particularly the concentrate
120 121 130 131 132 133	Product and spray are poisonous if absorbed by skin contact, inhaled or swallowed
190	Repeated minor exposure may have a cumulative poisoning effect
210 211	Avoid contact with eyes and skin
220 223	Do not inhale spray mist
373	Obtain an emergency supply of atropine tablets 0.6 mg
279 281 282 290 291 292 294 297 300 303	When preparing and using the prepared spray wear protective waterproof clothing, cotton overalls buttoned to the neck and wrist and a washable hat, elbow-length PVC gloves, goggles and half-facepiece respirator with combined dust and gas cartridge (canister)
340 341 342	If product on skin, immediately wash area with soap and water
350	After use and before eating, drinking or smoking, wash hands, arms and face thoroughly with soap and water
360 361 363 364 366	After each day's use, wash gloves, goggles, respirator and if rubber wash with detergent and warm water and contaminated clothing

EC 400 g/L or less in ethylene glycol monomethyl ether

100 101	Very dangerous, particularly the concentrate
120 121 130 131 132 133	Product and spray are poisonous if absorbed by skin contact, inhaled or swallowed
160 162 164	May irritate the eyes and skin
190	Repeated minor exposure may have a cumulative poisoning effect
210 211	Avoid contact with eyes and skin
220 222 223	Do not inhale vapour or spray mist
373	Obtain an emergency supply of atropine tablets 0.6 mg
279 280 281 282 283 290 292 294 297 300 303	When opening the container, preparing and using the prepared spray or using the product wear cotton overalls buttoned to the neck and wrist and a washable hat, elbow-length PVC gloves, goggles and half-facepiece respirator with combined dust and gas cartridge (canister)
330 331 332	If clothing becomes contaminated with product or wet with spray remove clothing immediately
340 341 342	If product on skin, immediately wash area with soap and water
350	After use and before eating, drinking or smoking, wash hands, arms and face thoroughly with soap and water
360 361 363 364 366	After each day's use, wash gloves, goggles, respirator and if rubber wash with detergent and warm water and contaminated clothing

5.3 Information provision

5.3.1 Labels

Registrants provided labels for monocrotophos technical grade active constituent (TGAC). The labels need to be revised in accordance with NOHSC regulations (NOHSC, 1994c).

All current formulated products containing monocrotophos are hazardous substances and require a reference to the material safety data sheet (MSDS) on the product label.

5.3.2 Material Safety Data Sheet

A MSDS is required for monocrotophos technical grade active constituent where it is handled by Australian workers.

MSDS are required for all current monocrotophos products and need to be prepared in accordance with NOHSC regulations (NOHSC, 1994d).

5.4 Occupational Exposure Monitoring

5.4.1 Atmospheric monitoring

There is a NOHSC Exposure Standard for monocrotophos of 0.25 mg/m^3 time weighted average (TWA) (NOHSC, 1995a). This should be listed on the product MSDS.

5.4.2. Health Surveillance

NOHSC has placed organophosphate pesticides on the Schedule for Health Surveillance (Schedule 3 Hazardous Substances for which Health Surveillance is Required). Guidelines for monitoring of organophosphate insecticides have been endorsed by NOHSC (NOHSC, 1995b). The employer is responsible for providing health surveillance where a requirement has been established as a result of a workplace assessment process.

6 CONCLUSIONS

Worker exposure during end use

Fruit trees (apple, pears and bananas)

The risk for workers applying monocrotophos by high volume airblast spraying based on predicted exposure was high and unacceptable, even if mixer/loader exposure was eliminated. Monocrotophos is applied only by aerial spraying on bananas (Section 3.2.2). However, information from grower groups is that monocrotophos is no longer used in Queensland on bananas (Section 3.2.2).

Based on the qualitative risk assessment, continued use of aerial spraying for bananas would be acceptable, because it is available only to licensed/authorised personnel in this context.

As the risk could not be quantified, the following control measures are needed for aerial spraying on bananas:

- Use of enclosed mixing/loading systems;
- Farm chemical user training for workers handling monocrotophos (addressed below);
- Health surveillance to be conducted when appropriate, for workers handling monocrotophos (Section 5.4.2);
- Human flagging in aerial operations is not acceptable, unless flaggers are protected by engineering controls such as cabs.

Other uses for pome fruit (apples and pears) are not supported as the risk is unacceptable. Measured worker exposure data are needed to quantify risk for these uses.

Vegetables including potatoes, French beans, tomatoes and sweet corn

The risk for workers applying monocrotophos by high volume or low volume boomspraying, based on predicted exposure was high and unacceptable, even if mixer/loader exposure was eliminated.

Monocrotophos may be applied by aerial spraying on potatoes. Based on the qualitative risk assessment, continued use of aerial spraying for potatoes is acceptable, since in this context it is available only to licensed and authorised personnel.

As the risk could not be quantified, the following control measures are needed for aerial spraying on potatoes:

- Use of enclosed mixing/loading systems;
- Farm chemical user training for workers handling monocrotophos (addressed below);
- Health surveillance to be conducted when appropriate, for workers handling monocrotophos (Section 5.4.2);
- Human flagging in aerial operations is not acceptable, unless flaggers are protected by engineering controls such as cabs.

Monocrotophos use on tomatoes, French beans and sweet corn is not supported as the risk is unacceptable. Measured worker exposure data are needed to quantify risk for these uses.

Broadacre (tobacco, cereals, wheat, oilseeds and cotton)

The risk for workers applying monocrotophos for high volume and low volume boomspraying based on predicted exposure was high and unacceptable, even if mixer/loader exposure was eliminated.

Monocrotophos is applied mainly by aerial spraying on broadacre crops. Based on the qualitative risk assessment, continued use of aerial spraying for cotton, lucerne, maize, non-crop areas (locust control), sorghum, wheat, soybeans, sunflower and tobacco is acceptable, since in this context it is available only to licensed and authorised personnel.

As the risk could not be quantified, the following control measures are needed for aerial spraying on broadacre crops:

- Use of enclosed mixing/loading systems;
- Farm chemical user training for workers handling monocrotophos (addressed below);
- Health surveillance to be conducted when appropriate, for workers handling monocrotophos (Section 5.4.2);
- Human flagging in aerial operations is not acceptable, unless flaggers are protected by engineering controls such as cabs.

Groundspraying on broadacre crops is not supported as the risk is unacceptable. Measured worker exposure data are needed to quantify risk for this use.

Non-fruit bearing trees

This use could not be assessed. Continued use is not supported unless worker exposure data is provided for assessment.

Flowers-control of budworms (permit use in Queensland)

This is very similar to high volume boomspraying of tomatoes and application rates are the same. The risk for workers applying monocrotophos for high volume or low volume boomspraying, based on predicted exposure was high and unacceptable, even if mixer/loader exposures were eliminated. The permit use of monocrotophos for control of budworms is not supported as the risk is unacceptable.

Worker exposure during re-entry

There is a re-entry period of 5 days on the registered label for Azodrin 400 Systemic Insecticide/Miticide cautioning workers not to handle treated crops after spraying unless wearing protective clothing. The following statement should be on all labels of registered products of monocrotophos.

Re-entry Period

Do not allow entry for 5 days after treatment. If bug checking or exceptional circumstances require prior entry, limit duration of entry and wear cotton overalls buttoned to the neck and wrist and elbow-length PVC gloves. Clothing must be laundered after each day's use.

Others

Monocrotophos and the products under review are hazardous substances and are covered by regulations to control workplace hazardous substances.

Monocrotophos TGAC labels should be in accordance with the NOHSC Code of Practice for Labelling of Workplace Substances (NOHSC, 1994c).

Monocrotophos TGAC and all registered products require a MSDS. The MSDS should be compiled in accordance with the NOHSC Code of Practice for the Preparation of Material Safety Data Sheets (NOHSC, 1994d).

NOHSC does not recommend revision of the existing Safety Directions for monocrotophos at this stage. Existing safety directions are different for EC and AC formulation and should be reviewed. Revision of the safety directions may be required when the additional data requested for certain uses of monocrotophos are received and assessed.

The additional (unquantified) risk of mixing of monocrotophos with other anticholinesterase chemicals is not acceptable and this statement should be listed on the labels. Data would be needed to support any tank mixing proposal.

NOHSC recommends that appropriate training courses (eg Farm Chemical Users Course or equivalent) be identified for all workers involved in the use of monocrotophos.

Only aerial spraying (limited information) is considered to be relatively safe in comparison with other application methods due to its minimal exposure to users. NOHSC recommends that, use of monocrotophos products to be restricted to emergency uses under permit use only.

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