DISULFOTON (074)

EXPLANATION

Residue aspects of disulfoton were reviewed by the JMPR in 1973, 1975, 1979, 1981, 1984, 1991 and 1994. At the 1996 CCPR MRLs set "at or about the limit of determination" were amended from 0.01 to 0.02 mg/kg after a recommendation from the Ad Hoc Working Group On Methods of Analysis (ALINORM 97/24 para. 52). Several delegations expressed concern at the high levels of estimated intakes relative to the ADI and it was noted that processing data were not available for refinement of the estimation of intake. The Committee requested revised intake calculations and decided to keep all other proposals at step 7C (ALINORM 97/24, paras. 53 and 54).

In 1997, the CCPR was informed that additional data would be available for the 1998 JMPR and disulfoton MRLs were kept at Step 7B pending the 1998 evaluation. The present Meeting received new residue data on lima beans, cotton, lettuce and potatoes, as well as reports of recent processing studies on coffee, cotton seed, maize, sorghum and wheat. Processing data on potatoes were also submitted, although minimal information was provided on the field conditions and the analytical methods used. The Meeting received summaries of data reviewed in the previous monographs on disulfoton for the estimation of STMRs and refinement of the dietary intake calculations.

IDENTITY

ISO Common name: disulfoton

Chemical name

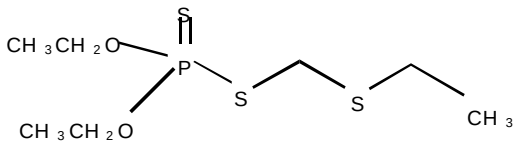
IUPAC: *O*,*O*-diethyl *S*-2-ethylthioethyl phosphorodithioate

CA: *O*,*O*-diethyl *S*-[2-(ethylthio)ethyl] phosphorodithioate

CAS no: [298-04-4]

Synonyms: disyston

Structural formula:



Molecular formula: $C_8H_{19}O_2PS_3$

Molecular weight: 274.4

Physical and chemical properties

Pure active ingredient

Appearance: colourless oil with a characteristic odour

Vapour pressure:	7.2 mPa (20°C), 13 mPa (25°C), 22 mPa (30°C)
Melting point:	<–25°C
Boiling point:	128°C at 1 mm Hg
Octanol/water partition coefficient:	log P_{ow} = 3.95
Solubility:	water 12 mg/l (20°C). Readily miscible with *n*-hexane, dichloromethane, isopropanol, toluene.
Specific gravity:	1.144 g cm^{-3} (20°C)
Hydrolysis:	Hydrolysed in alkaline media. Half-life at 22°C: 133 days (pH 4), 169 days (pH 7), 131 days (pH 9)
Photolysis:	Half-life 1-4 days

Formulations

Disulfoton is formulated as granules (GR) 5%–15%, as an emulsion concentrate (EC) 960 g/l and a suspension concentrate (SC) 720 g/l.

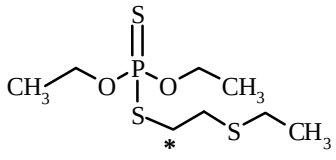
METABOLISM AND ENVIRONMENTAL FATE

Plant metabolism

The metabolism of disulfoton in cotton plants, lemon trees, beans and alfalfa plants was reviewed in previous monographs. In many of the studies, [^{32}P]disulfoton was used, and metabolites which did not contain the phosphorus label were not identified or fully characterized.

In earlier studies, the transformation of unlabelled disulfoton applied as a seed dressing to cotton, as a foliar spray to lettuce, and as soil and foliar applications to asparagus was investigated (JMPR, 1991).

New studies describing the metabolism of [^{14}C]disulfoton in lettuce, potatoes, wheat and soya beans have been provided by the manufacturer. The position of the ^{14}C label is indicated by an asterisk in the structural formula below.



* label position

[^{14}C]disulfoton was applied to soil at a rate of 3.2 kg ai/ha before planting lettuce (Fought, 1994c). Plants were harvested 49 days after planting (normal harvest). The total radioactive residue (TRR) in lettuce was 3.74 mg/kg disulfoton equivalents. Soil samples (2.5 cm depth) were taken at planting and at harvest; the total radioactive residues were 10 and 2.52 mg/kg disulfoton equivalents at planting and harvest respectively.

Acidic methanol (1% TFA/MeOH[N1]) extracted 93% of the TRR from homogenised lettuce. Approximately 84% of the TFA/MeOH extract was soluble in acetonitrile and 9% was soluble in water. The remaining filter cake contained 7% of the TRR, of which only 1% remained after consecutive acidic and basic hydrolyses.

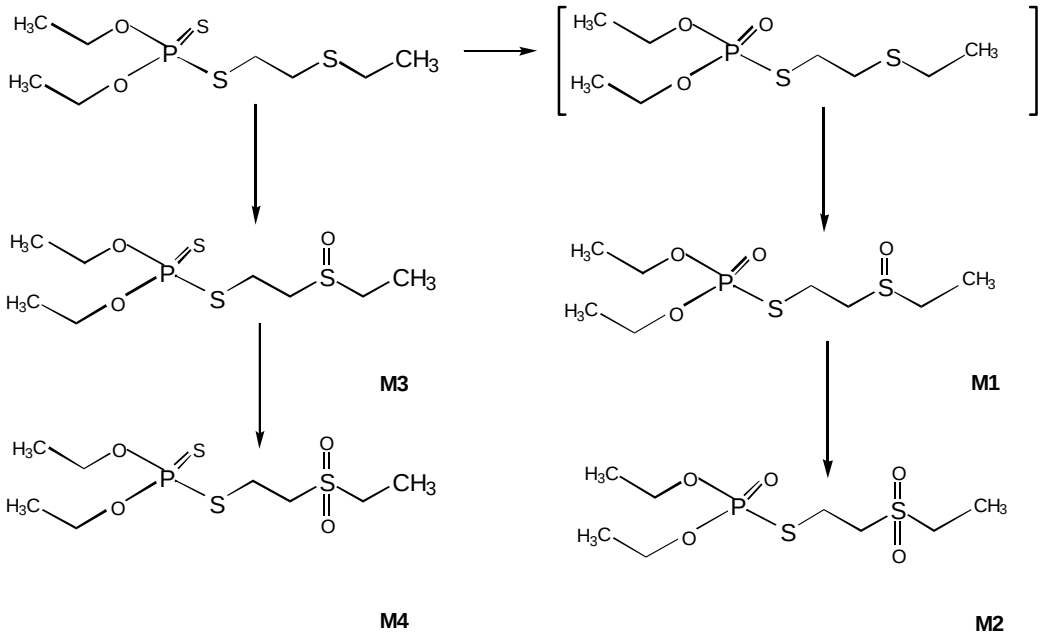
The main metabolites in mature lettuce, identified by HPLC, were disulfoton sulfone (M4), disulfoton oxygen analogue sulfone (M2), disulfoton oxygen analogue sulfoxide (M1) and disulfoton sulfoxide (M3) at 26, 23, 6 and 5% of the total radioactivity respectively, a total of 60%, The details are shown in Table 1. The structures of the major metabolites are shown in Figure 1.

Table 1. Distribution of radioactive residues in mature lettuce 49 days after planting in soil treated with [^{14}C]disulfoton at the rate of 3.2 kg ai/ha.

Compound	Metabolites in extracted fractions, % of TRR and (mg/kg as disulfoton)			
	Acetonitrile	Aqueous	Acidic	Total
M1 disulfoton oxygen analogue sulfoxide	6 (0.22)	<1 (<0.04)		6 (0.22)
M2 disulfoton oxygen analogue sulfone	22 (0.82)	1 (0.04)		23 (0.86)
M3 disulfoton sulfoxide	5 (0.19)	<1 (0.04)		5 (0.19)
M4 disulfoton sulfone	25 (0.94)	1 (0.04)		26 (0.98)
5		< 1 (<0.04)		
6 M5 (tentative identification)	1 (0.04)	1 (0.04)		2 (0.08)
7 M9 (tentative identification)	1 (0.04)			1 (0.04)
8	1 (0.04)			1 (0.04)
9	1 (0.04)		1 (0.04)	2 (0.07)
10	2 (0.07)		1 (0.04)	3 (0.11)
11 M6 (tentative identification)	<1 (<0.04)			<1 (<0.04)
12	7 (0.26)	2 (0.07)		9 (0.33)
13	12 (0.45)	3 (0.11)	<1 (<0.04)	15 (0.56)
14 M7 (tentative identification)	1 (0.04)	1 (0.04)		2 (0.07)
15			1 (0.04)	1 (0.04)
Total				96 (3.59)

Metabolites 12 and 13, which were not identified, accounted for 24% of the total extractable radioactivity. Four metabolites which totalled 6% of the TRR were tentatively identified as 2-(ethylsulfonyl)ethanol (M5), 2-(ethylthio)ethanesulphonic acid (M9), 1-(ethylsulfonyl)-2-(methylthio)ethane (M6) and 1-(ethylsulfinyl)-2-(methylsulfinyl)ethane (M7). Disulfoton and disulfoton oxygen analogue [N2]were not detected.

Figure 1. Disulfoton metabolism in lettuce.



Disulfoton oxygen analogue is shown as an intermediate as it was not identified in the study.

The storage stability of the total radioactive residue in lettuce was investigated by HPLC. Ethyl acetate extracts prepared immediately after harvest and after 13 months frozen storage were compared. Ethyl acetate extracted 58% of the TRR after harvest and 65% after storage. Analysis of the extracts showed that the relative amounts of the main metabolites were the same, although the extracted proportion of the TRR had changed slightly. The results showed that the metabolites extracted at harvest were stable in the freezer for 13 months and that the total radioactivity was also stable.

[^{14}C]disulfoton was applied to soil at a rate of 7.87 kg ai/ha (1.76 times the maximum recommended US rate) before planting potatoes, and two foliar applications were made 33 and 69 days after planting at a rate of 2.24 kg ai/ha, twice the label rate (Fought *et al.*, 1994b). Plants were grown under field conditions for 2 months, then moved to a greenhouse for 3 months. Potatoes were harvested 99 days after planting and soil samples (5 cm depth) were taken at planting and at harvest.

The total radioactive residues were 12 and 0.97 mg/kg disulfoton equivalents at planting and harvest respectively in the soil, and 3.71 mg/kg in the tubers. Acid methanol extracted 91% of the TRR in tubers, with 9% remaining in the filter cake. The extracted material was largely soluble in acetonitrile (78% of the TRR) with 13% water-soluble.

Disulfoton sulfone (M4), sulfoxide (M3), oxygen analogue sulfone (M2) and oxygen analogue sulfoxide (M1) accounted for 2% of the TRR. The hydrolysis products 1-(ethylsulfinyl)-2-(methylsulfinyl)ethane (M7), 1-(ethylsulfonyl)-2-(methylthio)ethane (M6) and 2-(ethylsulfonyl)ethanol (M5) constituted 4, 1 and 11% of the TRR respectively.

The storage stability of the acidic methanol extracts of potato tubers was investigated by determining the total radioactivity in samples prepared after harvest and after 8 months of frozen storage. Ninety two per cent of the TRR was extracted at harvest and 91% after storage. Disulfoton and the main metabolites M1, M2, M3 and M4 were not detected.

The radioactive residue in the tubers was further examined by extraction with acetonitrile/H_2O followed by dilute HCl (Hall and Hartz, 1996b). Soxhlet extraction and ion-exchange chromatography were employed before identification by GC-MS and thermospray MS. This solvent combination extracted 99% of the TRR, of which 75% was identified as shown in Table 2.

Table 2. Compounds identified in radioactive residues extracted from potato tubers after a soil treatment (7.87 kg ai/ha) and two foliar applications (2.24 kg ai/ha) of [^{14}C]disulfoton.

Compound	% of TRR	mg/kg
Sulfinyl lactate conjugate of 2-(ethylsulfonyl)ethylene (M18)	53	2.27
Cysteine conjugate of 2-(ethylsulfonyl)ethylene (M16)	9	0.40
Thiolactate conjugate of 2-(ethylsulfonyl)ethylene (M17)	7	0.28
Disulfoton oxygen analogue sulfoxide (M1)	<1	0.015
Disulfoton oxygen analogue sulfone (M2)	<1	0.032
Disulfoton sulfone (M4)	<1	0.003

The results show that the organophosphorus triesters M1-M4 constituted only a small proportion of the radioactive residues in the tubers. Most of the radioactivity is incorporated in amino acid conjugates of 2-(ethylsulfonyl)ethylene which may be formed by β-elimination from disulfoton oxygen analogue sulfone. Both 2-(ethylsulfonyl)ethylene and 2-(ethylsulfonyl)ethanol were tentatively identified at 5% of the TRR. The metabolic pathways proposed for disulfoton in plants are shown in Figure 2.

Wheat was planted in soil treated with [^{14}C]disulfoton at the rate of 0.97 kg ai/ha (Fought *et al.*, 1994d). At 37 and 63 days after planting, two foliar sprays were applied at a rate of 0.85 kg ai/ha. The plants were grown under field conditions for 2 months, then transferred to a greenhouse for another month. Soil samples (2.5 cm depth) were taken at the time of treatment and at harvest. Immature plants were sampled immediately before the first foliar application 37 days after planting. Mature plants were harvested 90 days after planting and grain and chaff were separated for analysis. Plants which were left to dry were collected as straw and forage 104 days after planting.

The forage samples included chaff separated from the wheat heads. The TRR in the samples are shown in the Table.

Interval	Sample	Disulfoton equivalents, mg/kg
Planting	Soil	3.05
Immature	Plants	4.62
Harvest	Soil	0.65
	Grain	2.80
	Forage	36.2
	Straw	40.2

Grain, forage and straw samples were extracted with 1% TFA/MeOH and immature plants with acetone. The proportion of the radioactivity extracted varied as shown. The organophosphorus triesters accounted for a small proportion of the total radioactivity in all the samples, as shown in Table 3.

Sample	Fraction	% of TRR
Wheat grain	TFA/MeOH + CH_3CN	45
	Filter cake	55
Wheat forage	TFA/MeOH + CH_3CN	75
	Filter cake	23
Wheat straw	TFA/MeOH + CH_3CN	76
	Filter cake	23
Immature wheat	acetone	61
	Filter cake	39

Table 3. Distribution of residues in immature wheat, grain, straw and forage after a soil treatment at 0.97 kg ai/ha and two foliar applications at 0.85 kg ai/ha.

Metabolite	^{14}C, % of TRR and (mg/kg as disulfoton)			
	Immature wheat	Wheat grain	Wheat forage	Wheat straw
M1 disulfoton oxygen analogue sulfoxide	1 (0.05)	1 (0.03)	5 (1.88)	6 (2.41)
M2 disulfoton oxygen analogue sulfone	14 (0.65)	<1 (0.1)	8 (2.97)	8 (3.21)
M3 disulfoton sulphoxide	<1 (0.02)	1 (0.03)	6 (2.21)	2 (1.00)
M4 disulfoton sulfone	6 (0.28)	1 (0.03)	4 (1.45)	4 (1.81)

The triesters constituted 23% of the TRR in wheat forage, 20% in wheat straw, 21% in immature wheat and <4% in wheat grain. 2-(ethylsulfonyl)ethanol was tentatively identified at 42% or 1.18 mg/kg in wheat grain and at 5% or 1.81 mg/kg in wheat forage. The remaining radioactivity was characterized as a mixture of polar compounds of low molecular weight.

The storage stability of the radioactive residues in wheat forage was determined by comparing the extracts of forage prepared after harvest and 12 months later. TFA/MeOH extracted 79% of the TRR after harvest and 76% after 12 months of frozen storage. Four metabolite peaks were identified, together with a peak containing polar compounds.

Metabolite	% of TRR	
	Harvest	12 Months
Disulfoton oxygen analogue sulfoxide	7	5
Disulfoton oxygen analogue sulfone	12	8
Disulfoton sulfoxide	10	6
Disulfoton sulfone	9	5
Polar compounds	41	52

The percentages of the four metabolites were comparable after 12 months storage, while the percentage of polar compounds increased. Wheat forage, straw and grain were extracted with 1% TFA/MeOH 7 and 12 months after harvest. The proportions of the TRR extracted were similar: 77% from forage, 75% from straw and 49% from grain after 7 months; 79% from forage, 77% from straw and 45% from grain after 12 months.

Soya beans were planted in soil treated with [^{14}C]disulfoton at the rate of 1.84 kg ai/ha, grown under field conditions for 2 months then transferred to a greenhouse for another month (Fought *et al.*,1994a) Soil samples (5 cm depth) were collected at the time of treatment and at harvest. Some mature plants were harvested 85 days after planting for collection of bean, hull and forage samples. The remaining plants were left to dry for 2 weeks and collected as hay. The TRR in the various samples is shown below.

Time of sampling	Sample	disulfoton equivalents, mg/kg
Planting	Soil	2.88
Harvest	Soil	0.32
	Beans	1.39
	Hulls	8.05
	Forage	27.0
	Hay	43.7

Extraction with 1% TFA/MeOH followed by acid hydrolysis released a high proportion of the radioactivity:

Sample	% of TRR extracted		
	TFA/MeOH + CH_3CN	HCl	Filter cake
Beans	67	25	5
Hulls	79	18	1
Forage	93	5	1
Hay	85	12	1

Less than 4% of the extracted ^{14}C was in the triesters, as shown in Table 4.

Table 4. Distribution of radioactivity in soya beans, hulls, forage and hay after a soil treatment at 1.84 kg ai/ha.

Metabolite	% of TRR and (mg/kg as disulfoton)			
	Beans	Hulls	Forage	Hay
M1 disulfoton oxygen analogue sulfoxide	<1 (0.01)	<1 (0.01)	<1 (0.02)	<1 (0.01)
M2 disulfoton oxygen analogue sulfone	<1 (0.01)	<1 (0.01)	<1 (0.04)	<1 (0.01)
M3 disulfoton sulphoxide	<1 (0.01)	<1 (0.01)	<1 (0.02)	<1 (0.02)
M4 disulfoton sulfone	<1 (0.01)	<1 (0.01)	<1 (0.01)	<1 (0.02)

2-(ethylsulfonyl)ethanol was tentatively identified at 6% of the TRR in hay, 4% in hulls, 26% in beans and 7% in forage.

The storage stability of the TRR in the soya bean forage was investigated. TFA/MeOH extracted 93% of the TRR both immediately after harvest and after 9 months of frozen storage. The chromatographic profile was similar in both extracts. Neither disulfoton nor the triester metabolites were detected.

Identification of the other metabolites in the beans and forage was facilitated by Soxhlet extraction of the residual solids with CH_3CN and water, followed by base extraction and ion exchange chromatography (Hall and Hartz, 1996a). The procedure extracted 94% and 66% of the TRR from the forage and beans respectively, of which 89% and 40% were positively identified (Table 5).

Table 5. Distribution of metabolites in soya beans and soya bean forage after a soil treatment at 1.84 kg ai/ha. The main identified components of the TRR were 2-(ethylsulfonyl)ethanol in the forage and 2-(ethylsulfonyl)acetic acid in the beans.

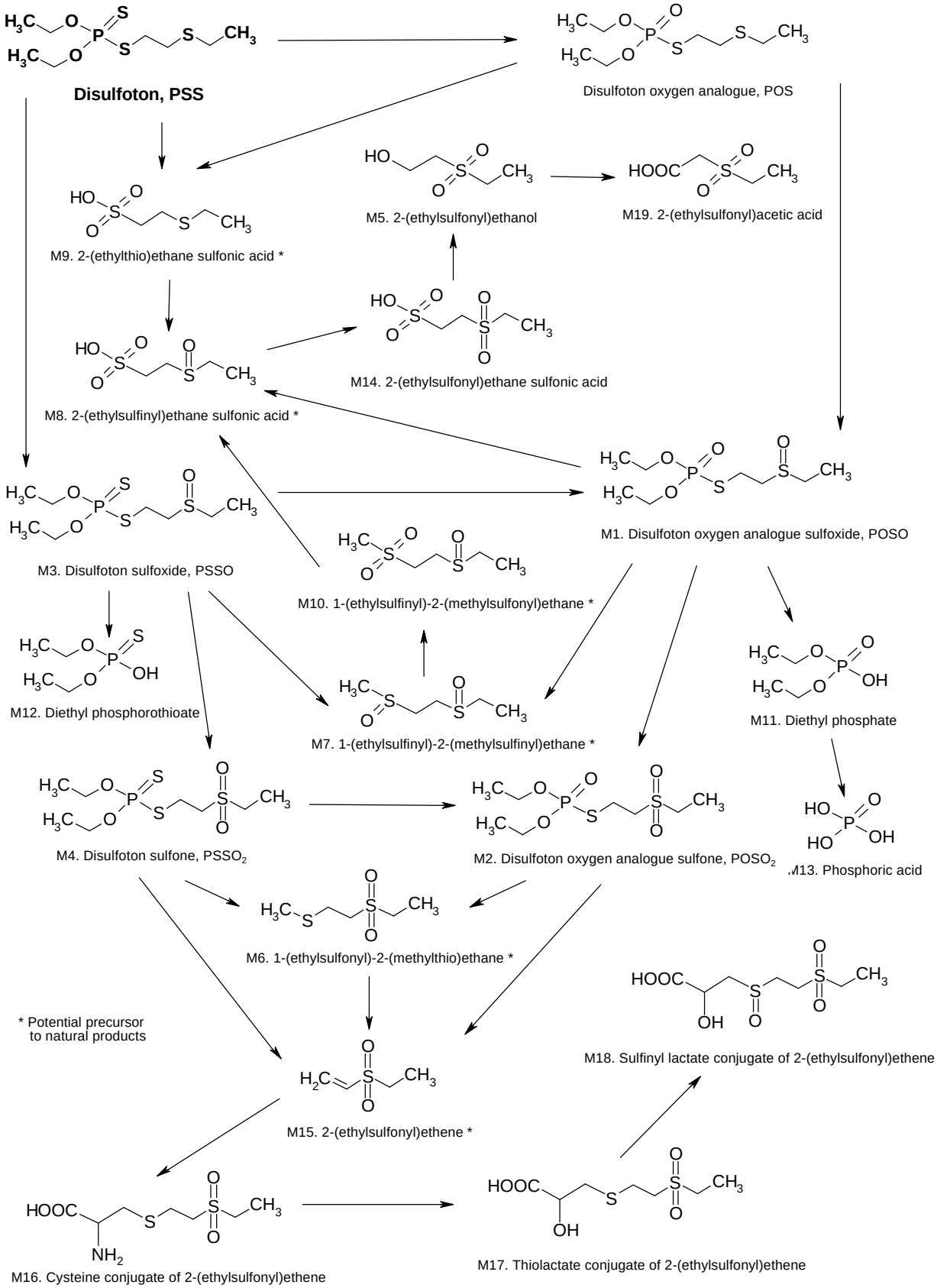
Metabolite	% of TRR and (mg/kg as disulfoton)	
	Soya beans	Soya bean forage
M18 2-(ethylsulfinyl)ethylsulfonic acid	<1 (0.01)	10 (2.21)
M19 2-(ethylsulfonyl) acetic acid	39 (0.51)	22 (5.08)
M5 2-(ethylsulfonyl)ethanol	–	58 (13.09)

In summary triester is similar in all the crops and four common metabolites were identified and characterized: disulfoton sulfoxide, disulfoton oxygen analogue sulfoxide, disulfoton sulfone, and disulfoton oxygen analogue sulfone. Neither unchanged disulfoton nor disulfoton oxygen analogue were detected in any of the reported studies, so the inclusion of the oxygen analogue (demeton-S) in the residue definition is of questionable practical importance. Cleavage of the triesters led to the formation of sulfonyl and sulfonic acid products. The single metabolite common to lettuce, wheat, potatoes and soya beans was 2-(ethylsulfonyl)ethanol. Derivatives or precursors of this compound such as 2-(ethylsulfonyl)acetic acid, 2-(ethylsulfinyl)ethanesulfonic acid, 2-(ethylsulfonyl)ethanesulfonic acid and 1-(ethylsulfinyl)-2-(methylsulfonyl)ethane were tentatively identified in various crops and crop parts. In potatoes, conjugation with glutathione followed by reduction and deamination of the conjugate was observed in addition to the common hydrolytic and oxidative pathways.

In reported metabolism studies on cotton with [^{32}P]disulfoton (Bull, 1965), hydrolytic products such as phosphoric acid, *O*,*O*-diethyl hydrogen phosphorothioate and diethyl phosphate

were identified in addition to disulfoton sulfone and sulfoxide, and disulfoton oxygen analogue sulfone and sulfoxide. These are also included in Figure 2.

Figure 2. Proposed metabolic pathways of disulfoton in plants.



METHODS OF RESIDUE ANALYSIS

Analytical methods

Enforcement methods

In a regulatory method reported by The Netherlands (Netherlands, 1966) disulfoton and its oxidized metabolites are all determined by gas chromatography with an ion trap or nitrogen-phosphorus detector. The limit of determination is 0.01-0.05 mg/kg for a variety of food samples. The mean recoveries of disulfoton and disulfoton sulfone in lettuce were reported as 76 and 94% respectively, with fortification at 0.29 mg/kg (n = 10) of each compound. In potatoes the limit of determination was 0.01 mg/kg with 115% recovery at 0.1 mg/kg. The compound used in the determination was not specified.

Specialised methods

Three specialised methods of analysis were reported by the manufacturer. In method 00043 (Thornton, 1967, revised 1978) disulfoton and its metabolites are quantified by gas chromatography with a KC1 flame ionization detector. The method involves extraction and precipitation to remove interfering plant products, followed by oxidation with $KMnO_4$ to convert disulfoton and its oxon and their sulfoxides to the corresponding sulfones. This method was reported in the 1973 monograph and the 1991 periodic review. Recoveries were determined with added disulfoton and the oxon sulfoxide and sulfone at 0.1 mg/kg each in maize kernels, molasses, potatoes, sorghum fodder, sorghum grain, soya beans, strawberries, sugar, sugarcane and wheat grain, at 0.4 mg/kg in wheat straw, and at 0.5 mg/kg in cotton seed. Recoveries ranged from 73 to 114% for disulfoton, 73 to 122% for disulfoton oxygen analogue sulfoxide and 90 to 108% for the sulfone. The limit of determination was 0.1 mg/kg, and the limit of detection was reported as 0.02 mg/kg.

A rapid screening method for the determination of disulfoton and the same metabolites in alfalfa and wheat was subsequently reported (Thornton, 1974). It is a modification of the procedure described above in which some of the clean-up steps have been amended. Recoveries [N3] with fortification at 1 mg/kg were in the range 80-100%. The limit of determination is in the range 0.1-0.2 mg/kg.

A modified method for the determination of disulfoton and the same metabolites in cotton seed was described by Seym (1996a). The modification of the Thornton procedure includes an extra partitioning step with hexane and CH_3CN before oxidation with $KMnO_4$. Cotton seed was fortified with mixtures of disulfoton, disulfoton sulfoxide, disulfoton sulfone, disulfoton oxon, disulfoton oxon sulfoxide and disulfoton oxon sulfone at 0.01, 0.02 or 0.1 mg/kg of each compound, giving total concentrations of 0.06, 0.12 and 0.6 mg/kg. Recoveries ranged from 75 to 103% at 0.06 mg/kg, 63 to 85% at 0.12 mg/kg and 75 and 90% at 0.6 mg/kg. The limit of determination was 0.01 mg/kg for each compound or 0.06 mg/kg for the mixture.

Fortification level, mg/kg	Recovery, %
0.06 (0.01 mg/kg of each compound)	75, 84, 103
0.12 (0.02 mg/kg of each compound)	63, 72, 75, 76, 81, 85
0.6 (0.1 mg/kg of each compound)	75, 90

Stability of pesticide residues in stored analytical samples

The storage stability of disulfoton and its oxidized metabolites in a range of crops and processed commodities was investigated by Wiedmann and Koch (1994). Samples of alfalfa forage and hay, broccoli, dry coffee beans, cotton seed, lettuce, peanut meal, oil and soapstock, green peas, potatoes, sorghum, strawberries, sweet corn, tobacco, tomatoes and juice, pomace and ketchup, and wheat grain, bran, flour, shorts, forage and straw were fortified with a mixture of disulfoton, its sulfone and sulfoxide or of disulfoton oxygen analogue and its sulfone and sulfoxide. Each sample contained

0.5 mg/kg disulfoton equivalents of each compound, totalling 1.5 mg/kg of the P=S compounds (disulfoton, disulfoton sulfoxide and disulfoton sulfone) or the P=O compounds (disulfoton oxon and its sulfoxide and sulfone). Samples were stored at –22°C and analysed after 0, 6, 12, 16 and 24 months[N4]. The limit of determination was 0.01 mg/kg. Recoveries of the P=S compounds ranged from 74 to 113% and of the P=O compounds from 74 to 116%.

After 24 months of frozen storage, no decomposition of the P=S compounds was found in alfalfa forage or hay, broccoli, lettuce, peanut oil, green peas, potatoes, sorghum, strawberries, sweet corn, tobacco, tomato juice, ketchup or pomace, or wheat flour, shorts, grain, forage or straw. Coffee beans, cotton seed, peanut meal and wheat bran showed <9% decomposition of the P=S compounds.

No decomposition of the P=O compounds was found in broccoli, lettuce, green peas, sorghum, strawberries, tomatoes (whole or juice), or wheat flour, shorts or straw after 24 months. Less than 25% decomposition was found in alfalfa forage and hay, coffee beans, peanut meal and oil, potatoes, sweet corn, tobacco, tomatoes (whole, ketchup and pomace), and wheat bran, grain and forage. There was 37% decomposition in cotton seed.

In a subsequent study (Lemke, 1996) the stability of the disulfoton P=S and P=O compounds in the same commodities was investigated for 36 months of frozen storage[N5], with analyses by the revised method of Thornton (1978). The extent of decomposition is shown in Table 6.

Table 6. Decomposition of disulfoton P=S and P=O compounds in various commodities after 36 months of frozen storage.

% Decomposition of P=S compounds	Sample
0	Alfalfa (forage and hay), broccoli, coffee beans, sweet corn, cotton seed, lettuce, green peas, strawberries, wheat grain, bran, flour, forage, straw and shorts
1	Peanut meal, tomato pomace,
3	Tobacco
4	Tomato juice
6	Peanut oil
8	Sorghum grain, tomato ketchup
9	Potato tubers
18	Peanut soapstock
% Decomposition of P=O compounds	Sample
0	Alfalfa hay, broccoli, cotton seed, green peas, strawberries, tomatoes (whole, juice, ketchup, pomace), wheat flour, bran, shorts, forage and straw
2	Alfalfa forage, peanut oil,
3	Lettuce
4	Coffee beans
5	Peanut meal
6	Wheat grain
11	Sweet corn
19	Tobacco
22	Potato tubers
37	Peanut soapstock

The greatest degradation of both P=S and P=O compounds was in peanut soapstock.

The storage stability of disulfoton and its metabolites in processed potato products was reported by Lenz (1996). Potato chips, flakes, wet and dry peel were fortified with 1.5 mg/kg of a mixture of the P=S compounds (disulfoton, its sulfoxide and sulfone) and 1.5 mg/kg of the P=O

compounds (the corresponding oxons) and stored at –22°C for 13 months. Wet potato peel was analysed after 24 months storage. The revised method of Thornton (1978) was used.

After 13 months storage the P=S compounds had decomposed by 2% in wet potato peel, 3% in dry peel, 5% in chips, and 23% in flakes, and the P=O compounds by 0% in wet peel, 4% in dry peel, 8% in chips and 17% in flakes. The limit of determination was 0.3 mg/kg for both P=S and P=O mixtures.

USE PATTERN

Disulfoton is a systemic pre-emergent and post-emergent insecticide used for the control of a variety of insect pests such as aphids, mites, leafhoppers, leafminers, nematodes, thrips and beetles. The active ingredient is formulated as granules, EC and SC formulations, and generally applied to the soil at planting as a soil injection, or at sowing in-furrow, as a side-dressing (*i.e.* at the side of the furrow), or as a broadcast spray . Foliar sprays may be applied after planting (pre-emergent) or at a post-emergence stage of growth. Information on registered use patterns was provided by the manufacturer and the UK and German governments.

On US labels, soil applications are expressed as lb product/acre and also as oz product/1000 square foot of row or 1000 ft of row. Row spacing rate charts are included to allow the grower to calculate the amount of product to be applied in accordance with the corresponding row spacing. As the rates applied in the residue trials are expressed as lb product/acre and these rates are also shown on the labels provided, only these rates are shown in the GAP Table. Row spacing rates are shown in the footnotes to the Table.

Table 7. Registered uses of disulfoton on vegetables and cereals.

Crop	Country	Form	Application				PHI,
			Method	Rate, kg ai/ha	Spray conc, kg ai/hl	No.	days
Barley	Canada	GR 15%	Soil treatment	1.12		1-2	60
Barley	USA	EC 960 g/l	Soil injection	1.12[1]		1 [2]	60[3]
			Foliar application	0.56-1.12[4]		1	30
Barley	USA	GR 15%	Drilling or broadcast[5]	1.12		1-2[6]	60, 30[7]
Beans	Canada	GR 15%	Soil treatment, side-dressing	1.12-2.25		1	60
Beans	Japan	GR 50 g/kg		2.0		1	60
Beans	USA	GR 15%	In soil band at planting	1.12-2.23[8]		1	60
Beans	USA	EC 960 g/l	Soil injection or side-dressing	1.12-2.24		1	60
Beans	Japan	GR 5%	In furrow	2.0		1	60
Beans (French and runner))	UK	GR 10.7%	Soil application	1.18		1	42
Broad beans	UK	GR 10.7%	Foliar	0.909		1	42
Broccoli	Canada	GR 15%	Soil treatment, side-dressing	1.12		1	42

[1] 7.1 g ai/1000 ft of row;
[2] Maximum application 2.24 kg ai/ha/season, soil + foliar.
[3] 30 days withholding period for forage.
[4] Low rate up to tillering and higher rate after tillering.
[5] Drilling or broadcast at planting or broadcast post-emergent.
[6] 21 day re-treatment interval
[7] 30 days grazing withholding period.
[8] 25.5-51 g ai/1000 ft of row

Crop	Country	Form	Application				PHI,
			Method	Rate, kg ai/ha	Spray conc, kg ai/hl	No.	days
Broccoli	USA	GR 15%	In soil bed[9]	1.12[10]		1	14
Broccoli	USA	EC 960 g/l	Side-dressing	1.12		1	14
Broccoli	Mexico	GR 100 g/kg	Band application to soil	1.0		1	na
Broccoli	UK	GR 5%	Soil application	2.92		1	42
Broccoli	UK	GR 6.2%	Soil application	3.48		1	42
Brussels sprouts	USA	GR 15%	In soil bed or soil band	1.12[11]		1-2	30
Brussels sprouts	USA	EC 960 g/l	Side-dressing or injection to soil	1.12		1-2	30
Brussels sprouts	UK	GR 5%	Soil application	2.92		1	42
Brussels sprouts	UK	GR 6.2%	Soil application	3.48		1	42
Brussels sprouts	UK	GR 10.7 %	Soil application	1.5		1	42
			Foliar	1.5		1	
Cabbage	Canada	GR 15%	Soil treatment, side-dressing	1.12		1	42
Cabbage	USA	GR 15%	In soil bed or in soil band	1.12-1.70[12]	No high rate in label.	1	42
Cabbage	UK	GR 5%	Soil application	2.92		1	42
Cabbage	UK	GR 6.2%	Soil application	3.48		1	42
Cabbage	USA	EC 960 g/l	Side-dressing or soil injection	1.12-2.24		1	42
Cabbage	UK	GR 10.7%	Soil application	1.5		1	42
			Foliar	1.5			
Cabbage	Mexico	GR 100 g/kg	Band application	1.0-1.5			na
Cabbage	Japan	GR 5%	In furrow	1.5-3.0		1	na
Calabrese	UK	GR 5%	Soil application	2.92		1	42
Carrot	UK	GR 10.7%	Soil application	2.25		1	42
			Foliar	1.18			
Cauliflower	Canada	GR 15%	Soil treatment, side-dressing	1.12		1-2	30
Cauliflower	USA	GR 15%	In soil bed or soil band	1.12[13]		1-2	40
Cauliflower	USA	EC 960 g/l	Side-dressing or injection to soil	1.12		1-2	40
Cauliflower	Mexico	GR 100 g/kg	Soil treatment	1.0		1	na
Cauliflower	UK	GR 5%	Soil application	2.92		1	42
Cauliflower	UK	GR 6.2%	Soil application	3.48		1	42
Cauliflower	UK	GR 10.7%	Soil application	1.5		1	42
			Foliar	1.5		1	
Celery	UK	GR 10.7%	Soil application	2.25		1	42
Coffee	USA[14]	GR 15%	Under tree canopy	4.3-8.6 kg ai/ha[15]		2	90
Coffee	South Africa	GR 5%		3.3-6.6		1	90
Coffee	South Africa	50 g/kg	Under trees	5.5		1	90
Coffee	Brazil	75 g/kg	Under trees	2.25-5.25		1	90

[9] In soil bed or over the plants after emergence or side of the furrow after planting.
[10] 31.5 g ai/1000 ft of row
[11] 31.5 g ai/1000 ft of row
[12] 48 g ai/1000 ft of row
[13] 31.5 g ai/1000 ft of row.
[14] For Puerto Rico only.
[15] 0.3-0.6 g ai/ft of tree; 2 m trees and 2200 trees/ha.

Crop	Country	Form	Application				PHI,
			Method	Rate, kg ai/ha	Spray conc, kg ai/hl	No.	days
Coffee	Honduras	80 g/kg	Under trees	4.8-7.2		1-3	na
Corn	Canada	GR 15%	Band application, soil treatment	1.12		1	100
Corn	USA	EC 960 g/l	Band application	1.12		1[16]	28
			Foliar	0.56-1.12		1	28
Cotton	Greece	GR 100 g/kg (10 GR)	At planting	1.0-1.5		1	60
Cotton	USA	GR 15%	In furrow	0.67-1.12[17]		1[18]	28
Cotton	USA	EC 960 g/l	In furrow or soil injection	0.66-1.12		1-2[19]	28
			Post-planting in furrow	2.24			90
			Foliar	0.22-0.63		1-3	
Cotton	Mexico	GR 100 g/kg	In furrow	1.2-2.0		1	na
Field beans	UK	GR 10.7%	Foliar	1.18		1	42
Herbs (various)	UK	GR 10.7%	Soil application, drilling	1.18		1	42
Kohlrabi	UK	GR 5%	Soil application	2.92		1	42
Lettuce	Canada	GR 15%	Side-dressing, soil treatment	1.12-2.25		1	na
Lettuce	USA	GR 15%	In soil band	1.12-2.8[20]		1	NS
Lettuce	USA	EC 960 g/l	Side-dressing or soil injection	1.12-2.24		1	60
Marrow	UK	GR 10.7%	Soil application	1.18		1	42
Oats	Canada	GR 15%	Soil treatment	1.12		1-2	60
Onion	Japan	GR 5%	In furrow	2.0		1	na
Parsley	UK	GR 10.7%	Drilling in soil	1.18		1	42
Parsnip	UK	GR 10.7%	Soil application	1.18		1	42
			Foliar	1.18			
Peanut	USA	GR 15%	In furrow	1.12-2.23[21]		1	80
Peas	Canada	GR 15%	In furrow spray, soil treatment	1.12-2.62		1	50
Peas	USA	GR 15%	Drilling or broadcast	1.12-2.80		1	50
Peas (and lentils)	USA	EC 960 g/l	Side-dressing or soil injection; in furrow spray	1.12-2.80		1	50
Pecans	USA	GR 15%	Band around tree	1.68-3.36		1[22]	80
Pecans	USA	EC 960 g/l	Band application to soil	1.68-3.36		1	80
			Foliar	0.84-1.68		3[23]	30
Peppers	USA	GR 15%	In soil band	1.12-2.23[24]		1	90
Pineapple	Honduras	80 g/kg	Soil treatment	4.8-7.2		1-3	90
Pineapple	Japan	GR 5%	Soil treatment	2.0-2.5		1-3	120
Pineapple	France	GR 5%	Soil treatment	0.5 g ai/plant		1	na

[16] Apply one soil and one foliar treatment per season.
[17] For a 40 inch row spacing; 21-34 g ai/1000 sq. ft of row or 5 to 8 oz for any row spacing.
[18] On irrigated cotton, two treatments may be necessary, soil incorporated side-dress application; re-treatment interval of 21 days.
[19] Maximum of 3 applications of disulfoton per season. If soil treatments, then foliar application is not recommended. If foliar applications then soil treatment within the same season is not recommended. Last foliar application should be before bloom.
[20] 17-34 g ai/1000 ft of row.
[21] 31.5-62.5 g ai/1000 sq. ft of row.
[22] One application per season in six foot bands around the tree.
[23] No more than 3 applications per season; by aircraft 0.84-1.12 kg ai/ha.
[24] 28.5-56.5 g ai/1000 ft of row.

Crop	Country	Form	Application				PHI,
			Method	Rate, kg ai/ha	Spray conc, kg ai/hl	No.	days
Potato	Canada	GR 15%	In furrow, soil treatment	1.16		1	90
			Side-dressing, soil treatment	1.16		1	
			In furrow	2.25-3.38		1	90
Potato	Greece	GR 100 g/kg		1.5-2.5		1	60
Potato[25]	USA	GR 15%	In furrow or soil band	2.27-3.44[26]		1	75
			Broadcast	3.36-4.48		1	
Potato	USA	EC 960 g/l	Broadcast, pre-planting	3.36-4.48[27]			
			Soil injection, side-dressing; in furrow	2.24-3.36			75
			Foliar	0.42-1.12		1-3[28]	30
			Foliar	3.36		1	60
Potato	South Africa	GR 5%	In furrow	1.0		1	90
Potato	Mexico	GR 100 g/kg	In furrow	2.0-3.0		1	na
Potato	Japan	GR 5%	In furrow	2.0		1	na
Potato	UK	GR 10.7%	Soil application	1.7		1	42
Radish (Japanese)	Japan	GR 5%	In furrow	1.5-2.0		1	na
Sorghum	USA	GR 15%	In furrow or	0.84-1.12[29]		1	30
			band in soil				
			Post-planting	1.12		1	
Sorghum	USA	EC 960 g/l	In furrow or soil band	0.84-1.12		1-2	34[30]
			Side-dressing in soil	1.12		1	
			Foliar	0.28-0.56		1-2	7
			Foliar[31]	0.28-0.56		1-3	34
Soya beans	USA	GR 15%	In furrow or band	1.12[32]		1	75
Strawberry	UK	GR 10.7%	Foliar	1.18		1	42
Sugar beet	UK	GR 10.7%	Foliar	1.18		1	42
				0.59		2	
Sugar beet	UK	GR 5%	In furrow, soil treatment	1.0		1	30
			Foliar	1.0			30
Tomatoes	USA	EC 960 g/l	In furrow or side-dressing in soil; broadcast spray	1.12-3.36		1-2	30
Tomatoes	Mexico	GR 100 g/kg	In furrow	1.0-3.0		1	na
Tomatoes	Japan	GR 5%	Side-dressing; soil treatment	1.5-3.0		1	na
Wheat	Canada	GR 15%	Soil treatment	1.12		1	na
Wheat	USA	GR 15%	Drilling or broadcast	0.5-1.12[33]		1	75
Wheat	USA	EC 960 g/l	Soil injection	1.12		1	
			Foliar[34]	0.28-0.84		1-3	30

[25] Maximum of 2 applications per season, 1 in furrow and 1 broadcast.
[26] 63.8-97.8 g ai/1000 ft of row.
[27] Maximum of 2 soil applications per season regardless of method of application or formulation used.
[28] No more than 3 sprays per season.
[29] 25.5-34 g ai/1000 sq. ft of row.
[30] With a maximum of 2 soil applications-34 days for harvest and 45 days for fodder; maximum of 3 foliar applications and 2 soil treatments-34 days for harvest and 60 days for fodder.
[31] At 50% seed head.
[32] 34 g ai/1000 sq. ft of row.
[33] Rate ranges from 0.5 to 1.12 kg ai/ha in relation to row spacing.; 7.1 g ai/1000 ft of row.
[34] 1 fall application and 1-2 spring applications; 30 days re-treatment interval.

RESIDUES RESULTING FROM SUPERVISED TRIALS

Data from supervised trials which have not previously been evaluated on lima beans, cotton, lettuce and potatoes are shown in Tables 8-11.

Table 8	Lima beans. *USA.*
Table 9	Cotton. *Greece.*
Table 10	Lettuce. *USA.*
Table 11	Potatoes. *Netherlands.*

Data which were reviewed in the 1991 and 1994 monographs are interpreted in the light of current GAP in Tables 12-30.

Residues, application rates and spray concentrations have generally been rounded to 2 significant figures or, for residues near the limit of detection, to 1 significant figure. Although trials included control plots, residues in the untreated samples are not reported unless they exceeded the limit of determination. Residues from trials according to GAP are underlined; those used to estimate STMRs are double underlined. All analyses were conducted according to the revised method of Thornton (M00318, 1978) unless otherwise stated. All residues, unless otherwise stated, are defined as the sum of disulfoton sulfone, disulfoton sulfoxide, disulfoton oxygen analogue sulfone and disulfoton oxygen analogue sulfoxide, expressed as disulfoton.

Lima beans. A double side-dress pre-emergent application of disulfoton was made at 2.3 kg ai/ha (Anon., 1976a). Minimal field details were reported. The results are shown in Table 8. There was little rainfall during the trials and the crops were furrow irrigated. Samples of pods and beans were taken at normal harvest intervals of 105 and 106 days after treatment. The method of Thornton (M00034) was used to determine the residues and recoveries of 70 to 118% were reported from fortification with disulfoton, disulfoton oxygen analogue sulfone and sulfoxide at concentrations of 0.1 and 0.5mg/kg.

Cotton. The results of trials in Greece are shown in Table 9 (Seym, 1996b,c). Disulfoton was applied at sowing at 1 kg ai/ha by granule spreader in combination with a tractor and seeder. Trial plots ranged from 1786 to 3836 m^2 and 494 to 2074 m^2 in the 1993 and 1994 trials respectively. Irrigation methods where stated, included gun pump and drip irrigation. Samples were taken 150 to 169 days after treatment (80-90% bolls open). After sampling, the bolls were delinted and stored at −18°C for 4 to 10 months before analysis.

Lettuce. The results of six US trials are shown in Table 10 (Duah, 1997a). In each trial a single side-dress was applied at sowing at a rate equivalent to 1.1-2.2 kg ai/ha[N6] by injector shanks mounted in front and on each side of the planter. The trial plots ranged from 88 to 333 m^2 and irrigation was predominantly by sprinkler and furrow. Control and treated samples of head lettuce (with wrapper leaves) were harvested between 62 and 116 days after planting, and the leaf lettuce between 60 and 90 days after planting. The intervals between harvest and analysis were typically 3 to 7 months. All samples were homogenised and stored at –15°C; the storage stability of analytical samples of lettuce was reported independently (Lemke, 1996).

Potatoes. Trials in The Netherlands and the USA were reported by the government of The Netherlands. Disulfoton was applied at planting at 1.5 kg ai/ha to the soil and tubers were harvested after 113 days. No field or climate details were reported. A published analytical method (Dutch) was also provided. The results are shown in Table 11.

Table 8. Disulfoton residues in lima beans resulting from a double side-dress application of disulfoton at planting, USA, California, 1975.

Variety	Application				PHI, days	Sample	Residues, mg/kg	Reference
	Form.	kg ai/ha[1]	kg ai/hl	No.[2]				
Mezcla	GR 15%	2.3		1	78 93 106 106 106	vines beans pods	<0.01 <0.01 <0.01 <0.01 <0.01	Exp. 461-470-75H (Anon. 1976a). 50690
Sutter pink	GR 15%	2.3		1	105	beans, dry	<0.01	Exp. 461-477-75H 50692
Mezcla	GR 15%	2.3		1	78 93 106	vines	0.07 0.11 <0.01	Exp. 461-467-75H 50691

[1] 3 gallons of spray /1000 ft of row; 30 inch row spacing, 4 rows/plot, 50 foot long plot.
[2] Double side-dress applied at pre-emergence stage.

Table 9. Disulfoton residues in cotton seed resulting from supervised trials according to GAP in Greece.

Location year, (variety)	Application[1]				PHI, days	Residues, mg/kg	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
Alexandria 1993 (Corina)	10 GR	1.0		1	163	≤0.12	RA-2037/93 300683
Corifi 1993 (Corina)	10 GR	1.0		1	153	≤0.12	RA-2037/93 303720
Larisa), 1993 (Acala-Zeta)	10 GR	1.0		1	169	≤0.12	RA-2037/93 303739
Agios Dimitrios), 1993 (Zeta 2)	10 GR	1.0		1	154	≤0.12	RA-2037/93 303742
Nikea 1994 (Acala SJ-2)	10 GR	1.0			158	≤0.06	RA-2053/94 402044
Girtoni 1994 (Acala SJ-2)	10 GR	1.0			158	≤0.06	RA-2053/94 402052
Petra 1994 (Zeta 2)	10 GR	1.0			150	≤0.06	RA-2053/94 402060
Nisi 1994 (Corina)	10 GR	1.0			155	≤0.06	RA-2053/94 402079

[1]Application was by granule spreader whereby the product is applied simultaneously with the seed in the row.

Table 10. Disulfoton residues in lettuce (head and leaf), resulting from soil application in supervised trials in the USA.

State, year (variety)	Application				PHI, days	Sample	Residues, mg/kg	Reference
	Form.	kg ai/ha	kg ai/hl	No.				
California 1995, (Salad bowl)	EC 960 g/l	1.1	1.8	1	60	Lettuce, leaf	1.09 1.15	Rep. 107520 FCA-D1004-95H
California 1995 (Green supreme)	EC 960 g/l	1.1	0.29	1	90	Lettuce, leaf	<0.05 <0.05	Rep. 107520 458-DI005-95H
Florida 1996 (Slobolt)	EC 960 g/l	1.1	2.3	1	73	Lettuce, leaf	0.57 0.59	Rep. 107520 VBL-DO006-95H
California 1995, (Great Lakes 6)	EC 960 g/l	1.1	1.8	1	97	Lettuce, head	0.22 0.15	Rep. 107520 FCA-DI001-95H

Arizona 1995 (Empire)	EC 960 g/l	1.2	0.25	1	116	Lettuce, head	<0.05 <0.05	Rep. 107520 458-DI002-95H
Florida 1996 (South Bay)	EC 960 g/l	1.2	2.0	1	62	Lettuce, head	≤0.05 ≤0.05	Rep. 107520 VBL-DI003-95H

Table 11. Disulfoton residues in potatoes resulting from soil applications in The Netherlands and the USA.

Country, year, (variety)	Application				PHI, days	Residues, mg/kg	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
Netherlands, 1971 (Bintjie).	–	1.5		1	113	0.05, 0.10, 0.03, <0.01 *c* 0.02	Report R 3957 (1973)
USA (California) 1995 (Green supreme)	–	1.5		1	113	<0.01, <0.01, 0.10, 0.21 *c* 0.12	

Interpretation Tables derived from new and previously reported data

Data which were evaluated by the JMPR in 1991 and 1994 (and in the case of rice in 1973) as well as those in Tables 8-11 above are interpreted in Tables 12-30.

Table 12. Interpretation table for disulfoton residues in barley from trials reported in Table 2 1991 and Table 5 1994. The trials were with soil and foliar applications in the USA and foliar sprays in Canada.

Country,	Application				PHI,	Residues,	
Year,	Form.	kg ai/ha	kg ai/hl	No.	days	mg/kg	Report No.
Canadian GAP		1.12		1-2	60		
Canada 1976	720 EC	1.12 foliar		2	30	0.01	49085 (1991)
US GAP	EC	0.56-1.12		1	30		
USA 1976	720 EC	1.12		2	29	0.06	49263 (1991)
				2	31	0.09	49262 (1991)
				2	30	0.02	49087 (1991)
				2	30	0.14 c 0.11	49088 (1991)
				2	30	≤0.01	49089 (1991)
				2	30	0.01	49090 (1991)
				2	30	≤0.01	50841 (1994)
				2	30	0.04	49091 (1991)
				1	74	<0.01	49230 (1991)
				1	154	<0.01	49201 (1991)
USA 1976	960 EC	1.12		2	31	0.10	68995 (1991)
					31	0.10	68996 (1991)
	720 EC	1.12		2	32	≤0.01	49264 (1991)
	720 EC	0.56 + 1.12		1 + 1	30	0.19 c 0.11	49261 (1994)
USA 1989[1]	15 GR + 960 EC	1.12 + 0.84		1 + 2	30	≤0.01	99130 (1991)
	15 GR + 960 EC	1.12 + 0.84		1 + 2	31	0.03	99130 (1991)
US GAP	GR/EC	1.12		1-2	60		
USA 1976	720 EC	1.12		1	74	≤0.01	49230 (1991)
USA 1976	15 GR	1.12		1	80	0.01	49203 (1991)
USA 1976	15 GR	1.12		1	74	≤0.01	49202 (1991)
USA 1976	960 EC	1.12		2	59	<0.02	91478 (1991)
				2	62	<0.02	91478 (1991)

Country,	Application				PHI,	Residues,	
Year,	Form.	kg ai/ha	kg ai/hl	No.	days	mg/kg	Report No.
				2	63	≤0.02	91478 (1991)
USA 1976	15 GR	1.12		2	61	0.02	49204 (1991)
		1.12		2	83	0.03	49200 (1991)
	15 GR	1.12		1	79	<0.01	49265 (1991)
	15 GR	1.12		2	61	≤0.01	49205 (1991)
	15 GR	1.12		2	62	≤0.01	49266 (1991)

[1]In-furrow at planting plus a ground application and a foliar application.

Table 13.Interpretation table for disulfoton residues in beans (lima beans, kidney beans and snap beans) from trials reported in Table 2 1991, Table 3 1994 and Table 8 1998 (shaded). Trials were with a soil application at planting, a soil injection or side-dress in the USA and an in-furrow treatment in Japan. Beans were analysed.

Country, Year, Type of bean	Application				PHI, days	Residues, mg/kg	Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
US GAP	EC/GR	1.12-2.24		1	60		
USA 1975	15 GR	2.3		1	106	≤0.01	461-470-75H
		2.3		1	105	≤0.01	461-477-75H
USA 1975		1.5		1	105	≤0.01	50692 (1994)
USA 1976	15 GR	3.16		1	86	0.03	49327 (1994)
USA 1976	960 EC	3.16		1	86	<0.01	49329 (1994)
USA 1976	960 EC	3.16		1	66	≤0.01	49208 (1991)
Dry beans		3.48		1	59	≤0.01	49328 (1991)
		2.18		1	60	≤0.01	49207 (1991)
	15 GR	3.16		1	66	≤0.01	49282 (1991)
		3.48		1	59	≤0.01	49288 (1991)
USA 1976	960 EC	3.87		1	70	0.02	49280 (1991)
Lima beans	15 GR	3.87		1	70	0.01	49281 (1991)
USA 1976	960 EC	3.48		1	52	0.10	49283 (1991)
Snap beans		1.55		1	60	≤0.01	49289 (1991)
		3.48		1	61	≤0.01	49284 (1991)
		3.16		1	63	0.04	49146 (1991)
		3.16		1	65	0.11	49279 (1991)
	15 GR	3.48		1	52	0.11	49212 (1991)
		1.55		1	60	≤0.01	49290 (1991)
		3.48		1	61	≤0.01	49285 (1991)
		3.16		1	63	0.14	49145 (1991)
		3.16		1	64	0.06	49715 (1991)
Japanese GAP	GR	2.0		1	60		
Japan 1972	5 GR	2.0		2	68	≤0.01	36/72 (1991)
Kidney beans		4.0		2	68	<0.01	
		2.0		2	62	≤0.01	
		4.0		2	62	<0.01	

Table 14. Interpretation table for disulfoton residues in brassica vegetables from trials reported in Table 2 1991 and Tables 2 and 3 1994. Trials were with a soil treatment or side-dress in the USA and an in-furrow treatment in Japan.

Crop	Application				PHI,	Residues,	Reference
Country, Year,	Form.	kg ai/ha	kg ai/hl	No.	days	mg/kg	Report No.
BROCCOLI							
US GAP	GR/EC	1.12		1	14		
Canadian GAP	GR	1.12		1	42		
USA 1987	960 EC	1.12 + 1.68		1 + 1	14	<0.02	91147[1] (1991)
					30	<0.02	
	960 EC	1.12 + 1.68		1 +1	14	0.05	
					41	<0.02	
	960 EC	1.12 + 2.04		1 + 1	15	0.03	
					29	0.11	
	15 GR + 960 EC	1.12 + 2.04		1 + 1	14	0.03	
					41	<0.02	
	15 GR + 960 EC	1.12 + 2.04		1 + 1	15	0.06	
					29	0.09	
	15 GR	1.12 + 2.04		1 + 1	14	<0.02	
					30	<0.02	
CABBAGE, head							
US GAP	EC	1.12-2.24		1	42		
	GR	1.12-1.70		1	42		
Canadian GAP	GR	1.12		1	42		
USA 1987	960 EC	1.12 + 1.72		1 + 1	30	0.09	91152[2] (1991)
					42	0.17	
	960 EC	1.12 + 3.16		1 + 1	31	0.02	
					42	<0.02	
		1.12 +1.30		1+ 1	39	<0.02	
					51	<0.02	
		1.12 + 1.72		1 + 1	32	<0.02	
					41	0.02	
		1.12		2	30	<0.02	
					42	<0.02	
	15 GR + 960 EC	1.12 + 3.16		1 + 1	31	0.03	
					42	<0.02	
	960 EC + 15 GR	1.12 + 1.30		1 + 1	39	<0.02	
					51	<0.02	
	15 GR	1.12 + 1.72		1 + 1	30	0.23	
					42	0.17	
	15 GR	1.12 + 1.72		1 + 1	32	<0.02	
					41	0.03	
	15 GR	1.12 + 1.48		1 + 1	30	<0.02	
					42	<0.02	
	960 EC	1.12 + 3.16		1 + 1	29	0.07	
					43	0.02	
	960EC	1.12 + 1.72		1 + 1	30	0.12	
					42	0.06	
	15 GR + 960 EC	1.12 + 3.16		1 + 1	15	0.11	
					29	0.03	
	15 GR	1.12 + 1.72		1 + 1	30	0.32	
					42	0.08	

Crop	Application				PHI,	Residues,	Reference
Country, Year,	Form.	kg ai/ha	kg ai/hl	No.	days	mg/kg	Report No.
Japanese GAP	GR	1.5-3.0		1	na		
Japan 1972	5 GR	2		1	57	0.073	27/72 (1991)
		4		1	57	0.096	
		2		1	69	0.072	28/72 (1991)
		4		1	69	0.063	
CAULIFLOWER							
US GAP	EC\GR	1.12		1-2	40		
Canadian GAP	GR	1.12		1-2	30		
USA 1987	960 EC	1.12		3	30	0.01	91154[3] (1991)
					40	0.31	
		1.12 + 1.68		1 +2	30	<0.01	
					40	<0.01	
		1.12 + 1.0		1 + 2	38	<0.01	
	15 GR	1.12		3	30	0.02	
					40	0.04	
	15 GR	1.12 + 1.68		1 + 2	30	<0.01	
					40	<0.01	
	15 GR	1.12		3	30	<0.01	
					40	0.01	
	15 GR	1.12 + 1.0		1 + 2	28	0.05	
					38	0.01	

[1]One soil spray followed by one side-dress spray.
[2]One soil broadcast followed by one side-dress spray.
[3]One broadcast application followed by two side-dress sprays.

Table 15. Interpretation table for disulfoton residues in coffee beans from trials reported in Table 2 1991. Trials were with soil application under the tree canopy.

Country, Year,	Application				PHI,	Residues,	Reference
	Form.	kg ai/ha	kg ai/hl	No.	days	mg/kg	Report No.
Puerto Rico GAP		4.3-8.6[1]		1-2	90		
(USA use pattern)		g ai/tree					
Puerto Rico 1986	GR	7.2		1	89	0.09 berries	91497 (1991)
						0.10 beans	
		28.8[2]		1	89	05 berries	
						0.2 beans	
		72.2[3]		1	89	0.28 berries	
						0.17 beans	

[1]Calculated from tree height of 2m, assuming 2200 trees/ha (0.3-0.6 g ai/30 cm of tree height).
[2]2.4 g ai/30 cm tree height, fourfold rate.
[3]6 g ai/cm tree height, tenfold rate.

Table 16. Interpretation table for disulfoton residues in cotton seed from trials reported in Table 2 1991, Table 11 1994 and Table 9 above (shaded). Trials were with applications at planting or before planting and post-plant in the USA and at planting in Greece.

Country, year,	Application				PHI,	Residues,	Reference
	Form.	kg ai/ha	kg ai/hl	No.	days	mg/kg	Report No.

Country, year,	Application				PHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
Greek GAP	GR	1.0-1.5		1	60[1]		
Greece 1993	10 GR	1.0		1	163	<0.12	RA-2037/93
					153	<0.12	
					169	<0.12	
					154	<0.12	
Greece 1994	10 GR	1.0		1	158	<0.06	RA-2037/94
					158	<0.06	
					150	<0.06	
					155	<0.06	
US GAP	EC	0.63-1.12		1			
		0.21-0.63		1-3			
		2.24		1	90		
		1.12		1	28		
	GR	0.67-1.12		1	28		
USA 1967	SC≡EC	2.24		1	127	0.1	21636[2]
		2.24		1	105	<0.03	21637[2]
		6.72		1	136	0.02	21639[2]
		4.48		1	110	0.02	21640[2]
		2.24		1	110	0.05	21641[2]
		2.24		1	145	<0.03	21642[2]
		2.24		1	88	<0.02	21643[2]
		2.24		1	133	<0.04	21644[2]
USA 1969	LC≡EC	1.12		3	99	<0.11 c 0.10	24014[3] (1994)
		1.12		3	89	0.04	24019[3] (1994)
		1.12		3	94	<0.05	24023[3] (1994)
		1.12		3	111	0.03	24029[3] (1994)
		1.12		3	88	0.12	24030[3] (1994)
		1.12		3	94	<0.05	24042[3] (1994)
		1.12		3	111	0.03	24044[3] (1994)
		1.12		3	88	0.12	24045[3] (1994)
		1.12		3	89	0.04	24046[3] (1994)
		0.5 + 1.12		1 + 3	45	<0.03	24018[4] (1994)
		0.5 + 1.12		1 + 3	33	0.03	24021[4] (1994)
		0.5 + 1.12		1 + 3	90	<0.06	24022[4] (1994)
		0.5 + 1.12		1 + 3	90	<0.06	24041[4] (1994)
		0.5 + 1.12		1 + 4	95	0.10	24020[4] (1994)
		0.5 + 1.12		1 + 4	95	0.10	24040[4] (1994)
USA 1972	15 GR	2.24		2	28	<0.19	33227[5] (1994)
		1.12		2	28	<0.19	
		2.24		2	28	<0.19	33228[5] (1994)
		1.12		2	28	<0.19	
USA1979	5 GR	2.3 + 3.68		1 + 1	119	<0.01	67811 ?
USA1979	5 GR	2.3 + 3.68		1 + 1	119	0.02	67812 ?
USA 1985	15 GR +	1.12 + 0.22		1 + 3	31	<0.01	87300 (1991)
	960 EC				35	<0.01	
		1.12 + 0.22		1 + 3	28	<0.01	87301 (1991)
					35	<0.01	
		1.12 + 0.22		1 + 3	35	<0.01	87302 (1991)
		1.12 + 0.22		1 + 3	28	<0.01	87363 (1991)
					35	<0.01	
	960 EC	1.12 + 0.22		1 + 3	31	<0.01	87303 (1991)

Country, year,	Application				PHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
					35	≤0.01	
		1.12 +0.22		1 + 3	28	≤0.01	87304 (1991)
					35	≤0.01	
		1.12 + 0.22		1 + 3	35	≤0.01	87305 (1991)
		1.12+ 0.22		1 + 3	28	≤0.01	87364 (1991)
					35	≤0.01	
USA 1987	960 EC + 15 GR+ 15 GR	0.5 + 0.93 + 1.12		1 + 1 +2	27	≤0.01	91487[6] (1991) 354-DI092-86D
		0.5 + 0.97 + 1.16		1 + 1 +2	38	0.43	BMS-DI095-86D[6] (1991)
		0.5 + 0.98 + 1.17		1 + 1+ 2	27	≤0.01	RTX-DI096-86D[6] (1991)
		0.5 + 0.92 + 1.13		1 + 1+ 2	28	0.05	458-DI093-86D[6] (1991)
		0.5 + 0.97 + 1.16		1 + 1 + 2	28	≤0.01	456-DI094-86D[6] (1991)
		0.5 + 0.93 + 2.24		1 + 1 + 2	47	≤0.01	354-DI097-86D[6] (1991)
		0.5 + 0.97 + 2.32		1 + 1+ 2	92	≤0.01	BMS-DI100-86D[6] (1991)
		0.5 + 0.97 + 2.34		1 + 1 + 2	83	≤0.01	RTX-DI101-86D[6] (1991)
		0.5 +0.92 + 2.26		1 + 1 + 2	90	0.05	458-DI098-96D[6] (1991)
		0.5 + 0.97 + 2.32		1 + 1 + 2	90	0.02	456-DI099-86D[6] (1991)

[1]From planting to harvest.
[2]Side-dress spray at squaring.
[3]Foliar spray.
[4]Seed treatment at 0.5 kg ai/100 kg seed plus 3 or 4 foliar treatments at 1.12kg ai/ha.
[5]In-furrow plus band side-dress.
[6]Seed treatment at 0.5 kg ai/100 kg seed, plus in-furrow application at planting and side-dress application post-emergent.

Table 17: Interpretation table for disulfoton residues in garden peas from trials reported in Table 2 1991 and Table 4 1994. Trials were with in-furrow and side-dress applications, USA.

Country, year,	Application				PHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
US GAP	GR	1.12-2.8		1	50		
	EC	1.12-2.24		1	50		
Canadian GAP	GR	1.12-2.62		1	50		
1976 (peas)	720 EC	2.8		1	49	≤0.01	49209[1] (1991)
					59	≤0.01	
					69	<0.01	
					79	<0.01	
	720 EC	2.8		1	56	≤0.01 peas	49210[1] (1991)
						≤0.01 pods	
					78	<0.01 peas	
						<0.01 pods	
	720 EC	2.8		1	33	0.02 peas	49298[1] (1991)
						<0.01 pods	
				1	50	≤0.01 peas	
						0.02 pods	

Country, year,	Application				PHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
					60	≤0.01 peas	
						0.08 pods	
					71	<0.01 peas	
						0.03 pods	
	720 EC	2.8		1	49	≤0.01	50840[1] (1991)
	15 GR	2.8		1	60	≤0.01	49299[1] (1991)
	15 GR	2.8		1	33	0.04 peas	49300[1] (1994)
						0.10 pods	
	15 GR	2.8		1	56	≤0.01 peas	49301[1] (1991)
						≤0.01 pods	
					70	<0.01 peas	
						<0.01 pods	
					78	<0.01 peas	
						<0.01 pods	
					85	<0.01 peas	
						<0.01 pods	
	15 GR	2.8		1	49	≤0.01	49302[1] (1991)
					59	≤0.01	
					69	<0.01	
					79	<0.01	
1976	15 GR	2.8		1	67	<0.01 pods	50670[1] (1991)
1978	720 EC	2.8		1	81	<0.01 peas	65779[1] (1994)
						<0.01 pods	
1969	720 EC	3.36		3	29	1.06	24138[2] (1994)
(Southern peas)[3]	720 EC	2.24		2	30	0.28	24139[2] (1994)
	720 EC	2.24		2	30	0.04	24140[2] (1994)
	720 EC	3.36		2	28	1.48	24141[2] (1994)
	720 EC	2.24		2	28	0.24	24150[2] (1994)
	720 EC	2.24		2	28	0.24	24151[2] (1994)
	10 GR	3.36		2	30	0.23	24193[2] (1994)
	10 GR	2.24		2	28	0.31	24205[2] (1994)
	10 GR	3.36		2	30	<0.02	24188[2] (1994)
	10 GR	2.24		2	30	<0.02	24204[2] (1994)

[1]Double side-dress, early post-emergent.
[2]Side-dress at planting and post-emergent.
[3]Black-eyed or Southern peas (green peas).

Table 18. Interpretation table for disulfoton residues in lettuce from trials reported in Table 10 above and Table 2 1991. Trials were with soil side-dress applications in the USA.

Country, year,	Application				PHI, days	Residues, mg/kg	Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
US GAP	960 EC	1.12-2.24		1	60		
1985	960 EC	1.1		1	60	0.11	91473
leaf lettuce		2.23		1	59	≤0.03	
		2.44		1	50	0.56	
		1.05		1	61	≤0.03	
		2.92		1	60	0.06	
1985	960 EC	1.1		1	61	0.64	
head lettuce		2.23		1	62	≤0.03	
		2.44		1	60	0.44	
		2.92		1	59	0.10	

		1.05		1	61	0.04	
1995	960 EC	1.1		1	60	1.09, 1.15	107520
leaf lettuce		1.14		1	73	0.57, 0.59	
1995	960 EC	1.21		1	62	<0.05, <0.05	
head lettuce							

Table 19. Interpretation table for disulfoton residues in maize from trials reported in Table 2 1991 and Table 6 1994. Trials were with side-dress applications and foliar sprays in the USA.

	Application				PHI,	Residues,	Reference
Country, year,	Form.	kg ai/ha	kg ai/hl	No.	days	mg/kg	Report No.
US GAP	EC	1.12		1[1]	28		
		0.56-1.12		1	28		
Canadian GAP	GR	1.12		1	100		
1975	720 EC	1.12		3	35	<0.01	44179[2] (1991)
	720 EC	1.12		3	24	<0.01	44181[2] (1991)
	720 EC	1.12		3	29	<0.01	44183[2] (1991)
	720 EC	1.12		3	28	<0.01	44184[3] (1991)
					42	0.07	
	720 EC	1.12		3	28	<0.01	49307[4] (1991)
					35	<0.01	
	720 EC	1.12		3	21	<0.01	49476[4] (1991)
					28	<0.01	
	720 EC	1.12		3	21	<0.01	53294[4] (1994)
					28	<0.01	
					35	<0.01	
					42	<0.01	
	720 EC	1.12		3	21	<0.01	53298[4] (1994)
					28	<0.01	
					35	<0.01	
					42	<0.01	
	720 EC	1.12		3	21	<0.01 *c*	53297[5] (1994)
						0.05	
					28	<0.01	
1987	960 EC	1.46 + 1.12		1 + 1	27	<0.02	91482 (1991)
							255-DI068-86D[6]
					45	<0.02	
	960 EC	1.22 + 1.12		1 + 1	28	<0.02	HIN-DI069-86D[6]
					45	<0.02	
	960 EC	1.22 + 1.12		1 + 1	27	<0.01	STF-DI070-86P[6]
					47	<0.01	
	960 EC	1.46 + 1.12		1 + 1	29	<0.02	251-DI066-86D[6]
					45	<0.02	
	960 EC	1.46 + 1.12		1 + 1	28	<0.02	252-DI067-86D[6]
					45	<0.02	

[1]One soil and one foliar treatment per season.
[2]Foliar spray.
[3]ULV aerial application.
[4]Foliar spray.
[5]Topical pre-emergent.
[6]Side-dress and foliar spray.

Table 20. Interpretation table for disulfoton residues in oats from trials reported in Table 2 1991. Trials were with a broadcast spray at planting or broadcast sprays both pre- and post-emergent in the USA.

	Application				PHI,	Residues,	Reference
Country, year,	Form.	kg ai/ha	kg ai/hl	No.	days	mg/kg	Report No.
Canadian GAP	GR	1.12		1-2	60		

Country, year,	Application				PHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
USA 1976	15 GR	1.12		2	61	<0.01	49214[1]
	15 GR	1.12		2	62	<0.01	49215[1]
	15 GR	1.12		2	66	<0.01	49216[1]
	15 GR	1.12		1	79	<0.01	49215[1]
	720 EC	1.12		1	79	<0.01	49297[2]
	720 EC	1.12		1	80	<0.01	49314[2]

[1]Broadcast application pre- and post-emergent.
[2]Broadcast spray incorporated at planting.

Table 21. Interpretation table for disulfoton residues in peanuts from trials reported in Table 2 1991. Trials were with a side-dress and band application in the USA.

Country, year,	Application Form.	kg ai/ha	kg ai/hl	No.	PHI, days	Residues, mg/kg	Reference Report No.
US GAP	GR	1.12-2.23		1	80		
USA 1987	15 GR	1.72		2	62	0.02	91492
kernels					72	0.02	
	15 GR	2.26		2	60	0.09	91492
	15 GR	2.20		2	61	<0.01	91492
					75	<0.01	
	15 GR	2.29		2	85	<0.01	91492

Table 22. Interpretation table for disulfoton residues in pecan nuts from trials reported in Table 2 1991 and Table 12 1994. Trials were with foliar and aerial applications in the USA.

Year,	Application Form.	kg ai/ha	kg ai/hl	No.	PHI, days	Residues, mg/kg	Reference Report No.
US GAP	EC	1.68-3.36		1	80		
		0.84-1.68		1-3	30		
		0.84-1.12		1-3	30		
1971	720 EC	1.68		3	22	0.21	32688[1] (1994)
		1.12		3	22	0.08	32683[1] (1994)
		5.40		3	28	<0.05	32684[1] (1994)
		2.24		3	41	<0.1 (c = 0.1)	32685[1] (1994)
		3.58		3	30	<0.01	32686[1] (1994)
		2.24		3	28	0.22	32687[1] (1994)
		3.36		3	41	<0.11	32689[1] (1994)
		5.38		3	30	0.05	32690[1] (1994)
		3.36		3	28	0.43	32691[1] (1994)
		6.72		3	31	<0.08	32692[1] (1994)
		5.88-7.06		3	26	<0.03	32693[1] (1994)
1975	720 EC	1.12		3	31	<0.01 kernel 0.85 shell	44344[2] (1991)
		1.68		3	30	0.01 kernel <0.01 shell	44345[2] (1991)
		1.68		3	31	<0.01 kernel <0.01 shell	44346[2] (1991)
		1.12		4	30	<0.02 kernel 0.03 shell	44347[2] (1991)
s		1.12		3	30	<0.01 kernel <0.01 shell	44348[2] (1991)

[1]Foliar spray. [2]Aerial spray.

Table 23. Interpretation table for disulfoton residues in pineapples from trials reported in Table 2 1991 from Martinique and Brazil.

Country, year,	Application Form.	kg ai/ha	kg ai/hl	No.	PHI, days	Residues, mg/kg	Reference Report No.
French GAP	GR	0.025[1]		1	na		
Martinique 1966	5 GR	0.025[1,2]		1	92	<0.1	4/66
	5 GR	0.025[1]		1	61	<0.1	
	5 GR	0.025[1]		1	29	<0.1	
Honduras GAP	GR	4.8-7.2		1-3	90		
	GR	2.5-3.0 (0.1[1])		1	na		
Brazil 1983	2.5 GR	0.075[1]		1	90	<0.1	65780

Country, year,	Application				PHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
	2.5 GR	0.075[1]		1	60	<0.1	
	2.5 GR	0.15[1]		1	90	<0.1	
	2.5 GR	0.15[1]		1	60	<0.1	

[1]g ai/plant [2]Spread into the upper leaves and on the bottom of the stigma.

Table 24. Interpretation Table for disulfoton residues in potatoes from trials reported in Table 2 1991 and Table 11 1998 (shaded). Trials were with in-furrow, side-dress and band applications in the USA and a broadcast application in Japan.

Country, year,	Application				PHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
US GAP	EC	3.36-4.48[1]		1-2			
		2.24-3.36[2]		1-2	75		
		0.42-1.12[3]		1-3	30		
		3.36[4]		1	60		
	GR	2.27-3.44[5]		1-2			
		3.36-4.48[6]		1			
USA 1968	720 SC	3.36		2	60	0.11	21980[7] (1991)
		3.36		2	63	0.31	21990[7] (1991)
		3.36		2	61	<0.02	21992[8] (1991)
USA 1967	10 GR + 720 SC	3.36 + 3.36		1 + 1	60	0.15	21576[9] (1991)
					87	0.08	
	10 GR + 720 SC	3.36 + 3.36		1 + 1	60	0.07	21588[9] (1991)
					87	0.16	
USA 1968	10 GR + 720 SC	3.36 + 3.36		1 + 1	60	0.07	21959[7] (1991)
	10 GR + 720 SC	3.36 + 3.36		1 + 1	60	0.01	21961[7] (1991)
	10 GR	3.36		2	63	<0.01	21989[7] (1991)
	10 GR	3.36		2	60	0.09	21993[7] (1991)
					90	0.20	
USA 1973	15 GR	1.12 + 3.36		1 + 1	78	0.13, 0.23	39081[10] (1991)
USA 1986	15 GR	3.36		2	75	<0.01	91467[11] (1991)
	15 GR	3.36		2	64	0.06	91467[12] (1991)
					77	<0.01	
Japanese GAP	GR	2.0		1	na		
Japan 1971	5 GR	2.0		1	85	0.04	90/71[13] (1991)
	5 GR	2.0		1	105	0.07	
	5 GR	2.0		1	85	0.12	
	5 GR	2.0		1	105	0.10	
Netherlands 1971		1.5		1	113	0.05, 0.10, 0.03, <0.01 c 0.02	R 3957 (1998)
USA 1995		1.5		1	113	<0.01, <0.01, 0.10, 0.21 c 0.12	

[1]Pre-plant broadcast application. [2]In-furrow, soil injection or side-dress at planting.
[3]Foliar spray. [4]Foliar spray.
[5]In-furrow application. [6]Broadcast application.
[7]In-furrow, side-dress application. [8]Double band, side-dress application. (Continued)
[9]At planting, side-dress spray. [10]Post-emergent band application (side-dress).

[11]Soil application.
[12]Post-emergent aerial application.
[13]Broadcast application.

Table 25. Interpretation table for disulfoton residues in Japanese radishes from trials reported in Table 2 1991. Trials were with an in-furrow application in accordance with GAP in Japan.

Country, year,	Application				PHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
Japanese GAP	GR	1.5-2.0		1	na		
Japan 1977	5 GR	1.0		1	61	0.05	N463/76
					67	0.01	
	5 GR	1.5		1	61	0.12	
					67	0.10	
	5 GR	1.0		1	56	0.02	N 465/76
					63	0.05	
	5 GR	1.5		1	56	0.14	
					63	0.08	
	5 GR	1.0		1	61	0.02	N 467/76
					68	0.02	
	5 GR	1.5		1	61	0.02	
					68	0.03	
	5 GR	1.0		1	75	0.004	N 469/76
					82	0.004	
	5 GR	1.5		1	75	0.004	
					82	0.004	
Japan 1978	5 GR	1.0		1	102	0.008	N 569.78
					112	0.01	
	5 GR	1.5		1	102	0.02	
					112	0.02	

Table 26. Interpretation table for disulfoton residues in rice from trials reported in Table 1 1973.

Year	Application				PHI, days	Residues, mg/kg	Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
Japanese GAP	GR	2 0-3.0		1-2	50		
1971	5 GR	3.0		1	119	<0.01	20/71
	5 GR	3.0		1	139	<0.01	19/71
1972	5 GR	3.0		1	90	<0.01	34/72

Table 27. Interpretation table for disulfoton residues in sorghum from trials reported in Table 2 1991 and Tables 7 and 8 1994. Trials were with in-furrow, side-dress and foliar applications in accordance with GAP in the USA.

Year	Application				ssPHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
US GAP	GR	0.84-1.12[1]		1	30		
1969	10 GR	1.12		1	32	0.02	24049
	10 GR	1.12		1	33	0.04	24051
	10 GR	1.12		1	30	0.01	24052
	10 GR	1.12		1	35	0.04	24053
	10 GR	1.12		1	29	0.02	24054
	10 GR	1.12		1	30	<0.01	24055
	10 GR	1.12		1	32	0.08	24056

Year	Application				ssPHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
1969	10 GR	1.12		3	30	<0.01	24048
1971	15 GR	1.12		3	30	<0.02	33159
1971	15 GR	1.12		3	30	0.02	33154
1971	15 GR	1.12		4	30	<0.05	33155
1971	15 GR	1.12		3	47	0.09	33161
1975	15 GR	1.22 + 1.12		1 + 3	33	0.01	49466
1975	15 GR	1.22 + 1.12		1 + 3	33	0.01	49466
1972	15 GR	1.68		4	30	<0.05	33153
1972	15 GR	1.68		4	29	0.04	33157
1972	15 GR	1.68		3	30	0.06	33160
US GAP	EC	0.84-1.12[2]		1			
		1.12[3]		1			
		1.12[4]		1			
		0.28-0.56		[5]	34		
		0.28-0.56		1-2	7		
		0.28-0.56		3	34		
1987	960 EC	1.12		2	7	0.24	353-DI064-86D
					14	0.04	(OK)[6]
	960 EC	1.12		2	7	0.15	353-DI065-86D
					14	0.08	(OK)[6]
	960 EC	1.12		2	5	1.46	352-DI062-86D
					13	0.87	(TX)[6]
	960 EC	1.12		2	5	3.67	352-DI063-86D
					13	2.52	(TX)[6]
1968	720 EC	0.56		1	35	<0.01	23397[7]
1968	720 EC	1.12		2	7	0.28	23969[7]
	720 EC	1.12		2	7	<0.01	23970[7]
	720 EC	1.12		2	7	0.09	23973[7]
	720 EC	1.12		2	7	0.73	23974[7]
	720 EC	1.12		2	7	0.39	23975[7]
	720 EC	1.12		2	7	0.56	23976[7]
1971	720 EC	1.12 + 1.12+ 0.56		1 + 1+ 3	34	<0.01	29388[8]
	720 EC	1.12 + 1.12 + 0.56		1 + 1+ 3	46	<0.01	29391[8]
	15 GR + 15 GR	1.12 + 1.12		1 + 3	29	0.10	33158[9]
1975	15 GR + 15 GR	1.46 + 1.12		1 + 2	29	0.08	49934[10]
	720 EC	1.46 + 1.12		1 + 2	29	0.23	49936
1970	720 EC 15 GR 720 EC	1.12 + 1.12 + 0.56		1 + 1 + 3	34	<0.01	29839[11]

[1]In furrow or band in soil at planting.
[2]At planting in-furrow application.
[3]At planting band application.
[4]Post planting side-dress application.
[5]Any soil plus any foliar application.
[6]Foliar spray, ground or aerial application.
[7]Foliar spray.
[8]In-furrow side-dress and foliar spray.
[9]Pre-emergent band application and broadcast.
[10]Side-dress and foliar application.
[11]In-furrow and side-dress and foliar spray.

Table 28. Interpretation table for disulfoton residues in sugar beet from trials in the USA reported in Table 2 1991. Trials were with in-furrow and foliar sprays and topical applications.

Country, year	Application				PHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
Chile GAP	GR	1.0		1	30		
USA 1970	10 GR + 720 SC	1.7 + 1.12		1 + 5	15	0.03	27025[1]
	10 GR + 720 SC	1.7 + 1.12		1 + 5	15	<0.01	27077[2]
	10 GR + 720 SC	1.12		6	15	0.01	27078[3]
	15 GR + 720 SC	1.8 + 1.12		1 + 5	15	0.02	26974[3]
	15 GR + 720 SC	1.8 +1.12		1 + 5	15	<0.03	26975[3]
	15 GR + 720 SC	1.3 + 1.12		1 + 5	21	0.01	27023[3]
	15 GR + 720 SC	1.7 + 1.12		1 + 5	15	0.01	27024[3]
	15 GR + 720 SC	1.7 + 1.12		1 + 5	15	0.04	27075[3]
					31	0.06	
	15 GR + 720 SC	1.10 + 1.12		1 + 3	28	0.02	50671[4]
	15 GR + 15 GR	1 64 + 1.12		1 + 3	29	<0.01	49295[4]
	15 GR + 15 GR	1.64 + 1.12		1 + 3	30	<0.01	49296[4]
					40	0.03	
	15 GR + 15 GR	1.50 + 1.12		1 + 3	28	0.06	50833[4]
					40	0.01	
	15 GR + 15 GR	1.50 + 1.12		1 + 3	31	0.06	53066[4]

[1]In-furrow and foliar sprays.
[2]Soil band and foliar sprays.
[3]In-furrow and topical application over the row.
[4]In-furrow and topical applications over the row.

Table 29. Interpretation table for disulfoton residues in tomatoes from trials reported in Table 2 1991. Trials were with drip and side-dress applications in accordance with GAP in the USA and Japan.

Country, year,	Application				PHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
US GAP	EC	1.12-3.36		1-2	30		91474
USA 1987	960 EC	1.46		2	14	0.02	456-DI109-86D
					20	<0.01	(1991)
					27	<0.01	
	960 EC	2.09		2	14	0.36	457-DI110-86D
					21	0.01	(1991)
					28	0.02	
	720 EC	1.46		2	14	<0.01	458-DI111-86D
					21	<0.01	(1991)
					28	<0.01	
Japanese GAP	GR	1.5-3.0		1	na		
Japan 1977	5 GR	0.05[1]		1	70	<0.01	N 476/76
	5 GR	0.1[1]		1	70	<0.01	N 476/76
	5 GR	3.0 + 0.1[1]		1 + 1	30	0.05	N 476/76
					41	0.05	
	5 GR	0.05[1]		1	38	0.03	N 477/76
	5 GR	0.1[1]		1	38	0.05	
	5 GR	3.0 + 0.1[1]		1 + 1	33	0.04	N 477/76

[1]g ai/plant.

Table 30. Interpretation table for disulfoton residues in wheat from trials reported in Table 2 1991 and Tables 9 and 10 1994. Trials were with in-furrow and foliar applications according to US GAP.

Country, year	Application				PHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
US GAP	EC	1.12		1[1]	na		
		0.28-0.84		1-3[2]	30		
	GR	1.12		1[3]	75		
USA 1967	720 SC	1.12		1	29	<0.01	21416[4] (1994)
USA 1968	720 EC	0.84		2	30	<0.02	23115[4] (1994)
	720 SC	0.84		2	29	<0.1	23117[4] (1994)
	720 SC	0.84		3	33	0.14	23118[4] (1994)
USA 1970	720 SC	0.28 + 0.56 + 1.12		2 + 1 + 1	30	<0.01	26557[4] (1994)
	720 LC	0.28 + 0.56 + 1.12		2 + 1 + 1	30	0.02	26579[4] (1994)
	720 LC	0.28 + 0.56 + 1.12		2 +1 +1	30	0.24	26580[4] (1994)
	720 LC	0.28 + 0.56 + 1.12		2 + 1 + 1	30	0.18	26581[4] (1994)
	720 LC	0.28 + 0.56 + 1.12		2 + 1 + 1	30	0.02	26582[4] (1994)
	720 LC	0.28 + 0.56 + 1.12		2 + 1 +1	29	0.01	26583[4] (1994)
	720 LC	0.84 + 1.12		2 + 2	30	<0.01	26895[4] (1994)
	720 LC	0.84 + 1.12		2 + 2	29	0.05	26896[4] (1994)
	720 LC	0.28 + 0.56 + 1.12		2 + 1 + 1	29	0.27	26905[4] (1994)
	720 LC	0.84 + 1.12		2 + 2	30	0.02	26944[4] (1994)
	720 LC	0.84 + 1.12		2 + 2	30	0.01	26945[4] (1994)
	720 LC	0.28 + 0.56 + 1.12		2 + 1 + 1	33	0.02	26946[4] (1994)
	720 LC	0.84 + 1.12		2 + 2	33	0.04	26947[4] (1994)
	720 LC	0.84 + 1.12		2 + 2	30	<0.01	26954[4] (1994)
	720 LC	0.84 + 1.12		2 + 2	30	0.19	26956[4] (1994)
	720 LC	0.84 + 1.12		2 + 2	29	0.05	26961[4] (1994)
	720 LC	0.84 + 1.12		2 + 2	33	0.03	26962[4] (1994)
	720 LC	0.28 + 0.56 + 1.12		2 + 1 +1	33	0.04	26963[4] (1994)
USA 1988	960 EC	0.84		2	31	<0.01	87173[4] (1991)
				2	31	<0.01	
				2	31	<0.01	
				2	31	<0.01	
				2	31	<0.01	
				2	31	<0.01	
				2	31	<0.01	
USA 1987	15 GR + 960 EC	1.12 + 0.84		1 + 2	26	<0.02	91477[5] (1991)
	15 GR + 960 EC	1.12 + 0.84		1 + 2	29	<0.02	
	15 GR + 960 EC	1.12 + 0.84		1 + 2	30	0.02, <0.02	
	15 GR + 960 EC	1.12 + 0.84		1 + 2	32	<0.02	
	15 GR + 960 EC	1.12 + 0.84		1 + 2	37	<0.02	
	15 GR + 960 EC	1.12 + 0.84		1 + 2	38	<0.02	

Country, year	Application				PHI, days	Residues, mg/kg	Reference Report No.
	Form.	kg ai/ha	kg ai/hl	No.			
	15 GR + 960 EC	1.12 + 0.84		1 + 2	31	<0.02	
	960 EC	0.84		2	28	<0.02	
	960 EC	0.84		2	31	<0.02	
USA 1989	15 GR + 960 EC	1.12 + 0.84		1 + 2	30	<0.01	99130[5] (1991)
winter wheat	15 GR + 960 EC	1.12 + 0.84		1 + 2	30	0.03	
	15 GR + 960 EC	1.12 + 0.84		1 + 2	31	<0.01	
	15 GR + 960 EC	1.12 + 0.84		1 + 2	31	<0.01	
	15 GR + 960 EC	1.12 + 0.84		1 + 2	30	<0.01	
	15 GR + 960 EC	1.12 + 0.84		1 + 2	31	0.01	
	15 GR + 960 EC	1.12 + 0.84		1 + 2	30	0.01	
	15 GR + 960 EC	1.12 + 0.84		1 + 2	27	<0.01	
	15 GR + 960 EC	1.12 + 0.84		1 + 2	29	<0.01	
	15 GR + 960 EC	1.12 + 0.84		1 + 2	29	0.01	
	15 GR + 960 EC	1.12 + 0.84		1 + 2			
USA 1975	15 GR	1.12		2	26	0.16	43155[6] (1994)
	15 GR	1.12		2	26	<0.05	43615[6] (1994)
	15 GR	0.56		2	26	0.05	43617[6] (1994)
	15 GR	1.12		2	26	<0.05	43621[6] (1994)
Canada 1989	720 LC	0.84		1	30	<0.01	99215[4] (1994)
	720 LC	0.84		1	30	<0.01	
	720 LC	0.84		1	30	<0.01	
	720 LC	0.84		1	30	0.11	

[1]Soil injection.
[2]Foliar sprays; 1 autumn and 2 spring applications.
[3]Drilling or broadcast.
[4]Foliar spray.
[5]Soil broadcast or in-furrow and aerial or ground foliar sprays.
[6]Broadcast application.

FATE OF RESIDUES IN STORAGE AND PROCESSING

In storage

No information.

In processing

The Meeting received information on the fate of disulfoton during the processing of coffee, cotton seed, maize, potatoes, sorghum and wheat.

In the trials reported by the manufacturer, processing factors are calculated on the basis of average residues in the raw agricultural and processed commodities. All analyses were by the revised

method 00318 of Thornton (1978) in which residues are oxidized to disulfoton sulfone and disulfoton oxygen analogue sulfone.

Coffee. Disulfoton 15 GR was applied at a rate 3 g ai/30 cm tree height (112 g product/tree, 16.8 g ai/tree) to the soil around coffee trees at the time of berry filling (Duah 1997b). The application rate was approximately 5 times the maximum label rate. Trees were 4-5 years old and the plot was 633 m^2. The beans were harvested 89 days after treatment and the skin, pulp and endocarp were removed to leave the green beans. Samples were removed for analysis and the remaining beans were processed into roasted beans and instant coffee. Samples of green and roasted beans, and instant coffee were analysed for disulfoton residues. The limit of determination was 0.1 mg/kg.

Table 31. Disulfoton residues in coffee beans and their processed products after a single soil treatment at 112 g ai/tree.

Sample	Residues, mg/kg[1]	Processing factor
Coffee beans (green)	0.289, 0.298, 0.302	
Roasted coffee beans	<0.1, <0.1, <0.1, <0.1, <0.1, <0.1	<0.3
Instant coffee	<0.1, <0.1, <0.1	<0.3

[1]Replicate samples analysed.

Recoveries were 87 to 106% from green coffee beans, 77 to 109% from roasted coffee beans and 73 to 100% from instant coffee over all the individual components of the residue definition. Overall, recoveries from instant coffee were lower (average 78%) for each compound at 0.1 mg/kg.

Cotton. In a US processing study (Freeseman, 1997), disulfoton was applied in-furrow at a rate equivalent to 5.48 kg ai/ha[N7]. 24 days after planting (1st leaf stage), a soil injection at 10.92 kg ai/ha was applied on each side of the row, and 51 days after planting (6-8 leaf stage), a foliar spray was applied at 3.15 kg ai/ha. Two additional foliar sprays were applied at 7-day intervals, with the final spray at squaring, 111 days before harvest. Each individual treatment was 5 times the maximum recommended rate. GAP in the USA dictates that soil and foliar treatments are not both made within the same crop year, so the treatment regime was exaggerated. The cotton was mechanically harvested and ginned and the seed was processed into meal, hulls and refined, bleached and deodorised oil. Undelinted seed samples were stored frozen for 12 months and the processed commodities for 9, 8 and 7 months before analysis. The storage stability of disulfoton residues in undelinted cotton seed was reported by Wiedmann and Koch (1994) and Lemke (1996). The residues found in the cotton seed and processed products are shown in Table 32. As all the residues were below the LOD, processing factors could not be calculated.

Table 32. Residues in cotton seed and processed commodities after an in-furrow treatment (5.48 kg ai/ha), soil injection (10.92 kg ai/ha) and three foliar sprays (3.15 kg ai/ha).

Sample	Residues[1], mg/kg
Undelinted cottonseed	<0.025, <0.025, <0.025
Hulls	<0.025, <0.025, <0.025
Meal	<0.025, <0.025, <0.025
Refined, bleached, deodorised oil	<0.025, <0.025, <0.025

[1]Replicate samples analysed. Limit of determination = 0.025 mg/kg

Recoveries were determined with fortification either with individual compounds or mixtures of the three P=S and three P=O compounds. Recoveries were 76 to 112% from undelinted cotton

seed, 84 to 112% from hulls, 72 to 92% from meal and 72 to 112% from oil. The limit of determination was 0.025 mg/kg.

Maize. In a US processing study (Duah, 1997c), disulfoton was applied as a band at planting at a rate equivalent to 6.72 kg ai/ha, and 7 days before harvest a foliar spray was applied at 5.6 kg ai/ha. Both applications were 5 times the US label rate. Mature maize was mechanically harvested 7 days after the foliar application and immediately frozen. All commodities were stored and analysed within 6 months of harvest. The maize was used to generate aspirated grain fractions and starch, grits, meal, flour, refined, bleached and deodorised (RBD) wet and dry milling oil. The grain, aspirated fractions and processed commodities were analysed for disulfoton residues with the results shown in Table 33.

Table 33. Disulfoton residues in maize and its processed commodities from a band application of 6.72 kg ai/ha at planting and a foliar spray of 5.6 kg ai/ha 7 days before harvest.

Sample	Residues, mg/kg[1]	Processing factor
Grain	0.38, 0.45, 0.40	
Aspirated grain fractions	3.31, 6.19, 3.13, 4.34	10.3
Starch	<0.1, <0.1, <0.1	<0.25
Grits	<0.1, <0.1, <0.1	<0.25
Meal	<0.1, <0.1, <0.1	<0.25
Flour	<0.1, <0.1, <0.1	<0.25
RBD wet milling oil	<0.1, <0.1, <0.1	<0.25
RBD dry milling oil	<0.1, <0.1, <0.1	<0.25

[1]Replicate samples analysed. Limit of determination = 0.1 mg/kg based on total residues.

The results show concentration of residues from processing of the RAC to aspirated grain fractions by a factor of about 10. On further processing, no residues above the limit of determination were found in any of the products.

Residues in sweet corn were stable during 6 months of frozen storage (Wiedmann and Koch, 1994). No data were available on the storage stability of processed maize commodities.

Recoveries in the individual commodities were determined by fortification separately with disulfoton, disulfoton sulfone and sulfoxide, and disulfoton oxygen analogue, and its sulfone and sulfoxide, and mixtures of the three P=S compounds and of the three oxons. Fortification concentrations were 0.1 mg/kg of the individual compounds and 0.2 and 0.45 mg/kg of the three-compound mixtures in all commodities except aspirated grain fractions where 3 and 6 mg/kg concentrations were used.

Potatoes. A Canadian and several US processing studies were reported (Anon., 1968). Potatoes were treated with 10% GR at 48, 64 or 72 oz/acre, either as an in-furrow plus side-dress or a band spray at planting followed by a side-dress. The tubers were harvested 60 or 87 days after planting. Field details and validation data were not reported. The results are shown in Table 34.

Table 34. Processing data for potatoes not previously reviewed.

Sample	Residues, mg/kg	Processing factor	Report
Whole potato, raw	0.15, 0.08		21576
Peel, raw	0.13, 0.10	0.87, 1.25	
Potato, peeled, raw	0.23, 0.09	1.53, 1.13	
Potato, peeled, boiled	0.05, 0.05	0.33, 0.63	
Whole potato, raw	0.04		21998
Peel, raw	0.07	1.75	
Potato, peeled, raw	0.05	1.25	
Potato, peeled, boiled	<0.01	0.25	
Whole potato, raw	<0.02		21989
Peel, raw	0.35	17.5*	
Potato, peeled, raw	0.09	4.5*	
Potato, peeled, boiled	<0.02	1	
Whole potato, raw	0.15		21984
Peel, raw	0.05	0.33	
Potato, peeled, raw	0.03	0.2	
Potato, peeled, boiled	0.03	0.2	
Whole potato, raw	0.27		21980
Peel, raw	0.73	2.7	
Potato, peeled, raw	0.31	1.15	
Potato, peeled, boiled	0..08	0.3	
Whole potato, raw	<0.02		21962
Peel, raw	<0.02	1	
Potato, peeled, raw	<0.01	0.5	
Potato, peeled, boiled	<0.01	0.5	
Whole potato, raw	<0.01		21961
Peel, raw	<0.02	2	
Potato, peeled, raw	<0.01	1	
Potato, peeled, boiled	<0.01	1	
Whole potato, raw	0.08		21960
Peel, raw	0.07	0.88	
Potato, peeled, raw	0.07	0.88	
Potato, peeled, boiled	0.01	0.13	
Whole potato, raw	0.07		21959
Peel, raw	<0.02	0.29	
Potato, peeled, raw	<0.01	0.14	
Potato, peeled, boiled	<0.01	0.14	
Whole potato, raw	0.02		21602
Peel, raw	0.06	3	
Potato, peeled, raw	0.02	1	
Potato, peeled, boiled	0.09	4.5*	
Whole potato, raw	0.07, 0.16		21588
Peel, raw	0.15, 0.08	2.14, 0.5	
Potato, peeled, raw	0.08, 0.05	1.14, 0.31	
Potato, peeled, boiled	0.05, 0.02	0.71, 0.13	

*Outliers. Not included in the calculation of the average processing factor.

In a recent potato processing study (Harbin 1997a), disulfoton was applied in-furrow at planting at a rate equivalent to 16 kg ai/ha, and foliar applications were made at the rate of 5.4 kg ai/ha 61, 75 and 89 days after planting. All application rates were five times the maximum US GAP. Mature tubers were harvested 30 days after the final foliar application. Samples were taken for analysis and the remainder were processed into granules, chips, wet peel and dry peel; the dry peel was not analysed. The tubers were stored frozen for 711 days; granules and chips for 399 days, and

wet peel samples for 731 days. The residues in potato tubers were shown to be stable for 24 months, and in chips, granules and wet peel for 13 months (Wiedmann and Koch, 1994; Lemke, 1996; Lenz, 1996).

Table 35. Residues in potato tubers and processed commodities after an in-furrow treatment at 16 kg ai/ha and three foliar sprays at 5.4 kg ai/ha.

Sample	Residues, mg/kg[1]	Processing factor
Tubers	0.37, 0.34, 0.40	
Granules	0.66, 0.48, 0.43	1.4
Chips	0.22, 0.21, 0.18	0.54
Wet peel	0.56, 0.65, 0.71	1.7

[1]Replicate samples analysed. LOD = 0.1 mg/kg in tubers and [0.25 mg/kg in processed commodities.

Recoveries of disulfoton at fortification levels of 0.25 mg/kg were 93 to 95% from tubers, 87 to 92% from granules, 76 to 82% from chips and 86 to 90% from wet peel, and at 0.1 mg/kg recoveries of disulfoton, disulfoton sulfoxide and sulfone from tubers were 83, 79 and 88% respectively. Recoveries of disulfoton oxygen analogue sulfoxide at 0.25 mg/kg were 119 to 122 % from tubers, 100 to 110 % from granules, 98 to 106% from chips and 112 to 118% from wet peel. At 0.1 mg/kg recoveries of disulfoton oxygen analogue, its sulfoxide and sulfone from tubers were 105, 96 and 109% respectively.

Sorghum. Disulfoton was applied at planting in-furrow at a rate equivalent to 3.66 kg ai/ha, and as a side-dress application at the same rate 111 days after planting (Harbin, 1997b). Three foliar sprays were applied at 1.7 kg ai/ha 125, 138 and 152 days after planting (at ripening). All the applications were 3 times the maximum US label rate.

Sorghum was mechanically harvested 161 days after planting or 8 days after the final foliar application. Mature grain was sampled for analysis and the remaining grain processed into aspirated grain fractions. The grain and aspirated fractions were stored frozen for 15 months and 4 months respectively before analysis. Residues of disulfoton were shown to be stable for 24 months of frozen storage without any degradation (Wiedmann and Koch, 1994). The residues in the grain and aspirated grain fractions are shown in Table 36.

Table 36. Disulfoton residues in sorghum grain and aspirated grain fractions after an in-furrow treatment and a side-dress application at 3.66 kg ai/ha and three foliar sprays at 1.7 kg ai/ha.

Sample	Residues, mg/kg[1]	Processing factor
Sorghum grain	1.57, 1.34, 1.68	
Aspirated grain fractions	3.95, 4.04, 4.07	2.7

[1]Replicate samples analysed. Limits of determination 0.25 mg/kg in grain and 0.5 mg/kg in aspirated grain fractions.

Recoveries of disulfoton, its sulfoxide and sulfone at 0.25 mg/kg from sorghum were 99, 106 and 101% respectively, and for a mixture of the three compounds at 1.5 mg/kg 83, 80 and 116%. In aspirated grain fractions, recoveries were 94, 101 and 101% for disulfoton, its sulfoxide and sulfone at 1 mg/kg, and 82, 78 and 78% for the mixture of the three compounds at 3.75 mg/kg. Recoveries of disulfoton oxygen analogue, its sulfoxide and sulfone were 110, 99, 110% from grain at 0.25 mg/kg and 117, 97 and 118% from grain fractions at 0.5 mg/kg. Recoveries of a mixture of the three compounds at 0.45 mg/kg were 97, 114 and 123%.

Wheat. In a study by Harbin (1997c) disulfoton was applied at planting in-furrow at 6.53 kg ai/ha. Three foliar applications at 4.2 kg ai/ha followed 61, 75 and 89 days after planting. The wheat was harvested 120 days after planting or 31 days after the final foliar spray and immediately frozen. The total application of disulfoton was five times the maximum US rate. The wheat was processed into aspirated grain fractions, bran, flour, germ, middlings and shorts, with the results shown in Table 37.

Table 37. Disulfoton residues in wheat grain and processed products after an in-furrow application at 6.53 kg ai/ha and three foliar sprays at 4.2 kg ai/ha (Harbin, 1997c).

Sample	Residues, mg/kg[1]	Average residue, mg/kg	Processing factor
Grain	0.94, 0.98, 0.82, 0.79	0.88	
Bran	0.99, 0.73, 0.78	0.83	0.94
Flour	0.18, 0.16, 0.16	0.17	0.19
Germ	1.91, 1.85, 1.84	1.87	2.1
Middlings	0.37, 0.30, 0.42	0.36	0.41
Shorts	0.90, 0.96, 1.08	0.98	1.1
Aspirated grain fractions	1.27, 1.09, 1.19	1.18	1.3

[1]Residues in replicate samples. The limit of determination for grain and all processed commodities was 0.25 mg/kg for all analytes.

Recoveries of disulfoton, disulfoton sulfoxide and disulfoton sulfone ranged from 71 to 91%, 75 to 107% and 78 to 96% respectively from all samples over the fortification range 0.25-0.5 mg/kg. Mixtures of the three compounds at total concentrations of 0.75 to 1.50 mg/kg were used to fortify grain, bran, germ, shorts and aspirated grain fractions. Recoveries of the mixtures ranged from 72 to 106%.

Recoveries of disulfoton oxygen analogue, its sulfone and sulfoxide were 82 to 103%, 77 to 114% and 74 to 99% respectively from all samples at 0.25 mg/kg. Recoveries of mixtures of the three compounds at total concentrations of 0.3 and 0.9 mg/kg were 75, 77 and 79% from germ and 87, 91 and 93% from shorts.

Processing data from the 1991 evaluation

The manufacturer provided information on processing data which had been reviewed in the 1991 monograph. Details of the trials are not repeated here but references and report numbers are given. The data are shown in Tables 38 to 42.

Table 38. Processing data for peanuts.

Sample	Residues, mg/kg	Processing factor	Reference
Peanut meat	0.01	-	Report 96726
Presscake	<0.01	<1	
Peanut oil, crude	0.06	6	Leslie, 1988
Peanut oil, refined	0.01	1	
Soapstock	0.02	2	

Table 39. Processing data for tomatoes.

Sample	Residues, mg/kg	Processing factor	Reference

Sample	Residues, mg/kg	Processing factor	Reference
Tomato	0.15		Report 91475
Juice	<0.05	<0.27	RTX-DI112-86P
Puree	0.18	1.2	Bailey, 1987a
Paste	0.26	1.73	
Pulp, wet	0.15	1	
Pulp, dry	0.19	1.27	

Table 40. Processing data for maize.

Sample	Residues, mg/kg[1]	Processing factor	Reference
Dry kernels	0.01		Report 91483
Flour	<0.01	<1	455-DI106-86P
Hulls	<0.01	<1	Bailey, 1987b
Meal	<0.01	<1	
Oil, crude	<0.01	<1	
Oil, refined	<0.01	<1	
Germ	<0.01	<1	
Grits	<0.01	<1	
Press cake	<0.01	<1	
Soapstock	<0.01	<1	

Table 41. Processing data for potatoes.

Sample	Residues, mg/kg[1]	Processing factor	Reference
Potato tuber	0.11		Report 91467/94417
Potato, dried	0.08	0.64	Calovich, 1987

Table 42. Processing data for wheat.

Sample	Residues, mg/kg	Processing factor	Reference
Grain	0.19		Report 94723
Low grade flour	0.03	0.16	STF-DI004-87P
Patent flour	0.01	0.05	Pither, 1988
Shorts	0.08	0.42	1991 JMPR
Bran	0.07	0.39	
Middlings	0.05	0.26	

The data reviewed in 1991 and at the present Meeting were combined to give the processing factors shown in Table 43.

Table 43. Collation of processing factors from 1991 and the present evaluation.

Sample	Processing Factor	Reference
Roasted coffee beans	<0.3	Report 107657 JMPR 1998
Instant coffee	<0.3	(Duah 1997b)
Cotton seed hulls	<1	Report 197541 (Freeseman, 1997)
Cotton seed meal	<1	JMPR 1998
Cotton seed oil, RBD	<1	
Maize aspirated grain fractions	10.3	Report 107691 (Duah, 1997c)
Starch	<0.25	JMPR 1998
Grits	<0.25	
Meal	<0.25	
Flour	<0.25	
RBD wet milling oil	<0.25	
RBD dry milling oil	<0.25	
Flour	<1	Report 91483 (Bailey, 1987b)
Hulls	<1	
Meal	<1	
Oil, crude	<1	
Oil, refined	<1	
Germ	<1	
Grits	<1	
Press cake	<1	
Soapstock	<1	
Potato granules	1.4	Report 107525 (Harbin, 1997a)
Potato chips	0.54	JMPR 1998
Wet peel	1.7	
Potato dried	0.64	Report 91467/94417 (Calovich, 1987)
Sorghum grain aspirated fractions	2.7	Report 107525 (Harbin, 1997b)
		JMPR 1998
Wheat bran	0.94	Report 107692 (Harbin, 1997c)
Flour	0.19	JMPR 1998
Germ	2.1	
Middlings	0.41	
Shorts	1.1	
Aspirated grain fractions	1.3	
Low grade patent flour	0.16	Report 94723 (Pither, 1988)
Patent flour	0.05	
Shorts	0.42	
Bran	0.39	
Middlings	0.26	
Peanut meat	1	Report 96726 (Leslie, 1988)
Presscake	<1	
Oil, crude	6	
Oil, refined	1	
Soapstock	2	
Tomato juice	<0.27	Report 91475 (Bailey, 1987a)
Purée	1.2	
Paste	1.73	

Sample	Processing Factor	Reference
Pulp, wet	1	
Pulp, dry	1.27	

The processing factors in Table 43 were used to estimate STMRs to refine the dietary intake calculations. Data from Table 34 (on potatoes) of the present monograph are not included as minimal details of the trials and analyses were reported.

Residues in the edible portion of food commodities

No information.

RESIDUES IN FOOD IN COMMERCE OR AT CONSUMPTION

National monitoring data were reported by The Netherlands.

Table 44. Monitoring data for disulfoton in The Netherlands (1994 to 1996).

Commodity	Samples analysed	Samples without residues (LOD = 0.02 mg/kg)	Samples with residues <MRL	Samples with residues >MRL	Mean, mg/kg	MRL, mg/kg
BERRIES AND SMALL FRUIT						
Grapes	667	667		6	<0.02[1]	0.02*
BULB VEGETABLES						0.02*
Onions (including pearl/cocktail onions)	97	96		1	<0.02[1]	0.02*
Shallots	18	17	1		<0.02[1]	0.02*
FRUITING VEGETABLES						
Tomatoes	1108	1108			<0.02	0.02*
Melons	390	390			<0.02	0.02*
LEAF VEGETABLES AND FRESH HERBS						
Iceberg lettuce	471	470		1	<0.02	0.02*

[1]For samples without residues (<LOD), half the LOD is taken for the calculation of the mean.
*Lower limit of determination (LOD).

NATIONAL MAXIMUM RESIDUE LIMITS

The national MRLs shown below were reported.

National MRLs

Country	MRL, mg/kg	Commodity
Argentina	0.4	Bean, dry
	0.5	Aubergine, cotton seed, cucumber, hops, lettuce, melon, peppers (sweet), potato, pumpkin, tomato
Australia	0.01	Milk, milk products
	*0.02	Eggs, poultry meat by-products
	0.02	Meat (mammalian), meat by-products, poultry meat
	0.5	Cotton seed, hops, potato, vegetables
Austria	0.1	Cereals, potato
	10	Hops
Belgium	*0.02	All food of animal origin, other plant commodities
	*0.05	Tea
	0.05	Cotton seed
	0.1	Wheat
Brazil	0.1	Coffee, peanut
	0.2	Cotton seed
	0.5	Beans, melon, watermelon, onion, potato, tomato
Canada	0.05	Broccoli, cabbage,
	*0.1	Asparagus, aubergine, barley, maize (corn), oats, peppers (sweet), wheat
	0.2	Potato
	0.5	Beans, lima beans, Brussels sprouts, cauliflower, lettuce (head), garden peas, spinach, tomato
EU[1]	*0.02	Eggs, fat, meat, meat by-products, meat (preparations of)
	0.02	Milk, milk by-products
EU[2]	T*0.02	Beans (dry), broccoli, Brussels sprouts, cabbage (head), cauliflower, celery, herbs, hops, kohlrabi, other legume vegetables, other stem vegetables, parsnip, pineapple, potato, squash (summer and winter), strawberry,
	*0.02	Berries (wild), bulb vegetables, chicory (witloof), citrus fruit, corn (sweet), cucurbits (with edible peel), grapes, leafy brassicas, lettuce and similar, mushrooms, nuts, berries and other small fruit, other brassica vegetables, other cereals, other cucurbits, other oilseeds, other pulses, other root and tuber vegetables, other tropical and sub-tropical fruit, peas (without pods), pome fruit, carne fruit (rubus), solanacea, spinach and similar, stone fruit, watercress
	*0.05	Cotton seed, tea
	0.1	Wheat
	0.2	Barley, sorghum
	3	Carrots
France	0.1	Pineapple
Germany	0.1	Cereals, other plant commodities
	0.2	Potato
	10	Hops
Italy	0.4	Aubergine, beans, beans (kidney), cabbage, maize/corn, melon, peas, potato, sugar beet, tobacco, watermelon
Japan	0.05	Fruit, pulses
	0.07	Rice
	0.1	Potato, vegetables
Luxembourg	0.02	All plant commodities
Malaysia	0.1	Coffee, nuts, pineapple, soya bean (dry)
	0.2	Cereals except corn
	0.5	Celery, maize/corn, potato, rice, sugar beet, vegetables
Mexico	0.1	Capsicum (pepper/chilli), soya bean
	0.3	Coffee, maize/corn, sorghum, sugar cane
	0.75	Asparagus, barley, beans, broccoli, Brussels sprouts, cabbage, cauliflower, chick-peas, cotton seed, lettuce, oats, peanut, pecan nut, pineapple, potato, rice, spinach, tomato, wheat
Netherlands	*0.05	Other plant commodities
New Zealand	<0.1[3]	Alfalfa, beans, brassica vegetables, carrot, cereals, forage crops, peas, potato
Paraguay	0.5	Garlic, onion, rice, tomato
South Africa	0.05	Wheat

Country	MRL, mg/kg	Commodity
	0.1	Coffee
	0.2	Cotton seed
	0.5	Criciferae, onion, potato, tomato
Spain	0.02	Cocoa, coffee, cola, forage crops (straw), fruit, fruit and vegetables (dry), nuts, other cereals, other oilseeds, pulses, spices, sugar beet, sugar cane, tea, tobacco, vegetables
	0.1	Cotton seed, maize/corn, sorghum
	0.5	Hops
UK[2]	*0.02	Almond, apple, apricot, artichoke, asparagus, aubergine, avocado, banana, beetroot, berries (wild),blackberry, boysenberry, buckwheat (common), cabbage (Chinese), cardoon, cashew nut, celeriac, cherry, chestnut, chicory (witloof), coconut, collard, cranberry, cress (garden), cucumber, cucurbits (with edible and inedible peel), currants (black, red, white), dates, dewberry, eggs, escarole, fat, fennel (common), figs, flax/linseed, fruit (wild), garlic, gherkin, gooseberry, grapes, grapefruit, hazelnut, horseradish, kiwifruit, kumquat, lamb's lettuce, leeks, lemons, lentils, lettuce, limes, litchi, macadamia nut, maize/corn, mandarins, mango, meat, meat (preparations of), melon, milk, milk products, millet (French), mushroom, mustard seed, nectarines, nut (para-), oats, olives, onion, oranges, other berry fruit, other brassica vegetables, other bulb vegetables, other citrus fruit, other leafy vegetables, other legume vegetables, other nuts, other oilseed, other pome fruit, other pulses, other root and tuber vegetables, other solanacea, other stem vegetables, other stone fruit, other tropical and sub-tropical fruit, parsnip (turnip-rooted), passionfruit, peas (garden, dry), peas (garden without pods), peach, peanut, peanut seed, pear, pecan nut, pepper (sweet), pistachio, pomegranate, poppy seed, pummelo, quince, radish, rapeseed, raspberry, rhubarb, rice, rutabaga, rye, salsify (black), sesame seed, shallot, soya seed, spinach, spring onion, sunflower seed, sweet corn, sweet potato, Swiss chard, tomato, topinambur, triticale, turnip (edible), walnut, watercress, watermelon, wine grapes, yams, zucchini
	0.05	Cotton seed
	0.1	Wheat
	0.2	Barley, sorghum
Uruguay	0.1	Tomato
	0.5	Garlic, onion, pepper (sweet), rice
USA[4]	0.1	Asparagus[5], pepper (sweet), soya bean
	0.25	Soya forage, soya hay
	0.3	Coffee, corn (sweet grain), maize/corn (grain), peanut hull, popcorn (grain), sugarcane, wheat (grain)
	0.5	Hops, sugar beet (root)
	0.75	Barley (grain), bean (dry), bean (kidney), bean (lima), broccoli, Brussels sprouts, cabbage, cauliflower, cotton seed, lettuce, oat (grain), peas (garden), peanut, pecan nut, pineapple, potato, rice, sorghum (grain), spinach, tomato
	2.0	sugar beet (leaves or top)
	5.0	Barley fodder, barley (green), barley straw, bean vines, clover (fresh), maize/corn fodder, maize/corn forage, oat fodder, oat (green), oat straw, peas (garden vines), peanut hay, pineapple bran, pineapple foliage, popcorn fodder, popcorn forage, rice straw, sorghum fodder, sorghum forage, sugar beet pulp (dry), sweet corn fodder, sweet corn forage, wheat fodder, wheat (green), wheat straw
	12	Clover hay

[1]Residue definition: sum of disulfoton and sulfones, expressed as disulfoton.
[2]Residue definition: sum of disulfoton, demeton-S and their sulfoxides and sulfones expressed as disulfoton.
[3]Generally <0.1 mg/kg; MRL not established.
[4]Residue definition: disulfoton and its cholinesterase-inhibiting metabolites.
[5]Regional tolerance in Idaho, Oregon, Washington and California.

APPRAISAL

Residue aspects of disulfoton were reviewed by the JMPR in 1973, 1975, 1979, 1981, 1984, 1991 and 1994. At the 1996 CCPR MRLs set "at or about the limit of determination" were amended from 0.01 to 0.02 mg/kg after a recommendation from the Ad Hoc Working Group On Methods of Analysis (ALINORM 97/24 para. 52). Several delegations expressed concern at the high levels of estimated intakes relative to the ADI and it was noted that processing data were not available for refinement of the estimation of intake. The Committee requested revised intake calculations and decided to keep all other proposals at step 7C (ALINORM 97/24, paras. 53 and 54).

In 1997, the CCPR was informed that additional data would be available for the 1998 JMPR and disulfoton MRLs were kept at Step 7B pending the 1998 evaluation. The present Meeting received new residue data on lima beans, cotton, lettuce and potatoes, as well as reports of recent processing studies on coffee, cotton seed, maize, sorghum and wheat. Processing data on potatoes were also submitted, although minimal information was provided on the field conditions and the analytical methods used. The Meeting received summaries of data reviewed in the previous monographs on disulfoton for the estimation of STMRs and refinement of the dietary intake calculations.

Plant metabolism

The metabolism of [^{14}C]disulfoton in lettuce, potatoes, wheat and soya beans was reported.

[^{14}C]disulfoton was applied to soil at a rate of 3.2 kg ai/ha before planting lettuce. Total radioactive residues of 3.7 mg/kg disulfoton equivalents were found in mature lettuce 49 days after treatment. Approximately 93% of the radioactivity was extracted with 1% trifluoroacetic acid in methanol (1%TFA/MeOH). Four major metabolites which were identified by HPLC accounted for a total of 60% of the radioactivity. The metabolites were disulfoton sulfone, disulfoton oxygen analogue sulfone, disulfoton oxygen analogue sulfoxide and disulfoton sulfoxide, which constituted 26, 23, 6 and 5% of the TRR respectively.

Potatoes were planted in soil treated with [^{14}C]disulfoton at a rate of 7.9 kg ai/ha. Two foliar sprays were applied 33 and 69 days after planting at a rate of 2.2 kg ai/ha. In tubers harvested 99 days after planting the total radioactive residues were 3.7 mg/kg as disulfoton. 1% TFA/MeOH extracted 91% of the total radioactivity in the tubers. The organophosphorus triesters (disulfoton sulfone and sulfoxide, disulfoton oxygen analogue sulfone and sulfoxide) constituted in total 2% of the TRR. Most of the radioactivity (69%) was incorporated into amino acid conjugates of 2-(ethylsulfonyl)ethylene which is formed from disulfoton oxygen analogue sulfone by hydrolysis and elimination of water.

Wheat was planted in soil treated with [^{14}C]disulfoton at a rate of 0.97 kg ai/ha. At 37 and 63 days after planting, two foliar sprays were applied at a rate of 0.85 kg ai/ha. Immature and mature plants were harvested 37 days (before the first foliar application) and 90 days after planting respectively. Straw and forage samples were collected 104 days after planting. The TRRs in grain, wheat forage and straw were 2.8, 36.2 and 40.2 mg/kg disulfoton equivalents respectively. Metabolites were identified and quantified by HPLC after extraction with 1% TFA/MeOH. The organophosphorus triesters in total were <4% of the TRR in grain, 23% in wheat forage and 20% in wheat straw.

Soya beans were planted in soil treated with [^{14}C]disulfoton at a rate of 1.8 kg ai/ha. Mature plants were harvested 85 days after planting and hay samples were collected 99 days after planting. The TRR in soya beans, forage and hay was 1.4, 27 and 43.7 mg/kg disulfoton equivalents respectively, of which 1% TFA/MeOH extracted 67, 93 and 85% respectively. The organophosphorus

triesters constituted less than 4% of the TRR in all of the samples. After further extraction, 39% of the TRR in the beans and 22% in the forage was identified as 2-(ethylsulfonyl)acetic acid. Another 58% of the TRR in the forage was identified as 2-(ethylsulfonyl)ethanol.

In summary, the metabolism studies indicated that there were common processes involved in the transformation of disulfoton in lettuce, potatoes, wheat and soya beans. The metabolism of disulfoton before hydrolysis of the triesters was similar in all the crops. Cleavage of the triesters led to the formation of alkylsulfonyl and sulfonic acid products such as 2-(ethylsulfonyl)ethanol and its oxidation product 2-(ethylsulfonyl)acetic acid. Both of these compounds were identified in soya beans and potatoes. Neither disulfoton nor its oxygen analogue (demeton-S) were identified in any of the metabolism studies; the inclusion of demeton-S in the residue definition was therefore questioned.

The question of including demeton-S in the residue definition was raised at the 1994 Joint Meeting and was discussed at the present Meeting in relation to the new crop metabolism studies provided. The Meeting agreed that although the disulfoton oxygen analogue was not isolated in any of the new metabolism studies reviewed and it would be oxidized to the corresponding sulfone in any determination of the total residue, there was no reason to remove it from the definition. The definition of the residue for compliance and MRLs and the estimation of dietary intake is *sum of disulfoton, demeton-S and their sulfoxides and sulfones, expressed as disulfoton.*

Analytical methods

Disulfoton is included in a multi-residue method reported by the government of The Netherlands. Recoveries from lettuce and potatoes were reported.

The determination of disulfoton in a number of types of sample was included in a general method. A rapid screening method for alfalfa and wheat was also reported. Recoveries were determined with mixtures of disulfoton, disulfoton oxygen analogue and their sulfones and sulfoxides and all recoveries were within acceptable limits (71 to 100%).

Stability of residues in stored analytical samples

The storage stability of disulfoton and its metabolites in a number of crops and processed commodities was investigated for periods up to 36 months. A loss of 37% of disulfoton oxygen analogue sulfone and sulfoxide was found in cotton seed after 24 months. In peanut soapstock losses of 18% of disulfoton sulfone and sulfoxide and 37% of disulfoton oxygen analogue sulfone and sulfoxide were found after 30 months. The Meeting considered that the reported losses were acceptable for storage periods up to 36 months.

Supervised residue trials

The manufacturer provided summaries of data reviewed in previous monographs on disulfoton (1991 and 1994) to estimate STMRs. These were combined with data from currently reviewed studies where appropriate. Only results from supervised trials conducted in accordance with GAP or current use patterns were used in the estimation of the STMRs.

Dry beans (Lima beans). The 1994 Meeting requested the provision of additional residue data reflecting GAP for beans. US GAP allows a maximum rate of 2.2 kg ai/ha to be applied as an in-furrow or side-dress application at planting. On registered US labels, a PHI of 60 days is indicated for beans. The 1994 monograph reported residues in lima beans and green vines of <0.01 and 0.06 mg/kg respectively, 92 days after a double side-dress application at 2.2 kg ai/ha. Data from the current evaluation were included in the estimation of a maximum residue level and an STMR for dry

beans. Although samples were harvested 105 and 106 days after treatment, the data were considered to be reflective of GAP for dry beans.

In US trials reported in the 1991 monograph application rates ranged from 1.6 to 3.9 kg ai/ha. GAP in Japan allows a maximum rate of application of 2 kg ai/ha with a PHI of 60 days. Data from four Japanese trials on kidney beans reviewed in 1991 were from treatments at 2 and 4 kg ai/ha, The residues in the beans were all <0.01 mg/kg 62 and 68 days after both treatments.

Residues reflecting GAP in the USA ranged from <0.01 to 0.14 mg/kg at pre-harvest intervals ranging from 52 to 106 days after treatment. The residues from the US and Japanese trials used to estimate the STMR were in rank order <0.01 (15), 0.01, 0.02, 0.04, 0.06, 0.10, 0.11 (2) and 0.14 mg/kg. The data do not support the existing MRL of 0.05 mg/kg for dry beans (Step 7B). The Meeting estimated a maximum residue level of 0.2 mg/kg and an STMR of 0.01 mg/kg for dry beans.

Cotton seed. Data from eight trials in Greece in 1993 and 1994 were reported. GAP in Greece allows application of disulfoton at rates of 1–1.5 kg ai/ha at planting with a PHI of 60 days. Cotton seed was harvested 150 to 169 days after planting (normal harvest) and the residues were below the limits of determination in all the samples of cotton seed. The limits of determination were 0.06 and 0.12 mg/kg based on fortifications with the six components of the defined disulfoton residue.

GAP in the USA allows an in-furrow treatment at 1.1 kg ai/ha, a post-planting in-furrow application at 2.2 kg ai/ha and up to three foliar sprays at 0.63 kg ai/ha. PHIs vary from 28 to 90 days according to the treatment regime. No more than three applications (soil and foliar) may be made. Residues reflecting GAP in the USA (1991 and 1994 evaluations) ranged from <0.01 to <0.19 mg/kg.

Residues resulting from GAP in the USA and Greece used in the estimation of the STMR were in rank order <0.01 (20), <0.02, 0.02, <0.03 (2), 0.03 (3), 0.04 (2), <0.05 (2), 0.05 (3), <0.06 (6), 0.10 (2), 0.11, <0.12 (4), 0.12 (2) and <0.19 (4) mg/kg.

The Meeting confirmed the previous recommendation for the draft MRL (Step 7B) of 0.1 mg/kg for cotton seed on the basis of the Greek and US data and estimated an STMR of 0.03 mg/kg.

Lettuce. Data from six US trials on head and leaf lettuce in 1995-6 were submitted for evaluation. GAP in the USA dictates a soil treatment at planting at 1.2-2.2 kg ai/ha and a PHI of 60 days. In the residue trials, disulfoton was applied as a single side-dress application at sowing at a rate of 1.1 or 1.2 kg ai/ha. Samples of leaf lettuce were taken 60 to 90 days after planting and head lettuce (with wrapper leaves) were sampled 62 to 116 days after planting. Residues in leaf lettuce ranged from <0.05 to 1.15 mg/kg and in head lettuce from <0.05 to 0.22 mg/kg. Five trials each on leaf and head lettuce in 1985 reported in the 1991 monograph were according to GAP and gave residues of <0.01-0.56 mg/kg in leaf and 0.01-0.64 mg/kg in head lettuce.

The residues resulting from US GAP from the 1985 and 1995-6 trials in rank order were leaf <0.03 (2), 0.06, 0.11, 0.56, 0.59 and 1.15 mg/kg; head <0.03, 0.04, <0.05 (2), 0.10, 0.44 and 0.64 mg/kg.

The Meeting confirmed the existing draft MRLs of 1 mg/kg for head lettuce and leaf lettuce and estimated STMRs of 0.11 and 0.05 mg/kg for leaf and head lettuce respectively.

Potatoes. Data were reported from two trials in The Netherlands (government submission). At planting, disulfoton was applied at a rate of 1.5 kg ai/ha and tubers were harvested after 113 days. There is no reported GAP for potatoes in The Netherlands. Field details were not reported although an analytical method was provided. The data could not be evaluated.

Data from the USA and Japan were evaluated in 1991. Residues from the US and Japanese trials used for the estimation of the STMR in rank order were <0.01 (3), 0.01, <0.02, 0.04, 0.06, 0.07 (3). 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.15, 0.16, 0.20, 0.23 and 0.31 mg/kg.

The Meeting confirmed the existing CXL of 0.5 mg/kg and estimated an STMR of 0.08 mg/kg for potatoes.

Processing studies

Processing studies on coffee, cotton seed, maize, potatoes and sorghum were reported.

In a coffee processing study, disulfoton was applied at a tenfold rate to the soil around coffee trees. Coffee beans were harvested and the initial preparation of the berries involved removal of the skin, pulp and endocarp to leave green beans. These were roasted and processed into instant coffee. Average residues in green coffee beans, roasted beans and instant coffee were 0.3, <0.1 and <0.1 mg/kg respectively. Processing factors for roasted coffee and instant coffee were both <0.3.

Cotton was treated at five times the maximum rate in a processing study with an in-furrow treatment at planting, a soil injection and three foliar sprays. The cotton was mechanically harvested and ginned. The resulting cotton seed was processed into meal, hulls and refined, bleached and deodorised (RBD) oil. The residues in the undelinted cotton seed, hulls, meal, and RBD oil were all <0.025 mg/kg. There was no concentration of disulfoton residues in any of the processed fractions. As residues were not detected in the raw agricultural commodity, processing factors could not be calculated.

Maize was treated with a band application at planting and a foliar spray 7 days before harvest at a total of approximately five times the recommended rate. Mature maize was mechanically harvested and processed into aspirated grain fractions (grain dust), starch, grits, meal, flour, and RBD oil produced by wet and dry milling. The average residues were 0.41 mg/kg in the grain, 4.24 mg/kg in aspirated grain fractions, and <0.1 mg/kg in grits, meal, flour, and RBD oil produced by wet and dry milling. The processing factors were 10.3 for the aspirated grain fractions and <0.25 for all the other fractions.

Two processing studies in potatoes were reported. In one the details were inadequate and the Meeting requested additional information to allow the study to be used for refining dietary intake calculations. In the second study an in-furrow treatment plus three foliar sprays were applied at five times the maximum recommended rate in the USA. Potatoes were harvested and processed into granules, chips, wet peel and dry peel. The average disulfoton residues, with processing factors in parentheses, were potatoes 0.37 mg/kg, granules 0.52 mg/kg (1.4), chips 0.2 mg/kg (0.54) and wet peel 0.64 mg/kg (1.7). Residues were concentrated in the granules and wet peel.

In a processing study on sorghum an in-furrow treatment, a side-dress application and three foliar sprays were applied at three times the recommended US rate. Sorghum was harvested and processed into aspirated grain fractions. The average residues in the sorghum grain and aspirated fractions were 1.5 and 4.0 mg/kg respectively, giving a processing factor of 2.7.

Wheat treated at three times the maximum recommended rate in the USA was harvested and processed into bran, flour, germ, middlings, shorts and aspirated grain fractions. The average residues, with processing factors in parentheses, were grain 0.88 mg/kg, bran 0.83 mg/kg (0.94), flour 0.17 mg/kg (0.19), germ 1.87 mg/kg (2.1), middlings 0.36 mg/kg (0.41), shorts 0.98 mg/kg (1.1) and aspirated grain fractions 1.18 mg/kg (1.3). Disulfoton residues were concentrated in the germ and aspirated grain fractions.

Estimation of STMRs for refinement of dietary intake calculations

Data evaluated by the 1991 and 1994 Meetings were combined with data supplied to the present Meeting for the estimation of STMRs to refine the dietary intake calculations.

US and Canadian data on barley were evaluated in 1991 and 1994. The residues in trials according to GAP in rank order were <0.01 (7), 0.01 (2), <0.02 (3), 0.02 (2), 0.03, 0.04, 0.06, 0.09 and 0.1 (2) mg/kg. The Meeting estimated an STMR of 0.02 mg/kg for barley.

Trials on broccoli in accordance with US and Canadian GAP were reviewed in 1991. The residues in rank order were <0.02 (6), 0.03 (2), 0.05, 0.06, 0.09 and 0.11 mg/kg. The Meeting estimated an STMR of 0.025 mg/kg.

Trials on head cabbage in the USA and Japan in accordance with GAP gave residues in rank order of <0.02 (12), 0.02 (3), 0.03, 0.06, 0.07 (3), 0.08, 0.09, 0.12, 0.17(2), 0.23 and 0.32 mg/kg. The Meeting estimated an STMR of 0.02 mg/kg for head cabbages.

Trials on cauliflower were reviewed in 1991. Although GAP in the USA and Canada allows a maximum of two sprays but three sprays were applied in the trials, the data were considered to be acceptable as the applications were made at an early stage of crop growth (pre-emergent and post-emergent). The residues in rank order were <0.01 (6), 0.01 (3), 0.02,0.03, 0.04, 0.05 and 0.31 mg/kg. The residue of 0.31 mg/kg was considered to be an outlier and was not used in estimating the STMR. The Meeting estimated an STMR of 0.01 mg/kg.

Three trials on coffee were reviewed in 1991. The rates of application were one, three and ten times the maximum recommended rate and the residues in the dry beans were 0.1-0.2 mg/kg. The Meeting could not estimate an STMR for coffee beans from only three results.

Residues in green peas and empty pods were reported in the 1991 and 1994 monographs. Data on Southern peas were not included in the estimation of the STMR as the trials were not compatible with current GAP in the USA. The residues in peas in six trials according to GAP were all <0.01 mg/kg and in the empty pods <0.01 (2), 0.02, 0.03 and 0.08 mg/kg. The Meeting estimated an STMR of 0.01 mg/kg for garden pea (shelled). As information on the weights of the whole pods in relation to the empty pods was not provided, an STMR for whole pods could not be estimated.

The 1994 Meeting considered the possibility of revising the maximum residue level of 0.01 mg/kg for maize estimated by the 1991 JMPR. The 1994 Meeting stated that the additional data provided since 1991 did not reflect GAP in the USA and that the MRL could not be set at 0.01* mg/kg as some residues had been determined at 0.01 mg/kg. Although GAP in the USA allows one soil treatment and a foliar spray, three sprays were applied in most of the trials reviewed in 1994. As the residues in most instances were below the limit of determination however, the present Meeting included the data from excessive treatments in estimating the maximum residue level and STMR. The residues in rank order were <0.01 (14), 0.01 and <0.02 (4) mg/kg. The Meeting estimated an STMR of 0.01 mg/kg and recommended a change in the existing MRL (Step 7B) from 0.01 mg/kg to 0.02* mg/kg.

Data on oats were reviewed in 1991. The results may be compared to Canadian GAP. Only three results may be strictly according to GAP, but as the treatment is either pre-emergent or early post-emergent, the data from all six trials could be considered for estimating an STMR. The Meeting concluded that on the basis of the recent studies of wheat metabolism where the four organophosphorus triesters constituted less than 4% of the TRR, and in view of the early application of the product, an STMR of 0 was appropriate.

Residues in peanut kernels were evaluated in 1991. The residues in four US trials reflecting GAP in rank order were <0.01 (2), 0.02 and 0.09 mg/kg. The Meeting estimated an STMR of 0.015 mg/kg for peanut.

Further information requested by the 1994 Meeting included additional residue data on pecans reflecting the higher aerial foliar application rates and data from soil applications according to GAP. The residues in trials reflecting GAP in rank order in the kernels were <0.01 (3), 0.01 and 0.02 mg/kg; and in whole nuts 0.08, 0.21 and 0.22 mg/kg. The Meeting concluded that there were enough trials reflecting GAP to estimate an STMR of 0.01 mg/kg for pecan kernels.

Data on pineapples from Martinique and Brazil were reviewed in 1991, in relation to GAP in France and Honduras. The residues in seven trials reflecting GAP were all <0.1 mg/kg at rates of 0.75 times to twice the maximum recommended rates. The Meeting estimated an STMR of 0 as the residues were below the limit of determination and were consistent with the results of recent metabolism studies.

Trials on Japanese radishes were reviewed in 1991. The residues in rank order were 0.004 (4), 0.008, 0.01, 0.02 (4), 0.03 (3), 0.06, 0.07, 0.10 (2), 0.12, 0.15 and 0.17 mg/kg. The Meeting estimated an STMR of 0.025 mg/kg for Japanese radish.

Data from the 1973 evaluation of disulfoton from Japan and the USA were submitted for the estimation of an STMR for rice. The Japanese data from only three trials. Twelve trials in the USA were reported but GAP was not identified and the residues were determined by a colorimetric method with a limit of quantification of 0.1 mg/kg. As recent GAP for the USA was not available and there were only three results from Japan, the Meeting could not estimate an STMR.

GAP for the treatment of sorghum in the USA allows a maximum of 2 soil treatments at 1.1 kg ai/ha followed by a maximum of three foliar applications at 0.56 kg ai/ha. The PHI for grain is 34 days after soil application and 7 days after foliar applications. Trials on sorghum were reviewed in 1991 and 1994. The residues resulting from excessive applications either at planting or post-planting were accepted for use in estimating an STMR, but those from excessive foliar treatments were not. As all the trials with foliar applications were either at twice the maximum recommended rate or with PHIs longer than 7 days, the foliar applications were not considered to reflect current GAP and the Meeting did not estimate an STMR for sorghum.

Trials on sugar beet reported in the 1991 monograph were with excessive treatment regimes. The data were originally evaluated against GAP from Chile, although the trials were conducted in the USA. The residues in rank order were <0.01 (3), 0.01 (4), 0.02 (2), <0.03, 0.03 (2), 0.04 and 0.06 (3) mg/kg. The Meeting considered that as recent GAP for sugar beet was not available and Chilean GAP could not be applied to the US trials, an STMR could not be estimated.

Residues in tomatoes were reported in 1991. The 1991 Meeting recommended an MRL of 0.1 mg/kg for tomatoes and the withdrawal of the MRL for vegetables. The residues in trials which reflect GAP in the USA and Japan were <0.01 (2), 0.02, 0.04 and 0.05 mg/kg. The Meeting considered that there were too few results to estimate an STMR.

Numerous trials on wheat were reviewed in 1991 and 1994. The residues in trials according to GAP in the USA and Canada in rank order were <0.01 (20), 0.01 (5), <0.02 (10), 0.02 (5), 0.03 (2), 0.04 (2), <0.05 (2), 0.05 (3), <0.1, 0.11, 0.14, 0.16, 0.18, 0.19, 0.24 and 0.27 mg/kg. The Meeting reaffirmed the existing draft MRL of 0.2 mg/kg and estimated an STMR of 0.02 mg/kg for wheat.

RECOMMENDATIONS

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

Note. The Meeting concluded that the dietary intake of disulfoton residues could in some circumstances exceed the ADI (see Dietary Risk Assessment below). As the present evaluation is not the first for disulfoton nor a full re-evaluation within the CCPR Periodic Review Programme however, the recommendations are for MRLs not MRLMs.

Definition of the residue for compliance with MRLs and for the estimation of dietary intake: sum of disulfoton, demeton-S and their sulfoxides and sulfones expressed as disulfoton.

Commodity		Recommended MRL, mg/kg		STMR, mg/kg
		New	Previous	
GC 0640	Barley	-	0.2	0.02
VD 0071	Beans (dry)	0.2	0.05	0.01
VB 0400	Broccoli	-	0.1	0.025
VB 0041	Cabbages, Head	-	0.2	0.02
VB 0404	Cauliflower	-	0.05	0.01
SO 0691	Cotton seed	0.1	0.1	0.03
VP 0529	Garden pea, shelled (succulent seeds)	-	0.02*	0.01
VL 0482	Lettuce, Head	1	1	0.05
VL 0483	Lettuce, Leaf	1	1	0.11
GC 0645	Maize	0.02*	0.01	0.01
CF 1255	Maize flour			0.0025
GC 0647	Oats	-	0.02*	0
SO 0697	Peanut	-	0.1	0.015
TN 0672	Pecan	-	0.1	0.01
FI 0353	Pineapple	-	0.1	0
VR 0589	Potato	0.5	0.5	0.08
VR 0591	Radish, Japanese	-	0.2	0.025
GC 0654	Wheat	-	0.2	0.02
CM 0654	Wheat bran			0.019
CF 1211	Wheat flour			0.004
CF 1210	Wheat germ			0.042

Collation of data for IEDI calculations

The STMRs and STMR-Ps estimated above are tabulated below for inclusion in the dietary intake refinement.

Commodity	MRL, mg/kg	STMR, mg/kg	STMR-P
Barley	0.2	0.02	
Beans, dry	0.2	0.01	
Broccoli	0.1	0.03	
Cabbages, head	0.2	0.02	
Cauliflower	0.05	0.01	
Coffee beans	0.2	–	
Coffee bean, roasted		–	
Coffee instant		–	
Cotton seed	0.1	0.03	
Cotton seed oil		0.03	$0.03 \times <1$
Garden peas (pods)	0.1	–	
Garden peas (shelled)	0.02	0.01	
Lettuce, head	1	0.11	
Lettuce, leaf	1	0.10	
Maize/corn	*0.02	0.01	
Maize/corn flour		0.01	0.01×0.25
Oats	0.02	0	
Peanut	0.1	0.015	
Peanut oil, refined		0.02	0.02×1
Pecan nut	0.1	0.01	
Pineapple	0.1	0	
Potato	0.5	0.08	
Potato chips		0.08	0.08×0.67
Potato, peeled and boiled		0.08	0.08×0.44
Radish, Japanese	0.2	0.025	
Rice	0.5	–	
Sorghum	1	–	
Wheat	0.2	0.02	
Wheat flour		0.02	0.02×0.19
Wheat bran		0.02	0.02×0.94
Wheat germ		0.02	0.02×2.1

FURTHER WORK OR INFORMATION

Desirable

1. Details of the potato processing study (Anon., 1968) for consideration in the refinement of dietary intake calculations.

2. Additional residues data for rice and sorghum to allow the estimation of an STMR for the calculation of dietary intake.

DIETARY RISK ASSESSMENT

In the current evaluation STMRs were estimated for 18 commodities. Where consumption data were available these STMRs were used in the estimates of dietary intake together with the existing MRLs and draft MRLs for 9 other food commodities.[35]

The estimated daily intake exceeds the ADI for the five GEMS/Food regional diets by the following percentages: Middle Eastern 190%, Far Eastern 920%, African 440%, Latin American 280% and European 160%.

The Meeting concluded that the dietary intake of disulfoton residues may exceed the ADI for all the GEMS/Food regional diets. Since the compound is neither new nor being evaluated in the CCPR Periodic Review Programme, the recommended MRLs are not designated as MRLMs.

Since the commodities which made a large contribution to the intake are rice and sorghum, further consideration should be given to these commodities to allow refinement of the dietary intake estimate at the international level.

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Page: 589
[N1]Extraction using acetone and CH_2Cl_2 and hexane, as with analytical residue method, showed that 66% of TRR was identifed as the four metabolites; 21% M2, 33% M4, 5% M1 and 7% M3. These values were comparable to the TFA/MeOH extraction.
Page: 589
[N2]MnO_4 oxidation of the metabolites during work-up to identify the compounds.
Page: 595
[N3] Recoveries were not individually reported for disulfoton and the metabolites in the matrices concerned.
Page: 596
[N4]N=3 at each time point for each P=O or P=S sample.
Page: 596
[N5]N=2 at 36 months for each P=S and P=O mixture.
Page: 601
[N6]Stated as 1.2 oz ai/1000 row feet or 15.7 to 31.4 oz ai/acre.
Page: 619
[N7]6 oz ai/1000-row foot.