Section 3

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1. INTRODUCTION

1.1. Performance questionnaires

The NRA sought information on the agricultural aspects of the use of monocrotophos by surveying groups in the community who use this chemical, provide technical advice on its use or supply this chemical to users. The purpose of the questionnaires was to gather information on use, performance, changed agricultural practices, adverse effects and trade and residues. The results form part of the efficacy report that appears in this section.

1.2. General use pattern

Monocrotophos is an organophosphate with broad-spectrum contact and systemic activity against insects and mites. It is applied using aerial, ground-rig and directed sprays and penetrates plant tissue rapidly and has residual activity. Ciba AG and Shell Chemical Co. USA introduced it in 1965.

The major crops where monocrotophos is used include sorghum, sunflowers, tomatoes, cotton, potato, lucerne, soybean and tobacco (see table 2 for more detailed information). The major pests that monocrotophos is used against include *Helicoverpa* spp., spurthroated locust, sorghum midge, western flower thrips, aphids, the green vegetable bug, mites, the stem Borer, potato tuber moth.

2. EFFICACY ASSESSMENT

2.1. Introduction

Chemical products containing monocrotophos must comply with contemporary assessment standards in order to achieve and maintain registration. Products approved by the NRA must be effective for the uses claimed on the product label.

The NRA surveyed State co-ordinators, commodity and industry organisations, users and registrants. The purpose of this survey was to gather information on the performance, changed agricultural practices, adverse effects, trade and residues relating the use of products containing monocrotophos. In particular, information was sought on whether the way in which products containing monocrotophos are presently used is the same as when they were first registered and that the present label directions are still applicable. The resulting information forms part of this efficacy assessment.

2.2. Registration status

There are five products containing monocrotophos currently registered in Australia by four registrants (Table 1). Examples of the crops/situations appearing on currently registered product labels are listed in Table 2.

Table 1 - Registered products containing monocrotophos *

Product Name	Applicant
Azodrin 400 Systemic Insecticide/Miticide	Cyanamid Agriculture Pty Ltd
Farmoz Monocron 400 Systemic Insecticide	Farmoz Pty Ltd
Farmoz Monocron 400 Systemic Insecticide/Miticide	Farmoz Pty Ltd
Nuvacron 400 Systemic Insecticide	Novartis Crop Protection Australasia Ltd
Phoskill 400 Systemic and Contact Insecticide	United Phosphorus Ltd

*** Note: This list does not include products which have not been renewed by applicants but which are still permitted to be sold for two years to clear stocks.**

Table 2 - Example of Crops/situations appearing on currently registered product labels

Crop/Situation	Target Pests	State
apples & pears	codling moth	NSW, Vic only
	light brown apple moth, mealy bug, woolly apple aphid (apples only), two-spotted mite	NSW, Vic, WA only
bananas	banana scab moth	Qld, NT only
beans: French	bean fly	Qld, NSW, Vic, Tas, WA, NT only
cotton	cotton tipworm, Helicoverpa spp.	Qld, NSW only
	thrips, aphids, cotton jassids, rough bollworm, cotton looper, mites, spurthroated locust	Qld, NSW, WA only
	migratory locust	WA only
	plague locust	NSW, WA only
lucerne	spotted alfalfa aphid	Qld, NSW, Vic, SA, WA only
	blue green aphid, lucerne aphid	Qld, NSW, Vic, WA only
	pea aphid	Vic only
lucerne, pasture	spurthroated locust, migratory locust	Qld, NSW, WA only
	plague locust	NSW, Vic, WA only
maize, millet, panicum, wheat	spurthroated locust, migratory locust	Qld, NSW, WA only
	plague locust	NSW, Vic, WA only
non-crop areas	spurthroated locust	Qld, NSW, WA only
potatoes	potato moth	Qld, NSW, Vic, Tas, SA, WA only
	potato aphid	Qld, Vic, Tas, SA, WA only
	green vegetable bug, leafhoppers	Qld only
	spurthroated locust	Qld, NSW, WA only
sorghum	sorghum midge	Qld, NSW, WA, NT only
	spurthroated locust, migratory locust	Qld, NSW, WA only
	plague locust	NSW, Vic, WA only
soybeans	green vegetable bug, spurthroated locust	Qld, NSW, WA only
	two spotted mite	Qld only
	spider mite	NSW only
	migratory locust	NSW, WA only
	plague locust	NSW, Vic, WA only
sunflowers	Helicoverpa spp., rutherglen bug	Qld only
sweet corn	budworm	Qld, NSW, Vic, NT only
tobacco	budworm (Helicoverpa punctigera), tobacco looper	Qld, NSW, Vic only
	green vegetable bug, stem borer, tobacco leaf miner, spurthroated locust	Qld, NSW only
tomatoes	Helicoverpa spp., two spotted mite, leaf miner, tomato russet mite	All states
	green vegetable bug	Qld, NSW, Tas, SA, WA only
non-fruit bearing trees	leaf hoppers, tree hoppers, thrips, aphids, psyllids, mealy bugs, scale insect	Qld, NSW, Vic, NT only

The total amount of monocrotophos active ingredient imported into Australia during the financial year 1996-1997 was approximately 47 tonnes. Limited information was obtained from the performance questionnaires indicating the relative distribution of use of monocrotophos. Further information was obtained from the registrants and is summarised in Table 3 below.

Table 3 -Approximate estimates of monocrotophos usage by crop/situation *

Crop/Situation	% Monocrotophos Used
Cotton	10.6
Pastures/Lucerne	5.9
Potato	6.9
Sorghum/Sunflower	45.7
Soybean	5.7
Tobacco	3.5
Tomato	21.7

***The above estimates will vary from year to year due to seasonal factors which play a role in determining pest population levels and crop areas planted.**

Supply and use of monocrotophos may also be permitted by the NRA in certain circumstances such as minor and/or emergency uses and for trial purposes. There are no current permits issued by the NRA for monocrotophos.

Information supplied to the NRA through performance questionnaires and submissions to the review indicate that monocrotophos is also used on celery and brassicas (particularly sprouts) and ornamental horticultural crops. These are not registered uses.

2.3. Permits

The Queensland Department of Primary Industries originally issued a permit for the use of monocrotophos to control budworm (*Helicoverpa* spp.) in commercial flower crops. This permit was transferred to the NRA after 15 March 1995 and is still current. The same permit allows the use of methamidophos for outbreaks of western flower thrips, which is a vector for the tomato spotted, wilt virus. The NRA has not issued any permits for the use of monocrotophos.

Permits for the use of monocrotophos for the control of western flower thrips on ornamentals are currently in place in NSW. It is used as part of resistance management strategies.

2.4. Current use patterns

The NRA received responses to its request for monocrotophos use information from all State chemical co-ordinators and registrants, from commodity/grower groups (4) and from growers (12).

In general, it appears that monocrotophos use may be in decline as reflected by the limited response to the performance questionnaires.

Monocrotophos is registered for agricultural use only and according to the current labels and the performance questionnaires the major uses are in cotton, lucerne, potato, sorghum, soybean, tobacco, tomatoes and commercial flower crops.

2.4.1 Cotton

Monocrotophos is registered for the control of aphids, *Helicoverpa* spp. (eggs and larvae), jassids, looper, mites, rough bollworm, tipworm (small larvae) and thrips. It is applied at the early stages of crop growth and generally before major pest infestations occur.

The withholding period is 21 days except for the control of *Helicoverpa* spp. where the withholding period on different product labels is either 21 or 30 days. For the control of *Helicoverpa* spp., label rates range from 800 to 1,600 g ai/ha, with the rate used depending on pest incidence. The label rate range for all other pests is 100 to 840 g ai/ha. There is some inconsistency in current product label information regarding frequency of application with only one label saying if re-application is required within 4 days to use an alternative chemical.

Information gained from performance questionnaires indicated that monocrotophos was not widely used on cotton. In Queensland monocrotophos is a fall back option for the control of tipworm when severe infestations occur. It appears that registrations for aphids and *Helicoverpa* spp. may be obsolete in cotton because better options are available. A Queensland consultant advised that although use of monocrotophos in cotton was small, (4% of their chemical business) it had in the past provided a useful backstop when options became limited. Monocrotophos is rarely used in Integrated Pest Management programs.

Western Australia has a spray program using monocrotophos on cotton in the Ord River Irrigation area to control cluster caterpillar (*Spodoptera*), *Helicoverpa* spp. and rough bollworm. This program also incorporates the control of aphid, leaf perforator, looper, mite and thrip if present. The label rate range is 720 to 1,120 g ai/ha spraying at least 3 times at 4 to 5 day intervals. The withholding period is 21 days.

2.4.2 Fruit

Monocrotophos is registered for use on apples and pears for the control of aphids, mealy bug, mites and moths. From the label information, monocrotophos is applied as a directed spray of 0.4 g ai/L as required from late October/early November. The frequency of application is dependent on pest incidence and climatic conditions. To meet the 28 day withholding period it is recommended to use alternative chemicals for the last cover spray before harvest.

Monocrotophos is not recommended for use if biological control of mites is being practised or if fruit is being exported to the USA where there are zero tolerance levels.

To control scab moth on bananas, monocrotophos is sprayed at a maximum of 800 g ai/ha every 7 to 14 days depending on pest activity. The withholding period is 10 days. Growers indicated that there was very little use of monocrotophos on bananas as chlorpyrifos was preferred. One respondent considered monocrotophos too toxic for people to use. There does not appear to be support for the continued use of monocrotophos on bananas in Queensland.

2.4.3 Grains

A maximum rate of 280 g ai/ha of monocrotophos is recommended for control of midge on sorghum. Application is recommended when 90% of heads have emerged and pests are active, with re-application dependent on insect pressure.

The Grains Council of Australia strongly supports the continued use of monocrotophos to control midge, as it is considered an alternative to the more frequently used synthetic pyrethroids. Usage of monocrotophos in sorghum for this purpose is limited because it is phytotoxic to some varieties of sorghum and the withholding period is long (42 days).

Monocrotophos is used for the control of *Helicoverpa* spp. on triticale and wheat at a maximum spray rate of 720 g ai/ha. Spraying is recommended when pests are in their early stages with repeat applications at 7 to 10 day intervals as necessary. The withholding period is 42 days for harvest or 7 days for grazing or cutting for stock food.

2.4.4 Non-fruit Bearing Trees

Monocrotophos is registered for the control of aphids, leaf eating insects, leaf and tree hoppers, mealy bug, psyllids, scale insects and thrips in non-fruit bearing trees by injection. A solution of 0.4 g ai/2 mL water is injected into the trunck of full crowned Angophora, Eucalypt, Ficus, Quercus and Tristania at 2 mL/cm of tree (excluding bark) diameter. For half crown or all other species 2 mL/2 cm is used. Reapplication is every 12 months if necessary. This procedure cannot be used on trees without leaves or trees that are < 5 cm in diameter.

2.4.5 Ornamental Horticulture

Monocrotophos is used to control budworm (*Helicoverpa* spp.) in commercial flower crops at the rate of 0.72 to 1.0 g ai /L. Monocrotophos was to be applied when established infestations of budworm larvae were >10 mm in length. Checks for phytotoxicity on a small number of plants is recommended prior to applying monocrotophos to the whole crop area. Care was advised during applications in enclosed areas.

The Queensland Ornamental Horticultural Industry advised that there is off-label (permit) use of monocrotophos to control western flower thrips on ornamentals. Monocrotophos is considered important because it has broad-spectrum activity and is effective against a wide range of pests. It is also considered important to maintain access to a wide range of chemicals so that phytotoxic problems can be avoided and as part of a rotation program to avoid chemical resistance by thrips.

2.4.6 Lucerne

Aphids are controlled by using monocrotophos at the label rate of 100 g ai/ha which is applied when necessary. The withholding period is 7 days.

2.4.7 Sunflowers

Monocrotophos is used for the control of grey cluster bug, *Helicoverpa* spp. and rutherglen bug in sunflowers at the maximum label rate of 720 g ai/ha. It is sprayed to control *Helicoverpa* spp. in their early stages and applications are repeated at 7 to 10 day intervals to prevent re-infestation. For the control of rutherglen bug, monocrotophos is applied at the budding stage and is re-applied according to pest incidence. To protect bees and ensure adequate pollination, treatment during flowering should be avoided. The withholding period is 5 days.

2.4.8 Tobacco

Monocrotophos appears to be important to the tobacco growing industry. It is registered for control of green vegetable bug, *Helicoverpa* spp., looper, leaf miner and stem borer. In general controlling *Helicoverpa* spp. will also control these other pests. There are two types of spray programs listed on the labels. In the first program, 0.6 to 1.2 g ai/L of directed spray is applied at 7 to 10 day intervals from transplanting to harvest, the interval being dependant on the pest incidence. The second program (64 g ai/100L of water) varies application volume depending on the stage of growth of the tobacco plant. A minimum of 90 L (57.6 g ai) of spray mixture is recommended per 6,000 plants during the early stages of growth. This is increased to 320 L (205 g ai) of spray mixture per 6,000 plants when plants are above 1.5 metres in height. The withholding period is 5 days.

Advice from Victoria is that monocrotophos is used on an irregular basis at the label rate. Farms are typically 10 to 12 hectares in size and two applications of monocrotophos are applied each season.

Monocrotophos is considered to be a strategic part of pest control options as it is used in rotation with carbamates and synthetic pyrethroids and is reputedly the most effective of the remaining registered chemicals which provide adequate control of sucking insects in tobacco. Information from Queensland indicates that it is the preferred option for the control of *Helicoverpa* spp. and stem borers.

2.4.9 Vegetables

Monocrotophos is registered for use in French beans to control bean fly. Label recommendations are 260 g ai/ha or 0.34 g ai/L as a directed spray. The withholding period is 21 days. It is applied at weekly intervals from 3 to 7 days after emergence and then at weekly intervals until blossoming or as required. Information from growers in Queensland shows that monocrotophos is being used at label rates.

One respondent used one application of monocrotophos on celery seedbeds to control bean fly maggot at a rate of 280 g ai/ha (similar to beans above). The respondent indicated that there was no alternative even though monocrotophos is not registered for this use. Information from Victoria indicates that there is some use on brassicas (particularly sprouts). Monocrotophos is not registered for this use, although with alternatives available its use is declining.

Monocrotophos is registered for the control of aphids, green vegetable bugs, leaf hoppers and moths on potatoes at a maximum rate of 400 g ai/ha and with a withholding period of 3 days. It is applied at 7 to 10 day intervals depending on pest activity. Information from growers indicates that monocrotophos is used against potato tuber moth at the label rates. Potato Growers indicated that monocrotophos is considered essential for the potato industry for the control of the potato tuber moth.

Green vegetable bug, *Helicoverpa* spp., leaf miner and mites on tomatoes are controlled by boom spraying with monocrotophos at a rate of 600 to 800 g ai/ha or as a directed spray at the rate of 0.6 to 1 g ai/L. Treatments for *Helicoverpa* spp. also control the other pests and are applied in response to pest activity, however monocrotophos is not to be applied more than four times per season. The withholding period is 4 days. Growers indicated that monocrotophos was used as per the label, but it was not used very often.

2.4.10 Sweet corn

Monocrotophos is registered for use on sweet corn to control budworm larvae before they reach protected sites within cobs. Label information indicates that monocrotophos is applied as a directed spray at a rate of 0.5 g ai/L or by boom at a rate of 400g ai/ha, 2 to 3 times per week during the silking period. The withholding period is 5 days. Information from Victoria indicated that there has been a reduction in the use of monocrotophos on sweet corn in the Gippsland region because alternatives are available.

2.4.11 Soybeans

Monocrotophos is registered for use on soybeans for the control of the green vegetable bug and mites. Label application rates range from 280 g ai/ha for green vegetable bug to 360 g ai/ha for mites. The withholding period is 5 days.

2.4.12 Locusts

Monocrotophos is registered for the control of spur-throated, migratory and plague locusts on a number of crops (Table 2). The recommended label application rate range is 140 to 360 g ai/ha. It is applied when the pest is at rest on the crop and re-applied as necessary. The lower rate is used against immature stages and the higher rate for adults.

The Grains Council of Australia strongly supports the retention of monocrotophos for use in locust control where its residual life gives protection over a period of time. It is used as a perimeter or boundary spray around crops and in this regard monocrotophos is often used as part of a strategic preventative control program. The Grains Council notes that care is needed with this chemical as it is phytotoxic to some varieties of sorghum and its 42 day withholding period limits its use.

2.5 Uses of particular importance to respective agricultural industries

Monocrotophos was considered to be of strategic importance for the following applications by the respondents to the questionnaires.

Queensland:

- for the control of stem borer and *Helicoverpa* spp. on tobacco
- a fall back option for cotton tipworm during heavy infestations
- for the control of budworms in flower species that are monocrotophos tolerant

Victoria:

- a useful insecticide/miticide which is used for the control of pests in cereals and pastures
- it is reputedly the most effective of the remaining registered chemicals which provide adequate control of sucking insects on tobacco

Western Australia:

- important for the potato industry
- one of the few organophosphates which kill *Helicoverpa armigera* and is used in the Ord River Irrigation area for resistance management of this pest.
- perhaps important for locusts

2.6 Methods of application

Growers indicated that farming practices had changed to include regular monitoring of pests to assist in determining which chemicals to use in a spray program. Growers also advised that improvements in spray equipment enable even application providing greater control of pests.

Information from the label indicates that monocrotophos is to be applied by directed spray, aircraft or ground rigs except for Victoria, Tasmania and potatoes in NSW where aerial spraying is prohibited. Bananas can only be sprayed aerially at a maximum application rate of 800 g ai/ha in a minimum of 20 litres of water per hectare, every 7 to 14 days depending on pest activity. The label warns that monocrotophos is not to be applied by fogging machines or back mounted knapsacks.

For aerial application an ultra low volume (ULV) or low volume spray is used with suitable equipment to provide a droplet size of approximately 100 to 200 microns (low volume application) or 90 to 120 microns (ULV). When applying as a low volume spray, the total spray volume should not be less than 10 L/ha.

Application by ground-rig requires a minimum of 250 L of water per hectare using cone nozzles or in a minimum of 150 L of water per hectare using fan-assisted rotary atomisers. Fan nozzles are not recommended.

The use of wetting agents is included in the label directions and varies between products for various crops or situations.

Monocrotophos is also used for non-fruit tree injection. Holes are drilled around the tree at 30 cm apart that are 5 cm deep, 1 to 5 cm in diameter and slanted downwards at 45^o. These holes must be at least 1.5 metres below the lowest branch. Monocrotophos is placed in the holes with an eyedropper and then the next day the holes are plugged with putty or mastic. The plugs and surrounding area are painted over with bitumen emulsion sealer.

2.7 Usage trends

The respondents of the performance questionnaires (with the exception of Victoria) generally conveyed a view that demand for use of monocrotophos would decline over the next 3 years. The main reasons given were the availability of effective, less hazardous and cheaper alternatives. The broad-spectrum activity of monocrotophos excludes it from Integrated Pest Management programs, particularly because of its toxicity to predatory mites. Varieties of lucerne have been developed that are resistant to aphids and as a result, dependence on monocrotophos is declining. Chemical resistance has developed in two spotted mites and possibly in the western flower thrip.

It is considered that monocrotophos is not a critical component of pest control strategies for agriculture in NSW and the demand for use in cotton will decrease because of the development of Bt cotton varieties.

Monocrotophos has very little use in Tasmania where it is registered for the control of mites, aphids and *Helicoverpa* spp. in vegetables. Alternative chemicals and/or predatory mites are used instead.

In the Alice Springs area of the Northern Territory, there was some minor use of monocrotophos in the tree injection of date palms to control pulvinaria scale. Malathion, dimethoate, or predatory mites have replaced monocrotophos for this use .

The South Australian respondents indicated that very little monocrotophos is used as there are alternatives such as parasites to control potato tuber moth. Other reasons given for the decline in its use in South Australia include the very low LD_{50} and the resulting concern for operator safety and also chemical resistance in the target species.

The Queensland respondents expect a decline in the use of monocrotophos because it interferes with Integrated Pest Management programs, there is resistance in spider mites, efficacy is questionable in field crops and bananas, and growers believe it is toxic to birds.

Usage trends differ between regions of Victoria. Information from the Gippsland region indicated that demand for monocrotophos would decrease because of efficacy issues and the existence of effective alternatives. North West Victoria indicated that the demand would not change, however many varieties of lucerne have been developed with resistance to spotted alfalfa aphids. Monocrotophos is highly toxic and is less likely to be used on grasshoppers in pastures because less persistent products are considered to be more appropriate. Contrary to the above, North East Victoria has advised that use on tobacco has increased over the last 3 to 5 years in place of synthetic pyrethroids and carbamate insecticides. In this context, monocrotophos is reputedly the most effective of the remaining registered chemicals which provide adequate control of sucking insects on tobacco.

The Grains Council of Australia strongly supports the continued registration of monocrotophos because of the need for the industry to have access to a range of effective chemicals. They also noted that monocrotophos needs to be used with appropriate caution, because of its high toxicity and it's potential for affecting non-target species.

2.8 Efficacy

Limited information was received regarding the efficacy of this chemical in the field. Generally growers, commodity groups and registrants had observed no problems with the efficacy of monocrotophos in the field.

Information from Queensland indicated that monocrotophos efficacy was questionable in field crops and bananas. In Victoria, it is considered that monocrotophos is not effective on mature grubs and there appear to be more effective alternatives.

Queensland, SA and NSW respondents indicate that resistance to monocrotophos appears to have developed in two-spotted mites. Resistance to monocrotophos in some populations of aphids and mites is also noted on some product labels.

2.9 Alternatives

Some alternatives to monocrotophos, used by respondents are listed below:

Crop/Situation	Alternative Chemical
spurthroated locusts	fenitrothion, chlorpyrifos
boll worm	carbamates, BT, alphamethrin
psyllid (lerp insects)	carbamates, dimethoate, methidathion
budworm	methomyl, alpha-fenvalerate
beans	dimethoate, endosulfan and permethrin (both for rotation)
bananas	chlorpyrifos
cotton	endosulfan (tipworm), dicofol (mites), dimethoate and omethoate (aphids)
fruit and veg	diazinon and methomyl
potato	chlorpyrifos
tobacco	methomyl and alpha-fenvalerate (Budworm), no alternative for green vegetable bug, none for Budworm or green vegetable bug, it is reputedly the most effective of the remaining registered chemicals which provide adequate control of sucking insects on tobacco (Victoria)
tomatoes	dimethoate, endosulfan and omethoate (both for rotation), pyrethroids, chlorpyrifos, methomyl

2.10 Phytotoxicity

Monocrotophos may cause leaf discolouration on many varieties of sorghum. Appropriate warnings appear on the labels. The labels contain lists of varieties that are sensitive and those that are not. Caution is recommended with new varieties and users are advised to spray a small area first before treating the whole crop.

Monocrotophos was first introduced into Australia around 1974, however it caused damage to red varieties of apples. Currently it is registered only for Granny Smith apples and specified varieties of pears.

Monocrotophos is important to the ornamental horticulture industry because of its broad-spectrum activity. It was considered important to maintain access to a wide range of chemicals so that phytotoxic problems can be avoided whilst also being able to use resistance management strategies to avoid the development of chemical resistance by the western flower thrip.

2.11 Integrated pest management

Monocrotophos is not included in any Integrated Pest Management programs because its broad-spectrum activity results in the loss of beneficial fauna such as predatory mites.

2.12 Resistance management

Generally monocrotophos was considered a chemical which can be used in rotation with other chemical groups in a program to limit the development of chemical resistance.

Monocrotophos is considered to be critical for pest control in tobacco in Victoria as it is used in rotation with carbamates and synthetic pyrethroids. The Western Australian respondents consider monocrotophos to be one of the few organophosphates that kill *Helicoverpa armigera* and it is used in the Ord River Irrigation Area for resistance management of this pest.

The Queensland Horticultural Industry has an off-label permit to use monocrotophos in a rotation program to reduce the development of chemical resistance in western flower thrips. Monocrotophos has broad-spectrum activity and so it can be used against a wide range of pests.

Advice from the Queensland Fruit and Vegetable Growers was that monocrotophos is used together with and not instead of, alternatives in rotation for resistance management. AusVeg advised that alternative chemicals are available for the control of the relevant pests and growers generally choose these alternatives.

2.13 Conclusions

Monocrotophos appears to be effective for the purposes indicated on product labels with only a few examples of chemical resistance being identified. The decline in use of monocrotophos seems to be related to other factors such as:

- Concerns about operator safety and toxicity to birds and other non-target species.
- Incompatibility with the use of Integrated Pest Management strategies.
- The long withholding period for some crops.
- The availability of other effective, less hazardous and more cost effective alternatives.
- Phytotoxicity in some varieties of sorghum.
- The development of lucerne varieties resistant to aphids.

There are some uses where monocrotophos seems to have an important current role to play. These are principally in relation to:

- Insecticide resistance management strategies in horticulture and the Victorian tobacco industry.
- Locust control, especially as a perimeter spray as part of a strategic preventative control program.
- Control of some specific pests in tobacco, potatoes, cotton, ornamental horticulture and cereals.

From the information available to the NRA, the efficacy of monocrotophos does not appear to be in question.

3 TRADE ASSESSMENT

3.1 Introduction

This assessment has been prepared as part of the overall review of monocrotophos under the Existing Chemicals Review Program (ECRP) of the National Registration Authority for Agricultural and Veterinary Chemicals (NRA). The ECRP was established by the Commonwealth Government as part of the National Registration Scheme to ensure that registered chemicals continue to comply with contemporary assessment standards.

One aspect of the contemporary standards with which chemicals must comply in order to achieve and maintain registration is that use of the chemical must not result in any unacceptable risk to trade between Australia and other countries.

To evaluate the risk to trade when reviewing a product the following matters are taken into consideration:

- Compatibility of MRLs with trading partners (including whether or not MRLs have actually been set in the importing country, compatibility of use patterns etc.)

- Registration status in importing countries (including whether or not the material is banned or restricted in those countries)

- Review status in recognised international forums (such as the Codex Alimentarius Commission) and whether the importing country is a member of the reviewing organisations or recognises those organisations

- Detection of violative residues by the National Residues Survey

- Detection of violative residues in domestic produce which may indicate problems with overall use patterns

- Violations of importing countries' residue limits detected as a result of any residue monitoring carried out by the respective importing countries.

These matters have been examined and the results follow.

3.2 Registration Status

3.2.1 Australia

There are 5 products currently registered in Australia. These have been listed in efficacy section. There are two current permits allowing use of monocrotophos in NSW and Qld on commercial flower crops to control certain pests.

Current use patterns are contained in the efficacy section.

3.2.2 Overseas

Monocrotophos is registered in many countries in the world including those listed in the following table:

Brazil	Bulgaria	Chile
Colombia	Costa Rica	Dominican Republic
Ecuador	Egypt	France
Greece	Guatemala	Honduras
India	Indonesia	Italy
Japan	Jordan	Kenya
Malaysia	Mexico	Mozambique
Myanbar	Nicaragua	Pakistan
Panama	Paraguay	Peru
Philippines	South Africa	Spain
Sudan	Thailand	Turkey
Zambia	Zimbabwe	

Australian agriculture covers a wide range of geographical regions and climate types and a correspondingly wide range of agricultural and horticultural crops. The registered uses and limitations applied in Australia compare with those countries with corresponding crops.

Products containing monocrotophos are not registered in USA or the UK and there are no MRLs set for monocrotophos by Argentina, China, Germany, Ireland, New Zealand or UK.

3.2.3. Use Patterns in Relevant Overseas Countries

Monocrotophos is used overseas for similar situations and pests as it is in Australia.

However, use patterns have not been properly defined for Australia and data to establish such use patterns is lacking. Since Australian use patterns have not been definitely established, it is not possible to compare them to those used overseas. It is, therefore, very difficult to establish whether use according to the approved Australian label will violate MRLs established overseas.

3.3. Exports to Other Countries

The majority of monocrotophos used in Australia is used on tobacco, sunflowers, sorghum, cotton, potato, soybeans and tomatoes and so particular emphasis has been placed on export of these commodities in examining the trade implications of the use of this chemical.

It should be noted that the reasons for use of this chemical in many crops appears to be for locust control, particularly in central Queensland.

The export quantity, estimated value and main markets for these key crops on which monocrotophos is used are detailed below.

3.3.1 Cotton

Cotton is established as Australia's fourth largest rural export with approximately 92% of the Australian cotton crop sold off shore. More than 70% is bought by Japan, South Korea and Indonesia but significant amounts are also sold to Taiwan, Malaysia, Thailand, Hong Kong, The Philippines, Italy and Germany.

Cotton is grown in more than 90 countries, 75 of which are developing countries and about 1/3 of total cotton produced enters the world trade. In this world market, Australia is the third largest exporter of cotton.

In 1995/96 Australia exported 311.4 kt of raw cotton worth $762.2 million. The Asian market purchased 281.4 kt, the main purchasers being Japan (69.1 kt) and Indonesia (99.1 kt), while 24.9 kt were sold to Europe (17.1 kt to Italy) and the remaining 5.1 kt sold to other countries. [(1)(2)(6)]

While the cotton fibre is the backbone of the crop, most parts of the plant have economic value. Cottonseed is Australia's largest oilseed crop and is used to produce cooking oil and high-protein animal feed as well as being a source of seed for the following seasons crop. In 1995/96 Australia exported 157.74kt of cottonseed, 0.18kt of cottonseed oil and 4.08kt of cottonseed and sunflower seed meal [(6)].

Of all the monocrotophos used on Australian agriculture and horticulture, 10.6% of this is used on cotton for the control of a number of insect pests. Monocrotophos was nominated in the efficacy component of this report as important in this industry for control of heavy infestations of Cotton tipworm in Queensland, only required occasionally, and for control of *helicoverpa armigeria* at the Ord River irrigation area in WA.

3.3.2 Potato

Potatoes are the world's fourth most important crop behind wheat, rice and corn, and provides significant contributions to rural and industrial economies in Australia.

Since the 1970's, production in Australia has increased from approximately 693,000 tonnes to 1,129,000 tonnes in 1993. In the year 1993/94, 13,259 tonnes ($4 million worth), of potatoes were exported. 73% of these exports came from West Australia. The main export markets are Mauritius and Singapore with the main smaller markets being Malaysia, PNG and Hong Kong. 1,907 tonnes ($0.67 million) of potato seed was exported to PNG, Sri Lanka, Malaysia and Tonga. [(1),(2),(7)]

The potato industry has lost market share to products such as pasta, rice and other carbohydrate foods. The industry is involved in diversification of the product and promotion especially of gourmet opportunities for specialty potatoes.

The amount of monocrotophos used on potatoes is 6.9% of total usage of this chemical. Monocrotophos was nominated as important for the control of potato tuber moth in potatoes in Queensland and West Australia.

3.3.3 Sorghum

The main market for sorghum is as a feed grain. Australian feed grain exports are dependant on several factors: US corn production; feed grain demand in Saudi Arabia; and feed grain demand from the Australian domestic market. In 1995/96, 410,000 tonnes ($97 million) were exported and 249,000 tonnes of that was for feed. The main export markets for Australian sorghum are Japan and Taiwan. [(2)]

The area planted to sorghum in Australia is forecast to increase in the future, with beef lot feeding expected to provide a major domestic market. Grain sorghum is a major component of the cropping system of North-east Australia and is used as a stock feed in the pig, cattle and poultry industries.

Sorghum and sunflowers are together estimated to have 45.7% of all monocrotophos usage used on them. A large amount of this is probably used on locust control around the perimeter of these crops in Queensland.

3.3.4 Tomato

Australian tomato production is considered small by world standards with an average of 233,000 tonnes grown in the past 6 seasons. The two major world producers, the US and European Union, produce 10 million tonnes and 7 million tonnes respectively. The total gross value of production of Australian tomatoes at farmgate in 1993/94 was $173.2 million and total Australian exports in 1995 was valued at $9.19 million (5894 tonnes). Major exports markets are New Zealand, Hong Kong and Singapore. (1)(7)

Tomatoes are considered a mature market worldwide with demand not expected to increase much unless marketing can stimulate consumers to use tomatoes more often. The Australian processed tomato market is essentially based on the domestic market but small numbers of processed product is exported to South East Asia, and the market for Australian processed tomatoes is expected to increase in the future. The major difficulties for export are market access, transport and quality outturn.

Approximately 21.7% of all monocrotophos used in Australia is applied to tomatoes. No uses have been highlighted as important for tomatoes.

3.3.5 Cut Flowers

Although flowers are not listed as a use on the labels, two states have issued permits to use monocrotophos in this situation. The Australian floricultural industry is estimated to be worth $270 million at farmgate ($350 million at retail level). Australian native flower production world-wide is valued at $400 million with Australia's contribution being $85 million. In world terms Australian production of Australian native flowers and exotic protea only adds up to around 10% of world production. Cut flower exports, both traditional and native, have grown from $2.9 million in 1980/81 to $27.1 million in 1996/97, and it is estimated that by the turn of the century exports will increase to $100 million. 93% of exports are native flowers and *proteaceae*. (1)(2)(7)

Australian flowers are exported to 45 countries. Japan is the major market for Australian flower exports (1,733 mt) followed by the USA (687 mt), Germany (404 mt) and the Netherlands (401 mt). In 1996/97 Asia purchased over 200 mt of cut flowers. Future markets are targeted in SEA. (1)(2)(7)

The Australian Nursery Plant production is valued at $466 million at the farmgate ($1.9b retail). Exports of live plants were valued at $7 million in 1994/95. (1)

Problems facing the export business is the strict quarantine requirements particularly at the two main markets, Japan and the USA. Hygiene is very important with pests and disease strictly monitored. A single insect can result in either rejection of the entire shipment or fumigation which can damage flowers and shorten vase life. Therefore, good insect control is vital to retain these markets.

No figures on the amounts of monocrotophos used on these products are available but advice from various groups is that this is an important chemical for the ornamental horticultural industry for the control of Budworm and Western Flower Thrip.

3.3.6 Other

The other export products that have main usage of monocrotophos are sunflowers and soybean.

Sunflowers are mainly grown to produce oil and are classified under the general MRL of vegetable oil or as an oilseed. Sunflowers are one of the four main oilseed crops in Australia along with Soybeans, canola and cottonseed. In 1996/97 the crop was estimated at 140,000 tonnes and by the turn of the century sunflower crops are anticipated to reach 500,000 tonnes. In 1994/95 10.50 kt were exported. Soybeans are also classified as an oilseed but also have separate MRLs for soybean. In 1994/95 4.35 kt were exported. The 1996/97 crop is estimated at 100,000 tonnes and by 2001 is anticipated to reach 250,000 tonnes(1)(2)(6). Approximately 5.7% of total monocrotophos usage is on Soybean. No uses have been identified as important for either soybeans or sunflowers.

Currently no tobacco is exported from Australia, although approximately 3.5% of the total usage of monocrotophos is on tobacco.

3.4 Potential Trade Problems

3.4.1 Maximum Residue Limits (MRLs)

It is anticipated that trade difficulties will arise in most cases from residue issues. Because there are some incompatibilities between Australian MRLs and overseas countries' MRLs, it is possible for residue violations to occur in produce which is produced according to Good Agricultural Practice.

The maximum residue limit (MRL) is defined as the maximum concentration of a residue, resulting from the officially authorised safe use of an agricultural or veterinary chemical, that is recommended to be legally permitted or recognised as acceptable in or on a food, agricultural commodity, or animals feed.

Australian MRLs are set by Commonwealth government authorities and are then adopted by the State governments for inclusion into their legislation. No agricultural chemical is registered for use unless MRLs have been set for that use of the chemical or has been exempted from the need to set an MRL (where the chemical would not occur in food or the level of residue is considered to be of no toxicological significance).

The monocrotophos MRLs which have been established in Australia for various crops, are detailed below in Table 1.

Table 1: Australian MRLs for monocrotophos [9]

Crop	**MRL mg/kg**	**Crop**	**MRL mg/kg**
Apple	0.5	Banana	0.5
Beans, except broad bean & soya bean	0.2	Broad Beans (green pods and immature seeds)	0.2
Cereal grains	*0.02	Cotton Seed	0.1
Edible offal (mammalian)	*0.02	Eggs	*0.02
Meat (mammalian)	*0.02	Milks	*0.002
Pear	0.5	Potato	0.1
Poultry, Edible offal of	*0.02	Poultry meat	*0.02
Sweet corn	*0.01	Tomato	0.5
Vegetable oils, edible	*0.05		

***The MRL is set at or about the limit of analytical quantitation**

A number of Australia's trading partners accept Codex MRLs for monocrotophos. In a number of cases Australian MRLs have been set for commodities where there are no Codex MRLs (see Table 2). It is therefore possible that, where Codex MRLs have been adopted, there could be residues above an importing country's MRL following normal use in Australian agricultural or horticultural production due to varying use patterns and pest pressures. This is also true for the MRLs that are set by individual countries.

The following table provides examples of where Australian, Codex and other countries MRLs differ and therefore the possibility of residue violations affecting Australia's trade may occur.

Table 2: Comparison of Codex [10], Australian [9] and other trading partners [11] MRLs in mg/kg:

Commodity	Codex	Australia	Korea	USA	Malaysia	Japan	Thailand	Italy
Apple	1	0.5	1	-	1	-	-	0.05
Cattle, pigs, sheep (meat)	*0.02	*0.02	0.02	-		-	0.02	-
Cottonseed	0.1	0.1	0.1	0.1	-	-	-	-
Cottonseed oil	*0.05	*0.05	-	-	-	-	-	-
maize	*0.05	*0.02	0.05	-	0.05	-	-	0.05
Pears	1	0.5	1	-	1	-	-	0.05
Potatoes	*0.05	0.1	0.05	0.1	-	0.05	0.05	0.05
sorghum	-	*0.02	-	-	-	-	0.02	-
soybean (immature)	*0.05	-	0.05	-	0.05	-	0.05	-
Vegetable oil	-	*0.05	-	-	0.05	-	-	-
Sweet corn	-	*0.01	0.05	-	-	0.05	0.05	-
Tomato	1	0.5	1	0.5	1	0.05	1	0.05
triticale	-	*0.02	-	-	-	-	-	-
wheat	*0.02	*0.02	-	-	-	-	-	-

***The MRL is set at or about the limit of analytical quantitation**

An associated difficulty with MRLs is that the Joint FAO/WHO Meeting on Pesticide Residues (JMPR) has recommended the removal of the Codex general fruit and vegetable MRLs for all chemicals, replacing them with individual fruit and vegetable MRLs provided that these are supported by appropriate data. This inevitably means that the crop /MRL combination on Australian registered labels based on Codex general fruit or vegetable MRLs will no longer be supported when these general MRLs are removed. However, monocrotophos only has a crop/MRL combination for vegetable oils.

The information in Table 2 clearly shows that many of our export markets have few MRLs for monocrotophos. The two crops with most support for MRLs across the countries are potatoes and tomatoes. There are also few Codex MRLs for monocrotophos. Countries that have not set MRLs tend to use the Codex MRLs or accept MRLs set at or about the limit of analytical quantitation.

Other comments

When comparing MRLs for crops between different countries, a number of things, other than the MRL assigned for a particular crop, need to be considered.

(1) The residue definition for monocrotophos in one country may not be identical to that used in another country. Monocrotophos could be defined as either the parent compound, or may include a number of the metabolites. In this situation, just comparing the MRL value would not be an accurate comparison between countries.

(2) The listing of individual crops under a generic group may also cause inaccuracies when comparing MRLs. An example is the definitions that are used in Taiwan. The fruits classified under the pome fruit category include not only apples and pears, but also peaches, apricots and a number of other fruits which Australia would classify under a different category. Their stone fruit category includes fruit such as mangoes, loquats and kiwifruit. However, Australian group entries are applied as described by the Codex classification scheme which is a recognised standard. Fruits and other products which are considered unusual in Australia and may not have data, still will have recognised groupings.

Harmonisation of Australian MRLs with those of Codex and other countries for groupings of crops, MRLs and residue definitions, would be a way to reduce the chances for residue violations in export crops.

3.4.2 Residue Detections

Where chemicals are used according to the label directions, residues above the Australian MRL are unlikely to occur. If growers use chemicals contrary to label instructions, there is a risk of residues occurring in produce at a level above the Australian MRL. Examples of misuse include: failure to observe the withholding period; applying too much chemical; repeating a treatment too soon after a previous treatment; and using a chemical on a crop or commodity for which there is no registered use. In some states off-label use regulations may allow use on a crop which have no MRLs and this could result in trade problems.

Another source of residues is unintended exposure of plants and animals to chemicals. This can occur, for example through spray drift from treatment of an adjacent crop, or poor animal and chemical management.

The National Residue Survey results in 1996 indicated that Australian produce is of a high standard, as few of the samples contained chemical residues above acceptable levels. Test results from a total of 46482 samples showed that only 140 residues above the MRL for all chemicals were detected. [(5)]

Organophosphate residues are becoming less frequent in meat species with less than 1% of the samples having residues. The organophosphates detected in 1996 were diazinon (5 residues), ethion (5 residues), fenthion (4 residues), chlorpyrifos (1 residue). There have been no residues above the MRL since 1992 and all of the organophosphate residues detected in the past 2 years have been less than the MRL.[(5)]

Inconsistencies between the Australian and Codex MRLs for various commodities may be a source of difficulty in relation to trade with those countries.

3.4.3 Australian Market Basket Survey (AMBS) [(8)]

The purpose of the AMBS is to monitor pesticides and contaminants present in food and then estimate their intakes in the diets of Australians.

For the organophosphate pesticides, the estimated dietary intakes in 1994 were all within acceptable safety standards. Monocrotophos was found in detectable levels in a small range of products. Residues were found in the following:
White bread - 0.01 mg/kg
Wholemeal bread - 0.02 mg/kg
Capsicum - 0.12 mg/kg.

The residue in capsicum is a violation, as there is no registered use on this vegetable, however, the residues in bread are comparable to the MRL of *0.02 mg/kg in cereal grains and do not constitute violations.

3.5 Data Submitted to Support Compliance with Overseas MRLs

Data have not been submitted to support compliance with MRLs. However, the residue trials used as the basis for the Chemical Residue Report were all overseas studies which have been used as the basis for establishing MRLs/tolerances in the respective countries. It would appear that the bulk of these studies were carried out in the US.

3.6 Other

The current ADI for monocrotophos is 0.0003 mg/kg bw/day.

The estimated intake in diets based on average energy intake range from 0.0012 mg/kg bw/day for an adult female to 0.0000072 mg/kg bw/day for a child aged two.[8]

The estimated intake based on the 95th percentile energy intake range from 0.0047 ug/kg for an adult female up to 0.0084 ug/kg for a child aged two. [8]

The National Residue Survey (NRS) generated data in a range of cereal commodities between 1/7/94 and 30/6/95, which showed no violations of monocrotophos within the sampling period.[5]

In a similar testing regime for animal commodities such as milk, eggs, meat and/or fat of sheep, cattle, pigs, horses, poultry etc monocrotophos was not detected.

The NRS analyses for organophosphates in cereals and commodities between 1994 – 1997 showed no violations for monocrotophos. The total number of samples analysed were 11,509. [5]

3.7 Advantages of Product

Several grower organisations and State departments of agriculture have commented on the usefulness of this chemical in preparing produce for market.

These advantages may be listed as follows:

- it provides another chemical group rotation option in resistance management strategies eg thrips in horticultural crops
- according to growers, it is comparatively much cheaper than alternatives
- it is considered important in the horticultural industry because it has a broad spectrum activity and is effective against a wide range of pests
- access to a wide range of chemicals in the horticultural industry is considered necessary to avoid problems of phytotoxicity
- concerns that ornamental horticultural industry as a minor user of chemicals will lose one of an already small range of chemicals.
- monocrotophos has been listed as a strategic pest control chemical for ornamentals, tobacco and potatoes

REFERENCES

1. Coombs, R, Horticulture Australia, Moorescope Publishing Pty Ltd, 1995

2. Coombs, R, Australian Agriculture, Moorescope Publishing Pty Ltd, 1997/98

3. The Royal Society for Chemistry European Directory of Agrochemical Products, Fourth Edn, Vol3: Insecticides and Acaricides 1990

4. British Crop Protection Council, The Royal Society of Chemistry, The Pesticide Manual Incorporating the Agrochemicals Handbook, 10th Edn, Crop Protection Publications, 1994.

5. Bureau of Resource Sciences (1997), Report on the National Residue Survey 1996 Results, Bureau of Resource Sciences, Canberra.

6. Australian Bureau of Agricultural and Resource Economics (1996), Australian Commodity Statistics, 1996.

7. The Australian Horticultural Statistics Handbook 1995/96 Edition

8. The 1994 Australian Market Basket Survey, Australian New Zealand Food Authority.

9. The MRL Standard. Maximum Residue Limits in Food and Animal Feedstuffs of Agricultural and Veterinary Chemicals and Associated Feedstuffs. The National Registration Authority for Agricultural and Veterinary Chemicals, January 1998.

10. Codex Alimentarius Commission, Codex Committee on Pesticide Residues, Residues of Pesticides in Foods and Animal Feeds, 1996

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4 RESIDUE ASSESSMENT

4.1 Introduction

The Pesticides and Agricultural Chemicals Committee (PACC) first considered monocrotophos residues in apples, pears and cotton seed in 1968. Throughout the 1970's and 1980's uses were extended into potatoes, tomatoes, sweet corn, bananas, beans and cereals. Labels of the various products are given in Appendix 1 and an outline of the PACC proceedings are included in Appendix 2.

4.1.1 Current Relevant MRLs

Australian MRLs[‡] for monocrotophos are listed below:

Table 1

Commodity	MRL (mg/kg)
Apple	0.5
Banana	0.5
Beans, except broad bean and soya bean	0.2
Broad bean (green pods and immature seeds)	0.2
Cereal grains	*0.02
Cotton seed	0.1
Edible offal (mammalian)	*0.02
Eggs	*0.02
Meat (mammalian)	*0.02
Milks	*0.002
Pear	0.5
Potato	0.1
Poultry, edible offal of	*0.02
Poultry meat	*0.02
Sweet corn (corn-on-the-cob)	*0.01
Tomato	0.5
Vegetable oils, edible	*0.05

Table contd.

Table 4

Animal Feed Commodity	MRL (mg/kg)
Straw and fodder (dry) of cereal grains	*0.02

Monocrotophos has an ADI of 0.0003 mg/kg bodyweight/day (ADI List, April 1997); JMPR ADI = 0.0006 mg/kg bodyweight/day (1993).

‡ MRL Standard published November 1996.

4.1.2 Maximum Treatment Regime

Maximum crop treatments, as indicated on currently registered monocrotophos product labels are shown in the table below:

Table 1

Crop	Pest	Application			Application Timing	WHP
		Rate	No.	Interval		
Apples, pears	Wooly aphid, mites, mealy bug	40 g ai/100L	–	10 days for mites; 3 weeks for other pests	At first sign of pest; late October to early November.	28 days
Bananas	Scab moth	800 g ai/ha	–	7 – 14 days	At first sign of pest activity.	10 days
Barley	Heliothis	720 g ai/ha	–	7 days	At first sign of pest activity.	6 weeks for harvest
Beans, french	Bean fly	260 g ai/ha or 34 g ai/100L	–	7 days	Onwards from 7 days after crop emergence.	21 days
Cotton	Heliothis, aphids, mites, bollworm, locust	1.6 kg ai/ha	–	10 days	At first sign of larvae and at egg hatching or from seedling stage of crop.	21 days (heliothis 30 days)
Lucerne	Aphids	100 g ai/ha	–	Re-apply as necessary	Apply when pests are active.	7 days (grazing)
Lucerne, pasture	Locust	280 g ai/ha 300 g ai/ha**	–	Re-apply as necessary	When pest is on the crop.	7 days (grazing)
Maize, millet, (panicum), wheat	Locust	280 g ai/ha	–	Re-apply as necessary	When pest is on the crop.	6 weeks harvest; 7 days grazing 5 days*
Pastures	Locust	300 g ai/ha	–	Not stated	At first sign of pest.	7 days (grazing)
Potatoes	Aphids, potato moth, leafhoppers, locust	400 g ai/ha	–	7 days	At first sign of pest activity, but before significant crop damage.	3 days
Sorghum	Sorghum midge, locusts	280 g ai/ha	–	Re-apply as necessary	At first sign of pest.	6 weeks harvest; 7 days grazing, 5 days*
Soyabeans	Mites, green vegetable bug, locusts	360 g ai/ha	–	Re-apply as necessary	Apply before infestation becomes damaging to crop.	5 days harvest 7 days grazing
Sunflowers	Heliothis	720 g ai/ha	–	Re-apply as necessary	Apply at budding, or when larvae are damaging to the crop.	5 days
Sweet corn	Budworm	400 g ai/ha or 50 g ai/100L	–	Re-apply according to pest activity.	Apply at first sign of pest activity and egg laying. Apply 2 or 3 times a week during silking period.	5 days
Tobacco	Budworm, locust	120 g ai/100L	–	7 days	Apply at first sign of pest activity.	5 days
Tomatoes	Mites	800 g ai/ha or 100 g ai/100L	4	Re-apply as necessary	Apply at first sign of pest activity.	4 days
Wheat, triticale	Heliothis	720 g ai/ha		7 days	Spray at early stages of pest activity.	42 days harvest; 7 days grazing

* 5 days on Farmoz Monocron and Phoskill 400 labels. ** Higher rate on Farmoz Monocron 400 and Phoskill 400 labels.

4.1.3 Use Patterns

Labels of all currently registered products display the use of monocrotophos for control of locusts. These uses should be considered separately as they are not 'typical' in overseas countries, and for comparative purposes *i.e.* MRLs, these uses will be discussed on an individual basis. It should also be noted that there are discrepancies in withholding periods for some commodities, *e.g.* maize, millet, wheat and sorghum, the withholding periods are 42 days for harvest and 7 days for grazing on the Azodrin 400 and Nuvacron 400 labels, whereas a withholding period of 5 days is shown on the Farmoz Monocron 400 and Phoskill 400 labels. As there is another use pattern for wheat apart from one for locust control, this will identify any obvious differences in withholding periods and the corresponding MRL. A similar situation is apparent for lucerne, in that there is a use pattern for locust control which can be compared to that for aphid treatment.

4.1.4 Current Uses

Data generated by the National Residues Survey from 1/7/94 to 30/6/95 in a range of cereal commodities, showed that there were no detected monocrotophos violations within that sampling period. Commodities sampled are listed below:

Table 2

Commodity	Samples tested from 1/7/94 to 30/6/95
Whole wheat	2957, 3843, 1527
Wheat flour	146, 66
Wheat bran	137, 144, 66
Barley	813, 691, 518
Sorghum	269, 70
Oats	54, 56, 85
Triticale	3

In a similar testing regime for animal commodities, including milk, eggs and meat and/or fat of sheep, cattle, pigs, horses, poultry, kangaroo, deer, emu and buffalo, monocrotophos was not detected.

In a submission forwarded by the Grains Council of Australia, it was proposed that registration be continued for the use of monocrotophos for control of spur-throated and migratory locusts in Queensland and NSW. Monocrotophos is used as part of a strategic preventative control program in Queensland, and its use is limited as it has been found to be phytotoxic to some sorghum varieties. In addition, it cannot be used close to harvest due to the existing 42 day withholding period. Registered uses of monocrotophos for control of sorghum midge in NSW, WA and Queensland do not appear to be significant and may be removed, although the use of an alternative chemical to the currently used synthetic pyrethroids would be welcomed. NRS analyses for organophosphates in cereals and cereal commodities conducted from 1994 to 1997, showed that no violations were detected for monocrotophos over that period. The total number of samples analysed were 11,509.

In the 1994 Market Basket Survey, it was reported that finite monocrotophos residues were found in white bread, wholemeal bread and capsicum at maximum levels of 0.01, 0.02 and 0.12 mg/kg, respectively. The detection in capsicum is a violation as there is no registered use of monocrotophos on capsicum, or other fruiting vegetables. The levels in bread however are comparable to the MRL of *0.02 mg/kg in cereal grains, and therefore do not constitute violations. These levels were found in two samples out of a total 1600 g of white bread and 1500 g of wholemeal bread. The survey indicated that of the numerous registered uses of monocrotophos, cereals were the only major current use of the chemical.

4.2 DISCUSSION

Data have been provided by Cyanamid and Novartis to support the review of monocrotophos. This has included copies of old JMPR reviews, plant metabolism studies and cattle feeding studies. Additional data which were previously submitted to the NRA for emergency uses of monocrotophos, are also included where relevant. Recent data reviewed by JMPR which have not been submitted by the applicants, have also been incorporated into the discussion where relevant.

4.2.1 Cereals

Australian data generated for wheat and barley are discussed in 4.7.1. Following 3 applications of monocrotophos at 1× and 2× the label rate, 720 and 1440 g ai/ha, samples were taken at 37 and 40 days after the final treatment. No detectable residues were found in barley grain, husks or straw. Detectable residues of 0.02 and 0.03 mg/kg were found in wheat husks and straw, respectively, following treatment at the 2× rate. The limit of determination was 0.02 mg/kg. The existing cereal MRL is *0.02 mg/kg with a withholding period of 42 days for harvest. There is also a Table 4 entry of *0.02 mg/kg for straw and fodder (dry) of cereal grains.

Many of the registered uses in cereals *i.e.* barley, maize, millet, sorghum and wheat are for locust control. The rates of application for locust control are lower than those for heliothis treatment, *i.e.* 280 g ai/ha as opposed to 720 g ai/ha, with the same 42 day withholding period. If locust infestation was treated inside the normal 42 day period before harvest, then finite monocrotophos residues may be detected in the grain, and this was considered by the PACC in 1975 when a MRL of 0.5 mg/kg was established for sorghum grain, maize, millet, panicum and wheat with a 5 day withholding period. The MRL was subsequently deleted in 1986. The existing MRLs for cereals and cereal straw and fodder are acceptable, however higher MRLs may be necessary for emergency use situations where a shorter withholding period may be appropriate. This would also require some label clarification, as the Farmoz Monocron 400 and the Phoskill 400 labels show both a 6 week and a 5 day withholding period, depending on whether the treatment is for locusts or heliothis, whereas the Nuvacron 400 and Azodrin 400 labels have only a 42 day withholding period regardless of the specific pest use.

From advice received from the Grains Council of Australia, the peak industry body for the Australian grains industry, the use of monocrotophos for locust control is restricted and the 42 day withholding period is adhered to. However, the withholding period of 5 days, as shown on some labels, must be deleted as the higher MRL corresponding to the shorter withholding period was deleted some time ago. Should it be considered necessary to sustain the shorter withholding period for emergency uses, registrants will be required to develop supporting data.

4.2.2 Sweet Corn

The existing MRL for sweet corn is *0.01 mg/kg, which was based on the limit of detection of the method. The withholding period on all labels is 5 days. The trial data show that upon a single application at 2× the recommended rate, monocrotophos was not detected at 3 days after treatment. A multiple treatment regime was not investigated. The current withholding period is acceptable based on a single application of monocrotophos. However, currently approved label directions call for multiple applications. Either use of the chemical in sweetcorn should be confined to a single application or data supplied which support the establishment of an MRL and withholding period under a multiple treatment regime such as is set out on current labels. The MRL should be raised to reflect the limit of determination of the analytical method as validated in Australia, *i.e.* *0.02 mg/kg.

4.2.3 Soya Beans

There is no existing MRL for soya beans as it was deleted in 1986 together with locust treatments on cereals, however all product labels carry a withholding period of 5 days after treatment for control of mites, green vegetable bugs and locusts. Data for soya beans are discussed in 4.7.3. The label rates are 280 g ai/ha for green vegetable bug and locusts and 360 g ai/ha for mite treatment. The data show that at 7 days following treatment at the rate of 400 g ai/ha, maximum residues of 0.54 mg/kg were found. At 4 – 8 days after treatment at 280 g ai/ha, monocrotophos residues ranged 0.05 – 0.33 mg/kg. Additional Australian data reviewed by JMPR, showed that following a single application at 450 g ai/ha, monocrotophos residues ranged 0.04 – 0.24 mg/kg at 1 – 5 days after treatment, and <0.02 – 0.33 mg/kg at 7 – 11 days after treatment.

If a soya bean MRL is to be re-instated with a 5 day withholding period, then a limit of 1 mg/kg would be appropriate. A decision was taken by the PACC in 1975 to set the MRL at 0.5 mg/kg. Alternatively, the withholding period could be extended to 14 days and a MRL of 0.2 mg/kg would be acceptable.. With a lower rate and removal of all uses except locust control, a MRL of 0.5

mg/kg with a 5 day withholding period would be acceptable. The CODEX MRL for monocrotophos in soya beans is *0.05 mg/kg, based on lower application rates and longer withholding periods than those registered in Australia.

Registrants should delete directions for use for soya beans from current labels, or propose a suitable MRL/withholding period combination to enable this use to be retained on labels.

4.2.4 Tomatoes

Data for tomatoes are discussed in 4.7.5. At the rate of 600 g ai/ha, residues ranged 0.14 – 0.55 mg/kg at the existing 4 day withholding period. The current MRL is 0.5 mg/kg, which was established with a 21 day withholding period[†]. The maximum label rate for tomatoes is 800 g ai/ha. Australian data reviewed by JMPR[‡] showed that residues ranged 0.25 – 0.36 mg/kg at 4 – 6 days following 11 to 12 applications of monocrotophos at 800 g ai/ha, applied at 7 day intervals.

It is recommended that the MRL be amended to 1 mg/kg with a 4 day withholding period, in accordance with the change proposed by PACC in 1976 and the current CODEX MRL for tomatoes. It is noted in this context that the CODEX MRL has been recommended for deletion.

4.2.5 Bananas

The maximum label rate for bananas is 800 g ai/ha, with a 10 day withholding period. Data described in 4.7.5. indicate that following 8 applications of monocrotophos at re-treatment intervals of 10 to 25 days, maximum residues of 0.45 mg/kg were found in the pulp of unbagged bananas at 10 days after treatment. After 4 consecutive sprays, maximum residues of 0.57 mg/kg were found at 6 days after application. Comparisons were made between residues found in bagged and unbagged bunches. The existing banana MRL of 0.5 mg/kg was based on the data provided. It should be noted that the residues were determined in the edible part of the fruit, without the peel, although the CODEX description includes the whole fruit. Therefore it is appropriate to qualify the existing MRL as ‘banana pulp’. Alternatively, it should be determined if current practice allows bunches to be bagged in the middle of a treatment regime, in which case the MRL may be lowered. Comment from growers on the use of monocrotophos on bananas and standard practices are required. There is no CODEX MRL for bananas.

4.2.6 Potatoes

Data for potatoes are discussed in 4.7.6. Following 4 foliar applications of monocrotophos at the maximum rate of 400 g ai/ha, residues were not detected in potato tubers at 3, 7 and 14 days after treatment. The current MRL for potatoes is 0.1 mg/kg with 3 day withholding period; the CODEX MRL is *0.05 mg/kg. Comment on the current use pattern for potatoes should be requested from applicants before any consideration is given to lowering the current Australian MRL to coincide with the Codex figure.. It is noted that if the only use to be retained in potatoes was for locust control, the MRL may be reduced to at or about the limit of analytical determination, *i.e.* *0.05 mg/kg with the current withholding period. The above data were presented to JMPR for the 1991 review.

4.2.7 Crops For Which Australian Data Were Not Available

Original Australian data were not made available to reviewers for the following crops: apples, pears, beans, broad beans, cotton and sunflowers. In most instances, appropriate MRLs are in place. However, apple and pear MRLs have been recommended for deletion by CODEX, and Australia should take a similar stance unless advice to the contrary is received from relevant agencies and/or industry organisations. Similarly with beans, it may be appropriate to delete the

[†] PACC decision May 1973.

[‡] JMPR reviews (1991), **113/1**, 504.

MRL unless supporting Australian data are submitted. For sunflowers, there is no MRL at present and therefore the use should be removed from all labels or data provided to support the establishment of a MRL. As far as cotton is concerned, registrants should be requested to provide data to support registered uses for heliothis, aphids, mites and locust control.

Data generated in Australia for apples and pears were reviewed by JMPR in 1975 (these data were not made available to ECRP reviewers). At the time of that review, monocrotophos was used on apples and pears in Australia and Italy only. Trials were conducted at rates ranging 20 to 40 g ai/100L with application by hand spraying; harvest ranged from 1 to 12 weeks after the final application. The data for hand spraying are shown below:

Table 3

Sample	Application		Residues (mg/kg) at weeks after treatment											
	Rate (g ai/100L)	No.	1	2	3	4	5	6	7	8	9	10	11	12
Apples	40	7		1.9	1.0	0.7								
		2												0.19
		3									0.94			
		4						1.2						
		5		2.1										
		1		1.9	0.7	0.96	0.68	0.94	0.99	0.67	0.46			
		1				0.92	0.86	0.70	0.46	0.44	0.55			
	20	4									0.18			
		6					0.51							
		9		1.8										
	38	2												0.26
		3							0.48					
		4				0.48								
		5				1.5								

Table 3 contd.

Sample	Application Rate (g ai/100L)	No.	Residues (mg/kg) at weeks after treatment 1	2	3	4	5	6	7	8	9	10	11	12
Pears	40	7	0.2	0.2	0.2	0.1								
		4		0.54										
	30	4			0.76									
	40	3				0.61								

Residues in apples from mechanical spraying are shown below:

Table 4

Application Rate (g ai/100L)	No.	Interval (weeks)	PHI (weeks)	Residues (mg/kg) Whole fruit	Peeled fruit
38	3 – 4	3 – 4	3	0.14	0.13
			5	0.12	0.08
			3	0.43	0.36
			3.5	0.66	0.54
38	4	4 + 4 + 9	4	0.13	0.12

In general, application of monocrotophos by mechanical spraying resulted in lower residues at the 4 week withholding period, when compared to application by hand spraying. Residues in whole fruit and peeled fruit are comparable, indicating that monocrotophos penetrates the skin/peel of treated fruit. The existing MRL of 0.5 mg/kg is lower than the CODEX MRL of 1 mg/kg. CODEX has recommended deletion of apple and pear MRLs.

Australian data for cotton were reviewed by JMPR in 1991 (these data were not made available to ECRP reviewers). In one trial, cotton seed was sampled at 55 days following 21 applications of monocrotophos at 950 g ai/ha, applied at 3 – 7 day intervals. Residues in cotton seed were below the limit of detection of 0.01 mg/kg. In another trial, 14 applications were made at rates of 640 g ai/ha for the first 7 applications and 1600 g ai/ha for the remaining 7 applications, at 7 to 14 days intervals. Residues in cotton seed were 0.16 mg/kg on day 0, 0.06 mg/kg at 10 days after treatment and 0.02 mg/kg at 17 days after treatment. The existing cotton seed MRL is 0.1 mg/kg with a 21 day withholding period; on some product labels the withholding period is 30 days for heliothis control.

Although use of monocrotophos on lucerne and pastures for locust control should be considered with other locust uses, no Australian data were provided in support of the continued use, and there are no existing Table 4 entries. The withholding period for grazing and cutting for stock food is 7 days after application. In the absence of appropriate data, the use for all pasture applications should either be removed, or data be generated.

4.2.8 Animal Feed Commodities and Animal MRLs

The only Table 4 entry for monocrotophos is straw and fodder of cereal grains set at *0.02 mg/kg. At such levels, animal MRLs would be established at or about the limit of analytical determination in animal tissues, milk and eggs. This is the current situation in Australia and is reflected by identical CODEX animal MRLs.

Other commodities for which MRLs are in place and would also have animal feed implications are apple/pear pomaces, green bean vines and cotton trash. Until decisions on the use of monocrotophos on these crops are made, changes to the existing animal MRLs are not recommended.

4.2.9 International MRLs

Overseas MRLs are tabulated below:

Table 5

Country	Commodity	MRL (mg/kg)
Austria	Hops	5.0
	Other	0.05
Belgium	Citrus fruits	0.2
	Coffee beans	0.1
	Soya bean oil	0.05
	Others	*0.02
Brazil	Coffee beans	0.1
	Corn	0.05
	Cotton seed	0.1
	Cotton seed oil	0.05
	Field beans	0.2
	Kale	0.1
	Peanuts	0.05
	Potato	0.05
	Soyabeans	0.05
	Sugarcane	0.1
	Watermelon	0.05
	Wheat	0.05
Canada	Apples	1.0
	Pears	0.5
	Tomatoes	0.5
Chile	Apples	1.0
	Citrus fruits	0.2
	Dry beans	0.2
	Milk and dairy products	*0.02
	Potatoes	*0.05
	Poultry, eggs	*0.02
	Sugar beet	*0.05
Denmark	Berries and small fruits	0.2
	Carrots	0.05
	Citrus fruits	0.2
	Leafy vegetables	0.2
	Pome and stone fruits	0.2
	Onions and other root vegetables	0.1
	Other fruits	0.2
France	Citrus fruits	0.2
	Grapes	0.2
	Pome fruits	0.2
Finland	Apples, pears	0.2
	Grapes	0.2
	Tomatoes	0.2
Hungary	Corn	0.05
	Sugarbeet	0.1

Table 5 contd.

Country	Commodity	MRL (mg/kg)
Israel	Almond	0.1
	Apples, pears	1.0
	Cotton seed	0.1
	Melons	0.5
	Olives	0.5
	Watermelon	0.1
Italy	Citrus fruits	0.05
	Pome fruits	0.05
	Grapes	0.05
	Cabbage	0.05
	Eggplant	0.05
	Olives	0.05
	Tomato	0.05
	Potato	0.05
	Sugarbeet	0.05
	Corn	0.05
Japan	Rice	0.05
	Vegetables	0.05
Malaysia	Apples, pears	1.0
	Citrus fruits	0.2
	Brussels sprouts, cauliflower, cabbage	0.2
	Maize	0.05
	Onions	0.1
	Coffee beans	0.1
	Tomatoes	1.0
	Soya beans	0.05
	Oil seed	0.05
	Root vegetables	0.05
Netherlands	Citrus fruits	0.2
	Beans	0.2
	Cabbages, head cabbages	0.2
	Corn	*0.05
	Cotton seed	0.1
	Coffee beans	0.1
	Eggs	*0.02
	Meat	*0.02
	Poultry meat	*0.02
	Milk	*0.002
	Onions	0.1
	Root and tuber vegetables	*0.05
	Oil seeds	*0.05
	Potato	*0.05
Norway	Beans	0.2
	Citrus fruits	0.2
	Brussels sprouts, Head brassicas, Cauliflower	0.2
	Carrot	*0.05
	Onions	0.1
	Peas	0.1
	Potato	*0.05
	Turnip	*0.05

Table 5 contd.

Country	Commodity	MRL (mg/kg)
South Africa	Barley	0.1
	Citrus fruits	0.1
	Carrots	0.05
	Cotton seed	0.05
	Potato	0.05
	Tomato	0.2
	Wheat	0.1
Spain	Berries and other small fruits	0.02
	Brassicas and leafy vegetables	0.02
	Bulb vegetables	0.02
	Citrus fruits	0.02
	Corn	0.05
	Cotton seed	0.1
	Grains	0.02
	Hay and forage crops	0.02
	Legumes	0.02
	Oilseeds	0.02
	Potato	0.02
	Root and tuber vegetables	0.02
	Stone fruits	0.02
	Sugar beet	0.02
	Sugar cane	0.02
	Sorghum	0.05
Switzerland	Citrus fruits	0.2
Taiwan	Citrus fruits (pulp)	0.05
	Citrus fruits (peel)	1.0
	Rice	0.02
	Root vegetables	0.05
U.S.A.	Cotton seed	0.1
	Peanuts	0.05
	Peanut hulls	0.5
	Potatoes	0.1
	Sugar cane	0.1
	Tomatoes	0.5
	Concentrated tomato products	2.0

CODEX MRLs as revised in 1994 are shown in the table below:

Table 6

Commodity	MRL (mg/kg)	Notes
Apple	1	Deletion recommended
Brussels sprouts	0.2	Deletion recommended
Cabbages, head	0.2	Deletion recommended
Carrot	*0.05	Deletion recommended
Cauliflower	0.2	Deletion recommended
Citrus fruits	0.2	
Coffee beans	0.1	Deletion recommended
Common bean (pods and/or immature seed)	0.2	
Cotton seed	0.1	
Cotton seed oil, crude	*0.05	

Table 6 contd.

Commodity	MRL (mg/kg)	Notes
Edible offal of cattle, pigs, and sheep	*0.02	
Eggplant	0.2	
Eggs	*0.02	
Goat meat	*0.02	
Goat, edible offal of	*0.02	
Hops, dry	1.0	Deletion recommended
Maize	*0.05	
Meat of cattle, pigs and sheep	*0.02	
Milk products	*0.02	
Milks	*0.002	
Onion, bulb	0.1	
Peanut	*0.05	
Pear	1	Deletion recommended
Peas (pods and succulent = immature seeds)	0.1	
Peppers, chilli	0.2	
Potato	*0.05	
Poultry meat	*0.02	
Poultry, edible offal of	*0.02	
Soya bean (immature seeds)	*0.05	
Sugar beet	*0.05	
Sugar cane	*0.02	
Tomato	1	Deletion recommended
Turnip, garden	*0.05	Deletion recommended
Watermelon	0.1	
Wheat	*0.02	

Deletion of CODEX MRLs has been recommended in cases where monocrotophos is no longer used for the commodity (28th session CCPR).

4.2.10 Maximum Daily Intake Calculations

A TMDI calculation incorporating all existing uses is equivalent to approximately 468% of the ADI. Removing crops for which Australian data were not provided, decreased the TMDI to 290% of the ADI. An EMDI incorporating processing factors for potatoes and tomatoes has brought the intake down to 127% of the ADI. Additional processing factors for cereals are to be incorporated (see Appendix 3).

4.2.11 Overview

It is clear from the assessment of residue data submitted during the review that there are a number of current use patterns which are not supported by adequate data.. These would include apples, pears, beans, broad beans, cotton, sunflowers, lucerne, pastures and tomatoes. Unless appropriate residue data are submitted which support these use patterns, retention of these uses is not sustainable. In this context it is recognized that uses must also be separated into emergency uses *i.e.* locust plagues and ‘typical agricultural uses’.

Another approach to deletion of certain crop MRLs may relate to the toxicological profile of the compound, and the TMDI/EMDI calculations show that the existing uses are equivalent to 1.1 – 5× the ADI. However, Estimated Daily Intake (EDI) figures published in the 1994 Market Basket Survey showed that the daily intake of monocrotophos ranged from <1% to 2.4% of the ADI for an average diet over six age-sex categories[✦], and from 1.5% to 2.8% of the ADI for a high energy intake diet over the six categories. Hence, the actual use of monocrotophos is low as represented by the EDI survey figures for a number of food commodities.

Monocrotophos was listed as a banned chemical by the USEPA in 1992 and many uses have been deleted. Tolerances are listed for peanuts, cotton seed, potatoes, sugarcane and tomatoes.

Preliminary comments received from Public Submissions suggest that monocrotophos should be retained as an alternative chemical to be used in resistance management programs. It is used by growers of tomatoes, apples, beans and sweet corn in Queensland, however in Tasmania alternative chemicals are used. The importance of registered uses to fruit and vegetable growers was not emphasised in either submission, and it did not seem imperative that the uses remain. Similarly for uses on cotton, as monocrotophos is not included in an integrated pest management program, it is only useful as an alternative when other options were limited.

On the basis of these submissions there do not appear to be any strong imperatives to retain uses which are in doubt because of a lack of data, except perhaps for emergency uses for control of plague locust on cereal crops.

4.3 RECOMMENDATIONS

The following recommendations are preliminary, in that advice from other agencies may lead to further changes.

1. There are no objections, from a residues point of view, to the continued registration of monocrotophos, subject to the following conditions.

2. The following amendments to the *MRL Standard* are recommended:

Table 1

Compound	**Food**		**MRL (mg/kg)**
Monocrotophos			
Delete:			
	FP 0226	Apple	0.5
	FI 0327	Banana	0.5

Table contd.

	VP 0061	Beans, except broad bean and soya bean	0.2
	VP 0522	Broad bean (green pods and immature seeds)	0.2
	SO 0691	Cotton seed	0.1
	FP 0230	Pear	0.5
	VO 0447	Sweet corn	*0.01
	VO 0448	Tomato	0.5
	VR 0589	Potato	0.1

[✦] Infant 9 months old (9.1 kg), toddler 2 years old (12.3 kg); girl 12 years old (41.5 kg); boy 12 years old (39.8 kg); adult female 25-34 years old (59.1 kg); adult male 25-35 years old (75.0 kg).

Add:

FI 0327	Banana (pulp)	0.5	
VO 0447	Sweet corn		*0.02
VO 0448	Tomato	1.0	
VR 0589	Potato		*0.02

3. The following withholding periods in relation to the above MRLs are recommended:

Bananas	10 days
Sweet corn	5 days
Tomatoes	4 days
Potatoes	3 days

4. The use pattern for sweetcorn defined on labels should be altered to specify a single application only, unless data are submitted which support compliance with the MRL after multiple applications.

5. Data are required to support current uses for lucerne, pastures and sunflowers, in addition to those commodities recommended for deletion in Table 1 of the *MRL Standard*. In the the event that such data are not forthcoming, these uses must be removed from all registered labels.

6. Directions for use for soya beans should be deleted from approved labels unless an MRL/withholding period proposal is received from registrants.

7. The 5 day withholding period for cereals which appears on the labels of some registered products in addition to the 42 day withholding period should be removed. Alternatively, application could be made for an increase in the MRL to accommodate the shorter withholding period..

4.4 METABOLISM TRIALS

Studies reviewed are referred to by subject and date, or by reference number as found in files R-00152 and R-00207. Full details of the references are given as endnotes in this evaluation report.

4.4.1 Plant Metabolism Studies

Cotton[i] (1967)

This published study describes the metabolism of monocrotophos on cotton plants. ^{32}P labelled monocrotophos was applied as a seed treatment, a topical foliar treatment, a stem treatment and by petiole injection. Radiolabelled compounds were identified by paper chromatography following extraction with acetone and water. The results showed that the same metabolites were found regardless of the application method. The data are summarised in the following table:

Table 7

Compound	% Of Total Administered Radioactivity At Days After Treatment			
	Seed Treatment (2 – 21 days)	Foliar/topical* (2 – 7 days)	Stem Treatment* (3 – 21 days)	Petiole Injection (3 – 21 days)
Monocrotophos**	20 – 80%	2 – 38%	30 – 85%	13 – 73%
Phosphoric acid	2 – 30%	1 – 10%	1 – 27%	1 – 5%
Dimethyl phosphate	1 – 7%	3 – 26%	2 – 11%	1 – 6%

O-demethyl monocrotophos	1 – 6%	2 – 19%	1 – 6%	2 – 5%
N-hydroxymethyl monocrotophos	4%	**	**	1%
Unknown A		1 – 10%		
Unknown B	1 – 13%	2 – 10%	0 – 4%	0 – 2%
Unextractable	3 – 48%	2 – 11%	4 – 42%	20 – 60%
% label recovered	9 – 26%	64 – 93%	Not stated	40 – 85%

* For the foliar and stem treatments, mature, young and expanding leaves were sampled. **The monocrotophos value also includes the *N*-hydroxymethyl metabolite for the foliar and stem treatments.

Overall, the data show that monocrotophos is the predominant component of the radioactivity applied to cotton plants. Significant proportions of dimethyl phosphate, phosphoric acid and *O*-demethyl monocrotophos were formed over time, indicating cleavage of the vinyl phosphate bond and demethylation at the phosphate end of the molecule. *N*-hydroxymethyl monocrotophos was only present in small quantities, indicating that the amide part of the molecule is stable to hydrolysis. Recoveries in the seed treatment study were low, suggesting that the radiolabel was bound into unextractable plant constituents. Unknown B was considered to be a conjugate of *N*-hydroxymethyl monocrotophos.

In summary, the major metabolites of monocrotophos found in cotton plants were dimethyl phosphate, phosphoric acid and *O*-demethyl monocrotophos, in addition to parent monocrotophos. Compounds which did not contain phosphorus would not have been detected using the ^{32}P label.

Maize, Cabbage and Apple (1972), Ref. 3[ii]

^{14}C-monocrotophos, labelled in either the *O*-methyl or *N*-methyl positions, was applied to the leaves of cabbage, the leaves and husks of maize and to the leaves and fruit of apple trees. Treated samples were taken at various intervals after application, and radioactive compounds were extracted, measured by scintillation counting and separated by thin-layer and paper chromatography. A similar distribution pattern of monocrotophos and its metabolites was found for all three crops. The data are summarised in Table 8.

Table 8

Compound*	% Distribution Of Applied Radioactivity At DAT		
	Apples	Maize	Cabbage
Monocrotophos	7D leaf 43 – 68 17D leaf 22 – 26 27D leaf 15 – 22 40D fruit 24 – 30 62D leaf 4 – 9 90D leaf 2 – 7	7D leaf 50 – 56 22D leaf 20 – 27 39D husk 40	10D 31 – 38 24D 12 – 14
O-demethyl monocrotophos and dimethyl phosphate	7D leaf 1 27D leaf 7 40D fruit 9 90D leaf 11	7D leaf 5 – 12 22D leaf 7 – 17 30D husk 3	10D 4 – 7 24D 3 – 6
N-hydroxymethyl monocrotophos	7D leaf <1 27D leaf 1 40D fruit 2 90D leaf <1	7D leaf <1 22D leaf <1 39D husk 2	10D 1 – 2 24D 1 – 2
N-demethyl monocrotophos	7D leaf 4 27D leaf 1 40D fruit <2 62D leaf <1	7D leaf 2 22D leaf <1	10D 2 24D 2

N-methyl acetoacetamide	7D leaf 1 27D leaf <1 40D fruit 2 90D leaf <1	Not detected	Not detected
Conjugates**	7D leaf 3 – 4 17D leaf, 2 – 8 40D fruit <1 62D leaf 1	7D leaf 1 –3 39D husk <1	10D 1 – 2 24D 1 – 2

* Values are averaged over both labels. **Conjugates were not individually characterised but identified by a chromatographic retention time.

In all three cases, a large proportion of the applied radioactivity was recovered as parent monocrotophos. The two metabolites of monocrotophos which were detected at significant levels were *O*-demethyl monocrotophos and dimethyl phosphate, the levels of which increased as a function of time. The distribution pattern of the radioactivity is similar to that observed for cotton, with the exception that phosphoric acid could not be detected due to the ^{14}C label. It should be noted that in the case of apples, the residue was predominantly located in the fruit and not the peel, whereas with maize the residue was in the husk and not the grain. These differences may have been due to a variation in application of the radioactivity to the plant.

In summary, the major residues formed after treatment of apples, maize and cabbage with monocrotophos are parent monocrotophos, *O*-demethyl monocrotophos and dimethyl phosphate, indicating cleavage of the phosphate-vinyl bond and demethylation at the phosphate end of the molecule.

4.4.2 Animal Metabolism Studies

Rats (1966)[iii]

Rats were treated by intraperitoneal injection with ^{32}P-monocrotophos at a dose rate of 5 mg/kg bodyweight. Urine was collected at 2 hour intervals and analysed for radioactivity. Approximately 45% of the administered dose was excreted within 6 hours after administration; after 24 hours greater than 65% had been excreted, 59% in urine and 6% in faeces. The radioactivity recovered in the excreta within 6 hours comprised 34% parent monocrotophos, 34% dimethyl phosphate, 10% *O*-demethyl monocrotophos, 20% hydroxymethyl monocrotophos and 2% phosphoric acid. Over the 48 hour period of the study, the major metabolite formed was dimethyl phosphate, present at levels four times greater than *O*-demethyl monocrotophos. Only trace amounts of *N*-demethyl monocrotophos were found during the 48 hour period of the study.

Lactating Goats (1965)[iv]

Reference to this study was made in the first JMPR review of monocrotophos[v]. Lactating goats received a single oral dose of 1 mg/kg bodyweight of ^{32}P monocrotophos. Within 72 hours after treatment, 1.4% of the administered radioactivity was detected in goats milk. Characterisation of the extractable radioactivity in milk at various intervals showed that the predominant component was parent monocrotophos ranging from 14 to 67% of the total extractable residue up to 24 hours after treatment. *N*-hydroxymethyl monocrotophos comprised 4 – 26% of the residue and *N*-demethyl monocrotophos approximated 2% of the total radioactive residue.

Lactating Goats (1987)[vi]

Two lactating goats were dosed with ^{14}C monocrotophos for three days, at the equivalent of 10 mg/kg in the feed. The animals were sacrificed within 24 hours of the final dose. By three days, an average of 66% and 13% of the administered dose was recovered in urine and faeces, respectively. Total radioactive residues in milk reached a maximum level of 0.2 mg/kg monocrotophos equivalents. At the end of the study period, total elimination in the milk accounted for 1.8% of the administered dose, of which 0.5% was present in butterfat. Total radioactive residues in liver, kidneys, muscle and fat were 0.13, 0.16, 0.07 and 0.03 mg/kg monocrotophos equivalents, respectively.

4.4.3 Metabolism of Vinyl Phosphate Insecticides (1973), *Ref. 2*[vii]

This review covers general metabolic and degradative processes of several vinyl phosphate compounds, including monocrotophos. Data described in plant studies 4.1.1. and 4.1.2. and the rat study 4.2.1 are summarised in this review, and shown in figure 1 (insects are included in the diagram). The metabolism of monocrotophos initially proceeds in three ways:

- cleavage of the phosphate-vinyl bond to give dimethyl phosphate
- demethylation at the phosphate end of the molecule to give *O*-demethyl monocrotophos
- hydroxylation at the *N*-methyl end of the molecule leading to *N*-hydroxymethyl monocrotophos

Demethylation of dimethyl phosphate and cleavage of the vinyl phosphate bond of *O*-demethyl monocrotophos lead to the formation of methyl phosphate, which is the precursor of phosphoric acid. All of the above reactions are common to plants, insects and rats.

Other data, included the degradation of monocrotophos in soils, with $t_{½}$ ranging from 6 to 8 days. The reactions in soils were thought to lead to the formation of dimethyl phosphate, *O*-demethyl monocrotophos and *N*-methyl acetoacetamide. Therefore it was concluded that crops grown in soil treated with monocrotophos were unlikely to be exposed to new residues which would not be present in treated crops.

4.4.4 Summary Of Metabolism Data

The metabolism of monocrotophos in plants and animals is summarised in the 1972 JMPR review[‡], and depicted in figure 1.

The major metabolites of monocrotophos following foliar application on plants were parent monocrotophos, *O*-demethyl monocrotophos, dimethyl phosphate and eventually phosphoric acid. The distribution of the products indicated that degradation of the compound proceeds by cleavage of the vinyl-phosphate bond and demethylation at the phosphate end of the molecule.

A similar degradation pattern of monocrotophos was observed in rats, where the major metabolites identified following injection with ^{32}P labelled monocrotophos were parent compound, dimethyl phosphate, *O*-demethyl monocrotophos and also *N*-hydroxymethyl monocrotophos. In lactating goats, the major metabolites were parent monocrotophos and *N*-hydroxymethyl monocrotophos. The additional step in the degradative process in animals includes demethylation at the amide end of the molecule. As parent monocrotophos is a major component of the residue in both plants and animals, the existing residue definition of parent only is appropriate.

4.5 ANALYTICAL METHODOLOGY

4.5.1 Determination Of Monocrotophos In Crops

Soya Beans Ref. 12[viii]

Soya beans are soxhlet extracted with CH_2Cl_2 for 4 hours. Hexane is added and the mixture is evaporated to remove CH_2Cl_2. The hexane solution is washed with water and the aqueous extracts are partitioned into CH_2Cl_2. The combined washes are dried over Na_2SO_4 and evaporated to a small volume. Hexane is added and the mixture evaporated to remove any CH_2Cl_2. The residues in hexane are passed through a florisil column and eluted with acetone. The acetone is evaporated to dryness and the remaining residue is dissolved in ethyl acetate for quantitation by GLC using a P

[‡] Reference 5.

specific thermionic detector. The limit of detection was 0.02 mg/kg. Recoveries in soya beans are shown below:

Table 9

Sample	% Recovery at 0.08 mg/kg	% Recovery at 0.8 mg/kg
Mature seeds	92	72
Immature seed	100	90
Pod (immature)	86	80

The method was used in trials described in Ref.s 8 and 10.

Tomatoes Ref. 13[ix]
The method as described is very similar to that above for soya beans. Tomatoes are macerated with CH_2Cl_2, and after addition of hexane to the extract, the CH_2Cl_2 is evaporated. The monocrotophos is partitioned into water and the water extracts are washed with CH_2Cl_2. The combined CH_2Cl_2 washes are dried and evaporated to dryness. The residue is taken up in ethyl acetate and quantitated using GLC with a P specific thermionic detector. The limit of detection was 0.01 mg/kg; recoveries averaged 85% with fortification in the range 0.1 to 2 mg/kg.

4.5.1.3. Sweet Corn[x]

The method is very similar to that described for tomatoes. There were no reported deviations to the prescribed method. The limit of detection of monocrotophos = 0.01 mg/kg; recoveries were:

Table 10

Sample	% Recovery at 0.08 mg/kg	% Recovery at 0.8 mg/kg
Mature seed	70	72
Immature seed	90	90

Vegetable Oils Ref. 9[xi]
Oil is dissolved in hexane and washed with water. The aqueous phase is saturated with salt and extracted with ethyl acetate. The ethyl acetate is evaporated and the residue is passed down a silica gel column. The column is eluted with ethyl acetate to remove any impurities, and the monocrotophos residue is eluted with acetone. The elute is evaporated to dryness and the residue is quantitated using GC with a P specific thermionic detector. Recoveries averaged 72% with fortification at 1 mg/kg; limit of detection = 0.02 mg/kg.

4.5.2 Determination Of Monocrotophos In Milk And Animal Tissues

MMS 65/66 and MMS 69/66 were cited as methods for determining *N*-hydroxymethyl monocrotophos and *N*-demethyl monocrotophos in milk and tissues, respectively, however the actual methods were not provided (Ref. 1)[xxi]. Recoveries were measured by adding quantities of *N*-hydroxymethyl monocrotophos and/or the glucose conjugate of *N*-hydroxymethyl monocrotophos to milk and tissue samples before work-up.

The following procedures were used to characterise radiochemical residues of monocrotophos and associated metabolites after oral administration of ^{32}P-monocrotophos to dairy cows[xii].

<u>Milk</u>: Acetone is mixed with milk and the resulting solid mass is filtered. The solids are then extracted with CH_3Cl and filtered again. The CH_3Cl extraction is repeated and the extracts are combined. The aqueous acetone filtrate from the first step is evaporated and extracted with CH_3Cl repeatedly. All of the CH_3Cl extracts are combined, dried over Na_2SO_4 and evaporated to dryness. The remaining residues are taken up in hexane and partitioned with CH_3CN. The CH_3CN extracts

are evaporated to dryness and the residues are re-dissolved in hexane for column chromatography. The eluate is collected in fractions, evaporated and each fraction is counted. The fractions as collected correspond to either monocrotophos, *N*-demethyl monocrotophos or *N*-hydroxymethyl monocrotophos.

Meat: Meat and offal tissues are cut up and blended with acetone. The solids are filtered, and the acetone extraction is repeated. After filtration of the acetone, the solids are extracted twice with CH_3Cl, and filtered. The acetone extracts are concentrated, filtered and washed with CH_3Cl. All of the CH_3Cl extracts are combined, dried and evaporated to dryness, taken up in hexane and chromatographed as above.

4.6. RESIDUE DEFINITION

The residue definition for monocrotophos is parent compound:

Monocrotophos monocrotophos

4.7 RESIDUE TRIALS

4.7.1 Wheat and Barley *Ref. 6*[xiii]

The recommended use pattern of monocrotophos on wheat and barley, as stated on the labels of the products concerned, is application at a rate of 720 g ai/ha with a minimum re-treatment interval of 7 days and a 42 day withholding period for harvest. In this trial, three applications of monocrotophos were made at the rates of 720 or 1440 g ai/ha, 1× or 2×. The re-treatment interval was 7 days. Samples of grain, husks and straw were taken at 37 and 40 days after the final application. Residues at levels of 0.02 and 0.03 mg/kg were found in wheat husks and straw, respectively, at 37 days after the 2× treatment; residues in all other wheat samples[✣] were below the limit of analytical determination, 0.02 mg/kg. Residues in barley grain, husks and straw were non-detectable.

Recoveries are shown below:

Table 11

Cereal	Sample	% Recovery at Fortification Levels (mg/kg)	
		0.1	1.0
Wheat	Grain	89	85
	Husks	92	89
	Straw	98	96
Barley	Grain	92	85
	Husks	95	89
	Straw	98	93

4.7.2 Sweet Corn *Ref 7*[xiv]

Sweet corn was treated with a single application of monocrotophos at 840 g ai/ha, 2.1×. The corn was sprayed before the cob was formed. Samples were taken at 3, 11, 15 and 24 days before harvest. Residues above the limit of detection of 0.01 mg/kg were not found in any of the samples; the data support the existing withholding period of 5 days for harvest. Recoveries ranged 70 – 90% with fortification at 0.08 and 0.8 mg/kg in both immature and mature corn.

4.7.3 Soya beans

Soya bean Seeds Ref. 8[xv]

✣ Of a total of 18 samples, non-detectable residues were found in 16.

Soya crops were treated with a single application of monocrotophos at a rate equivalent to 280 g ai/ha[*]. The crops were sprayed at one of three stages from when the beans were setting in the pods to when the beans were approaching maturity. Samples were taken for analysis from 1 to 25 days after treatment. The results are shown in Table 12.

Maximum monocrotophos residues were observed at 4 to 11 days after treatment, and ranged <0.02 – 0.33 mg/kg. The existing withholding period for soya beans on all product labels is 5 days after application for harvest[†]. At present there is no MRL for soya beans, however this would be based on the maximum rate of 360 g ai/ha which is used for mite control. An acceptable MRL would be 0.5 mg/kg corresponding to the existing withholding period.

Table 12

DAT	Monocrotophos residues (mg/kg) at varying sites; replicate analyses		
	Site 1	Site 2	Site 3
1		0.08, 0.05, 0.03, 0.08	
4			0.24, 0.05, 0.04, 0.05
6	0.20, 0.26, 0.07, 0.30		
8		0.14, 0.10, 0.33, 0.13	
10	0.07, 0.12, 0.05, 0.10		
11			<0.02, 0.03, <0.02, 0.02
15		0.03, 0.07, 0.05, 0.06	0.02, <0.02, <0.02
20	0.03, 0.02, 0.04, 0.08		
21		0.02, <0.02, <0.02, 0.02	
25			<0.02, <0.02, <0.02

Data have been corrected for recovery. Limit of detection = 0.02 mg/kg. Recoveries averaged 90% with fortification in the range 0.08 to 0.8 mg/kg.

Soyabeans Ref. 10[xvi]
Soya crops in Queensland were treated with a single application of monocrotophos at the rate of 400 g ai/ha. Samples were taken for analysis at 1, 7 and 14 days after treatment. The data are shown below:

Table 13

DAT	Monocrotophos residues (mg/kg)
1	0.11, 0.23, 0.05, 0.09
7	0.24, 0.54, 0.42, 0.28
14	0.05, 0.11, 0.09, 0.10

Limit of determination = 0.02 mg/kg. Recoveries averaged 90% at fortification levels of 0.1 and 1 mg/kg.

Monocrotophos levels reached a maximum of 0.54 mg/kg at 7 days then declined to 0.11 mg/kg at 14 days after treatment. As discussed above there is no MRL for soya beans, however an acceptable proposal would be a MRL of 0.5 mg/kg with a withholding period of 7 days. If the use in soya beans is to continue, then the withholding period may require some revision.

4.7.4 Tomatoes *Ref. 11*[xvii]

The maximum registered monocrotophos treatment on tomatoes is 800 g ai/ha with a label withholding period of 4 days. In this trial, tomato plants were treated with 4 applications of

[*] 280 g ai/ha is recommended for control of vegetable bug and locusts; the maximum recommended rate is 360 g ai/ha for mite treatment.
[†] 7 days for harvest on Farmoz Monocron 400 Systemic Insecticide label.

monocrotophos at the rate of 600 g ai/ha, at 7 to 10 day intervals. Tomatoes were sampled at 1, 4, 7 and 14 days after the final application. The following data were obtained:

Table 14

DAT	Monocrotophos residues (mg/kg)	Mean residue (mg/kg)
-1	0.19, 0.33, 0.07	0.20
1	0.36, 0.91, 1.1	0.79
4	0.14, 0.55, 0.26	0.32
7	0.36, 0.11, 0.36	0.28
14	0.14, 0.48, 0.13	0.25

Limit of detection = 0.01 mg/kg; recoveries averaged 85% with fortification at 0.1 to 1 mg/kg.

A pattern of decline of residues is demonstrated by the data. The current MRL for tomatoes is 0.5 mg/kg which was established with a withholding period of 21 days[❋]. At the existing withholding period of 4 days, a MRL of 1 mg/kg would be appropriate. However, at 7 days, the existing MRL is acceptable.

4.7.5 Bananas[xviii]

Bananas were treated with up to 8 applications of monocrotophos at the rate of 400 or 800 g ai/ha, at re-treatment intervals ranging 10 to 25 days. Bunches were bagged in some instances at 6 days after the fourth application; in other cases the bunches remained unbagged. The following results were found:

Table 15

Application Rate (g ai/ha)	Application No.	DAT	Monocrotophos residues in pulp (mg/kg)
400	4	6	0.39
	4 + 1*	2	0.04
	4 + 4*	12	0.04
800	4	6	0.57
	4 + 1*	2	0.33
	4 + 4*	12	0.09
400	8	2	0.31
		10	0.25
		16	0.31
800	8	2	0.56
		10	0.45
		16	0.43

* Number of applications made to bagged bunches. Limit of detection = 0.01 mg/kg.

The data show that a pattern of decline of monocrotophos residues is observed, however the decline is not as marked in the bunches which received 8 direct treatments. The registered use pattern for bananas is application at 800 g ai/ha with re-treatment at 7 to 14 day intervals and a withholding period of 10 days. The data from the unbagged treatments show that at 10 days after 8 applications, residues in banana pulp are 0.45 mg/kg and at 16 days are 0.43 mg/kg. This would allow the establishment of a MRL of 0.5 – 1 mg/kg. If standard growing practice allows several treatments to occur once the bunches have been bagged, then a MRL of 0.2 – 0.5 mg/kg would be appropriate. The existing banana MRL is 0.5 mg/kg which was based on the above data. If standard practice does not dictate that bunches are bagged in the middle of the treatment

[❋] PACC 1973.

regime then the MRL should be raised to 1 mg/kg, with the existing withholding period of 10 days. In addition, it should be noted that the residues were determined in the pulp of the banana only, whereas the MRL represents the whole fruit, unless the description is qualified, *i.e*. banana pulp❋.

4.7.6 Potatoes[xix]

Potato crops were treated with 4 foliar applications of monocrotophos at a rate equivalent to 420 g ai/ha. The re-treatment intervals ranged from 9 to 11 days. Tubers were sampled at 3, 7 and 14 days after the final application. The data are shown below:

Table 16

DAT	Residues in potatoes (mg/kg)
3	<0.01
7	<0.01
14	<0.01

Limit of detection = 0.01 mg/kg. Recoveries = 100%.

The existing MRL for potatoes is 0.1 mg/kg with a 3 day withholding period.

4.7.6 Animal Transfer Studies

Dairy Cows[xx]

As suitable analytical methodology was not available to determine the levels of monocrotophos and metabolites in milk, ^{32}P-labelled monocrotophos was used, and residues in milk and excreta were identified by radiotracer methods.

Two Guernsey cows† were fed alfalfa hay sprayed with ^{32}P-monocrotophos, at levels equivalent to 45 mg/kg in the diet for 14 days. During the study, milk was collected twice daily and samples of urine and faeces were collected at regular intervals. At the end of 14 days the animals were sacrificed and tissue samples were taken for analysis.

Following partitioning and chromatography, total radioactivity in each fraction was determined by scintillation counting before further characterisation. Recoveries in milk, meat and urine were determined by fortifying the samples with either ^{32}P or ^{14}C labelled monocrotophos and/or metabolites. Maximum radioactive residues in urine and faeces were found at days 2 to 4 of the study; thereafter the levels showed a steady decline. The major components of the radioactivity in urine were *O*-demethyl monocrotophos and dimethyl phosphate.

In milk, maximum residue levels were observed at 8 to 10 days of the study. In milk samples taken on days 9 – 10, total maximum ^{32}P radioactive residues of 4.7 and 5.6 mg/kg monocrotophos equivalents were detected. Maximum levels of monocrotophos, *N*-demethyl monocrotophos and *N*-hydroxymethyl monocrotophos residues were observed in days 4 to 6 milk samples:

Table 17

Day of Study	Total residues in milk (mg/kg) after treatment at 45 mg/kg in the feed		
	Monocrotophos	*N*-demethyl monocrotophos	*N*-hydroxymethyl monocrotophos
0–1	0.0086, 0.012	<0.0005, 0.003	<0.0005, 0.0013
2–3	0.008, 0.01	0.0017, 0.0019	0.0007, 0.0016
3–4	0.010, 0.011	0.0029, 0.0037	0.0012, 0.0016
5–6	0.013, 0.017	0.0005, 0.002	0.0008, 0.002

❋ CODEX Classification of Foods and Animal Feeds, 1989.

† Weight of animals approximately 455 kg; total dry feed intake per day was 12 kg.

7–8	0.0037, 0.0063	0.0012, 0.0029	0.0007, 0.0011
9–10	0.0061, 0.0085	0.0017, 0.0027	0.0009, 0.001
11–12	0.01, 0.019	0.0013, 0.0015	0.0006, 0.01
13–14	0.0096, 0.022	0.019, 0.003	0.0006, 0.0017

Individual figures refer to individual animals

Residues of 0.013 and 0.017 mg/kg monocrotophos in milk were equivalent to approximately 0.02 – 0.03% of the daily dose. These percentages indicate that the major component of the total radioactive residue in milk is not monocrotophos. These results are in contrast to those in the goat metabolism study described in 4.2.2. where monocrotophos was the major component of the residue in milk. Recoveries in milk ranged 87 – 90% for monocrotophos and 69 – 87% for *N*-hydroxymethyl monocrotophos, with fortification at 0.023 to 0.03 mg/kg.

In liver and muscle tissues, the following levels of residues were found:

Table 18

Tissue	Residues (mg/kg) at 14 days after exposure to 45 mg/kg in the feed		
	Monocrotophos	*N*-demethyl monocrotophos	*N*-hydroxymethyl monocrotophos
Liver	0.11, 0.13	0.05, 0.06	0.02, 0.04
Muscle (quadriceps)	0.023, 0.041	0.005, 0.008	0.003, 0.008

Recoveries in muscle ranged 78 – 83% for monocrotophos at a fortification level of 0.06 mg/kg and 50 – 87% for *N*-hydroxymethyl monocrotophos, with fortification at 0.046 mg/kg.

Dairy Cows Ref. 1[xxi]
In a continuation of the study above, two lactating cows were fed for 10 days with the glucose conjugate of *N*-hydroxymethyl monocrotophos, at levels equivalent to 20 mg/kg in the diet. The animals were milked twice daily, and composite samples of morning and evening milk were analysed for *N*-hydroxymethyl monocrotophos, its glucose conjugate and *N*-demethyl monocrotophos. The data showed that combined residues in milk were below 0.01 mg/kg monocrotophos equivalents throughout the period of the study. Recoveries ranged 70 – 90% with fortification at 0.05 mg/kg of *N*-hydroxymethyl monocrotophos or *N*-demethyl monocrotophos.

Samples of liver, kidney, meat and fat were taken at sacrifice. The following results were obtained:

Table 19

Sample	Residues in tissues (mg/kg)	
	N-hydroxymethyl monocrotophos and *N*-demethyl monocrotophos	*N*-hydroxymethyl glucose conjugate of monocrotophos
Liver	<0.01, 0.01	<0.01, 0.01
Kidney	<0.01, 0.01	0.01, 0.02
Meat	0.01, 0.01	<0.01, <0.01
Fat	0.02, 0.04	<0.01, <0.01

Residues of *N*-hydroxymethyl monocrotophos and *N*-demethyl monocrotophos were only found at detectable levels in the fat, whereas detectable levels of the glucose conjugate of *N*-hydroxymethyl monocrotophos were only found in kidney. Overall the study shows that only low levels of the degradation products of the glucose conjugate of *N*-hydroxymethyl monocrotophos are found in tissues of cows exposed to levels of 20 mg/kg in the diet.

Recoveries in the various tissues at a fortification level of 0.1 mg/kg are shown below:

Table 20

Sample	*N*-hydroxymethyl monocrotophos	Glucose conjugate of *N*-hydroxymethyl monocrotophos
Liver	135	100
Kidney	100	95
Muscle	108	78
Fat	106	87

4.8 FATE OF RESIDUES IN STORAGE AND PROCESSING

4.8.1 Storage

Storage stability data were not provided.

4.8.2 Processing

In Ref. 2[vii], the degradation of monocrotophos during processing was discussed. Monocrotophos readily decomposes at temperatures above 75° C, hence thermal degradation would play an important role during heating and cooking. As the compound is very water soluble, washing would readily remove surface residues from treated crops, *e.g.* in a reported tomato study[xxii], a cold water wash was shown to remove 36 – 72% of monocrotophos from treated tomatoes, while a hot lye peel* removed 72 to 93% of the residue. Canned tomato juice contained 7 – 25% and whole canned tomatoes 7 – 17% of the initial residue in the treated unwashed tomato.

In another study[xxiii], it was shown that washing did not remove the residues on citrus fruits, and penetration of the residues into the peel was apparent. However, the residues were not stable to processing into citrus pulp cattle feed which involved grinding, liming and drying. This type of process may be comparable to that found in feedlot situations in Australia, and therefore the exposure of cattle to any monocrotophos residues in feed is reduced.

In processing studies reviewed by JMPR[xxiv], monocrotophos residues in citrus peel and pulp comprised 10 – 20% and 25 – 50% respectively, of the residue in the whole fruit.

Commercial processing methods and the effects on monocrotophos residues in sunflower oil were studied; Ref.9[xi]. Crude sunflower oil was fortified with 1 mg/kg monocrotophos and subjected to alkali refining, bleaching and deodorisation. Monocrotophos was completely destroyed after alkali refining.

4.9 FAT SOLUBILITY

Monocrotophos is not a lipophilic compound, K_{ow} = 0.6 (calculated). It is 100% soluble in water and methanol, 80% soluble in dichloromethane, 70% soluble in acetone, 25% soluble in *n*-octanol and 6% soluble in toluene.

REFERENCES

* Tomatoes for canning are passed through an 18% NaOH solution heated to 82°C for 30 seconds then washed with water to remove the skin and residue.

Beynon, K.I. and Wright, A.N., *The Breakdown Of [^{14}C] Monocrotophos Insecticide On Maize, Cabbage And Apple*, *Pest. Sci.*, (1972), **3**, 277-292.

Beynon, K.I., Hutson, D.H. and Wright, A.N. , *The Metabolism And Degradation Of Vinyl Phosphate Insecticides*, Residue Reviews, Residues of Pesticides and Other Contaminants in the Total Environment, Editor F.A. Gunther, (1973), **47**, 55-142; Springer-Verlag Press.

Bull, D.L., and Lindquist, D.A., *Metabolism Of 3-Hydroxy-N-methyl-cis-crotonamide Dimethyl Phosphate (Azodrin) By Insects And Rats*, *J. Agric. Food Chem.*,(1966), **14**, 105-109.

Bull, M.S., and Kearney, E.M., Ciba-Geigy Australia Ltd, The determination of residues of monocrotophos in the grain, husks and straw of wheat and barley at harvest following multiple applications of the insecticide Nuvacron, Technical Report No. 85/9/1047, 20 September 1985.

Bull, M.S., Ciba-Geigy Australia Ltd ,Determination of Monocrotophos Residues in Sweet Corn, Technical Report No. 74/8/467, 6 August 1974.

Bull, M.S., Ciba-Geigy Australia Ltd Determination of Monocrotophos Residues in Soyabean Seeds, Ciba-Geigy Technical Report No. 73/5/407, 24 May 1973.

Bull, M.S., Ciba-Geigy Australia Ltd, Determination of Monocrotophos Residues on Tomatoes Following Multiple Treatment of Tomatoes with NUVACRON at 1.5 litres/hectare (Label Recommendation), Technical Report No. 76/7/571, 13 July 1975.

Bull, M.S., Ciba-Geigy Australia Ltd, The Determination of Monocrotophos Residues in Soyabean Seeds, Technical Report No. 75/6/511, 13 June 1975.

Butler, C.E., and Mathews, B.L., Shell Research Ltd, Residues Of Azodrin In Potatoes From Australia, Group Research Report WKGR.0103/69, 27 August 1969.

Ciba-Geigy Australia Ltd, R & D Analytical Method 133, *Determination of Monocrotophos (C-1414) Residues In Sweet Corn,* July 1974.

Ciba-Geigy Australia Ltd, R & D Analytical Method No. 124, *Determination Of Monocrotophos (C-1414) Residues In Soya Beans*, 13 April 1973.

Ciba-Geigy Australia Ltd., R & D Analytical Method No. 123, *Determination Of Monocrotophos (C-1414) Residues In Tomatoes*, October 1972.

Evaluations of Some Pesticide Residues In Food, 1972, 423-467.

Fahey, J.E., Nelson, P.E., and Gould, G.E., *Removal Of Azodrin Residues From Tomatoes By Commercial Preparative Methods*, *J. Agric. Food Chem.*, (1971), **19**, 81-82.

Lindquist, D.A. and Bull, D.L, Fate Of 3-Hydroxy-N-methyl-cis-crotonamide Dimethyl Phosphate In Cotton Plants, J. Agric. Food Chem., (1967), **15**, 267-272.

Menzer, R.L. and Casida, J.E., *Nature of Toxic Metabolites Formed In Mammals, Insects and Plants From 3-(dimethoxy phosphinoyloxy)-N, N-dimethyl-cis-crotonamide And Its N-methyl Analog*, , *J. Agric. Food Chem.*, (1965), **13**, 102-112.

Moore, B., and Bull, M.S., Ciba-Geigy Australia Ltd, The Effect of Individual Commercial Processing Techniques on Residues of Galecron, Nuvacron and Supracide in Edible Vegetable Oil, Technical Report No. 73/12/427, 19 December 1973.

Mucke, W., *Metabolism of Monocrotophos in Animals*, Reviews of Environmental Contamination and Toxicology (1994), **139**, 67-73 and references therein.

Pesticide Residues In Food, (1991), **113/1**, 487-513.

Potter, J.C., Shell Research Ltd, *Residues Of Azodrin Insecticide In Milk*, Shell Company Subject No. 61500 Insecticides, Technical Report No. M-24-65, 23 February 1966.

Shell Chemical (Australia) Pty Ltd, Report On Residues Of Monocrotophos In Bananas For Shell Chemical (Australia) Pty Ltd., 12 May 1983, trial no. S/AU/E17/89/81.

Shell Research Ltd, Cattle Feeding Studies With SD-13311, Shell Chemical Technical Report .

Shell Technical Report, Radiochemical Determination Of AZODRIN And Its Metabolites In Cows Milk, Urine, Faeces and Meat, Appendix to Shell Technical Report No. M-24-65, *Residues Of Azodrin Insecticide In* Milk, 23 February 1966.

Westlake, W.E., Gunther, F.A., and Jeppson, L.R., *Persistence Of Azodrin Residues On And In Valencia Oranges And In Laboratory-Processed Citrus Pulp Cattle Feed*, *J. Agric. Food Chem.*, (1970), **18**, 864.

Endnotes

[i] Fate Of 3-Hydroxy-N-methyl-cis-crotonamide Dimethyl Phosphate In Cotton Plants, D.A. Lindquist and D.L. Bull, J. Agric. Food Chem., (1967), **15**, 267-272.
[ii] *The Breakdown Of [^{14}C] Monocrotophos Insecticide On Maize, Cabbage And Apple*, K.I. Beynon and A.N. Wright, *Pest. Sci.*, (1972), **3**, 277-292.
[iii] *Metabolism Of 3-Hydroxy-N-methyl-cis-crotonamide Dimethyl Phosphate (Azodrin) By Insects And Rats*, D.L. Bull and D.A. Lindquist, *J. Agric. Food Chem.*,(1966), **14**, 105-109.
[iv] *Nature of Toxic Metabolites Formed In Mammals, Insects and Plants From 3-(dimethoxy phosphinoyloxy)-N, N-dimethyl-cis-crotonamide And Its N-methyl Analog*, R.L. Menzer and J.E. Casida, *J. Agric. Food Chem.*, (1965), **13**, 102-112.
[v] Evaluations of Some Pesticide Residues In Food, 1972, 423-467.
[vi] *Metabolism of Monocrotophos in Animals*, W. Mucke, Reviews of Environmental Contamination and Toxicology (1994), **139**, 67-73 and references therein.
[vii] *The Metabolism And Degradation Of Vinyl Phosphate Insecticides*, K.I. Beynon, D.H. Hutson and A.N. Wright, *Residue Reviews*, *Residues of Pesticides and Other Contaminants in the Total Environment*, Editor F.A. Gunther, (1973), **47**, 55-142; Springer-Verlag Press.
[viii] R & D Analytical Method No. 124, *Determination Of Monocrotophos (C-1414) Residues In Soya Beans*, Ciba-Geigy Australia Ltd.,13 April 1973.
[ix] R & D Analytical Method No. 123, *Determination Of Monocrotophos (C-1414) Residues In Tomatoes*, Ciba-Geigy Australia Ltd., October 1972.
[x] R & D Analytical Method 133, *Determination of Monocrotophos (C-1414) Residues In Sweet Corn*, Ciba-Geigy Australia Ltd., July 1974.
[xi] The Effect of Individual Commercial Processing Techniques on Residues of Galecron, Nuvacron and Supracide in Edible Vegetable Oil, B. Moore and M.S. Bull, Ciba-Geigy Australia Ltd, Technical Report No. 73/12/427, 19 December 1973.

[xii] Radiochemical Determination Of AZODRIN And Its Metabolites In Cows Milk, Urine, Faeces and Meat, Appemdix to Shell Technical Report No. M-24-65, *Residues Of Azodrin Insecticide In* Milk, 23 February 1966.
[xiii] The determination of residues of monocrotophos in the grain, husks and straw of wheat and barley at harvest following multiple applications of the insecticide Nuvacron, M.S. Bull and E.M. Kearney, Ciba-Geigy Australia Ltd, Technical Report No. 85/9/1047, 20 September 1985.
[xiv] Determination of Monocrotophos Residues in Sweet Corn, M.S. Bull, Ciba-Geigy Austra[illegible] Ltd, Technical Report No. 74/8/467, 6 August 1974.
[xv] Determination of Monocrotophos Residues in Soyabean Seeds, M.S. Bull, Ciba-Ge[illegible]ical Report No. 73/5/407, 24 May 1973.
[xvi] The Determination of Monocrotophos Residues in Soyabean Seeds, M.S. [illegible] Geigy [illegible]tralia Ltd, Technical Report No. 75/6/511, 13 June 1975.
[xvii] Determination of Monocrotophos Residues on Tomatoes Follow[illegible] of Tom[illegible]s with NUVACRON at 1.5 litres/hectare (Label Recommendation), [illegible] Bu[illegible] [illegible]tralia Ltd., Technical Report No. 76/7/571, 13 July 1975.
[xviii] Report On Residues Of Monocrotophos In Bananas [illegible] Lt[illegible] May 1983, trial no. S/AU/E17/89/81.
[xix] Residues Of Azodrin In Potatoes From Au[illegible] Shell Research Ltd., Group Research Report WKGR.01[illegible]/69, [illegible] August 19[illegible]
[xx] *Residues Of Azodrin Insecticide* [illegible] Co[illegible]ny Subject No. 61500 Insecticides, Technical Report No. M-24-65, 23 F[illegible]uary [illegible]6.
[xxi] Cattle Feeding Studies With SD-135[illegible] Sh[illegible] Tec[illegible] [illegible]port .
[xxii] *Removal Of Azodri[illegible] Residues From [illegible] Preparative Methods*, J.E. Fahey, P.E. Nelson and G.E. G[illegible], *J. Agric. Foo[illegible]* [illegible], 81-82.
[xxiii] *Persistenc[illegible] Azodri[illegible] Residues On And [illegible] Oranges And In Laboratory-Processed Citrus Pulp Ca[illegible]*, W[illegible] Westlake, F.A. [illegible]ther and L.R. Jeppson, *J. Agric. Food Chem.*, (1970), [illegible]864.
[xxiv] [illegible] *Resid[illegible]* [illegible] **3/1**, 487-513.