Section 4

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AGRICULTURAL ASSESSSMENT

1. INTRODUCTION

1.1 Performance Questionnaires

The NRA chose to gain information on the agricultural aspects of the use of endosulfan by surveying various groups involved as advisers, users and registrants of the chemical. This was accomplished by sending Performance Questionnaires to State coordinators, commodity and industry organisations, users and registrants. The purpose of the questionnaire was to gather information on use, performance, changed agricultural practices, adverse effects and trade and residues. The results form part of the efficacy and trade reports which appear in this section.

1.2 Use Pattern and Justification for Use

Endosulfan is widely used in Australian horticulture and agriculture and all State agricultural authorities support growers and commodity organisations in judging that it is essential for the viability of many crops in Australia.

An examination of performance questionnaires for endosulfan completed by growers, commodity organizations, State agricultural authorities and registrants indicates that its inclusion in IPM and resistance management programs, particularly for cotton, is a feature of the current use of this chemical.

The particular attributes of endosulfan which were nominated as making it eminently suitable for use as an IPM chemical were as follows:

- It is relatively ‘soft’ on pollinators, parasites and predators. In relation to bees, although it is not as damaging as some chemicals, labels nevertheless carry a warning that the material is dangerous to bees. This damage is minimised by spraying at times when bees are not actively foraging in the crops. In fact, much aerial application to cotton is carried out at night. In relation to its use in integrated mite control in apples and vineyards, the Tasmanian DPIF advises that *Typhlodromis pyri* and *Typhlodromis occidentalis* show nil or very minor effects from this chemical making it very useful for this purpose.
- It is relatively non-phytotoxic when compared to likely major control alternatives such as chlorpyrifos and dimethoate.

The usefulness of the chemical in resistance management strategies derives from the fact that it is one of the few effective organochlorine chemicals still registered. Since resistance management commonly depends on exposing insects to a variety of insecticide groups with different mechanisms of activity so that selection of resistance to any one group is slowed, the availability of this chemical may be the difference between the success or failure of a program.

Most States have recommended spray programs which include endosulfan as a critical component. A listing of these programs follows in Table 7-1:

Table 7-1 - *Spray programs recommended by State agricultural authorities including endosulfan*

State	Spray Program
Tasmania	• Basic spray plan for apples and pears • Gall mite and currant bud mite in black currants • Cyclamen mite control in strawberries and ornamentals • Integrated mite control in apples and vineyards*
Queensland	• Beans - *Helicoverpa*, green vegetable bug • Capsicum - cutworms, *Helicoverpa*, green vegetable bug • Cucurbits - cucumber moth, shield bug, green vegetable bug, thrips, potato aphid • Eggplant - eggfruit caterpillar • Tomatoes - aphids, loopers, *Helicoverpa*, Rutherglen bug*, green vegetable bug* • Pawpaws - fruit spotting bug* • Apples, grapes, stone fruit - plague thrips, apple dimpling bug* • Citrus - green planthopper, citrus planthopper, spined citrus bug, bronze orange bug, green vegetable bug, crusader bug* • Tropical and sub-tropical tree crops - fruit spotting bug* • Cotton** - Insecticide Resistance Management Strategy • Grain Legumes - pod sucking bugs, *Helicoverpa punctigera**
South Australia	• Citrus - spined citrus bug, katydid, leafhopper and other bugs*
Western Australia	Recommended as a standard thrips spray and for red legged earth mite control where bifenthrin is not registered. Documented in the WA Spray Guide
Victoria	• Canola - bare earth spray for red legged earth mite** • Sweet corn - *Helicoverpa***
New South Wales	• Apples - plague thrips* • Citrus - spined citrus bug* • Tropical fruit - macadamia flower caterpillar, fruit spotting bug • Cotton** - Insecticide Resistance Management Strategy
Northern Territory	• Cucurbits - cucumber moth • Mangoes - red banded thrips* • Vegetables - thrips palmii, various caterpillars* • Sorghum, sesame, mungbeans - *Helicoverpa*, leafroller** • Ornamentals - poinsettia whitefly*

*Integrated pest control program; **Resistance management strategy

1.2.1 Main Use Patterns

By far the major use of endosulfan is in cotton production (approximately 72% of product). In this crop, endosulfan is applied in accordance with the Insecticide Resistance Management Strategy (Cotton Pests and Pest Management) which is kept under review by an expert committee, which includes members from NSW Agriculture, CSIRO, AVCARE and the Cotton Research and Development Corporation.

In this strategy, endosulfan use is primarily aimed at control of native budworm (*Helicoverpa punctigera*) which is still susceptible to the chemical. It is therefore only applied early in the crop to avoid cotton bollworm (*Helicoverpa armigera*) which is moderately resistant to endosulfan. Growers are encouraged to use the LepTon Test Kit to determine which *Helicoverpa* species is present in the crop. In addition, spraying is only initiated when the pre-flowering *Helicoverpa* threshold (2 small or 1 medium larva/metre, monitor first position fruit retention) is reached. Spraying cotton crops with endosulfan is discontinued at a date (which is reviewed each year) towards the end of January. By this stage damaging *Helicoverpa* populations consist mainly of the endosulfan resistant

Helicoverpa armigera. Growers indicate that under this regime, between 4 and 6 endosulfan sprays per season are applied to cotton crops. It is interesting to note in relation to use in the 1996-97 season, that the number of endosulfan sprays has been halved to an average of 2.5. However, it is emphasised that this is an average figure only and numbers of sprays in some areas were significantly higher (eg Bourke 6.6 sprays).

This use of endosulfan conserves the populations of natural enemies for as long as possible and prevents the flaring of secondary pests such as mites, aphids and whitefly. It is also useful for suppression of early season sucking pests such as mirids. The alternative products for all these pests (the pyrethroids, organophosphates and the carbamates) are considered 'hard' on beneficials and the early season use of all these products has been clearly demonstrated to cause mid/late season flare of secondary pests (particularly mites).

Expert advice from the Australian Cotton Research Institute, Narrabri, further indicates that there is no doubt that the loss of endosulfan would result in a switch to the use of 'harder' chemicals earlier in the season, which would lead to a much greater use of less desirable chemicals (particularly the organophosphates) in the mid and late season. The situation is presently difficult with mites as the major secondary pest but the recent introduction into Australia of the 'B type' (or poinsettia strain) silverleaf whitefly *Bemisia tabaci,* will make the availability of endosulfan even more critical, as endosulfan is one of the most effective, non-flaring insecticidal control measures for this pest.

In relation to other broad acre crops, similar use patterns are adopted. However, it should be noted that cereal crops such as maize and sorghum mainly attract the partially resistant *Helicoverpa armigera* and endosulfan is therefore not the most efficient *Helicoverpa* control option in these crops.

Use in vegetables accounts for approximately 20% of the use of endosulfan. Information supplied by growers indicates that integrated pest management and resistance management practices are being adopted by the majority of growers in recognition of growing resistance problems. Spraying in response to damaging pest populations determined by crop monitoring is becoming the dominant use pattern in vegetable production. State agricultural authorities and other research organisations are assisting growers to calculate economic thresholds to enable them to make informed decisions about when spray application will be most effective.

In orchards, integrated pest management practices are also being employed by growers.

1.2.2 Methods of Application

Significant quantities of endosulfan are applied by air, since the major crop on which endosulfan is used is cotton which is cultivated in very large continuous areas. Difficulties have been encountered from time to time with drift of spray off target with consequent effects on native fauna such as birds and fish.

In response to these difficulties, strategies to minimise drift have been developed, including more use of large capacity boom sprayers and use of formulations for aerial application which are less likely to result in drift. Use of EC formulations instead of ULV formulations is being examined in the light of drift associated with aircraft spraying operations.

Endosulfan is widely used in IPM programs in orchards and, in common with many other older chemicals, endosulfan recommendations for use in orchards are given as a high volume rate per 100L. However, many orchardists are now using low volume (in some cases electrostatic ultra low volume) equipment to apply endosulfan, whereas original rates of use in orchard crops (and possibly, MRL determinations) were based on high volume application methods.

The main difficulty posed by this development stems from the fact that there are no directions on the label in relation to the amount of water which should be used in high volume applications to the various fruit crops specified on the labels. In relation to pome and stone fruit orchards, most estimates of spray volume fall between 1500-3000 L/ha. Thus, amounts of chemical between 997.5 - 1995 gai/ha could be applied during a high volume application. Growers are then taking these rates and applying them in a markedly reduced volume of water. Volumes of water applied during low volume application in orchards vary between 180-500 L/ha. Where electrostatic sprayers are used, volumes between 50-80 L/ha are applied.

In a high volume operation, there is a loss of chemical because of run-off (up to 50% according to some estimates). In a low volume spraying operation, the reduction in run-off (almost to non-existence in some cases), and better efficiency of equipment mean that there is a better rate of deposition of spray onto the target. It is therefore apparent that rates of use could be examined both from a standardization point of view and with a view to reducing the amount of chemical applied per hectare.

This could be achieved by reducing the rates of application of current products. Alternatively, in consultation with the registrant chemical companies, it may be possible to produce formulations of endosulfan which could be used at lower rates of use or which contain a lower concentration of endosulfan.

Nevertheless, rates of use and spray application in orchards is a complex matter which is not chemical specific and which is subject to ongoing research and investigation. The outcomes of this research will impact on labelling for all chemicals used in orchards, including endosulfan.

Growers who were surveyed indicate that in the IPM programs, sprays are only applied as a result of orchard monitoring, often by professional crop monitoring services, for pest pressure. In fact, there is evidence to suggest that even growers who do not plan to use a full IPM program apply sprays in response to pest monitoring. They further indicate that when sprays are applied, they are applied according to the current label directions.

Trial work has been carried out in citrus by State departments which shows that rates of use of endosulfan for IPM systems to control major pests can be significantly reduced compared with recommended label rates. For example, NSW Agriculture advises that a rate of 10 mL/100L can be used as opposed to the label rate of 57 mL/100L. This has the effect of reducing endosulfan usage in citrus orchards from 1596 gai/ha to 280 gai/ha, assuming an average spray volume in this type of orchard of 8000L/ha. In this regard advice has been received that spray volumes for high volume spraying of citrus are between 8000-10000L/ha because of the density of the foliage and the consequent difficulty of wetting the whole canopy. The Queensland Department of Primary Industries has developed a per hectare rate for citrus of 1L/ha, or 350 gai/ha which, although higher than the NSW rate when a water volume of 8000L is assumed, is identical if water volume of 10000L/ha is assumed.

It is therefore to be expected that lower rates of use may also be possible in other IPM applications.

The majority of vegetables tend to be cultivated in smaller plots and therefore conventional boom sprays are the major method of application for endosulfan in these crops.

2. EFFICACY ASSESSMENT

2.1 Background

One aspect of the contemporary assessment standards with which chemicals must comply in order to achieve and maintain registration is that use of products containing the chemical in accordance with the recommendations approved by the NRA for its use must be effective according to criteria determined by the NRA for the product.

Growers, commodity organizations, State agricultural authorities and the chemical industry have been surveyed for information on the performance of the chemical in the field, addressing aspects such as management strategies, methods of application and chemical failures. In particular, information has been sought on whether the way in which the chemical is presently used is the same as when it was first registered and whether the present label directions are still applicable.

These matters have been examined and the results presented in the following report.

2.2. Current Usage

2.2.1 Registration Status:

Endosulfan is widely registered/approved for use throughout the world. As well as being registered in most European countries, it is also registered in the USA, Canada and South East Asian countries such as Japan and Indonesia. It is used in these countries in a similar way to the way in which it is used in Australia.

There are 15 products containing endosulfan currently registered in Australia by 8 registrants and these are listed in Table 7-2:

Table 7-2 - ***Registered products containing endosulfan****

Product Name	Applicant
Campbell Endosulfan 350 EC Insecticide	Colin Campbell (Chemicals) Pty Ltd
Endosan Emulsifiable Concentrate Insecticide	Crop Care Australasia Pty Ltd
Endosan ULV Insecticide	Crop Care Australasia Pty Ltd
Davison Endosulfan 350 EC Insecticide	Davison Industries Pty Ltd
Davison Endosulfan 250 ULV Insecticide	Davison Industries Pty Ltd
Farm-oz Endosulfan 350 EC Insecticide	Farmoz Chemicals Pty Ltd
Farm-oz Endosulfan 240 ULV Insecticide	Farmoz Chemicals Pty Ltd
Thiodan ULV Insecticide	Hoechst Schering AgrEvo Pty Ltd
Thiodan Insecticide	Hoechst Schering AgrEvo Pty Ltd
Thiodan EC Insecticide	Hoechst Schering AgrEvo Pty Ltd
Thionex 350 EC Insecticide Spray	Makhteshim-Agan (Aust) Pty Ltd
Nufarm Endosulfan 350 EC Insecticide	Nufarm Ltd (Laverton)
Nufarm Endosulfan ULV 240 Insecticide	Nufarm Ltd (Laverton)
350 EC Bar Insecticide by Sanonda	Sanonda (Australia) Pty Ltd
240 ULV Bar Insecticide by Sanonda	Sanonda (Australia) Pty Ltd

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

It is widely used in IPM and resistance management strategies in many crops but has a particularly important role in cotton production. Other significant usage areas are grain legumes, oilseeds, vegetables and fruit.

An estimate of the relative distribution of use of endosulfan products by crop/crop grouping is:

Table 7-3 - ***Estimate of endosulfan usage by crop/crop grouping****

Crop/Crop Grouping	% of product used in crop
Cotton	72
Vegetables	20.5
Oilseeds	3
Pome & Stone Fruit	2
Exotic Fruit	2
Other	< 0.5

Information from another source indicates that approximately 900 tonnes of technical endosulfan are imported annually into Australia which would result in a quantity of formulated product of the order of 2.9 million litres assuming equal amounts of EC and ULV formulations are manufactured. Using the figures above, approximately 2.1 million litres of endosulfan concentrate would be used in cotton in Australia, with slightly more than half of this quantity being used in NSW and the remainder being used in Queensland.

It should be noted in relation to these estimates that seasonal factors play a major role in determining pest prevalence, pest complexes and areas planted and needing to be sprayed. Consequently, there can be significant variation from year to year in the amount of endosulfan used.

Crops appearing on currently registered product labels have been listed in the following table:

Table 7-4 - *Crops/Situations in which endosulfan is registered*

Canola (Rapeseed)	Avocadoes	Soybeans	Cape Gooseberry
Carrots	Bananas	Safflower	Capsicums
Cashews	Berry Fruit - Currants & related fruits	Pecans	Carambolas
Chou Moellier	Blueberries	Yellow Mombins	Carobs
Citrus	Cabbages, Cauliflower & other Crucifers & Leaf Vegetables	Sunflower	Cassia-Round Leafed
Clover & Medic Seed Crops	Casimoras	Pomegranates	Cereal Crop & Pasture
Cucurbits	Celery	Sesame	Cereals
Duboisia	Chickpeas, Cowpeas, Pigeon Peas, Adzuki Beans, Faba Beans, (Broad Beans)	Spinach	Cotton
Durians	Custard Apples	Sweet Corn	Grapes
Egg Plant	Granadillas	Sweet Potato	Green Beans
Green Peas, Field Peas, Peas, Snow Peas	Grass Seed Crops & Legume Pasture Seed Crops	Stone Fruit	Jaboticabas
Hides	Guavas and/or persimmons	Tamarillos	Lawns
Hides	Kiwifruit	Tobacco	Loquats
Leeks	Lablab beans	Tomatoes	Lucerne Seed Crops
Lima Beans	Linseed	Red Beet	Mangosteens
Lychees	Longans	Rhubarb	Okra
Navy Beans, Mung Beans	Low Chill Stone Fruit	Sapodillas	Pecan Nuts
Nursery Crops	Lupins	Spinach	Pineapples
Oilseeds	Macadamia Nuts	Taro	Potatoes
Ornamentals	Maize	Tea trees	Rambutans
Peanuts	Mammy apples	Strawberries	Rape
Pistachios	Mangoes	Vetch (Common)	Rollinias
Pome Fruit	Onions	Tea	Shallots
Raspberries	Passion Fruit	Wildflowers and Proteas	Sorghum
Rosella	Pawpaw	Turf	

Possession and use of endosulfan is also permitted by the NRA in certain circumstances such as minor and/or emergency uses and for trial purposes. Current permits which have been issued by the NRA for endosulfan are presented in the following table:

Table 7-5 - *Permits issued for endosulfan**

Crops	Pests	States
Vetch	*Helicoverpa spp.*, Cowpea aphid	NSW only
Black sapote	Fruit spotting bug	Qld only
Carrots	Rutherglen bug	Tas only

Soybeans, Mungbeans, Adzuki beans, Navy beans, peanuts	Evaluate efficacy against green vegetable bug, brown bean bug, redbanded shield bug & green mirid	Qld
Strawberries	western flower thrips	All States
Cotton (Pre-squaring only)	*Helicoverpa spp*	NSW

*Note: These crops may appear on registered labels but not for rates, pests etc nominated in permits. Permits may also be for trial purposes.

2.2.2 Registration Trends

Two of the most significant developments in the registration of endosulfan have been the inclusion of an export slaughter interval (ESI) on the labels and the increase of the MRL for stockfeeds from 0.03 mg/kg to 0.3 mg/kg. These developments have occurred as a result of concerns regarding the presence of endosulfan residues in export beef.

These concerns became focussed as a result of the discovery that some laboratories which had been analysing beef for pesticide residues had not been determining residues as total endosulfan (sum of α and β endosulfan and endosulfan sulfate), but only the α and β isomers. Since endosulfan sulfate is the most persistent breakdown product of endosulfan, a true indication of the residue situation in beef was only obtained when this gap in the data was identified and rectified.

Endosulfan is a cyclodiene organochlorine insecticide which is fat soluble. When cattle are fed material containing residues of this chemical or when they are directly exposed to it, the chemical accumulates in the fat as long as the exposure continues. That is, the material accumulates more quickly than it is metabolised or excreted. Although endosulfan is not registered or used in cattle, there have been instances where grazing cattle have been exposed to spray drift from spraying operations being conducted on adjacent crops. These cattle, when slaughtered, have exhibited residues in beef from consuming contaminated pasture and from direct absorption of the spray. Residues in beef have also resulted from cattle being fed prepared stockfeed which contains endosulfan residues.

Another characteristic of endosulfan which has proved to be important in this context is its persistence on foliage which is no longer actively growing. It has been ascertained that the rate of breakdown of endosulfan on the foliage of actively growing plants is significantly higher than the rate of breakdown on plants which are no longer actively growing. This is important where crops such as peas and peanuts are sprayed late in the season, harvested, and then cut for stockfood. Instances have also occurred of stockfood crops such as lucerne and sorghum being sprayed or contaminated by drift and then cut for stock food and residues still being high 6 - 9 months later.

Research conducted by the Queensland Department of Primary Industries' Animal Research Institute has determined that the half-life of endosulfan in cattle is 9-10 days and this research formed the basis of the recommended 42 day export slaughter interval (ESI). This gives a period equivalent to approximately four half lives to allow residues in the fat to drop to below the MRL once cattle have been placed on feed which is not contaminated with endosulfan residues.

In conjunction with the ESI, the following warning statement is also required on the labels of endosulfan products:

"Residues of this product may persist for long periods on some treated crop stubbles and in hay or silage made from treated crops such as maize, sorghum, grain legumes and table beans.
Feeding of these materials to livestock may produce residues in meat which exceed the maximum residue limits, for as long as 42 days after the last grazing/feeding.

Where it is possible that a crop will be ultimately grazed or form part of livestock feedstuff, avoid using this product late in the season when vegetative growth has been slowed or stopped."

Another significant development in the use of endosulfan is its widespread use in IPM and resistance management programs.

As far as resistance management strategies are concerned, the major advantage of endosulfan is that it is one of the few effective insecticides of the organochlorine group still registered and therefore it adds another chemical group in the rotation of chemical groups which is critical to the success of resistance management strategies. The more chemical groups there are available, the less exposure there is to individual groups and therefore the longer the time for resistant insects to be selected.

In terms of its use in IPM programs, it has major advantages. For example, it is 'soft' on beneficials and is not as potentially phytotoxic in some crops as some of the major alternatives, particularly organophosphates such as dimethoate and chlorpyrifos.

Because of its use in either or both of these situations, use of endosulfan in individual crops has been considerably reduced. For example, the Insecticide Resistance Management Strategy (Cotton Pests and Pest Management) developed and maintained by an expert committee with membership including representatives from NSW Agriculture, CSIRO, AVCARE and the CRDC has resulted in the reduction of the average number of sprays of endosulfan in cotton to 2.5 last season. It is emphasised that this is an average figure across the industry and in some districts the number of sprays was considerably higher eg 6.6 at Bourke. Nevertheless, because of the expansion of the overall area planted to cotton and other crops for which endosulfan is important, the amount of endosulfan required has remained relatively constant.

Performance questionnaires completed by registrant chemical companies indicate that they believe that this chemical has an important and continuing role in Australian agriculture.

Both NSW Agriculture and the Queensland Department of Primary Industries advise that they believe that there will be a continuing demand for endosulfan in cotton. However, there is some uncertainty as to the effect that introduction of transgenic cotton will have on the extent of the demand. NSW Agriculture advises that transgenic cotton is expected to be introduced commercially into Australia for the 1997 spring plant and that its introduction will undoubtedly reduce the need for early season endosulfan sprays. Nevertheless, they also advise that endosulfan sprays will still be required for the early season 'refugia' blocks of conventional cottons (perhaps up to 20% of the area) and possibly also for supplementary control of *Helicoverpa spp.* in the late season transgenic blocks as the their toxin efficacy drops off as the plants mature. The 'soft ' attributes of endosulfan would also be very desirable in the late season blocks to preserve the activity of any late season parasites/predators (particularly tachinid fly and ichneumonid/braconid wasp parasites).

The registrants also predict a drop in the need for endosulfan in cotton as a result of the introduction of transgenic cotton. However, they, like NSW Agriculture, believe that there will be a continued need for endosulfan in the resistance management strategy and point out that other pests may emerge as a result of the introduction of the transgenic cotton.

In addition, a number of respondents from all groups surveyed, pointed to the emergence of the poinsettia whitefly as a potential major pest in cotton which may not be contained by transgenic cotton.

A number of State agricultural authorities are pursuing research into use of endosulfan as follows:

Table 7-6 - ***Current research trials with endosulfan by State agricultural authorities***

State	Crop/pest/situation
Queensland	• Use of reduced rates of endosulfan with salt in grain legumes for podsucking bugs and mirids • cotton • Pest management in pawpaws • fruit sucking mirids
New South Wales	• cotton
Victoria	• No information
Tasmania	• Integrated mite control in apple orchards to reduce pesticide usage
Western Australia	• No trial work
South Australia	• No trial work
Northern Territory	• red banded thrips • cucumber moth
Australian Capital Territory	• No trial work

It should also be noted in this context that important trial work in citrus and cotton has been concluded, but reporting has not yet been finalised. The benefits of this trial work have therefore yet to be fully realised and the implications for the registration of this chemical are not yet clear.

For example, research conducted by NSW Agriculture shows that the rate of use of the 350 g/L EC formulation for endosulfan could be reduced from 57 mL/100L of water to 10 mL/100L of water in citrus for control of spined citrus bug in IPM programs, but this has not yet appeared on registered labels.

Registrants in general see little scope for the extension of the registration of endosulfan into other crops or situations. However, some activity in relation to formulation chemistry may be undertaken to improve the efficacy and safety of current formulations.

In this regard, several respondents noted that efficacy and stability of formulations are reduced under very hot conditions (above 38°C) or where concentrates are mixed with water with high pH.

Registrants also indicate that they have not received any legitimate complaints from growers in relation to labelling, handling or performance of the chemical. However, they also indicate that the cotton industry is moving to returnable containers because of difficulties encountered in handling and disposing of 200 L drums.

2.3 Evaluation of Efficacy

Information contained in the performance questionnaires from all sectors of the rural industry surveyed in relation to this chemical indicated that it was still efficacious for the purposes claimed. In fact, in orchard IPM situations, some growers advised that they had actually reduced their rates and frequency of use but were achieving the same level of control as when they had first used the chemical. This phenomenon could be attributable to a number of factors including use of more efficient application equipment (low volume application equipment, electrostatic sprayers as opposed to high volume boom sprayers) and better timing of sprays based on pest monitoring to achieve maximum effect on pest populations. It was also noted that label rates were in some cases being converted to rates per hectare for the purposes of using low volume equipment.

Registrants indicated that they did not have any information on any reduction in efficacy and had not received any complaints from growers in relation to failure to control nominated pests using this chemical.

However, three State departments indicated that they had been requested to investigate a number of complaints in relation to poor efficacy.As a general comment, both the Queensland and NSW departments noted that efficacy drops off in very hot weather. They also noted that there are ongoing resistance problems with *Helicoverpa armigera*.

In Queensland, the Department of Primary Industries has investigated complaints in relation to poor efficacy against *Helicoverpa armigera* in grain legumes. In all cases the problem was due to hard water used in tank mixes.

The Northern Territory Department of Primary Industries and Fisheries indicated that complaints of lack of efficacy against cucumber moth had been investigated. They found that the chemical had been applied to large larvae when they had moved to sheltering sites under the fruit (rockmelons) and contact with the spray was therefore reduced. In other investigations it had been noted that spray application was a difficulty in that concentrations in the applied spray were low and there was poor coverage of the crops.

2.4 Phytotoxicity

Expert opinion from the State departments is that endosulfan is generally less phytotoxic than possible alternatives which would be expected to be organophosphates such as dimethoate or chlorpyrifos. This is another reason why it is favoured as a chemical for use in IPM programs.

Phytotoxicity has been recorded in the literature on lima beans and alfalfa. Injury has also been noted on geraniums and some varieties of chrysanthemums under greenhouse conditions.

Some information on phytotoxicity has also been reported by State departments. The Tasmanian Department of Primary Industries and Fisheries advised that phytoxicity has been recorded on anthurium, rose and betula in addition to geraniums and chrysanthemums, while the Northern Territory DPIF advised that phytotoxicity has been recorded in their jurisdiction on some Brazilian cashew varieties.

2.5 Resistance Management

Endosulfan is one of the few remaining effective registered organochlorine insecticides and therefore has a vital role in insecticide resistance management strategies, particularly in managing resistance to carbamate and pyrethroid chemicals.

It is a key chemical in the Insecticide Resistance Management Strategy (Cotton Pests and Pest Management) as it is considered to be a relatively "soft' insecticide on beneficials and is particularly useful for early season control of *Helicoverpa spp*.

Although there is resistance to endosulfan in *Helicoverpa armigera*, it is at a much lower level than that for the pyrethroids and endosulfan is still very effective on the dominant early season fully susceptible *Helicoverpa punctigera*. If endosulfan was no longer available, a whole class of insecticide chemistry would be lost, which would make insecticide resistance management through rotation of chemical groups virtually unworkable. This, in turn, could put at risk the economic viability of the Australian cotton industry.

Queensland authorities advise that endosulfan is not effective against tomato russet mite although it is registered for control of this mite on tomatoes and eggplant. In addition, it was not effective against green peach aphid in trials in North Queensland although it is registered for control of aphids in several crops. However, the chemical still forms part of the recommended spray program for these crops.

2.6 Summary of Efficacy

Endosulfan is very widely used in Australian agriculture and horticulture and is an integral part of many spray programs recommended by State agricultural authorities.

Of particular importance is its use in integrated pest management (IPM) programs and resistance management strategies. It would appear that there are many of these programs which are, to some degree, dependent on the continued availability of endosulfan and in some cases, continued availability of endosulfan is critical. State agricultural authorities indicate that the chemical is essential for control of various pests in a number of major crops/crop groupings such as cotton and vegetables.

It has particular advantages for use in IPM, the major one being that it is 'soft' on pollinators, predators and parasites. In terms of its use in resistance management strategies, its importance is related particularly to the fact that it represents a whole class of insecticides (organochlorines) and therefore adds another whole group into any strategy in which it is used. Some experts have commented that loss of this group could make some resistance management strategies unworkable.

Although it was recognized that alternative chemicals/chemical groups (eg pheromones, microbial pesticides) and strategies such as more efficient monitoring of pests and biological/cultural controls may be able to replace chemicals such as endosulfan in the long term, State departments agreed that endosulfan is required for at least the next 3-5 years or beyond depending upon the success of future research.

In relation to use of this chemical in orchards, the recommendation of high volume rates per 100L of water without a guide as to the amount of water to be used per hectare is a difficulty in common with other older chemicals. Growers are not able to calculate a standard rate per hectare to use through the low volume equipment now commonly used in orchards. There can therefore be a considerable variation in the amounts of chemical applied per hectare.

Nevertheless, rates of use and spray application in orchards is a complex matter which is not chemical specific and which is subject to ongoing research and investigation. The outcomes of this research will impact on labelling for all chemicals used in orchards, including endosulfan.

Some producers reported difficulties handling and disposing of 200L drums. It is clear that these matters are already being considered by growers and the chemical industry in strategies such as bulk and/or refillable containers.

In general, there were no problems reported with the efficacy of endosulfan, although it was clearly recognized that there were significant levels of resistance in some pests to this chemical. Similarly, it was recognized that there were some difficulties with the chemical and the various formulations in heatwave conditions and appropriate strategies (such as applying at night, late in the evening or early in the morning) were being adopted to overcome these difficulties.

3. TRADE ASSESSMENT

3.1 Background

One aspect of the contemporary assessment 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, matters taken into consideration include the following:

- 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 the importing countries (including whether or not the material is banned or restricted in those countries)
- Review status in recognized international forums (such as the Codex Alimentarius Commission) and whether the importing country is a member of the reviewing organisations or recognizes those organisations.
- Detection of violative residues by the National Residue 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

There are 15 products containing endosulfan currently registered in Australia by 8 registrants and these are listed in Table 7-7:

Table 7-7 - *Registered products containing endosulfan**

Product Name	Applicant
Campbell Endosulfan 350 EC Insecticide	Colin Campbell (Chemicals) Pty Ltd
Endosan Emulsifiable Concentrate Insecticide	Crop Care Australasia Pty Ltd
Endosan ULV Insecticide	Crop Care Australasia Pty Ltd
Davison Endosulfan 350 EC Insecticide	Davison Industries Pty Ltd
Davison Endosulfan 250 ULV Insecticide	Davison Industries Pty Ltd
Farm-oz Endosulfan 350 EC Insecticide	Farmoz Chemicals Pty Ltd
Farm-oz Endosulfan 240 ULV Insecticide	Farmoz Chemicals Pty Ltd
Thiodan ULV Insecticide	Hoechst Schering AgrEvo Pty Ltd
Thiodan Insecticide	Hoechst Schering AgrEvo Pty Ltd
Thiodan EC Insecticide	Hoechst Schering AgrEvo Pty Ltd
Thionex 350 EC Insecticide Spray	Makhteshim-Agan (Aust) Pty Ltd
Nufarm Endosulfan 350 EC Insecticide	Nufarm Ltd (Laverton)
Nufarm Endosulfan ULV 240 Insecticide	Nufarm Ltd (Laverton)
350 EC Bar Insecticide by Sanonda	Sanonda (Australia) Pty Ltd
240 ULV Bar Insecticide by Sanonda	Sanonda (Australia) Pty Ltd

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

Possession and use of endosulfan is also permitted by the NRA in certain circumstances such as minor and/or emergency uses and for trial purposes. Current permits which have been issued by the NRA for endosulfan are presented in the following table:

Table 7-8 - *Permits issued for endosulfan**

Crops	Pests	States
Vetch	*Helicoverpa spp*., Cowpea aphid	NSW only
Black sapote	Fruit spotting bug	Qld only
Carrots	Rutherglen bug	Tas only
Soybeans, Mungbeans, Adzuki beans, Navy beans, peanuts	Evaluate efficacy against green vegetable bug, brown bean bug, redbanded shield bug & green mirid	Qld
Strawberries	western flower thrips	All States

Cotton (Pre-squaring only)	*Helicoverpa spp*	NSW

*Note: These crops may appear on registered labels but not for rates, pests etc nominated in permits. Permits may also be for trial purposes.

3.2.1 Food Commodities:

Current recommendations for use on crops are contained in section 1.2

It should be noted however, that in some States permits are not required for off-label use of chemicals and it is known that endosulfan is used off-label for some minor export crops.

3.3 Exports to Other Countries:

Use of endosulfan in Australian agriculture impacts significantly on Australia's exports of agricultural commodities, because of its widespread use in many agricultural and horticultural crops. The major commodities affected are fruits, vegetables, oilseeds, grain legumes and cotton.

In terms of value, the largest fresh fruit exports are currently citrus fruits, grapes and pome (apple and pear) fruit. In fact, oranges are the most valuable horticultural export crop followed by fresh apples, fresh grapes and fresh pears. Stone fruit are presently not a major export crop. However, significant rises in exports of stone fruit are expected over the next five years as a result of rapidly expanding stone fruit production. Tropical and sub-tropical fruit exports are also likely to be affected by modifications to the registration status of endosulfan.

Endosulfan is also registered for use in cotton, which is Australia's fourth largest agricultural export crop. In addition, oilseeds and grain legumes are significant export crops with a value of $105 and $400 million respectively.

Although oilseeds are unlikely to be greatly affected by alterations to the availability of endosulfan, the Queensland Department of Primary Industries advises that endosulfan is considered to be essential for the control of *Helicoverpa spp.*, green vegetable bug and podsucking bug in grain legumes in Queensland.

The main use of endosulfan in oilseeds (particularly canola) is as a bare earth treatment for red legged earth mite before planting. Thus, residues are unlikely to be an issue and in any case, bifenthrin and imidacloprid have been registered as alternative treatments.

3.3.1 Apples

Exports of fresh apples more than doubled in the 5 years from 1988-89 to 1992-93. This resulted in an increase in value from $15.6 million in 1988-89 to $31.9 million in 1992-93; or 31 kt (about 10% of production). In 1993-94 total exports rose to 39 kt of the 340 kt crop (11% of production and worth $38 million).

Whereas the UK once accounted for 50% of apple exports, the major outlet for Australian fruit is now South East Asia which purchased about 80% of the value of the 1993-94 crop. Malaysia (24% of sales), Singapore (22%) and Japan (14%) accounted for most sales in 1993-94. Tasmania was the main apple exporting State with more than 67% of the value of Australia's apple exports in 1993-94, followed by Western Australia (10%) and Victoria (8%). Tasmania has traditionally relied on exports and is once again leading the way by opening up new export markets (access to Japan for Tasmanian apples has just been finalised).

3.3.2 Pears

22% or 31 kt of pears with a value of $30 million were exported from Australia in 1992-93. The value of export production has dropped slightly to $27 million in 1996-97 (production volume not available). 60% of exports are to South East Asia, with the main markets being Singapore $9.8 million (29%), Malaysia $4.5 million (13%), Indonesia $3 million (9%), and Hong Kong $2.5 million (7.5%). The UK and Europe is also an important market, purchasing 25% ($8.8 million) worth of Australian pears while the USA/Canada purchased 5.6% worth $1.9 million .
It should be noted that fresh pears are the fourth most valuable horticultural export product after oranges, apples and grapes.
Australia also exports a significant quantity of canned pears, with an estimated value of $27 million in 1996-97.

3.3.3 Citrus

Fresh citrus exports average about 108 kt, worth $101 million to the Australian economy in 1994-95. Exports of citrus juices and other processed citrus products are also an important part of the industry's operations. In 1992-93 the value of these exports amounted to $22 million.

The major export market sector is South East Asia which currently takes about 75% of the total citrus exports. Other important market areas include New Zealand, USA, Canada and the Middle East.

3.3.4 Cotton

Cotton is firmly established as Australia's fourth largest rural export with a value for the 1995/96 season of $665 million. The growth of cotton as an export commodity has been very marked in recent years, particularly against a backdrop of a generally gloomy rural scene resulting from the impact of a severe national recession. In such a context, the importance of new export oriented industries is highlighted. Despite an international trade war and, locally, one of the most serious economic downturns in the post-war era, Australian cotton production has continued to grow. Australia is now the third largest exporter of cotton in the world.

Advice from authorities in Queensland and NSW indicates that the continued availability of endosulfan is vital to the economic survival of the Australian cotton industry.

3.3.5 Oilseeds (cotton seed, linseed, peanuts, canola, safflower, soybeans and sunflower)

While Australia is a net importer of oilseeds and oilseed products, it is also a regular exporter of oilseed products. Cotton seed has been the major export commodity, but sunflower seed can also be a significant export commodity depending on production. The Australian Oilseeds Federation considers that export opportunities exist for canola, sunflower seed, cotton seed and safflower seed, with the major export market for canola in Japan. Japan is the largest world importer of oilseeds after the European Union (EU). In 1993-94, the value of Australian exports of oilseed and oilseed products was approximately $105 million.

As noted above, bifenthrin and imidacloprid have been registered as alternative treatments to endosulfan in its major use as a bare earth treatment for red legged earth mite in these crops (especially canola). Endosulfan is still considered critical in the production of peanuts and sunflower seed.

3.3.6 Grain Legumes (adzuki beans, chickpeas, cowpea, faba beans, lima beans, lupins, mung beans, navy beans pigeon peas))

Grain legumes are exported for use as stock feed and for human consumption. Lupins and field peas are the main stock feed exports with most production directed to the European Union (EU). Smaller quantities are purchased by Korea and Japan.

The majority of Australia’s exports of grain legumes for human consumption are to India, which has purchased significant quantities of chickpeas, lentils and dried peas. Pakistan, Bangladesh and Sri Lanka have also purchased these products from Australia but not in the same quantities. The other major market is the Middle East, particularly the United Arab Emirates, Iran, Iraq and Egypt.

The total export value of grain legumes was $400 million in 1993-94.

3.3.7 Grapes (fresh and dried) and Wine

Production of grapes for export may also be affected by changes in the registration status of endosulfan. However, it is noted that although endosulfan is registered on grapes, none of the State agricultural authorities highlight grapes as a crop for which endosulfan is considered vital.

With this in mind, both dried fruit (mainly sultanas and currants) and fresh table grapes could be affected.Wine is also a valuable export commodity which potentially could be affected by use of parathion in the production of grapes used in wine making. ABARE indicates that exports of wine were valued at $470 million during 1996-97.

Exports of table grapes were around 14000 tonnes in 1996-97, worth approximately $34 million and although there is a general trend upwards in exports, they tend to reflect good or difficult production seasons.

Markets which are, or have recently been, important as export markets include Singapore, Malaysia, Indonesia, Hong Kong, United Kingdom and New Zealand. There are other markets in which the industry is interested but either have problems with quarantine restrictions or other trade impediments. These markets include Japan, Taiwan and Korea.

As far as dried vine fruits are concerned, the principal export crop is sultanas. In 1992-93 approximately 53000 tonnes of dried vine fruit (mostly sultanas) worth $95 million were exported from Australia. Germany, the United Kingdom, Canada, Japan and New Zealand are the major overseas markets accounting for about 80% of Australia's exports. The remainder is sold to other parts of Europe and Asia.

3.3.8 Other

Although some 5511 tonnes of stone fruit (mostly plums) were exported in 1994/95, there is expected to be a significant increase in exports over the next five years. IPM programs are an important part of pest management in this industry.

In addition, the use of endosulfan is very important for a number of smaller export crops which are in their infancy, but which could become extremely important in years to come. These can be loosely grouped as tropical and sub-tropical fruits and include crops such as loquats, lychees, berry fruit, avocadoes, mangoes, guavas and mangosteens. Other fruits such as durian, jackfruit and rambutans may also increase in significance in the coming years.

At present, the export value of this group of crops is of the order of $20-30 million, including associated produce such as preserves and juice. The main export markets for this type of produce are South East Asian countries such as Singapore, Malaysia and Indonesia and Arabian countries such as the United Arab Emirates and Egypt.

Although beef is not produced using endosulfan as an input, it is nevertheless affected by use of this chemical in Australian agricultural and horticultural production. Because of the nature of the chemical, residues can accumulate in the fat of mammals from direct exposure to spray drift and/or from consuming produce which has been treated with endosulfan during production. The value of beef exports to Australian trade is very significant at $3.8 billion.

3.4. Potential Trade Problems

Endosulfan is considered necessary in the production a number of important export crops. For example, both the Queensland and NSW agricultural authorities confirm grower and commodity group views that continued availability of endosulfan is essential for the cotton industry. In addition, a number of new horticultural crops which could develop into significant export industries would face severe difficulties unless endosulfan was available under current arrangements. A table listing the uses judged as essential by State agricultural authorities is included in Section 3.10.

Apart from production difficulties, it is anticipated that trade difficulties will arise in most cases from residue issues, although it is clear that there is regulatory activity in a number of countries at various levels to more closely regulate the use of endosulfan because of potential health effects.

There are two separate residue issues which have affected trade in various export commodities.

The first is the presence of endosulfan residues in produce following normal approved use of the chemical for control of pests in the crop from which the produce is derived.

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 while adhering to Australian registered use patterns.

See Table 7-9 for a comparison of some of the MRLs in question.

A number of Australia's trading partners, particularly in South East Asia, accept Codex MRLs for endosulfan. The Codex MRLs, in most cases, are less than the Australian MRLs (eg 0.1 as opposed to 0.2 mg/kg for meat; 1 mg/kg for pome fruit as opposed to 2 mg/kg) and therefore it is possible that, where Codex MRLs have been adopted, there could be residues above an importing country's MRL from normal use in Australian agricultural or horticultural production.

An associated difficulty is the fact that the Joint FAO/WHO Meeting on Pesticide Residues (JMPR) has recommended the removal of the Codex general fruit and vegetable MRLs for endosulfan and replacing them with individual fruit and vegetable MRLs provided these are supported by appropriate data. This inevitably means that crop/MRL combinations which were placed on Australian registered labels on the basis of Codex general fruit or vegetable MRLs will no longer be supported when these general MRLs are removed. Thus, for example, if there is no individual fruit MRL for rambutans and the general fruit MRL is removed, endosulfan residues in rambutans will create a problem for Australia and the importing country if that country has adopted Codex MRLs.

Table 7-9 - ***Comparison of selected MRLs for endosulfan***

Commodity	Countries' MRL/Tolerance for *endosulfan* (mg/kg)				
	Australia	Singapore	Japan	United States	Codex
Apples	2 (Fruits)	Accepts Codex MRLs	Accepts Codex MRLs	2	1 (pome fruits)
Pears	2 (Fruits)			2	1 (pome fruits)
Grapes	2 (Fruits)			2	1
Citrus	2 (Fruits)			Not listed	2 (fruits)
Stone Fruit	2 (Fruits)			2 (individual fruits are listed)	1 (for cherries, plums and peach)
Cotton seed	2			1	1
Cotton seed oil (crude)	0.5			Not listed	0.5
Meat (in the fat), Cattle , sheep and goats	0.2			0.2	0.1

Residue detections have been made by the National Residue Survey in many export commodities some examples of which are listed in Table 7-10:

Table 7-10 - ***Residues of endosulfan detected in export crops by the National Residue Survey****

Commodity	% of samples with endosulfan residues
Apples	4
Capsicums	30
Celery	25
Citrus	3.5
Dried vine fruits	2
Lettuce	3
Tomatoes	2.5
Melons	15
Raspberries	Not Available
Fresh Grapes	1

* Period 1/1/89 - 31/12/93

Note: The National Residue Survey no longer analyses export vegetables because of funding restrictions.

Although none of these detections was above the respective Australian MRL, there were occasional detections up to half MRL in vegetable crops such as celery and lettuce which would bring the residues into the order of those represented by the Codex MRL of 0.1 mg/kg. It is emphasised that such detections represented less than 0.5% of samples.

The second also results from the use of the chemical in the production of crops in accordance with approved labels, but is a result of off-target drift of chemical onto other crops or stock. This drift can result in excessive residues in non-target crops or animals. It can also result in contamination of crops which are either destined as animal feeds or which become animal feeds subsequent to harvest of the commodities for which they have been grown. Alternatively, they may be grazed as failed crops after having been sprayed with endosulfan.

The chemical nature of endosulfan is important in this scenario since it is fat soluble and accumulates in animal fat at a greater rate than it is metabolised if animals continue to intake contaminated food. Thus, cattle which have been fed consistently on material which contains endosulfan (in some cases in compliance with Australian residue limits) produce beef which may contain excessive levels of endosulfan residues. This problem has been accentuated by the practice of farmers selling crop remains for stock feed (eg pea and peanut hay) after the crop has been harvested.

In an effort to remove the potential for residue violations in meat, an additional period of 42 days, known as an export slaughter interval (ESI), has been recommended in situations where cattle have been fed with stockfeed containing or suspected to have contained endosulfan residues. It is considered that residues of endosulfan which have accumulated in cattle will have reduced to acceptable levels during this time period provided the source of contamination is removed.

3.5 Advantages of product

All sectors of agricultural production surveyed with performance questionnaires expressed similar views in relation to the advantages of endosulfan in agriculture and horticulture.

These advantages may be listed as follows:

- it is one of the few remaining organochlorine insecticides and therefore provides another chemical group rotation option in resistance management strategies
- according to growers, it is comparatively much cheaper than alternatives
- it is soft on pollinators, parasites and predators and is therefore suitable for, and widely used in, integrated pest management systems
- its phytotoxic effects are minimal compared to alternatives (eg dimethoate and chlorpyrifos) in some crops

Use of the chemical in IPM and resistance management strategies has caused a redution in the use of endosulfan because of the selective use of pesticide in both of these types of strategies. In the case of IPM, sprays are only applied in response to pest numbers reaching threshhold levels as indicated by monitoring of the crops. In resistance management strategies, the chemical becomes one of a number of sprays used and therefore the number of sprays of endosulfan will be reduced.

None of the growers surveyed use endosulfan without reference to either or both of these management options.

3.6. Overseas Registration Status

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

Some Overseas Countries in which endosulfan is registered

Argentina	New Zealand	Korea
Austria	Greece	Portugal
Bangladesh	India	Taiwan
Belgium	Hungary	Romania
Bolivia	Indonesia	Russian Federation

Brazil	Malaysia	South Africa
Canada	Poland	USA
China	Luxembourg	Spain
Czechoslovakia	Italy	Switzerland
Finland	Israel	Great Britain
France	Norway	Ireland
Pakistan	Japan	

Australian agriculture covers a wide range of geographical regions and climatic 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.. There is some variation in withholding periods, both longer and shorter, but generally they are of the same order.

With respect to regulatory activity in overseas countries, information available to the NRA suggests that The Netherlands will not allow registration of the current forms of endosulfan due to fish toxicity and the cold climate metabolism characteristics. However, if these matters were to be overcome by formulation changes or modifications to use patterns, endosulfan may be acceptable. In relation to registration in Sweden, it is noted that endosulfan is listed as a restricted chemical for environmental and health reasons. However, it may be registered under certain conditions. Advice from an Australian registrant indicates that it is not a commercially viable product in Sweden and therefore registration has not been pursued. The NRA is also aware of activity to limit the use of chemicals which have a certain level of toxicity in the Philippines, and that the toxicity of endosulfan results in it being excluded from use based on its current formulations.

3.6.1. Use Patterns in Relevant Countries Overseas

Endosulfan is mainly used for control of sucking, chewing and boring insects and mites in a very wide range of crops, including cereals, fruit (including citrus), vines, olives vegetables, ornamentals, potatoes, cucurbits, cotton, tea, coffee, rice, cereals, maize, sorghum, oilseed crops, hops, hazels, sugar cane, tobacco, alfalfa, mushrooms, forestry, glasshouse crops etc. It is also used to control tsetse flies.

Detailed information on specific use patterns in other countries is not readily available, although useful information on registered uses and withholding periods is contained in The European Directory of Agrochemical Products (See also Residue Evaluation Report)

3.6.2 MRLs in Overseas Countries

(See also Table 7-9 - Section 3.4)

The major countries to which Australia exports apples, pears and citrus are Singapore, Malaysia, Indonesia and Hong Kong. The UK and Europe is also an important market, with the USA/Canada as an important minor market.

Singapore, which receives some 29% of pear and 22% of apple exports accepts Codex MRLs, as do as Hong Kong and Japan.

Inconsistencies between the Australian and Codex MRLs for various commodities (See Section 3.4) may be a source of difficulty in relation to trade with these countries.

Endosulfan tolerances in the USA are generally similar to the corresponding MRLs in Australia. Although the USA does not recommend general fruit and vegetable MRLs/tolerances, the individual commodity MRLs are comparable to the general values recommended for Australia (2 mg/kg for fruit and vegetables and 0.2 mg/kg for meat).

3.6.3. Codex MRLs

(See also Section 4 - Residue Assessment)

Codex policy has been to remove general fruit and vegetable MRLs and to replace them with individual commodity MRLs where supporting data were available. In instances where supporting data are not available, there would be no MRL for that commodity.

As far as endosulfan is concerned, the general fruit MRL has been retained to date, although it was recommended for removal by JMPR in 1993. Since then, data have been submitted to enable setting of individual commodity MRLs for some of the fruit and vegetable commodities and commodity groups which had been covered by the general MRLs, and it would appear that others may be under development.

3.7. Export Slaughter Intervals

(See also Section 4 - Residue Assessment)

Following a number of incidents of residue violations in beef, an export slaughter interval for cattle of 42 days has been recommended for endosulfan. This means that if stock are fed on plant material containing (or suspected of containing) endosulfan residues, it is recommended that 42 days be allowed after feeding such material before slaughter of the animals.

Research conducted by the Queensland Department of Primary Industries (DPI) at its Animal Research Institute has indicated that the half-life of endosulfan in cattle is 9-10 days. This time period refers to the length of time for half the amount of active chemical present to break down or metabolise. 42 days therefore allows approximately four half lives to reduce endosulfan residues to below the MRL.

DPI also developed data which enabled the MRL for stock food to be increased from 0.03 mg/kg to 0.3 mg/kg. This new value has been incorporated in the MRL Standard.

3.8. Labelling Related to Trade

Labelling of endosulfan products has been amended by the addition of the following warning:

"Residues of this product may persist for long periods on some treated crop stubbles and in hay or silage made from treated crops such as maize, sorghum, grain legumes and table beans.
Feeding of these materials to livestock may produce residues in meat which exceed the maximum residue limits, for as long as 42 days after the last grazing/feeding.

Where it is possible that a crop will be ultimately grazed or form part of livestock feedstuff, avoid using this product late in the season when vegetative growth has been slowed or stopped."

3.9. Data Submitted to Support Compliance with Overseas MRLs

Data have not been submitted to support compliance with overseas MRLs. However, many of the existing MRLs appear to have been established on the basis of either overseas data or MRLs/tolerances. In many cases, Codex MRLs appear to have formed the basis of the Australian MRLs. (See Section 4 - Residue Assessment)

3.10. Authorities and Grower Views on Use

All groups represented during the survey of the current usage of this chemical indicated that this chemical was critical for their respective farming situation or the situations which they represented. A Table with the situations considered to be essential by respective State authorities follows:

Uses of endosulfan advised as essential by State agricultural authorities*

Crops	State / Essential Uses							
	Qld	NSW	Vic	SA	WA	Tas	NT	ACT
Cotton	*Helicoverpa spp* (early season)	*Helicoverpa spp* (early season)			*Helicoverpa spp* green mirid			No essential uses nominated
Pome Fruit	woolly aphid (apples only), thrips, apple dimpling bug, heliothis *(Helicoverpa spp)*	woolly aphid (apples only), thrips, apple dimpling bug, heliothis *(Helicoverpa spp)*	woolly aphid (apples only), thrips, apple dimpling bug, heliothis *(Helicoverpa spp)*		dimpling bug	woolly aphid		
Stone Fruit	IPM programs							
Ornamentals						mites (resistance management), thrips		
Grain Legumes (Pulses)	*Helicoverpa spp*, podsucking bugs (4 species)	*Helicoverpa spp*, podsucking bugs (4 species)					sucking bug complex	
Tropical and Subtropical fruits (including avocados)	fruit spotting bug (2 species), flower feeding caterpillars (mangoes), Pawpaw IPM	fruit spotting bug (2 species)					red banded thrips	
Macadamia	fruit spotting bug, flower feeding caterpillars, green vegetable bug	fruit spotting bug, macadamia flower caterpillar					melon aphid, red banded thrips	
Strawberries						cyclamen mite		
Vegetables (including green beans capsicums, cucurbits, eggplant, tomatoes)	*Helicoverpa spp*, green vegetable bug, Rutherglen bug, fruit spotting bugs, shield bug, eggfruit caterpillar, cucumber moth	*Helicoverpa spp*, green vegetable bug, Rutherglen bug, fruit spotting bugs, shield bug, eggfruit caterpillar, cucumber moth, western flower thrips	*Helicoverpa spp* (field tomatoes, sweet corn), a range of pests in glasshouse tomatoes ***(NOTE: Use in this situation will not be permitted unless satisfactory OH&S data are submitted)***		cucumber moth in Ord River Irrigation Area	Whitefly in glass house tomatoes. ***(NOTE: Use in this situation will not be permitted unless satisfactory OH&S data are submitted), Rutherglen bug***	melon thrips, cucumber moth, melon aphid, eggfruit caterpillar	
Citrus	*Helicoverpa spp*, leafhoppers, spined citrus bug	spined citrus bug IPM		spined citrus bug, leafhoppers and other bugs				
Other	*Helicoverpa spp* and green vegetable bug in tobacco, chewing and sucking pests in babacos and chokos		Tobacco (*Helicoverpa spp*)	lucerne seed wasp and native budworm in lucerne seed crops	*H. armigera* resistance management in all crops in the Ord River Irrigation Area	currant bud mite in blackcurrants, Rutherglen bug in seed crops	Sucking bug complex in pasture legume and other seed crops	

* Notes:

1. State agricultural authorities have nominated these uses on the basis that the viability of the resopective industries would be threatened by removal of endosulfan
2. These uses may be considered essential although there are other products registered for the nominated pests. This is because endosulfan is considered to be an essential part of a resistance management strategy or an integrated pest management strategy.

The main characteristics of endosulfan which were considered to contribute to its status as an essential chemical were:

- it is comparatively soft on beneficials including bees. In this regard, both producers and State departments emphasised the fact that because of this characteristic, secondary pest problems such as rapid aphid and mite population increases are not such a difficulty
- it is effective for the claimed purposes. In spite of the fact that there is documented resistance to the chemical, growers indicate that they are still obtaining acceptable control results in their IPM and resistance management programs
- it is comparatively cheap when compared with many other chemicals
- it is from another chemical group and therefore can be used in resistance management strategies as another chemical rotation.

It is also noted that although growers indicate that they do not see any necessity to alter the rates of use for this chemical, they also advise that they use lower rates than those recommended on the labels of the registered products. It is possible therefore, that the rates of use recommended on the labels for these products could be lowered without adversely affecting the efficacy. Some trial work would be required to establish any changes in rates of use.

Producers have not recorded any difficulties with label directions or actual spray operations. However, one grower commented that it would be helpful if a standard label format was used in setting out common information, given the complexity of some of the labels.

Several growers commented on the difficulty of decanting concentrate out of 5 and 10 L containers and one grower commented on difficulties associated with handling and disposing of 200 L drums.

3.11. Other

The most recent Australian Market Basket Survey provides the following information on endosulfan in the Australian diet.

The ADI for endosulfan is 6 ug/kg bw/day

The estimated intake (total of α-endosulfan, β-endosulfan and endosulfan sulphate) in diets based on the average energy intake range from 0.0131 ug/kg for an adult female to 0.0227 ug/kg for a child aged 2.

The estimated intake (total of α-endosulfan, β-endosulfan and endosulfan sulphate) based on the 95th percentile energy intake range from 0.0235 ug/kg for an adult female up to 0.0305 ug/kg for a child aged 2.

The maximum levels of endosulfan (total of α-endosulfan, β-endosulfan and endosulfan sulphate) found in Australian foods in the most recent Market Basket survey are:

beans, green	0.1049 mg/kg
celery	0.07 mg/kg
lettuce	0.0775 mg/kg
pears (endosulfan sulphate)	

	0.03 mg/kg
tomatoes	0.09 mg/kg

Endosulfan residues have also been detected in several commodities by the National Residue Survey which monitors pesticide residues in export commodities (See Section 3.4). In most cases, these residues have been well below the MRLs for these commodities.

3.12 Summary of Trade

Endosulfan is considered to be an essential chemical by all sectors of primary production surveyed. It is widely used in the production of many horticultural and agricultural crops and is considered to be necessary to the viability of a number of Australia's major export crops.

Advice from the Queensland Department of Primary Industries and NSW Agriculture is that this chemical is presently essential for the continued viability of the cotton industry in Australia. In spite of the introduction of transgenic cotton which produces the *Bacillus thuringiensis* toxin, entomologists are of the opinion that endosulfan with a modified use pattern will still be required by the cotton industry for a number of years to come. This industry has an export value approaching $1 billion.

Production of Australia's major fruit crops such as avocado, pome fruit and citrus would also be seriously affected by any removal or restriction of availability of endosulfan. The chemical is considered to be critical by government departments and growers alike for IPM programs for production of these fruit crops.

The viability of smaller horticultural industries which are in their infancy would also be threatened by limitations on the availability of endosulfan. The Queensland Department of Primary Industries advises that these crops are being established using integrated pest management as the major pest control option. Use of endosulfan in IPM in these programs is critical to their success. Although these industries only have a total value of some $20 million at present, the potential export earnings are considerably greater in the medium to long term.

Another aspect of Australia's trade which is indirectly affected by use of endosulfan is the unintentional contamination of beef with residues. This has resulted either from spray drift onto cattle directly or from cattle being fed contaminated feed. Action has been taken to eliminate the potential for violation of importing countries residue limits, the major initiative of this strategy being the introduction of an export slaughter interval of 42 days.The threat to Australia's trade posed by this issue could be considerable, given that Australian beef exports are worth of the order of $4 billion.

4. RESIDUE ASSESSMENT

4.1 Introduction

Residue questions raised by the meat industry:

1) The Australian meat industry has been alerted by recent residue violations of endosulfan in beef and beef products revealed in part by a special survey conducted by the National Residue Survey (NRS) during the period approximately spanning June 1995 to June 1997. Analyses of cattle fat samples from over 32,600 cattle tested from New South Wales and Queensland found that 176 animals contained endosulfan residues exceeding the existing MRL of 0.2 mg/kg. The Codex MRL is 0.1 mg/kg. The violations were clustered exclusively during the late spring and summer months when endosulfan is applied to crops. Although the overall violation rate was only one half of one percent and although the number of violations in the summer of 1996-1997 (24 violations) was greatly reduced compared to that from the summer of 1995-1996 (152 violations), the industry was concerned over the possibility of increasingly severe problems in the future caused by cattle feed and fodder contaminated with endosulfan.

2) The meat industry is also concerned about endosulfan residues in animal tissues caused by spray drift which lands on livestock directly or on crops that are fed to livestock.

Residue Questions Raised in Relation to Cropping MRLs

In addition to the questions above, it also came to the attention of the reviewers that the MRLs for the crops in Table 1, *MRL Standard*, may not reflect current Australian use patterns.

MRLs of Endosulfan in Australia and Codex

The following MRLs (mg/kg) have appeared in Table 1 and Table 4, *MRL Standard* (1996) and Codex document on MRLs (Joint FAO/WHO Food Standards programme, Codex Committee on Pesticide Residues, the Netherlands, April, 1996):

Table 1, ***MRL Standard***

Code	*Food*	*MRL (mg/kg)*
VR 0577	Carrot	0.2
MO 0812	Cattle, Edible offal of	0.2
MM 0812	Cattle meat [in the fat]	0.2
GC 0080	Cereal grains	0.2
VD 0526	Common bean [navy bean]	1
OC 0691	Cotton seed oil, crude	0.5
PE 0112	Eggs	*0.05
	Fruits	2
VO 0050	Fruiting vegetables, other than cucurbits	2
MO 0814	Goat, edible offal of	0.2
MM 0814	Goat meat [in the fat]	0.2
VD 0545	Lupin (dry)	1
ML 0106	Milks [in the fat]	0.5
VD 0536	Mung beans (dry)	1
SO 0088	Oilseed	1
VA 0385	Onion, Bulb	0.2
SO 0697	Peanut	1
VR 0589	Potato	0.2
PO 0111	Poultry, edible offal of	0.2
PM 0110	Poultry meat [in the fat]	0.2
GC 0649	Rice	0.1
MO 0822	Sheep, edible offal of	0.2
MM 0822	Sheep meat [in the fat]	0.2
VD 0541	Soybean (dry)	1
VO 0447	Sweet corn (corn-on-the-cob)	0.2
VR 0508	Sweet potato	0.2
DT 1114	Tea, Green, Black	30
TN 0085	Tree nuts	2
VO 0448	Tomato	2
	Vegetables [except carrot; common beans; lupin (dry); mung bean (dry); onion, bulb; potato; soybean (dry); sweet corn (corn-on-the-cob); sweet potato]	2

* the limit of analytical quantitation

MRLs adopted from Codex (According to Pesticide and Agricultural Chemicals Committee's meeting records):

Carrots	(1977)
Cotton	(1978)
Fruits	(1977)
Onions	(1977)
Potatoes	(1977)
Rice [in husk]	(1977)
Sweet potatoes	(1977)
Tea [dry manufactured]	(1977)
Tomatoes	(1977)

Vegetables (except carrots, potatoes, sweet potatoes, onions and berry vegetables) (1977)

MRLs set in Australia based upon residue data generated:

Cattle Meat [in the fat]	(1972)
Cereal grains	(1982)
Goat meat [in the fat]	(1980)
Milks	(1972)
Oilseed	(1972)
Peanut	(1975)
Poultry	(1986)
Sheep meat [in the fat]	(1972)
Sorghum	(1981)
Sweet corns	(1983)
Soybeans, mung beans, navy beans, lupins	(1982)

Table 4, ***MRL Standard***

Code	*Animal Feed Commodity*	*MRL (mg/kg)*
	Primary feed commodities	0.3

CODEX MRLS

Code	*Food*	*MRL (mg/kg)*
AL 1021	Alfalfa forage (green)	1
VP 0522	Broad bean (green pods and immature seeds)	0.5
VB 0400	Broccoli	0.5
VB 0403	Cabbage, Savoy	2
VB 0041	Cabbages, Head	1
SB 0715	Cacao beans	0.1
VR 0577	Carrot	0.2
VB 0404	Cauliflower	0.5
VS 0624	Celery	2
FS 0013	Cherries	1
AL 1023	Clover	1
SB 0716	Coffee beans	0.1
VP 0526	Common bean (pods and/or immature seeds)	0.5
SO 0691	Cotton seed	1
OC 0691	Cotton seed oil, crude	0.5
VC 0424	Cucumber	0.5
AO 20002	Fruits (except as otherwise listed)	2#
VP 0528	Garden pea	0.5
FB 0269	Grapes	1
VL 0480	Kale	1
VL 0482	Lettuce, Head	1
VL 0483	Lettuce, Leaf	1
GC 0645	Maize	0.1
MM 0095	Meat (from mammals other than marine mammals)	0.1
VC 0046	Melons, except watermelon	0.5
ML 0106	Milks	0.004
VA 0385	Onion, bulb	0.2
FC 0004	Oranges, Sweet, Sour	0.5
FS 0247	Peach	1
FI 0353	Pineapple	2@
FS 0014	Plums (including prunes)	1
FP 0009	Pome fruits	1
VR 0589	Potato	0.2
SO 0495	Rape seed	0.5
GC 0649	Rice	0.1
VD 0541	Soybean (dry)	1
VL 0502	Spinach	2
VC 0431	Squash, Summer	0.5
VR 0596	Sugar beet	0.1
AV 0596	Sugar beet leaves or tops	1
SO 0702	Sunflower seed	1
VR 0508	Sweet potato	0.2
DT 1114	Tea, Green, Black	30
VO 0448	Tomato	0.5
AL 1028	Trefoil	1
AO 10002	Vegetables (except as otherwise listed)	2#
GC 0654	Wheat	0.2

@ Denotes Post Harvest # Denotes withdrawal recommended (1993 JMPR)

Codex
1 (pome fruits)
1 (pome fruits)
1
2 (fruits)
1 (for cherries, plums and peach)
1
0.5
0.1

It is noted that the current Australian MRL of 0.3 mg/kg for endosulfan in Primary feed commodity, Table 4, *MRL Standard,* was increased from 0.03 mg/kg in 1996 as a result of a request by the industry, because this value was not based upon good agricultural practice and as a result, the residues in animal feed commodities normally exceeded 0.03 mg/kg and the feed commodities could not be sold. After consideration of animal transfer studies (based on continuous feeding tests for 38 days), the current MRL of 0.3 mg/kg was established as the maximum level of endosulfan that can be fed safely to cattle.

It is also noted that the Codex MRLs for **Alfalfa (green)** and **Clover** are set on basis of the use pattern of endosulfan. Animal transfer studies (or MRLs of animal commodities) appear not to have been considered in relation with these MRLs for animal feeds.

4.2. Use Pattern

Endosulfan products are used in Australia on various fruits, vegetables, field crops and pastures to control insect pests such as Heliothis, aphids, thrips, beetles and mites.

Based on current labels available, crops receiving treatments of endosulfan products are listed in the following table. The maximum use rate, the maximum number of applications and the withholding period are also presented. The labels used are Thiodan Insecticide (350 gai /L) or Thiodan ULV Insecticide (240 gai/L) by AgrEvo PtyLtd, Endosulfan 350EC Insecticide (350 gai /L) by Farmoz PtyLtd, Endosan ULV Insecticide (240 gai/L) by Crop Care Australasia (ICI Crop Care) PtyLtd, 350EC or 240 EC Bar Insecticide (350 or 240 gai/L) by Sanonda (Australia) PtyLtd, Endosulfan 350EC Insecticide (350 gai/L) and ULV 240 (240 gai/L) by Nufarm PtyLtd, Endosulfan 350EC (350 gai/L) or 240 ULV (240 gai/L) by Crop King PtyLtd, Endosulfan Insecticide (350 gai/L) by Rhone-Poulenc and Thionex 350 EC Insecticide (350 gai/L) by Makteshim-Agan (Australia) PtyLtd.

Off-label use was also checked with the Permit Group, Agricultural Registration Section of the NRA. Several permits are current for use on crops such as vetch and carrots for new pests. It is advised that there is off-label use legislation in Victoria where permits are not required for off-label use. One of the criteria of the off-label use is that the use should not be in conflict with a specific label condition/limitation/instruction required by the NRA as a condition of registration.

Crop	Pest	Maximum Rates	Max. No. of applications	Timing of applications	Method of application	WHP (days)
Apple	Thrips, Dimpling bugs	67 gai /100 L	5	Early pink to full Bloom	Air blast	14
Avocados	Spotting bugs etc	53 gai/100L	2	Infestation	Spray	14
Babacos	Spotting bugs	70 gai/100L	Unspecified	Unspecified	Spray	14
Bananas	Spotting bug etc	53 gai/100L	2	Infestation	Spray	14
Beans - green	Heliothis etc	735 gai/ha	Unspecified	Infestation	Spray	1
Beans: Soybeans, navy beans, mung beans	Heliothis etc	735 gai/ha	Unspecified	Infestation	Spray	28
Beetroot	Webworm aphids	67 gai/100L	Unspecified	Infestation	Spray	1
Berry fruit - currants & related fruit	Bud mite	67 gai/100L	2	Open flower	Spray	14
Blueberries	Beetles etc	53 g/100L	Unspecified	Infestation	Spray	14
Canola (oilseed rape)	Heliothis etc	735 gai/ha	Repeat as necessary	Infestation	Spray	28
Capsicums, okra, cape gooseberry	Thrips, aphids, white flies etc	735 gai/ha or 67 gai/100L	Every 10-14 days	Infestation	Spray	7
Cassia round leaf	Heliothis	720 gai/ha	Unspecified	Infestation	Spray	28
Carrots	Aphids	67 gai/100L	Repeat as required	Infestation	Spray	7
Carambolas	Spotting bugs	70 gai/100L	Unspecified	Unspecified	Spray	14
Carobs	Moth	70 gai/100L	Unspecified	Unspecified	Spray	14

Cashews	Heliothis etc	70 gai/100L	Unspecified	Unspecified	Spray	14
Casimiroas	Spotting bugs	70 gai/100L	Unspecified	Unspecified	Spray	14
Celery	Aphids etc	67 gai/100L	Every 10-14 days	Infestation	Spray	7
Cereals	Army worms, Heliothis	735 gai/ha	Unspecified	First sign of pest	Spray	28
Chick Peas, cowpeas, pigeon peas, adzuki beans, faba beans (broad beans)	Heliothis	ULV 3 L/ha 735 gai/ha	1-2	Flowering	Aerial and ground	28
Citrus including mandarins, lemons, oranges, grapefruit	Spined citrus bug	20 gai/100L	Unspecified	Overwintering pests and upon infestation	Spray	14
Chou moellier	Aphids	735 gai/ha	Unspecified	Infestation	Spray	28
Clover & medic seed crops	Heliothis Mites	735 gai/ha	Unspecified	Infestation	Spray	28 (grazing)
Coconuts	Peach moth	70 gai/100L	Unspecified	Unspecified	Spray	14
Cole vegetables (Brassicas)	Cabbage white butterfly, moth etc	735 gai/ha	Every 10-14 days	Unspecified	Spray	1
Cotton	Heliothis	ULV 3 L/ha 735 gai/ha	2-7 Average of 4	Boll fill / early season	Aerial and ground	28
Cucurbits	Aphids, thrips etc	67 gai/100L	Every 10-14 days	Unspecified	Spray	1
Custard apple	Spotting bug etc	53 gai/100L	2	Infestation	Spray	14
Durians	Spotting bugs	70 gai/100L	Unspecified	Unspecified	Spray	14
Eggplant	Aphids, thrips etc	735 gai/ha	Every 10-14 days	Infestation	Spray	7
Fruit: pome & stone	Aphids etc	67 gai/ha	Unspecified	Unspecified	Spray	14
Granadillas	Bugs	70 gai/100L	Unspecified	Unspecified	Spray	14
Grapevines	Thrips	67 gai/100L	Unspecified	Pre-blossom or as required	Spray	14
Grain legumes	Earth mite	350 gai/ha	Unspecified	Infestation	Spray	28 (Harvest) 42 (grazing)
Guavas, persimmons	Spotting bugs etc	53 gai/100L	2	Spring & autumn	Spray	14
Jaboticabas	Mirid bugs	79 gai/100L	Repeat as necessary	Unspecified	Spray	14
Kiwifruit	Caterpillars etc	53 gai/100L	Every 7-14 days	Pest present	Spray	14
Leafy vegetables (including Chinese cabbage, kale, mustard, spinach etc)	Aphids etc	735 gai/ha	Every 10-14 days	Pest present	Spray	1 (harvest) 42 (grazing)
Legume pasture seed crops, grass seed crops	Heliothis Budworm	720 gai/ha	Unspecified	Unspecified	spray	28 (grazing)
Legume vegetables (Common bean, green peas, green beans, lima beans, snow peas)	Podboror, aphids, Heliothis, caterpillar etc	ULV 3 L/ha 735 gai/ha	Repeat as necessary	Infestation	Ground or aerial spray	1 (harvest) 42 (grazing)
Linseed	Heliothis	735 gai/ha	Repeat as necessary	Infestation	Spray	28 (harvest or grazing)
Longans	Bugs	70 gai/ha	Repeat as necessary	Unspecified	Spray	14
Loquats	Bugs	70 gai/100L	Every 2-4 weeks	Unspecified	Spray	14
Lucerne (seed crops)	Heliothis	735 gai/ha	Unspecified	Infestation	Boom spray and aerial	28 (grazing)
Lupins	Helicoverp aphids	735 gai/ha	Repeat as necessary	Infestation	Spray	28 (harvest or grazing)
Lychees	Caterpillars	53 gai/ha	2	Flowering or Infestation	Spray	14

Macadamia nuts	Spotting bugs etc	53 gai/100L	3 or as required	Unspecified	Spray	14
Maize	Heliothis	735 gai/ha	Repeat sprays	Infestation	Spray	28
Mammey (Mammey apples)	Thrips	70 gai/ha	Repeat as necessary	Infestation	Spray	14
Onions	Thrips	67 gai/100L	As required	Unspecified	Spray	7
Passion fruit	Bugs etc	53 gi/100L	As required	Unspecified	Spray	14
Pasture (new sowings - direct drill or bare earth)	Mites	350 gai/ha	Unspecified	Unspecified	Spray by ground rig	28 (grazing)
Pasture (including clover, medic, lucerne, cereals, and legumes for animal feed)	Heliothis bugs, thrips, lucerne seed wasp, webspinner caterpillars, armyworms	735 gai/ha	Unspecified	To young insects	Spray	28
Pawpaws	Bugs	53 gai/ha	2	Infestation	Spray	14
Peas - field and green	Looper Aphids	735 gai/ha	Unspecified	Infestation	Spray	28 (harvest or grazing) 1 (harvest green beans)
Peanuts	Heliothis	735 gai/ha	Unspecified	Before pests develop	Spray	7
Pecan nuts	Heliothis	980 gai/ha	Unspecified	Infestation	Aerial or ground spray	14
Pine apples Post-harvest	Bugs	70 gai/100L	Unspecified	Infestation	Spray	14
Potatoes	Thrips, aphids etc	735 gai/ha	Every 10-14 days	Unspecified	Spray	7
Rambutans	Bugs	70 gai/100L	Unspecified	Pest damage	Spray	14
Raspberries	Bugs	70 gai/100L	Unspecified	Infestation	Spray	14
Rhubarb	Oriental cornboror	70 gai/100L	Unspecified	Infestation	Spray	7
Rollinias	Spotting bugs	70 gai/100L	Unspecified	After fruit set	Spray	14
Rosella	Worms, loopers	70 gai/100L	Unspecified	Infestation	Spray	7
Safflower	Heliothis	735 gai/ha	Unspecified	First sign of pest	Spray	28 (harvest or grazing)
Sapodillas	Peach moth	70 gai/100L	Repeat as required	Infestation	Spray	14
Shallots	Worms, loopers, bug	735 gai/ha	Unspecified	Infestation	Spray	7 (Harvest) 42 (grazing)
Sesame	Bugs	735 gai/ha	Unspecified	Unspecified	Spray	28
Silverbeet	Webworm	735 gai/ha	Unspecified	Unspecified	Spray	1
Sorghum	Heliothis	ULV 3 L/ha EC 2.1 L/ha	1-2	Flowering	Aerial and ground	28
Soybeans	Blue butterfly Moth	735 gai/ha	Repeat as necessary	Unspecified	Spray	28 (harvest or grazing)
Sunflower	Heliothis	ULV 3 L/ha 735 gai/ha	Repeat as necessary	Budding / Flowering	Aerial and ground	28 (harvest or grazing)
Strawberries	Mite, Heliothis	67 gai /100 L	Unspecified	At planting	Boom spray	14
Swede, turnip	Aphids etc	735 gai/ha	Every 10-14 days	Unspecified	Spray	1 (harvest) 42 (grazing)
Sweet corn	Heliothis	735 gai/ha	Unspecified	Unspecified	Spray	7
Sweet potato	Leaf minor	735 gai/ha	Every 10-14 days	Unspecified	Spray	7
Tamarillos	Bugs, aphids etc	70 gai/100L	Every 14 days	Unspecified	Spray	14
Taro	Caterpillars	70 gai/100L	Repeat as required	Pest damage	Spray	7
Tomatoes	Heliothis	735 gai/ha or 67 gai/100L	Every 14 Days	Throughout the season	Boom spray	1
Vetch (common)	Mite aphid Heliothis	735 gai/ha	Unspecified	Unspecified	Spray	28 (harvest or grazing)
Yellow mombins	Spotting bugs	70 gai/100L	Unspecified	Unspecified	Spray	14

ULV - 240-250 Ultra low volume formulation
EC - 350 Emulsifiable concentrate

Withholding periods: It is noted that a grazing withholding period (WHP) is specified on some labels (e.g. Farmoz) but not on others.

Some labels have a Label Warning attached to it which reads “Residues of this product may persist for long periods on some treated crop stubbles and in hay or silage made from treated crops such as maize, sorghum, grain legumes and table beans. Feeding of these materials to livestock may produce residues in meat and milk which exceed the maximum residue limit, for as long as 42 days after the last grazing/feeding. Where it is possible that a crop will be ultimately grazed or form part of livestock feedstuff, avoid the use of this product late in the season when vegetative growth has been slowed or stopped”.

It is noted that on most labels, legume seed crops are to be treated. Only on one label (Rhone-Poulenc), is it specified that endosulfan is also used on legume pasture, which includes seed crops and general grazing crops.

In terms of animal feeding, major crops are cereals and legume pastures. It is estimated that, on average, other treated crops, including cotton, vegetables and fruits will not exceed 20% in animal diets. In drought situations, the percentage of such crops in animal diets may increase.

Regarding crop types, major uses would be cereal (grains) including sorghum and maize, legumes (vegetables or pulses and animal feeds), vegetables (leafy, fruiting, root and tuber vegetables), fruits (pome and stone fruits) and cotton.

In terms of distribution of endosulfan usage in crops, major crops are cotton (72%), vegetables (20.5%), oilseeds (3%), pome and stone fruit (2%), exotic fruit (2%) and others (<0.5%) (based on information provided by one registrant, see Trade Report, ECRP Review, Endosulfan). Apparently, cereals and pastures are the smallest use groups for endosulfan.

According to the survey results of Performance Questionnaires by the ECRP program for endosulfan, it appears that only cotton would be sprayed several times (up to 4) in a season. The vast majority of crops would be sprayed only once or twice during the season. Where multiple applications occur, an interval of re-application would be 7-10 days for cotton and 10-14 days for vegetables. Exceptional use patterns occur during plague conditions as described by a NSW Agriculture official (fax correspondence dated 3/8/1995 for a follow up study on an MRL violation incident) in which a bean crop with plague conditions was sprayed 4 to 6 times with as brief as 1 to 2 day application intervals.

4.3. Metabolic studies

4.3.1. Animal Metabolism

Lactating Cows

Reference - Keller JG (1959), Subacute feeding study-dairy cows, Report No. A14206, Hazleton Laboratories, Palo Alto California.

Dairy cows were exposed to ^{14}C-labelled Thiodan (specific activity 4.35-1.9 µCi/mg) for 30 days, and the partitioning of endosulfan residues into various body tissues and the rate of residue depletion were studied. Blood samples were also analysed for endosulfan residues. Daily dosages of 0.3, 3.0, and 30 mg/kg in hay (dryweight) were administered to groups of three animals through the diet. At the end of the 30 day treatment period, two animals from each group were immediately sacrificed and the third was sacrificed after being fed on an endosulfan free diet for 14 more days. The total radioactive residues (expressed as mg/kg ^{14}C Thiodan equivalents) in the kidney, liver, omental fat and blood samples were determined by radioassay. The highest concentration of total radioactive residue was found in the liver at all dosage levels (see Table 4.1.3.1). At the end of the 30 day treatment period, the residue concentration in the livers of two animals from each group averaged 0.35, 2.45, and 25.3 mg/kg at the 0.3, 3.0, and 30 mg/kg dosage levels, respectively. ^{14}C Thiodan-derived residues depleted from the livers during the 14-day recovery period at the rate of 69%, 55%, and 37% for the 0.3, 3.0, and 30 mg/kg dosage levels, respectively. In the kidney, no apparent loss of ^{14}C Thiodan-derived residues was observed during the 14 day recovery period at 0.3 mg/kg dosage level but depletions of 62% and 78% were observed for the 3.0 mg/kg and 30 mg/kg dosage levels, respectively. In the fat tissue, the ^{14}C Thiodan—derived residues depleted more rapidly (71% , 83%, and 98% for 0.3, 3.0, 30 mg/kg dosage levels, respectively) during the 14 day recovery period.

In the blood, ^{14}C Thiodan-derived residues were below the sensitivity of the method (<0.06 mg/kg) on the first day of treatment for both 0.3 mg/kg and 3.0 mg/kg dosage levels and <0.17 mg/kg for 30 mg/kg dosage. No apparent change in the residue in blood was evident during the entire study period for 0.3 mg/kg dosage. At 3.0 and 30 mg/kg dosages, the residue concentrations gradually increased during the 30 day treatment period but decreased to <0.06 and 0.94 mg/kg, respectively, during the 14 day recovery period.

Table 4.1.3.1 Total radioactive residues in the liver, kidney, and omental fat, expressed as mg/kg of ^{14}C Thiodan equivalents.

Dosage	Liver		Kidney		Omental fat	
(mg/kg)	0 day*#	14 day**	0 day*#	14 day**	0 day*#	14 day**
0.3	0.35	0.11	0.05	0.05	0.07	<0.02
3.0	2.45	1.10	0.34	0.13	0.71	0.12
30	25.3	16.0	6.29	1.36	7.08	0.13

* Termination of the 30-day feeding period.
** 14 days after the termination of the 30-day feeding period.
# average from two animals.

Lactating Goats

Reference - Indraningsih, McSweeny, CS, and Ladds, PW, Residues of Endosulfan in the tissues of lactating goats. ***Aust. Vet. J.*** **1993, 70(2), 59-62.**

In this study, technical grade endosulfan was orally administered at the rate of 1 mg/kg body weight to 12 lactating goats for 28 days. The dose rate was calculated to be equivalent to *ca.* 29 mg/kg of endosulfan in the feed.

At the end of the 28 day treatment, groups of 3 animals and their respective offspring were slaughtered at 1, 8, 15, and 21 days and various tissue samples were collected for analysis. Higher total residues (in mg/kg) were found in kidney (0.29), gastro-intestinal tract (0.20), and liver (0.12) compared to the fat (0.06) at day 1. Also at day 1, residues of 0.06, 0.04, 0.04, 0.02, 0.006, and 0.006 mg/kg were seen in the brain, muscle, spleen, milk, heart, and lung, respectively. The residue levels declined in all tissues after day 1, except in the kidney where the residues peaked at 0.47 mg/kg on day 8. No detectable residues were found in milk on day 8. On the third week of sampling residues were not detected in any tissues tested. The sulfate was the main residue in the liver and fat, whereas all other tissues contained mainly α–endosulfan (see table below). No residues were detected in the tissues of the offspring except for traces of α–endosulfan present in the liver on day 1.

The analytical method involved the extraction of the sample into hexane/acetonitrile followed by gas chromatographic analysis. Recoveries for α–endosulfan, β–endosulfan, and endosulfan sulfate were 93.1±2.3%, 90.5±4.6%, and 84.5±5.7%, respectively, and the results have been adjusted for the respective recovery rates.

Table 4.1.2.1 Residues of endosulfan in organs of goat, 24 hours after dosing with technical grade endosulfan at the rate of 1 mg/kg body weight for 28 days.

	α–Endosulfan	β–Endosulfan	Endosulfan sulfate
Kidney	0.220	0.059	0.012
Gastro-intestinal tract	0.190	<0.001	<0.001
Liver	0.010	0.021	0.097
Fat	0.015	0.002	0.040
Muscle	0.033	0.009	<0.001
Spleen	0.026	0.010	0.002
Lung	0.006	<0.001	0.001
Heart	0.005	<0.001	<0.001

Sheep

Reference - Gorbach SG et al (1968), Metabolism of Endosulfan in milk sheep. *J.Agr. Food Chem*. 16(6):950-953.

Lactating sheep were given a single dose (0.3 mg/kg body weight) of ^{14}C-labelled (methylene group) endosulfan (specific activity 95 µc/mg). The dosage was calculated to be equivalent to *ca.* 8 mg/kg in the feed. Total radioactivity was eliminated in 22 days through faeces (50%), urine (41%), and milk (1%). The residue concentration in the milk dropped to 2.0 ppb during this period. After 40 days, analysis of one animal indicated that the residue concentrations in selected organs and tissues (liver, large intestine, and fat) were less than 0.03 mg/kg. Unchanged endosulfan was found in the faeces but not in the urine. Two main metabolites in the urine were the endosulfan diol and the endosulfan hydroxy ether.

Mice

Reference - Kellner & Christ (1968), Investigations with Endosulfan-^{14}C in mice. Report No. A14217(German), A53842(Translation), Hoechst, Germany.

Mice were treated with ^{14}C-endosulfan, and excretion and distribution was measured radiometrically. The substance was administered in three ways; as a single dose (80 µg in 0.5 mL of oil), as a single dose incorporated in the diet (18.6 mg/kg), and as a 21 day feeding period at the rate of 18.6 mg/kg in the diet. The main route of elimination of the substance was via faeces. Up to 25% of the radioactivity was eliminated in the urine after the end of the 21 day feeding period. Analysis of organ and tissue samples indicated a rapid elimination of the substance after the single dose compared to the prolonged feeding.

At 21 days after the single dosing, a maximum concentration of 0.2 mg/kg of was found in the lung and liver. By comparison, 21 days after the termination of the prolonged feeding, a maximum residue of 2.6 mg/kg was found in the liver (Table 4.1.5.1). The total radioactivity recovery of the study was *ca.* 94%.

Table 4.1.5.1 Total ^{14}C endosulfan residue in various tissues (at 21 days after the final treatment) for the three treatment regimes.

Organ, tissue	Total radioactive residue expressed as ^{14}C Endosulfan equivalents (mg/kg)		
	Treated with 80µg in 0.5 mL of oil per animal (4mg/kg b.w) SINGLE DOSE	Treated in the diet at 18.6 mg/kg SINGLE DOSE	Treated in the diet 18.6 mg/kg for 21 days
	21 days after treatment	21 days after treatment	21 days after the last treatment
Liver	0.2	0.07	2.6
Lungs	0.2	0.03	0.7
Kidney	0.1	0.02	0.6
Muscle	0.08	0.01	0.5
Fat	0.08	0.01	0.2
Brain	0.08	0.02	0.4

Rats

Reference 1—Dorough HW et al (1978), Fate of Endosulfan in rats and toxicological considerations of apolar metabolites. Pestic. Biochem. Physiolo. 8:241-252.

Metabolism of individual isomers, α– and β–, of ^{14}C-endosulfan in rats was investigated by administration of a single oral dose and as a dietary supplement for 14 days. Four dosage regimes used 5 mg/kg of α– or β–endosulfan, 25 mg/kg α–endosulfan, and 25 mg/kg of a mixture of 7:3 α– and β–endosulfan. Both isomers appear to behave in similar fashion with 75% and 13% of the single dose being eliminated via faeces and urine, respectively, after 5 days. Of the total radioactivity consumed in the 14 day feeding period, 56% had been eliminated in the faeces and 8% in the urine. After 14 days of feeding at 5 mg/kg of endosulfan, maximum ^{14}C-endosulfan equivalents in the body tissue occurred in the kidney and liver, *ca.* 3 mg/kg and 1 mg/kg, respectively. At 5 mg/kg dosage, residue concentration in the visceral fat and subcutaneous fat showed greater variability compared to other tissues, but no apparent accumulation in the fat was evident 3 days after the termination of the 14 day treatment period (Table 4.1.6.1).

Table 4.1.6.1 Residue concentrations in different organs of rats fed at 5 mg/kg of ^{14}C labelled endosulfan in the diet. The concentrations are expressed as ^{14}C endosulfan equivalents.

Days	Kidney	Liver	Vicseral fat	Subcutaneous fat	Muscle	Brain
On treatment						
1	0.43	0.29	0.29	0.31	0.02	0.03
14	3.23	1.07	0.56	0.23	0.05	0.07
Post treatment						
1	3.04	0.86	0.44	0.05	0.05	0.05
3	2.05	0.53	0.21	<0.02	0.02	0.06
7	1.60	0.32	<0.02	<0.02	<0.02	0.04
14	0.93	0.15	<0.02	<0.02	<0.02	0.02

Reference 2 - Kellner & Eckert (1983), Hoe 02671 - ^{14}C: Pharmacokinetic and residue determinations after oral and intravenous administration to rats. Report No. A49584(German), A49745(Translation), Hoechst, Germany.

In another study, ^{14}C-endosulfan (labelled at 1,2,3,4, and 7 positions of the molecule) was administered orally (2 mg/kg body weight, equivalent to 40 mg/kg in the diet) and by intravenous injection (0.5 mg/kg body weight) to male and female rats. There were sex dependent differences in the development of the blood levels. Maximum concentrations in the blood, after oral administration, were found to be 0.25± 0.06 mg/kg (males) and 0.18±0.05 mg/kg (females). Excretion was higher in the faeces than in the urine independent of the route of administration. Highest concentrations 7 days after oral administration were found in the kidneys (1.8 mg/kg) followed by liver of males (0.23 mg/kg) or liver of females (0.48 mg/kg) and retroperitoneal fat of the female (0.16 mg/kg). The concentrations were less than 0.15 mg/kg in all other organs and tissues including the fat. Radioactivity recoveries were up to 98% of the applied dose.

4.3.2 Overview - Animal Metabolism

The metabolism studies indicate that endosulfan sulfate is the major metabolite in animal tissues. While total radioactivity was mainly found in liver and kidney (for cattle), endosulfan sulfate was concentrated more in the offal than in fat (goat study). Compared to cattle, it seems that goats could have a much higher metabolism/elimination rate for endosulfan if the residue values cited in Table 4.1.2.1 approximate plateau values. At the feeding level of *ca.* 29 mg/kg in the diet, residues were about 0.06 mg/kg in the fat of goat 24 hours after last feeding. At a similar feeding level (30 mg/kg), cattle had residues of 7.08 mg/kg, expressed as total radioactivity, on day 0 after the last dosing. The residues decreased with time in offal and fat in the cattle study.

Sheep metabolism suggested that elimination of endosulfan occurred within 3 weeks after a single administration.

4.3.3 Plant Metabolism

Apples

Reference - Schwab W (1995) Metabolism in apples (*Malus sylvestris* var. domestica) following single treatment of a young tree with ^{14}C-labelled test substance. Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. CM93/040, Document No. A53662. 19 January 1995.

^{14}C-labelled [5a,9a]-endosulfan was applied to a young apple tree at the rate of 1.5 kg ai/ha by hand spraying to investigate the residue content in the fruit and the degradation of the substance on the leaves. In the fruits, the total radioactive residue has been identified as the isomers α– and β–, and the sulfate, amounting to 0.50, 0.43, and 0.02 mg eq/kg or 50.7, 43.1, 1.5% of total radioactivity, respectively, at day 21. In leaves, two additional metabolites were detected, of which only one was identified as the endosulfan diol. The major residue component on the leaves after 21 days was found to be the sulfate, amounting to 12 mg/kg (51% of the applied radioactivity) followed by the β-isomer (29%). The relative ratio between the α–isomer to β–isomer varied from 2:1 in the initial mixture to 0.3:1 after 21 days presumably due to high volatility of the α–isomer. However, different metabolism rates of the two isomers with the formation of the sulfate could also play an important role. Total radioactive recoveries as determined by liquid scintillation counting were 97% and 87% for fruits and leaves, respectively. The residue composition was determined by HPLC, TLC, and GC-MS techniques.

Tomato

Reference - Burkle WL & Wurz S (1990), Hoe 002671 (Endosulfan)-14C metabolism in tomato plants after three applications at a rate of 635 g/ha. Report No. A44894. Hoechst Aktiengesellschaft, Germany, 17 December 1990.

To investigate the metabolism of endosulfan on tomato plants, ^{14}C-labelled substance (at positions 6,7,8,9, and 10) was applied 3 times at 7 day intervals at the rate of 635 g ai/ha. The leaves were sampled up to 48 days after the last application and analysed for residues by HPLC and scintillation counting. Consistent with its much greater volatility, the α–isomer dissipated faster compared to the β–isomer. There were indications of a degradation product containing three Cl atoms formed in minor quantities. Endosulfan diol and the endosulfan lactone were also formed as minor metabolites. The extractable residues were greater than 73% of the total radioactive residues. The composition of the bound residue was analysed after acid or enzymatic hydrolysis of the leaf samples, which indicated that a significant portion consisted of the conjugates of the endosulfan diol (50% of the bound residues). The total radioactive residues in the tomato fruits decreased from 0.4 mg eq/kg (on day 27) to 0.03 mg eq/kg (day 48). The isomers, α– and β– (2:1), comprised *ca.* 75% of the total radioactive residue on the tomatoes. Endosulfan sulfate accounted for 15% (27 days after the last treatment).

Cucumber

Reference - Burkle WL (1995), Hoe 002671 Metabolism in cucumber (*Cucumis sativus*) following three treatments with the 14C-labelled test substance at 7 day intervals and a nominal rate of 530 g ai/ha each. Report No. CM93/039. Document No. A56011. Hoechst Schering AgrEvo GmbH, Germany, 27 November 1995.

The metabolism of endosulfan on cucumber plants was investigated by 3 applications of ^{14}C-labelled endosulfan at 7 day intervals at the nominal rate of 530 g ai/ha. Leaf and fruit samples were analysed up to 14 days after the last application. Both leaf and cucumber samples gave the same three main components, α–isomer, β–isomer and the sulfate. Endosulfan sulfate was present as the main component at 21.4% and 17.7% in the cucumber and leaf samples, respectively. Analysis of the more polar components after acid hydrolysis of the samples indicated the presence of the endosulfan diol at a level of 5.7% of the total radioactive residues. The extractable residues ranged between 87-90% and 79-91% in the cucumber and leaves, respectively, mainly consisting of the α–isomer, β–isomer and endosulfan sulfate. Analyses were carried out using HPLC, MS, and liquid scintillation counting techniques.

4.3.4 Overview - Plant Metabolism

Plant metabolism studies indicated that endosulfan sulfate is the main metabolite in plants. With prolonged treatment, more polar metabolites were formed on plant leaves consisting mainly of the conjugates of endosulfan diol. The ratio between the α–isomer and β–isomer (2:1) changes with time in favour of the β–isomer presumably due to the higher volatility of the α–isomer compared to the β–isomer. However, different metabolism rates of the two isomers with the formation of the sulfate could also play an important role.

4.4. Analytical methods

Most of the currently available methods are based on GLC techniques coupled with electron capture detection. The majority of the methods are capable of detecting endosulfan and its main metabolite, endosulfan sulfate in plant and animal materials.

Analytical methods used in the determination of endosulfan have been reviewed by JMPR (1989). A typical method would involve the following:

Sample to be analysed is homogenized in a solvent, usually n-hexane or acetonitrile, and filtered. The filtrate is further purified by solvent extraction using water/n-hexane or water/acetonitrile. The organic layer is dried with sodium sulfate and further purified by column chromatography (eg. on florosil, eluting with 30%-50% diethyl ether in n-hexane). The eluate is then evaporated to dryness and the residue redissolved in a known volume of n-hexane. An appropriate portion of the hexane solution is injected into the gas chromatograph for separation and final analysis of the components.

In general, LODs of 0.01 mg/kg have been reported for each of the α-isomer, β-isomer, and endosulfan sulfate. The method recoveries were in the range of 69-120%.

4.5. Residue Definition

The current residue definition for endosulfan is the sum of α-isomer, β-isomer, and endosulfan sulfate. This residue definition is consistent with that used by JMPR and Codex. The analytical methods described in Section 4.4 adequately measure all the components in the residue definition.

4.6. Residue Studies on Crops

Several incidents involving endosulfan MRL violations in cattle meat have taken place in recent years as a result of animal feeding of endosulfan treated crops or crops contamined with spray drift. A follow up study was undertaken by the NSW Agriculture Department. The incident and the residue study are presented below:

Follow up study on an incident of MRL violations

Reference - Fax message from K.W. McDougal, NSW Agriculture, 4/8/1995, 10 pages

Because endosulfan residues were found in calves at higher than the MRL of 0.2 mg/kg on a farm, NSW Agriculture conducted a follow up study of the incident and analysed endosulfan residues in crops that were, or were likely to be, fed to animals. The crops identified were bean plants and sorghum. Detailed application number and pre-harvest interval or WHP were not provided in some cases.

In the first situation, bean plants were treated with endosulfan (350 EC) 4-6 times before harvest, with the last application sprayed 14 days before harvest (the WHP is 28 days). Immediately after harvest, cattle were allowed to graze the plants for 8 days, while grazing pastures at the same time. Calves were weaned 17 days and slaughtered on the 18th day.

A total of 27 calves out of 41 showed endosulfan residues higher than the MRL of 0.2 mg/kg in fat.

Bean plants were collected for residue analysis 75 days after last spray, or 61 days after harvest. Sorghum samples were also taken about 120 -150 days after spray. High residues were found in the samples collected. It remains unknown whether residues were expressed on wet or dry weight basis. The analyst indicated "as received". Residue results from bean plants and sorghum are summarised below in the table:

Table 7.1 Residues in bean plants and sorghum (leaves, heads and grains)

Crops & parts	Appl. rate (gai/ha) & No.	Pre-Harvest Interval & (Pre-sampling days)	Residues (mg/kg)			Total residues (mg/kg)
			alpha -	beta -	sulfate	
Bean plants (fodder)	735 (4-6)	14 (75)	0.98	1.5	4.4	6.9
Bean plants (fodder)	735 (2-3)	10 (42)	1.8	3.4	4.8	10
Sorghum (head)	735 (?) (ULV)	? (110)	0.06	0.35	0.73	1.1
Sorghum (leaf)	735 (?) (ULV)	? (110)	0.5	2.3	7.1	7.9
Sorghum leaf	735 (?)	? (120-150)	1.1	4.2	5.4	9.7
	(ULV)		0.06	0.15	2.6	2.8
			0.27	0.64	3.6	4.5
			0.38	1.4	4.9	6.7
			0.11	0.26	3.4	3.8
			0.3	0.93	5.3	6.5
Sorghum heads	735 (?)	? (120-150)	0.01	0.03	0.52	0.56
	(ULV)		0.02	0.10	0.44	0.56
Sorghum grains	735 (?)	? (120-150)	<0.005	0.007	0.06	0.07
	(ULV)		0.005	0.01	0.07	0.08
			0.008	0.02	0.02	0.05

The results showed that major residues were endosulfan sulfate among the plant organs analysed. Residues remained high after harvest of plants and were in the same order of magnitude in both bean plants and sorghum leaves. However, it should be noted that sorghum was collected much later than beans. Unfortunately, it is unknown whether leaf samples of sorghum were from living plants or dead stubble in the field.

It is evident that residues in sorghum leaves were generally greater than 40 times those in sorghum grains. Assuming residues in beans (dry) were 1 mg/kg (the MRL in the *MRL Standard*) and the residues in bean plants would decline to 3 mg/kg on day 28 after last spray, the residues in bean plants would still be 3 times higher than in the grain.

The findings on the higher residues in leaves than grains of sorghum and beans are expected to have a general application to other crops, as it is recognised that endosulfan is not a systemic insecticide and grains are normally protected from direct spray by a layer of tissues (e.g. shell, pod, etc).

The above analyses did not show a time course of residue decline in living plants or the residue situations at the label specified WHP of 28 days. However, the bean study showed that the maximum residues were 10 mg/kg at 14 days after application and 75 days before harvest. At a half-life of 14 days (see Section 7.2), the residues at 28 days after application would be 5 mg/kg. In the event that this data was expressed on wet weight basis (for forages), residues in fodder (dry weight) should be at least 2x higher.

In the following sections, data provided by registrants from studies conducted mainly in Germany or Spain were reviewed. Two studies on cotton and one study on soybeans were available from Australia.

4.6.1 Animal Feeds

Crops such as cereals including sorghum, wheat and barley, and legume pastures constitute a major part of animal feeds in the form of fodder (hay), forage, or grains (e.g. sorghum and lupin pulses). These crops are therefore treated separately in this section. It should be pointed out, however, that the trials usually did not measure residues in fodder or forage.

Legume Animal Feeds

Reference - Endosulfan, Pesticide Residues in Food, 1989, JMPR

Legume animal feeds, including alfalfa, red clover and trefoil, were sprayed once with endosulfan. The residues in supervised trials carried out over several years showed large variations (Table 7.2.1).

The results show that residues declined with time, rapidly in the early stage within 14 days after application and then slowly. In fresh (green) forage after a PHI of 21 days, residues ranged from 0.1 to 1 mg/kg, whereas after 14 days residues exceeded 1 mg/kg in 1 of 6 trials. In most of the trials however, residues were about 0.6 - 0.7 mg/kg. No data were available on the residues in dry matter, e.g., in fodder. The highest residues of 0.99 mg/kg on day 21 in fresh weight are likely to approximate 4 mg/kg in dry weight, assuming that water content is 80% of the green material. The half-lives of the residues in the trials varied from 2 - 14 days, but were generally on the order of 3-7 days.

It is noted that the JMPR evaluation has not considered animal feeding at the residue level of 0.99 mg/kg in animal diet when recommending the current Codex MRL of 1 mg/kg for alfalfa (green).

Table 7.2.1 Residues resulting from supervised trials on legume animal feed and miscellaneous fodder and forage crops

Crop	Year of trial	Application		Formula-tion	Total residue, mg/kg Interval (days) after application				
		No.	Rate ai (kg/ha) (g/100L)		0/1	3/4	7	14	21
Alfalfa forage (green)	1977	1	0.53	EC35		20.3	7.5	0.64	
	1978	1	0.35	EC35	6.8	7.2	5.2	2.9	0.99
	1977	1	0.35	EC35		10.6	4.7	0.6	
	1977	1	0.21	EC35		2.7	1.2	0.35	
	1974	1	0.21	WP35	16.2	4.6	1.3		
	1974	1	0.21	WP35	12.6	0.6	0.2		
	1974	1	0.21	WP35	9.0	0.1	0.15		
	1974	1	0.21	EC35	17.3	3.6	1.3		
	1974	1	0.21	EC35	4.6	0.15	0.14		
	1961	1	0.28	EC	14.5		2.4	0.2	0.05
	1961	1	0.28	EC	2.7		1.0	0.1	0.1
Clover, red	1974	1	0.21	WP35	12.8	0.9	0.4		
	1974	1	0.21	EC35	8.6	1.2	0.7		
	1974	1	0.21	WP35	10.0	2.8	2.0		
	1964	1	0.21	EC	8.2		2.2	0.6	0.3
Trefoil	1964	1	0.28	EC	6.8		1.0	0.7	0.6

Sorghum

Reference - Thiodan Residues - Sorghum, Hoechst Australia Limited, 13.11.80.

As sorghum is identified as one of the sources of endosulfan violation in cattle meat, it is dealt with in this section.

Sorghum was sprayed once with Thiodan ULV at a rate of 3.0 L (0.72 kg ai/ha). Samples of sorghum grains were taken from treated plants 58 days after application and stored frozen. Grains samples were analysed with GC by AnalChem PtyLtd for the alpha-, beta-isomers and endosulfan sulphate. Recovery rates of over 80% were obtained for all three compounds.

Residue results indicate that alpha- beta-isomers were below the limit of detection of 0.05 mg/kg, whereas **the sulphate was detected at 0.1 mg/kg.** No time course study was provided.

Reference - Colson, C (1981) Thiodan EC & ULV and Decis EC & ULV for control of Heliothis & sorghum midge in sorghum, Hoechst Australia Limited

Sorghum was sprayed once with Thiodan ULV and EC at rates 0.72, 0.735 and 1.44 kg ai/ha in Quirindi, NSW. Samples of sorghum heads were taken on days 21 and 28 days after application. Sorghum grains were thrashed out of heads by hands before bulking and sent to AnalChem PtyLtd for residue analysis. Residue data presented were only for ULV applications at the rates of 0.72 and 1.44 kg ai/ha, however. Detection limit = 0.002 mg/kg.

The applicant commented that by 28 days after spraying, the residues were mainly in the form endosulfan sulphate.

It is noted that residues were also detected at high concentrations in untreated control samples. The applicant did not indicate whether they were true numbers or interference from other sources in the chromatography.

Sample, appl. rate (kg/ha) and formulation	WHP (days)	Endosulfan residues (mg/kg)			
		alpha	beta	sulfate	total
Untreated		0.07	0.08	0.07	
Grains, 720 (ULV)	21	0.004	0.03	0.32	0.37
	28	<0.002	0.02	0.15	0.17
Grains, 1440 (ULV)	21	0.55	0.18	0.35	1.05
	28	0.01	0.05	0.52	0.58

The data appear to be part of an application for registration in Australia. The MRL of 0.2 mg/kg was set for Cereal grains.

Reference - Singh YP et al (1988) Residues of phosphamidon, Endosulfan and monocrotophos in/on sorghum grains. Indian Journal of Entomology 50 (1), 17-23.

Endosulfan was sprayed twice, at an interval of 15 days, to sorghum plants at a rate of 0.5 kg (mistaken as mg in the article) ai/ha. Samples of sorghum grains were taken at days 0, 5, 11 and 20 (at harvest) after second application and stored deep frozen. Solvents were used to extract endosulfan residues which were eventually stored frozen. Recovery rate was unknown and residue analysis was done with a bioassay technique using fruit fly

(Drosophila melanogaster). A standard curve for mortality of fruit fly against endosulfan concentration was presented.

Results (Table 7.3.3) indicated that endosulfan decreased in sorghum grains with time. The researchers concluded that the half life of endosulfan in sorghum grain was 12 days.

Table 7.3.3 Residues in sorghum grains treated with endosulfan and sampled 58 days after second spray

Sample	Appl. Rate	Appl No.	Residues (mg/kg) day 0	day 5	day 11	day 20
Sorghum grains	0.5 kg/ha	2	3.12	1.13	0.40	undetected
			2.86	1.16	0.37	undetected
			3.44	1.22	0.37	undetected

4.6.2 Other Crops, Including Vegetables, Fruits And Cotton

Cereals (wheat, barley, maize, sweet corn), beans (soybeans, navy beans, mung beans & other grain pod crops, lupins)

Reference - Thiodan ULV Insecticide, Additional Use Claims, Supplement to Submission To TGAC/PACC, dated 9th October, 1981, Hoechst Australia Limited, AgrVet Department, Section E - Residues, 31/5/1982

Information provided in this reference was supplied in support of registration in Australia (1982). The registrant provided overseas and Australian residue data generated on wheat, barley, corn, and soybeans. Endosulfan was applied generally one time at the rate below the current Australian use rate of 735 gai/ha. Samples in Australian trials were analysed by AnalChem Pty Ltd for endosulfan residues including endosulfan sulfate.

The residue results indicated that endosulfan sulfate was the major component of the residues in soybeans, and not barley, at 28 days after application (Table below). Both overseas and Australian data revealed that residues declined with time in the grains or heads (barley), with a general half life of 7-10 days at high concentrations (above 1 mg/kg). At low concentrations, the residues declined at a lower rate with a much longer half life. The company indicated that the high residues of 0.24 mg/kg in barley on day 28 were not in line with the decline trend of the rest of the residue data.

It is noted from the French trial that corn cob leaves contained endosulfan residues 91 days after one spray at the rate of 1,225 gai/ha.

Table 7.3 Residues in trialled wheat, barly, corn grains and soybean seeds

Crop & trial location	Appl. No. & interval days	Appl. rate (g ai/ha) (formulation)	WHP (days)	Residues (mg/kg) alpha	beta	sulfate	total
Wheat grains	1	315 (EC)	0				0.8
			7				0.3
			14				0.1
Germany	1	630 (EC)	0				2.5
			15				0.2
			22				0.2
	1	630 (EC)	0				0.9, 1.1
			11				0.2, 0.4
			21				0.2, 0.2
France	1	525 (EC)	34				0.03
			36				0.1
			53				0.09

Barley grains, Australia	1	350 (EC)	4	0.13	0.56	-	0.67
			9	0.05	0.48	-	0.53
			12	0.05	0.24	-	0.29
			13	0.05	0.20	-	0.25
			20	0.02	0.10	-	0.12
			26	0.013	0.045	-	0.058
			28	0.05	0.19	-	0.24
Barley head*, Australia	1	360 (ULV)	5	9.5	14.8	<0.1	24.4
			19	0.3	0.64	0.1	1.04
			26	0.3	0.7	0.09	1.09
	1	480 (ULV)	5	27.8	58.4	1.9	88.1
			19	0.77	1.2	0.17	2.14
			26	0.5	0.74	0.16	1.40
Corn grain, Germany	1	1.05 (EC)	70				0.02 0.02
Corn grain, France	1	1.225 (EC)	91				nd
Corn cob leaves, France	1	1.225 (EC)	91				1.26 1.26
Corn cob, France	1	1.225 (EC)	91				nd
Soybean (seed)	2	735 (EC)	14	nd**	nd	nd	nd
			21	nd	0.04	0.12	0.16
			28	0.02	0.04	0.21	0.27
Australia	2	1.470 (EC)	14	nd	nd	nd	nd
			21	0.02	0.07	0.19	0.28
			28	nd	0.02	0.07	0.09
	1	720 (ULV)	21	nd	nd	nd	nd
			28	nd	nd	0.01	0.01
	1	1.440 (ULV)	21	0.01	nd	nd	0.01
			28	0.01	nd	nd	0.01
	1	735 (EC)	21	nd	nd	nd	nd
			28	nd	nd	0.02	0.02
	1	1,440 (EC)	21	nd	nd	0.03	0.03
			28	0.02	nd	0.13	0.15

* Barley heads only were collected as samples, as barley grains were not separable from the heads at early growth stage.
* Limit of detection = 0.01 mg/kg

The company argued that due to the similarity of the use pattern, the residue data generated from soybeans (seeds) should be applicable to other legume plants such as navy beans, mung beans, lupins and other grain pod crops. The MRL of 0.2 for Cereals and 1 for the beans and lupins were established on the basis of these data.

Other information on residues of endosulfan in the crops mentioned above is also available in the following references and therefore summarised below.

Wheat

Reference - Krebs B (1994), Endosulfan residues data summary from supervised trials and processing studies in wheat. Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. PSR94/030, Document No. A53969. 12 December 1994.

Summary data from thirteen trials conducted in Germany and France were available for review. However, the majority of trials did not reflect Australian use patterns (0.74 kg ai/ha, 28 day WHP).

Table 7.5 Residues in cereals after treatment with endosulfan

Country	Crops & parts	Appl. rate (kg ai/ha)	App. No.	WHP (days)	Total residues
Germany & France	Wheat grain Bran	2.10	1	28	0.19 0.28

	Bread (whole meal)				0.13
	Bread (refined meal)				0.049
France & Germany	Maize stem & leaves	0.70	2	0 28-48	3-12 2.68
	Maize grain	0.70	2	63-70	0.015 - 0.02
	Maize cob leaves	0.70	2	54 70	0.2 0.065
	Maize Stem & leaves	0.66		54 - 70	0.97
	Maize grain	0.66		54 - 70	0.015

In one trial conducted in Germany, wheat plants were sprayed once with 350 EC formulation at the rate of at 2.10 kg ai/ha (ca. 3 times the Australian rate) at the formation of grains. After 28 days, analysis of grains, bran, whole meal bread, and refined meal bread revealed residues of 0.19, 0.28, 0.13, and 0.049 mg/kg, respectively. Three other studies with the same formulation (1 application at 0.53 kg ai/ha) gave a maximum residue 0.03-0.10 mg/kg in 34-53 days.

Maize

Reference - Krebs B (1994), Endosulfan residues data summary from supervised trials and processing studies in maize. Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. PSR94/031, Document No. A53970. 12 December 1994.

Summaries of studies conducted in France and Germany on maize between 1974 and 1983 have been provided.

In six studies, 2 applications of the 350 EC formulation were made at the rate of 0.7 kg ai/ha and stem and leaves, cob, cob leaves, and grain were analysed over a period of up to 70 days. The last application was made 2-2.5 months before harvest. Stem and leaves had residues of 3.0-12.00 mg/kg (day 0) which reduced to a maximum residue of 2.68 mg/kg at 28-48 days. Whole cob had 0.015-0.1 mg/kg in the period of 14-48 days. The grain residue was determined at 63-70 days and was found to be low (0.015-0.02 mg/kg). Grain residues have not been determined around the current WHP in Australia. Cob leaves had residues of 0.2-0.065 mg/kg at 54-70 days. The recoveries were 76-100% with an LOD of 0.01 for individual components of the residue.

In other studies, a higher concentration (1.05 kg ai/ha) of the 350 EC formulation was applied once to maize plants, which resulted in a maximum residue of 0.015 mg/kg in the whole cob at day 14.

Studies conducted in 1983 with the 329 g/kg WP formulation at the rate of 0.66 kg ai/ha gave a maximum residue of 0.97 mg/kg in the stem and leaves. The grain residues were low (0.015 mg/kg) but the data corresponds to analyses carried out 54-70 days after the last application.

Only limited residue data are available on stem and leaves of maize and there are no data available for fodder, hay or forage of cereals in general. The maize data suggest that endosulfan residues were about 3 mg/kg in leaves at the WHP of 28-48 days and 1.3 mg/kg at 91 days. It is unknown whether the residues were expressed on dry or wet basis. But it is noted, as drawn from two Indian publications, that endosulfan in sorghum leaves or cowpea fodder had a half life of 1.33 or 2.8 days, respectively. As the analytical methods were not up to standards and the application rates were unclear, the data were not further evaluated.

Legume Vegetables

Reference - Krebs B (1994), Endosulfan residues data summary from supervised trials and processing studies in Legume vegetables (fresh). Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. PSR94/025, Document No. A53964. 12 December 1994.

Summaries of studies on beans and peas conducted in Germany and Spain have been provided with the submission. The trials did not normally reflect Australian use patterns. Residues measured included endosulfan sulfate. In the succulent seeds, residues were all lower than 0.5 mg/kg on the WHP of 14 or 21 days. Fodder or forage was not analysed for residues.

Crop	No. of trials	Application			Portion analysed	Residues	WHP
		Rate (kg ai/ha)	Conc (ai%)	No.		(mg/kg)	(days)
Dwarf bean	4	0.21-0.32	0.035	3	Seed with pods	0.015 - 0.06	11-14
	8	1.21 - 2.1	0.105	1	Seed with pods	0.01 - 0.05	14
Broad bean	3	0.32	0.035	3	Seed with pods	0.02 - 0.09	14
	1	0.32	0.053	1	Seed with pods	0.3	21
						0.03	28
Peas	4	0.32	0.053	3	Seed with pods	0.02 - 0.2	11-21
						0.01- 0.02	20-28

Fruiting Vegetables

Reference - Krebs B (1994), Endosulfan residues data summary from supervised trials and processing studies in fruiting vegetables. Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. PSR94/023, Document No. A53962. 12 December 1994.

Summary reports on supervised trials on tomatoes conducted in Germany have been submitted for evaluation.

Tomatoes

The data from trials conducted with application rates similar to that of Australia (0.74 kg ai/ha, 1 day WHP) were assessed. The highest residues were 0.244 mg/kg at a WHP of 1 day in the fruit. The sulfate was the predominant species. The current MRL of 2 mg/kg for tomato would seem to be too high based on these residue data.

Oilseeds

Reference - Krebs B (1994), Endosulfan residues data summary from supervised trials and processing studies in oilseeds. Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. PSR94/026, Document No. A53965. 12 December 1994.

Summaries of supervised studies conducted on Oilseed rape, soybean, cotton, and sunflower have been provided with the submission.

Table 7.9 Residues in oil seeds after treatment with endosulfan.

Country	Crops & parts	Appl. rate (kgai/ha)	Appl. No.	WHP (days)	Total max. residues (mg/kg)
(not specified)	Oilseed rape	0.75	3-4	26	0.04
				28	0.03
		0.9	1	28	0.33 and below
		0.42	2	39	0.3
Australia	Soybeans	0.72	1	28	0.03
		1.44	1	28	0.03
		0.77		28	0.02
		1.44		28	0.15
Brazil	Soybeans	0.53	1-3	29	0.08
					0.3
		0.53	1-2	30	0.6
Australia	Cotton seed	0.74	13-15	25	0.035
				44	0.02
Spain	Cotton seed	0.63 - 1.11	1	0	0.68-2.99
				15	0.02-0.25
USA	Sunflower seed	0.84-1.12		74-109	0.008-0.61

The residue results support the existing MRL of 1 mg/kg for Oilseed for the use pattern described in the above Table with a WHP of 28 days. As cotton is the major crop for endosulfan use, cotton residue trial data are summarised below.

Cotton

Reference - as above for Oilseeds

Two Australian studies were conducted in 1974, where 13-15 aerial applications of 350 EC formulation were applied on cotton plants at the rate of 0.74 kg ai/ha. Growth stage at last application varied from just before boll opening to 10% boll opening. Seed residues at 25 and 44 days after the final application were found to be between 0.02 mg/kg and 0.035 mg/kg. The metabolite endosulfan sulfate had been included in the residue analysis.

More recent studies conducted in Spain used one application of the 350 EC formulation at the rate of 0.63 -1.11 kg ai/ha. Growth stage at application varied from 15-80% bolls open. Residues in seeds of 0.68-2.99 mg/kg at day 0 decreased to 0.25-0.02 mg/kg at day 15.

No residue data on other parts of the plant were available for evaluation.

The Australian and Spanish residue data support the existing MRL of 1 mg/kg for Oilseed, provided that the residues measured included endosulfan sulfate.

Pome Fruits

Reference - Krebs B (1994), Endosulfan residues data summary from supervised trials and processing studies in oilseeds. Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. PSR94/020, Document No. A53959. 12 December 1994.

Summaries of trials conducted in Germany and the UK between 1967 and 1987 on apples and pears were available. However, the data were not considered suitable for the establishment of Australian MRLs for this commodity group because the use rates of all trials were less than 50% of the Australian rate (2 kg ai/ha, 14 WHP). The summarised results are presented asfollows:

Table 7-26 - Residues of endosulfan in pome fruits from studies conducted in Europe

Crops	No. of trials	Application rate kgai/ha	 No.	Portion analysed	WHP (days)	Residues (mg/kg)
Apple	5	0.4-0.53	4	fruit	21	0.055-0.63
	4	0.7	3	fruit	21 28	0.015-0.1 0.015-0.03
	3	0.49-0.74	4	fruit	21-22	0.06-0.7
	4	0.85	2	fruit	20-21	0.015-0.019
Pears	4	0.85	2	fruit	21-22	0.03-0.6

From the data shown, the current Australian MRL of 2 mg/kg would be considered marginally low.

Stone Fruits

Reference - Krebs B (1994), Endosulfan residues data summary from supervised trials and processing studies in stone fruit. Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. PSR94/021, Document No. A53960. 12 December 1994.

Summaries of a total of 30 studies conducted in Germany (28 trails) and Spain (2 trails) have been submitted for evaluation. However, all trials conducted in Germany used lower application rates than the Australian use rate of 2 kg ai/ha (WHP 14 days). The two trials conducted more recently (in 1992) in Spain on peaches used rates comparable to those of Australia. No details of the analytical methods are available. The residue data of the two Spanish trials on peaches are summarised in the following table (7.11.1).

Table 7.11.1. Residues of endosulfan in peaches from studies conducted in Spain.

Formulation: 350 EC No of applications: 1 Growth stage: harvesting		
Application rate (kg ai/ha)	Withholding period (days)	Residues (mg/kg)
1.68	0 3 7 15	2.67 1.00 0.98 0.73
1.94	0 3 7 15	3.85 0.88 0.50 0.31

The data support a MRL of 2 mg/kg for peaches (in Stone fruit) at a WHP of 14 days.

Potatoes

Reference - Krebs B (1994), Endosulfan residues data summary from supervised trials and processing studies in potatoes. Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. PSR94/027, Document No. A53966. 12 December 1994.

Summaries of 3 studies conducted in Germany in 1983 have been considered for evaluation. The data are shown in the Table 7.12.1. No detectable residues of α–, β–, and endosulfan sulfate were found in any sample tested up to 14 days after application (LOD of 0.01 mg/kg). Analytical method recoveries for all three residue components were in the range of 115-119%.

Table 7.121. Residues of endosulfan in potato tubers from studies conducted in Germany.

Formulation: 28.2 g/kg DP Application rate: 0.71 kg ai/ha Growth stage: 14 days before harvest		
No. of Applications	Withholding period (days)	Total Residues* (mg/kg)
2	0-14	0.015
2	0-14	0.015
3	0-14	0.015

* α– , β–, and the sulfate all below LOD.

These residue data support the current Australian MRL of 0.2 mg/kg for potatoes at the same use patterns.

Savoy cabbages

Reference - Krebs B (1994h), Endosulfan residues data summary from supervised trials and processing studies in savoy cabbage. Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. PSR94/024, Document No. A53963. 12 December 1994.

Summaries of 33 studies from Germany conducted during the period of 1974-1983 indicated a maximum 0 day residue of 21.46 mg/kg in the cabbage head. Formulations 350 EC and 329-350 WP were used at the rate of 0.21-0.53 kg ai/ha as 1-3 applications. At 5-7 days, the residues were in the range of 0.035-3.43 mg/kg.

The residue data do not support the current Australian MRL of 2 mg/kg for Vegetables at a 1 day WHP. The Australian use rate of 0.735 kg ai/ha is higher than the trial rate.

4.7. Animal Transfer Studies

Biopsy Study on Cattle

The following three transfer studies were conducted in 1995 and 1996 in Australia and reviewed by the Residue Section of the NRA in 1996. The review has resulted in the establishment of the current MRL of 0.3 mg/kg for Primary feed commodities in Table 4, *MRL Standard*. The residue trials and review results are presented as follows:

Reference - Endosulfan uptake study: Preliminary report. Meat Research Corporation, 1996

Two groups of 6 Hereford steers were fed either 0.3 or 3 mg/kg endosulfan in the diet daily for 38 days. The composition of the endosulfan administered was 70:30, α:β. One animal which did not eat the treated ration initially had the daily dose administered by stomach tube. Tail base fat biopsies were taken at either 0, 3, 9, 17, 30 and 38 days or 0, 6, 13, 22, 30 and 38 days. All animal body weights increased slightly over the duration of the trial. Analysis was by GLC with electron capture detection. Recovery was above 85% for both α and β endosulfan and endosulfan sulfate. Only endosulfan sulfate was measured.

The results are given in Table 8.1.1.

At both dietary intakes, the fat residues did demonstrate a plateau, with the plateau concentration estimated to be reached between 2 and 3 weeks. A dose-response relationship was also demonstrated.

The average plateau concentrations were 0.081 mg/kg at 0.3 mg/kg and 0.85 mg/kg at 3 mg/kg. The biomagnification factors (plateau concentration/diet concentration) were 0.27 and 0.28 at 0.3 and 3 mg/kg respectively.

The median of the maximal residues at 0.3 mg/kg was 0. 078 to 0. 081 mg/kg. At 3 mg/kg intake the median residue was between 0.81 and 0.94 mg/kg.

Table 8.1.1 Residues of endosulfan sulphate in steers fed at 0.3 or 3 mg/kg in the diet for 38 days.

Mg/kg in diet	day 0	day 3	day 6	day 9	day 13	day 17	day 22	day 30	day 38
0.3	< 0.005	0.016		0.043		0.078		0.078	0.07
0.3	< 0.005	0.009		0.041		0.072		0.068	0.07
0.3	< 0.005	0.012		0.024		0.096		0.099	0.1
0.3	< 0.005		0.015		0.045		0.072	0.066	0.062
0.3	< 0.005		0.017		0.051		0.076	0.08	0.081
0.3	< 0.005		0.019		0.049		0.091	0.1	0.079
3.0	< 0.005	0.44		0.8		0.8		0.94	0.88
3.0	< 0.005	0.17		0.37		0.54		0.58	0.57
3.0	< 0.005	0.061		0.086		0.3		0.72	0.7

3.0	< 0.005		0.19		0.64		0.81	0.75	0.78
3.0	< 0.005		0.18		0.84		1	1	1
3.0	< 0.005		0.23		0.96		0.89	1.2	1.1

It should be noted that endosulfan sulphate was not present in the treated feed, that only endosulfan sulphate was measured to determine the final residue and subcutaneous tail fat was assumed to be a reliable indicator of overall fat residues. The trial described below demonstrates that equivalent residues can be seen whether endosulfan sulphate is or is not added to the isomers in the feeding mix, that endosulfan sulphate is the only significant residue seen in the fat of animals and that subcutaneous tail fat residues are representative of maximum fat residues.

Reference - Mawhinney, H. (1996) Characteristics of Endosulfan depletion in the fat of cattle following ingestion of contaminated feed, Final Report (DAQ. 109), Queensland Department of Primary Industries

Five groups of five Hereford steers were fed 0.1, 26.2 (average), 2, 5 and 2 mg/kg total endosulfan in the diet daily for 12 days and thereafter given clean feed while the trial continued for a further 28 days. The composition of the endosulfan dose for groups 1, 3 and 5 was 1:3:6 of α:β:sulphate and for group 1 was 1.05:1:4.5. Group 4 was only administered the isomeric forms in the ratio α:β : 1:3. Subcutaneous fat was biopsied from the tail base on days 1, 7, 14, 21, and 28 after cessation of feeding treated feed. On day 28, perirenal fat, liver and kidney were also sampled. The method used was as described in study above.

Depletion curves indicated that the half-life for groups 2 to 5 were on average 7.2 days (95% CI = 6.6 - 8 days) (see table 8.1.2.1 and Fig 8.1.2.1). For group 1 (@ 0.1 mg/kg) the half-life was 25.4 days (95% CI = 18.8 - 39.1 days). This extended half-life at the lowest treatment rate could account for a slow second elimination phase. This second phase appears to occur at less than the current MRL of 0.2 mg/kg. Other results are given in Table 8.1.2.2.

The decline curves show that at the feeding level of 2 mg/kg, endosulfan sulfate dissipates to below the MRL of 0.2 mg/kg on day 21 after withdrawal from feeding. At the feeding level of 5 mg/kg, the residues at 28 days were 0.24 mg/kg which would require at least another 14 days to decline to the MRL of 0.2 mg/kg (see residues of 0.21 mg/kg at feeding level of 2 mg/kg on day 14, Table 8.1.2.1). In other words, the sulfate would be reduced to the MRL of 0.2 mg/kg 42 days after withdrawal from feeding at 5 mg/kg.

Fig. 8.1.2.1. Residue decline curve in biopsied fat of cattle which were consecutively fed endosulfan for 12 days at the rates of 5, 2 and 2 mg/kg.

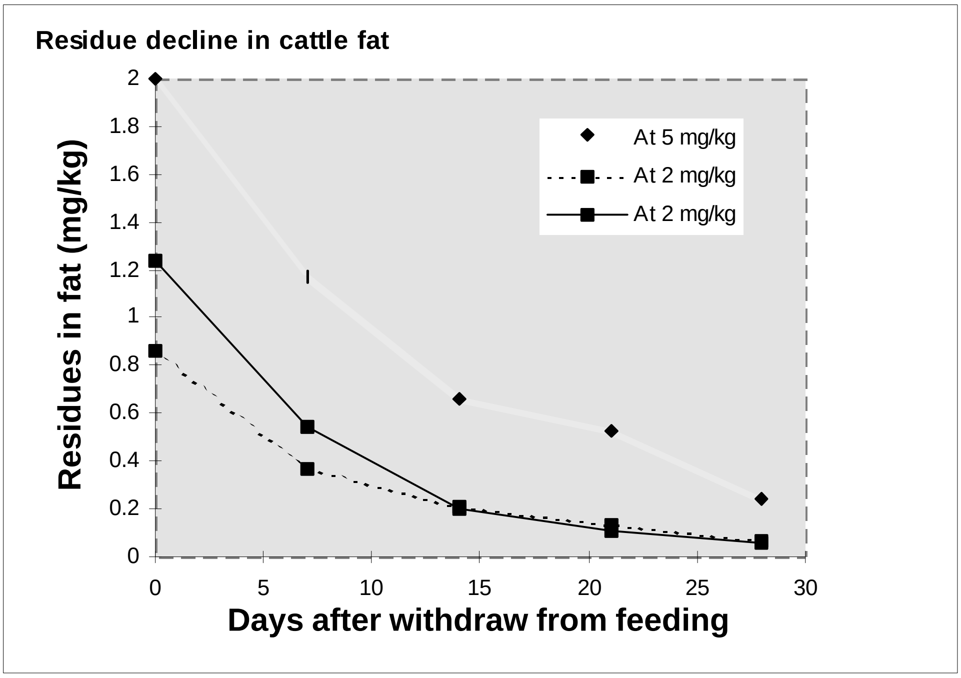

Table 8.1.2.1 Residues (mg/kg) of endosulfan sulfate in cattle (fat around rim/tail).

Daily Dosage (mg)	Concentration in feed (mg/kg) Feeding for 12 days	Post Treatment (days) 0	7	14	21	28
*	17.2 (2.8, 2.6, 11.8)	4.18-12.0	2.93-7.89	1.73-3.15	0.82-2.65	0.36-1.57
50	5.0 (0.5, 1.5, 3.0)	0.75-2.00	0.07-1.17	0.31-0.66	0.11-0.53	0.07-0.24
20	2.0 (0.2, 0.6, 1.2)	0.17-0.86	0.18-0.37	0.15-0.21	0.08-0.13	0.03-0.07
20	2.0 (0.5, 1.5, 0.0)	0.24-1.24	0.18-0.54	0.10-0.20	0.05-0.11	0.03-0.06
1.0	0.1 (0.01, 0.03, 0.06)	0.02-0.04	0.01-0.03	0.02-0.03	0.01-0.02	0.01-0.02

* This group of animals were fed lucerne bailed product treated with endosulfan.
Numbers within brackets in the 2nd column correspond to the relative amounts of isomers α– and β– , and the sulfate.

Table 8.1.2.2: Plateau concentration, biomagnification and retention indices in an endosulfan depletion study

Group	mg/kg in feed	av day 12 fat residue* (mg/kg)	biomagnification factor
1	0.1	0.03	0.3
2	26.2	9.88#	0.38
3	2	0.45	0.23
4	5	1.47	0.29
5	2	0.62	0.31

* measured as endosulfan sulphate
# β residues were: <0.01 to 0.057 mg/kg

Although no data were presented to indicate that each treatment group had reached plateau residue levels in fat, the data presented in the above table is consistent with the dose-response relationship seen in 7.1.1 with the exception of group 3. Group 3 (treatment at 2 mg/kg in the diet) would have been expected to have a plateau at around 0.65 mg/kg instead of the 0.45 mg/kg as seen.

The results for both 2 mg/kg treatment groups (groups 3 and 5) were fairly equivalent and indicate that similar results could be obtained by treating feed with both isomers and the sulphate or both isomers alone.

When compared to liver and kidney residues, subcutaneous fat samples had on average 4x the residue in liver samples and 10x the residue in kidney samples. The offal MRL is the same as that for fat, ie 0.2 mg/kg. Comparison of tail, brisket and renal fat residues indicated no significant differences between the various fat depots.

Table 8.1.2.3 The distribution of endosulfan sulfate residues in the fat from three different sites at slaughter (28 days after the termination of feeding).

Concentration in feed (mg/kg)	Rim/tail	Brisket	Renal
17.2 (2.8, 2.6, 11.8)	0.36-1.57	0.30-1.92	0.25-0.84
5.0 (0.5, 1.5, 3.0)	0.07-0.24	0.066-0.18	0.048-0.15
2.0 (0.2, 0.6, 1.2)	0.03-0.07	0.034-0.069	0.027-0.061
2.0 (0.5, 1.5,0.0)	0.03-0.06	0.031-0.077	0.022-0.058
0.1 (0.01, 0.03, 0.06)	0.01-0.02	0.008-0.017	0.007-0.014

Reference - Endosulfan depletion trial, S.E. Dunn, 30 October 1995, DAN 092.

Cattle (cows and steers) that had been exposed (time of exposure not stated) to treated sorghum stubble with endosulfan residues of 4.5 - 9.7 mg/kg were used in a residue depletion trial. Initially 21 animals were sampled on day 1 but only 12 were carried through to sampling on days 11 and 28 (slaughter). These 12 animals had the highest residues at the initial sampling and were kept on residue free feed until slaughter at day 28. Subcutaneous fat samples were taken on days 1, 11 and 28 with renal fat also sampled on day 28. All animals either gained weight slightly or maintained body weight for the 28 days of testing.

The initial residues in the 12 animals ranged from 0.95 to 2.4 mg/kg (mean = 1.62 mg/kg). Residues at slaughter ranged from 0.04 to 0.57 mg/kg (median residues at 0.18 mg/kg and mean at 0.20 mg/kg). The highest residues at slaughter were seen in the heaviest/fattest steers. These animals initially weighed over 450 kg and gained 10 to 30 kg bodyweight in the last 14 days but residue depletion was only 15 to 30% of the initial residue. Other animals that had very high initial residues depleted to less than 10% of the initial residue and only maintained bodyweight over this period. The half life in these heavy steers was estimated as 13.4 days whilst the other animals ranged from 5.9 to 6.5 days. Renal fat levels ranged between 30 to 72% of the sc fat levels.

Reference - Determination o Thiodan I, II, and sulfate residues in milk and cow tissues. Niagara Chemical division, FMC Corporation, R&D Department, Middleport, New York. 1965

Milk cows were fed a combination of endosulfan isomers (5.0 mg/kg) plus endosulfan sulfate (5.0 mg/kg) in their diets, daily for 30 days. Two cows were killed at the end of the treatment period. A further 2 animals were maintained on a control diet for an additional 30 days prior to being killed. Milk samples were collected at specified times throughout the study.

Endosulfan sulfate was the only residue detected in the milk and tissues. In the milk, the sulfate was present in amounts ranging from 0.01 to 0.16 mg/kg (on whole milk basis) (Table 8.1.4). The sulfate was also detected in fat (0.89 mg/kg), liver (0.63 mg/kg) and kidney (0.07 mg/kg) tissue samples of cows killed immediately following treatment. In the animals from the withdrawal group, only the fat samples contained residues of endosulfan sulfate (about 0.14 mg/kg). This is consistent with a half life in fat of about 7-14 days.

Table 8.1.4. Residues in milk and tissues of milking cows

Days after feeding started	Milk residues of endosulfan sulfate (mg/kg)			
	Cow 1	Cow 2*	Cow 3	Cow 4
0	ND	ND	ND	ND
2	0.05	0.022	0.02	0.02
8	0.16	0.034	0.08	0.05
10	0.15	0.063	0.04	0.05
14	0.12	0.047	0.06	0.05
18	0.14	0.061	0.07	0.05
22	0.16	0.072	0.08	0.03
26	0.11	0.031	0.06	0.04
30	0.12	0.051	0.05	0.04
37	0.02	ND		
44	0.01	ND		
51	ND	ND		
60	ND	ND		
Tissues on day 30	Tissue residues of endosulfan sulfate (mg/kg)			
Fat	0.89	0.89	trace	0.14
Liver	0.63	0.49	ND	ND
Kidney	0.07	0.05	ND	ND
Muscle	ND	trace	ND	ND

* The residues for this cow were uncorrected for recovery and could be higher.
Recovery was 92% for endosulfan sulfate and 83% for endosulfan α-, β- isomers in milk, and 91 and 90% in tissues, respectively.
ND = not detectable
Trace = 0.01 - 0.02 mg/kg

Sheep, goat, milks, poultry, eggs

No adequate transfer studies are available for these categories. Some published papers did not address residue decline in the tissues or milks and hence were not reviewed.

4.8. Storage Stability and Processing

Summaries of processing studies on tomatoes, apples, plums, soybeans, and wheat have been provided with the submission.

Apples

Reference - Krebs B (1994), Endosulfan residues data summary from supervised trials and processing studies in pome fruit. Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. PSR94/020, Document No. A53959. 12 December 1994.

A processing study indicates that the residues concentrate in the peel, core and pomace. The peeled apples and apple cider contained no detectable residue. Other studies also indicate similar trends where residues were found to be 5-30% (in juice and mash) and 140-160% (in pomace) compared to the initial level in the fresh fruit.

Soybeans

Reference - Krebs B (1994), Endosulfan residues data summary from supervised trials and processing studies in oilseeds. Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. PSR94/026, Document No. A53965. 12 December 1994.

Studies from Brazil indicated that endosulfan residues could concentrate up to 3-4 times in the crude oil when raw beans were ground and solvent extracted. Very little or no residues were found in the pressed cake. The oil refining process generally tends to reduce the residue content, but in one case it was shown that the refined oil contained a similar level of residue as the crude oil. Baking and cooking of the beans tend to reduce the endosulfan residue content by 30-50%.

Wheat

Reference - Krebs B (1994), Endosulfan residues data summary from supervised trials and processing studies in wheat. Hoechst Schering AgrEvo GmbH, Federal Republic of Germany, Report No. PSR94/030, Document No. A53969. 12 December 1994.

One study from Germany investigated the effect of processing on the residue content in wheat grain. After one application at the rate of 2.1 kg ai/ha, the grain contained a residue of 0.19 mg/kg (at 28 days PHI). Bran, wholemeal bread, and refined bread had residues of 0.28 mg/kg (150% of the grain residue), 0.13 mg/kg (68%), and 0.045 mg/kg (24%), respectively.

Cotton

Reference - JMPR 1971 & 1974)

JMPR 1971 has reviewed some data on cotton products. Cotton plants were aerially sprayed with Thiodan 2 EC at the rates of 1.13 kg ai/ha and 3.39 kg ai/ha for 5 applications each and harvested 9 days after the last application. The residues in various processed products are shown in Table 9.6.1. Current Australian labels recommend lower rates (maximum of 0.74 kg ai/ha) and a longer withholding period (28 days) for grazing and harvest. Residues concentrate in the linters and linter motes by a factor up to 14.

Table 9.6.1 Maximum residues in cotton products 9 days after application of Thiodan 2 EC.

Product	Rate (kg ai/ha)	Maximum residues (mg/kg)		
		α– and β–isomers	Sulfate	Total
Ginned seed	1.13 3.39	0.20 0.80	0.05 0.36	0.25 1.16
Crude oil	1.13 3.39	0.13 0.24	0.03 0.04	0.16 0.28
Refined oil	1.13 3.39	ND 0.14	ND 0.03	ND 0.17
Linters	1.13 3.39	0.29 2.8	ND ND	0.29 2.8
Linter motes	1.13 3.39	2.4 15.2	1.19 4.2	3.6 19.5
Hulls	1.13 3.39	0.04 1.0	ND 0.10	0.04 1.10
Meal	1.13 3.39	0.04 ND	ND ND	0.04 ND
Soap stock	1.13 3.39	0.02 0.06	ND ND	0.02 0.06

ND denotes not detected.

The processing studies suggest that endosulfan can be concentrated on the outside tissues of treated crops. For example, higher residue levels were detected in wheat bran, apple pomace, cotton linters and linter motes than in the respective raw commodities. Therefore, residues could be significant when processed parts of some treated crops are fed to animals.

Information on storage stability is not available, but stability is not believed to be a serious problem, as endosulfan residues are stable under natural conditions in senescent or dead crops and/or animals.

4.9. Fat Solubility

The fat solubility of endosulfan depends on the relative proportions of the isomers, α– and β–, present in a given mixture. A mixture containing a ratio of 2:1 α– and β–isomers has a fat solubility (at 37 ^{o}C) of 178 g/kg, whereas those of pure α– and β– isomers were reported to be 182 g/kg and 85 g/kg, respectively. The corresponding octanol/water partition coefficients (log P_{ow}) were calculated to be 4.74 (α–isomer) and 4.79 (β-isomer) at pH 5. The main metabolite in plants and animals, endosulfan sulfate, has a log P_{ow} of similar magnitude (3.66). Animal metabolism studies indicated that endosulfan residues tend to preferentially accumulate in certain tissues but are rapidly eliminated from tissues and organs when the animals were fed uncontaminated feed.

4.10. Discussion

4.10.1 Overview

Endosulfan is only used in crop protection and not for veterinary purposes. Contamination in animal tissues is expected to result mainly from feeding crops or crop parts that have been either treated with, or contaminated by the spray drift of, endosulfan.

Metabolism studies on both animals and plants showed that the metabolite endosulfan sulfate is the major residue in both plant and animal tissues. The sulfate also has a significantly longer half life than the alpha and beta isomers and is usually the only isomer detected in animal fat. The half-life of total residues would vary between 3 and 14 days in both plants and animals in the range of 1 -10 mg/kg, especially for broad-leaf plants. The half life in leaves of cereals including sorghum and maize appears to be much longer at a later stage of growth, as residues in both sorghum and maize were detected even months after endosulfan application. Also, elimination in animal tissues is longer at low concentrations (around 0.1 mg/kg). Residues in harvested crops or dead materials do not appear to degrade.

Recent incidents involving animal MRL violations in Australia were partly associated with misuse of endosulfan, as the crops were harvested 10 days after spray when the residues could be as high as 10 mg/kg, while the WHP was 28 days. In addition, the development of new analytical techniques in the early 90's has enabled easy quantitation of endosulfan sulfate in plant and animal tissues.

The grazing WHP of 28 days does not appear to be consistently sufficient to allow decline of residues to levels that are consistent with existing animal commodity MRL's. This period of time is more consistent with primary food commodities (e.g. grains) than that required for grazing.

As a remedy to the incidents, a withdraw from slaughter interval of 42 days was introduced in early 1996 to all beef producers. A label warning was also required to be attached to each label produced after 1995, indicating the risk of feeding animals with crops treated with endosulfan. The slaughter interval of 42 days accommodates the maximum feeding level of endosulfan at about 5 mg/kg (dry weight) .

Cattle transfer studies with biopsied samples undertaken in 1996 have made it possible to set a MRL of 0.3 mg/kg for Primary feed commodity. The feeding level of 0.3 mg/kg would provide substantial safety to the feeding of livestock with resulting satisfactory residue levels in animal commodities. To eliminate the need of the 42 day withdraw from slaughter period, the feeding level must be at or lower than 0.3 mg/kg.

For primary animal feed commodities, it is considered necessary to maintain the slaughter interval of 42 days if the current use patterns of endosulfan products are to be continued. The data available confirms that a single application of endosulfan to crops could result in residues much higher than 0.3 mg/kg in fodder of treated crops (dry weight) at a WHP of 28 days.

Alternatively, use patterns could be adjusted so that plant residues would be at or below 0.3 mg/kg. However, the appropriate pest management will determine use patterns and some current use of endosulfan may be discontinued due to incompatibility with animal commodity residues.

Primary animal feed commodities are generally derived from pastures (for cattle, sheep and goat) and cereals (grains for cattle, poultry and pigs; hays for cattle and sheep). Other crops or crop parts, especially fodder of legume vegetables, can also be fed to animals. According to the cattle transfer studies, any crops or crop parts contaminated with residues above 0.3 mg/kg, when fed continuously for 10 days, will result in residues exceeding the MRL of 0.2 mg/kg in meat [in the fat]. Crops or crop parts that fall into both categories, i.e., with residues above 0.3 mg/kg and likely to be fed for over 10 days, are represented by the majority of the crops including vegetables specified on the draft label. Commodities of fruit species may not be fed to animals to a great extent, but processed parts of some fruits containing high residues are likely to be fed to some animals.

The residue data provided on crops by registrants were not normally generated in line with the current Australian use patterns (rate of application, application number and WHP). Much of the data was produced overseas. Cattle transfer studies are considered valid and significant in making decisions on the MRL of Primary animal feeds. However, valid data are not available for other animal species or milks, although the primary problems have been related to cattle. A solution to the cattle issues will undoubtedly resolve outstanding /potential difficulties with goats and sheep.

4.10.2 Crop MRLs - Residue Risk and Management in Crops

Table 4 MRL: 0.3 mg/kg for Primary feed commodities (dry weight)

Residues in animal tissues are derived from feeding crops or crop parts that have been treated, or contaminated, with endosulfan through deliberate applications and/or spray drift. In this section, only the former is discussed. Spray drift is detailed in a separate section.

The current MRL of 0.3 mg/kg for Primary feed commodity is considered valid from the animal residue point of view. With this MRL in force, residues in cattle fat are not expected to be exceeding the MRL of 0.2 mg/kg at a 0 day slaughter interval.

However, the primary animal feed commodity MRL was not set on the basis of Australian GAP. From the limited data available, it appears that actual residues in animal feeds including forage, fodder or hay are significantly higher than the residues covered in Table 1, *MRL Standard*, for foods such as grains in cereals.

There is currently a 42 day Export Slaughter Interval (ESI) which coincides and most likely accommodates continuous feeding of cattle at the feeding level of no more than 5 mg/kg.

Three possible options are available for management of residues in animal feeds:

- To maintain the current MRL of 0.3 mg/kg for a 0 day slaughter interval and at the same time to delete the uses of endosulfan on a large number of crops.
- To allow the presence of residues between 0.3 to 5 mg/kg in animal feeds and at the same time employ the 42 days slaughter interval. This approach enables continued use

of endosulfan on some crops. It has to be recognised that there is some risk of residue violations inherent with this approach, because not all people involved in food/crop processing and cattle production may be aware of the requirement. An educational effort by the various State Departments of Agriculture would be essential in minimizing this risk.

- To increase the MRL on basis of agricultural practice which could lead to residues as high as 10 mg/kg at harvest and set appropriate animal commodity MRLs that are consistent with these feeding levels. To do so would certainly require the establishment of equivalent Codex MRLs, as high animal commodity MRLs would place Australia at odds with relevant standards in our major trading partners. An alternative approach is to set MRLs for only those commodities that are deemed necessary for pest management using endosulfan and/or those where the residue picture is compatible with management of animal commodity residue levels.

Complete data are not available for assessing residues in all animal feeds, therefore to permit continuing use of endosulfan, residue trials are required for some crops (or parts of a crop) that will be fed to animals. This may include cereals, legume vegetables, pastures, cotton, some fruits such as citrus and vegetables. The NSW Agriculture pamphlet “Endosulfan Update” indicated that the following crops were identified as the actual sources of beef contamination (> Australian MRL) in NSW: **crop stubble, grain (?), vegetable waste, vegetable stubble, orchard, cotton stubble, and maize silage**. In the following table, a rough estimate has been made for a list of crops and the residues in them that could end up in an animal diet. It assumes that the rest of the diets would be residue free and the current MRLs for the raw commodities represent the residues in the crops.

Table 11.2 Estimates of possible residues in animal diets in feedlot

Crop	Crop part as feeds	Animals to be fed	Percentage of the feeds in total diet	Current MRL for raw commodities or feeds	Possible residues in the feeds (mg/kg)*	Residues in total diet
Apple	Pomace	cattle	20%	2	3.2	0.64
Cotton	Trash	cattle	20%	NA	2	0.4
	Meal	cattle	20%	NA	NIL	NIL
Legumes	Pulses	cattle	80%	1	1	0.8
	Fodder	cattle	80%	NA	6	4.8
Sorghum	Grain	cattle	80%	0.2	0.2	0.16
	Grain	poultry	80%	0.2	0.2	0.16
	Leaves	cattle	80%	NA	6	4.8
Pastures (lucerne, clover etc)	Forage	cattle sheep, goat	80%	1 (Codex, green)	3 (dry weight)	3
Vegetables	Waste outside leaves	cattle	20%	2	6 (dry weight)	1.2

* Residues are based on processing studies (apple and cotton on linters and motes), recent follow up studies on violation incidents (legumes and sorghum), and estimates (vegetables).

Cereals are not listed in general and may be similar to sorghum, if the use pattern on them is the same as sorghum.

The estimates indicate that **at a 0 day slaughter interval**, **legume pulses or fodder, sorghum fodder, pastures, vegetables and apple pomace will result in residues higher than 0.2 mg/kg in Meat [fat], when fed to animals** for a continued period of time (over 10 days), as residues in total diets are over 0.3 mg/kg (dry weight). Legume and sorghum fodder and pastures could contain residues as high as 4.8 mg/kg and a slaughter interval of 42 days would be the minimum to allow depletion of residues to below the MRL of 0.2

mg/kg for meat [in the fat]. Only cereal grains, including sorghum grains, can be fed to cattle without the need for a slaughter interval. The situation for cotton, the major crop for endosulfan application, is less clear. There is insufficient data available for assessment of cotton stubble. However, if the use pattern is modified to accommodate an 8-10 week WHP, then 42 day slaughter interval will be satisfactory to permit grazing at harvest.

As identified in the table, cereals and legumes, including legume pastures, comprise the major threat in regard of residues, followed by vegetables, pulses, apple pomace and possibly cotton stubble and/or trash.

Although cereals and legume pastures are major feed sources for animals, especially cattle, they constitute the smallest overall usage of endosulfan. Advice from State agricultural authorities indicates that production of cereals and legume pastures would not be seriously effected by restriction on endosulfan use, although sweet corn production may be an exception in some circumstances. In relation to production of cereals and legume pastures, it is noted that only one of a dozen current labels contain recommendations for pastures, rather than pasture seed crops. It is therefore reasonable to expect that low usage in production of these crops will reduce the risk of violation of animal MRLs.

In relation to cereals and pasture pest control, endosulfan might be used for the control of some pests such as redlegged earth mite as a bare-soil treatment. Endosulfan does not degrade quickly in soil and persists for a long time (DT_{50} for total endosulfan in the field is 5-8 months, *The Pesticide Manual*, 1995). Pasture plants will be grazed together with some soils on roots, which are contaminated with endosulfan. It is envisaged that a cow can consume up to 1 kg of soil a day in normal circumstances and up to 3 kg in drought situations. At a residue level above 5 mg/kg in soil with an intake of 1 kg of soil per day, the residues in cattle tissues would exceed the Codex MRL of 0.1 mg/kg. It is not clear at this stage whether unacceptable cattle contamination also occurs through residues in soil with bare-soil and/or seedling treatments in plants, especially pastures.

To reduce the risk of high residues present in the crops requiring endosulfan treatment, the use pattern has to be restricted, e.g., longer WHP, fewer applications and longer intervals of re-applications should be all considered (see Section 11.4). Moreover, residue trials have to be conducted to generate residue data on these crops.

Any residue trials to be conducted will have to accommodate the use pattern as specified on labels. Processing studies are required for some crops such as citrus fruits to indicate the extent to which the residues will be concentrated in the processed parts (citrus pulp) that could be fed to cattle. Crops that need residue data include cereals and pastures (if endosulfan will be used on them continuously), cotton, legume vegetables (various beans and peas) or pulses, peanuts, potatoes, rape, citrus fruits and pome fruits.

In the event that endosulfan is to be continuously used on all crops as specified on the current labels, the Table 1 MRLs for these crops (foods) shall be maintained and/or modified on basis of future residue data.

Table 1 MRLs:

Australian residue data are not available for the majority of the crops listed on the labels. Where residue data were generated, the trials were not conducted in accordance with the current use pattern. The current full MRLs, if maintained, cannot be supported in the absence of proper data and should be replaced by temporary MRLs. MRLs for major crops or crop groups are discussed below in the event that crops in concern are requested to be kept on the current label for further use of endosulfan:

Cereal grains: The Australian MRL is 0.2 mg/kg, which, in accordance with Codex definition of Cereal grains, covers crops such as wheat, barley, oat, rice, sorghum and maize etc. In Table 1 of the current *MRL Standard*, there are separate MRLs for **Rice** (0.1 mg/kg) and **Sweet corn (corn-on-the cob)** (0.2 mg/kg). By current standard, either both entries should be incorporated into the group MRL for Cereal grains or the group MRL for Cereal grains split into MRLs for individual crop species. As far as trade is concerned, there is no Codex MRL for Cereal grains. Codex MRLs are set at 0.2 mg/kg for Wheat, 0.1 mg/kg for Rice and Maize. Other major cereal crops such as barley, sorghum and oats etc are not covered by Codex MRLs.

Should cereals be removed from the current label use of endosulfan and no off-label use permitted, the MRLs for cereal grains and other cereal crops shall be deleted. As a consequence, residue data on cereal grains and the forage, fodder or hay shall not be required.

Cotton: Cotton is the major crop for which endosulfan is required for the control of heliothis. Although use on cotton may be reduced to a certain extent with introduction of Bt cotton in various states, cotton remains a significant target for endosulfan use. There is presently a MRL of 0.5 mg/kg for **Cotton seed oil, crude** and a group MRL of 1 mg/kg for **Oilseed**. As the provided residue data on the 1974 trials may not necessarily accommodate current use patterns, the MRLs for Cotton seed oil, crude, and cotton seed as Oilseed should be changed to temporary ones.

Oilseed: The group MRL of 1 mg/kg in Australian *MRL Standard* has included rape (canola), soybean, cotton, linseed, peanut, sesame, safflower, sunflower etc. Codex MRLs are set separately for cotton seed (1 mg/kg), rape seed (0.5 mg/kg), soybean seed (1 mg/kg) and sunflower seed (1 mg/kg). The Australian MRLs for Oilseed should be converted to a temporary MRL. New residue data and/or scientific argument shall be required for granting full MRLs for the commodities. Presently, some residue trials on cotton seed and soybeans are available in Australia. Residue trials are needed for the forage and fodder of the plants.

Peanut: There is a separate MRL of 1 mg/kg for peanut in Australian *MRL Standard*. Peanut should have been covered by the MRL of 1 mg/kg for **Oilseed**, according to Codex definition. Again, adequate residue data are not available for peanut and new residue trials including processing study are required to accommodate the use pattern. Forage and fodder should be incorporated into the residue trials.

Fruits: A group MRL of 2 mg/kg was adopted from Codex and is set in the Australian *MRL Standard*. The Codex MRL for Fruits was withdrawn in 1993. To be consistent with Codex, the Australian MRL for Fruits should be deleted. Instead, temporary group MRLs of **Pome fruits, Citrus fruits, Stone fruits, Assorted tropical and sub-tropical fruits - edible (or inedible) peel** and **Berries and other small fruits** can be established for those fruit groups for which representative species of plants require the use of endosulfan. The current labels show that endosulfan is used on at least 30 species of fruit plants, covering all groups mentioned above. Since Australian residue trials were not conducted with any species of fruits, the MRLs for all six groups shall be set at 2 mg/kg for a period of 3 years. Upon receipt of residue data and/or scientific argument, including processing studies, full MRLs may be granted for individual species or groups.

Vegetables: There is currently a MRL of 2 mg/kg for **Vegetables [except carrot; common beans; lupin (dry); mung bean (dry); onion, bulb; potato; soybean (dry); sweet corn (corn-on-the-cob); sweet potato]** which was adopted from Codex. The Codex MRL for vegetables was withdrawn in 1993. Again, the Australian group MRL for Vegetables should be deleted. For the continued use of endosulfan on the vegetables, individual or group MRLs shall be established for various species of the vegetables. According to current labels, the group MRL can be set for **Brassica (cole or cabbage) vegetables, Head cabbages, Flowerhead brassicas**, **Leafy vegetables (including Brassica leafy vegetables), Stalk and stem vegetables, Legume vegetables, Root and tuber vegetables,** and **Fruiting vegetables other than Cucurbits.** The first two groups include vegetable species belonging to the genus Brassica and cole vegetables such as kale, mustard, and spinach. Legume vegetables refer to the commodities which are derived from the succulent seed and immature seeds of leguminous plants commonly known as peas and beans. They include chickpeas, cowpeas, common bean, field peas, pigeon peas, adzuki beans, faba beans, green peas, green beans, lima beans, snow peas, soybeans, mung beans, navy beans etc. The last two groups cover the fruit species of Beetroot, Capsicums, Cape gooseberries, Eggplant, Okra, Swede turnip, and Taro**.** Individual MRLs can be kept for **Shallots, Onion (bulb),** and **Silverbeet** on a temporary basis. All the MRLs shall be made valid for 3 years only. Upon assessment of newly generated residue data and/or scientific argument, they shall be changed to full MRLs or deleted.

Pulses: Pulses are derived from the mature seeds, naturally or artificially dried, of leguminous plants known as beans (dry) and peas (dry). A great number of pulse plants are subject to use of Endosulfan for the control of heliothis and other pests. MRLs have been set at 1 mg/kg for **Common bean (dry) [navy bean], Mung beans (dry), Lupin (dry)** and **Soybean (dry)** on basis of soybean residue data. Neither residue data nor MRLs are available for other crops on the current label, i.e., chick peas, cow peas, pigeon peas, adzuki beans, broad bean, lima bean, snow peas and garden pea (for field pea and green pea). At Codex, MRLs are set only for Soybean (dry) (1 mg/kg) and Garden pea (0.5 mg/kg). The residue trials conducted in 1981 with soybean used a maximum of 2 applications and did not necessarily address the maximum residue situation. To cover other grain legume species, a temporary MRL of 1 mg/kg for **Pulses** is recommended and shall be confirmed or amended upon assessment of newly generated residue data. The registrants should conduct residue trials with representative legume species such as garden pea and common bean etc to demonstrate residues in both immature pods and pulses (dry seeds) with the current use pattern. It is reiterated that forage and fodder residue data be generated.

Others: These include commodities which are not mentioned in the above MRLs and appear on the current labels. Australian residue data are not available and trials should be conducted to address the use pattern. The crops include **carrots, onions, potato, tomato, sweet potato, tea (green, black)** and **tree nuts** which, by definition, includes macademia nuts, pecan nuts, cashews and coconuts.

4.10.3 Spray Drift - Residue Risk

State departments of Agriculture officers have reported that the application of the ULV formulation results in residues in crops or animals around the application sites. In the NSW Agriculture pamphlet Endosulfan Update, dated 22/11/1996, the following crops were said to be identified as the sources of spray drift leading to contaminated beef (residues >Australian MRL): cotton, canola, sorghum, sunflowers, potatoes, and tree crops.

Data are not available for assessment of possible magnitude of endosulfan residues in crops or animals in surrounding areas of the application sites. It is expected that residues in crops in the areas with spray drift should be lower than the crops actually treated and decrease gradually with distance. A number of other factors such as wind direction also contribute to the extent of spray drift. It cannot be generalised, in the absence of relevant data, what would be the distance at which the crops would be safe for animal grazing immediately after spray takes place in the neighbouring property, though the magnitude of the problem could be substantially reduced by effective buffer zones to protect neighboring crops and animals. Furthermore, animals exposed to contaminated feed would be less likely to have residues in excess of the animal commodity MRL, if the 42 day slaughter interval were employed.

Additional measures could include: the prohibition of the use of the ULV formulation, although the issue of intrinsic volatility of endosulfan will still remain; an implementation of a grazing restraint (28 days corresponding to about 2 half lives); and identify conditions where aerial spraying is acceptable including delivery systems.

It is considered necessary that residue data on untargeted crops and animals in surrounding areas be supplied.

Finally, it is considered prudent to keep the slaughter interval of 42 days to accommodate the spray drift situations.

4.10.4 Animal MRLs - Residue Management in Animals

The Codex MRLs for endosulfan are set at 0.1 mg/kg for **Meat (from mammals other than marine animals)** and 0.004 mg/kg for **Milks**. There is no Codex MRL for **Poultry** and eggs.

Australian MRLs are set at 0.2 mg/kg for Cattle meat [in the fat], Sheep meat [in the fat], and Goat meat [in the fat], edible offal of cattle, sheep and goat. The MRL for Milks [in the fat] is 0.5 mg/kg. The Australian MRL is higher than Codex for meat [in the fat] and milks (the Codex MRL is expressed on a whole milk basis and 25 times diluted).

Residue data were generated in Australia for cattle to address the feeding rates of 0.3 and 3 mg/kg of endosulfan in diet. The data showed that at 0.3 mg/kg, total residues of endosulfan will not exceed the current Australian MRL of 0.2 mg/kg for cattle meat [in fat]. While the metabolism studies suggest that total radioactivity is higher in liver than fat, there are no new data generated to confirm that this is the case for endosulfan and the sulfate. Residue situation with calves that suck milk from mother cows is not clear. There is no information available about the relationship between milk residues and residues in tissues of calves. At a feeding level of 0.5 mg/kg, the current MRL for Milks [in fat], it is considered unlikely that residues in tissues of sucking calves will exceed the MRL of 0.2 mg/kg for Meat [in fat].

The goat metabolism study showed that at a feeding level of 1 mg/kg in diet, total endosulfan residues were about 0.3 mg/kg in kidney, 0.15 mg/kg in liver, 0.06 mg/kg in fat and 0.04 mg/kg in muscle after consecutive feeding for 28 days. It is expected that at a feeding level of 0.3 mg/kg, the residues in all tissues will be lower than 0.2 mg/kg, the current Australian MRL.

It is considered appropriate to extrapolate the metabolism studies from goat to sheep.

There are no data available for pigs. Being a monogastric animal, pigs could have the residue situation as shown by mice or rats. In the metabolism studies, mice fed consecutively for 21 days at a feeding level of 18.6 mg/kg in diet showed the following total radioactive residues: 2.6 mg/kg in liver, 0.6 mg/kg in kidney, 0.2 mg/kg in fat and 0.5 mg/kg in muscle. On the assumption that residue levels are proportional to the dose rates, the feeding level of 0.3 mg/kg would lead to residues of 0.04 mg/kg in liver and below 0.04 mg/kg in all other tissues.

From this point of view, it is not expected that residues in pig tissues will exceed 0.2 mg/kg at a feeding level of 0.3 mg/kg in diet.

With the information provided above, it is considered possible to recommend group MRLs of 0.2 mg/kg for **Meat (mammals) [in fat]** and **Edible offal of (mammals)** for endosulfan.

The existing MRLs for individual mammal animal species should be deleted. MRLs for Poultry commodities and Eggs remain unchanged.

The MRL for **Milks [in the fat]** is equivalent to residues of 0.02 mg/kg expressed on a whole milk basis. The Codex MRL for Milks is 0.004 mg/kg and 5 times lower. Based on the residue trial conducted on milk cows (see 8.1.4), residues in milk could be 0.08 mg/kg at a feeding level of 5 mg/kg on a whole milk basis, which is equal to 2 mg/kg of endosulfan in milk [in fat]. Extrapolation indicates that at the feeding level of 1 mg/kg of endosulfan, residues in milk will be lower than the current MRL of 0.5 mg/kg [in fat]. To avoid residue violations in milk, it is considered appropriate to recommend a feeding restraint for milk cows, which is aimed to prohibit feeding crops or crop parts treated with endosulfan to lactating cows. In this regard, the milk MRL should be converted to a temporary one and the Table 4 entry of the *MRL Standard* for endosulfan observed, which is 0.3 mg/kg for Primary feed commodities.

4.10.5 Withholding Period (WHP) - Residue Reduction

Presently, a WHP of 28 days appears generally on label for some crops that are likely to be fed to animals. This includes legumes, canola and sunflower. For human foods, the WHP varies between 1 and 28 days. Vegetables and fruits have a WHP of 7 or 14 days usually. Some labels specify both food harvest WHP and grazing WHP of 28 or 42 days.

The **human food WHP** for all commodities except for vegetables and pulses, lupins in particular, which can be fed to animals, is considered appropriate at the present time. One residue violation was found for celery after an NRS residue survey. Evidence was not obtained to suggest that the violation was due to an inappropriate WHP.

The **grazing WHP** or **animal feed WHP** of 28 days is the focus of this section. Mismanagement of this WHP could directly result in unacceptable residues in animal tissues.

While the WHP is traditionally set according to good agricultural practice, establishment of a new WHP for endosulfan application has to be achieved in association with considerations of residues that could occur in the commodities in concern. The longer the WHP, the lower the residues.

Investigation on legume plants (pulses) shows that the use pattern for these crops requires applications of endosulfan 6-8 weeks before harvest, except for mung beans and navy beans (about 4 weeks). For citrus, the period is 8-12 weeks before harvest.

Some labels have a label warning attached (see Section 4, Use pattern). The label warning has not specified a WHP and merely indicated that “Where it is possible that a crop will be ultimately grazed or form part of livestock foodstuff, avoid the use of this product late in the season when vegetative growth has been slowed or stopped.”

According to the limited data available, the half life of endosulfan residues in live plants varied between 3 to 14 days. The variation occurred in the same plant species or variety. Endosulfan residues do not degrade significantly in harvested crops.

As an example, the residue analysis conducted for **bean plants** (or fodder, see Section 7.1) indicated that endosulfan residues were 10 mg/kg on day 10 after 2-3 sprays (or 32 days after harvest) and 6.9 mg/kg on day 14 after 4-6 sprays (or day 61 after harvest) at the application rate of 735 gai/ha (re-application interval presumably shorter than 14 days). On the assumption that the half life of endosulfan is 14 days in the living bean plants and the residues did not change in amount after harvest, the residues would be about 5 mg/kg at day 28, the specified WHP on label. Therefore, in order to permit grazing or consumption of fodder, a slaughter interval of 42 days would be necessary.

Using this same approach, the following table (next page) can be constructed which demonstrates how animal MRLs can be met. Where data are sparse, or non-existent, then additional measures such as prohibition or extended withdraw from slaughter interval will be necessary.

Situations for failed crops are not considered in this table and it is discouraged to feed animals with failed crops that were treated with endosulfan.

Crops or crop parts that are not mentioned in this table may not have been considered as an essential use for endosulfan. There is little information that can be used to assess the possible residue magnitude in some of these crops. Cereals such as sorghum and sweet corn are likely to have a longer half-life than 14 days and therefore a slaughter interval of 42 days may not necessarily address the residues if the crops receive late applications of endosulfan and are fed to animals. It is strongly discouraged to continue the use of endosulfan on cereals. For other crops, stubble or forages, which are likely to be fed to animals, it is advised that the grazing WHP be set at 8 weeks after application of endosulfan and at the same time the slaughter interval of 42 days employed. With a WHP shorter than 8 weeks, the treated crops should generally not be fed to animals.

Milking cows would produce milk with residues not higher than the current Australian MRL of 0.5 m/kg [in fat] when feeding residues at and/or below 1 mg/kg in the feeds (dry weight). If the feeds such as apple pomace as discussed in the table are fed at 20% in the total animal diet, it is not expected that residues in milk will violate the Australian MRL. It is advised that the feeds mentioned in the table do not exceed 20% of the total diet.

Crop/commodity*	WHP	Magnitude of residues (mg/kg)	Management
Cotton	8-10 weeks		
Seed		<0.05	nil
Meal		<0.05	nil
Hull		<0.05	nil
Gin trash		2**	42 day slaughter interval
Stubble		unknown	42 day slaughter interval
Apples	4-6 weeks		
Pomace		3.2	42 day slaughter interval
Grain legumes	4 weeks		
Stubble		5**	42 day slaughter interval
Grains/pulses		0.8	42 day slaughter interval
Oilseeds			
Stubble	bare soil treatment	considered to be <0.3 mg/kg	nil, if residues below 0.3 mg/kg
Pasture seed legumes			
Hay, fodder	2 weeks ?	unknown	Do not feed to animals
Tropical and subtropical fruits			
Processed fruit by-products	6-8 weeks	unknown	42 day slaughter interval
Legume vegetables/animal feeds			
Forage/stubble	1 day	unknown	Do not feed to animals
	4 weeks	5**	42 day slaughter interval
Other vegetables (eg tomato, leafy vegetables)			
Forage/stubble	1 day	unknown	Do not feed to animals
	4 weeks	5**	42 day slaughter interval
Citrus	8-12 weeks		
Pulp		unknown, or below 5 mg/kg	42 day slaughter interval

* The crops are recommended as essential for use of Endosulfan by States Department of Agriculture.
** This data is based on extrapolation and the real figure could be higher.

It is recognised that animals could be run in orchards for a few days in a season. There are no relevant residue data to demonstrate the residue magnitude. But orchard has been identified as one of the sources of endosulfan contamination by NSW. It is considered necessary to restrict this practice after spraying the orchard with endosulfan or impose 42 day slaughter interval after a 28 day grazing restriction period.

The following WHP and/or restraints for endosulfan application, if appropriate, should be incorporated onto all current labels for the crops that are considered suitable to remain for further use and at the same time have potential to be fed to animals:

4.10.5.1 Human Foods

SEE THE WHPS SPECIFIED IN THE INSTRUCTION TABLE[1].

4.10.5.2 Animal Feeds (cereals, legumes, vegetables, oilseed plants, potatoes, orchard, vegetable and fruit wastes, etc)

[1] The Instruction Table on labels has not been described in this report. The WHPs for human foods on the Instruction Table will remain as on current labels.

DO NOT RE-APPLY WITHIN 7 DAYS.

DO NOT GRAZE ORCHARDS AFTER APPLICATION.

DO NOT FEED TREATED CROPS OR CROP PARTS (EXCEPT COTTONSEED/MEAL) TO LACTATING COWS PRODUCING MILK FOR HUMAN CONSUMPTION.

4.10.5.3 For Processed Commodities (apple pomace, citrus pulp etc)

Where processed commodities such as fruit peels in a cannery are traditionally traded as animal feeds, exchanges of information on crop and animal produce residues between farmers and processors should be actively promoted and facilitated by grower organisations and government agencies.

4.11. Maximum Daily Intake Calculation

The established ADI value for endosulfan is 0.007 mg/kg/day (as of 31 December 1996). The ANZFA Market Basket Survey has revealed, on the basis of total residue analysis, that the estimated daily intake (ESI) of the chemical is below 3% of the ADI in the worst case scenario where food intake for 2 year old toddlers was considered (page 47, The 1994 Australian Market Basket Survey, ANZFA). The exact daily intake of endosulfan residues should be obtained from the calculation in the toxicological report in this ECRP program.

4.12. Residues in Cattle - Current Situation in the USA

Reference - Mawhinney H (1996), Endosulfan residue in cattle-the current situation in the USA. A report prepared as part of a consultancy sponsored by the Meat Research Corporation. April 1996.

It is reported that endosulfan is used on over 80 food and non-food crops in the USA. A large proportion of it is used in the production of vegetables and fruits in California and Florida. Australia and the USA have very similar usage of endosulfan. Neither country uses it in veterinary applications.

Until recently, endosulfan sulfate was considered to be at minimal risk of producing detectable residues in slaughter animals in the USA. However, it was included as a target analyte in the US National Residue Program (NRP), primarily due to its detection among other organo-chlorine (OC) and organo-phosphate (OP) pesticide residues in the multi-residue screening method. The lack of emphasis placed on residues of this chemical in the fat of animals and nil detections over a long period of time resulted in the reduction of testing laboratory proficiency for the detection of endosulfan residues. Low recoveries (as much as 20%) and insensitive detection systems associated with analytical methods may contribute to residues being not detected under certain situations. However, it is recognized that residue control mechanisms in place through good farming practices may be in some way responsible for the absence of detection of endosulfan residues in meat fat in the US meat industry.

In the USA, the majority of beef cattle come from feedlots. Under feedlot conditions animals are fed, 90-140 days prior to slaughter, with feedstock that has been stringently monitored for pesticide residues. The bulk of the diet contains grains, particularly corn as well as wheat, milo, and barley. Cottonseed, soybean meals, and animal proteins are used as supplements and corn silage and alfalfa hay are used as principal roughages. The majority of feedlots are located in western Corn Belt, the eastern Great Plains and High Plains. The climatic conditions in these areas allow the cultivation of feed crops with minimal use of pesticides. The development of such a pattern is attributed to the availability of cleaner feedstock from surrounding areas resulting in reduced feed-costs.

Beef cattle arrive at feedlots from various parts of the country. They spend sufficiently long periods in feedlots, at least ten times the average half life (*ca*. 9 days) of endosulfan sulfate, which allows the residue concentration to drop down to safe levels, even though the animals may have been exposed to contaminated feedstock in the early part of their life.

4.13. Residues in Food in Commerce at Consumption (NRS Data)

The following survey results indicate that there are residue violations mainly, if not exclusively, on cattle meat [in fat]. Other food MRLs were not found to be violated.

According to the studies conducted in 1995 and 1996 by the National Residue Survey's (NRS) Targeted Testing Program, more than 99.4% of the beef samples tested were in compliance with the Australian MRL of 0.20 mg/kg. A similar percentage was in compliance with Codex MRL of 0.1 mg/kg. Furthermore, *ca.* 98% of the samples had no detectable Endosulfan residues. The data have been obtained from properties in NSW and QLD. The NRS data are summarised in the Table below.

The surveyed results were produced between July 1995 and May 1996 when the recommended slaughter interval of 42 days was about to be implemented. It should be expected that with the slaughter interval in action, no more MRL violations would take place. This should be confirmed by the NRS in a later stage when the new survey results become available.

Table 14 Levels of residues (mg/kg) detected in beef.

Year	No. of samples analysed	No. of samples with residues (mg/kg)					No. of properties	
		0.02-0.05	0.05-0.10	0.11-0.20	>0.20	Total	NSW	QLD
Jul 1995-5 Mar 1996	13881	97	85	27	62	271	49	45

Levels of endosulfan residue found in different commodities as indicated by the Australian Market Basket Survey conducted during January 1988-November 1996 indicate that no residue violations have occurred in the commodities tested, except in one situation involving celery. In the few cases where a residue has been detected, it was found to be at or below 50% of the MRL for that commodity.

4.14 Trade Considerations

A separate Trade Report is part of the ECRP program and details will not be provided in this evaluation. It should be pointed out that the Australian MRL for cattle meat is 0.2 mg/kg, which is higher than the Codex MRL of 0.1 mg/kg. The difference implies that cattle beef that meets Australian standard may not necessarily meet Codex standard.

As part of the management of endosulfan residue problem, it is possible and may be necessary to adjust Australian MRL for cattle beef and/or other commodities for domestic use, depending on the daily intake calculation. At this stage, the MRL can only be maintained.

Where cattle beef for export is monitored through routine residue analysis for various residues including endosulfan (sulfate), the risk of violation of Codex MRL is considered low.

The group MRLs for vegetables and fruits were deleted in Codex in 1993. Codex MRLs are available for a small number of vegetable and fruit species. A large number of Australian commodities of fruits, vegetables and others including oilseeds or oils could have higher MRLs than Codex, or MRLs which do not exist in Codex or in an importing country.

The ultimate resolution to the trade barrier is to have the Codex MRLs for various commodities including cattle meat changed to meet the use pattern in Australia. This will only be possible on basis of good agricultural practice and solid scientific residue data generated from such use patterns.

4.15. Conclusions

Consequential to the discussions above, there is no objection, from a residues perspective, to the continued registration of endosulfan products. Re-registration of endosulfan is subject to certain amendments being made to the MRLs, WHPs and labels and to the requirement of further residue data and/or solid scientific argument on all commodities except Cattle meat [in fat].

Maximum Residue Limits:

It is recommended that the current MRLs in Table 1 of the MRL Standard, be amended as follows:
The following MRLs are to be deleted:

Code	Food	MRL (mg/kg)
VR 0577	Carrot	0.2
MO 0812	Cattle, Edible offal of	0.2
MM 0812	Cattle meat [in the fat]	0.2
GC 0080	Cereal grains	0.2
VD 0526	Common bean [navy bean]	1
OC 0691	Cotton seed oil, crude	0.5
PE 0112	Eggs	*0.05
	Fruits	2
VO 0050	Fruiting vegetables, other than cucurbits	2
MO 0814	Goat, edible offal of	0.2
MM 0814	Goat meat [in the fat]	0.2
VD 0545	Lupin (dry)	1
ML 0106	Milks [in the fat]	0.5
VD 0536	Mung beans (dry)	1
SO 0088	Oilseed	1

VA 0385	Onion, Bulb	0.2
SO 0697	Peanut	1
VR 0589	Potato	0.2
GC 0649	Rice	0.1
MO 0822	Sheep, edible offal of	0.2
MM 0822	Sheep meat [in the fat]	0.2
VD 0541	Soybean (dry)	1
VO 0447	Sweet corn (corn-on-the-cob)	0.2
VR 0508	Sweet potato	0.2
DT 1114	Tea, Green, Black	30
TN 0085	Tree nuts	2
VO 0448	Tomato	2
	Vegetables [except carrot; common beans; lupin (dry); mung bean (dry); onion, bulb; potato; soybean (dry); sweet corn (corn-on-the-cob); sweet potato]	2

The following MRLs are to be set:

Code	Food	MRL (mg/kg)
FT 0005	Assorted tropical and sub-tropical fruits - edible peel	T2
FT 0006	Assorted tropical and sub-tropical fruits - inedible peel	T2
FB 0004	Berries and other small fruits	T2
VB 0040	Brassica (cole or cabbage) vegetables, Head cabbages, Flowerhead brassicas	T2
GC 0080	Cereal grains	T0.2
FC 0001	Citrus fruits	T2
OC 0691	Cotton seed oil, crude	T0.5
	Curcurbits	T2
PE 0112	Eggs	T*0.05
VO 0050	Fruiting vegetables, other than cucurbits	T2
VL 0013	Leafy vegetables (including Brassica leafy vegetables)	T2
VP 0034	Legume vegetables	T2
MM 0095	Meat (mammalian) [in the fat]	0.2
ML 0106	Milks [in the fat]	T0.5
SO 0088	Oilseed	T1
VA 0385	Onion, Bulb	T0.2
FP 0002	Pome fruits	T2
VD 0070	Pulses	T1
GC 0649	Rice	T0.1
VR 0075	Root and tuber vegetables	T2
VA 0388	Shallots	T2
VS 0017	Stalk and stem vegetables	T2
FS 0003	Stone fruits	T2
DT 1114	Tea, Green, Black	T30
TN 0085	Tree nuts	T2

The temporary MRLs will be withdrawn on 31 December 2000, unless data are submitted to support these MRLs.

The following data are considered essential:

- Animal feeds - Forages, fodder or hays of such plants as cereals (including sorghum and maize), pastures ,canola, sunflower, legume vegetables, potato, peanuts, and legume crops for pulse production.
- Human food – All commodities which have been assigned a temporary MRL in the table above.
- Processing studies - Cereals, fruits (citrus and apple), cotton and other oilseeds and grapes.
- Animal commodities: Animal transfer study in cattle including milk analysis and poultry feeding studies including analysis of eggs.

Some MRLs may be deleted from this table in any case, depending on decisions regarding the remaining uses of endosulfan.

The Table 4 MRL of 0.3 mg/kg for Primary animal feed should remain. Unless strategies are established to accommodate residues higher than 0.2 mg/kg in meat (mammalian)[in the fat], or residue data are generated for individual animal feed commodities, the MRL should stay unchanged.

In relation to any future applications for registration, it is strongly recommended that residue data on any likely animal feeds, forage, fodder or hay, processed remains from raw commodities such as citrus pulp, apple pomace, cotton meal, cotton trash, rice hull, vegetable wastes etc, be generated by addressing the maximum treatment regimes (i.e. application rate, number of applications, and intervals between re-applications). The time course of the residue decline should be demonstrated in all trials.

All residue trials should be conducted in accordance with Residue Guidelines published in the NRA Gazette. Residue trials must address the maximum treatment regimes. The residue trials are expected to be submitted to the NRA for evaluation by 30 June 2000.

All feedlots and/or abattoirs for beef export should be equipped with a residue analysis lab for monitoring of residues in feed or animal produce. Where it is impractical to have an on-site laboratory, monitoring could be contracted to other laboratories.

All future Australian residue data should be submitted to Codex Alimentarius Commission for review, so that Codex MRLs for endosulfan can encompass Australian use patterns. It is noted that endosulfan has been scheduled for periodic review by the Codex in 2000.

Withholding period (WHP) and restraint:

All current withholding periods (WHPs) for human food, including pulses and leafy vegetables, should remain. Pulses, brassica and leafy vegetables, when treated for human consumption only, shall not be deemed different from other human food commodities in this regard. The establishment of a grazing WHP shall depend on the maintenance of the slaughter interval of 42 days and/or on the feasibility of not feeding crops of concern.

FOR HUMAN FOODS

SEE THE WHPS SPECIFIED IN THE INSTRUCTION TABLE.

FOR ANIMAL FEEDS (INCLUDING PULSES, VEGETABLES, VEGETABLE AND FRUIT WASTES, FODDER AND FORAGE):
DO NOT RE-APPLY WITHIN 7 DAYS.
DO NOT GRAZE ORCHARDS AFTER APPLICATION.
DO NOT FEED TREATED CROPS OR CROP PARTS (EXCEPT COTTONSEED/MEAL) TO LACTATING COWS PRODUCING MILK FOR HUMAN CONSUMPTION.

A grazing WHP of **four weeks** plus 42 days slaughter interval should be observed for legumes and vegetables. A grazing WHP of **eight weeks** plus 42 days slaughter interval should be observed for maize and sorghum forage.

Where processed commodities such as apple pomace, citrus pulp or fruit peels in a cannery are traditionally traded as animal feeds, exchanges of information on crop and animal produce residues between farmers and processors should be actively promoted and facilitated by grower organisations and government agencies.

The following crop harvest WHPs and withhold from slaughter intervals are to be included in Label Instructions as shown below:

Crop/Commodity	Crop Harvest WHP	Animal Management
Cottonseed/meal	4 weeks	Nil slaughter interval
Apples & Pomace	4weeks	42 day slaughter interval
Grain legumes & Pulses and Fodder/stubble	4weeks	42 day slaughter interval
Pasture seed legumes	4 weeks	42 day slaughter interval
Tropical and sub-tropical fruits & fruit by-products	4 weeks	42 day slaughter interval
Legume vegetables	4 weeks	42 day slaughter interval
Other vegetables (eg tomato, leafy vegetables)	4 weeks	42 day slaughter interval
Citrus & citrus pulp	4 weeks	42 day slaughter interval

The following crop/commodities are special cases which require different treatment to avoid violations of animal MRLs. The following information is to be included on labels as shown below:

Crop/Commodity	Crop Harvest WHP	Animal Management
Cotton trash	Not Applicable	Do not feed to animals
Legume vegetables	2 day	Do not feed to animals
Maize grain	8 weeks	Nil slaughter interval
Maize fodder	8 weeks	42 day slaughter interval
Other vegetables (eg tomato, leafy vegetables)	2 day	Do not feed to animals
Sorghum grain	8 weeks	Nil slaughter interval
Sorghum fodder	8 weeks	42 day slaughter interval

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