MALATHION (049)

EXPLANATION

Malathion is an insecticide used world wide in a large number of fruit, vegetables and cereal crops. It was originally scheduled for periodic re-evaluation by the 1995 JMPR. The review was postponed at the 1994 CCPR as the manufacturer informed the meeting that a long term study would not be available before the end of 1995 (ALINORM 95/24, para 115). It was re-scheduled for periodic re-evaluation of residues by the 1999 JMPR at the 1995 CCPR (ALINORM 95/24A, Appendix IV). The manufacturer provided residue data, GAP information and relevant critical supporting studies to support existing CXLs. Relevant data have also been provided in support of residue limits for alfalfa, asparagus, avocado, snap beans, carrot, clover, corn, cotton seed, cucumbers, fig, flax, guava, lettuce leaf, maize, melons, okra, mustard greens, onions, bulb, green onion, mango, papaya, potato, sorghum, sugar apple and watercress. Other data on use pattern, methods of residue analysis, residue in food in commerce or at consumption and national residue limits were provided by the Governments of Australia, The Netherlands, Poland, Thailand and the UK.

IDENTITY

ISO common name: malathion

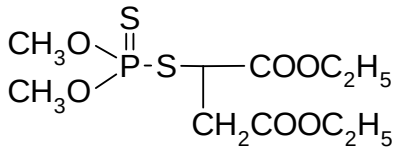
Chemical names:

IUPAC: diethyl (dimethoxythiophosphorylthio)succinate
S-(1,2-bis(ethoxycarbonyl)ethyl *O,O*-dimethyl phosphorodithioate

CA: diethyl [(dimethoxyphosphinothioyl)thio]butanedioate

CAS number: 121-75-5

Structural formula:



Molecular formula: $C_{10}H_{19}O_6PS_2$

Molecular weight: 330.3

Physical and chemical properties

Pure active ingredient:

Appearance: colourless to pale yellow liquid.

Vapour pressure: 5.3 mPa at 30°C

Melting point: 2.85°C

Octanol-water partition coefficient: K_{ow} = 560; log K_{ow} = 2.75

Solubility:	in water 148.2 mg/l at 25°C. readily soluble in hydrocarbons, esters and alcohols. moderately soluble in aliphatic hydrocarbons (62 g/l in n-hexane).	
Specific gravity:	1.23 g/ml at 25°C.	
Hydrolysis:	half-lives	107 days at pH 5 6.21 days at pH 7 0.49 days at pH 9
Photolysis:	half-life	156 days at pH 4, 25°C
Thermal stability:	stable at ambient temperatures (below 25°C). decomposes rapidly at temperatures above 100°C	

Technical material:

Min. purity: 95%.

Main impurities: *O*,*O*,*S*-trimethyl phosphorothioate.

Melting range: not relevant.

Stability: stable for at least two years when stored at ambient temperatures in the unopened original container.

Formulations

Table 1 shows the main types of formulation registered for use internationally. EC = emulsifable concentrate; ULV = ultra low volume.

Table 1. Formulations of malathion.

Product Formulation	Active ingredient	Concentration
CLEAN CROP Malathion 57 EC	Malathion	570 g/l
Fyfanon ULV	Malathion	1186 g/l
CLEAN CROP Malathion 8 Aquamul	Malathion	950 g/l
Fyfanon EC	Malathion	560 g/l
Fyfanon	Malathion	599 g/l
Fyfanon 8 LB. EMULSION	Malathion	958 g/l
Malathion 5	Malathion	599 g/l
Malathion 55	Malathion	599 g/l
CLEAN CROP Malathion 8 EC	Malathion	958 g/l
CLEAN CROP Malathion Methoxychlor Spray	Malathion Methoxychlor	240 g/l 240 g/l
Malathion ULV	Malathion	1186 g/l
CLEAN CROP Malathion ULV	Malathion	1162 g/l
CLEAN CROP Malathion ULV	Malathion	1173 g/l

Product Formulation	Active ingredient	Concentration
MARMAN Malathion ULV	Malathion	1173 g/l
MURPHY Liquid Malathion	Malathion	500 g/l

METABOLISM AND ENVIRONMENTAL FATE

Animal metabolism

Studies were submitted on the metabolism of radiolabelled malathion in laying hens and goats.

Hens. The metabolism, excretion and tissue distribution of [^{14}C]malathion (9.4 μCi/mg specific activity, 96.4% purity, labelled at the 2 and 3 positions of the succinate moiety) was studied in the hen (Cannon *et al*., 1993). Four laying hens were dosed daily for 4 days with encapsulated malathion and corn starch. Each dose corresponds to 3.8 mg malathion per hen (body weight about 1500 g) or 25 ppm in the feed based on an estimated feed intake of 150 g/hen. Four control hens received capsules containing corn starch only. Eggs were collected each day and the eight chickens were killed approximately 24 hours after administration of the last dose and heart, liver, muscle (light and dark meat), kidneys, skin plus underlying fat, other fat and the intestinal tract were collected, cubed and frozen until analysis.

The total radioactive residue (TRR) was determined in aliquots of the tissues, eggs, and excreta by scintillation counting after combustion to $^{14}CO_2$ or dilution with cocktail. The analytical methods employed for isolation of the radioactive residues included sequential extraction of tissue and egg samples with diethyl ether and methanol, both containing 0.1% trifluoracetic acid, followed by hydrolysis with sodium hydroxide, and enzymatic treatment with protease. The extracts were analysed by HPLC with a radio detector on reverse and anion exchange columns, with a carbohydrate column for the identification of glycerol.

Malathion was metabolized within 24 hours, with approximately 26% of the radioactivity excreted. The highest concentration of radioactivity was found in the faeces, with a TRR of 14 mg/kg malathion equivalents at day 2 and 7.65 mg/kg at day 7.

In the egg yolks collected on the first two days of treatment the TRR was ≤ 0.01 mg/kg, and increased to 0.96 mg/kg by the fourth day. Egg whites, however, contained significant radioactivity on day 1 and day 4 (Table 2).

Table 2. Total radioactive residues in egg yolks and whites.

Sample	^{14}C, mg/kg as malathion			
	Day 1	Day 2	Day 3	Day 4
Egg yolk	<0.01	0.03	0.35	0.96
Egg white	0.32	0.18	0.21	0.33

The results of serial solvent extraction showed that ethyl ether extracted most of the TRR on day 1 from egg white but subsequently the majority was extracted at the methanol and hydrolysis stages. By contrast ether extracted more from later samples of egg yolk (Table 3).

Table 3. Distribution of radioactive residues in extracts of egg whites and yolks.

Fraction	Egg white, % of TRR		Egg yolk, % of TRR	
	Day 1	Day 4	Day 2	Day 4
Ether/TFA	62.5	6.1	33.3	77.1
Methanol/TFA	9.4	21.2	-	7.3
0.2N NH_4OH	3.1	3.0	-	-
3N NaOH	3.1	48.5	66.7	26.0
Total extracted	78.1	78.8	100.0	110.4

The highest concentration of radioactivity in tissue was observed in kidney and liver samples (1.08 and 0.77 mg/kg as malathion respectively), and the lowest level (0.11 mg/kg) was found in light and dark muscle (Table 4).

Table 4. Total radioactive residues in hen tissues.

Tissue	TRR, mg/kg as malathion
Liver	0.77
Kidney	1.08
Heart	0.28
Muscle	0.11
Fat	0.18
Skin	0.16
GIT	0.42

The extraction of the tissues showed a fairly broad distribution of activity between ether, methanol and alkaline hydrolysis fractions, except in fat where the activity was mainly in the ether fraction (Table 5).

Table 5. Distribution of radioactive residues in extracts of tissues.

Fraction	Liver, % of TRR	Muscle, % of TRR	Fat, % of TRR
Ether/TFA	29.7	27.3	100.0
Methanol/TFA	21.6	18.2	5.6
0.2N NH_4OH	1.4	-	-
3N NaOH	23.0	63.6	5.6
Total extracted	75.7	109.1	111.2

Malathion was found to be used as a carbon source, with the radioactivity being incorporated in fatty acids, glycerol, tricarboxylic cycle acid intermediates and protein (Table 6). These components contained ^{14}C at levels from 0.01 to 0.2 mg/kg malathion equivalent. No malathion or any products of immediate metabolism were observed at levels exceeding 0.02 mg/kg in any of the samples, except the white from one egg on day 1, in which significant activity as malathion carboxylic acid was detected. This result, however, was attributed to contamination by the faeces, extracts of which were shown to contain the metabolite.

Table 6. Identification of radioactive residues in fat and tissues of laying hens.

Sample	^{14}C, % of TRR						
	Triglyceride	Oleic acid	Pyruvic acid	Lactic acid	Fumaric acid	Protein	Total
Heart	-	-	-	3.6	-	28.6	32.2
Kidney	4.6	-	1.5	2.3	-	26.0	34.4
Liver	32.4	18.9	12.2	-	1.4	29.7	94.6
Muscle	-	-	-	18.2	-	36.4	54.6
Fat	66.7	-	-	-	-	22.2	88.9
Skin	37.5	-	-	-	-	50.0	87.5
Egg white (day 2)	-	-	-	-	-	61.1	61.1
Egg yolk (day 3)	65.7	-	-	-	-	28.6	94.3

Goats. The metabolism, excretion, and [^{14}C]malathion (9.8 μCi/mg specific activity, 96.4% purity, labelled at the 2 and 3 positions of the succinate moiety) were studied in the goat (Cannon *et al.*, 1992). Two animals were dosed with 172.2 mg malathion in capsule per goat per day for five days, 115 ppm in the diet based on an estimated feed intake of 2 kg/goat/day. The test animals and the control were slaughtered approximately 24 hours after the last dose. Urine, faeces, and milk were collected during the dosing period, and heart, liver, muscle, fat and rumen contents were analysed. The samples were homogenised, and aliquots were either combusted to $^{14}CO_2$ or directly counted to determine the TRR. The analytical procedures were similar to those for hens. Milk was fractionated into fat, whey and casein components, which were analysed by HPLC in reverse mode and with columns designed for carbohydrate separation.

Malathion was rapidly metabolized after dosing, with 45-70% of the radioactivity excreted within 24 hours (Table 7).

Table 7**.** Excretion of radioactive residues by goats.

Day	^{14}C, % of dose			
	Goat 1		Goat 2	
	Urine	Faeces	Urine	Faeces
1	60.3	9.3	41.9	4.5
2	28.8	13.8	64.0	8.2
3	56.9	13.8	68.8	8.6
4	43.9	16.9	64.0	9.1
5	56.3	14.6	63.2	9 7
Average	49.2	13.7	60.4	8.0

Most of the ^{14}C residues in milk were extracted by polar solvents (Table 8) and up to 93% of the residues were identified (Table 9). Radioactivity in milk increased from 1.4 mg/kg as malathion at day 1 to 2.5 mg/kg at day 4 and decreased to 2.14 mg/kg at day 5.

Table 8. Distribution of radioactive residues in extracts of milk (average values**).**

Fraction	Day 1, % of TRR	Day 5, % of TRR
Hexane	5.7	5.6
Ether	15.2	13.8
Methanol/TFA	74.4	68.5
0.2N NH_4OH	4.9	4.2

Fraction	Day 1, % of TRR	Day 5, % of TRR
3N NaOH	0.4	0.6
Total extracted	100.6	92.7

Table 9**.** Identification of radioactive residues in milk.

	^{14}C, % of TRR			
	Triglycerides	Lactose	Protein	Total
Goat 1	16.8	70.5	6.0	93.3
Goat 2	19.5	58.6	4.1	82.2

The mean TRR in tissues was 2.26 mg/kg as malathion in liver, 1.96 mg/kg in kidneys, 0.38 mg/kg in heart, 0.24-0.28 mg/kg in muscle, 1.0 mg/kg in fat (omental) and 1.88 mg/kg in rumen contents. The radioactivity extracted by polar and non-polar solvents and after hydrolytic action was more evenly distributed in liver and heart extracts than in fat (Table 10)

Table 10. Distribution of radioactive residues in extracts of fat and tissues.

Fraction	Fat, % of TRR	Liver, % of TRR	Heart , % of TRR
Ether/TFA	83.8	18.0	21.1
MeOH/TFA	3.7	40.9	29.0
0.2N NH_4OH	2.0	4.5	2.7
3N NaOH	3.0	30.2	50.2
Total extracted	92.5	93.6	103.0

Malathion was utilized as a carbon source for the production of triglycerides, acids of the tricarboxylic acid cycle and lactose. In summary, 82-93% of the TRR in milk samples, 70-80% in fat, 94-115% in muscle, and 77-83% in other tissues was identified. The distribution of the identified products in fat and tissues is shown in Table 11.

Table 11. Identification of radioactive residues in fat and tissues of goats.

Sample	^{14}C, % of TRR							
	Tri-glyceride	Oleic acid	Stearic acid	Pyruvic acid	Lactic acid	Fumaric acid	Protein	Total
Fat								
- back	71.8	6.3	-	-	-	-	2.3	80.4
- omental	68.0	2.0	-	-	-	-	4.7	74.7
-perirenal	61.3	-	2.8	-	-	-	5.6	69.7
Heart	12.8	-	-	5.1	10.3	2.6	46.2	77.0
Kidney	5.8	1.8	-	8.2	9.4	2.3	46.2	73.8
Liver	3.1	4.5	1.3	27.8	5.8	1.8	39.0	83.3
Muscle								
- Semi-m	53.8	-	-	11.5	11.5	-	38.5	115.3
- L. Dorsi	50.0	8.3	-	-	11.1	2.8	22.2	94.4

In kidney, the metabolites malathion monocarboxylic acid and dicarboxylic acid were detected at 0.06 mg/kg and <0.05 mg/kg as malathion respectively. These were found in high concentration in the urine. No malathion or any products arising from primary metabolism were

observed at levels above 0.05 mg/kg in any other sample analysed. Proposed metabolic pathways of malathion in goats are shown on Figure 1. Structures of standards used in the metabolism studies on animals and plants are shown in Figure 2.

Plant metabolism

The metabolism of [^{14}C]malathion in cotton plants was examined by Wootton and Johnson (1992a). The plants were grown outdoors in pots in California. [^{14}C]malathion (7.4 mCi/mol specific activity, 97.4% purity, labelled at the 2 and 3 positions of the succinate moiety) was sprayed on the field at a rate of 1.46 kg ai/ha at 9 to 33 day intervals, with a total of ten applications. Cotton leaves and mature and immature bolls were separately collected approximately 18 hours after the last application. Mature cotton bolls were manually processed into seed, lint and gin trash. The TRR in the immature bolls, lint and gin trash was 55.6, 217 and 428 mg/kg malathion equivalents respectively. The radioactive residues were isolated by successive extraction of the samples with acidified acetonitrile/water, methanol/chloroform/acetone and potassium phosphate buffer, this last extract being partitioned with chloroform. The organic extracts were analysed by HPLC and TLC. The distribution of the radioactive residues in the various extracts of cotton leaves and seed is shown in Table 12.

Table 12**.** Distribution of radioactive residues in extracts of cotton leaves and seed.

Extract	Leaves, % of TRR	Seed, % of TRR
Hexane	—	26.9
Chloroform	49.9	12.2
Aqueous	16.1	5.0
Buffer	15.5	7.9
Extracted solids	15.4	15.3
Recovered	96.9	67.3

Figure 1. Proposed metabolic and incorporation scheme of malathion in lactating goats.

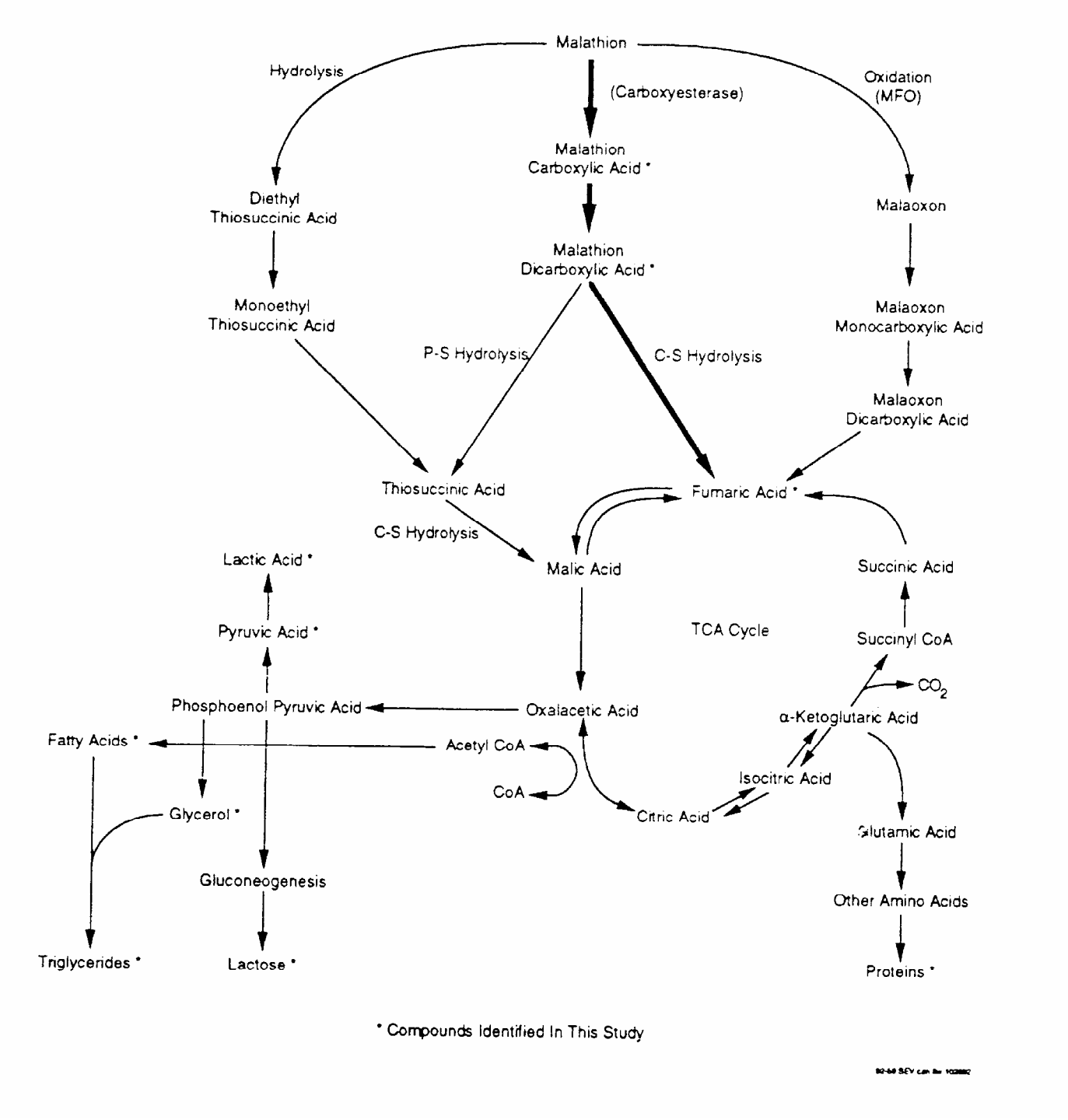
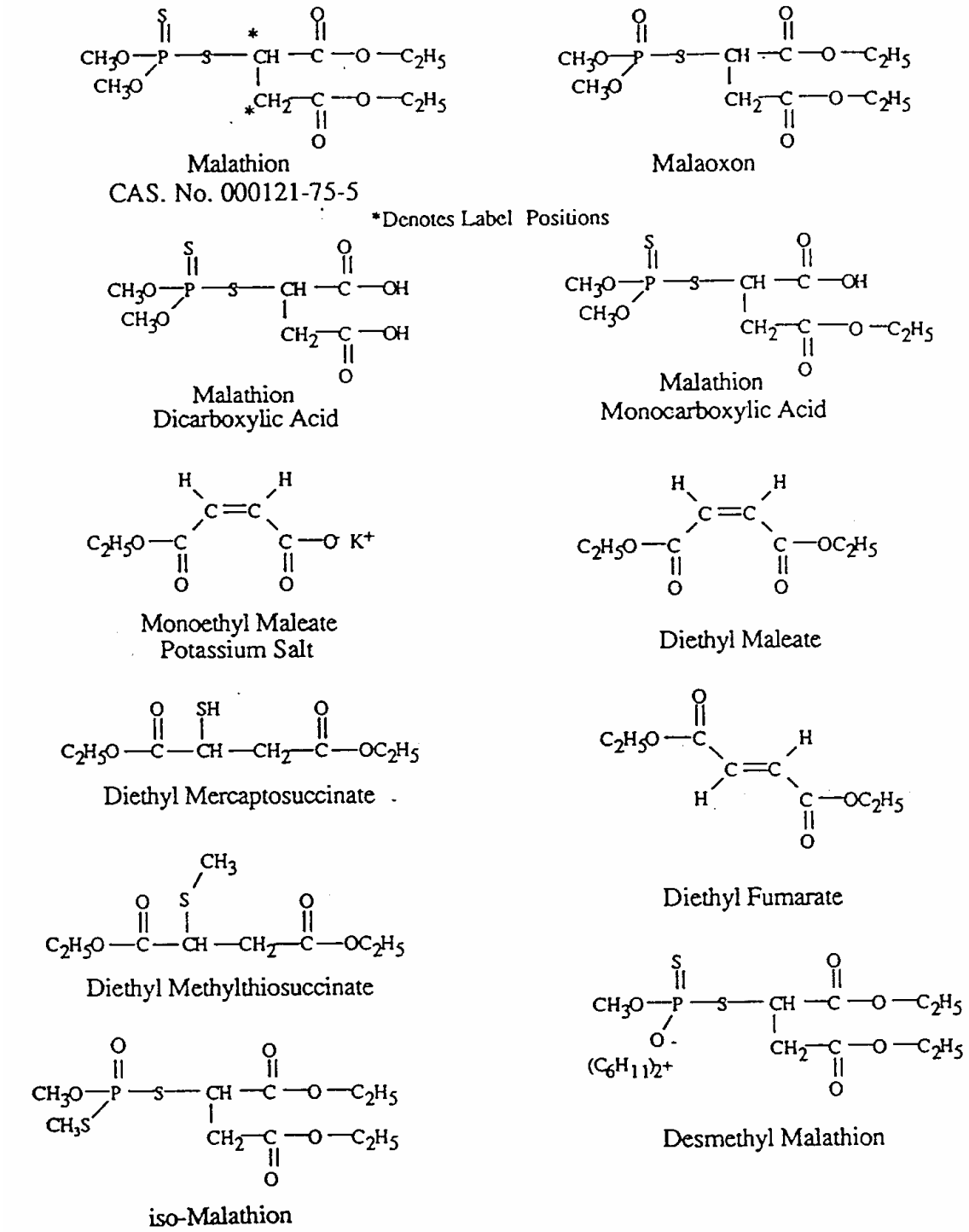


Figure 2. Structures of malathion and metabolite standards used in the metabolism studies.



Malathion was the major component identified in organic solvent extracts of the cotton seed and malathion monocarboxylic acid the most prominent metabolite. Other compounds identified are shown in Table 13. In the polar extract succinate was the major component (2.0% of the TRR), others being citrate and fumarate. Radioactivity was also found to be incorporated into starch, protein, pectin, lignin, hemicellulose and cellulose (total 14.6% of the TRR).

Table 13. Identification of radioactive residues in cotton seed.

Compound	% of TRR	mg/kg as malathion
Malathion	32.5	48.70
Malaoxon	0.2	0.3
Diethyl maleate	0.2	0.3
Monoethyl maleate	0.2	0.3
Malathion dicarboxylic acid	<0.1	<0.01
Malathion monocarboxylic acid	2.6	3.9
Diethyl fumarate	0.3	0.45
Diethyl methylthiosuccinate	<0.1	<0.01
Desmethyl malathion	0.1	0.15
Malathion mixed ester (methyl + ethyl)[1]	0.5	0.75
Tetraethyl dithiodisuccinate	0.3	0.45
TOTAL	36.7	55.3

[1]This residue was found to be an impurity in malathion, so the malathion residue was 33% (49.45 mg/kg).

Wheat. The metabolism of [^{14}C]malathion (7.16 mCi/mol specific activity, 97% purity, labelled at the 2 and 3 positions of the succinate moiety) in wheat forage, grain and straw was examined in a study conducted in California (Wootton and Johnson, 1992b). The compound was applied three times at 1.68-1.8 kg ai/ha when plants were at the late tillering stage, the boot stage and approximately 1 week before the final harvest. Forage samples were collected one week after the second treatment. Mature wheat was separated into straw, grain and chaff. The radioactive residues were isolated as before. The organic extracts were analysed by HPLC and TLC. The distribution of radioactive residues in various extracts is summarized in Table 14.

Table 14. Distribution of radioactive residues in extracts of wheat forage, grain and straw.

Extract	Forage, % of TRR	Grain (%TRR)	Straw, % of TRR
Chloroform	32.7	35.0	21.3
Aqueous	22.5	5.5	39.2
Buffer	16.2	12.8	6.3
Extracted solids	17.4	28.9	17.2
Recovered	88.8	82.2	84.0

Malathion was the major component identified in organic solvent extracts of the wheat fractions, and malathion monocarboxylic and dicarboxylic acids the major metabolites (Table 15). ^{14}C residues were also found to be incorporated in starch, protein, pectin, lignin, hemicellulose and cellulose.

Table 15. Identification of radioactive residues in wheat forage, grain and straw.

Compound	Forage		Grain		Straw	
	% of TRR	mg/kg	% of TRR	mg/kg	% of TRR	mg/kg
Malathion	7.0	3.76	26.6	2.76	10.4	13.94
Malaoxon	ND	ND	0.4	0.04	0.1	0.2
Diethyl maleate	0.6	0.32	ND	ND	0.4	0.5
Monoethyl maleate	ND	ND	0.2	0.02	ND	ND
Diethyl mercaptosuccinate	ND	ND	ND	ND	<0.1	0.03
Malathion dicarboxylic acid	4.9	2.63	1.1	0.11	0.1	0.09
Malathion monocarboxylic acid	6.0	3.22	0.5	0.05	7.3	9.8
Diethyl fumarate	0.2	0.11	ND	ND	0.1	0.22
Diethyl methylthiosuccinate	0.1	0.05	<0.1	<0.01	ND	ND
Desmethyl malathion	0.4	0.21	ND	ND	0.1	0.11
Malathion mixed (methyl + ethyl) ester[1]	8.1	4.35	0.8	0.08	0.6	0.79
Tetraethyl dithiodisuccinate	0.3	0.16	ND	ND	0.1	0.13
TOTAL	27.6	14.81	29.6	3.06	19.3	25.81

ND = not detected (<0.01 mg/kg)
[1]This residue was found to be an impurity in malathion, so the total malathion residue is 8.11 mg/kg in forage, 2.84 mg/kg in grain, and 14.73 mg/kg in straw.

Alfalfa. The metabolism of [^{14}C]malathion (2.84 mCi/mmol specific activity, 97% purity, labelled at the 2 and 3 positions of the succinate moiety) in alfalfa forage and hay was examined in a study conducted in California (Wootton and Johnson, 1992c). Malathion was applied at 2.0-2.1 kg ai/ha, when plants were 6-12 and 18-24 inches respectively. Mature plants (55 days post planting) were harvested 18 hours after the last application. After extraction with acidified organic solvents, the labelled residues were identified by HPLC and TLC. The distribution of the radioactive residues in the extracts is shown in Table 16.

Table 16. Distribution of radioactive residues of malathion in extracts of alfalfa forage and hay.

Fraction	Forage, % of TRR	Hay, % of TRR
Chloroform	57.2	27.5
Aqueous	15.9	17.7
Buffer	9.0	19.6
Extracted solids	3.9	16.6
Recovered	86.0	81.4

The major component was malathion, and the most prominent metabolite was malathion monocarboxylic acid (Table 17). ^{14}C residues were also found to be incorporated in starch, protein, pectin, lignin, hemicellulose and cellulose.

Table 17. Identification of residues in organic extracts of alfalfa forage and hay.

Compound	Forage		Hay	
	% of TRR	mg/kg	% of TRR	mg/kg
Malathion	40.5	56.72	14.6	31.33
Malaoxon	ND	ND	0.8	1.82
Iso-malathion	ND	ND	0.2	0.43
Diethyl maleate	0.5	0.74	0.2	0.47
Monoethyl maleate	ND	ND	0.3	0.69
Diethyl mercaptosuccinate	0.2	0.23	0.1	0.16
Malathion dicarboxylic acid	ND	ND	1.5	3.42
Malathion monocarboxylic acid	9.8	13.77	2.7	5.79
Diethyl methylthiosuccinate	0.1	0.17	ND	ND
Diethyl fumarate	0.1	0.21	0.1	0.38
Desmethyl malathion	0.5	0.67	0.2	0.52
Malathion mixed (methyl + ethyl) ester[1]	1.5	2.08	1.8	3.81
Tetraethyl dithiodisuccinate	<0.1	0.04	0.6	1.26
TOTAL	53.2	74.63	23.1	50.09

ND = not detected (<0.01 mg/kg
[1] This residue was found to be an impurity in malathion, so the total malathion residue is 35.14 mg/kg in hay and 58.80 mg/kg in forage.

Lettuce. The metabolism of [^{14}C]malathion (2.3 mCi/mmol specific activity, 98.8% purity, labelled at the 2 and 3 positions of the succinate moiety) in lettuce was examined in a study conducted in California (Wootton and Johnson, 1992d). Malathion was applied 6 times at a rate of 2.0 kg ai/ha and plants were harvested 14 days after the last treatment. After sample extraction with acidified organic solvents, the labelled compounds were identified by TLC and HPLC. The major component identified in organic solvent extracts of treated lettuce was malathion, representing 36.8% of the TRR (160.9 mg/kg). The most prominent metabolite was malathion monocarboxylic acid at 12.8% of the TRR (56 mg/kg as malathion). Malaoxon was present at 1.2% of the TRR (5.3 mg/kg). Other compounds identified are shown in Table 18. Polar extracts contained citrate, succinate and fumarate.

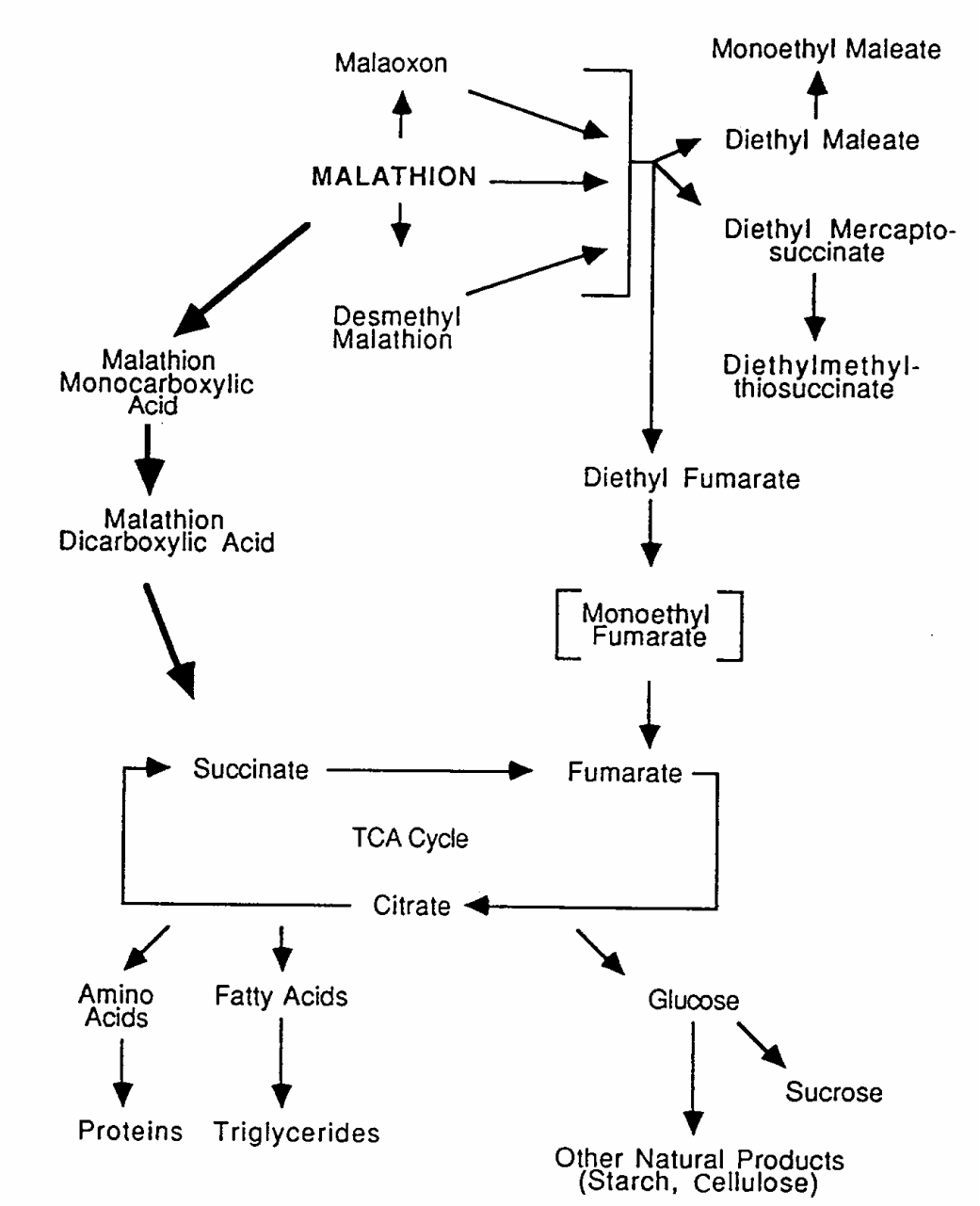
Table 18. Identification of radioactive residues in lettuce.

Component	% of TRR	mg/kg
Malathion	30.9	135.07
Malaoxon	1.2	5.25
Diethyl maleate	0.4	1.74
Monoethyl maleate	0.3	1.38
Malathion dicarboxylic acid	0.9	3.93
Malathion monocarboxylic acid	12.8	56.12
Diethyl fumarate	0.1	0.44
Desmethyl malathion	0.3	1.31
Malathion mixed (methyl + ethyl) ester [1]	5.9	25.79
Tetraethyl dithiodisuccinate	0.2	0.88

[1] This residue was found to be an impurity in malathion, so the total malathion residue in lettuce was 36.8% (160.86 mg/kg)

The metabolism of malathion is similar in alfalfa, lettuce, wheat and cotton and proceeds via de-esterification to the dicarboxylic acid which is cleaved to give succinic acid which is incorporated into the plant constituents (Figure 3). Analysis of polar extracts showed that ^{14}C activity was associated with citrate, succinate and fumarate moieties. The ^{14}C-residues in the alfalfa and wheat forage and hay, wheat grain and straw and cotton seed extracted solids were associated with endogenous plant constituents such as starch, protein, lignin and cellulose.

Figure 3. Proposed metabolic pathways of malathion in wheat, alfalfa, cotton and lettuce.



Environmental fate in soil

The adsorption and desorption of malathion (90 μCi/mg specific activity, 96% purity, labelled at the 2 and 3 positions of the succinate moiety) were studied in 5 soils using the batch technique according to US-EPA (FIFRA) guideline N163-1 and complying with GLP (Blumhorst, 1989). Initial concentrations were approximately 100, 10, 1 and 0.1 μg/ml and the solution:soil ratio was 5:1. Treated samples were flushed with nitrogen, and the tubes capped and shaken for 2 hours at 22°C. For desorption, 10 ml 0.01 M $CaCl_2$ was added to the soil suspension remaining in the tubes and the tubes shaken and centrifuged as before. Regression analysis of the log transformed data showed that the adsorption and desorption isotherms were highly linear over the concentration ranges and well described in Freundlich equation. The K_d and K_{oc} constants, together with the soil properties are shown in Table 19.

Table 19. Soil properties and malathion adsorption and desorption constants.

Soil	pH	CEC[1] meq/100g	Clay content	Organic matter %	Organic carbon %	Adsorption		Desorption	
						K_d	K_{oc}	K_d	K_{oc}
Sandy loam	6.9	5.6	8	1.1	0.55	0.83	151	0.89	161
Sand	6.2	1.9	4	0.8	0.4	1.23	308	1.67	418
Loam	6.1	10.6	18	2.0	1.0	1.76	176	1.63	163
Silt loam	7.4	15.7	26	2.7	1.35	2.47	183	2.08	154
Sandy loam	4.5	5.6	10	1.2	0.6	1.60	267	2.03	338

[1] cation exchange capacity

Malathion was adsorbed in moderate amounts by the soils examined, which places it in the medium mobility class. Adsorption generally increased as soil organic matter, clay content and cation exchange capacity increased.

Malathion was fairly stable under the experimental conditions, accounting for 74.2 to 98.6% of the TRR in the adsorption and desorption solutions. The ß-monocarboxylic acid was the main degradation product detected, ranging from 0.1% of the TRR in sand to 19% in loam (Table 20).

Table 20. Formation of malathion carboxylic acid in soil solution systems.

Soil	Adsorption solution, % of TRR		Desorption solution, % of TRR	
	Malathion	β-monocarboxylic acid	Malathion	β-monocarboxylic acid
Sandy loam	92.8	3.3	93.5	5.3
Sand	98.6	0.1	96.4	0.3
Loam	88.7	6.8	74.2	19
Silty loam	87.8	8.6	83.4	13.4
Sandy loam	94.3	1.4	94.3	2.2

The aerobic degradation of malathion was evaluated in a study with a loam soil representative of agricultural soils in the Midwest of the USA (Blumhorst, 1990). [^{14}C]malathion was applied to a nonsterile soil (2 samples) and sterile soil (1 sample) at a rate of 6.88 - 8.86 mg/kg dry weight (7.63 - 7.75μCi), corresponding to the maximum label rate of 7.01 kg ai/ha. Samples were kept in the dark at 22°C. Sub-samples for analysis were taken immediately after treatment, after 6 hours and after 1, 2, 3, 4, 7, 14 and 92 days. In the non-sterile soil, malathion was rapidly degraded with an average half-life of 4.9 hours. After 6 hours malathion represented, on average, 21.9% of the applied ^{14}C which dropped to 2.6% after 1 day. The main extractable product was malathion dicarboxylic acid, representing a mean of 13.8 and 1.1% of the TRR after 6 hours and 4 days respectively. Bound residues mainly associated with the humin fraction of soil organic matter, and $^{14}CO_2$ were both

significant products (>50% of the TRR at day 7). Dissipation of ^{14}C by volatilization was insignificant.

The degradation of [^{14}C]malathion under aerobic and anaerobic conditions on a loamy sand soil collected in Buelah, Arkansas was studied by Saxena (1988). Samples were fortified with [^{14}C]malathion at 3.12 mg/kg and maintained at 25°C in the dark. Humidified air was drawn through the system to maintain aerobic conditions and duplicate samples were taken after 8, 16 and 26 hours and 3, 7, 11, 21, 31, 63, 94 and 162 days. After 26 hours, 4 samples were rendered anaerobic by flooding with water and nitrogen until the end of the study and sub-samples were taken 30 and 62 days after flooding.

Malathion was degraded with a half-life of 1 day under aerobic conditions. The major degradation products were $^{14}CO_2$ (up to 58.4% of the TRR on day 162), soil bound residues (up to 25.7% of the TRR on day 94) and malathion dicarboxylic acid (up to 62.3% of the TRR on day 7). Under anaerobic conditions the half-life of malathion was less than 30 days, although the exact value could not be determined with only 2 samples. The major degradation products were the same as for aerobic degradation.

The dissipation of malathion after application to bare soil and cotton was evaluated in a field dissipation study conducted in California (Rice *et al.*, 1990; Jacobsen *et al.*, 1993). Six applications at a rate of 1.13 kg ai/ha were made at 7-day intervals. Soil core samples were taken after each application and 1, 3, 7, 14 and 28 days after the final application. The results are shown in Table 21.

Table 21. Malathion residues (mg/kg dry weight) in soil samples taken from a treated crop plot and bare ground plot after each application and one day after the last application (LOD = 0.01 mg/kg).

	Crop plot							Bare ground plot						
Soil depth	1st appln	2nd appln	3rd appln	4th appln	5th appln	6th appln	+1 day	1st appln	2nd appln	3rd appln	4th appln	5th appln	6th appln	+1 day
0-15 cm	0.055	0.072	0.13	0.11	0.13	0.082	0.14	0.088	0.037	0.087	0.047	0.062	0.067	0.11
15-30 cm	0.064	0.047	0.14	0.072	0.072	0.066	0.13	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
30-45 cm	<LOD	<LOD	0.023	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

Residues of malathion could not be detected in any soil samples later than one day following the last application. Malathion dicarboxylic acid was only detected at 0.11 mg/kg in soil from the bare ground plot 1 day after the final application and in one sample from the 30-45 cm soil layer in the cotton plot after the second application (0.016 mg/kg). Residues of malaoxon could not be detected in any sample analysed.

The dissipation half-life of malathion could not be determined because the residues dissipated too rapidly.

The photodegradation of [^{14}C]malathion (10 mg/kg) on the surface of sandy loam soil was studied under a 12 hours light/12 hours dark cycle and a dark control over a 30-day period (Dykes *et al.*, 1990). The soil was maintained at about 25°C and samples were taken after 1, 4, 7, 11, 21, 26 and 30 days. The rate constant and extrapolated half-life of malathion were 0.00399 day^{-1} and 173 days respectively in the exposed soil and 0.01092 day^{-1} and 63.5 days respectively in the control soil. The shorter half-life in the control sample is believed to be a result of increased microbial activity on the test compound. After 30 days, the total volatiles accounted for <6% of the initial dose in both exposed and unexposed systems, and malathion accounted for 83.2 and 93.4% of the recovered activity in the exposed and control soils respectively.

The leaching potential of [^{14}C]malathion and its degradation products was evaluated in a study on four types of soil (Nixon, 1995). Flasks containing treated soil (5.3 mg/kg of malathion, 75% field capacity) were incubated in the dark at 25°C and sampled at 0 and 21 hours (sand), 0, 2 and 4

hours (sandy loam) and 1.5 hours (loam and silty clay). Once half-lives were determined (Table 22), six flasks of each soil were treated and aged for approximately one half-life. Two flasks of each soil were sampled following dosing, two at the ageing period and two were mixed thoroughly and added to the top of replicate columns containing untreated soil of the same type. Malathion and/or its degradation products exhibited moderate mobility with 5 to 74.4% of the applied radiocarbon passing through the columns in the leachate (Table 22).

Table 22. ^{14}C distribution in leachate and soil sections following column leaching of aged residues under saturated flow conditions.

Soil	Half-life, hours	Total leachate, % of applied ^{14}C	Soil sections, cm
Sand	14.3	48.4	50.9
Sandy loam	2.1	74.4	20.2
Loam	0.5	61.8	29.8
Silty clay	0.9	5.0	99.1

[^{14}C]malathion was present only in sand leachate at 1.9% of the applied radioactivity. Dicarboxylic and monocarboxylic acids were present in all soils except silty clay, the dicarboxylic acid being the main product (Table 23). The mono- and dicarboxylic acids showed greater potential for leaching, but this was mitigated by their relatively rapid mineralization.

Table 23. Quantitative characterization of ^{14}C malathion residues in the leachate fractions (% of applied radioactivity).

Soil	Fraction	Malathion	Dicarboxylic acid	Monocarboxylic acid
Sand	2nd	1.9	17.5	13.3
Sandy loam	1st	nd	6.9	0.8
	2nd	nd	47.6	4.2
	3rd	nd	11.8	0.1
	4th	nd	2.8	nd
Loam	1st	nd	10	6.6
	2nd	nd	20.4	6.4
	3rd	nd	12.4	1.2

The volatility of malathion from a silt loam soil was assessed in a study using [^{14}C]malathion formulations at the recommended field rate with air flows of 100 or 300 ml/min and soil at 50% or 75% field capacity (Spare *et al.*, 1991). The results showed little or no recovery of volatiles either as malathion or CO_2 with the exception of the EC formulation at 50% soil moisture and 100 ml/min gas flow, where 26.5% of the applied dose was recovered as CO_2. There was no discernible pattern of volatility with soil moisture or purge flow rate (Table 24).

Table 24. Volatility of malathion in three formulations.

Formulation	Maximum air concentrations, µg malathion/m^3	Maximum volatility, µg malathion/cm^2/h
RTU[1]	5.4 - 21.5	1.2-3.6 x 10^{-3}
ULV[2]	1.8 - 5.4	0.4 x 10^{-3}
EC[3]	18.4 - 74.5	1.8 x 10^{-3} - 1.7 x 10^{-2}

[1]Ready-to-use
[2]Ultralow volume
[3]Emulsifiable concentrate

Environmental fate in water/sediment systems

The degradation of malathion in a water/sediment system was evaluated under aerobic and anaerobic conditions (Blumhorst, 1991a,b;1997). Samples were fortified with [^{14}C]malathion at 1.108 - 1.02 mg/kg and maintained at 22°C in the dark. In the aerobic study, sub-samples of water and sediment were taken for analysis immediately after treatment and after 6 hours and 1, 3, 7, 14 and 30 days. Under anaerobic conditions, sampling was continued to 118 days. The initial degradation products were monocarboxylic acids of malathion (α and β isomers), demethyl monocarboxylic acids, dicarboxylic acid and demethyl dicarboxylic acid (Table 25) which underwent further degradation.

Table 25. Half-life of malathion and maximum product concentrations in aerobic and anaerobic water/sediment systems.

	Aerobic		Anaerobic	
	water	sediment	water	sediment
Half-life (days)	1.09	2.55	2.49	2.45
Monocarboxylic acids, % of applied ^{14}C	28.81 (day 3)	3.61 (6 hours)	28.46 (day 4)	4.52 (6 hours)
Dicarboxylic acid, % of applied ^{14}C	46.38 (day 7)	6.39 (day 7)	20.91 (day 14)	5.20 (day 4)
Demethyl monocarboxylic acids, % of applied ^{14}C	23.87 (day 30)	4.69 (day 30)	20.77 (day 7)	8.06 (day 45)

Dissipation by volatilization was minimal in both studies (<0.5 and <0.1% of the applied ^{14}C, in aerobic and anaerobic conditions, respectively). Under anaerobic conditions, total radioactive residues in the sediment (extracted + bound) gradually decreased with time whereas mineralization increased, accounting for 56% of the applied radioactivity at day 118 after application. In the aerobic system, mineralisation and bound residue formation increased to 24 and 10% of the applied ^{14}C, 30 days after treatment respectively.

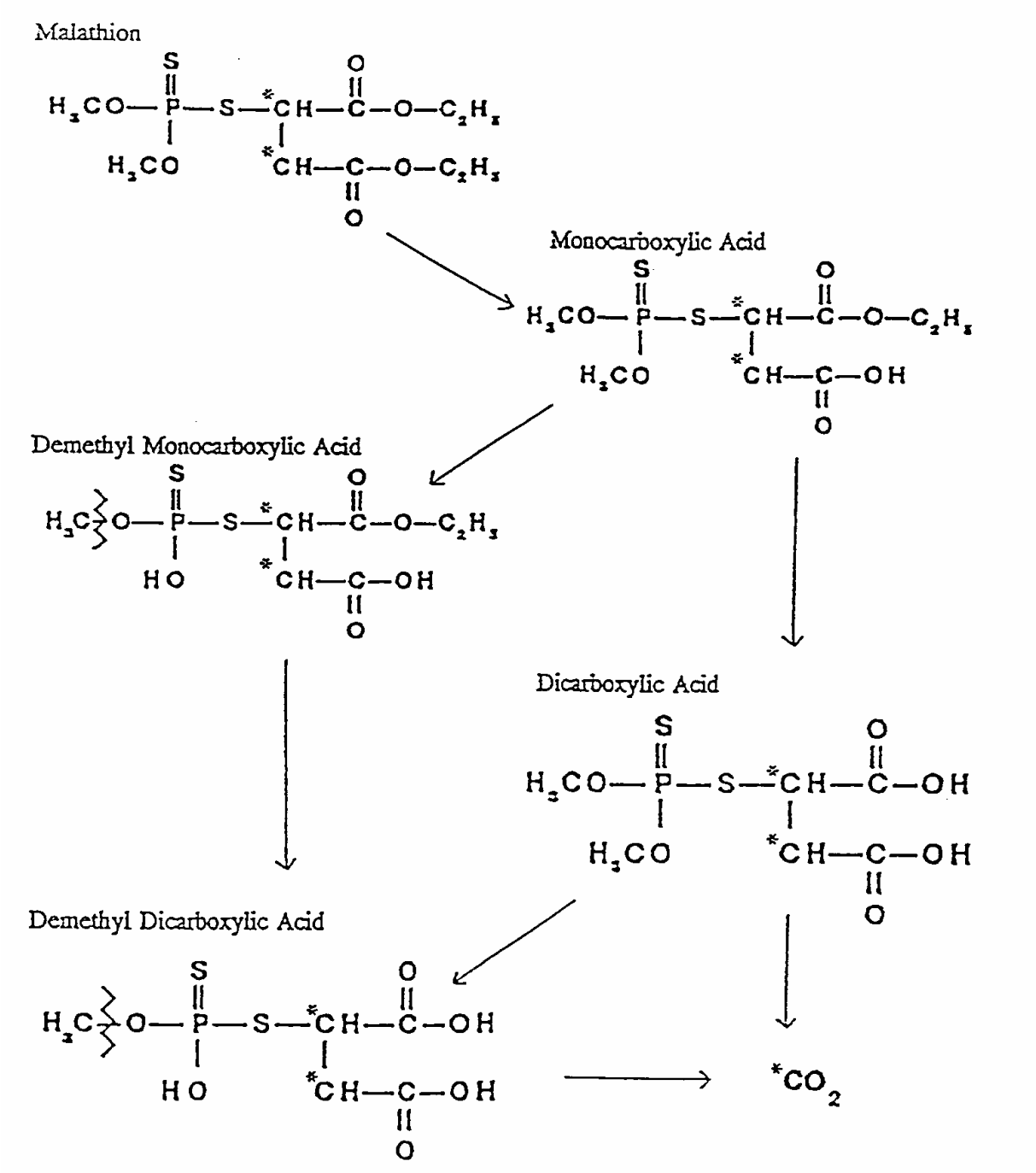
Proposed degradation pathways in aerobic aquatic system are shown in Figure 4.

METHODS OF RESIDUE ANALYSIS

Analytical methods for the determination of malathion and malaoxon in wheat grain and its processed commodities, cotton seed, alfalfa, head lettuce, green onions, oranges and their processed commodities, corn, tomatoes and their processed commodities and avocados were reported (Buttrey and Butz, 1995). Malathion and malaoxon are extracted from most samples with acetonitrile or acetonitrile/water (80:20). Dry samples are hydrated before the extraction. Lipids are removed from the extracts with hexane and the analytes are partitioned 3 times with dichloromethane. Clean-up of the organic extract is on activated carbon and silica gel solid-phase extraction cartridges. The analytes are quantified by gas chromatography with a flame photometric detector in the phosphorus mode (FPD-P). Recoveries of malathion and malaoxon averaged 89.6% and 98.2% respectively. The LOD is 0.01 mg/kg for all raw and processed human food and 0.05 mg/kg for raw and processed animal feed.

Multi-residue methods for the analysis of pesticides amenable to gas chromatography were reported by The Netherlands. Non-fatty samples (<5% fat content) are extracted with ethyl acetate and sodium sulfate or acetone followed by partition with dichloromethane and petroleum ether. No clean-up is necessary and the analytes are determined by GLC with a nitrogen-phosphorus detector (NPD) or ion trap detector. The LOD for malathion and malaoxon is 0.02 mg/kg and recoveries ranged from 97 to 106%.

Figure 4. Proposed malathion degradation pathway in aerobic aquatic system (*labelled position)



In market basket survey and monitoring programmes in Australia organophosphorus insecticides are extracted with acetone, partitioned into dichloromethane/hexane and cleaned up by gel permeation chromatography. The analytes are determined by GLC with an NPD or FPD-P with an

LOD of 0.01 or 0.02 mg/kg. In another method dialysis through a semi-permeable membrane and alumina column clean-up preceded analysis by GLC.

Stability of residues in stored analytical samples

Clayton (1996) assessed the stability of malathion and malaoxon in various raw agricultural and processed commodities during freezer storage for twelve months. Duplicate samples were fortified with 0.50 mg/kg malathion and malaoxon and stored at <-5°C up to 12 months. The results show that the analytes are stable under the conditions of the study, with 69 to 105% of malathion and 91 to 109% of malaoxon remaining (Tables 26 and 27).

Table 26. Storage stability of malathion and malaoxon in raw commodities at <-5°C.

Sample	Analyte	Mean % remaining after nominal storage periods (months)[1]					
		0	1	2	3	6	12
Cotton seed	Malathion	89	79	108	94	91	92
	Malaoxon	101	57	80	99	121	90
Wheat grain	Malathion	94	63	68	77	76	60
	Malaoxon	98	75	77	76	78	74
Wheat forage	Malathion	84	76	76	70	69	68
	Malaoxon	84	90	88	82	80	95
Wheat straw	Malathion	72	82	102	76	88	79
	Malaoxon	86	77	89	67	83	81
Leaf lettuce	Malathion	99	NA	99	97	103	94
	Malaoxon	97	NA	117	99	111	109
Potato tubers	Malathion	88	75	83	88	100	66
	Malaoxon	92	87	93	90	91	70
Tomato fruit	Malathion	83	90	96	109	100	91
	Malaoxon	77	94	107	103	75	102

NA = not analysed
[1] Recoveries corrected for mean concurrent procedural recoveries <100%. Average procedural recoveries for raw agricultural commodities ranged from 82 to 99% for malathion and 91 to 111% for malaoxon

Table 27. Storage stability of malathion and malaoxon in processed commodities at <-5°C.

Sample	Analyte	Mean % recovery after nominal storage periods (months)[1]				
		0	1	3	6	12
Cotton seed						
Meal	Malathion	78	104	105	102	106
	Malaoxon	87	104	97	94	90
Hulls	Malathion	71	96	85	99	93
	Malaoxon	82	92	88	85	86
Oil	Malathion	78	103	94	97	97
	Malaoxon	91	91	103	102	95
Wheat						
Bran	Malathion	95	91	105	87	101
	Malaoxon	80	84	95	84	83
Flour	Malathion	102	104	104	100	104
	Malaoxon	105	102	110	116	99
Middlings	Malathion	92	94	118	90	98
	Malaoxon	84	96	106	87	91
Shorts	Malathion	96	91	101	103	102
	Malaoxon	96	90	96	99	98
Tomato						
Pomace	Malathion	101	102	98	112	101
	Malaoxon	104	103	105	105	101
Ketchup	Malathion	89	98	99	110	102
	Malaoxon	102	85	104	124	103

Sample	Analyte	Mean % recovery after nominal storage periods (months)[1]				
		0	1	3	6	12
Juice	Malathion	87	99	94	101	102
	Malaoxon	87	93	93	117	101

[1] Recoveries corrected for mean concurrent procedural recoveries <100%. Average procedural recoveries for processed commodities ranged from 69% to 105% for malathion and 92% to 111% for malaoxon.

USE PATTERN

Table 28 shows the registered uses of malathion in the crops discussed in this evaluation and the countries in which they are grown as of February 1998.

Table 28. Registered uses of malathion (if not indicated, application by foliar spray, from the ground and in the field; ai = active ingredient; EC= emulsible concentrate; ULV= ultra low volume).

Crop	Country	Form.	Application rate				PHI, days
			No.	kg ai/ha	Water l/ha	kg ai/hl	
Alfalfa	USA	EC		1.2-1.96	112		
		ULV		0.5-1.1			0-5
Apples	Australia	EC				0.06	3
	UK	EC				0.057-0.114	4
	USA	EC		0.8-1.6	3370/22[1]		3
		EC		2.7-20	1123-8987/225-1125		3
		EC		3.2-6.4	4494	0.07-0.14	3
		EC	12			0.11-0.16	4
Apricots	UK	EC				0.057-0.114	4
	USA	EC		1.6	2246/22[1]		7
		EC		5.4-12	1123-8987/225-1125		7
		EC		3.6-4.8	3370	0.1-0.14	7
		ULV		0.7-1.4			0
Asparagus	USA	EC		1.2-1.6	112		1
		EC		1.7	225-675/>56		1
Avocados	USA	EC		4.6-10	225-675/>56		7
		EC		3.6	3370	0.1	7
Beans	Australia	EC				0.06-0.1	3
	UK	EC		1.26	600		4
	USA	EC		1.6-2.0	112		1
		EC		1.7-2.4	225-675/>56		1
		ULV		0.7			1
Beans, Broad	Poland	EC	1-2	0.30	200-600	0.05-0.15	7
Beans, Dry	USA	EC		1.2-1.6			1
		ULV		0.7			1
Blackberries	UK	EC		0.00168		0.075	4
	USA	EC		2.4	2246/22[1]		1
		EC		2.4	2247	0.1	1
		EC		1.3-4.6	225-675/>56		1
Blueberries	USA	EC		1.2-2.6	2246/22[1]		1
		EC		1.7-2.8	225-675/>56		1
		EC		0.8-1.6	1123-2247	0.07	1
		ULV		0.8			0
Brassica vegetables	Thailand	EC		0.42-1.25	1000	0.042-0.125	
Broccoli	USA	EC		0.1-1.6	112		3
		EC		2.0-3.4	225-675/>56		3
Cabbages	Australia	EC				0.06-0.1	3
	Poland	EC	1-2	0.3-0-0.375	200-600	0.05-0.19	7
	USA	EC		0.1-1.6	112		7

Crop	Country	Form.	Application rate				PHI, days
			No.	kg ai/ha	Water l/ha	kg ai/hl	
		EC		2.0-3.4	225-675/>56		7
		EC				0.06-1.0	3
Carrots	Australia	EC				0.06-0.1	3
	Poland	EC	1-4	0.3-0.375	200-600	0.05-0.19	7
	UK	EC		1.26	600		4
	USA	EC		1.2-1.6	112		7
		EC		1.1-2.2	225-675/>56		7
Celery	Australia	EC				0.06-0.1	3
	UK	EC		1.26	600		4
	USA	EC		1.2	112		7
		EC		1.3-2.0	225-675/>56		7
Cereals	Australia	EC		0.24-1.1			1
		ULV		0.24-0.88			1
		EC				1.2	[5]
Cherries	UK	EC				0.075-0.114	4
	USA	EC		0.8-1.2	2246/22[1]		3
		EC		3.4-10	1123-8987/225-1125		3
		EC		3.2-4.8	4494	0.07-0.1	3
		ULV		1.0-1.3			1
Chestnuts	USA	EC		0.6	2246/22		0
		EC		2.7-6.8			
Citrus	Australia	EC				0.06-0.1	3
	Thailand	EC		0.042-0.125	5	0.002-0.006	3
	USA	EC		1.0-1.6	1123/22[1]		7
		EC		1.1-28.4	934-7476		7
		EC				0.06-0.1	3
Clover	USA	EC		1.2-1.6	112		
		ULV		0.7-1.0			
Corn	USA	EC		1.3	225-675/>56		5
		ULV		0.266-0.533			5
Corn, Field	USA	EC	3-5	1.2-1.6			5
		ULV		0.266-0.533			5
Corn, Sweet	USA	EC		1.2	112		5
	Thailand	EC		0.83	500	0.166	-
Cotton	USA	EC		0.4-3.14			
		ULV		0.3-1.4			0
Cucumbers	USA	EC		1.2	112		1
		EC		1.3-2.3	225-675/>56		3
		EC		1.2-1.6			1
Cucurbits	Australia	EC				0.03-0.1	3
		ULV		0.53-1.06			3
Figs	USA	EC		2.7	3370/22[1]		3
		EC		3.3	1123-8987/225-1125		3
Fruit trees	Australia	EC				0.05-1.25	3
	Poland	EC	2-3	0.625	500-1000	0.06-0.125	7
Grapes	Australia	EC				0.06-0.1	3
	USA	EC		1.2	2246-3089		3
		EC		2.3-3.1	1123-8987/225-1125		3
		EC		1.2-2.4	562-2247	0.1-0.2	3
		EC				0.06-0.1	3
Grass	USA	EC		1.2-1.6	112		
		ULV		0.5-0.8			
Guavas	USA	EC		1.0	1123-8987/225-1125		2
Herbs (except Celery leaves and Parsley)	Netherlands	EC EC	1-3 1-3	0.07-0.03	200-800	0.037	10/14 4
Lettuce	Australia	EC				0.06-0.1	3
	UK	EC		1.26	600		4

Crop	Country	Form.	Application rate				PHI, days
			No.	kg ai/ha	Water l/ha	kg ai/hl	
	USA	EC		1.6-2.4	112		7/14[2]
		EC		1.7-2.7	225-675/>56		7/14[2]
		EC	12			0.11-0.16	4
Macadamia nuts	USA	EC		4.0-20	1123-8987/225-1125		0
		EC		Up to 16.7		0.0013	
Maize	*see* Corn						
Mangoes	USA	EC		1.0	1123-8987/225-1125		2
	Thailand	EC		0.655-1.942	1560	0.042-0.125	3
Melons	USA	EC		1.2-2.3			1
Mint	USA	EC		1.2-1.6	112		7
Mushrooms	Netherlands	EC	2-5	1.25	2500	0.5	7
	USA	EC		1.9		0.13	1
Mustard greens	USA	EC		0.8-1.6	112		7
Okra	USA	EC		1.2-1.9	112		1
		EC		2.0	225-675/>56		1
Onions	Australia	EC				0.09	3
	Poland	EC	1-2	0.3-0.375	200-600	0.06-0.19	7
	UK	EC		1.26	600		4
	USA	EC		1.3-2.7	225-675/>56		3
Onions, including greens	USA	EC		1.2-2.4	112		3
Papayas	USA	EC				0.10-0.14	
Peaches	Australia	EC				1.05-1.06	
	UK	EC				0.057-0.114	4
	USA	EC		1.6	2246/22[1]		7
		EC		3.3-12	1123-8987/225-1125		7
		EC		1.8-4.8	1286-3370	0.14	7
Pears	Australia	EC				0.06	3
	UK	EC				0.057-0.114	4
	USA	EC		0.8-1.6	3370/22[1]		1
		EC		2.7-20	1123-8987/225-1125		1
		EC		2.4-4.8	3370	0.07-0.14	1
		EC	12			0.11-0.16	4
Peas	Australia	EC		0.63			3
		ULV		0.65			3
	Poland	EC	1-2	0.3	200-600	0.05-0.15	7
	UK	EC		1.26	600		4
	USA	EC		1.2-1.6	112		3
		EC		1.3-3.3	225-675/>56		3
		ULV		0.7			14
Peppers	USA	EC		1.0-1.2	112		3
		EC		1.0-2.0	225-675/>56		3
		EC	12			0.11-0.16	4
Pome fruit	Australia	ULV		0.53-0.66			3
	USA	EC				0.06	3
Potatoes	UK	EC		1.26	600		4
	USA	EC		0.8-1.2	112		0
		EC		1.1-3.3	225-675/>56		0
Raspberries	Poland	EC	1-2	0.625	750-1000	0.06-0.085	-
	UK	EC		0.00168-0.00252		0.075-0.114	4
	USA	EC		1.2-2.4	2246/22[1]		1
		EC		1.3-4.6	225-675/>56		1
		EC		2.4	2247	0.1	1
Rice	Australia	EC	1	0.3			
		ULV		0.82-0.83			
	Thailand	EC		0.311-0.415	375-500	0.083	-
	USA	EC		0.8-2.0	112		7
		EC		2.0	225-675/>56		7

Crop	Country	Form.	Application rate				PHI, days
			No.	kg ai/ha	Water l/ha	kg ai/hl	
		ULV		0.7			7
Sorghum	Australia	ULV		0.65-1.06			
	USA	EC		1.2	112		7
		ULV		0.7-1.0			7
Spinach	Poland	EC	1-2	0.3	200-600	0.05-0.15	7
	USA	EC		1.6	112		7
		EC		1.3-2.7	225-675/>56		7
Stone fruit	Australia	EC				0.06	3
		ULV		0.53-1.06			3
Strawberries	Poland	EC	1-2	0.625	750-1000	0.06-0.085	7
	USA	EC		1.2-2.4	2246/22[1]		3
		EC		1.3-2.7	225-675/>56		3[3]
		EC	12			0.11-0.16	4
Strawberries, currants, other berries and small fruits	Netherlands	EC	1-4	0.19-0.45	500-1200	0.0375	4
Sweet corn	*see* Corn						
Tomatoes	Australia	EC				0.06-0.1	3
	Poland	EC	1-2	0.3	200-600	0.05-0.15	7
	USA	EC		1.3-2.3	225-675/>56		3
		EC		2.3-4.0			5
		EC	12			0.11-0.16	4
		ULV		0.2-0.7			1
Turnips	USA	EC		0.8-1.6	112		3/7[4]
Vegetables	Netherlands	EC	1-3	0.07-0.30	200-800	0.037	4
		EC/G	1-3	0.19-0.56	500-1500	0.037	3/10/14
	Poland	EC	1-2	0.3-0-0.45	200-600	0.05-0.225	7
Walnuts	USA	EC		1.18-3.14	4672		
Watercress	USA	EC		1.3-2.7	225-675/>56		7
Wheat	USA	EC		1.2-1.7	112		7
		EC		1.7	225-675/>56		7
		EC				2.4	[5]
		ULV		0.3-0.7			7

[1]air application
[2]7 days for head lettuce and 14 days for leaf lettuce
[3]may also be incorporated in soil before planting
[4] in case tops are to be used for food or feed
[5]storage bin

RESIDUES RESULTING FROM SUPERVISED TRIALS

All the trials were in the USA. The results are shown in Tables 29 to 68. All samples were analysed for malathion and malaoxon. Trials with the same entry in the Tables were carried out at the same site. Some trials included sub-plots, separated from each other by a sufficient distance to avoid the possibility of contamination by spray drift. Residues from sub-plots under exactly the same application regime were regarded as being from one trial and the highest residue was considered for estimations of maximum residues levels and STMRs. Replicate analyses of the same samples were averaged and the mean result recorded. Unless otherwise indicated, all trials were conducted outdoors by foliar ground spray. Underlined residues were within maximum GAP (± 30%) and were considered for estimating MRL and STMR.

Oranges. In six trials in California and Florida with ground application of an EC formulation with 3 x 7 kg ai/ha, residues of malathion at 7 days PHI ranged from 0.42 to 1.90 mg/kg. In eight trials with aerial or ground application of a ULV formulation at or above the proposed label rate (10 x 0.196 kg ai/ha) residues ranged from <0.01 to 2.9 mg/kg (Table 29).

Table 29. Residues of malathion and oxon in oranges (whole fruit).

State Year	Form.	Application No.	Application kg ai/ha	Application kg ai/hl	PHI, days	Residue, mg/kg Malathion	Residue, mg/kg Malaoxon	Reference
California 1992 AA920117	EC	3	7	0.312	7	0.42	0.02	CA3
					14	0.43	0.02	
					7	1.9	<0.01	CA1
					14	2.4	0.01	
					7	1.3	0.02	CA2
					14	0.5	0.02	
	ULV aerial	10	0.196	29.2	1	0.05	<0.01	CA3
					7	0.08	<0.01	
					14	0.02	<0.01	
					1	0.03	<0.01	CA1
					7	<0.01	<0.01	
					14	<0.01	<0.01	
					1	0.03	<0.01	CA2
					7	0.02	<0.01	
					14	0.03	<0.01	
Florida 1992 AA920117	EC	3	7	0.312	7	0.75	<0.01	FL2
					14	0.26	<0.01	
					7	1.0	0.01	FL1
					14	0.64	0.02	
					7	0.79	0.02	FL3
					14	0.4	0.01	
	ULV aerial	10	0.196	29.2	1	<0.01	<0.01	FL2
					7	<0.01	<0.01	
					14	<0.01	<0.01	
					1	0.02	<0.01	FL1
					7	<0.01	<0.01	
					14	0.01	<0.01	
					1	<0.01	<0.01	FL3
					7	<0.01	<0.01	
					14	<0.01	<0.01	
05142.94	ULV	4	0.8		1	2.9	<0.05	FL25
					7	2.2	<0.05	
					1	2.5	<0.05	FL26
					7	0.54	<0.05	

Apples. In four trials on apples at 1.4 kg ai/ha, residues of malathion at 2 to 3 days after the last application were 0.05 to 2.6 mg/kg. In one trial at a fivefold rate the residue was 2.5 mg/kg (Table 30).

Table 30. Residues of malathion and oxon in apples (Study 04768).

State Year	Application No.	Application kg ai/ha	Sample	PHI, days	Residues, mg/kg Malathion	Residues, mg/kg Malaoxon	Reference
WA	5	1.4	Whole fruit	2	0.32, 0.19	<0.05. <0.05	WA51, WA52
TN	5	1.4	Whole fruit	3	2.64	0.08	TN07
CA	5	1.4	Whole fruit	3	0.05	<0.05	CA77
MI	5	1.4	Whole fruit	3	0.14	<0.05	MI31
NY	5	1.4	Whole fruit	2	0.28	<0.05	NY26
	5	7	Whole fruit	2	2.5	<0.05	NY26
			Juice		0.33	<0.05	
			Pomace		10	0.07	

Pears. In three trials on pears, residues of malathion at a PHI of 1 day ranged from 0.34 to 1.9 mg/kg (Table 31).

Table 31. Residues of malathion and oxon in pears (Study 04827), 1994.

State Year	Application			PHI, days	Residues, mg/kg		Reference
	No.	kg ai/ha	kg ai/hl		Malathion	Malaoxon	
CA	5	1.4		1	1.9	0.33	CA79
NY	5	1.4		1	0.59	<0.05	NY27
WA	5	1.4		1	0.34	<0.05	WA53

Cherries. In twelve trials on sweet and tart cherries with 6 ground or aerial applications malathion residues at 1 or 3 days PHI ranged from 0.02 to 2.6 mg/kg (Table 32).

Table 32**.** Residues of malathion and oxon in cherries.

State Year	Form	Application			PHI, days	Residues, mg/kg		Reference
		No.	kg ai/ha	kg ai/hl		Malathion	Malaoxon	
Sweet cherries								
CA, 1993	EC	6	2x 1.12 4x 8.96		3 7 14	1.8 0.24 0.09	0.01 <0.01 <0.01	CA1
	ULV aerial	6	1.366		1 4 7 14	0.08 0.13 0.19 0.09	<0.01 <0.01 <0.01 <0.01	
OR, 1993	EC	6	4.2		3 7 14	0.45 0.51 0.05	<0.01 <0.01 <0.01	OR1
	ULV aerial	6	1.366		1 4 7 14	0.17 0.06 0.05 0.03	<0.01 <0.01 <0.01 <0.01	
MI, 1993	EC	6	4.2		3 7 14	0.26 0.05 <0.01	<0.01 <0.01 <0.01	MI1
	ULV aerial	6	1.366		1 4 7 14	0.02 <0.01 <0.01 <0.01	<0.01 <0.01 <0.01 <0.01	
Tart Cherries								
MI, 1993	EC	6	4.2		3 7 14	2.6 0.41 0.05	0.02 <0.01 <0.01	MI1
	ULV aerial	6	1.366		1 4 7 14	0.03 0.02 0.01 <0.01	<0.01 <0.01 <0.01 <0.01	
MT, 1993	EC	6	4.2		3 7 14	1.6 0.43 0.18	<0.01 <0.01 <0.01	MT1
	ULV aerial	6	1.366		1 4 7 14	0.47 0.23 0.13 0.05	<0.01 <0.01 <0.01 <0.01	
NY, 1993	EC	6	4.2		3 7 14	1.1 0.03 <0.01	<0.01 <0.01 <0.01	NY1
	ULV aerial	6	1.366		1 4 7 14	0.34 0.42 <0.01 <0.01	<0.01 <0.01 <0.01 <0.01	

Apricots and peaches. In one trial on apricots and four on peaches, residues of malathion at a PHI of 6-7 days varied from 0.16 to 1.4 mg/kg (Table 33).

Table 33. Residues of malathion and oxon in apricots and peaches (whole fruit).

State	Application		PHI,	Residues, mg/kg		
	No.	kg ai/ha	days	Malathion	Malaoxon	Reference
Apricots						
CA	4	4.2	6	0.60	<0.05	
Peaches[1]						
CA	4	4.2	7	0.16	<0.05	CA53
GA	5	4.2	7	0.25	<0.05	GA2
MI	4	4.2	7	1.2	<0.05	MI11
NJ	4	4.2	7	1.4	<0.05	NJ11

[1]Sampling to analysis 845-905 days; checked storage stability 469 days

Grapes. In six trials on grapes at 1.2-3.1 kg ai/ha, residues of malathion at a PHI of 3 days ranged from 0.33 to 2.7 mg/kg (Table 34).

Table 34. Residues of malathion and oxon in grapes (whole fruit).

State Year	PHI, days	Residues, mg/kg Malathion	 Malaoxon	 Reference
CA 1992	3 7 14	0.33 0.14 0.10	<0.01 <0.01 <0.01	CA1
1993	3 7 14	1.2 0.52 0.41	0.02 0.03 0.04	CA2
	3 7 14	0.78 0.98 0.32	0.03 0.05 0.04	CA3
	3 7 14	2.7 1.7 0.49	0.13 0.12 0.06	CA4
WA 1993	3 7 14	0.94 0.69 0.81	0.01 <0.01 0.01	WA1
NY 1992	3 7 14	0.58 0.19 0.22	<0.01 <0.01 <0.01	NY1

Strawberries. Seven trials on strawberries using an EC or WP formulation were within GAP rates (1.3-2.7 kg ai/ha). Residues of malathion at 3 days PHI ranged from 0.09 to 0.59 mg/kg (Table 35).

Table 35. Residues of malathion and oxon in strawberries (whole fruit).

State Year	 Form	Application No.	 kg ai/ha	PHI, days	Residue, mg/kg Malathion	 Malaoxon	 Reference
CA 1993	EC	6	2.2	3 7 14	0.25 0.07 0.05	0.05 <0.01 <0.01	AA920122.CA1,
	EC	6	2.2	3 7 14	0.39 0.31 0.12	0.01 0.03 <0.01	AA920122.CA2
1992	EC	6	2.1	3	0.53	<0.05	05152.92
	WP	6	2.24	3	0.59	0.063	05152.92

State Year	Form	Application No.	Application kg ai/ha	PHI, days	Residue, mg/kg Malathion	Residue, mg/kg Malaoxon	Reference
FL 1993	EC	6	2.2	3 7 14	0.19 0.02 0.01	<0.01 <0.01 <0.01	AA920122.FL1
OR 1993	EC	6	2.2	3 7 14	0.16 0.05 0.04	<0.01 <0.01 <0.01	AA920122.OR1
PA 1993	EC	6	2.2	3 7 14	0.09 0.01 0.02	<0.01 <0.01 <0.01	AA920122.PA1

Berries. In eleven trials on blueberries using ground or aerial application, residues of malathion at 0-1 day varied from 0.06 to 7.5 mg/kg (Table 36).

In 6 trials on blackberries and in 4 on raspberries with WP or EC formulations, residues of malathion at a 1-day PHI varied from 1.3 to 11 mg/kg. (Table 36).

Table 36. Residues of malathion and oxon in berries.

State	Form	Application No.	Application kg ai/ha	Application kg ai/hl	PHI, days	Residue, mg/kg Malathion	Residue, mg/kg Malaoxon	Reference
Blueberries (Study No. AA920105)								
MI	EC	4	1.4		1 4 7 14	1.4 0.09 0.08 0.04	0.02 <0.01 <0.01 <0.01	MI1
	EC	4	1.4		1 4 7 14	0.26 0.05 0.04 0.01	0.03 <0.01 <0.01 <0.01	MI2
	ULV aerial	5	0.71		0 4 7 14	0.55 0.05 0.15 0.02	<0.01 <0.01 <0.01 <0.01	MI1
	ULV aerial	5	0.71		0 4 7 14	0.06 <0.01 <0.01 <0.01	<0.01 <0.01 <0.01 <0.01	MI2
ME	EC	4	1.4		1 4 7 14	3.2 0.56 0.32 0.32	0.05 0.03 0.02 0.02	ME1
	EC	4	1.4		1 4 7 14	7.1 2.2 1.0 0.76	0.14 0.10 0.07 0.05	ME2
	EC	7	0.751		0 4 7 14	2.8 0.39 0.16 0.14	0.03 0.01 0.01 0.01	ME2
	ULV aerial	5	0.877		0 4 7 14	4.0 0.43 0.18 0.07	0.02 <0.01 <0.01 <0.01	ME1
	ULV aerial	5	0.877		0 4 7 14	7.5 0.51 0.24 0.45	0.03 0.01 0.01 0.02	ME2

State	Form	Application			PHI, days	Residue, mg/kg		Reference
		No.	kg ai/ha	kg ai/hl		Malathion	Malaoxon	
OR	EC	4	1.4		1	0.29	0.03	OR1
					4	0.12	0.01	
					7	0.09	<0.01	
					14	0.02	<0.01	
	EC	4	1.4		1	1.2	0.03	OR2
					4	0.31	0.01	
					7	0.13	<0.01	
					14	0.09	<0.01	
Blackberries (Study No. 04774)								
CA	EC	4	2.1		1	2.0	0.05	CA82
	WP	4	2.24		1	1.6	0.04	CA82
OR	EC	4	2.27		1	3.9	0.06	OR14
	WP	4	2.24		1	11[1]	0.11	OR14
	EC	4	2.27		1	2.6	0.04	OR18
	WP	4	2.24		1	3.4	0.05	OR18
Raspberries (Study No. 4835)								
WA	EC	4	2.24		1	2.6	0.07	WA[1]40
	WP	4	2.24		1	1.3	0.06	WA[1]40
	EC	4	2.24		1	4.7	0.07	WA[1]39
	WP	4	2.24		1	4.9	0.07	WA[1]39

[1]Three other replicate samples had residues of 2.1, 2.7 and 3.3 mg/kg. Result calculation was based on peak response more than 10% outside the calibration range.

Assorted tropical and sub-tropical fruits. In two trials on avocados, two on figs, three on guavas, one on sugar apples, one on mangoes and three on papayas, malathion residues 1 to 7 days after the last application ranged from <0.05 to 0.56 mg/kg (Table 37).

Table 37. Residues of malathion and oxon in assorted tropical fruits.

State Year	Application		PHI, days	Residue, mg/kg		Reference
	No.	kg ai/ha		Malathion	Malaoxon	
Avocado (Study No. AA92102)						
CA, 1993	2	5.264	7	0.08	<0.01	CA1
			14	0.05	<0.01	
	2	5.264	7	0.07	<0.01	CA2
			14	0.05	<0.01	
Fig (Study No. 04793)						
CA, 1992	1	2.8	5	0.32	<0.05	4793
	3	2.8	5	0.36	<0.05	4793
					<0.05	
Guava (Study No. 04799)						
Hawaii, 1933	12	1.4	2	0.30	0.18	HI01
			7	0.13	0.09	
FL, 1993	13	1.4	2	0.24	<0.05	FL21
			7	0.12	<0.05	
FL, 1995	11	1.4	1	0.10	<0.05	FL06
			6	<0.05	<0.05	
Papaya (Study No. 03727)						
Hawaii, 1993	12	1.4	1	0.56	<0.05	HI02
			7	0.11	<0.05	
FL, 1993	12	1.4	1	0.06	<0.05	FL07
			7	<0.05	<0.05	
FL, 1994	12	1.4	1	<0.05	<0.05	FL53
			7	<0.05	<0.05	
Sugar apple						
FL, 1994	8	1.4	3	0.31	<0.05	
			7	0.08	<0.05	

State Year	Application No.	Application kg ai/ha	PHI, days	Residue, mg/kg Malathion	Residue, mg/kg Malaoxon	Reference
Mango (Study No. B4814)						
FL, 1995	8	1.4	1 6	0.07, <0.05, <0.05 <0.05	<0.05 (3) <0.05	Fl09, FL08, FL07

Onions. In six trials on bulb onions and six on green onions (bulb including the leaves), residues of malathion at 3 days PHI ranged from 0.02 to 0.59 mg/kg in bulb onions and from 0.18 to 5.0 mg/kg in green onions (Table 38).

Table 38. Residues of malathion and oxon in onions.

State Year	Application Form	Application kg ai/ha	PH, days	Residue, mg/kg Malathion	Residue, mg/kg Malaoxon	Reference
Bulb onions (Study No. AA920115)						
CA		5 X 1.74	3	0.08	<0.01	Study No.° AA
	EC		7	0.03	<0.01	920115 CA1
1993			14	0.02	<0.01	
			3	0.35	0.02	Study No.° AA920115 CA2
			7	0.42	0.02	
			14	0.23	0.02	
NE	EC	5 X 1.74	3	0.37	<0.01	Study No.° AA920115 NE1
			7	0.16	<0.01	
1993			14	0.05	<0.01	
NY	EC	5 X 1.74	3	0.59	<0.01	Study No.° AA920115 NY1
			7	0.24	<0.01	
1993			14	0.11	<0.01	
OR	EC	5 X 1.74	3	0.02	<0.01	Study No.° AA920115 OR1
			7	<0.01	<0.01	
1992			14	<0.01	<0.01	
TX	EC	5 X 1.74	3	0.11	<0.01	Study No.° AA920115 TX1
			7	0.03	<0.01	
1993			14	<0.01	<0.01	
Green onions (Study No. AA920116)						
CA	EC	5 X 1.74	3	5.0	0.02	Study No. AA920116 CA1
			7	0.97	0.01	
1993			14	0.27	<0.01	
			3	0.18	0.02	Study No. AA920116 CA2
			7	0.17	0.01	
			14	0.02	<0.01	
NE	EC	5 X 1.74	3	0.19	<0.01	Study No. AA920116 NE1
			7	0.01	<0.01	
1993			14	<0.01	<0.01	
NY	EC	5 X 1.74	3	0.35	<0.01	Study No. AA920116 NY1
			7	0.23	<0.01	
1993			14	0.03	<0.01	
OR	EC	5 X 1.74	3	2.5	0.02	Study No. AA920116 OR1
			7	0.22	<0.01	
1992			14	0.02	<0.01	
TX	EC	5 X 1.74	3	0.69	0.03	Study No. AA920116 TX1
			7	0.11	<0.01	
1993			14	<0.01	<0.01	

Broccoli. In five trials on broccoli, malathion residues from 3 to 5 days after the last application varied from 0.02 to 9.3 mg/kg (Table 39).

Table 39. Residues of malathion and oxon in broccoli.

State	Application	PHI,	Residue, mg/kg	

Year	Form	No.	kg ai/ha	days	Malathion	Malaoxon	Reference
NY 1992	EC	6	1.4	4	0.02	<0.02	NY22
1994		5	1.4	5	0.02	<0.02	NY12
TN 1992	EC	5	1.4	3	9.3	0.13	TN04
WA 1992	EC	6	1.4	3	0.10	0.02	WA28
CA 1992	EC	5	1.4	2	0.31	<0.02	CA34

Cabbage. In 8 trials on head cabbages, samples taken with and without the wrapper leaves at 7 days PHI had residues of malathion of <0.05 mg/kg, with the exception of one trial with a residue of 0.10 mg/kg (Table 40).

Table 40**.** Residues of malathion and oxon in cabbages.

State Year	Sample	Application Form	Application kg ai/ha	PHI, days	Residue, mg/kg Malathion	Residue, mg/kg Malaoxon	Reference
FL 1992	with wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	Study No. 04778 FL48
	without wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	
WA 1992	with wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	Study No. 04778 WA22
	without wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	
OH 1992	with wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	Study No. 04778 OH17
	without wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	
WI 1992	with and without wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	Study No. 04778 WI09
IN 1992	with and without wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	Study No. 04778 IN05
NR 1992	with wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	Study No. 04778 NY21
	without wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	
TX 1992	with wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	Study No. 04778 TX37
	without wrapper leaves	EC	6 x 1.4	7	0.10	<0.05	
CA 1992	with wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	Study No. 04778 CA57
	without wrapper leaves	EC	6 x 1.4	7	<0.05	<0.05	

Cucumber. In nine trials on cucumbers, malathion residues at a 1 day PHI ranged from <0.01 to 0.10 mg/kg (Table 41).

Table 41. Residues of malathion and oxon in cucumbers.

State Year	Application Form	Application kg ai/ha	PHI, days	Residues, mg/kg Malathion	Residues, mg/kg Malaoxon	Reference
CA	EC	3 x 2.1	1	0.02	<0.01	Study No. AA920111 CA1
1992/1993			4	<0.01	<0.01	
			7	<0.01	<0.01	
			14	<0.01	<0.01	
FL	EC	3 x 2.1	1	≤0.01	<0.01	Study No. AA920111 FL1
1992/1993			4	<0.01	<0.01	
			7	<0.01	<0.01	
			14	<0.01	<0.01	

State Year	Application Form	kg ai/ha	PHI, days	Residues, mg/kg Malathion	Malaoxon	Reference
MI 1992/1993	EC	3 x 2.1	1	0.10	<0.01	Study No. AA920111 MI1
			4	<0.01	<0.01	
			7	<0.01	<0.01	
			14	<0.01	<0.01	
	EC	3 x 2.1	1	0.02	<0.01	Study No. AA920111 MI2
			4	<0.01	<0.01	
			7	<0.01	<0.01	
			14	<0.01	<0.01	
NC 1992/1993	EC	3 x 2.1	1	0.03	<0.01	Study No. AA920111 NC1
			4	<0.01	<0.01	
			7	<0.01	<0.01	
			14	<0.01	<0.01	
	EC	3 x 2.1	1	0.01	<0.01	Study No. AA920111 NC2
			4	<0.01	<0.01	
			7	<0.01	<0.01	
			14	<0.01	<0.01	
NJ 1992/1993	EC	3 x 2.1	1	0.02	<0.01	Study No. AA920111 NJ1
			4	<0.01	<0.01	
			7	<0.01	<0.01	
			14	<0.01	<0.01	
TX 1992/1993	EC	3 x 2.1	1	0.06	<0.01	Study No. AA920111 TX1
			4	<0.01	<0.01	
			7	<0.01	<0.01	
			14	<0.01	<0.01	
	EC	3 x 2.1	1	0.03	<0.01	Study No. AA920111 TX2
			4	<0.01	<0.01	
			7	<0.01	<0.01	
			14	<0.01	<0.01	

Melons. In two trials on cantaloupes and one trial on watermelons residues at 1 day ranged from <0.05 to 0.80 mg/kg (Table 42).

Table 42. Residues of malathion and oxon in cantaloupes and watermelons.

State Year	Application Form	kg ai/ha	PHI, days	Residue, mg/kg Malathion	Malaoxon	Reference
Cantaloupe						
CA 1992	EC	6 x 1.12	1	<0.05	<0.05	Study No. 04815
TX 1992	EC	6 x 1.12	1	0.80	0.05	Study No. 04815
Watermelon						
GE 1992	EC	6 x 1.12	1	<0.05	<0.05	Study No. 04815

Mushrooms. In one trial with two sub-plots on mushrooms in Pennsylvania in 1994, malathion was applied four times as an EC formulation at the GAP rate 1.9 kg ai/ha. No residues of malathion or malaoxon were detected (<0.05 mg/kg) at a PHI of 1 day.

Peppers. In seven trials on bell peppers residues of malathion at 3 days ranged from <0.01 to 0.08 mg/kg (Table 43).

Table 43. Residues of malathion and oxon in bell peppers.

State Year	Application Form	kg ai/ha	PHI, days	Residue, mg/kg Malathion	Malaoxon	Reference

State Year	Application Form	Application kg ai/ha	PHI, days	Residue, mg/kg Malathion	Residue, mg/kg Malaoxon	Reference
CA 1992/1993	EC	5 x 1.8	3	0.05	<0.01	CA1
			7	<0.01	<0.01	
			14	<0.01	<0.01	
	EC	5 x 1.8	3	0.08	<0.01	CA2
			7	<0.01	<0.01	
			14	<0.01	<0.01	
FL 1992/1993	EC	5 x 1.8	3	≤0.01, <0.01	<0.01, <0.01	FL1, FL2
			7	<0.01, <0.01	<0.01, <0.01	
			14	<0.01, <0.01	<0.01, <0.01	
MI 1992/1993	EC	5 x 1.8	3	0.02	<0.01	MI1
			7	<0.01	<0.01	
			14	<0.01	<0.01	
NC 1992/1993	EC	5 x 1.8	3	≤0.01	<0.01	NC1
			7	<0.01	<0.01	
			14	<0.01	<0.01	
NJ 1992/1993	EC	5 x 1.8	3	≤0.01	<0.01	NJ1
			7	<0.01	<0.01	
			14	<0.01	<0.01	
TX 1992/1993	EC	5 x 1.8	3	≤0.01	<0.01	TX1
			7	<0.01	<0.01	
			14	<0.01	<0.01	

Tomatoes. In fourteen trials on tomatoes at 1.74 or 3.84 kg ai/ha the growth stage at final application was mature fruit, early maturity or late flowering. Residues of malathion at a PHI of 1 day varied from 0.10 to 1.2 mg/kg and at a higher rate from 0.13 to 1.2 mg/kg (Table 44).

Table 44**.** Residues of malathion and oxon in tomatoes (EC formulations).

State Year	Application No.	Application kg ai/ha	PHI, days	Residue, mg/kg Malathion	Residue, mg/kg Malaoxon	Reference
CA 1993	5	1.74	1	0.21	<0.01	CA1
			3	0.16	<0.01	
			7	0.04	<0.01	
			14	0.01	<0.01	
	5	1.74	1	0.10	<0.01	CA2
			3	0.07	<0.01	
			7	<0.01	<0.01	
			14	<0.01	<0.01	
	5	1.74	1	0.33	<0.01	CA3
			3	0.13	<0.01	
			7	0.06	<0.01	
			14	0.32	<0.01	
	5	3.84	3	0.70	<0.01	CA1
			7	0.16	<0.01	
			14	0.03	<0.01	
	5	3.84	3	0.13	<0.01	CA2
			7	0.02	<0.01	
			14	<0.01	<0.01	
	5	3.84	3	0.73	<0.01	CA3
			7	0.15	<0.01	
			14	0.03	<0.01	
FL 1992	5	1.74	1	0.14	<0.01	FL1
			3	0.12	<0.01	
			7	0.02	<0.01	
			14	<0.01	<0.01	
	5	3.84	3	0.73	<0.01	
			7	0.05	<0.01	
			14	<0.01	<0.01	

State Year	Application No.	Application kg ai/ha	PHI, days	Residue, mg/kg Malathion	Residue, mg/kg Malaoxon	Reference
MI 1993	5	1.74	1 3 7 14	0.27 0.05 <0.01 <0.01	<0.01 <0.01 <0.01 <0.01	MI1
	5	1.74	1 3 7 14	0.17 0.08 <0.01 <0.01	<0.01 <0.01 <0.01 <0.01	MI2
	5	3.84	3 7 14	0.23 0.05 <0.01	<0.01 <0.01 <0.01	MI1
	5	3.84	3 7 14	0.54 0.03 <0.01	<0.01 <0.01 <0.01	MI2
NJ 1992	5	1.74	1 3 7 14	0.41 0.19 0.05 <0.01	<0.01 0.01 <0.01 <0.01	NJ1
	5	3.84	3 7 14	1.2 0.15 0.01	0.05 <0.01 <0.01	

Sweet corn. Twelve trials were conducted on sweet corn with either ground application of an EC formulation or aerial application of a ULV formulation. After five days malathion residues in the kernels and cobs ranged from <0.01 to 0.02 mg/kg, and in the forage from <0.05 to 2.4 mg/kg from ground applications and from 0.06 to 41 mg/kg from aerial applications (Table 45).

Table 45. Residues of malathion and oxon in sweet corn.

State Year	Application Form	Application No.	Application kg ai/ha	Sample	PHI, days	Residue, mg/kg Malathion	Residue, mg/kg Malaoxon	Reference
CA 1993	EC	5	1.4	Kernel + cob	5 14	≤0.01 <0.01	<0.01 <0.01	CA1
	EC	5	1.4	Forage	5 14	2.4 1.0	0.21 0.12	
	ULV (aerial)	5	0.683	Kernel + cob	5 14	<0.01 <0.01	<0.01 <0.01	
	ULV (aerial)	5	0.683	Forage	5 14	41 17	0.19 0.11	
FL 1993	EC	5	1.4	Kernel + cob	5 14	≤0.01 <0.01	<0.01 <0.01	FL1
	EC	5	1.4	Forage	5 14	0.20 <0.05	<0.05 <0.05	
	ULV (aerial)	5	0.683	Kernel + cob	5 14	<0.01 <0.01	<0.01 <0.01	
	ULV (aerial)	5	0.683	Forage	5 14	0.12 <0.05	<0.05 <0.05	
MN 1993	EC	5	1.4	Kernel + cob	5 14	≤0.01 <0.01	<0.01 <0.01	MN1
	EC	5	1.4	Forage	5 14	1.7 0.09	<0.05 <0.05	
	ULV (aerial)	5	0.683	Kernel + cob	5 14	<0.01 <0.01	<0.01 <0.01	
	ULV (aerial)	5	0.683	Forage	5 14	19 1.6	<0.05 <0.05	
NY 1992	EC	5	1.4	Kernel + cob	5 14	≤0.01 <0.01	<0.01 <0.01	NY1
	EC	5	1.4	Forage	5 14	0.33 <0.05	<0.05 <0.05	

State Year	Application			Sample	PHI, days	Residue, mg/kg		Reference
	Form	No.	kg ai/ha			Malathion	Malaoxon	
	ULV (aerial)	5	0.683	Kernel + cob	5 14	<0.01 <0.01	<0.01 <0.01	
	ULV (aerial)	5	0.683	Forage	5 14	6.9 1.3	<0.05 <0.05	
WA 1993	EC	5	1.4	Kernel + cob	5 14	<0.01 <0.01	<0.01 <0.01	WA1
	EC	5	1.4	Forage	5 14	<0.05 <0.05	<0.05 <0.05	
	ULV (aerial)	5	0.683	Kernel + cob	5 14	<0.01 <0.01	<0.01 <0.01	
	ULV (aerial)	5	0.683	Forage	5 14	0.06 <0.05	<0.05 <0.05	
WI 1993	EC	5	1.4	Kernel + cob	5 14	0.02 <0.01	<0.01 <0.01	WI1
	EC	5	1.4	Forage	5 14	<0.05 <0.05	<0.05 <0.05	
	ULV (aerial)	5	0.683	Kernel + cob	5 14	<0.01 <0.01	<0.01 <0.01	
	ULV (aerial)	5	0.683	Forage	5 14	0.67 <0.05	<0.05 <0.05	

Okra. In two trials on okra, malathion residues at 1 day were <0.05 and 2.1 mg/kg (Table 46).

Table 46**.** Residues of malathion and oxon in okra.

State year	Application			PHI, days	Residue, mg/kg		Reference
	Form	No.	kg ai/ha		Malathion	Malaoxon	
TX 1992	EC	4 +2	1.68	3 1	<0.05 <0.05	0.10 0.05	Study No. 04820
SC 1994	EC	4 +2	1.68	2 1	0.12 2.1	<0.05 <0.05	

Lettuce. In six trials on leaf lettuce, malathion residues at a PHI of 14 days ranged from <0.01 to 3.1 mg/kg in samples with and without the wrapper leaves. Residues in head lettuce 14 days after the last application (the recommended PHI is 7 days) ranged from 0.01 to 0.17 mg/kg (Table 47).

Table 47**.** Residues of malathion and oxon in lettuce.

State Year	Application		PHI, days	Residue, mg/kg		Reference
	Form	kg ai/ha		Malathion	Malaoxon	
Leaf leattuce						
CA 1992	EC	6 x 2.1	7 14	3.3 0.99	<0.01 <0.01	Study No. AA920114 CA1
1993	EC	6 x 2.1	7 14	16 3.1	0.24 0.08	Study No. AA920114 CA2
AZ	EC	6 x 2.1	7 14	0.04 <0.01	<0.01 <0.01	Study No. AA920114[1] AZ1
FL	EC	6 x 2.1	7 14	<0.01 <0.01	<0.01 <0.01	Study No. AA920114[1] FL1
NJ	EC	6 x 2.1	7 14	0.04 <0.01	<0.01 <0.01	Study No. AA920114[1] NJ1
WA	EC	6 x 2.1	7 14	0.10 <0.01	<0.01 <0.01	Study No. AA920114[1] WA1
Head lettuce						
CA 1992	EC	6 x 2.1	14 21	0.06 0.16	<0.01 <0.01	Study No. AA920126 CA1
1993	EC	6 x 2.1	14 21	0.17 0.07	0.04 0.03	Study No. AA920126 CA2

State Year	Application		PHI,	Residue, mg/kg		
	Form	kg ai/ha	days	Malathion	Malaoxon	Reference
	EC	6 x 2.1	14	0.01	<0.01	Study No. AA920126 CA3
			21	<0.01	<0.01	

[1] wrapper leaves were removed before analysis

Mustard greens. In seven trials on mustard greens at 1.23 or 1.4 kg ai/ha, malathion residues at 7 days ranged from <0.05 to 1.1 mg/kg. In seven other trials at twice these rates residues ranged from <0.05 to 5.9 mg/kg (Table 48).

Table 48. Residues of malathion and oxon in mustard greens.

State	Application			PHI,	Residue, mg/kg		Reference
Year	Form	No.	kg ai/ha	days	Malathion	Malaoxon	
AZ	EC	6	1.23	7	0.46	<0.05	Study No. 04817
1992		3	2.45	7	0.59	<0.05	
CA	EC	6	1.4	7	0.07	<0.05	Study No. 04817
1992		3	2.8	7	0.05	0.07	
GA	EC	6	1.4	7	0.52	<0.05	Study No. 04817
1992		3	2.8	7	2.6	<0.05	
IN	EC	6	1.4	9	<0.05	0.06	Study No. 04817
1992		3	2.8	9	<0.05	0.10	
NC	EC	3	1.4	7	0.07	0.07	Study No. 04817
1992							
SC	EC	6	2.8	6	3.2	0.08	Study No. 04817
1992							
TX	EC	6	1.4	7	1.1	<0.05	Study No. 04817
1993		3	2.8	7	5.9	0.10	
WA	EC	6	1.4	7	<0.05	<0.05	Study No. 04817
1992		3	2.8	7	<0.05	<0.05	

Spinach. In five trials on spinach according to GAP (1.3-2.7 kg ai/ha), malathion residues at a PHI of 7 days ranged from <0.05 to 2.2 mg/kg. One trial gave a residue of 36 mg/kg (Table 49).

Table 49. Residues of malathion and oxon in spinach.

State	Application		PHI,	Residues, mg/kg		Reference
Year	Form	kg ai/ha	days	Malathion	Malaoxon	
NJ	EC	3 x 2.24[1]	7	36	<0.05	Study No. 04842
1992/1995			7	0.35	<0.05	Study No. 04842
WA 1992	EC	3 x 2.24	7	<0.05	<0.05	Study No. 04842
CA 1993	EC	3 x 2.24	7	0.16	<0.05	Study No. 04842
TX 1993	EC	3 x 2.24	7	2.2	<0.05	Study No. 04842
SC 1995	EC	3 x 2.24	7	1.1	<0.05	Study No. 04842

[1]Rate based on field notes. Actual rate was probably much higher, in view of the malathion residue

Watercress. In three trials on watercress, residues of malathion were <0.05 mg/kg in samples taken at 3 and 7 days (Table 50).

Table 50. Residues of malathion and oxon in watercress.

State	Application				PHI,	Residue, mg/kg	
Year	Form	No.	kg ai/ha	type	days	Malathion	Malaoxon
FL	EC	5	1.4	spray	3	<0.05	<0.05
					7	<0.05	<0.05

State Year	Application				PHI, days	Residue, mg/kg	
	Form	No.	kg ai/ha	type		Malathion	Malaoxon
	EC	5	1.4	chemigation	3	<0.05	<0.05
					7	<0.05	<0.05
HW	EC	2	0.5	spray	7	<0.05	<0.05

Beans. Ten trials on lima beans and snap beans by aerial application at the GAP rate (0.7 kg ai/ha) gave malathion residues at a PHI of 1 day from <0.01 to 0.90 mg/kg (Table 51).

Table 51. Residues of malathion and oxon in lima and snap beans from aerial application of an ULV formulation at 3 x 0.683 kg ai/ha (samples included the pods).

State Year	PHI, days	Residue, mg/kg		Reference
		Malathion	Malaoxon	
Lima beans (Study N° AA920125)				
CA	1	0.90	0.02	CA1
1993	4	0.44	<0.01	
	7	0.08	<0.01	
	14	0.01	<0.01	
	1	0.05	<0.01	CA2
	4	<0.01	<0.01	
	7	<0.01	<0.01	
	14	<0.01	<0.01	
NC	1	0.71	<0.01	NC1
1993	4	0.52	<0.01	
	7	0.02	<0.01	
	14	<0.01	<0.01	
PA	1	0.49	<0.01	PA1
1993	4	0.16	<0.01	
	7	0.13	<0.01	
	14	<0.01	<0.01	
WI	1	0.41	<0.01	WI1
1992	4	0.03	<0.01	
	7	0.02	<0.01	
	14	<0.01	<0.01	
Snap beans (Study N° AA9200103)				
FL	1	≤0.01	<0.01	FL1
1993	4	<0.01	<0.01	
	7	<0.01	<0.01	
	14	<0.01	<0.01	
NY	1	0.13	<0.01	NY1
1993	4	<0.01	<0.01	
	7	0.03	<0.01	
	14	<0.01	<0.01	
OR	1	0.56	<0.01	OR1
1993	4	0.07	<0.01	
	7	0.01	<0.01	
	14	0.24	<0.01	
WI	1	0.12	<0.01	WI1
1992	4	0.01	<0.01	
	7	<0.01	<0.01	
	14	<0.01	<0.01	
1993	1	0.21	<0.01	WI2
	4	<0.01	<0.01	
	7	<0.01	<0.01	
	14	<0.01	<0.01	

Peas. Three trials on peas using EC formulations were at 5 x 2.8 kg ai /ha. Malathion residues in peas with pods at 2 to 3 days ranged from 0.34 to 0.96 mg/kg and in dry forage from 2.9 to 32 mg/kg (Table 52).

Table 52 Residues of malathion and oxon in peas with pods.

State year	Application Form	Application kg ai/ha	PHI, days	Sample	Residue, mg/kg Malathion	Residue, mg/kg Malaoxon	Reference
CA 1992	EC	5 x 2.8	3	Peas with pods	0.96	0.08	4823.92-CA*22
			3	Fresh forage	18	0.22	
			3	Dry forage	32	0.51	
1994	EC	5 x 2.8	2	Peas with pods	0.34	<0.02	4823.94-CA*42
			7	Fresh forage	10	<0.02	
			13	Dry forage	14	<0.02	
WI 1992	EC	5 x 2.8	3	Peas with pods	0.38	0.04	4823.92-WI03
			3	Fresh forage	5.3	0.10	
			3	Dry forage	2.9	0.08	

Dry beans. In ten trials on dry beans with two aerial applications according to GAP (0.7 kg ai/ha) malathion residues ranged from 0.01 to 1.2 mg/kg at a PHI of one day or longer (Table 53).

Table 53**.** Residues of malathion and oxon in dry beans.

State Year	Application Form	Application kg ai/ha	PH, days	Residues, mg/kg Malathion	Residues, mg/kg Malaoxon	Reference
CA 1993	ULV	3 x 0.683	1	0.62	<0.01	Study No. AA920104 CA1
			4	0.34	0.02	
			7	0.45	0.02	
			14	0.23	<0.01	
	ULV	3 x 0.683	1	0.73	0.02	Study No. AA920104 CA2
			4	1.2	0.07	
			7	0.38	0.01	
			14	0.12	<0.01	
	ULV	3 x 0.683	1	0.42	<0.01	Study No. AA920104 CA3
			4	0.16	<0.01	
			7	0.28	<0.01	
			14	0.39	<0.01	
ID 1993	ULV	3 x 0.683	1	0.39	<0.01	Study No. AA920104 ID1
			4	0.29	0.01	
			7	0.02	<0.01	
			14	0.13	<0.01	
MI 1992	ULV	3 x 0.683	1	0.36	<0.01	Study No. AA920104 MI1
			4	0.04	<0.01	
			7	<0.01	<0.01	
			14	<0.01	<0.01	
1993	ULV	3 x 0.683	1	0.05	<0.01	Study No. AA920104 MI2
			4	<0.01	<0.01	
			7	<0.01	<0.01	
			14	0.01	<0.01	
	ULV	3 x 0.683	1	0.07	<0.01	Study No. AA920104 MI3
			4	0.02	<0.01	
			7	<0.01	<0.01	
			14	0.01	<0.01	
NE 1993	ULV	3 x 0.683	1	<0.01	<0.01	Study No. AA920104 NE1
			4	<0.01	<0.01	
			7	0.10	<0.01	
			14	<0.01	<0.01	
	ULV	3 x 0.683	1	<0.01	<0.01	Study No. AA920104 NE2
			4	0.02	<0.01	
			7	<0.01	<0.01	
			14	0.10	<0.01	
NY 1993	ULV	3 x 0.683	1	0.05	<0.01	Study No. AA920104 NY1
			4	<0.01	<0.01	
			7	0.16	<0.01	
			14	<0.01	<0.01	

Potatoes. In fifteen trials on potatoes with EC formulations at 1.74 kg ai/ha with two applications, malathion residues were <0.01 mg/kg in all but one sample at a 0 day PHI (Table 54).

Table 54. Residues of malathion and oxon in potatoes.

State Year	Application		PHI, days	Residue, mg/kg		Reference
	Form	kg ai/ha		Malathion	Malaoxon	
CA 1993	EC	2 x 1.74	0	<0.01	<0.01	Study No. AA920119 CA1
ID 1993	EC	2 x 1.74	0	<0.01	<0.01	Study No. AA920119 ID1
			0	<0.01	<0.01	Study No. AA920119 ID2
			0	<0.01	<0.01	Study No. AA920119 ID3
			0	<0.01	<0.01	Study No. AA920119 ID4
			0	<0.01	<0.01	Study No. AA920119 ID5
			0	<0.01	<0.01	Study No. AA920119 ID6
			0	<0.01	<0.01	Study No. AA920119 ID7
			0	<0.01	<0.01	Study No. AA920119 ID8
ME 1993	EC	2 x 1.74	0	<0.01	<0.01	Study No. AA920119 ME1
			0	<0.01	<0.01	Study No. AA920119 ME2
			0	<0.01	<0.01	Study No. AA920119 ME3
			0	<0.01	<0.01	Study No. AA920119 ME4
NE 1993	EC	2 x 1.74	0	<0.01	<0.01	Study No. AA920119 NE1
WI 1993	EC	2 x 1.74	0	0.02	<0.01	Study No. AA920119 WI1

Turnips. In trials on turnips with EC formulations at 1.4 kg ai/ha or SC at 2.35-2.8 kg ai/ha malathion residues in tops ranged from <0.05 to 3.4 mg/kg and in roots from <0.05 to 0.13 mg/kg at 7 days. In one trial at a higher rate (South Carolina), residues in tops were 15 and 10 mg/kg and in roots 0.11 mg/kg (Table 55).

Table 55**.** Residues of malathion and oxon in turnips.

State Year	No. of	PHI, days	Sample	Residue, mg/kg		Reference
				Malathion	Malaoxon	
GA	3	7	Tops	0.66	<0.05	GA[1]26
1992	+2	7	Tops	1.4	<0.05	
			Roots	0.09	<0.05	
OH	3	7	Tops	<0.05	<0.05	OH[1]18
1992	+2	7	Tops	<0.05	<0.05	
			Roots	<0.05	<0.05	
TX	3	7	Tops	1.8	<0.05	TX[1]38
1992	+2	7	Tops	0.89	<0.05	
			Roots	<0.05	<0.05	
WA	3	7	Tops	<0.05	<0.05	WA[1]27
1992	+2	7	Tops	0.99	<0.05	
			Roots	<0.05	<0.05	
CA	3	7	Tops	0.63	<0.05	CA[1]13
1993	+2	7	Tops	3.4	<0.05	
			Roots	0.13	<0.05	
IN	5	7	Tops	<0.05	<0.05	IN07
1994			Roots	<0.05	<0.05	
SC	3	7	Tops	15	0.11	SC[1]01
1993	+2	7	Tops	10	<0.05	
			Roots	0.11	<0.05	

Carrots. In six trials on carrots with an EC formulation at 1.4 kg ai/ha, malathion residues ranged from <0.05 to 0.54 mg/kg at 6-8 days (Table 56).

Table 56**.** Residues of malathion and oxon in carrots.

State	No. of	PHI,	Residue, mg/kg

			Malathion	Malaoxon
CA 1994 [1]	7	7	0.36	<0.05
FL 1994	9	8	<0.05	<0.05
NJ 1994	7	6	0.11	<0.05
TX 1994	7	7	0.54	<0.05
WA 1994	7	7	0.12	<0.05
WI 1994	7	7	<0.05	<0.05

[1]application rates were calculated from spray swath rather than row width (55% lower)

Celery. In two trials on celery in Florida and California, malathion was applied as an EC formulation at 3 x 1.68 kg ai/ha (Study N°. 04781), which is within GAP (1.2-2.0 kg ai/ha). Residues of malathion at 7 days were 0.91 and 1.2 mg/kg and of malaoxon <0.05 mg/kg.

Asparagus. In four trials on asparagus with EC formulations at 9 x 1.4 kg ai/ha, malathion residues ranged from 0.10 to 0.69 mg/kg at a one day PHI (Table 57).

Table 57. Residues of malathion and oxon in asparagus.

State Year	Application		Residue, mg/kg		Reference
	Form	kg ai/ha	Malathion	Malaoxon	
CA, 1994/1995	EC	9 x 1.4	0.69	<0.05	Study No. 04770
NJ, 1994/1995	EC	9 x 1.4	0.48	<0.05	
WA, 1994/1995	EC	9 x 1.4	0.10	<0.05	
WI, 1994/1995	EC	9 x 1.4	0.13	<0.05	

Wheat. Twenty two trials on winter and spring wheat according to GAP were with either ground applications of EC or aerial applications of ULV formulations. Malathion residues at a PHI of 7 days ranged from <0.01 to 0.28 mg/kg in grain, from <0.05 to 2.4 mg/kg in forage, and from <0.05 to 34 mg/kg in straw (Table 58).

Table 58**.** Residues of malathion and oxon in wheat.[1]

State year	Application				Sample	PHI, days	Residues, mg/kg		Reference
	Form	No.	kg ai/ha	kg ai/hl			Malathion	Malaoxon	
Winter wheat (Study N° AA920127)									
KS 1993	EC	3	1.4		Grain	7	0.04	<0.01	KS1
						14	0.02	<0.01	
					straw	7	1.6	<0.05	
						14	1.2	<0.05	
	EC	3	1.4		Forage	7	<0.05	<0.05	
						14	<0.05	<0.05	
	EC	3	1.4		Grain	7	0.04	<0.01	KS2
						14	0.01	<0.01	
					straw	7	0.66	<0.05	
						14	0.36	<0.05	
	EC	3	1.4		Forage	7	<0.05	<0.05	
						14	<0.05	<0.05	

State year	Application				Sample	PHI, days	Residues, mg/kg		Reference
	Form	No.	kg ai/ha	kg ai/hl			Malathion	Malaoxon	
	ULV (aerial)	3	0.683		Grain	7	0.04	<0.01	KS1
						14	0.06	<0.01	
					straw	7	6.5	<0.05	
						14	3.9	<0.05	
	ULV (aerial)	3	0.683		Forage	7	0.49	<0.05	
						14	0.29	<0.05	
	ULV (aerial)	3	0.683		Grain	7	0.04	<0.01	KS2
						14	0.03	<0.01	
					straw	7	7.2	<0.05	
						14	1.2	<0.05	
	ULV (aerial)	3	0.683		Forage	7	1.9	<0.05	
						14	1.7	<0.05	
MT	EC	3	1.4		Grain	7	0.08	<0.01	MT1
						14	0.02	<0.01	
					straw	7	0.68	<0.05	
						14	0.35	<0.05	
	EC	3	1.4		Forage	7	<0.05	<0.05	
						14	<0.05	<0.05	
	ULV (aerial)	3	0.683		Grain	7	0.08	<0.01	
						14	0.02	<0.01	
					straw	7	3.2	<0.05	
						14	1.2	<0.05	
	ULV (aerial)	3	0.683		Forage	7	0.27	<0.05	
						14	<0.05	<0.05	
OH	EC	3	1.4		Grain	7	<0.01	<0.01	OH1
						14	<0.01	<0.01	
					straw	7	<0.05	<0.05	
						14	<0.05	<0.05	
	EC	3	1.4		Forage	7	0.09	0.05	
						14	<0.05	<0.05	
	ULV (aerial)	3	0.683		Grain	7	0.03	<0.01	
						14	0.36	<0.01	
					straw	7	1.6	<0.05	
						14	2.0	<0.05	
	ULV (aerial)	3	0.683		Forage	7	0.23	<0.05	
						14	<0.05	<0.05	
OK	EC	3	1.4		Grain	7	0.10	<0.01	OK1
						14	0.02	<0.01	
					straw	7	2.2	<0.05	
						14	0.29	<0.05	
	EC	3	1.4		Forage	7	0.05	<0.05	
						14	<0.05	<0.05	
	ULV (aerial)	3	0.683		Grain	7	0.20	<0.01	OK2
						14	0.05	<0.01	
					straw	7	12	<0.05	
						14	10	<0.05	
	ULV (aerial)	3	0.683		Forage	7	2.3	<0.05	
						14	0.36	<0.05	
	ULV (aerial)	3	0.683		Grain	7	0.28	<0.01	
						14	0.09	<0.01	
					straw	7	5.1	<0.05	
						14	12	<0.05	
	ULV (aerial)	3	0.683		Forage	7	1.8	<0.05	
						14	2.3	<0.05	
WA	EC	3	1.4		Grain	7	0.03	<0.01	WA1
						14	0.02	<0.01	
					straw	7	3.2	0.13	
						14	1.3	<0.05	
					Forage	7	<0.05	<0.05	
						14	<0.05	<0.05	

State year	Application				Sample	PHI, days	Residues, mg/kg		Reference
	Form	No.	kg ai/ha	kg ai/hl			Malathion	Malaoxon	
	ULV (aerial)	3	0.683		Grain	7	<u>≤0.01</u>	<0.01	
						14	<0.01	<0.01	
					straw	7	<u>1.0</u>	0.06	
						14	0.15	<0.05	
					Forage	7	<u>≤0.05</u>	<0.05	
						14	<0.05	<0.05	
Spring wheat (Study N° AA92124)									
ND	EC	3	1.4		Grain	7	<u>0.02</u>	<0.01	ND1
						14	0.02	<0.01	
					straw	7	<u>2.5</u>	<0.05	
						14	1.4	<0.05	
	EC	3	1.4		Forage	7	<u>≤0.05</u>	<0.05	
						14	<0.05	<0.05	
	ULV (aerial)	3	0.683		Grain	7	<u>0.10</u>	<0.01	
						14	0.04	<0.01	
					straw	7	<u>18</u>	<0.05	
						14	21	<0.05	
	ULV (aerial)	3	0.683		Forage	7	<u>1.3</u>	<0.05	
						14	0.33	<0.05	
	EC	3	1.4		Grain	7	<u>0.04</u>	<0.01	ND2
						14	0.03	<0.01	
					straw	7	<u>0.81</u>	<0.05	
						14	1.0	<0.05	
	EC	3	1.4		Forage	7	<u>≤0.05</u>	<0.05	
						14	<0.05	<0.05	
	ULV (aerial)	3	0.683		Grain	7	<u>0.22</u>	<0.01	
						14	0.23	<0.01	
						7	<u>8.4</u>	<0.05	
					straw	14	5.4	<0.05	
	ULV (aerial)	3	0.683		Forage	7	<u>0.19</u>	<0.05	
						14	0.05	<0.05	
	ULV (aerial)	3	0.683		Grain	7	<u>0.09</u>	<0.01	ND3
						14	0.07	<0.01	
					straw	7	<u>34</u>	0.08	
						14	31	0.08	
	ULV (aerial)	3	0.683		Forage	7	<u>2.4</u>	<0.05	
						14	0.91	<0.05	
WA	EC	3	1.4		Grain	7	<u>0.14</u>	<0.01	WA1 (A)
						14	0.05	<0.01	
					straw	7	<u>9.4</u>	0.29	
						14	3.8	0.13	
	EC	3	1.4		Forage	7	<u>≤0.05</u>	<0.05	WA1
						14	<0.05	<0.05	
	ULV (aerial)	3	0.683		Grain	7	<u>≤0.01</u>	<0.01	WA1 (A)
						14	<0.01	<0.01	
					straw	7	<u>1.4</u>	0.05	
						14	0.41	<0.05	
	ULV (aerial)	3	0.683		Forage	<u>7</u>	<0.05	<0.05	WA1
						14	<0.05	<0.05	

[1]Separate plots were sampled for forage and grain/straw

One trial was conducted in 1994 in Illinois to measure the residues in grain treated post-harvest with malathion. The storage bin was treated with 2.4 kg ai/hl of an EC formulation according to GAP and the wheat grain received an application of 8 g ai/1000 l grain of a dust formulation during and after bin loading, followed by two other treatments with the dust formulation. The malathion residue in the grain after 59 days of storage was 7.5 mg/kg (Table 59).

Table 59**.** Residues of malathion and oxon in wheat grain after post-harvest treatment.

Treatment	PHI, days	Residues, mg/kg	
		Malathion	Malaoxon
1 x 4 g ai/1000 l grain immediately after transfer to storage bin	0	50	<0.01
1 x 4 g ai/1000 l grain after 59 days of storage	59	7.5	<0.01

Sorghum. Eight trials on sorghum were with either ground application of an EC formulation or aerial application of a ULV formulation. Malathion residues in the grain at 7 days ranged from 0.02 to 2.2 mg/kg (Table 60).

Table 60**.** Residues of malathion and oxon in sorghum grain.

State Year	Application			PHI, days	Residue, mg/kg		Reference
	Form	No.	kg ai/ha		Malathion	Malaoxon	
NE 1993	EC	3	1.4	7	0.07	<0.01	Study No. AA920121 NE1
				14	<0.01	<0.01	
	EC	3	1.4	7	0.02	<0.01	Study No. AA920121 NE2
				14	0.01	<0.01	
	ULV (aerial)	3	0.683	7	0.34	<0.01	Study No. AA920121 NE1
				14	0.30	<0.01	
	ULV (aerial)	3	0.683	7	0.10	<0.01	Study No. AA920121 NE2
				14	0.13	<0.01	
TX 1993	EC	3	1.4	7	0.49	<0.01	Study No. AA920121 TX1
				14	0.36	<0.01	
	EC	3	1.4	7	0.12	<0.01	TX2
				14	0.04	<0.01	
	ULV (aerial)	3	0.683	7	2.2	0.08	Study No. AA920121 TX1
				14	1.5	0.06	
	ULV (aerial)	3	0.683	7	2.0	<0.01	Study No. AA920121 TX2
				14	0.79	<0.01	

Maize. Twenty one trials on field corn according to GAP were with either ground application of an EC formulation (GAP is 1.2 -1.6 kg ai/ha) or aerial application of a ULV formulation (GAP is 0.266-0.533 kg ai/ha). Malathion residues after 7 days (GAP PHI is 5 days) were <0.01 to 0.02 mg/kg in grain, <0.05 to 1.2 mg/kg in forage and 1.3 to 24 mg/kg in straw (Table 61).

Table 61. Residues of malathion and oxon in maize.

County Year	Formulation	Application			Sample	PHI, days	Residues, mg/kg		Reference
		No.	kg ai/ha	kg ai/hl			Malathion	Malaoxon	
IA 1992/ 1993	EC	3	1.4		Grain	7	0.01	<0.01	IA1
						14	<0.01	<0.01	
					Forage	7	<0.05	<0.05	
						14	<0.05	<0.05	
					Straw	7	1.3	<0.05	
						14	1.2	0.08	
	EC	3	1.4		Grain	7	0.02	<0.01	IA2
						14	<0.01	<0.01	
					Forage	7	<0.05	<0.05	
						14	<0.05	<0.05	
					Straw	7	3.4	0.10	
						14	3.0	0.19	

County Year	Formulation	Application No.	kg ai/ha	kg ai/hl	Sample	PHI, days	Residues, mg/kg Malathion	Malaoxon	Reference
	EC	3	1.4		Grain	7	0.02	<0.01	IA3
						14	<0.01	<0.01	
					Forage	7	<0.05	<0.05	
						14	<0.05	<0.05	
					Straw	7	3.2	0.07	
						14	2.5	0.12	
	ULV (aerial)	3	0.683		Grain	7	<0.01	<0.01	IA1
						14	<0.01	<0.01	
					Forage	7	0.06	<0.05	
						14	<0.05	<0.05	
					Straw	7	2.0	<0.05	
						14	5.0	<0.05	
	ULV (aerial)	3	0.683		Grain	7	<0.01	<0.01	IA2
						14	<0.01	<0.01	
					Forage	7	0.09	<0.05	
						14	0.06	<0.05	
					Straw	7	4.5	<0.05	
						14	6.7	<0.05	
	ULV (aerial)	3	0.683		Grain	7	<0.01	<0.01	IA3
						14	<0.01	<0.01	
					Forage	7	1.2	<0.05	
						14	0.16	<0.05	
					Straw	7	8.0	<0.05	
						14	6.5	<0.05	
	ULV (aerial)	3	0.683		Grain	7	<0.01	<0.01	IA4
						14	<0.01	<0.01	
					Forage	7	<0.05	<0.05	
						14	<0.05	<0.05	
					Straw	7	1.4	<0.05	
						14	0.81	<0.05	
IL 1992/ 1993	EC	3	1.4		Grain	7	0.02	<0.01	IL1
						14	<0.01	<0.01	
					Forage	7	<0.05	<0.05	
						14	<0.05	<0.05	
					Straw	7	4.7	0.08	
						14	2.3	0.10	
	EC	3	1.4		Grain	7	<0.01	<0.01	IL2
						14	<0.01	<0.01	
					Forage	7	<0.05	<0.05	
						14	<0.05	<0.05	
					Straw	7	1.8	0.06	
						14	5.2	0.23	
	ULV (aerial)	3	0.683		Grain	7	<0.01	<0.01	IL1
						14	<0.01	<0.01	
					Forage	7	0.22	<0.05	
						14	<0.05	<0.05	
					Straw	7	24	0.07	
						14	18	0.12	
	ULV (aerial)	3	0.683		Grain	7	<0.01	<0.01	IL2
						14	<0.01	<0.01	
					Forage	7	0.15	<0.05	
						14	<0.05	<0.05	
					Straw	7	4.8	<0.05	
						14	6.6	<0.05	
	ULV (aerial)	3	0.683		Grain	7	<0.01	<0.01	IL3
						14	<0.01	<0.01	
					Forage	7	0.21	<0.05	
						14	0.34	<0.05	
					Straw	7	22	0.07	
						14	12	0.06	

County Year	Formulation	Application No.	kg ai/ha	kg ai/hl	Sample	PHI, days	Residues, mg/kg Malathion	Malaoxon	Reference
NE 1992/ 1993	EC	3	1.4		Grain	7	<u>≤0.01</u>	<0.01	NE1
						14	<0.01	<0.01	
					Forage	7	<u>0.12</u>	<0.05	
						14	<0.05	<0.05	
					Straw	7	<u>2.3</u>	0.07	
						14	0.66	<0.05	
	ULV (aerial)	3	0.683		Grain	7	<u>0.02</u>	<0.01	NE1
						14	<0.01	<0.01	
					Forage	7	0.17	<0.05	
						14	<u>0.24</u>	<0.05	
					Straw	7	<u>13</u>	0.05	
						14	3.3	<0.05	
	ULV (aerial)	3	0.683		Grain	7	<u>≤0.01</u>	<0.01	NE2
						14	<0.01	<0.01	
					Forage	7	<u>0.76</u>	<0.05	
						14	0.28	<0.05	
					Straw	7	<u>6.9</u>	0.05	
						14	4.0	<0.05	
OH 1992/ 1993	EC	3	1.4		Grain	7	<u>≤0.01</u>	<0.01	OH1
						14	<0.01	<0.01	
					Forage	7	<u>0.19</u>	<0.05	
						14	<0.05	<0.05	
					Straw	7	9.9	0.13	
						14	<u>11</u>	0.22	
	ULV (aerial)	3	0.683		Grain	7	<u>≤0.01</u>	<0.01	
						14	0.01	<0.01	
					Forage	7	<u>0.09</u>	<0.05	
						14	<0.05	<0.05	
					Straw	7	<u>11</u>	0.05	
						14	6.3	0.05	
TX 1992/ 1993	EC	3	1.4		Grain	7	<u>≤0.01</u>	<0.01	TX1
						14	<0.01	<0.01	
					Forage	7	<u>≤0.05</u>	<0.05	
						14	<0.05	<0.05	
					Straw	7	3.1	0.09	
						14	<u>4.5</u>	0.13	
	ULV (aerial)	3	0.683		Grain	7	<u>≤0.01</u>	<0.01	
						14	<0.01	<0.01	
					Forage	7	<u>0.07</u>	<0.05	
						14	<0.05	<0.05	
					Straw	7	4.6	<0.05	
						14	<u>12</u>	0.11	
WI 1992/ 1993	EC	3	1.4		Grain	7	<u>≤0.01</u>	<0.01	WI1
						14	<0.01	<0.01	
					Forage	7	<u>≤0.05</u>	<0.05	
						14	<0.05	<0.05	
					Straw	7	13	0.23	
						14	<u>19</u>	0.73	
	ULV (aerial)	3	0.683		Grain	7	<u>≤0.01</u>	<0.01	
						14	<0.01	<0.01	
					Forage	7	<u>0.25</u>	<0.05	
						14	0.07	<0.05	
					Straw	7	<u>12</u>	0.15	
						14	7.3	0.07	

One trial was conducted to determine the residues in maize grain treated post-harvest with malathion. The storage bin was treated with 2.4 kg ai/hl of an EC formulation according to GAP and the grain received an application of 8g ai/1000 l grain of a dust formulation during and after bin loading. Two other treatments were made with dust formulation (Table 62). Malathion residues in grain after 60 days of storage were 6.9 mg/kg.

Table 62. Residues of malathion and oxon in maize grain after post-harvest treatment.

Treatment	PHI, days	Residue, mg/kg	
		Malathion	Malaoxon
1 x 4g ai/1000 litre grain immediately after transfer to storage bin	0	80	0.02
1 x 4g ai/1000 litre grain after 60 days of storage	60	6.9	0.03

Nuts. In two trials on chestnuts**,** malathion residues at a PHI of 2 days were 0.08 and 0.58 mg/kg. In two trials on macadamia nuts and two on walnuts, no residues (<0.05 mg/kg) were detected after a 1- or 7-day PHI in samples with and without the shells (Table 63). The labels state that application to the three types of nuts may be at harvest.

Table 63. Residues of malathion and oxon in nuts treated with EC formulations.

State Year	Application		Sample	PHI, days	Residue, mg/kg	
	No.	kg ai/ha			Malathion	Malaoxon
Chestnut (Study N°. A4783)						
FL 1995	4	5.6	Hulls removed	2	0.58	<0.05
	4	5.6	Hulls removed	2	0.08	<0.05
Macadamia nuts (Study N° 04812)						
HW 1992	7	1.0	Hulls and shell removed	1	<0.05	<0.05
	7	1.0	Hulls and shell removed	1	<0.05	<0.05
Walnuts (Study N° 04851)						
CA, 1992	3	2.8	Hulls and shell removed	7	<0.05	<0.05
1995	3	2.8	Hulls and shell removed	7	<0.05	<0.05

Cotton. Seventeen trials on cotton were with ground applications of EC formulations or air applications of ULV and ready-to-use (RTU) formulations. Malathion residues in cotton seed at a 0 or 1 day PHI ranged from 2.1 to 14 mg/kg (Table 64).

Table 64. Residues of malathion and oxon in cotton.

State Year	Application			PHI, days	Residue, mg/kg		Reference
	Form	No.	kg ai/ha		Malathion	Malaoxon	
AZ 1993	EC	25	2.8	0	4.1	0.06	Study No. AA920110 AZ1
				1	3.9	0.06	
				4	2.4	<0.05	
				7	1.8	0.13	
				14	3.0	0.37	
	Ready-to-use (aerial)	25	1.3	0	4.2	0.10	
				1	1.5	0.07	
				4	2.1	0.11	
				7	1.3	0.14	
				14	3.3	0.34	
CA 1993	E C	25	2.8	0	5.6	0.06	Study No. AA920110 CA1
				1	5.9	0.06	
				4	5.2	0.06	
				7	1.8	<0.05	
				14	0.23	<0.05	
	E C	25	2.8	0	14	0.12	Study No. AA920110 CA2
				1	7.1	0.07	
				4	7.6	0.10	
				7	4.3	0.06	
				14	4.2	0.06	
	ULV aerial	25	1.4	0	5.4	<0.05	Study No. AA920110 CA1
				1	5.4	<0.05	
				4	2.1	<0.05	
				7	2.0	<0.05	
				14	1.2	<0.05	

State Year	Application			PHI,	Residue, mg/kg		
	Form	No.	kg ai/ha	days	Malathion	Malaoxon	Reference
	ULV (aerial)	25	1.4	0 1 4 7 14	5.6 7.1 4.0 2.0 1.3	0.05 0.07 <0.05 <0.05 <0.05	Study No. AA920110 CA2
	Ready-to-use (aerial)	25	1.3	0 1 4 7 14	4.3 4.8 2.4 1.8 1.1	0.06 0.07 <0.05 <0.05 <0.05	Study No. AA920110 CA1
	Ready-to-use (aerial)	25	1.3	0 1 4 7 14	4.7 3.5 2.1 1.7 0.90	0.05 0.05 <0.05 <0.05 <0.05	Study No. AA920110 CA2
LA 1993	E C	25	2.8	0 1 4 7 14	7.8; 6.0 7.4; 4.7 2.3; 2.3 1.4; 1.2 1.4; 0.65	<0.05; <0.05 0.05; <0.05 <0.05; <0.05 <0.05; <0.05 <0.05; <0.05	Study No. AA920110 LA1; LA2
	ULV Aerial	25	1.4	0 1 4 7 14	2.1 2.1 0.48 0.40 0.14	<0.05 <0.05 <0.05 <0.05 <0.05	Study No. AA920110 LA1
	Ready-to-use (aerial)	25	1.3	0 1 4 7 14	5.4 1.9 0.50 0.74 0.25	0.07 0.07 <0.05 <0.05 <0.05	Study No. AA920110 LA2
TX 1192/1993	E C	25	2.8	0 1 4 7 14	3.8 3.1 2.1 0.66 0.73	0.07 0.07 0.10 <0.05 0.07	Study No. AA920110 TX1
	E C	25	2.8	0 1 4 7 14	3.0 2.9 2.4 2.9 2.1	0.08 0.09 0.09 0.12 0.12	Study No. AA920110 TX2
	ULV (aerial	25	1.4	0 1 4 7 14	6.4 3.2 2.0 2.1 1.4	0.10 0.06 0.07 0.06 0.07	Study No. AA920110 TX1
	ULV (aerial)	25	1.4	0 1 4 7 14	2.7 1.5 1.8 1.6 0.45	<0.05 <0.05 <0.05 0.06 0.06	Study No. AA920110 TX2
	Ready-to-use (aerial)	25	1.3	0 1 4 7 14	4.9 2.6 1.9 0.67 0.57	0.12 0.09 0.11 0.07 0.06	Study No. AA920110 TX1
	Ready-to-use (aerial)	25	1.3	0 1 4 7 14	1.8 2.3 0.92 0.87 0.36	<0.05 0.07 <0.05 0.05 0.05	Study No. AA920110 TX2

Flax. In one trial on flax in Nevada in 1994 (Study No. 04795) malathion was applied as an EC formulation at a proposed GAP rate of 1 x 0.56 kg ai/ha. Samples of straw, seed and meal were analysed. No residues of malathion or malaoxon were detected in any sample (<0.05 mg/kg) 52 days after application (the proposed GAP PHI is 45 days).

Mint. In three trials on mint, malathion residues at a PHI of 7 days ranged from 0.51 to 1.4 mg/kg in fresh mint and 5.7- 9.1 mg/kg in mint oil. In four trials at a fivefold rate the residues were 13-56 mg/kg in fresh mint and 140-460 mg/kg in oil (Table 65).

Table 65**.** Residues of malathion and oxon in peppermint and spearmint at 7 days PHI.

State year	Application			Sample analysed	Residues, mg/kg		Reference
	No.	kg ai/ha	kg ai/hl		Malathion	Malaoxon	
WI	3	1.1		Fresh peppermint	1.4	<0.05	Study No. 04829 WI15
1992	3	5.3		Fresh peppermint	56	0.12	
				Peppermint oil	460	0.10	
1993	3	1.1		Fresh peppermint	0.51	<0.05	Study No. 04829 WI19
				Peppermint oil	5.7	<0.05	
	3	5.3		Fresh peppermint	13	0.23	
				Peppermint oil	190	0.08	
IH	3	1.1		Peppermint oil	9.1	<0.05	Study No. 04829 IH15
1993	3	5.3		Peppermint oil	140	0.08	
	3	1.1		Fresh peppermint+spearmint[1]	1.2	0.10	Study No. 04829 IH14
				Spearmint oil	8.0	<0.05	
	3	5.3		Fresh peppermint+spearmint[1]	32	0.40	
				Spearmint oil	200	0.13	

[1]Composite sample from trials IH14 and IH15

Clover. Fourteen trials on clover were with ground application of an EC or aerial application of ULV formulation. The applications were made before each cutting. Malathion residues in clover forage at day 0 or later (GAP allows application at harvest) varied from 2.8 to 95 mg/kg. Residues in clover hay ranged from 4.4 to 120 mg/kg (Table 66).

Table 66. Residues of malathion and oxon in clover.

State Year	Application			Sample	PHI, days	Residue, mg/kg	
	Form	No.	kg ai/ha			Malathion	Malaoxon
GA	EC	2	1.4	Forage/hay	0	17/35	0.08/0.25
1993				1st cut	1	8.4/24	0.08/0.18
					4	8.0/14	0.11/0.14
					7	6.5/11	0.08/0.16
	ULV aerial	2	0.68	Forage/hay	0	33/34	0.06/0.17
				1st cut	1	28/24	0.09/0.18
					4	5.5/9.2	<0.05/0.07
					7	6.3/13	0.06/0.09
ID	EC	2	1.4	Forage/hay	0	71/21	0.10/0.22
				1st cut	1	7.5/10	<0.05/0.11
					4	2.5/7.0	<0.05/0.09
					7	2.4/6.6	<0.05/0.07
					14	0.68/2.9	<0.05/<0.05
				2nd cut	0	88/120	0.11/0.46
					1	44/74	0.11/0.30
					4	21/12	0.19/<0.05
					7	4.3/16	<0.05/0.07
					14	2.8/13	<0.05/0.06

State Year	Application			Sample	PHI, days	Residue, mg/kg	
	Form	No.	kg ai/ha			Malathion	Malaoxon
	ULV aerial	2	0.68	Forage/hay 1st cut	0	46/58	<0.05/0.35
					1	11/22	<0.05/0.18
					4	7.0/14	<0.05/0.11
					7	5.5/14	<0.05/0.09
					14	1.9/7.6	<0.05/<0.05
				2nd cut	0	56/98	0.05/0.27
					1	51/96	0.06/0.29
					4	45/30	0.11/0.06
					7	18/26	<0.05/0.06
					14	8.5/13	<0.05/0.06
MI	EC	2	1.4	Forage/hay 1st cut	0	20/16	<0.05/
					1	2.2/8.9	<0.05
					4	2.0/7.1	<0.05/<0.05
					7	2.0/3.0	<0.05/<0.05
					14	1.1/3.4	<0.05/<0.05
				2nd cut	0	37/64	<0.05/<0.05
					1	9.4/30	0.12/0.50
					4	3.1/11	<0.05/0.24
					7	2.6/4.3	<0.05/0.07
					14	2.5/4.8	<0.05/<0.05
				3rd cut	0	73/34	<0.05/<0.05
					1	32/49	0.13//0.25
					4	10/4.7	0.10/0.45
					7	3.1/7.2	<0.05/<0.05
					14	1.3/1.6	<0.05/0.05
							<0.05/<0.05
	ULV aerial	2	0.68	Forage/hay 1st cut	0	3.2/4.4	<0.05/<0.05
					1	0.39/0.48	<0.05/<0.05
					4	0.19/0.32	<0.05/<0.05
					7	0.10/0.32	<0.05<0.05
					14	0.12/0.14	<0.05/<0.05
				2nd cut	0	8.7/20	<0.05/0.16
					1	0.20/2.7	<0.05/<0.05
					4	0.09/1.7	<0.05/<0.05
					7	0.15/0.54	<0.05/<0.05
					14	0.12/0.20	<0.05/<0.05
				3rd cut	0	14/9.4	<0.05/0.08
					1	8.3/19	<0.05/0.20
					4	3.3/0.41	<0.05/<0.05
					7	0.69/1.7	<0.05/<0.05
					14	0.66/0.35	<0.05/<0.05
MN	EC	2	1.4	Forage/hay 1st cut	0	57/13	0.11/0.05
					1	22/15	<0.05/0.06
					4	12/18	<0.05/0.11
					7	5.6/13	<0.05/0.07
					14	4.9/5.0	<0.05/<0.05
	ULV aerial	2	0.68	Forage 1st cut	0	60/11	<0.05/<0.05
					1	52/12	<0.05<0.05
					4	56/93	0.16/0.29
					7	40/8.6	0.15/<0.05
					14	46/13	0.10/<0.05
NY	EC	2	1.4	Forage/hay 1st cut	0	36/5.7	<0.05/<0.05
					1	39/9.7	0.05/<0.05
					4	2.5/6.6	<0.05/<0.05
					7	3.9/21	<0.05/0.13
					14	2.8/7.5	<0.05/0.07
				2nd cut	0	95/86	0.11/0.32
					1	51/25	0.11/0.34
					4	11/15	0.05/0.12
					7	4.7/12	<0.05/0.09
					14	2.9/4.4	<0.05/0.07

State Year	Application			Sample	PHI, days	Residue, mg/kg	
	Form	No.	kg ai/ha			Malathion	Malaoxon
	ULV aerial	2	0.68	Forage/hay 1st cut	0	9.5/26	0.05/0.11
					1	4.8/22	<0.05/0.06
					4	3.9/9.7	<0.05/0.06
					7	1.2/5.8	<0.05/<0.05
					14	1.8/4.9	<0.05/<0.05
				2nd cut	0	16/18	<0.05/<0.05
					1	20/24	<0.05/0.09
					4	7.7/26	<0.05/0.15
					7	4.4/10	<0.05/0.07
					14	3.4/4.7	<0.05/<0.05
OK	EC	2	1.4	Forage/hay 1st cut	0	31/53	0.10/0.22
					1	9.4/20	<0.05/<0.05
					4	1.2/4.7	<0.05/<0.05
					7	0.71/2.1	<0.05/<0.05
					14	0.20/1.4	<0.05/<0.05
				2nd cut	0	18/36	0.07/0.21
					1	7.7/10	0.05/0.10
					4	1.5/2.6	0.05/0.10
					7	0.79/1.3	<0.05/<0.05
					14	0.47/0.97	<0.05/<0.05
	ULV aerial	2	0.68	Forage/hay 1st cut	0	25/90	<0.05/0.30
					1	24/55	<0.05/0.09
					4	11/22	<0.05/0.06
					7	7.2/16	<0.05/0.05
					14	0.83/5.3	<0.05/<0.05
				2nd cut	0	2.9/33	<0.05/0.16
					1	39/32	<0.05/0.10
					4	5.6/19	<0.05/0.15
					7	5.2/15	<0.05/0.07
					14	1.4/1.9	<0.05/<0.05
WI	EC	2	1.4	Forage/hay 1st cut	0	14/5.4	<0.05/<0.05
					1	7.8/9.2	<0.05/0.06
					4	2.0/12	<0.05/12
					7	0.74/2.5	<0.05/2.5
					14	0.37/1.1	<0.05/1.1
				2nd cut	0	40/80	<0.05/0.40
					1	27/90	<0.05/0.41
					4	7.1/13	<0.05/0.07
					7	6.4/20	<0.05/0.14
					14	3.1/8.7	<0.05/0.05
	ULV aerial	2	0.68	Forage 1st cut	0	2.8/3.3	<0.05/<0.05
					1	1.2/5.0	<0.05/<0.05
					4	0.95/3.9	<0.05<0.05
					7	1.6/4.0	<0.05/<0.05
					14	0.48/1.9	<0.05/<0.05
				2nd cut	0	38/93	<0.05/0.22
					1	26/84	<0.05/0.24
					4	13/35	<0.05/0.14
					7	11/42	0.05/0.23
					14	8.5/23	0.05/0.10

Alfalfa. Two series of eleven trials on alfalfa were with a ground application of either an EC or air application of a ULV formulation. The applications were made before each cutting. Malathion residues in alfalfa forage at day 0 (GAP allows application at harvest) were 0.99 to 98 mg/kg. Residues in hay (PHI 0 day or later) were 1.5 to 175 mg/kg (Table 67).

Table 67. Residues of malathion and oxon in alfalfa (Study No. AA920101).

State Year	Application				Sample analysed	PHI, days	Residue, mg/kg		Reference
	Form	No.	kg ai/ha				Malathion	Malaoxon	

State Year	Application Form	No.	kg ai/ha		Sample analysed	PHI, days	Residue, mg/kg Malathion	Malaoxon	Reference
CA 1993	EC	2	1.4		Forage/hay	0	51/6.1	0.13/<0.05	CA1
					1st cut	1	16/3.8	0.07/<0.05	
						4	2.9/0.93	0.11/<0.05	
					2nd cut	0	34/43	0.14/0.46	
						1	12/12	0.13/0.48	
						4	1.1/4.4	0.10/0.28	
					3rd cut	0	64/27	0.26/0.39	
						1	8.1/12	0.07/0.30	
						4	2.1/2.2	0.16/0.16	
	ULV aerial	2	0.68		Forage/hay	0	72/52	0.09/0.31	
					1st cut	1	34/79	0.07/0.43	
						4	9.5/19	0.06/0.14	
					2nd cut	0	43/26	<0.05/0.14	
						1	19/8.1	<0.05/0.22	
						4	8.7/26	<0.05/0.16	
					3rd cut	0	41/56	0.08/0.41	
						1	49/34	0.08/0.39	
						4	16/11	0.07/0.18	
IA 1993	EC	2	1.4		Forage/hay	0	51/	0.08	IA1
					1st cut	1	6.5/	<0.05	
						4	0.16/	<0.05	
					2nd cut	0	60/17	0.10/0.30	
						1	1.5/2.0	<0.05/<0.05	
						4	0.42/1.5	<0.05/<0.05	
					3rd cut	0	92/17	0.06/0.20	
						1	2.5/3.1	<0.05/0.07	
						4	1.2/1.3	<0.05/<0.05	
	ULV aerial	2	0.68		Forage/hay	0	23/20	<0.05/0.06	
					1st cut	1	9.8/19	<0.05/0.07	
						4	2.1/8.8	<0.05/<0.05	
					2nd cut	0	36/14	<0.05/<0.05	
						1	5.3/4.3	<0.05/<0.05	
						4	0.53/1.6	<0.05/<0.05	
					3rd cut	0	95/25	<0.05/0.05	
						1	6.3/7.5	<0.05/<0.05	
						4	7.8/10	<0.05/<0.05	
ID 1993	EC	2	1.4		Forage/hay	0	53/	0.08	ID1
					1st cut	1	24/	<0.05	
						4	1.4/	<0.05	
					2nd cut	0	94/140	0.11/0.64	
						1	95/89	0.14/0.53	
						4	30/34	0.13/0.57	
	ULV aerial	2	0.68		Forage/hay	0	20/12	<0.05/<0.05	
					1st cut	1	16/30	<0.05/0.07	
						4	1.1/3.5	<0.05/<0.05	
					2nd cut	0	25/67	<0.05/0.10	
						1	48/74	<0.05/0.28	
						4	21/66	<0.05/0.40	
MI 1993	EC	2	1.4		Forage/hay	0	28/	0.06	MI1
					1st cut	1	40/	<0.05	
						4	14/	<0.05	
					2nd cut	0	37/20	0.10/0.20	
						1	0.55/0.96	<0.05/<0.05	
						4	0.05/0.26	<0.05/<0.05	
					3rd cut	0	54/7.7	0.13/0.06	
						1	11/6.5	<0.05/0.08	
						4	0.73/0.06	<0.05/<0.05	

State Year	Application Form	No.	kg ai/ha		Sample analysed	PHI, days	Residue, mg/kg Malathion	Malaoxon	Reference
	ULV aerial	2	0.68		Forage/hay	0	9.0/5.6	<0.05/<0.05	
					1st cut	1	0.07/0.42	<0.05/<0.05	
						4	0.07/0.14	<0.05/<0.05	
					2nd cut	0	9.7/6.2	<0.05/<0.05	
						1	0.27/0.24	<0.05/<0.05	
						4	0.18/<0.05	<0.05/<0.05	
					3rd cut	0	8.7/2.1	<0.05/<0.05	
						1	3.2/3.1	<0.05/<0.05	
						4	0.70/0.05	<0.05/<0.05	
MN 1993	EC	2	1.4		Forage/hay	0	35/	0.06	MN1
					1st cut	1	1.0/	<0.05	
						4	0.20/	<0.05	
					2nd cut	0	29/2.0	0.06/<0.05	
						1	20/3.1	<0.05/<0.05	
						4	0.96/1.1	<0.05/<0.05	
	ULV aerial	2	0.47-0.68		Forage/hay	0	5.7/8.6	<0.05/<0.05	
					1st cut	1	5.5/3.3	<0.05/<0.05	
						4	3.8/2.3	<0.05/<0.05	
					2nd cut	0	21/9.7	<0.05/<0.05	
						1	2.2/8.5	<0.05/<0.05	
						4	2.0/0.43	<0.05/<0.05	
NE 1993	EC	2	1.4		Forage/hay	0	23/	<0.05	NE1
					1st cut	1	11/	<0.05	
						4	0.33/	<0.05	
					2nd cut	0	45/20	0.08/0.16	
						1	2.5/1.8	<0.05/<0.05	
						4	0.57/0.57	<0.05/<0.05	
					3rd cut	0	28/1.5	0.09/<0.05	
						1	5.4/0.20	<0.05/<0.05	
						4	0.41/0.29	<0.05/<0.05	
	ULV aerial	2	0.68		Forage/hay	0	17/19	<0.05/<0.05	
					1st cut	1	15/7.7	<0.05/<0.05	
						4	0.79/1.7	<0.05/<0.05	
					2nd cut	0	32/38	<0.05/0.08	
						1	11/13	<0.05/<0.05	
						4	2.6/7.0	<0.05/<0.05	
					3rd cut	0	22/4.6	0.06/<0.05	
						1	9.4/1.9	<0.05/<0.05	
						4	1.7/1.8	<0.05/<0.05	
PA 1993	EC	2	1.4		Forage/hay	0	98/46	0.11/0.27	PA1
					1st cut	1	53/33	0.16/0.25	
						4	4.7/5.5	0.13/0.15	
					2nd cut	0	19/3.9	0.06/<0.05	
						1	0.98/1.6	<0.05/<0.05	
						4	0.27/0.57	<0.05<0.05	
					3rd cut	0	65/3.2	0.09/<0.05	
						1	19/3.1	<0.05/<0.05	
						4	0.94/0.10	<0.05/<0.05	
	ULV aerial	2	0.68		Forage/hay	0	22/33	<0.05/0.10	
					1st cut	1	20/24	0.06/0.12	
						4	5.3/6.8	<0.05/<0.05	
					2nd cut	0	10/21	<0.05/<0.05	
						1	10/10	<0.05/<0.05	
						4	7.1/11	<0.05/<0.05	
					3rd cut	0	19/26	<0.05/0.05	
						1	38/20	0.06/<0.05	
						4	14/8.7	<0.05/<0.05	
SD 1992	EC	2	1.4		Forage/hay	0	47/11	0.13/0.08	SD1
					1st cut	1	2.0/0.89	<0.05/<0.05	
						4	0.33/0.28	<0.05/<0.05	
						7	0.07/0.22	<0.05/<0.05	
						14	0.07/<0.05	<0.05/<0.05	

State Year	Application Form	No.	kg ai/ha		Sample analysed	PHI, days	Residue, mg/kg Malathion	Malaoxon	Reference
	ULV aerial	2	0.54-0.71		Forage/hay 1st cut	0	1.8/3.5	<0.05/<0.05	
						1	0.30/0.43	<0.05/<0.05	
						4	0.09/0.23	<0.05/<0.05	
						7	<0.05/0.05	<0.05/<0.05	
						14	<0.05/0.08	<0.05/<0.05	
1993	EC	2	1.4		Forage/hay 1st cut	0	70/175	0.15/2.1	SD1A
						1	31/64	0.10/0.87	
						4	4.0/5.8	<0.05/0.10	
	ULV aerial	2	0.68		Forage/hay 1st cut	0	29/135	<0.05/0.43	
						1	18/81	<0.05/0.35	
						4	/37	/0.09	
WA 1993	EC	2	1.4		Forage/hay 1st cut	0	22/16	<0.05/0.10	WA1
						1	1.7/3.7	0.07/0.07	
					2nd cut	0	68/28	0.07/0.27	
						1	11/5.7	<0.05/<0.05	
						4	0.24/0.85	<0.05/<0.05	
					3rd cut	0	81/6.7	0.10/0.05	
						1	12/1.8	<0.05/<0.05	
						4	0.20/0.26	<0.05/<0.05	
	ULV aerial	2	0.68		Forage/hay 1st cut	0	0.99/2.8	<0.05/<0.05	
						1	0.27/0.44	<0.05/<0.05	
					2nd cut	0	4.5/2.9	<0.05/<0.05	
						1	0.84/0.22	<0.05/<0.05	
						4	<0.05/0.06	<0.05/<0.05	
					3rd cut	0	12/2.1	<0.05/<0.05	
						1	0.33/0.10	<0.05/<0.05	
						4	0.06/<0.05	<0.05/<0.05	
WI 1992	EC	2	1.4		Forage/hay 1st cut	0	42/52	0.05/0.33	WI1
						1	12/17	<0.05/0.09	
						4	0.89/3.4	<0.05/<0.05	
						7	0.54/2.6	<0.05/<0.05	
						14	0.16/0.27	<0.05/<0.05	
					2nd cut	0	32/85	<0.05/0.59	
						1	46/83	<0.05/0.54	
						4	6.6/6.7	<0.05/0.07	
						7	1.4/	<0.05	
						14	0.32/	<0.05	
	ULV aerial	2	0.68		Forage/hay 1st cut	0	5.2/3.3	<0.05/<0.05	
						1	2.1/1.6	<0.05/<0.05	
						4	1.6/0.47	<0.05/<0.05	
						7	1.0/0.32	<0.05/<0.05	
						14	1.0/0.08	<0.05/<0.05	
					2nd cut	0	21/45	<0.05/0.21	
						1	22/46	<0.05/0.24	
						4	18/13	<0.05/0.05	
						7	6.8/	<0.05	
						14	1.5/	<0.05	

Grasses. In twenty trials on various grasses with ground EC or air ULV application malathion residues at the allowed 0 day PHI varied from 2.0 to 190 mg/kg in forage and from 1.9 to 260 mg/kg in hay (Table 68).

Table 68**.** Residues of malathion and oxon in grasses at 0 day PHI (Study No. AA920113).

State Year	Application Form	No.	kg ai/ha		Sample	Residue, mg/kg Malathion	Malaoxon
AR 1993	EC	3	1.4		Forage	25	0.23
					Hay	6.0	0.08
	ULV aerial	2	1.0		Forage	80	0.07
					Hay	30	0.14

State Year	Application				Sample	Residue, mg/kg	
	Form	No.	kg ai/ha			Malathion	Malaoxon
KS 1992	EC	3	1.4		Forage	72	<0.05
					Hay	4.0	<0.05
	ULV aerial	2	1.0		Forage	83	<0.05
					Hay	34	<0.05
KY 1993	EC	3	1.4		Forage	2.0	<0.05
					Hay	1.9	<0.05
	ULV aerial	2	1.0		Forage	19	<0.05
					Hay	33	<0.05
MO 1993	EC	3	1.4		Forage	68	0.06
					Hay	58	0.19
	ULV aerial	2	1.0		Forage	68	<0.05
					Hay	55	0.16
NY 1993	EC	3	1.4		Forage	29	0.06
					Hay	24	0.34
	ULV aerial	2	1.0		Forage	10	<0.05
					Hay	68	0.34
OK 1992	EC	3	1.4		Forage	22	0.05
					Hay	42	0.15
	ULV aerial	2	1.0		Forage	44	<0.05
					Hay	54	<0.05
PA 1993	EC	3	1.4		Forage	130	0.06
					Hay	260	0.80
	ULV aerial	2	1.0		Forage	190	0.16
					Hay	130	0.70
SD 1993	EC	3	1.4		Forage	55	0.06
					Hay	36	0.12
	ULV aerial	2	1.0		Forage	74	0.06
					Hay	46	0.08
TN 1993	EC	3	1.4		Forage	34	0.18
					Hay	61	0.52
	ULV aerial	2	1.0		Forage	30	<0.05
					Hay	100	0.34
VA 1993	EC	3	1.4		Forage	75	0.05
					Hay	66	0.73
	ULV aerial	2	1.0		Forage	38	<0.05
					Hay	27	0.07

FATE OF RESIDUES IN PROCESSING

All the processing studies were in the USA and simulated commercial procedures.

Oranges. In a processing study in California, malathion was applied at 8 times the label rate (1.75 kg ai/ha) and oranges were harvested after 7 days. Samples of whole oranges, oil, juice, peel, dried pulp and molasses were analysed. Malathion was concentrated in oil (factor 219), dried pulp (factor 10) and molasses (factor 1.4) (Table 69).

Table 69. Malathion residues in oranges and their processed products.

Sample	Residues, mg/kg		Processing factor	
	Malathion	Malaoxon	Malathion	Malaoxon
Orange	0.18	<0.01	-	-
Oil	40	0.04	219	4
Juice	<0.01	<0.01	<0.05	-
Peel	0.10	<0.01	0.55	-
Dried pulp	1.8	<0.05	10	-
Molasses	0.26	<0.01	1.4	-

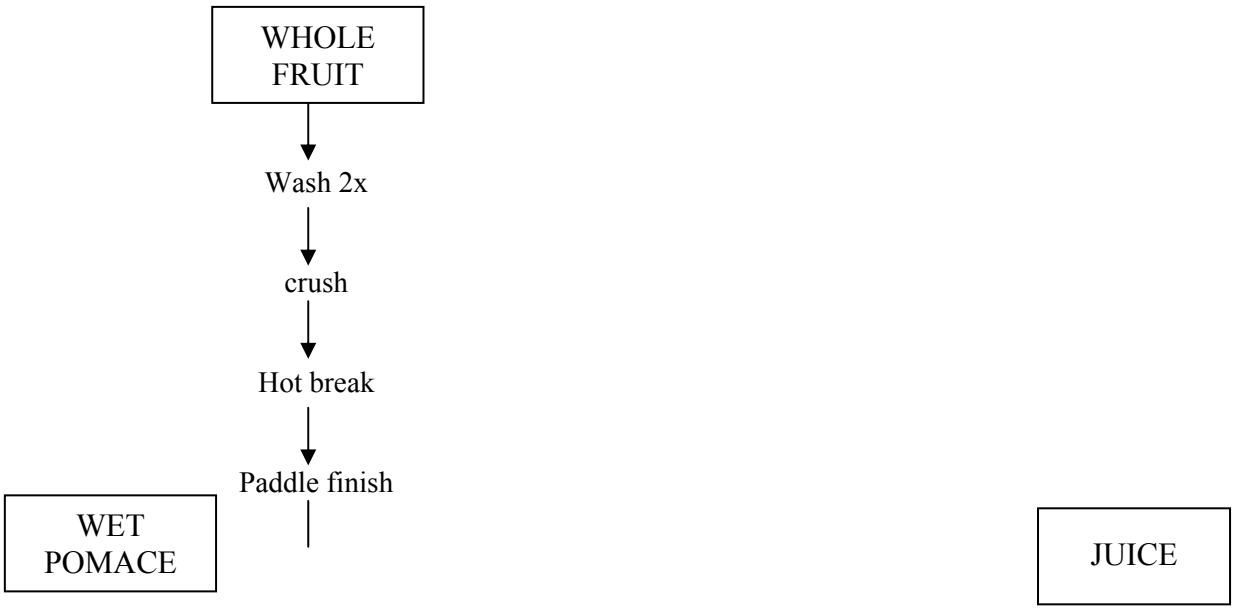
Grapes. In a processing study in California, malathion was applied twice at 10.5 kg ai/ha (5 times the label rate) and grapes were harvested 3 days after the last application. Malathion was concentrated in wet pomace (factor 2.5), dry pomace (factor 11) and raisin waste (factor 6) (Table 70).

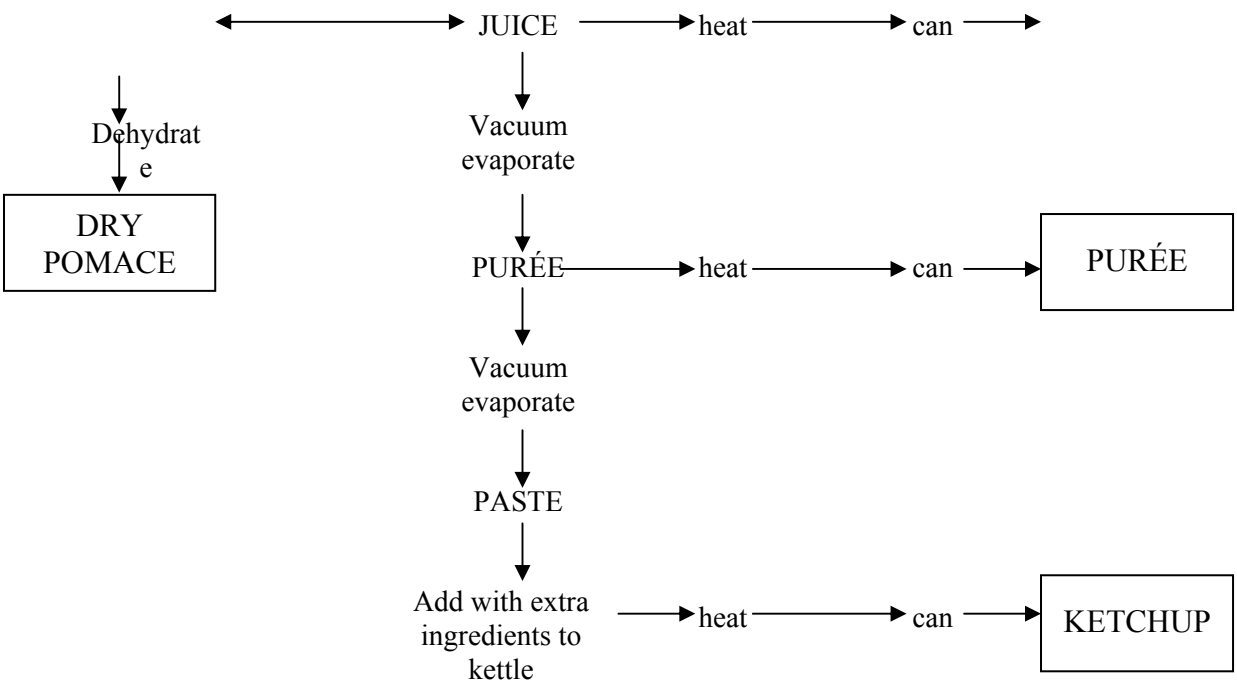
Table 70. Malathion residues in grapes and their processed products.

Sample	Residue, mg/kg		Processing factor	
	Malathion	Malaoxon	Malathion	Malaoxon
Whole grapes	0.79	0.04	-	-
Juice	0.07	0.01	0.08	0.25
Wet pomace	2.0	0.07	2.5	1.8
Dry pomace	8.8	0.18	11	4.5
Raisins	0.34	0.02	0.43	0.5
Raisin waste	4.9	0.48	6	12

Tomatoes. In a processing study in California, malathion was applied at 5 x 19.2 kg ai/ha (5 times the maximum label rate) and tomatoes harvested 1 day after the last application were processed according to a simulated commercial procedure. The fruit were flume-spray washed twice, crushed, heated to 91.1°C, and passed through a 0.83 mm screen. The portion that did not pass through the screen (wet pomace) was dried and a sub-sample of the juice that passed through the screen was heated in a steam-jacketed kettle to >65.6°C and canned. The cans were sealed and heated for at least 50 minutes at ≥115.6°C. Another sub-sample of the juice was concentrated by vacuum evaporation to produce purée. A sub-sample of the purée was heated to 90°C and canned. Another sub-sample of the purée was vacuum-condensed to paste and mixed with other ingredients to produce ketchup, heated to 92.2°C in a steam-jacketed kettle and canned. The procedure is shown in Figure 5.

Figure 5. Flow chart of tomato processing procedure.





Malathion residues were concentrated in wet pomace by a factor of 1.7 and dry pomace by a factor of 13.3 (Table 71).

Table 71. Malathion residues in processed tomatoes and processed fractions.

	Residue, mg/kg		Processing factor	
Sample	Malathion	Malaoxon	Malathion	Malaoxon
Tomato	24	0.17	-	-
Juice	0.69	<0.01	0.03	<0.06
Purée	14	0.10	0.58	0.59
Ketchup	18	0.14	0.75	0.82
Dry pomace	320	2.5	13.3	14.7
Wet pomace	41	0.23	1.7	1.4

Snap beans. In a processing study in Oregon malathion was applied at 3 x 3.4 kg ai/ha (5 times the maximum label rate) and beans were harvested 1 day after the last application. The beans were washed in water, the debris, stems and blossom ends were removed, and the beans mechanically cut. The removed parts were analysed as cannery waste, in which malathion was concentrated 8.3 times (Table 72).

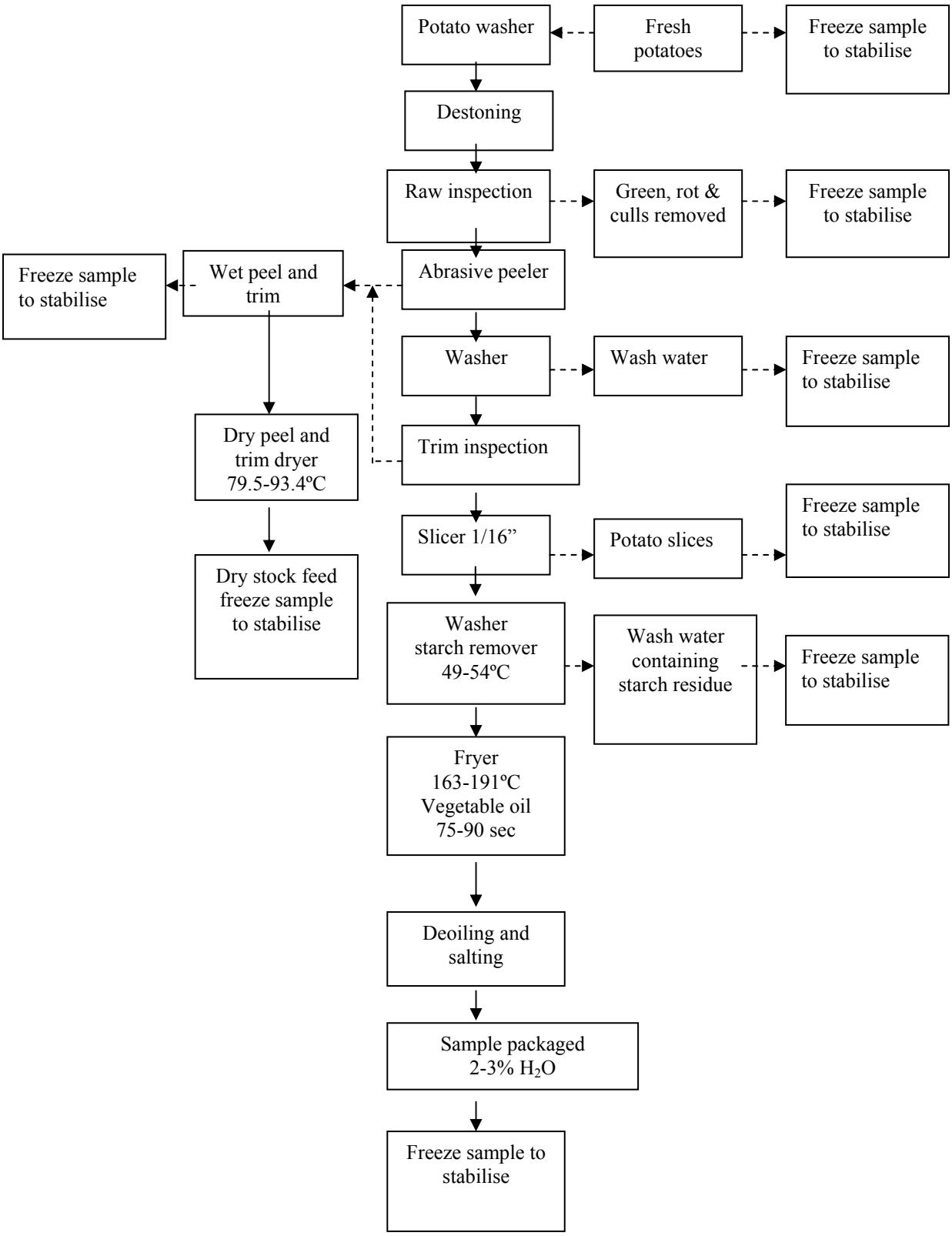
Table 72. Malathion residues in snap beans and processed fractions.

Samples	Residue, mg/kg		Processing factor	
	Malathion	Malaoxon	Malathion	Malaoxon
Whole bean	0.55	<0.01	-	-
Cut bean	<0.01	<0.01	<0.02	-
Cannery waste	4.6	<0.05	8.3	-

Potatoes. In a processing study in Washington malathion was applied at 2 x 8.7 kg ai/ha (5 times the maximum label rate) and potatoes were harvested on the day of the last application. Tubers were processed according to a simulated commercial procedure. Potatoes were tub-washed, batch-peeled, hand-trimmed to remove damaged areas, sliced, fried at 160 to 167.7°C, drained, salted and packaged as potato chips. The remaining washed raw potatoes were steam-peeled, mechanically scrubbed, hand-trimmed to removed damaged portions and the wet peel was hydraulically pressed. The pressed peel was mixed with the cut trim waste and a sample collected and packaged as the wet peel fraction. The remaining wet peel was air-dried, milled, and a sample packaged as the dry peel fraction. A sub-sample of raw peeled tubers was sliced, spray-washed with water to remove free starch, pre-cooked at 67.8 to 73.9°C in a stainless steel steam-jacketed kettle and cooled to <32.2°C. A sub-sample of the cooled potato slices was steam-cooked at 99.4°C, mashed in a commercial meat grinder, mixed with reweighed food additives, dried to 10% moisture in a fluid-bed drier, sifted through a US 30-mesh screen, air-cooled to 8-10% moisture and passed through a US 60-mesh screen. The material passing through the screen was packaged as potato granules. The procedure is shown in Figure 6.

Samples of whole potato tubers, granules, dry peel, wet peel and chips were analysed. The residue level was <0.01 mg/kg in the whole potato tubers. Malathion residues were detected only in dry peel at a level of 0.06 mg/kg.

Figure 6. Potato processing.



Maize. In a processing study in Texas, malathion was applied at 3 x 7 kg ai/ha (5 times the maximum label rate) and the grain harvested 7 days after the last application. Samples of whole grain, grain dust, grits, meal, flour, crude and refined oil (dry milling and wet milling), B&D oil (dry milling and wet milling) and starch were analysed. Residues of malathion were detected only in grain dust (Table 73).

In a post-harvest trial on maize, the storage bin was treated with 2.4 kg ai/hl of an EC formulation and the grain received 3 applications of a dust formulation during and after bin loading and storage for 59 days. Residues in the processed fractions are shown in Table 73.

Table 73**.** Residues of malathion in maize and processed fractions.

Treatment	Sample analysed	Residues, mg/kg		Processing factor	
		Malathion	Malaoxon	Malathion	Malaoxon
Pre-harvest (Study AA920312)	Grain	<0.01	<0.01	-	-
	Aspirated grain fraction (>2540 µm)	0.99	<0.05	99	-
	Aspirated grain fraction (≤2540 µm)	0.74	<0.05	74	-
Post-harvest (Study No. 41702)	Grain	6.9	0.03	-	-
	Aspirated grain fraction (>2540 µm)	1170	17	170	567
	Aspirated grain fraction (≤2540 µm)	670	7.5	97	250
	Grits	5.2	0.05	0.75	1.7
	Meal	12	0.09	1.7	3
	Flour	14	0.12	2.0	4
	Dry-milled crude oil	31	0.10	4.5	3.3
	Dry-milled refined oil	9.5	<0.01	1.4	<0.33
	Dry milled bleached/deodorized oil	0.11	<0.01	0.016	<0.33
	Wet-milled starch	0.02	<0.01	0.002	<0.33
	Wet-milled crude oil	43	0.10	6.2	3.3
	Wet-milled refined oil	24	<0.01	3.5	<0.33
	Wet-milled bleached/deodorized oil	0.15	<0.01	0.02	<0.33

Rice. In a processing study in Louisiana, malathion was applied at 3 x 7 kg ai/ha (5 times the maximum rate) and grains were harvested 7 days after the last application. Residues of malathion were concentrated by factors of 1.7 in grain dust >2540 µm, 2.5 in dust <2540 µm, and 5.5 in hulls (Table 74).

Table 74. Residues of malathion in rice and processed fractions (Report No. AA9200137).

Sample	Residues, mg/kg		Processing factor	
	Malathion	Malaoxon	Malathion	Malaoxon
Grain	24	0.52	-	-
Polished rice	0.54	<0.01	0.02	<0.02
Hulls	135	2.5	5.5	4.8
Bran	16	0.22	0.67	0.42
Grain dust ≥ 2540	42	0.83	1.7	1.6
Grain dust <2540	62	1.5	2.5	2.9

Wheat. In a processing study in Kansas, malathion was applied at 3 x 7 kg ai/ha (5 times the maximum label rate) and grain was harvested 7 days after the last application. Residues of malathion were concentrated in grain dust by factors of 36 in dust >2540 µm and 56 in dust <2540 µm, and by 2.2 in middlings. In another study with post-harvest treatment, the storage bin was treated with 2.4 kg ai/hl of an EC formulation and the grain with 3 applications of a dust formulation during and after bin loading and after 59 days of storage. Residues were concentrated in the aspired grain fraction, with processing factors of 1.25 and 35 for dust >2540 µm and ≤2540 µm respectively (Table 75).

Table 75. Residues of malathion in wheat and processed fractions.

Sample	Residues, mg/kg		Processing factor	
	Malathion	Malaoxon	Malathion	Malaoxon
Grain (pre-harvest) (Report No. AA9200136)	1.5	0.02	-	-
Bran	0.61	<0.01	0.41	<0.5
Middlings	3.3	0.03	2.2	1.5
Shorts (>240μm)	0.59	<0.01	0.39	<0.5
Patent flour (<132 μm)	0.35	<0.01	0.23	<0.5
Grain dust ≥ 2540	54	0.76	36	38
Grain dust <2540	84	1.2	56	60
Grain (post-harvest) (Report No. 41701)	8.0	<0.01	-	-
Aspirated grain fraction (>2540 μm)	10	<0.05	1.25	-
Aspirated grain fraction (≤2540 μm)	283	0.56	35	56

Cotton. In a processing study in Mississippi, malathion was applied at 25 x 14 kg ai/ha (3.3 times the maximum label rate) and cotton seed was harvested at the day of the last application. Residues of malathion were not concentrated in any of the fractions analysed (Table 76).

Table 76. Residues of malathion in cotton and processed cotton (Report No. AA9200131)

Sample	Residues, mg/kg		Processing factor	
	Malathion	Malaoxon	Malathion	Malaoxon
Seed	330	0.69	-	-
Hulls	255	0.86	0.77	1.24
Meals	23	0.15	0.07	0.22
Crude oil	220	0.30	0.67	0.43
Refined oil	215	0.03	0.65	0.04
Bleached and deodorized oil	2.5	<0.01	0.008	<0.014

RESIDUES IN FOOD IN COMMERCE OR AT CONSUMPTION

The Government of Australia submitted monitoring data from a market basket survey study in 1996 and target enforcement monitoring studies from 1996 to 1998. In the survey study malathion was detected in psyllium husk (maximum 0.02 mg/kg), silverbeet (maximum 0.50 mg/kg) and strawberries (maximum 0.10 mg/kg). In enforcement monitoring, 289 samples of fruits, grain and vegetables were analysed (LOD 0.02 and 0.05 mg/kg). Malathion was detected at half the MRL in one celery sample.

In monitoring by The Netherlands from 1994 to 1996 analysed 19828 samples of 31 fruits, vegetables and cereals. Twelve percent of the samples had detectable residues, with a mean of <0.02 mg/kg.

NATIONAL MAXIMUM RESIDUE LIMITS

The following national MRLs were reported.

Country	Commodity	MRLs, mg/kg
Australia Residue definition: malathion	Wheat bran unprocessed	20
	Beans, lentil, dry, cereal grains, dried fruits, grapes, peanut, tree nuts	8
	Citrus fruits	4
	Kale, tomato	3
	Fruits (except blueberries, citrus fruits, dried fruits, grapes, pear, strawberry), other vegetables	2
	Mammalian edible offal, mammalian, meat fat, eggs, milk fat, poultry fat meat, poultry edible offal, strawberry,	1
	Blueberries, cauliflower, chard (silver beet), egg plant, garden pea, kohlrabi, pear,	0.5

Country	Commodity	MRLs, mg/kg
	peppers, sweet (capsicums), root and tuber vegetables, turnip, garden, chard	
The Netherlands	Bran	20
Residue definition:	Dried fruit, pulses, cereals	8
malathion, including	Other vegetables	3
malaoxon, expressed as	Citrus fruit, whole meal	2
malathion	Other fruit, root and tuber vegetables	0.5
	Tea	0.1
	Other food commodities	0.02
Poland	Cereals grains	8
	Citrus fruit	2
	Fruits except citrus fruits, vegetables	0.5
	Tea	0.1

APPRAISAL

Malathion is an insecticide and acaricide which was originally scheduled for periodic re-evaluation by the 1995 JMPR. The review was postponed by the 1994 CCPR and re-scheduled for periodic re-evaluation of residue aspects in 1999. The manufacturer provided residue data, information on GAP and studies to support existing CXLs. Other data on use patterns, methods of residue analysis, residues in food in commerce or at consumption and national residue limits were provided by the governments of Australia, The Netherlands, Thailand, Poland and the UK.

Metabolism

Studies of metabolism in animals and plants were with [^{14}C]malathion labelled at the 2 and 3 position of the succinate moiety.

In laying hens dosed with the equivalent of 25 ppm in the feed for 4 days, malathion was metabolised within 24 hours. The highest concentration of radioactivity was in the faeces, with a total radioactive residue (TRR) of 14 mg/kg as malathion at day 2. In the egg yolks radioactivity was detected by the fourth day, with a TRR of 0.96 mg/kg. In egg whites the TRR was 0.33 mg/kg on days 1 and 4. The highest concentration of radioactivity in the tissues was in the kidneys and liver (1.08 and 0.77 mg/kg respectively) and the lowest levels were in light and dark muscle (0.11 mg/kg). No malathion or any products of immediate metabolism exceeded 0.05 mg/kg in any of the samples except the white from one egg (day 1), where significant activity from malathion carboxylic acid was detected. This result, however, was attributed to contamination by faeces, which had been shown to contain the metabolite. Incorporation of ^{14}C was found in carboxylic acids, proteins and triglycerides. The extensive metabolism of malathion in hens results in low residues in the eggs and tissues.

In goats dosed with the equivalent of 115 ppm malathion in the diet for five days, the highest concentration of radioactivity was found at day 5, with fat, kidney and liver samples showing 1.42-2.23 as malathion. The TRR in heart and muscle samples ranged from 0.26 to 0.39 mg/kg. Radioactivity in the milk increased from 1.42 mg/kg at day 1 to 2.46 mg/kg at day 4 then decreased to 2.14 mg/kg on day 5. In the kidneys, the monocarboxylic acid was detected at 0.06 mg/kg. No malathion or any immediate metabolites were observed at levels above 0.05 mg/kg in any other sample analysed. [^{14}C]Malathion was found to be a carbon source for the production of triglycerides, which were incorporated in the tricarboxylic acid cycle and lactose. The extensive metabolism of malathion in goats again results in low residues in the milk and tissues

Metabolism studies on rats evaluated by the 1997 JMPR also showed that malathion was rapidly absorbed, biotransformed and excreted within 24 h. Most of the administered dose was recovered in the urine (76-90% of the TRR) and faeces (6.6-14%), with below 1% in the tissues. The main metabolites were malathion monocarboxylic and dicarboxylic acids .

Plant metabolism studies on cotton, wheat, alfalfa and lettuce showed that the metabolism of malathion in plants proceeds via malathion dicarboxylic acid to succinic acid which is incorporated into plant constituents such as starch, proteins, pectin, lignin, hemicellulose and cellulose.

Cotton plants were treated at 1.46 kg ai/ha and leaves and mature and immature bolls collected approximately 18 h after the last application. The TRR in immature bolls, lint and gin trash was 55.6, 217 and 428 mg/kg malathion equivalents respectively. The main component identified in organic solvent extracts of the seed was malathion, representing 33% of the total radioactive residue (49.4 mg/kg). Malathion monocarboxylic acid and malaoxon were at 2.6% and 0.2% of the total radioactivity in the residue respectively. Polar extracts contained 12.9% of the TRR of which 9.6% was characterized, with succinate the main component (2.0% of the TRR). Approximately 67% of the radioactivity was recovered in the experiment.

In wheat plants treated three times at 1.68-1.8 kg ai/ha, malathion was the main component of the organic solvent extracts, representing 13%, 27% and 11% of the TRR in forage, grain and straw respectively. Malathion monocarboxylic acid (6% of the TRR in forage 0.5% in grain, 7.3% in straw) and malathion dicarboxylic acid (4.9% of the TRR in forage, 1.1% in grain and 0.1% in straw) were the main metabolites. Malaoxon was present at low levels (<0.01-0.4% of the TRR). From 82 to 89% of the radioactivity was recovered from each wheat fraction.

When alfalfa plants were treated twice with malathion at 2.0-2.1 kg ai/ha, samples harvested 18 h after the last application contained malathion as the main residue (42% of the TRR in forage and 16.4% in hay), followed by malathion monocarboxylic acid (9.8% and 2.7% in forage and hay) and malaoxon (0.8% of the TRR in hay). More than 80% of the radioactivity was recovered in the experiment.

Malathion was applied at 6 x 2.0 kg ai/ha to lettuce and the plants were harvested 14 days after the last treatment. Malathion represented 36.8%, malathion monocarboxylic acid 12.8% and malaoxon 1.2% of the total radioactivity in the residue. Aqueous extracts contained 44% of the TRR and organic extracts 58% of the TRR.

In summary, the metabolism of malathion in animals and plants is qualitatively similar. Malathion is hydrolysed to mono and dicarboxylic acids and these metabolites are further degraded and incorporated into animal and plant constituents. A major quantitative difference is that no parent compound or primary metabolite was detected in animal tissues, eggs or milk, whereas in plants malathion was the main residue with up to 12.8% of the TRR representing its monocarboxylic acid metabolite.

Environmental fate

All the studies were with malathion labelled at the 2 and 3 positions of the succinate moiety.

Adsorption/desorption

Malathion was adsorbed in moderate amounts by sandy loam, sand, loam and silt loam soils with K_d varying from 0.83 to 2.47 and K_{oc} from 151 to 308. Adsorption generally increased as soil organic matter, clay content and cation exchange capacity increased. The ß-substituted monocarboxilic acid was the main degradation product representing 0.1 to 8.6% of the TRR in adsorption solutions and 0.3 to 9% of the TRR in desorption solutions. The experiment lasted approximately 3 h and the samples

were flushed with nitrogen initially. Malathion was fairly stable under the experimental conditions, accounting for 74.2 to 98.6% of the TRR.

When [^{14}C]malathion was applied to 2 non-sterile soils at 6.88-8.86 mg/kg dry weight kept in the dark at 22 °C, the half life was 4.9 h. After 1 day malathion represented on average 2.6% of the TRR. The main extractable product was malathion dicarboxylic acid (13.8 and 1.1% of the TRR after 6 h and 4 days respectively). Bound residues and $^{14}CO_2$ represented >50% of the TRR at day 7. Dissipation of ^{14}C residues by volatilization was insignificant. No degradation of malathion was observed after 4 days in the sterile control sample.

A study of aerobic and anaerobic degradation of malathion on a loamy sand soil was conducted at 25°C in the dark. The main degradation products in both systems were malathion dicarboxylic acid (up to 62.3% of the TRR on day 7 under aerobic conditions), $^{14}CO_2$, and bound residues. Malathion was degraded with a half-life of 1 day under aerobic conditions and <30 days under anaerobic conditions.

The dissipation of malathion was studied in bare soil and in a cotton field after six applications at 1.13 kg ai/ha. No residues were found below a 30 cm depth in the crop plot or below 15 cm in the bare ground plot. Malathion was not detected in any soil samples later than one day after the last application (up to 0.14 mg/kg dry weight). Malathion dicarboxylic acid was detected in only two samples (at 0.11 mg/kg in bare soil one day after the last application and at 0.016 mg/kg in the cotton plot after the second application). No malaoxon was detected in any sample analysed (<0.01 mg/kg).

Photodegradation does not appear to be a major mechanism of degradation of malathion. In a study with sandy loam fortified on the surface with 10 mg/kg [^{14}C]malathion and kept at 25°C under a 12-hour light/12-hour dark cycle over a 30-day period, the rate constant and extrapolated half-life of malathion were 0.00399 day^{-1} and 173 days respectively. A shorter half-life of 63.5 days found in the control sample (24 h dark) is believed to be a result of increased microbial activity.

The leaching potential of [^{14}C]malathion and its degradation products was evaluated in 4 types of soil aged for approximately one half-life (14.3, 2.1, 0.5 and 0.9 h for sand, sandy loam, loam and silty clay respectively). Two flasks of each soil were sampled after dosing, two at the ageing period and two mixed thoroughly and added to the top of replicate columns containing untreated soil of each type. Five to 74.4% of the radioactivity was found in the leachate. Malathion was found to leach only from the sand column (1.9% of the TRR). The dicarboxylic acid was the main compound, with up to 47.5% of the TRR in the leachates, followed by the monocarboxylic acid (0.1 to 13.3% of the TRR).

The volatility of malathion was evaluated in a silt loam soil spiked with the “Ready to use”, ULV and EC formulations at the recommended field rate, with air flows of 100 and 300 ml/min and 50% and 75% soil field capacity. Volatile ^{14}C was found only with the EC formulation (50% soil moisture and 100 ml/min), where 26.5% of the applied dose was recovered as CO_2.

The aquatic degradation of malathion in a water/sediment system fortified with 1.108-1.02 mg/kg was evaluated under aerobic and anaerobic conditions at 22°C in the dark. The two monocarboxylic acids, demethyl-monocarboxylic acids, dicarboxylic acid and demethyl-dicarboxylic acid were mainly associated with the water, with maximum concentrations from 20.9 to 46.4% of the TRR. In the sediment the concentrations ranged from 3.6 to 8.1%. Dissipation by volatilization was minimal, with <0.5 and <0.1% of the TRR in aerobic and anaerobic conditions respectively. Half-lives of malathion in water and sediment in aerobic conditions were 1.09 and 2.55 days respectively and in anaerobic conditions 2.49 and 2.45 days.

Analytical methods for malathion and malaoxon in plants and processed commodities were submitted by the manufacturer. The analytes are extracted with acetonitrile and acetonitrile/water (80:20), the organic extract is cleaned up on activated carbon and silica gel extraction cartridges and the analytes are quantified by gas chromatography with a flame photometric detector in the phosphorus mode. Recoveries of malathion and malaoxon averaged 89.6% and 98.2% respectively. The LOD is 0.01 mg/kg for all raw and processed human food analysed and 0.05 mg/kg for raw and processed animal feed. For dry samples a hydration step is included before the extraction. Lipids are removed from the extracts with hexanes and the analytes are partitioned 3 times with dichloromethane.

In a multi-residue method reported by The Netherlands for non-fatty samples, no clean-up is necessary and the analytes are determined by GLC with an NPD or ion-trap detector. The LOD for both malathion and malaoxon is 0.02 mg/kg. In an Australian method for organophosphorus insecticides, clean-up was by gel-permeation chromatography and dialysis from a semi-permeable membrane followed by alumina column. The analytes are determined by GLC with an NPD or FPD with an LOD of 0.01 and 0.02 mg/kg.

The stability of residues in stored analytical samples was determined in various raw and processed agricultural commodities. Duplicate samples were fortified with 0.50 mg/kg malathion and malaoxon and stored at <-5°C for 12 months. The analytes were stable for 12 months, with 69 to 105% of malathion and 91 to 109% of malaoxon remaining at the end of the study.

Definition of the residue

In plants, malathion was the main residue. The highest metabolite concentration (monocarboxylic acid) was 13% of the labelled residue. This metabolite is rapidly metabolized further in animals. The Meeting agreed that the residue should be defined as malathion *per se* for compliance with MRLs and for the estimation of dietary intake.

Residues resulting from supervised trials

All the trials were in the USA during the years 1990 to 1997.

Oranges. In six trials in California and Florida with ground applications of EC formulations below the maximum GAP for citrus (28.4 kg ai/ha), residues of malathion at 7 days PHI varied from 0.42 to 1.9 mg/kg. Eight other trials with ULV formulations with aerial and ground application at the proposed or higher rates gave residues ranging from <0.01 to 2.9 mg/kg.

As no data from trials at the maximum GAP rate were reported the Meeting could not recommend an MRL for oranges and as no data were reported for other citrus fruits, the Meeting recommended withdrawal of the existing MRL.

Apples. In three trials in Tennessee, California and Michigan below the maximum GAP rate (20 kg ai/ha), residues at 3 days PHI varied from 0.05 to 2.6 mg/kg. Three other trials at shorter PHIs or higher rates showed residues ranging from 0.19 to 2.5 mg/kg and as no data from trials at the maximum GAP rate were reported, the Meeting recommended withdrawal of the existing MRL.

Pears. In three trials below maximum GAP rate (20 kg ai/ha) in California, New York and Washington, residues at a PHI of 1 day were 0.34 to 1.9 mg/kg. As there were no trials at the maximum GAP rate, the Meeting recommended withdrawal of the existing MRL for pears.

Cherries. In one trial on sweet cherries in California with ground application at maximum GAP (10 kg ai/ha, 3 days PHI), the residues were 1.8 mg/kg. Other trials with ground application at a lower rate gave residues ranging from 0.26 to 2.6 mg/kg. In another six trials in California, Oregon, Michigan, Montana and New York with aerial ULV application at the GAP rate (1.0-1.3 kg ai/ha, 1-day PHI), the residues were 0.02, 0.03, 0.08, 0.17, 0.34 and 0.47 mg/kg.

It is clear that ground application gives higher residues than aerial application, even when the application rate is not the maximum allowed by GAP.

The Meeting concluded that insufficient data from trials with ground application at the maximum GAP rate had been reported and recommended withdrawal of the existing MRL for cherries.

Apricots and peaches. In one trial on apricots and four on peaches in New Jersey, Michigan, California and Georgia with 4-5 applications of 4.2 kg ai/ha, residues after 6 or 7 days varied from 0.16 to 1.4 mg/kg. GAP rate for these commodities is 1.6 to 12 kg ai/ha. As no data from trials at the maximum GAP rate were reported, the Meeting could not recommend an MRL for apricot and recommended withdrawal of the existing MRL for peaches.

Grapes. In six trials in California, Washington and New York at 2.1 kg ai/ha (the GAP rate is 2.3-3.1 kg ai/ha), residues at a PHI of 3 days ranged from 0.33 to 2.7 mg/kg. As no data from trials at the maximum GAP rate were reported, the Meeting recommended withdrawal of the existing MRL for grapes.

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Strawberries. In seven trials in Pennsylvania, Oregon, California and Florida with EC or WP formulations within the range of EC GAP rates (1.2-2.7 kg ai/ha), residues at 3 days PHI were 0.09, 0.16, 0.19, 0.25, 0.39, 0.53 and 0.59 mg/kg.

The Meeting estimated a maximum residue level of 1 mg/kg, the same as the previous MRL, and an STMR of 0.25 mg/kg for strawberries.

Blueberries. In seven trials in Michigan, Oregon and Maine, with ground applications of EC formulations at 0.75 and 1.4 kg ai/ha (GAP 1.7-2.8 kg ai/ha), residues at a 1-day PHI varied from 0.26 to 7.1 mg/kg. In another four trials with aerial applications of a ULV formulation close to the GAP rate (0.8 kg ai/ha) residues at a 0-day PHI were 0.06, 0.55, 4.0 and 7.5 mg/kg.

The Meeting estimated a maximum residue level of 10 mg/kg and an STMR of 2.27 mg/kg for blueberry.

Blackberries and raspberries. In six trials in California and Oregon on blackberries and four in Washington on raspberries with WP and EC formulations within the EC GAP range at 2.1-2.27 kg ai/ha (GAP is 1.3-4.6 kg ai/ha), residues at 1 day varied from 1.3 to 11 mg/kg.

As no data from trials at the maximum GAP rate were reported, the Meeting recommended withdrawal of the existing MRLs for blackberries and raspberries.

Avocado. In two trials in California at 5.3 kg ai/ha (GAP rate is 5.4-12 kg ai/ha), residues were 0.07 and 0.08 mg/kg at 7 days PHI. As no data from trials at the maximum GAP rate were reported, the Meeting could not estimate a maximum residue level for avocado.

Figs. In two trials in California within the GAP range (2.7–3.3 kg ai/ha) samples harvested at a longer PHI than the proposed GAP interval contained malathion residues of 0.32 and 0.36 mg/kg. As no trials were conducted according to GAP, the Meeting could not estimate a maximum residue level or an STMR.

Guavas. Three trials in Hawaii and Florida were at a higher rate than the proposed GAP (1.0 kg ai/ha, 2 days PHI). Malathion residues 1 or 2 days after the last application were 0.10, 0.24 and 0.30 mg/kg. As no trials were according to GAP, the Meeting could not estimate a maximum residue level or an STMR.

Mangoes and sugar apples. In one trial on each in Florida at the proposed GAP rate for mangoes (1.4-11.2 kg ai/ha) the residues were 0.31 mg/kg at 3 days and 0.07 mg/kg at 1 day. As no trials were according to approved GAP, the Meeting could not estimate a maximum residue level or an STMR.

Papayas. In three trials in Hawaii and Florida according to the proposed GAP (1.4-14 kg ai/ha), malathion residues (PHI 1 day) ranged from <0.05 to 0.56 mg/kg. As no trials were according to approved GAP, the Meeting could not estimate a maximum residue level.

Onions. In six trials on bulb onions and six on green onions in California, Oregon, New York, Texas and Nebraska within the GAP range (1.2-2.4 kg ai/ha), residues of malathion at 3 days PHI were 0.02, 0.08, 0.11, 0.35, 0.37 and 0.59 mg/kg in bulb onions and 0.18, 0.19, 0.35, 0.69, 2.5, 5.0 mg/kg in green onions.

The Meeting estimated a maximum residue level of 1 mg/kg and an STMR of 0.23 mg/kg for bulb onions and a maximum residue level of 5 mg/kg and an STMR of 0.52 mg/kg for green onions,

Broccoli. In five trials in New York, Tennessee, Washington and California at 1.4 kg ai/ha (GAP is 0.1-3.4 kg ai/ha)), the residues at 3-5 days PHI varied from 0.02 to 9.3 mg/kg. As no trials were at the maximum GAP rate, the Meeting recommended withdrawal of the existing MRL for broccoli.

Cabbage. In fourteen trials on head cabbages in Wisconsin, Ohio, New York, Florida, Washington, California, Indiana and Texas at 1.4 kg ai/ha (GAP is 0.1-3.4 kg ai/ha), samples with or without the wrapper leaves at 7 days PHI had malathion residues of <0.05 (13) and 0.10 mg/kg. As no trials were at the maximum GAP rate, the Meeting could not estimate a maximum residue level.

Cucumbers. Nine trials were conducted in Florida, New Jersey, Texas, North Carolina, California and Michigan. GAP allows up to 1.6 kg ai/ha with PHI of 1 day and up to 2.3 kg ai/ha with PHI of 3 days. Trials carried out at 2.1 kg ai/ha gave residues at a PHI of 1 day of <0.01, 0.01, 0.02 (3), 0.03 (2), 0.06 and 0.10 mg/kg.

The Meeting estimated a maximum residue level of 0.2 mg/kg and an STMR of 0.02 mg/kg.

Cantaloupes and watermelons. In two trials on cantaloupes and one trial on watermelons in Georgia, California and Texas at 6 x 1.12 kg ai/ha (GAP for melons is 1.2-2.3 kg ai/ha), residues at a 1-day PHI were <0.05 (2) and 0.80 mg/kg. As there were so few trials and none was at maximum GAP, the Meeting could not estimate a maximum residue level or STMR.

Mushrooms. In one trial in Pennsylvania at the GAP rate of 4 x 1.9 kg ai/ha, malathion residues were <0.05 mg/kg at a PHI of 1 day. There were insufficient data from trials according to GAP to estimate a maximum residue level or an STMR.

Peppers. In seven trials in New Jersey, Florida, North Carolina, California, Michigan and Texas close to maximum GAP (2.0 kg ai/ha), malathion residues at 3 days PHI were ≤0.01 (4), 0.02, 0.05 and 0.08 mg/kg. The Meeting estimated a maximum residue level of 0.1 mg/kg and an STMR of 0.01 mg/kg.

Tomatoes. The maximum GAP for tomatoes in the USA is 2.3 kg ai/ha with a PHI of 1 day and up to 4.9 kg ai/ha with a PHI of 5 days. In seven trials in New Jersey, Florida, Michigan and California at 1.74 kg ai/ha, malathion residues at a 1 day PHI were 0.10, 0.14, 0.17, 0.21, 0.27, 0.33 and 0.41

mg/kg. In seven other trials at 3.84 kg ai/ha, residues varied from 0.13 to 1.2 mg/kg 3 days after application. These trials did not comply with GAP and were not used for evaluation.

The Meeting estimated a maximum residue level of 0.5 mg/kg and an STMR of 0.21 mg/kg.

Sweet corn. In six trials in Wisconsin, Washington, Montana, California, Florida and New York with ground applications of an EC formulation close to the maximum GAP rate (1.6 kg ai/ha) residues in the kernels + cobs at 5 days PHI were <0.01 (5) and 0.02 mg/kg. In six trials with aerial application of a ULV formulation the residues were <0.01 mg/kg. There is no approved use of aerial application on sweet corn in the USA.

The Meeting estimated a maximum residue level of 0.02 mg/kg and an STMR of 0.01 mg/kg for sweet corn (grain).

The residues in the forage from the 12 trials were also determined. Those from the ground applications are evaluated with the residues in field corn (maize) forage.

Okra. In two trials in South Carolina and Texas within the GAP range (1.2-2.0 kg ai/ha), malathion residues at a 1-day PHI were <0.05 and 2.1 mg/kg.

There were insufficient data to estimate a maximum residue level or an STMR.

Lettuce. In two trials in California on leaf lettuce according to GAP (1.6-2.7 kg ai/ha), the residues at a PHI of 14 days were 0.99 and 3.1 mg/kg. In four other trials at the same rate in New Jersey, Florida, Washington and Arizona, wrapper leaves were removed from the samples before analysis. In 3 trials in California on head lettuce at the same rate, residues ranged from 0.01 to 0.17 mg/kg after 14 days.

The Meeting concluded that there were insufficient data from trials according to GAP to estimate a maximum residue level for leaf lettuce. As there were no trails according to GAP on head lettuce the Meeting recommended withdrawal of the existing MRL.

Mustard greens. In seven trials in South Carolina, North Carolina, Indiana, Washington, California, Georgia, Texas and Arizona according to GAP (0.8-1.6 kg ai/ha), malathion residues at 7 days PHI were <0.05 (2), 0.07 (2), 0.46, 0.52 and 1.1 mg/kg. In seven other trials conducted at nearly twice the higher GAP rate the residues ranged from <0.05 to 5.9 mg/kg.

The Meeting estimated a maximum residue level of 2 mg/kg and an STMR of 0.07 mg/kg.

Spinach. In five trials in New Jersey, Texas, South Carolina, Washington and California within the GAP range (1.3-2.7 kg ai/ha.), malathion residues at a PHI of 7 days were <0.05, 0.16, 0.35, 1.1 and 2.2 mg/kg. One trial under the same conditions gave a residue of 36 mg/kg. As all the other residues in spinach and other leafy vegetables were in a much lower range, this value was not considered for estimation.

The Meeting estimated a maximum residue level of 3 mg/kg and an STMR of 0.35 mg/kg.

Watercress. In three trials in Florida and Hawaii at 0.5 and 1.4 kg ai/ha (GAP is 1.3-2.7 kg ai/ha), residues of malathion were <0.05 mg/kg in samples taken after 7 days. As there were no trials at maximum GAP, the Meeting could not estimate a maximum residue level.

Beans. Five trials were conducted on lima beans in Wisconsin, Florida, Pennsylvania, North Carolina and California, and five on snap beans in Wisconsin, Oregon and New York with aerial applications according to GAP (0.7 kg ai/ha). At a PHI of 1 day, the residues were <0.01, 0.05, 0.12, 0.13, 0.21, 0.41, 0.49, 0.56, 0.71 and 0.90 mg/kg.

The Meeting estimated a maximum residue level of 1 mg/kg and an STMR of 0.31 mg/kg for beans, except broad beans and soya beans. The Meeting also recommended withdrawal of the existing MRL of 2 mg/kg for common beans.

Peas. In two trials in California and Wisconsin close to the maximum GAP rate (3.3 kg ai/ha) malathion residues at 3 days were 0.38 and 0.96 mg/kg in peas with pods and 2.9 and 32 mg/kg in dry forage. One other trial gave residues of 0.34 mg/kg in peas with pods 2 days after the last application.

The Meeting concluded that there were too few trials according to GAP and recommended withdrawal of the existing MRL.

Beans, dry. In ten trials in Michigan, California, Idaho, New York and Nebraska with aerial applications according to GAP (0.7 kg ai/ha), malathion residues at 1 day were 0.07, 0.10 (2), 0.16, 0.36, 0.39, 0.42, 0.62 and 1.2 mg/kg.

The Meeting noted that the existing MRL was based on post-harvest treatment and estimated a maximum residue level of 2 mg/kg and an STMR of 0.36 mg/g for dry beans.

Potatoes. In fifteen trials in Idaho, Maine, Florida, Wisconsin and Nebraska at 2 x 1.74 kg ai/ha (GAP is 0.8-3.3 kg ai/ha), malathion residues at day 0 were <0.01(14) and 0.02 mg/kg. As no data from trials at the maximum GAP rate were reported, the Meeting could not recommended a maximum residue level.

Turnips. In six trials in Georgia, Indiana, Ohio, California, South Carolina, Washington and Texas near the maximum GAP rate (1.6 kg ai/ha), malathion residues in the tops at 7 days were <0.05 (2), 0.99, 1.4, 1.8 and 3.4 mg/kg, and in the roots ≤0.05 (4), 0.09 and 0.13 mg/kg. In one trial at the higher rate, residues in the tops were 15 and 10 mg/kg and in the roots 0.11 mg/kg.

The Meeting estimated a maximum residue level of 0.2 mg/kg and an STMR of 0.05 mg/kg for turnip roots, and a maximum residue level of 5 mg/kg and an STMR of 1.195 mg/kg for turnip tops.

Carrots. In six trials in Wisconsin, New Jersey, Florida, Washington, California and Texas at 1.4 kg ai/ha (GAP is 1.2-2.4 kg ai/ha) residues ranged from <0.05 to 0.54 mg/kg after 7 days. As no data from trials at the maximum GAP rate were reported, the Meeting could not estimate a maximum residue level.

Celery. In two trials in Florida and California within the GAP range (1.2-2.0 kg ai/ha), residues at 7 days were 0.91 and 1.2 mg/kg. There were insufficient data from trials according to GAP reported and the Meeting recommended withdrawal of the existing MRL.

Asparagus. In four trials in California, New Jersey, Washington and Wisconsin close to maximum GAP (1.7 kg ai/ha), residues at 1 day were 0.10, 0.13, 0.48 and 0.69 mg/kg.

The Meeting estimated a maximum residue level of 1 mg/kg and an STMR of 0.305 mg/kg.

Wheat. Twenty trials were conducted in Oklahoma, Kansas, Ohio, Washington, North Dakota and Montana on winter and spring wheat according to GAP with either ground application of an EC formulation (GAP is 1.2-1.7 kg ai/ha) or aerial application of a ULV formulation (GAP is 0.3-0.7 kg ai/ha). The residues at a PHI of 7 days in grain from the trials with ground applications were <0.01, 0.02, 0.03, 0.04 (3), 0.08, 0.10 and 0.14 mg/kg and from trials with aerial applications <0.01 (2), 0.03, 0.04 (2), 0.08, 0.09, 0.10, 0.20, 0.22 and 0.28 mg/kg. The residues from the two applications

constitute a single population with residues of <0.01 (3), 0.02, 0.03 (2), 0.04 (5), 0.08 (2), 0.09, 0.10(2), 0.14, 0.20, 0.22 and 0.28 mg/kg.

In a single trial with post-harvest application of dust formulation according to GAP, the residue in the grain after 59 days of storage was 7.5 mg/kg. This trial was not considered in the estimation as one trial in not enough to reflect residues from post-harvest applications.

The Meeting estimated a maximum residue level of 0.5 mg/kg and an STMR of 0.04 mg/kg for wheat grain.

In forage the residues on a fresh weight basis from ground applications were <0.05 (9) and 0.09 mg/kg and from aerial application <0.05, 0.19, 0.23, 0.27, 0.49, 1.3, 1.8, 1.9, 2.3 and 2.4 mg/kg. The two residue populations are distinct so the higher residues from the aerial applications were used for estimation. The range of the moisture contents of the analysed samples was stated to be 70-85%, with a mean of 78.4%. Applying this value to the median and highest residues from aerial application (0.895 and 2.4 mg/kg respectively) gives values on a dry weight basis of 4.14 and 11 mg/kg.

The Meeting estimated a maximum residue level of 20 mg/kg and an STMR of 4.14 mg/kg for wheat forage.

In straw the residues from ground applications were <0.05, 0.66, 0.68, 0.81, 1.6, 2.2, 2.5, 3.2, 3.8 and 9.4 mg/kg, and from aerial applications 1.0, 1.4, 3.2, 5.1, 6.5, 7.2, 8.4, 12, 18 and 34 mg/kg. As in forage, the residues in straw were higher from ground applications and were used for estimation. The Meeting estimated a maximum residue level of 50 mg/kg and an STMR of 6.85 mg/kg for wheat straw (fodder).

Sorghum. In four trials in Texas and Nebraska with ground applications of EC formulations close to the GAP rate (1.2 kg ai/ha) the residues in the grain at 7 days PHI were 0.02, 0.07, 0.12 and 0.49 mg/kg. In four other trials with aerial applications of a ULV formulation according to GAP (0.7-1.0 kg ai/ha) residues were 0.13, 0.34, 2.0 and 2.2 mg/kg at 7 days. The residues from both modes of application, considered to be a single population, were 0.02, 0.07, 0.12, 0.13, 0.34, 0.49, 2.0 and 2.2 mg/kg.

The Meeting estimated a maximum residue level of 3 mg/kg and an STMR of 0.235 mg/kg for sorghum (grain).

Maize. Twenty one trials on field corn in Indiana, Illinois, Nebraska, Ohio, Texas and Wisconsin at GAP rate were with either ground applications of EC formulations (GAP is 1.2-1.6 kg ai/ha, 5 days PHI) or aerial applications of ULV formulations (GAP is 0.266-0.533 kg ai/ha, 5 days PHI). In the grain the residues 7 days after the last application from the ground trials were <0.01 (5), 0.01, 0.02 (3) mg/kg and from the aerial trials <0.01 (11) and 0.02 mg/kg. The residues from both applications form a single population with the rank order ≤0.01 (16), 0.01, 0.02 (4) mg/kg.

In a post-harvest trial according to GAP the residue in the grain after 60 days of storage was 6.9 mg/kg. This trial was not considered in the estimation as one result is not enough to reflect residues from post-harvest applications.

The Meeting estimated a maximum residue level of 0.05 mg/kg and an STMR of 0.01 mg/kg for maize (grain).

The residues in the forage from the ground applications were <0.05 (7), 0.12 and 0.19 mg/kg and from the aerial applications <0.05, 0.06, 0.07, 0.09 (2), 0.15, 0.24, 0.34, 0.22, 0.25, 0.76 and 1.2 mg/kg. The residues in the sweet corn forage from ground applications according to GAP were <0.05 (2), 0.20, 0.33, 1.7 and 2.4 mg/kg. The three populations can be combined, giving residues in rank

order of <0.05 (10), 0.06, 0.07, 0.09 (2), 0.12, 0.15, 0.19, 0.20, 0.22, 0.24, 0.25, 0.33, 0.34, 0.76, 1.2, 1.7 and 2.4 mg/kg. Applying a moisture content of 56% (specified for sweet corn and corn forage in the FAO Manual) to the median and the highest residues in the three populations (0.09 and 2.4 mg/kg respectively) gives values on a dry weight basis of 0.20 and 5.4 mg/kg respectively.

The Meeting estimated a maximum residue level of 10 mg/kg and an STMR of 0.20 mg/kg for maize forage.

In straw, the residues from ground applications were 1.3, 1.8, 2.3, 3.2, 3.4, 4.5, 4.6, 4.7, 11 and 13 mg/kg and from aerial applications 1.4, 5.0, 6.6, 6.7, 6.9, 8.0, 11, 12 (2), 19, 22, 24 mg/kg. The two applications give the single population of residues in rank order 1.3, 1.4, 1.8, 2.3, 3.2, 3.4, 4.5, 4.6, 4.7, 5.0, 6.6, 6.7, 6.9, 8.0, 11 (2), 12 (2), 13, 19, 22 and 24 mg/kg.

The Meeting estimated a maximum residue level of 50 mg/kg and an STMR of 6.65 mg/kg for maize fodder.

Nuts. In two trials in Florida on chestnuts close to the maximum GAP rate (6.8 kg ai/ha), the residues at 2 days were 0.08 and 0.58 mg/kg. In two trials on macadamia nuts in Hawaii far below maximum GAP rate (16.7 kg ai/ha) the residues were <0.05 mg/kg at 1 day. In two trials on walnuts in California near the maximum GAP rate (3.14 kg ai/ha), no residues were detected at 7 days. For the three uses on nuts the labels state that application may be at the time of harvest.

As the data from trials at the maximum GAP rate were limited, the Meeting could not estimate a maximum residue level for malathion in chestnuts, macadamia nuts or walnuts, and recommended the withdrawal of the existing MRL for tree nuts.

Cotton. Seventeen trials were conducted in Texas, Arizona, California and Louisiana according to GAP with either ground applications of EC formulations (GAP is 0.4-3.14 kg ai/ha) or air applications of ULV and Ready-to-use formulations (ULV GAP is 0.3-1.4 kg ai/ha). The residues in the cotton seed at a 0-day PHI from EC formulations were 3.0, 3.8, 4.1, 7.1, 7.8 and 14 mg/kg, and from Ready-to-use formulations 2.3, 4.2, 4.3, 4.8, 4.9 and 5.4 mg/kg and from ULV formulations 2.1, 2.7, 5.4, 5.9 and 6.4 mg/kg. The residues from the three formulations, which constitute a single population, were 2.1, 2.3, 2.7, 3.0, 3.8, 4.1, 4.2, 4.7, 4.8, 4.9, 5.4 (2), 5.9, 6.4, 7.1, 7.8 and 14 mg/kg.

The Meeting estimated a maximum residue level of 20 mg/kg and an STMR of 4.8 mg/kg for cotton seed.

Flax. In one trial in Nevada at a proposed GAP rate of 1 x 0.56 kg ai/ha, no residues were found in samples of straw, seed or meal after 52 days (the LOD is 0.05 mg/kg). There were insufficient data to estimate a maximum residue level or an STMR for flax.

Mint. In three trials on peppermint and spearmint in Wisconsin and Idaho below the maximum GAP rate (1.6 kg ai/ha), the residues in fresh mint at a PHI of 7 days were 0.51, 1.2 and 1.4 mg/kg and in mint oil 5.7, 8.0 and 9.1 mg/kg. In four trials at about 3 times the maximum GAP the residues were 13-56 mg/kg in fresh mint and 140-460 mg/kg in oil.

As there were no trials at the maximum GAP rate, the Meeting could not estimate a maximum residue level for mint.

Clover. Twenty six trials were conducted in Wisconsin, Michigan, Idaho, Oklahoma, Georgia, New York and Minnesota with either ground application of an EC formulation at 1.4 kg ai/ha (GAP is 1.2-1.6 kg ai/ha) or aerial application of a ULV formulation at 0.68 kg ai/ha (GAP is 0.7-1.0 kg ai/ha). Two applications were made before each cutting (up to 3 cuts) and each cut was considered to be one trial. Samples were taken after 0 to 14 days (GAP allows application at harvest).

The residues in the forage at day 0 from trials with the EC formulation were 14, 17, 18, 31, 20, 37, 39, 40, 57, 71, 73, 88 and 95 mg/kg, and from trials with the ULV formulation 2.8, 3.2, 8.7, 9.5, 14, 16, 25, 33, 38, 39, 46, 56 and 60 mg/kg. The residues from the two modes of application constitute one population with residues of 2.8, 3.2, 8.7, 9.5, 14 (2), 16, 17, 18, 20, 25, 31, 33, 37, 38, 39 (2), 40, 46, 56, 57, 60, 71, 73, 88 and 95 mg/kg. The range of moisture contents of the analysed sample was stated to be 71-85%, with a mean of 81%. Applying this value to the median and highest residues (32 and 95 mg/kg respectively) gives values on a dry weight basis of 168 and 500 mg/kg.

The Meeting estimated a maximum residue level of 500 mg/kg and an STMR of 168 mg/kg for clover forage.

In hay, the residues from foliar applications were 9.2, 9.7, 16, 21, 34, 35, 36, 53, 64, 86 90 and 120 mg/kg, and from aerial applications 4.4, 5.0, 12, 15, 18, 19, 20, 26, 33, 49, 58, 90, 93 and 98 mg/kg. These formed a single population with residues of 4.4, 5.0, 9.2, 9.7, 12, 15, 16, 18, 19, 20, 21, 26, 33, 34, 35, 36, 49, 53, 58, 64, 86, 90 (2), 93, 98 and 120 mg/kg.

The Meeting estimated a maximum residue level of 150 mg/kg and an STMR of 33.5 mg/kg for clover hay.

Alfalfa. Two series of eleven trials each were conducted in Pennsylvania, Wisconsin, Michigan, South Dakota, Iowa, Washington, California, Minnesota, Idaho and Nebraska either with ground application of 1.4 kg ai/ha of an EC formulation (GAP is 1.2-1.96 kg ai/ha) or aerial application of 0.68 kg ai/ha of an ULV formulation (GAP is 0.5-1.1 kg ai/ha). Two applications were made before each cutting (up to 3 cuts) and samples were taken after 0 to 14 days (GAP allows application at harvest).

Malathion residues in forage at day 0 from trials with the EC formulation were 19, 22, 23, 28, 29, 34, 35, 37, 40, 42, 45, 45, 47, 51 (2), 53, 54, 60, 64, 65, 68, 70, 81, 92, 95 and 98 mg/kg, and from aerial application 0.99, 1.8, 4.5, 5.2, 5.7, 8.7, 9.0, 9.7, 10, 12, 17, 20, 21, 22, (3), 23, 25, 29, 32, 36, 38, 41, 43, 72 and 95 mg/kg, forming a single population with residues of 0.99, 1.8, 4.5, 5.2, 5.7, 8.7, 9.0, 9.7, 10, 12, 17, 19, 20, 21, 22 (4), 23 (2), 25, 28, 29 (2), 32, 34, 35, 36, 37, 38, 40, 41, 42, 43, 45, 46, 47, 51 (2), 53, 54, 60, 64, 65, 68, 70, 72, 81, 92, 95 (2) and 98 mg/kg. The Meeting was informed that the moisture contents of the forage samples varied from 71-85%, with a mean of 78%. This value was used to calculate the median and highest residues in forage on a dry weight basis: 157 and 445 mg/kg.

The Meeting estimated a maximum residue level of 500 mg/kg and an STMR of 157 mg/kg for alfalfa forage (dry weight).

In hay, the residues at day 0 after EC treatment were 1.5, 2.0, 3.2, 3.9, 6.1, 6.5, 7.7, 11, 16, 17 (2), 20 (2), 27, 43, 46, 52, 85, 140 and 175 mg/kg and after aerial treatment 2.1 (2), 2.8, 2.9, 3.3, 3.5, 4.4, 4.6, 5.6, 6.2, 8.6, 9.7, 12, 14, 19, 20, 21, 25, 26 (2), 33, 38, 45, 52, 56, 67 and 135 mg/kg, forming a single population with residues of 1.5, 2.0, 2.1 (2), 2.8, 2.9, 3.2, 3.3, 3.5, 3.9, 4.4, 4.6, 5.6, 6.1, 6.2, 6.5, 7.7, 8.6, 9.7, 11, 12, 14, 16, 17 (2), 19, 20 (3), 21, 25, 26 (2), 33, 38, 43, 45, 46, 52 (2), 56, 67, 85, 135, 140 and 175 mg/kg.

The Meeting estimated a maximum residue level of 200 mg/kg and an STMR of 17 mg/kg for alfalfa fodder (hay).

Grasses. Twenty trials in Montana, Virginia, Oklahoma, South Dakota, Kansas, Tennessee, Arkansas, Pennsylvania, Kentucky and New York were with either ground application of an EC formulation (GAP is 1.2-1.6 kg ai/ha) or aerial application of a ULV formulation (GAP is 0.5-0.8 kg ai/ha). The residues at day 0 (GAP allows application at harvest) in grass forage were 2.0, 19, 10, 22, 25, 29, 30,

34, 38, 44, 55, 68 (2), 72, 74, 75, 80, 83, 130 and 190 mg/kg and in hay 1.9, 4.0, 6.0, 24, 27, 30, 33, 34, 36, 42, 46, 54, 55, 58, 61, 66, 68, 100, 130 and 260 mg/kg.

The Meeting estimated a maximum residue level of 200 mg/kg and an STMR of 49.5 mg/kg for grass forage and a maximum residue level of 300 mg/kg and an STMR of 44 mg/kg for grass hay.

Fate of residues in processing

In a processing study on oranges, malathion was applied at 8 times the label rate and oranges were harvested 7 days after the last application. Malathion was concentrated in oil (processing factor 219), dried pulp (processing factor 10) and molasses (processing factor 1.4). The residues in the juice were decreased considerably (processing factor <0.05).

In a processing study with grapes, malathion was applied at 5 times the label rate and grapes were harvested 3 days after the last application. Malathion was concentrated in wet pomace (processing factor 2.5), dry pomace (processing factor 11) and raisin waste (processing factor 6). The residues in juice and raisins were decreased considerably with processing factors of 0.08 and 0.43 respectively.

Tomatoes were treated with malathion at 5 times the maximum label rate and harvested 1 day after the last application. Malathion residues were concentrated in the wet pomace (processing factor 1.7) and dry pomace (processing factor 13.3), and decreased in juice, purée and ketchup with processing factors of 0.03, 0.58 and 0.75 respectively.

In a processing study on snap beans in Oregon, malathion was applied at 5 times the maximum label rate and beans were harvested 1 day after the last application. The beans were washed in water, the debris, stems and blossom ends were removed and the beans mechanically cut to give cut beans. Residues were concentrated in the removed parts (cannery waste) with a processing factor of 8.3, and residues in cut beans decreased considerably with a processing factor of<0.02.

Potatoes were treated at 5 times the maximum label rate and harvested on the day of the last application. Residues in whole potato tubers, granules, wet peel and chips were <0.01 mg/kg. Malathion was detected only in the dry peel at a level of 0.06 mg/kg.

Malathion was applied at 5 times the maximum label rate to field corn and the grain harvested 7 days after the last application. Whole grain, grain dust, grits, meal, flour, crude and refined oil (dry milling and wet milling), bleached and deodorised oil (dry milling and wet milling) and starch were analysed. Malathion was detected only in grain dust at levels of 0.99 and 0.74 mg/kg in dust >2540 μm and ≤2540 μm respectively.

In a post-harvest trial according to GAP, the residues were concentrated in the aspirated grain by processing factors (PF) of 170 and 97 in >2540 μm and ≤2540 μm fractions respectively, meal (PF = 1.7), flour (PF 2.0), dry milled crude oil (PF 4.5), dry milled refined oil (PF 1.4), wet milled crude oil (PF 6.2) and wet milled refined oil (PF 3.5). The residues were decreased in grits, dry and wet milled bleached/deodorized oil and wet milled starch, by processing factors of 0.7, 0.016, 0.02 and 0.002 respectively. The Meeting concluded however that it was unlikely that malathion would be concentrated in flour, and agreed not to estimate a maximum residue level for maize flour.

In a processing study on rice, malathion was applied at 5 times the maximum rate and grain was harvested 7 days after the last application. The residues were concentrated in grain dust (PF 1.7 in dust >2540 μm and 2.5 in dust <2540 μm) and in hulls (PF 5.5). The residues were decreased in polished rice and bran by processing factors of 0.02 and 0.67 respectively. The Meeting concluded that it was unlikely that malathion would be decreased after processing to bran.

In a processing study on wheat, malathion was applied at 5 times the maximum label rate and grain was harvested 7 days after the last application. Malathion residues were concentrated after processing in grain dust, with a factor of 36 in dust >2540 μm and of 56 in dust ≤ 2540 μm and in middlings (between 240 and 730 μm) with a processing factor of 2.2. In bran, shorts (>240 μm) and patent flour (<132 μm), residues were reduced with processing factors of 0.41, 0.39 and 0.23 respectively. The Meeting concluded however that it was unlikely that malathion residue in wheat would be decreased after processing to bran. In another study with post-harvest treatment conducted according to GAP, residues in grain were concentrated in the aspirated grain fraction, with PF 1.25 and 35 for dust >2540 μm and ≤2540 μm respectively.

In a processing study on cotton, malathion was applied at 3.3 times the maximum label rate and cotton seed was harvested on the day of the last application. The residues of malathion decreased in all fractions analysed, with processing factors of 0.77 in hull, 0.07 in meal, 0.67 in crude oil, 0.65 in refined oil and 0.008 in bleached and deodorized oil.

Residues in food in commerce or at consumption

Monitoring by the governments of Australia and The Netherlands from 1994 to 1998 showed that malathion residues were undetectable (LOD 0.02 and 0.05 mg/kg) in most of the samples of fruit, grain and vegetables analysed. In a market survey in Australia malathion was detected only in psyllium husk (maximum 0.02 mg/kg), silver beet (maximum 0.50 mg/kg) and strawberries (maximum 0.10 mg/kg). In enforcement monitoring of 289 samples, malathion was detected only in one celery sample. In monitoring in The Netherlands from 1994 to 1996 12% of the 19828 samples analysed had detectable residues, with a mean of <0.02 mg/kg.

RECOMMENDATIONS

On the basis of data from supervised residue trials the Meeting estimated the maximum residue levels and STMRs listed below. The maximum residue levels are recommended for use as MRLs.

Definition of the residue for compliance with MRLs and for the estimation of dietary intake: malathion.

Commodity		Recommended MRL, mg/kg		STMR, mg/kg
CCN	Name	New	Previous	
AL 1020	Alfalfa fodder	200		17
AL 1021	Alfalfa forage (green)	500 dry wt.		157 dry wt.
FP 0226	Apple	W	2	
VS 0621	Asparagus	1		0.305
VP 0071	Beans (dry)	2	8 Po	0.36
VP 0061	Beans, except Broad bean and Soya bean	1		0.31
FB 0264	Blackberries	W	8	
FB 0020	Blueberries	10	0.5	2.27
VB 0400	Broccoli	W	5	
VB 0041	Cabbages, Head	W	8	
VB 0404	Cauliflower	W	0.5	
VS 0624	Celery	W	1	
GC 0080	Cereal grains	W	8 Po	
VL 0464	Chard	W	0.5	
FS 0013	Cherries	W	6	
FC 0001	Citrus fruits	W	4	
AL 1023	Clover	500 dry wt.		168 dry wt.
AL 1031	Clover hay or fodder	150		33.5

Commodity		Recommended MRL, mg/kg		STMR, mg/kg
CCN	Name	New	Previous	
VP 0526	Common bean (pods and/or immature seeds)	W	2	
SO 0691	Cotton seed	20		4.8
	Cotton seed meal			0.34
	Cotton seed oil, blanched and deodorized			0.038
OC 0691	Cotton seed oil, crude	13		3.21
OR 0691	Cotton seed oil, edible	13		3.12
VC 0424	Cucumber	0.2		0.02
DF 0167	Dried fruits	W	8	
VO 0440	Egg plant	W	0.5	
VL 0476	Endive	W	8	
FB 0269	Grapes	W	8	
AF 0162	Grass forage	200		49.5
AS 0162	Hay or fodder (dry) of grasses	300		44
VL 0480	Kale	W	3	
VB 0405	Kohlrabi	W	0.5	
VD 0533	Lentil (dry)	W	8	
VL 0482	Lettuce, Head	W	8	
GC 0645	Maize	0.05		0.01
AS 0645	Maize fodder	50		6.65
AF 0645	Maize forage	10 dry wt.		0.20 dry wt.
VL 0485	Mustard greens	2		0.07
	Nuts (whole in shell)	W	8	
VA 0385	Onion, Bulb	1		0.23
FS 0247	Peach	W	6	
FP 0230	Pear	W	0.5	
VP 0063	Peas (pods and succulent = immature seeds)	W	0.5	
VO 0051	Peppers	0.1	0.5	0.01
FS 0014	Plums (including Prunes)	W	6	
FB 0272	Raspberries, Red, Black	W	8	
VR 0075	Root and tuber vegetables [1]	W	0.5	
CM 0650	Rye bran, unprocessed	W	20 PoP	
CF 1250	Rye flour	W	2 PoP	
CF 1251	Rye wholemeal	W	2 PoP	
GC 0651	Sorghum	3		0.235
VL 0502	Spinach	3	8	0.35
VA 0389	Spring onion	5		0.52
FB 0275	Strawberry	1	1	0.25
VO 0447	Sweet corn (corn-on the-cob)	0.02		0.01
VO 0448	Tomato	0.5	3	0.21
JF 0448	Tomato juice	0.01		0.00
	Tomato ketchup			0.09
	Tomato pomace, wet			0.20
	Tomato pomace, dry			1.6
	Tomato purée			0.07
VR 0506	Turnip, Garden	0.2	3	0.05
VL 0506	Turnip greens	5		1.20
GC 0654	Wheat	0.5		0.04
AF 0654	Wheat forage	20 dry wt.		4.14 dry wt.
AS 0654	Wheat straw and fodder, dry	50		6.85

[1] Except Turnip, Garden

FURTHER WORK OR INFORMATION

Desirable

1. Farm animal feeding studies.

2. Processing studies on wheat, rice and maize (corn) treated pre-harvest.

DIETARY RISK ASSESSMENT

Chronic intake

Thirty six STMRs were estimated for malathion. There were consumption data for 20 commodities which were used with the STMRs for the dietary intake calculation. The results are shown in Annex III.

International Estimated Daily Intakes for the five GEMS/Food regional diets, based on estimated STMRs, were 0% of the ADI. The Meeting concluded that the intake of residues of malathion resulting from its uses that have been considered by the JMPR is unlikely to present a public heath concern.

Acute intake

The international estimate of short-term intake (IESTI) for malathion was calculated for the commodities for which maximum residue levels and STMRs were estimated and for which consumption data (large portion consumption, unit weight) were available. The results are shown in Annex IV. The IESTI varied from 0 to 0.017 mg/kg body weight in the general population and from 0 to 0.058 mg/kg body weight in children. As no acute reference dose has been established, the acute risk assessment for malathion was not finalized.

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