CHLORPYRIFOS (017)

EXPLANATION

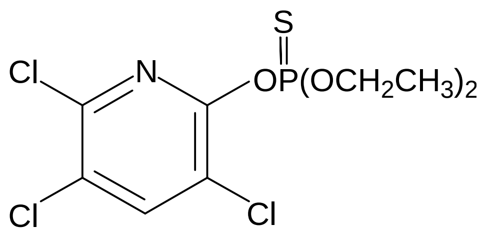
Chlorpyrifos was originally evaluated by the JMPR in 1972 with several subsequent evaluations for residues, most recently in 1995. The 1982 JMPR allocated an ADI of 0.01 mg/kg bw. At the 25th Session of the CCPR in 1993 (ALINORM 93/24A para. 251) chlorpyrifos was identified as a candidate for periodic review. The 29th Session in 1997 scheduled periodic reviews for toxicology in 1999 and for residue chemistry in 2000. The 1999 toxicology review confirmed the ADI of 0.01 mg/kg bw and also established an acute reference dose (acute RfD) of 0.1 mg/kg bw.

Information was supplied by the manufacturer on the identity and physical properties of the active ingredient and technical material, metabolism in plants and animals, environmental fate, storage stability, animal feeding studies, field trials, GAP (national labels) and fate of residues in processing. The governments of Australia, Germany, The Netherlands, Poland, Thailand and the USA provided additional information.

IDENTITY

ISO common name:	chlorpyrifos
Chemical name:	
IUPAC	*O,O*-diethyl *O*-3,5,6-trichloro-2-pyridyl phosphorothioate
CA	*O,O*-diethyl *O*-(3,5,6-trichloro-2-pyridinyl) phosphorothioate
CAS No.:	2921-88-2
CIPAC No.:	221
Synonyms:	Dowco* 179, ENT 27311, OMS 971, Lorsban, Dursban

Structural formula:



Molecular formula:	$C_9H_{11}Cl_3NO_3PS$
Molecular weight:	350.6

Physical and chemical properties

Pure active ingredient

Vapour pressure:	2.0 x 10^{-5} mm Hg or 2.67 x 10^{-6} mPa at 25°C (Chakrabarti and Gennrial, 1987)
Melting point:	42°C

Octanol/water coefficient:	P_{OW}= 50125 (range 41335-58173) or log P_{OW} = 4.7001, at 20°C (McDonald, *et al.*, 1985)
Solubility (g/100 g solvent at 25°C) in:	water: 1 x 10^{-4} methanol: 45 ethanol: 63 xylene: 400 1,1,1-trichloroethane: 400 diethyl ether: 510 carbon disulfide: 590 chloroform: 630 acetone: 650 methylene chloride 714 benzene: 790 (Dow Chemical Co., 1987)
Specific gravity:	1.51
Hydrolysis:	rate of hydrolysis is independent of pH below pH 7, with a half-life of 72 days at 25°C in sterile buffered water. The hydrolysis is base-catalysed under alkaline conditions, with a half-life of 16 days at pH 9 (McCall, 1986, GH-C 1791).
Photolysis:	photolysis of chlorpyrifos in aqueous systems occurs fairly rapidly with 3,5,6-trichloro-2-pyridinol (TCP) as the main product. The average aqueous photolysis half-life of chlorpyrifos under mid-summer conditions at 40°N is about 30 days. TCP has a predicted photolysis half-life of 15 minutes based on a quantum yield study (Racke, 1993; Batzer *et al.*, 1990, GH-C 2417).

Technical material:

Appearance:	white granular solid
Purity:	minimum 97% (w/w) chlorpyrifos
Melting point:	41.5-43.5°C
Hydrolysis:	63-day half-life at pH 5, 23-day half-life at pH 8, phosphate buffer, 25°C). Hydrolysis rate increases approximately 3-fold for every 12°C rise. Natural waters and water containing copper or other chelating metals cause more rapid degradation than phosphate buffer, with half-lives from 1.5 days to 35 days in other media (Dow Chemical Co., 1987)

Formulations

Emulsifiable concentrate (EC) formulations containing 120, 225, 278 or 480 g chlorpyrifos/l

Wettable powder (WP) formulations containing 250 or 500 g chlorpyrifos/kg

Granular formulations (G) containing 50, 100 or 150 g chlorpyrifos/kg

Water-Dispersible Granule (WG) formulations containing 750 g chlorpyrifos/kg

Lorsban IPE (impregnated polyethylene), containing 1% chlorpyrifos, is a polyethylene resin impregnated with chlorpyrifos and extruded to form plastic bags for use as shrouds for bananas bunches.

METABOLISM AND ENVIRONMENTAL FATE

Animal metabolism

Metabolism studies on rats, hens and goats were reported. The rat study (Nolan *et al.*, 1987) was previously submitted to the WHO for review by the 1999. The main route of elimination was in the urine, 84-92% of the administered dose. No chlorpyrifos was detected in the urine, and the main metabolites were 3,5,6-trichloro-2-pyridinol (TCP), its glucuronide conjugate and possibly its sulfate conjugate.

In the poultry study (Bauriedel, 1986), 16 acclimatized White Leghorn laying hens were divided into 4 groups of 4 hens each. The hens in three of the groups each received a daily oral dose of 2.26 mg of [^{14}C]chlorpyrifos, labelled on the ring C adjacent to the ester bond (C-2) and on C-6. The specific activity was 16,085 dpm/µg. This corresponded to an average dietary level of 20 ppm, based on actual feed consumption during the test period of ten consecutive days. Feed consumption in the three treated groups ranged from 112 to 121 g/bird/day. Eggs and excreta were collected each day and pooled by group. About 12 hours after the final dose, the birds were killed and samples of tissues were pooled by group and stored frozen (-15^{o}C).

Tissues, excreta and eggs were combusted and analysed for radioactive carbon dioxide by liquid scintillation counting (LSC). The radiochemical procedures were validated by the analysis of fortified control tissue and excreta samples. At fortifications of 7500 dpm (1800 dpm for egg yolk and fat), recoveries were >90%, except from muscle at 86%. The ^{14}C concentrations in the combined treated group tissues, expressed as chlorpyrifos, were kidney 0.154 mg/kg, liver 0.054 mg/kg, muscle 0.10 mg/kg, fat 0.198 mg/kg, skin 0.126 mg/kg, gizzard 0.024 mg/kg, and heart 0.068 mg/kg. The concentration in the gastrointestinal tract contents ranged from 0.224 to 0.393 mg/kg in the three treated groups. No radioactivity was detected in the control tissues (<0.006 to <0.015 mg/kg).

Eggs were separated into yolks and whites and combined by group and day. The radioactivity concentration in the whites reached a plateau of about 0.026 mg/kg on day 7. That in the yolks appeared to be reaching a plateau of 0.15 mg/kg on day 9 or 10. The excreta accounted for 88-94% of the total administered dose.

Tissue samples were extracted with acetone and the extracts evaporated to dryness under nitrogen, redissolved in hexane and partitioned with acetonitrile. The acetonitrile fractions from egg yolks were subjected to silica gel column chromatography. Solids from the acetone extraction of liver were extracted with methanol/6 N HCl and then with methanol. Separate liver samples were hydrolysed with 0.6 N NaOH for 3 hours at 70^{o}C. The hydrolysate was adjusted to pH 1 and extracted with benzene/acetonitrile (1:1).

The extracts and residual solids were radioanalysed by LSC, and combustion followed by LSC respectively. However, the study did not reveal the ^{14}C in terms of chlorpyrifos found in the original samples and the individual extracts and residual solids, so the efficiencies of the processes could not be independently ascertained. The percentages of the TRR (total radioactive residue) in the various sample extracts were provided in flowcharts. The recoveries of the radioactive residues, based on these summary values, are shown in Table 1.

Table 1. Distribution of ^{14}C in extracts and solid residues from the tissues of hens dosed orally with 2.26 mg [^{14}C]chlorpyrifos for 10 days; 164 µCi per hen.

Sample, and (mg/kg as chlorpyrifos)	Fraction	% of TRR
Liver (0.054)	Acetone	53
	Acidic methanol	14
	Methanol	1
	Solid residue	12
	Total extracted	68
	Total recovered	80
Liver, base hydrolysate	Benzene/acetonitrile	75
	Aqueous	6
	Solid residue	12
	Total extracted	81
	Total recovered	93
Egg yolk (0.15)	Acidic acetone	99
Kidney (0.15)	Acidic acetone	85
	Solid residue	8
	Total extracted	85
	Total recovered	93
Skin (0.13)	Acidic acetone	92
	Solid residue	7
	Total extracted	92
	Total recovered	99
Fat (0.20)	Acidic acetone/hexane	105
	Solid residue	0

Extracts were analysed by TLC and HPLC and compounds identified by co-chromatography with authentic standards of chlorpyrifos, 3,5,6-trichloro-2-pyridinol (3,5,6-TCP), diethyl 3,5,6-trichloro-2-pyridyl phosphate (chlorpyrifos oxon) and sodium *O*-ethyl *O*-(3,5,6, trichloro-2-pyridyl) phosphorothioate. HPLC was on a C-18 column connected to a radiochemical detector, a UV detector (293 nm) and a fraction collector. TLC was on silica gel 60 F-254 plates. A TLC linear analyser was used to locate regions of radioactivity, which were scraped and analysed by LSC.

GC-MS was used only to confirm [^{14}C]chlorpyrifos. The compound was isolated from appropriate extracts by HPLC, gel permeation chromatography and TLC.

The compounds identified in the extracts are shown in Table 2.

Table 2. Labelled compounds identified in hen tissues and eggs.

Sample	% of ^{14}C in sample			
	Chlorpyrifos (CP)	3,5,6-trichloro pyridinol (TCP)	Unknown D	Unknown E
Kidney	1	71		
Egg yolk	32	49		
Liver	<1	<1	10	7
Liver (hydrolysed)	<1	64	<1	<1
Skin	70	13		
Fat	88	<1		

In the goat metabolism study (Glas, 1981a,b; Wilkes *et al*., 1980) two female goats were dosed orally with gelatin capsules containing 400 µl of a dosing solution containing 0.32 mCi/ml benzene (0.256 mCi/goat/day) twice a day for 10 days with [^{14}C]chlorpyrifos (2.99 mCi/mmole) labelled in the C-2 and C-6 positions. There was no control goat. Feed consumption was monitored.

The first goat consumed 2000 g and the second 700-2000 g each day (average 1560 ± 462 g per day). The dietary exposures were 15 ppm and 19 ppm respectively.

Milk and urine samples were collected twice daily, faeces each morning, and all were stored frozen. Within 24 hours of the final dose, the goats were slaughtered and tissues collected. Aliquots were oxidized and quantified by liquid scintillation counting. The urine and faeces contained 79-89% of the total administered dose, and about 2% was found in the milk and tissues. The residue in the milk reached a maximum on day 8 and decreased slightly thereafter. The results are shown in Table 3.

Table 3. Residues in the tissues and milk of goats dosed orally for 10 days with [^{14}C]chlorpyrifos at 15 and 19 ppm.

Sample	[^{14}C]chlorpyrifos equivalents, mg/kg	
	Goat 1 (15 ppm)	Goat 2 (19 ppm)
Fat	0.10	0.22
Liver	0.18	0.27
Kidney	0.26	0.35
Muscle	0.03	0.03
Skin	0.11	0.18
Milk	0.024 (day 8, PM)	0.047 (day 8, PM)

Fat, liver, kidney and milk were extracted with solvents to identify the compounds. The fat was extracted with hexane, the extract partitioned with acetonitrile, and the residual solids hydrolysed with 0.5 N potassium hydroxide for one hour at 70°C. The hydrolysate was extracted with ether, evaporated to dryness and partitioned with hexane/acetonitrile.

Liver and kidney were each extracted with aqueous methanol (20/80), then the extracts were concentrated and extracted with diethyl ether/hexane (50/50). The residual solids were hydrolysed in the same manner as the fat solids.

The percentages of radioactivity recovered from the tissues by the solvent extractions were not reported. Muscle was not extracted because of the low radioactivity.

Four different extraction methods were used for the milk: (1) benzene from pH >12 solution; (2) basic hydrolysis (1 N potassium hydroxide, 60°C, 3 h) followed by acidification and benzene extraction; (3) hexane extraction, partition of hexane with acetonitrile; (4) mixture with water and dilute hydrochloric acid followed by extraction with benzene. The percentages of the total radioactivity recovered by the procedures were (1) 65-72%, (2) 96-97%, (3) 55-63%, (4) 83-87%. Mild basic hydrolysis (2) released almost all of the radioactivity.

Tissue samples were hydrolysed with 0.6 N potassium hydroxide (1 h, 70°C), and the mixture acidified and extracted with diethyl ether. The ether was evaporated to dryness and the residual oils partitioned with hexane/acetonitrile. Base hydrolysis released more than 94% of the total residue from all tissues.

Tissue and milk extracts were analysed by HPLC on a reverse-phase C-18 column. Fractions collected at one-minute intervals were measured by liquid scintillation counting and standards analysed under the same chromatographic conditions with a UV detector (293 nm).

Urine was acidified and extracted with diethyl ether. Preparative HPLC (ODS-2 reverse-phase) was used to isolate the labelled compounds.

Tentative identifications were confirmed by GC-MS in the CI mode. A splitter at the end of the GC column diverted a fraction of the column effluent to a radioactivity monitor. Purified extracts were also analysed by direct probe MS in the CI or EI mode.

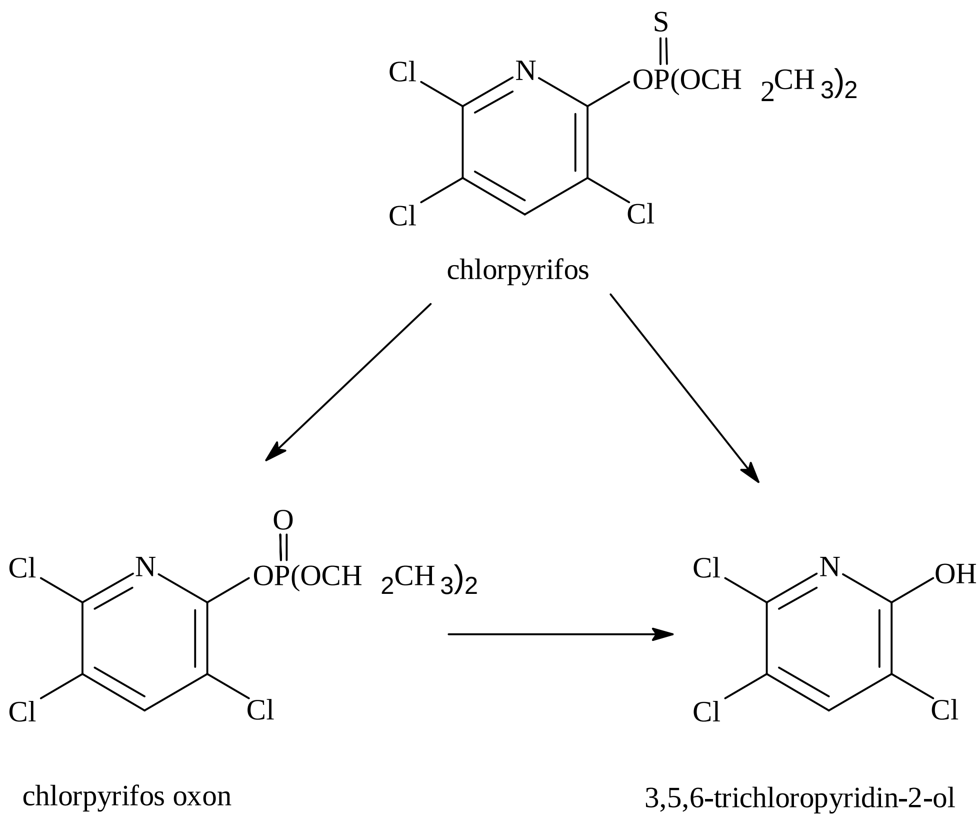
The results are shown in Table 4.

Table 4. Residues in the urine, tissues and milk of goats dosed orally for 10 days with [^{14}C]chlorpyrifos, expressed as % of total ^{14}C in sample and mg/kg as chlorpyrifos..

Sample	Compound or fraction													
	Chlorpyrifos		3,5,6-trichloro-2-pyridinol (TCP)		∃-glucuronide conjugate of TCP		*S*-ethyl, *O*-(3,5,6-trichloro-2-pyridyl) phosphorothioic acid		Ether extract of base hydrolysate of solvent-extracted residue		Un-extractable		Total directly hydrolyseable to TCP	
	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg[1]	% of TRR
Urine		0 0				90 80		8 19						91 94
Milk (day 7)	0.015 0.021	66 74	0.002 0.002	15 13							0.004 0.004	17 13	0.021 0.027	>92 >94
Fat	0.07 0.17	74 79	0.01 0.02	23 19							<0.01 <0.01	2 2	0.098 0.22	>98 >98
Liver[2]	<0.01 <0.01	3.5 0.2	0.09 0.12	85 82					<0.01 0.01	5 4	<0.01 0.01	4 5	0.17 0.26	>95 >95
Kidney[3]	<0.01 <0.01	0.7 1.1	0.13 0.13	92 92					<0.01 <0.01	2 1	0.01 0.02	5 5	0.26 0.35	>94 >94

[1] As chlorpyrifos equivalents. To convert to TCP, multiply by 0.56.
[2] Liver also contained 9.6% or 0.03 mg/kg unidentified (goat 1) and 2% or 0.01 mg/kg (goat 2).
[3] Kidney contained ≤ 0.5% (<0.01 mg/kg) unidentified.

Figure 1. Primary metabolic pathways of chlorpyrifos in livestock.



Plant metabolism

The metabolism of [^{14}C]chlorpyrifos, labelled on ring carbons 2 and 6, was studied on the leaves of maize, soya bean and sugar beet (Bauriedel, 1986). Seeds of the three crops were grown in 20 cm pots in a glasshouse. Twenty four maize plants were in a chamber which enabled volatile products to be collected. Labelled chlorpyrifos, specific activity 1.9 Ci/mole, was applied to the upper leaf surfaces as 1:l drops. The treated area was about 50 cm^2 on the third corn leaf, second trifoliate soya bean leaf, and fourth sugar beet leaf. Zero time samples were taken and analysed to determine the application rate (DPM). Typically, 200 :g of [^{14}C]chlorpyrifos was applied to each plant, and the treated leaf areas were excised, rinsed with methanol and radioanalysed after combustion or homogenized in 75% acetone at intervals to extract metabolites. The untreated plant parts were radioanalysed to ascertain the extent of translocation.

Extracts were analysed by HPLC, using a reverse-phase C-18 column, a variable wavelength UV detector and a fraction collector. One-minute fractions of eluates were collected and analysed by LSC. Standards included chlorpyrifos, chlorpyrifos oxon (diethyl 3,5,6-trichloro-2-pyridinyl phosphate), desethyl acid (*O*-ethyl *O*-3,5,6-trichloro-2-pyridinyl phosphorothioic acid, sodium salt), 3,5,6-TCP and the methoxy analogue 2,3,5-trichloro-6-methoxy pyridine (“the methoxypyridine” or TMP).

The tentative HPLC identification of 3,5,6-TCP was confirmed by GC-MS in the CI mode. Extracts were derivatized with *N,O*-bis(trimethylsilyl)acetamide, or BSA.

In the closed chamber experiment with corn plants, 99% of the applied radioactivity (90 :g/plant) was removed by a solvent rinse at time 0. By day 4 this had decreased to 1% and the volatile radioactivity had increased from 0 to 84%. Radioactivity in the treated leaf segment was highest 12 hours after application, 29% of that applied, and had decreased to 11% by day 4. Translocated radioactivity increased to 0.8% by day 4. The total recovery was 96%.

Plants treated with radiolabelled chlorpyrifos were analysed 8 and 16 days after application. The combined surface rinses and leaf extracts of maize, soya bean and sugar beet at day 8 contained 7.0%, 9.8% and 6.4% of the applied radioactivity, and at day 16, 5.5%, 6.9% and 6.2% respectively. Chlorpyrifos concentrations ranged from 0.1% to 4% of the applied radioactivity. HPLC analysis indicated the absence of the methoxypyridine, the oxon and the TCP. The metabolites were polar.

The polar metabolites in the extracts were separated from chlorpyrifos by evaporating the acetone solvent to dryness and partitioning the residue between ether and water, followed by acid and alkaline hydrolysis of the aqueous phase (1 N, 135^{o}C, 1 h) and enzyme hydrolysis with ∃-glucosidase (pH 5.0, 37^{o}C, 4 h). The results are shown in Table 5. No other aglycone was produced by the hydrolyses. More severe hydrolytic conditions did not produce additional 3,5,6-TCP.

Table 5. Percentage of radioactive residue in the aqueous fractions from leaf surfaces 16 days after treatment converted to 3,5,6-TCP by various treatments, as determined by HPLC.

Treatment	% of TRR present as TCP		
	Maize	Soya bean	Sugar beet
Untreated aqueous extract	6.5	0.0	0.0
Heat	45	49	54
Acid hydrolysis	48	58	58
Base hydrolysis[1]	46	55	54
Enzyme hydrolysis[2]	38	30	25

[1] 2,3,5-TCP confirmed by GC-MS.

[2] ∃-glucosidase. Controls (no enzyme) generated 3.7-4.3%.

The percentage of applied radioactivity that could not be removed from the treated leaves by extraction with 75% acetone increased with time after treatment, but the insoluble portion never exceeded 3% of the applied radioactivity. The results are shown in Table 6.

Table 6. Insoluble radioactive residues.

Days after treatment	Insoluble ^{14}C, % of leaf content	Insoluble ^{14}C, % of applied
Maize		
4	5.5	0.5
8	10	1.0
16	19	1.3
28	26	1.6
Soya bean		
16	29	3.1
Sugar beet		
16	17	1.4

The metabolism of [^{14}C]chlorpyrifos, labelled on ring carbons 2 and 6, was studied in field corn (Bauriedel and Miller, 1986a). The stock solution contained 0.117 g [^{14}C]chlorpyrifos/ml methylene chloride at a specific activity of 3.0 Ci per mole or 18996 dpm per :g. A granular formulation (3.48 ml stock solution per 8 g granules) for application to the ground and an emulsifiable concentrate formulation (8.56 ml of stock to 2 ml “Lorsban” blank) for foliar application were prepared.

The test site, a sandy loam field in Midland, Michigan, USA, consisted of four 180 cm rows with 76 cm spacing. Three of the four rows were treated at planting by T-band application. The granular formulation was sprinkled by hand into the band and furrow and immediately covered with soil previously removed from the 15 cm band. The application was equivalent to 1 lb of a 150 g/kg granular formulation per 1000 ft. row or 223 mg ai/m of row. The fourth row was planted without treatment and all four rows were surrounded by rows of untreated corn.

When the plants were about 50 cm high with 10 leaves, the untreated row and two of the treated rows were foliar-sprayed at a rate equivalent to 1.68 kg chlorpyrifos ai/ha.

At 96 days after soil application or 49 days after foliar application, green forage (3 plants) was taken from each plot. The grain was full and starting to dent. The plants were cut 7.5 cm above the soil line, shredded and homogenized, air-dried, ground to a fine powder and stored frozen.

153 days after planting, the mature crop was harvested and the fodder, without the grain, was chopped, air-dried and ground. The grain was homogenized. All samples were stored frozen.

Plant samples were extracted with acetone or diethyl ether in a Soxhlet extractor or with 75% aqueous acetone in a blender. Samples and/or extracts were hydrolysed with 1 N sodium hydroxide (1 h at 135^{o}C). The mixtures were neutralized or acidified and extracted with diethyl ether.

The total radiocarbon content of the plant samples was measured by combustion and LSC, and of the extracts by LSC. Extracts were analysed by HPLC, on a reverse-phase C-18 column, with a variable wavelength UV detector (280 nm) and a fraction collector. Two linear-gradient solvent systems were used. One-minute fractions were collected and analysed by LSC. Reference compounds were chlorpyrifos, the oxon, the desethyl acid, 3,5,6-TCP and the methoxypyridine. The identification of 3,5,6-TCP was confirmed by GC-MS in the CI mode.

The concentrations of ^{14}C (as chlorpyrifos) are shown in Table 7.

Table 7. ^{14}C residues in field corn samples after the application of [^{14}C]chlorpyrifos to the ground at 0.223 g ai/m at planting and/or to the foliage at 1.68 kg ai/ha 49 days after planting.

Application	^{14}C, mg/kg as chlorpyrifos		
	Green forage (96 days post-plant)	Dry fodder (153 days post-plant)	Grain (153 days post-plant)
Soil (T-Band)	0.08	0.46	0.09
Soil + Foliar	1.62	4.16	0.13
Soil + Foliar	1.61	4.12	0.13
Foliar	2.40	4.04	0.04

Green forage that received both treatments was extracted with 75% acetone, releasing 28% of the TRR, about 3% of which (0.05 mg/kg as chlorpyrifos) was identified as chlorpyrifos (by HPLC) and 1% (0.02 mg/kg) as 3,5,6-TCP. About 11% of the TRR was very polar, eluting in the dead volume, and about 25% of the polar material (6% of the TRR) was base-hydrolysed to 3,5,6-TCP. Direct base hydrolysis of the green forage solubilized 91% of the TRR and 30% of the TRR (0.48 mg/kg) was identified and confirmed by GC-MS as 3,5,6-TCP.

Dry fodder that had received both treatments was extracted with 75% acetone, which released 18% of the TRR. Chlorpyrifos and 3,5,6-TCP accounted for 2% (0.08 mg/kg) and 3% (0.12 mg/kg) of the TRR respectively. Acetone extractions of a separate dry fodder sample showed 1% chlorpyrifos, 8% 3,5,6-TCP and 3% (0.12 mg/kg) of the methoxypyridine but the last was not confirmed by GC-MS. Direct base hydrolysis (1 N sodium hydroxide, 100°C, 4 h) released 89% of the TRR; 16% of the TRR (0.67 mg/kg) was identified as 3,5,6-TCP.

Grain that received both treatments was hydrolysed (1 N sodium hydroxide, steam bath, 4 h) and then acidified and extracted with diethyl ether. Only 1.6% of the TRR was in the extract. Grain samples were sequentially extracted with ether, 75% aqueous acetone and 0.1 N sodium hydroxide. The radioactive residual solid was physically separated on 50 and 200 mesh screens. This may be indicative of incorporation of the radiolabel into protein (4% of total ^{14}C), cellulose (14%), gluten (8%) and starch (34%).

Corn forage samples stored frozen for about 3 years were further analysed in a supplementary study (Lewer, 1990). Forage samples were extracted sequentially with acetone, acetone/water (50/50), 0.17 M sodium chloride, 0.02 M EDTA, 1.25 M NaOH, 0.1 M $NaClO_2$ and 6 M NaOH. The final residue was freeze-dried. The procedure was designed to isolate chlorpyrifos and all low molecular weight metabolites, and to solubilize high molecular weight polysaccharides, hemicellulose and lignin. Each fraction was analysed by LSC or combustion and LSC, and by HPLC. The distribution of the residues is shown in Table 8.

Table 8. Distribution of the labelled residue from the sequential extraction of corn forage (20.87 g, 1.61 mg/kg as chlorpyrifos).

Fraction	Characterization	% of TRR	mg/kg as chlorpyrifos
Acetone	Chlorpyrifos and unconjugated metabolites	30	0.48
50% aqueous acetone	Conjugated metabolites	10	0.16
0.17 M sodium chloride, reflux	Polysaccharide	10	0.16
0.2 M EDTA, reflux	Polysaccharide	7	0.11
1.25 M sodium hydroxide	Hemicellulose	9	0.15
0.1 M sodium chlorite, 80°C	Lignin	26	0.42
6 M sodium hydroxide	Hemicellulose	1	0.02
Residue		0.3	<0.01
Total ^{14}C recovered		93	

The extracts were analysed by HPLC but all showed similar ^{14}C profiles, a broad envelope of radioactivity over a 14 min range with varying amounts of 3,5,6-TCP and other compounds superimposed. The required separation was not achieved. Acidification of the sodium chlorite extract precipitated 7.0% of the TRR, possibly in lignin. From the HPLC analyses, the amount of free 3,5,6-TCP was estimated as 3% of the TRR, and bound 3,5,6-TCP as 3.4% (from the sodium chloride and EDTA extractions). The unknown superimposed compounds were estimated to each be <0.1 mg/kg and all were more polar than 3,5,6-TCP.

In a second extraction procedure, homogenized forage was refluxed with 1 M sodium hydroxide for 2.5 h. The supernatant liquid was removed and the procedure was repeated twice on the residual solid. About 83% of the TRR was solubilized. HPLC analysis showed total 3,5,6-TCP (free and conjugated) to be 24% of the TRR, 0.39 mg/kg.

The metabolism of [^{14}C]chlorpyrifos, labelled on ring carbons 2 and 6, in sugar beet was studied by Bauriedel and Miller (1986b). A stock solution containing 0.117 g [^{14}C]chlorpyrifos per ml methylene chloride at a specific activity of 3.0 Ci per mole or 18996 dpm per :g was used to prepare a granular formulation (2.0 ml stock solution per 5 g granules) for application to the ground and an emulsifiable concentrate formulation (8.56 ml of stock to 2 ml “Lorsban” blank) for foliar application.

The trial was conducted in a field of sandy loam soil in Midland, Michigan, USA. The plot consisted of 4 1.8 m rows with 75 cm row spacing. The rows were surrounded by additional sugar beet plants. Three rows were treated at planting by T-band application. The granular formulation was sprinkled into the band and furrow at 1.0 lb formulation per 1000 feet of row or 1.126 g ai/m.

Fifty-five days after planting, chlorpyrifos was applied to the foliage of the untreated row and to two of the three treated rows at a rate equivalent to 2 pints of formulation per acre or 1.12 g ai/m. The plants nearly filled the rows.

Foliage samples were taken 38 days after planting and the remainder of the crop was harvested at maturity, 163 days after planting. Tops and beets were separated. The tops were chopped, blended and stored frozen, and the beets were washed, diced and frozen. Subsamples were radioassayed by combustion and LSC.

Samples were extracted or hydrolysed as in the corn study, and analyses were with the same HPLC system. The ^{14}C concentrations, expressed as chlorpyrifos, are shown in Table 9.

Table 9. ^{14}C residues in sugar beet samples after the application of [^{14}C]chlorpyrifos at 0.126 g ai/m at planting and/or to the foliage at 1.12 kg ai/ha 56 days after planting.

Application	^{14}C as chlorpyrifos, mg/kg		
	Green foliage (38 days post planting)	Mature tops (163 days post planting)	Mature beets (163 days post planting)
Soil (T-Band)	0.61	0.02	0.11
Soil + Foliar	0.67	0.06	0.21
Soil + Foliar	0.81	0.04	0.23
Foliar (56 days post plant)	-	0.04	0.11

Extraction of green foliage with 75% acetone released about 90% of the radioactivity. HPLC analysis with two solvent systems revealed traces of 3,5,6-TCP and chlorpyrifos, and substantial amounts of polar compounds (87% of the TRR), and alkaline hydrolysis yielded 3,5,6-TCP as a major product (57% of the TRR).

Mature tops that had had both treatments were extracted sequentially with acetone and 75% acetone. The former removed chlorophyll and carotenes but only 4% of the ^{14}C. The aqueous acetone extracted about 45% of the TRR. Solid phase extractions and HPLC analysis revealed no chlorpyrifos, traces of 3,5,6-TCP and a mixture of polar compounds. Alkaline hydrolysis (1 N sodium hydroxide) released 65% of the TRR. HPLC analysis demonstrated that 3,5,6-TCP accounted for 29% of the TRR.

Freeze drying of the beet samples yielded 2-4% of the radioactivity in the cold trap. HPLC, confirmed by GC-MS, identified the methoxypyridine.

Methanol extraction of the beets released 85% of the TRR. Upon cooling, sucrose crystallized (with 10 g of dry beet yielding 8 g sucrose), and was recrystallized and analysed for radioactivity. Alkaline hydrolysis of the sucrose did not produce an aglycone fraction. The highest ratio of sucrose to beet radioactivity, 0.51, was in the samples which received soil treatment only, and the lowest, 0.16, was in those receiving only foliar treatment. This suggests incorporation of radioactivity from the soil. Sucrose accounted for about 40% of the TRR in beets receiving both soil and foliar treatments.

HPLC analysis of the residual liquid from the sucrose crystallization showed the presence of the methoxypyridine (7% of the TRR, including the freeze-dried portion), 3,5,6-TCP (36% of the TRR) and chlorpyrifos (<0.5%). A separate beet sample was extracted with acetone to ascertain whether the methanol solvent converted the pyridinol to the methoxypyridine and similar results were obtained.

A beet sample that had received both treatments was hydrolysed with sodium hydroxide, yielding only 3,5,6-TCP. The proportion of the label released by the hydrolysis was not reported.

A Golden Delicious apple tree (1.8 x 1.5 m) was sprayed nine times during the 1980 season with a WP formulation at 0.1 kg ai/hl chlorpyrifos (Bauriedel and Miller, 1980). The 8th and 9th applications, made 10 days apart, were with [^{14}C]chlorpyrifos labelled on C-2 and C-6 of the pyridinyl ring. The treatment solution contained 180 mg of the labelled chlorpyrifos mixed with 180 mg of blank formulation suspended in 300 ml water. Fourteen days after the final application 155 apples were picked and stored in a refrigerator. The total radioactivity in the apples is shown in Table 10.

Table 10. ^{14}C residues in apples picked 14 days after two treatments with [^{14}C]chlorpyrifos.

No. of apples	^{14}C, mg/kg as chlorpyrifos		
	Peel	Pulp and seed	Whole apple
14	0.72	0.005	0.09[1]
12	0.86	0.005	0.09[1]
25	-	-	0.14
4 individual apples	1.1±0.6	0.004±0.002	-

[1] Calculated from residues in peel and pulp/seed.

Duplicate samples of apple peel (142 g and 110 g) were sequentially extracted with acetone and 50% aqueous methanol. The acetone extract was concentrated and extracted with ethyl ether. The ether phase contained 48-50% of the total ^{14}C activity in the peel. The residual aqueous phase contained 8-10%. The methanol did not extract any more activity. The methanol-peel mixture was refluxed for 2 hours with 0.4 N or 1.0 N sodium hydroxide, centrifuged and the insoluble material washed with methanol and dried in a vacuum. The alkaline supernatant was concentrated, made acidic (pH 2) and extracted with diethyl ether. This ether fraction contained 35-37% of the total radioactivity in the peel. The residual aqueous fraction contained 1.4-1.5% and the residual solid contained 3.3-4.5%.

The extracts were analysed by HPLC on a C-18 reverse-phase column with a linear gradient of aqueous methanol containing 0.01 M ammonium acetate. One-minute eluate fractions were collected and analysed by LSC. Identifications of chlorpyrifos and 3,5,6-TCP were confirmed by GC-MS in the CI mode. The identifications and characterizations are shown in Table 11.

Table 11. Identification and characterization of the labelled residue isolated from the peel of apples treated with [^{14}C]chlorpyrifos.

Metabolite	% of ^{14}C in peel	^{14}C, mg/kg as chlorpyrifos, in peel (total 0.79 mg/kg)	Characterization
Chlorpyrifos	36	0.28	
3,5,6-TCP (free)	5.3	0.04	
3,5,6-TCP (conjugated)	1.2	<0.01	
Unknown A-1	4.2	0.03	Metabolite with 2 Cl, polar
Unknown A-2	4.2	0.03	Metabolite with 2 Cl, polar
Unknown B	5.2	0.04	Found in the aqueous fraction from the acetone extraction. Converted to 3,5,6-TCP by refluxing with 1 N NaOH for 2 h
Unknown C	5.4	0.04	Formed from the base hydrolysis of the post-extraction methanol/peel mixture. Natural incorporation postulated because of lack of 3,5,6-TCP in mixture.
Unknown D	4.3	0.03	
Unknown E	5.6	0.04	

Soya beans were sprayed mid-season 1980 with an EC formulation containing [^{14}C]chlorpyrifos labelled on C-2 and C-6 of the pyridinyl ring at 1.12 kg ai/ha (Bauriedel and Miller, 1981). The specific activity of the labelled chlorpyrifos was 2.5 Ci per mole and 520.5 mg plus 1 ml of emulsifiable concentrate blank and 120 ml of water was applied to 4.6 m^2 of crop. A forage sample was taken 14 days after treatment and beans and field trash were collected at normal harvest 52 days after treatment. Trash was defined as stems, branches, husks and a few leaves and petioles. Subsamples were dried, combusted and assayed by LSC. The remaining samples were stored frozen. The results are shown in Table 12.

Table 12. Total ^{14}C as chlorpyrifos in soya beans after mid-season foliar application at 1.12 kg ai/ha.

Sample	^{14}C, mg/kg, as harvested	^{14}C, mg/kg, dry basis
Forage homogenate	5.09	25.9
Forage leaves, top		112
Forage leaves, middle		45.8
Forage leaves, bottom		24.8
Forage seeds-pods		4.4
Forage stem-petiole		11
Beans		0.50
Field trash		4.15

Beans were extracted sequentially with n-hexane, methanol and 50% aqueous methanol and the residual solid was assayed for radioactivity. Forage and field trash were extracted sequentially with acetone and 50% aqueous methanol, and the residual solids and aqueous fractions after solvent extraction were radioassayed. The residual solids were all hydrolysed for 2 hours in 1 N sodium hydroxide in 80% aqueous methanol. The filtrates were concentrated, acidified to pH 2 and extracted with diethyl ether. The aqueous layers from these extractions were also base-hydrolysed.

Non-polar metabolite fractions were cleaned up by sublimation or steam distillation. Aqueous (polar) fractions were prepared for HPLC analysis by vacuum evaporation and re-solution in 30% aqueous methanol. Polar fractions from bean samples required C-18 SPE clean-up.

Extracts were analysed by HPLC and TLC, and GC-MS (CI mode) was used to confirm the identities of chlorpyrifos and 3,5,6-TCP. HPLC separations were on a reverse-phase C-18 column with a linear gradient of aqueous methanol containing 0.01 M ammonium acetate. Eluates were collected at one minute intervals and assayed by LSC. Non-polar fractions were also analysed by TLC.

A portion of the soya bean oil from the beans in the hexane fraction was hydrolysed and extracted to isolate glycerol and fatty acids. A portion of the soya bean insolubles after the solvent extractions was treated with sodium hydroxide to isolate protein (globulin). The purified natural products were radioanalysed. The ^{14}C concentration in the glycerol and fatty acids was about the same as in the oil, suggesting natural incorporation.

The distribution of the ^{14}C activity in the extracts and hydrolysates is shown in Table 13. The data were inadequate to determine the overall recovery.

Table 13. Distribution of ^{14}C in the extracts of soya bean samples.

Fraction	^{14}C, % of TRR[1]	^{14}C, mg/kg as chlorpyrifos
Soya bean		
Hexane	19.7	0.10
Acetone	20.1	0.10
50% methanol	21.2	0.11
Alkaline hydrolysis	31.0	0.16
Residual solid	8.0	0.04
Forage		
Acetone	64.2	3.3
50% methanol	12.4	0.63
Alkaline hydrolysis	18.4	0.94
Residual solid	5.0	0.25
Field trash		
Acetone	32.7	1.4
50% methanol	45.3	1.9
Residual solid	10.2	0.43

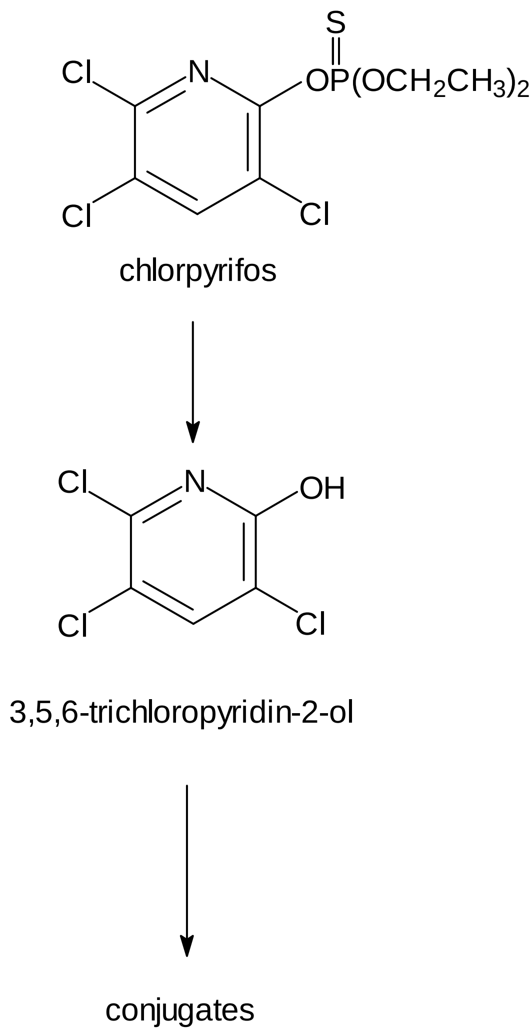
[1]Reported values appear to have been normalized to 100% total recovery.

Table 14 shows the distribution of ^{14}C in the soya bean samples.

Table 14. Identification and characterization of ^{14}C residues from the foliar mid-season application of [^{14}C]chlorpyrifos to soya beans at 1.12 kg ai/ha.

Compound or fraction	^{14}C, % of TRR and mg/kg as chlorpyrifos					
	Bean (0.50 mg/kg)		Forage (5.09 mg/kg)		Field trash (4.15 mg/kg)	
	% of TRR	mg/kg	% of TRR	mg/kg	% of TRR	mg/kg
Chlorpyrifos	2.6	0.013	36	1.8	29	1.3
3,5,6-TCP (free)	8.8	0.044	5.7	0.29	6.0	0.25
3,5,6-TCP (conjugated)	0.0	0.0	18	0.92	25	1.1
Most abundant unknown	6.8	0.034	6.6	0.34	4.6	0.19
Incorporated ^{14}C-activity (protein)	66.0	0.33	-	-	-	-

Figure 2. Proposed metabolic pathway of chlorpyrifos in plants.



Environmental fate in soil

A laboratory study compared the degradation of chlorpyrifos in different soils under aerobic, aerobic/anaerobic and anaerobic conditions (Bidlack, 1979). For the aerobic experiments, 50 g soil samples were treated with [^{14}C]chlorpyrifos at 7.6 kg/ha and incubated at 75% of water capacity at 0.33 bar at 25°C in the dark. For the aerobic/anaerobic experiments, Commerce loam or Stockton Clay adobe soil (100 g) fortified with [^{14}C]chlorpyrifos at 7.6 kg/ha was incubated aerobically for 30 days; 1 g of dry alfalfa was then added to each soil, which was covered with 100 ml of water. The soil containers were purged with nitrogen and incubated. For the anaerobic experiments, the same soils (100 g) were mixed with alfalfa (1 g) and flooded with 100 ml water. The flasks were purged with nitrogen, sealed and incubated at 25°C in the dark until anaerobic gases evolved when [^{14}C]chlorpyrifos was added at 7.6 kg/ha, the flasks were re-purged with nitrogen and sealed and incubation was resumed. In all cases CO_2 production was monitored by sodium hydroxide solution traps on the incubation flasks.

Soils and sodium hydroxide solutions were assayed for radioactivity by combustion and LSC, and by LSC respectively. The soils were extracted sequentially with 1.5 M phosphoric acid/diethyl ether and 6.5 N sodium hydroxide/diethyl ether, and the extracts analysed by TLC.

The half-life of chlorpyrifos under aerobic conditions varied from 11 days in Commerce loam to 141 days in German 2:3 standard soil (sandy loam). The half-life in Stockton clay adobe was 107 days. The average for the seven soil types was 63 days. The half-lives under aerobic/anaerobic conditions were 58 days for Stockton clay adobe and 15 days for Commerce loam, and under anaerobic conditions 51 days and 39 days. Degradation did not follow first-order kinetics. A two-compartment model was applied.

The distribution of the radioactive compounds in the Commerce and Stockton soils at various times under aerobic and anaerobic conditions is shown in Tables 15-17.

Table 15. Identification of the residue after application of [^{14}C]chlorpyrifos to Commerce loam and Stockton clay soil, aerobic conditions.[1]

Compound	Commerce loam/Stockton clay, % of applied radioactivity							
	Days after treatment							
	0	7	14	30	60	120	270	360
Chlorpyrifos	99/95	65/89	45/85	20/77	11/66	6/46	2/30	2/24
Pyridinol (3,5,6-TCP)	3.2/1.1	29/5.1	38/7.8	11/12	4.3/15	2.5/18	1.5/20	0.9/22
Methoxypyridine (TMP)	0/0	0/0	0/0	1.6/<0.1	1.5/1.3	1.6/2.9	0.5/4.5	<0.1/4.6
CO_2	0/0	2/0.6	10/1.5	57/3.9	74/8.1	82/14	83/26	88/27
Unidentified[2]	0.7/2.5	3.9/4.5	4.6/5.6	6.8/5.7	6.6/6.7	5.7/9.7	3.7/8.0	7.0/17
Unextracted	0.9/2.8	3.0/3.9	3.1/4.5	4.0/4.9	3.7/5.4	3.2/10	3.7/12	4.0/11
Total	104/101	103/103	101/104	100/104	102/101	101/101	94/100	102/106

[1] The other five soils generally yielded results between the loam and clay. Barnes loam and Catlin silty clay loam contained more methoxypyridine, 11% and 6% maximum at 120 days respectively.
[2] Includes radioactivity found on TLC plates at R_f 0.11, 0.40 and at the point of application, and radioactivity extracted by cold sodium hydroxide solution but not extractable into diethyl ether.

Table 16. Identification of the residue from the application of [^{14}C]chlorpyrifos to Commerce loam and Stockton clay soil, anaerobic conditions.

Compound	Commerce loam/Stockton clay, % of applied radioactivity								
	Days after treatment								
	0	7	14	30	60	90	180	270	360
Chlorpyrifos	91/92	79/80	71/74	65/73	36/48	22/37	12/22	4.6/16	2.1/12
Pyridinol (3,5,6-TCP)	1.1/2.2	12/ 9.2	20/14	26/20	56/40	72/51	78/57	93/51	92/64
Methoxypyridine (TMP)	0/0	0/0	0.7/0	0/0	0/0	0/0	0/0	0/0	0/0
CO_2	0/0	0.1/0.1	0.1/0.1	0/0.2	0.1/0.2	0.4/0.3	0.4/0.8	0.6/0.8	0.6/1.1
Unidentified[1]	0.8/0	2.3/6.3	2.9/1.2	1.1/4.4	3.2/2.3	2.0/4.3	2.8/6.2	0.6/9.9	7.5/6.1

Compound	Commerce loam/Stockton clay, % of applied radioactivity								
	Days after treatment								
	0	7	14	30	60	90	180	270	360
Unextracted	0.8/2.4	1.8/4.8	1.4/2.3	2.4/10	0.5/4.5	0.5/2.6	0.5/6.7	0.9/5.0	0.8/11
Total	94/97	95/100	95/92	94/108	96/95	97/95	94/93	100/83	101/82

[1] Includes radioactivity found on TLC plates at R_f 0.11, Rf 0.40 and at the point of application, and radioactivity extracted by cold sodium hydroxide solution but not extractable into diethyl ether.

Table 17. Identification of residue from the incubation of [^{14}C]chlorpyrifos to Commerce loam and Stockton clay soil, aerobically for 30 days, then anaerobically for 330 days.

Compound	Commerce loam/Stockton clay, % of applied radioactivity					
	Days after treatment					
	30	60	90	180	270	360
Chlorpyrifos	29/46	19/47	12/39	9.9/13	3.0/22	2.8/13
Pyridinol (3,5,6-TCP)	24/29	36/30	42/13	48/22	35/54	55/49
Methoxypyridine (TMP)	0.2/0	0/0.8	0/0	0.1/0.2	0.6/0.1	0/0.1
CO_2	32/4.5	32/4.8	33/5.8	31/5.9	25/6.2	30/6.1
Unidentified[1]	4.6/5.1	5.7/3.1	4.6/4.8	3.3/6.9	9.9/8.3	7.3/13
Unextracted	4.1/2.8	1.9/4.7	1.8/3.5	4.0/5.9	4.3/12	4.1/16
Total	94/87	95/90	93/66	96/54	78/103	99/97

[1] Includes radioactivity found on TLC plates at Rf 0.11, Rf 0.40 and at the point of application, and radioactivity extracted by cold sodium hydroxide solution but not extractable into diethyl ether

Numerous other studies have been conducted on the degradation of chlorpyrifos in soil (Ware, 1993) with calculated half-lives of chlorpyrifos ranging from 1.9 to 1600 days, depending on soil type and environmental conditions.

The degradation of the metabolite TCP in soil has been studied by Ware (1993). Summary information states that the half-life of TCP in 15 different soils at a concentration of 1 mg/kg ranged from 10 to 325 days, with an average of 73 days. During the 100-day incubation, mineralization to carbon dioxide accounted for 8-77% of the applied material. Another study (Ware, 1993) considered TCP mineralization in 29 different soils. Between 2.4 and 45% of the applied 1 mg/kg TCP was mineralized to carbon dioxide during 21 days of incubation. There was no reliable correlation with pH, percentage of organic carbon, cation-exchange capacity, texture, moisture-holding capacity, or sorptive capacity. A microbiological factor was strongly indicated.

The volatility of [^{14}C]chlorpyrifos from soil has been reported by McCall, *et al.* (1985). The [^{14}C]chlorpyrifos labelled on C-2 and C-6 of the pyridinyl ring had a specific activity of 1.99 mCi/mole and was mixed with unlabelled material in acetone to a concentration of 3.67 mg/ml. There was no formulation blank. Ninety µl of the acetone solution (330:l) was applied to the surface of 55 g of soil 2.5 cm deep, adjusted to 100% of 1/3 bar moisture, to simulate an application rate of 1.12 kg ai/ha. The sealed apparatus was swept with air at 1.0 km/h and polyurethane plugs were used to capture the volatilized chlorpyrifos. The plugs were extracted with acetone and the extract was radioassayed.

The volatility of chlorpyrifos in various soils is shown in Table 18. The data fit first-order kinetics. Half-lives ranged from 45 to 163 hours, equivalent to 80, 290 and 260 g volatilized/ha/day from German, Kawkawlin and Commerce soils respectively.

Table 18. Volatility of [^{14}C]chlorpyrifos applied at 1.12 kg/ha.

% chlorpyrifos remaining in soil					
Time (h)	Mississippi Commerce loam	Time (h)	German sandy loam	Time (h)	Michigan Kawkawlin sandy clay loam
0.0	100	0.0	100	0.0	100
2.5	98	3.0	99	2.0	98
7.0	94	6.0	98	4.0	95
10.5	89	8.0	97	8.5	89
24.0	71	23	90	24	70
36.0	62	29	89	32	62

In a confined rotational crop trial (Hamburg, 1994, GH-C 3284) [^{14}C]chlorpyrifos, labelled on C-2 and C-6 of the pyridinyl ring, with a specific activity of 2.45 mCi/mmol, or 15522 dpm/:g was diluted in acetone and the 12 test plots were treated with 366 mg. Each plot consisted of plywood boxes lined with polyethylene and filled with sandy loam soil (75 cm x 90 cm x 5 cm). Three plots were untreated controls. The remaining plots were situated 76 m downwind of the controls and were sprayed with the test solution (110 ml per plot).

Each of the treated plots was planted with a single crop of carrots, lettuce or wheat 30 or 132 days after treatment (DAT). Before the plantings, the soil in each plot was tilled to a depth of 7.5 cm and sampled. Lettuce and carrot seeds were planted in five planting lines to depths of 0.5-0.6 cm and 1.0 cm respectively. Wheat seed was broadcast and pushed to a depth of 3.2 cm. The plots were maintained in secured greenhouses in Watsonville, California. Immature (tiller stage) and mature wheat, 50% mature and mature carrots and mature lettuce were harvested from both plantings with control samples, and frozen until processed.

The total radioactivity in the soil at various intervals, in immature carrot roots, mature carrot roots and tops, lettuce, wheat forage (immature), grain and straw/chaff was determined by combustion and LSC. The radioactive residues were extracted with 50% aqueous acetone and water, and the extracts cleaned up by SPE. The SPE eluates and the residual solids from the acetone/water and water extractions were refluxed with 1.0 N sodium hydroxide for 4 hours, neutralized and extracted with ethyl acetate The total ^{14}C residues and their distribution in the extracts are shown in Table 19.

Table 19. Total residues in carrots, wheat and lettuce planted 30 and 132 days after treating the soil with [^{14}C]chlorpyrifos at 5.3 kg ai/ha.[1]

Crop	DAT/ DAA[2]	TRR, mg/kg as chlor-pyrifos	% of TRR in acetone /water	% of TRR in water	% of TRR in residual solid 1	% of TRR in hydrolysate of residual solid 1 in ethyl acetate/in water	% of TRR residual solid 2 after hydrolysis	% of TRR extracted
Immature carrot root	30/77	0.54	50	3.3	38	12/19	15	84
	132/209	0.38	70	3.3	30	-	-	73
Carrot root	30/138	0.19	76	4.7	25	5.2/10	7.1	96
	132/259	0.28	72	3.8	19	4.0/12	3.1	92
Carrot tops	30/138	0.61	35	8.4	50	14/17	19	74
	132/259	0.38	52	7.4	35	10/14	7.8	83
Lettuce	30/75	0.23	51	5.6	52	12/26	-	95
	132/187	0.083	34	6.3	57	-	-	40

Crop	DAT/ DAA[2]	TRR, mg/kg as chlor-pyrifos	% of TRR in acetone /water	% of TRR in water	% of TRR in residual solid 1	% of TRR in hydrolysate of residual solid 1 in ethyl acetate/in water	% of TRR residual solid 2 after hydrolysis	% of TRR extracted
Immature wheat (forage)	30/60	0.66	52	6.4	26	9.9/6.2	7.5	74
	132/172	0.26	43	6.5	43	-	-	50
Wheat grain	30/138	0.30	22	17	76	6.6/54	14	100
	132/270	0.43	19	2.9	80	-	-	22
Wheat straw/chaff	30/138	0.80	35	8.0	48[3]	11/11	21[4]	65
	132/270	1.3	40	11	46	-	-	51

[1] Rate is 5.3 times the seasonal direct application rate for wheat in the USA. No GAP for carrot or lettuce.
[2] DAT: interval from application of chlorpyrifos to the soil to planting. DAA: interval from application of chlorpyrifos to harvest of the crop.
[3] Further characterized as 7-13% cellulose and 7.3- 17% lignin.
[4] Further characterized as 9.3-11% cellulose and 6.9% lignin.

The solid residue from the base hydrolysis of some samples was further analysed for cellulose. Buffered potassium permanganate and *tert*-butanol were used to oxidize and dissolve the non-cellulose components of the pellets. The cellulose residues were demineralized and washed in oxalic acid and hydrochloric acid in ethanol.

Cellulose and lignin were isolated from the residual solids from the acetone/water and water extractions. The solids were autoclaved with 2.5 M sodium hydroxide, filtered, and the filter cake (cellulose) washed with boiling 2.5 M sodium hydroxide and water. The lignin in the filtrate was precipitated with concentrated hydrochloric acid.

Cellulose and lignin were also isolated by extraction with 2 M hydrochloric acid/1,4-dioxane (1:9) by shaking for 5 hours at 70^{o}C. The residue was collected as cellulose. The supernatant was concentrated and added to diethyl ether and the residue collected as lignin.

Starch was isolated from the residue from the neutral solvent extraction of wheat grain by extraction with dimethylsulfoxide:water (90:10). The addition of ethanol to the extract precipitated the starch.

Cellulose and starch samples were broken down by treatment with acid and then derivatized with phenylhydrazine to produce osazones suitable for HPLC and GC-MS analyses.

HPLC, one-dimensional TLC and GC-MS were used to analyse the extracts and derivatives. Reversed-phase or amino-bonded columns were used for HPLC and fractions were collected at one-minute intervals and analysed by LSC. TLC was used for co-chromatography of suspected TCP with an authentic TCP standard, and GC-MS to confirm the identity of TMP and TCP.

The identification or characterization of the labelled residue in the rotational crops is shown in Table 20.

Table 20. Identification of labelled residues in crops planted in soil 30 or 132 days after treatment with [^{14}C]chlorpyrifos.

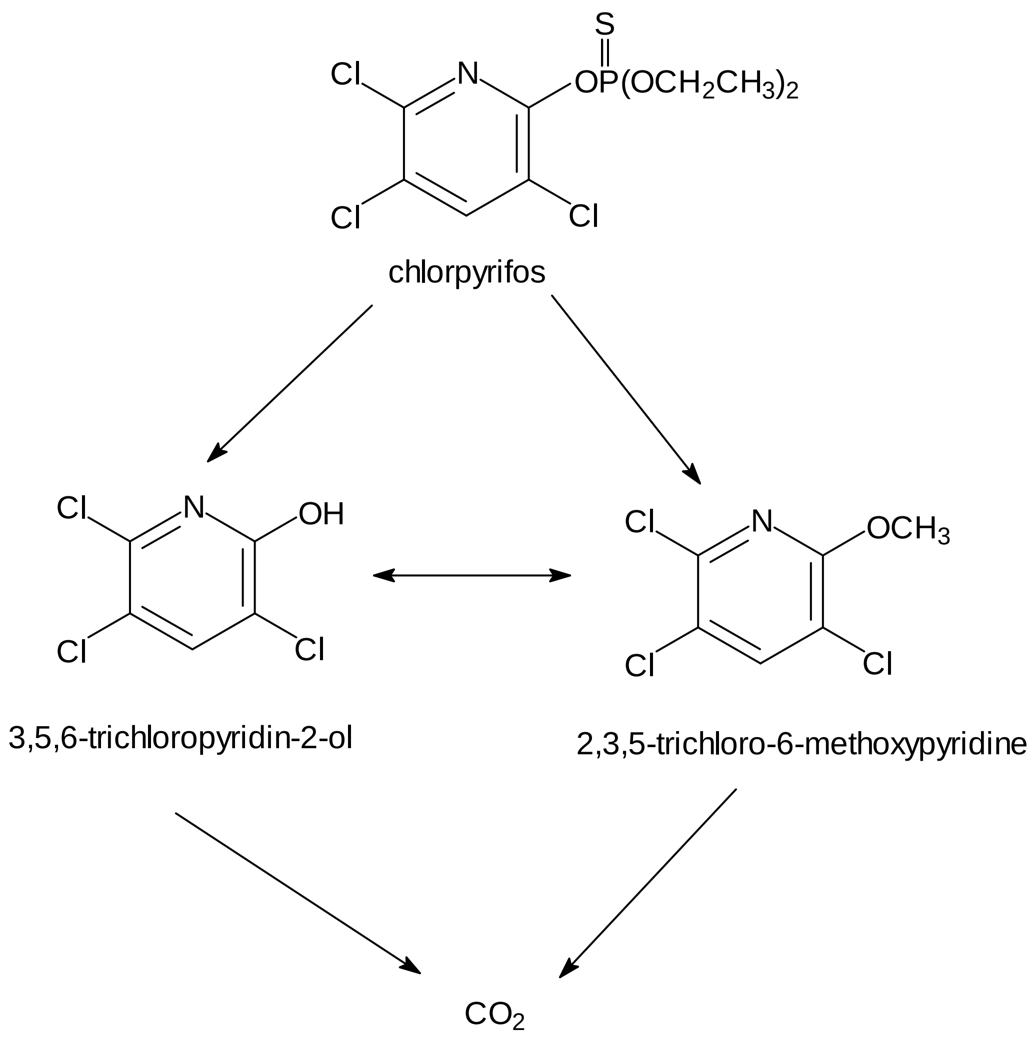
Compound or fraction	^{14}C, % of TRR/mg/kg as chlorpyrifos, in					
	30 DAT Carrot root	132 DAT Carrot root	30 DAT Lettuce	30 DAT Wheat forage	30 DAT Wheat straw	30 DAT Wheat grain
Chlorpyrifos	2.0/0.004	0	0	0	0	0
TCP	10/0.019	7.3/0 .020	5.3/0.012	8.1/0.054	4.3/0.035	0.3/0.001
TMP	26/0.050	36/0.10[2]				0
Cellulose				4.6/0.030	9.3-13/ 0.059-0.11	8.5/0.025

Compound or fraction	^{14}C, % of TRR/mg/kg as chlorpyrifos, in					
	30 DAT Carrot root	132 DAT Carrot root	30 DAT Lettuce	30 DAT Wheat forage	30 DAT Wheat straw	30 DAT Wheat grain
Lignin					6.9-17/ 0.055-0.14	
Starch						46/0.14
Glucose[1]	21/0.040	28/0.08	32/0.075		21/0.16	49/0.14
TOTAL	59%	71%	37%	13%	42-55%	104%

[1]Glucose identification is tentative, based on extract fraction and HPLC retention time.
[2]Concentration of TMP in carrot peel was 54% of TRR or 0.14 mg/kg, and in peeled carrots 13% of TRR or 0.022 mg/kg.

The proposed pathways of degradation of chlorpyrifos in soil are shown in Figure 3. The data show that chlorpyrifos is degraded in large part by hydrolysis to TCP, which can then be further degraded to CO_2 or methylated to form TMP, which itself may be reversibly changed to the pyridinol or possibly degraded to CO_2.

Figure 3. Proposed pathways of degradation of chlorpyrifos in soil.



Environmental fate in water/sediment systems

The manufacturer did not provide any original studies, but submitted a review by Ware (1993) on which the following information on the environmental fate in water/sediment systems is based.

Owing to its non-polar nature, chlorpyrifos has a low solubility in water and great tendency to partition from aqueous into organic phases in the environment. It has a strong affinity for soil, as shown by an average soil and sediment adsorption coefficient (K_{OC}) of 8498 ml/g, based on 28 laboratory studies by the batch equilibrium method. The coefficient ranged from 973 to 31000. TCP has only a moderate affinity for soil, with values of K_{OC} of 18.5-389 ml/g, average 159 ml/g.

A typical leaching trial of several in the laboratory and in the field was with Commerce loam (0.68% organic carbon), Tracy sandy loam (1.12% organic carbon) and Catlin silty clay loam (2.01% organic carbon) treated with [^{14}C]chlorpyrifos (0.5 kg/ha) and eluted with 51 cm of water through 30 cm glass columns packed with the same soils. 95-99% of the chlorpyrifos remained in the top 2 cm of the column, with none below the top 5 cm. A maximum 1.3% of the applied radioactivity was in the leachates. In field leaching studies under natural rainfall and irrigation conditions at 1.1-2.2 kg ai/ha, chlorpyrifos remained in the top 20 cm layer of soil throughout the growing season. One field trial indicated that TCP has at least a moderate tendency to be leached. In a citrus grove trial chlorpyrifos was applied three times at 1.12 kg ai/ha during the growing season with rainfall and irrigation of 110 and 48 cm respectively. Chlorpyrifos was confined to the upper 15 cm of soil, but TCP was found at depths of 46 cm.

METHODS OF RESIDUE ANALYSIS

Analytical methods

Methods for the determination of chlorpyrifos in plant and animal tissues, water and soil have been developed. Chlorpyrifos is determined by gas chromatography, generally with flame photometric detection. Extraction and clean-up methods may vary, depending on the sample. The limit of quantification (LOQ) is usually 0.01 mg/kg. The methods used in the determination of residues of chlorpyrifos in supervised field trials are described below and summarized in Table 21. All analyses are by GLC with flame photometric detection, except in methods ACR 71.1, ERC 87.05 and BRC 93.1 where an ECD is used.

ACR 71.1-Animal tissues, including milk and cream
Chlorpyrifos is extracted from the sample with hexane in the presence of sodium chloride, and partitioned into acetonitrile. Materials interfering with gas chromatographic analysis are removed by clean-up on a silica gel column. A second silicic acid column is required for complete clean-up of cream samples. Residues are determined by electron-capture gas chromatography.

ACR 71.14-Peaches
The sample is blended with acetone. The extract is filtered and the filtrate partitioned with an equal volume of methylene chloride. The acetone-methylene chloride layer is percolated through anhydrous sodium sulfate and then evaporated to dryness with a jet of dry air. The residue is taken up in hexane and partitioned into acetonitrile. The combined acetonitrile extracts are evaporated to dryness, the residue is redissolved in acetone for analysis.

ACR 72.1-Pork muscle, liver, kidney and fat
ACR 72.3-Poultry tissues and eggs
Chlorpyrifos is extracted by blending with acetone or hexane. The extracts are filtered. The hexane filtrate is evaporated with a jet of dry air and the acetone filtrate partitioned with an equal volume of methylene chloride, percolated through anhydrous sodium sulfate and evaporated to dryness with a jet of dry air. The residues are taken up in hexane and cleaned up by acetonitrile partition and a silica gel column. The solvent is evaporated and the analysis completed as in ACR 71.4.

ACR 72.9-Sweet corn forage, kernels and husk

The sample is blended with acetone. The extract is filtered and the filtrate is concentrated by evaporation with a jet of dry air. The acetone filtrate is transferred to an aqueous sodium sulfate solution and the chlorpyrifos is partitioned into hexane. The hexane layer is percolated through a column of anhydrous sodium sulfate and then concentrated by evaporation with a jet of dry air. The analysis is completed as in ACR 72.1.

ACR 72.15-Beans, including forage, sugar beet

Samples are blended with acetone and an aliquot of the extract is evaporated to near dryness under a Snyder column. After the addition of sodium sulfate, the residue is dissolved in hexane and cleaned up on a Florisil column before analysis.

ACR 72.15.S1-Kidney and field beans, peas and vines

After extraction, evaporation and sodium sulfate addition as in ACR 72.15, the residue is dissolved in hexane, which is flashed through a Florisil column carrying the chlorpyrifos with it. The hexane is evaporated and the residue rechromatographed on a second Florisil column in benzene. The benzene is evaporated and the sample taken up in acetone for analysis

ACR 73.5-Sugar beet, sorghum and maize

The sample is blended with acetone. The extract is filtered, the acetone evaporated, and the residue dissolved in hexane. Hexane-acetonitrile partition and clean-up on a 10% silica gel column follow. The eluting solvent is evaporated to dryness. The residues are redissolved in acetone and an aliquot is analysed.

ACR 73.5.S1-Cotton seed, wheat and processed fractions, maize, sunflower and processed fractions, apples and processed fractions, citrus and processed fractions

The sample is homogenized on a “Polytron” with acetone. The procedure is then the same as ACR 73.5 except that a 20% silica gel column is used for clean-up.

ACR 73.5.S2-Juices, especially citrus

The method is then the same as ACR 73.5 except that methanol is used for extraction.

ACR 73.6-Sugar beet juices, citrus molasses

The sample is blended with methanol and the extract filtered, and an aliquot of the filtrate is mixed with a 5% aqueous sodium sulfate solution and partitioned with hexane. The hexane layer is dried by percolating through a column of anhydrous sodium sulfate and then concentrated by evaporation. After a silica gel column clean-up the hexane eluate is evaporated to dryness. The residue is redissolved in acetone and an aliquot analysed.

ACR 74.4-Cotton and processed fractions

The sample is blended with acetone. An aliquot of the extract is evaporated to near dryness under a Snyder column, then azeotroped with hexane to a small volume. The residue is redissolved in methanol and chromatographed on an acidic alumina column. The eluate is mixed with water and partitioned with hexane. The hexane layer is further cleaned up by partitioning with acetonitrile and chromatographing on Florisil before analysis.

ACR 75.1-Oils

The sample is shaken with methanol to extract the chlorpyrifos, then filtered and diluted to a known volume. An aliquot is partitioned with hexane in the presence of water. The hexane phase is dried, evaporated to a small volume and added to a Florisil column from which the compound is eluted with benzene. The benzene is evaporated and the residue dissolved in acetone for analysis.

ACR 75.4-Citrus oil
The sample is blended with acetone, the extract filtered, and the acetone evaporated. The residue is taken up in hexane and the hexane is partitioned with acetonitrile. The acetonitrile is evaporated and the residue redissolved in hexane. The sample is chromatographed on a Florisil column and the eluate is evaporated to dryness. The residue is redissolved in acetone for analysis.

ACR 76.3-Sorghum silage, grain and processed fractions, citrus pulp
The sample is blended with acetone. The extract is filtered and the filtrate is concentrated on a hot plate under a Snyder evaporation column. The concentrate is added to a 5% aqueous sodium sulfate solution and the chlorpyrifos extracted with hexane. The hexane layer is percolated through a column of anhydrous sodium sulfate, concentrated, partitioned with acetonitrile and cleaned up on a silica gel column. The eluate is concentrated on a hot plate under a Snyder column, then taken to dryness with a jet of dry air. The residue is redissolved in acetone for analysis.

ACR 76.3.S1-Peanuts and processed fractions, sorghum and processed fractions, tomatoes and processed fractions, sunflower and processed fractions, coffee beans, apples, cotton seed
The sample is blended with acetone on a "Polytron". The extract is filtered and an aliquot is concentrated on a hot plate under a Snyder column. Sodium sulfate is added to absorb the residual water and the chlorpyrifos is extracted with hexane. A hexane-acetonitrile partition is used for clean up. The acetonitrile is concentrated and taken to dryness as before and the residue redissolved in acetone for analysis.

ACR 76.9-Tomatoes
Samples are blended with acetone/hexane to extract the chlorpyrifos and evaporated to near dryness under a Snyder column. The remaining acetone/hexane is removed by evaporating to near dryness with benzene. The residue is dissolved in acetone/benzene and cleaned up by gel permeation chromatography. The benzene eluate is reduced to a known volume for analysis.

ACR 78.10-Alfalfa forage and hay
The sample is blended with acetone. The extract is centrifuged and a portion diluted as before and analysed directly.

ACR 79.8-Citrus fractions
Chlorpyrifos is extracted with hexane. The hexane extract is evaporated to a small volume and analysed directly.

ACR 84.4-Head and leaf lettuce, citrus, peppers, tomatoes, pears, cereal grains and forage, berries, onions, strawberries, kernels and hulls, alfalfa seed, sweet corn, sorghum forage, fodder and grain, peanuts
ACR 84.4.S1-Alfalfa forage and hay
An acetone extract is evaporated and the residue taken up in water for clean-up on a C-18 Sep-Pak eluted with methanol. The eluate is diluted with water and extracted with a known volume of hexane for analysis.

ACR 84.4.S3-Alfalfa forage and hay, field corn and processed fractions, sorghum and processed fractions, sugar beet, sunflower, apples, grapes
This method is the same as ACR 84.4 except that a capillary column is used.

ACR 90.2-Sunflower seeds and hulls, corn oil
The sample is homogenized with acetone, centrifuged, and an aliquot evaporated. The chlorpyrifos is partitioned from the co-extracted water into hexane, which is partitioned with acetonitrile. The acetonitrile is evaporated to dryness and the residue taken up in water and passed through a C-18

“Sep-Pak” which is eluted with methanol. The eluate is taken up in phosphoric acid, which is partitioned into a known volume of hexane for analysis.

ACR 90.5-Apples, pears
A methanol extract is centrifuged and an aliquot taken up in dilute phosphoric acid. This is partitioned with hexane for analysis.

ERC 87.05-Sugar beet
An acetone macerate is diluted with water and partitioned with hexane. An acetonitrile partition and Florisil mini-column clean-up are followed by gas chromatography with electron capture detection.

ERC 90.13-Bananas, sugar beet, soil
ERC 92.26 –Peaches, cauliflower
ERC 92.28- Onions
ERC 92.30- Peas
ERC 92.31- Beans
ERC 92.38-Citrus
ERC 93.13-Cabbage, Chinese cabbage
ERC 94.1-Grapes
ERC 96.04-Carrots
Chlorpyrifos is extracted by macerating with acetone/water, additional water is added and chlorpyrifos partitioned into hexane. The hexane solution is analysed on a capillary column with flame photometric detection.

BRC 93.1-Cotton seed
Ground samples are extracted with acetone and an aliquot evaporated. A 5% aqueous sodium chloride solution is added and the mixture partitioned with hexane, then the hexane with acetonitrile. Water is added and the solution partitioned with hexane which is evaporated to dryness. The residue is reconstituted in hexane and passed through a “Bond-Elut” silica column, the column washed with hexane and the chlorpyrifos eluted with an excess of hexane, and the eluate evaporated to dryness. The residue is taken up in hexane and the chlorpyrifos determined by gas chromatography with an electron capture detector.

RAM 1312-Almond kernels and hulls
Residues are extracted by blending with hexane, which is filtered. An aliquot is partitioned with acetonitrile and the acetonitrile evaporated to dryness. The sample is cleaned up on a deactivated silica gel column. The eluate is evaporated to dryness and the residue taken up in hexane for analysis.

Enforcement and multiresidue methods

The Government of The Netherlands submitted a multiresidue methods for the determination of chlorpyrifos in a variety of crops and products (Netherlands, 1996). The extraction methods for non-fatty samples included ethyl acetate for fruits and vegetables, and acetone followed by partition for fruits, vegetables and potatoes, nuts, cereals, pulses, oil seeds, tropical seeds and dried fruits, garlic, herbs and spices. Non-fatty ($\leq$5%) animal products are minced, mixed with sodium sulfate, and extracted with acetone/acetonitrile (1:10). Fatty animal meat is rendered at 65^{o}C for 8 h and the fat dissolved in light petroleum. Cheese is extracted with light petroleum. Butter is mixed with sodium sulfate and shaken with n-pentane. Avocado is extracted overnight with acetone:methylene chloride (50/50). Oils seeds are ground and extracted in a Soxhlet with light petroleum ether for 8 h. Milk is extracted either by light petroleum/acetone (50:50) or by a modified AOAC procedure.

Extracts are cleaned up by gel permeation chromatography. The eluent is acetone/cyclohexane (2:1), and the GPC column (450 mm x 10 mm) is packed with Bio-Beads SX-3.

Analyses are by GLC on a capillary column with an FPD or NPD, with confirmation with an ion-trap detector (ITD) or by GC-MS. The relative retention times on various columns are DB-1 1.00, DB-5 0.98, DB-1701 0.91, and DB-wax 0.72. The m/z fragments are 197-201, 258-262 and 314-318. With an ITD, the recoveries of chlorpyrifos from lettuce fortified at 0.03 mg/kg were 103 ± 8.5%, n = 10, and at 0.17 mg/kg 111 ± 3.5%, n = 10.

Adequate methods for the enforcement of tolerances in plant and animal commodities are described in United States Food and Drug Administration Pesticide Analytical Manual (PAM), Volume 2. For plant commodities, there are three GLC methods (Methods I, II and VI) with flame photometric detection (FPD) and a stated limit of detection of chlorpyrifos of 0.01 mg/kg. The recoveries of chlorpyrifos from fortified bananas (0.01-5.0 mg/kg), peaches (0.01-1.0 mg/kg) and cotton seed (0.01-0.1 mg/kg) were 91 ± 4%, 80 ± 2% and 94 ± 10% respectively. In a confirmatory procedure residues are hydrolysed to TCP, which is determined by GLC or GC-MS. For animal commodities, PAM Vol. 2 describes Method IV, with determination by GLC with electron capture detection. The stated limit of detection of free TCP in meat is 0.01 mg/kg. The recovery of chlorpyrifos from beef fat fortified at 0.1 mg/kg was 84%.

The US FDA PESTDATA database (PAM Vol. 1, Appendix II, 1993) indicates that chlorpyrifos is completely recovered (>80%) by FDA multiresidue method protocols D (Section 232.4) and E (Section 212.1/232.1, non-fatty matrices) and partially recovered (50-80%) by multiresidue method protocol E (Section 211.1/232.1, fatty matrices).

Table 21. Summary of methods for determination of residues of chlorpyrifos. All determinations are by GLC.

Method no.	Date	Sample	Detector	Fortification, mg/kg	Mean recovery	LOQ, mg/kg	Reference
Fruit samples							
Pome fruits							
ACR 76.3.S1	1976	Apples	FPD	0.05-2.0	92 ± 6	0.05	GH-C 1485
ACR 73.5.S1	1973	Whole apples	FPD	0.01-10.0	96 ± 3	0.01	GH-C 1107
ACR 90.5	1990	Whole apples	FPD	0.01-0.50	96 ± 1	0.01	GH-C 2397
ACR 90.5	1990	Whole apples	FPD	0.01-1.0	98 ± 12	0.01	GH-C 2449
ACR 84.4	1984	Whole pears	FPD	0.01-2.0	90 ± 3	0.01	GH-C 1789
ACR 90.5	1990	Whole pears	FPD	0.01-0.30	98 ± 11	0.01	GH-C 2449
Citrus fruits							
ACR 73.5.S1	1973	Grapefruit, whole	FPD	0.01-1.0	86 ± 6	0.01	GH-C 1441
		Peel frits	FPD	1.0	71	1.0	GH-C 1441
		Finisher pulp	FPD	1.0	75	1.0	GH-C 1441
		Chopped peel	FPD	1.0	73	1.0	GH-C 1441
ACR 73.5.S1	1973	Whole lemons	FPD	0.01-1.0	89 ± 6	0.01	GH-C 1441
		Peel frits	FPD	0.01-0.10	74 +/-6	0.01	GH-C 1441
		Finisher pulp	FPD	0.01-0.10	74 ± 2	0.01	GH-C 1441
		Chopped peel	FPD	0.01-0.10	71 ± 0	0.01	GH-C 1441
ACR 73.5.S1	1973	Whole oranges	FPD	0.01-1.0	88 ± 4	0.01	GH-C 1441
		Peel frits	FPD	1.0	75	1.0	GH-C 1441
		Finisher pulp	FPD	1.0	74	1.0	GH-C 1441
		Chopped peel	FPD	1.0	74	1.0	GH-C 1441
ACR 73.5.S1	1973	Whole tangelos	FPD	0.01-1.0	86 ± 5	0.01	GH-C 1441
		Peel frits	FPD	0.02-0.10	76 ± 9	0.02	GH-C 1441
		Finisher pulp	FPD	0.01-0.10	77 ± 0	0.01	GH-C 1441
		Chopped peel	FPD	0.01-0.10	74 ± 5	0.01	GH-C 1441
ACR 73.5.S2	1973	Grapefruit juice	FPD	0.10	75	0.10	GH-C 1441

Method no.	Date	Sample	Detector	Fortification, mg/kg	Mean recovery	LOQ, mg/kg	Reference
		Press liquor	FPD	0.10	78	0.10	GH-C 1441
		Emulsion water	FPD	0.10	63	0.10	GH-C 1441
ACR 73.5.S2	1973	Lemon juice	FPD	0.01-0.10	72 ± 4	0.01	GH-C 1441
ACR 73.5.S2	1973	Press liquor	FPD	0.01-0.10	76 ± 2	0.01	GH-C 1441
		Emulsion water	FPD	0.01-0.10	77 ± 1	0.01	GH-C 1441
		Orange juice	FPD	0.10	78	0.10	GH-C 1441
ACR 73.5.S2	1973	Press liquor	FPD	0.10	74	0.10	GH-C 1441
ACR 73.5.S2	1973	Emulsion water	FPD	0.10	70	0.10	GH-C 1441
		Tangelo juice	FPD	0.01-0.10	81 ± 1	0.01	GH-C 1441
		Press liquor	FPD	0.01-0.10	77 ± 1	0.01	GH-C 1441
ACR 73.5.S2	1973	Emulsion water	FPD	0.01-0.10	72 ± 2	0.01	GH-C 1441
ACR 73.6	1973	G. fruit molasses	FPD	0.01-0.10	93 ± 15	0.01	GH-C 1441
		Lemon molasses	FPD	0.01-0.10	82 ± 14	0.01	GH-C 1441
		Orange molasses	FPD	0.01-0.10	84 ± 16	0.01	GH-C 1441
		Tangelo molasses	FPD	0.01-0.10	84 ± 11	0.01	GH-C 1441
ACR 75.4	1975	Grapefruit oil	FPD	0.10-5.0	60 ± 6	0.10	GH-C 1441
		Lemon oil	FPD	0.10-1.0	71 ± 7	0.10	GH-C 1441
		Orange oil	FPD	0.10-3.0	78 ± 1	0.10	GH-C 1441
		Tangelo oil	FPD	0.10-5.0	86 ± 23	0.10	GH-C 1441
ACR 76.3	1976	Grapefruit pulp	FPD	1.0	68	1.0	GH-C 1441
		Lemon pulp	FPD	1.0	75	1.0	GH-C 1441
		Orange pulp	FPD	1.0	69	1.0	GH-C 1441
		Tangelo pulp	FPD	0.05-0.10	71 ± 1	0.05	GH-C 1441
ACR 79.8	1979	G.fruit rinse water	FPD	0.01	113	0.01	GH-C 1441
		Lemon rinse water	FPD	0.01	116	0.01	GH-C 1441
		Orange rinse water	FPD	0.01	111	0.01	GH-C 1441
ACR 84.4	1984	Whole oranges	FPD	0.01-2.0	88 ± 5	0.02	GH-C 1724
ACR 84.4	1984	Oranges	FPD	0.01-1.0	89 ± 4	0.01	GH-C 2554
ERC 92.38	1992	Lemon peel	FPD	0.01-5.0	82 ± 4	0.01	GHE-P 3228
	1992	Lemon pulp	FPD	0.01-5.0	90 ± 4	0.01	GHE-P 3228
	1992	Mandarin peel	FPD	0.01-5.0	85 ± 8	0.01	GHE-P 3213
	1992	Mandarin pulp	FPD	0.01-5.0	97 ± 6	0.01	GHE-P 3213
Stone fruits							
ACR 71.14	1971	Peaches	FPD	0.01-1.0	80 ± 5	0.01	GH-C 479
ERC 92.26	1992	Peaches	FPD	0.01-1.0	100 +/ 4	0.01	GHE-P 3139
Small fruits and berries							
ACR 84.4.S3	1984	Grapes	FPD	0.01-1.0	88 ± 9	0.01	GH-C 3272
ERC 94.1	1994	Grapes	FPD	0.01 -1.0	94 +/-7	0.01	GHE-P 4968
ACR 84.4	1984	Blueberries	FPD	0.01-2.0	90 ± 8	0.01	GH-C 1832
ACR 84.4	1984	Strawberries	FPD	0.01-10.0	86 ± 4	0.01	GH-C 1871
ACR 84.4	1984	Black raspberries	FPD	0.01-2.0	85 ± 7	0.01	GH-C 1903
		Blackberries	FPD	0.01-2.0	89 ± 7	0.01	GH-C 1903
		Red Raspberries	FPD	0.01-2.0	89 ± 4	0.01	GH-C 1903
		Boysenberries	FPD	0.01-2.0	97 ± 6	0.01	GH-C 1903
Tropical fruits							
ERC 90.13	1990	Bananas, whole	FPD	0.01-2.0	90 ± 14	0.01	GHE-P 3349
		Bananas, pulp	FPD	0.01-2.0	92 ± 8	0.01	
ERC 90.13	1990	Bananas, peel	FPD	0.01-2.0	90 ± 17	0.01	
Vegetable samples							
Brassica vegetables							

Method no.	Date	Sample	Detector	Fortification, mg/kg	Mean recovery	LOQ, mg/kg	Reference
ERC 93.13	1993	Cabbage	FPD	0.01-1.0	103+/-6	0.01	GHE-P 3634
ERC 92.26	1992	Cauliflower -plant	FPD	0.01-1.0	97 +/-3	0.01	GHE-P 3212
		Rest of plant	FPD	0.01-1.0	85 +/-7	0.01	GHE-P 3212
		Curd	FPD	0.01-1.0	97 +/-8	0.01	GHE-P 3633
Legume vegetables							
ACR 72.15.S1	1972	Kidney beans	FPD	0.05-1.0	98 ± 2	0.01	GH-C 1157
		Kidney pods	FPD	0.05-1.0	98 ± 2	0.01	GH-C 1157
		Kidney whole plant	FPD	0.05-1.0	91 ± 3	0.05	GH-C 1157
		Kidney vines	FPD	0.05-1.0	91 ± 3	0.05	GH-C 1157
		Field bean vines	FPD	0.05-1.0	88 ± 6	0.05	GH-C 1157
		Field beans	FPD	0.05-1.0	89 ± 4	0.05	GH-C 1157
ACR 72.15.S1	1972	Peas plus pod	FPD	0.05-1.0	81 +/-6	0.05	GH-C 1158
		Pea vines	FPD	0.05-1.0	82 ± 5	0.05	GH-C 1158
		Pea whole plant	FPD	0.05-1.0	82 ± 5	0.05	GH-C 1158
ACR 72.15.S1	1972	Snapbean forage	FPD	0.01-2.0	92 ± 2	0.01	GH-C 660
		Snapbeans	FPD	0.01-0.50	87 ± 4	0.01	GH-C 660
ERC 92.31	1992	Beans-whole plant	FPD	0.01-1.0	94 ± 6	0.01	GHE-P 3231
		Rest of plant	FPD	0.01-1.0	94 ± 8	0.01	GHE-P 3231
		Beans	FPD	0.01-1.0	94 ± 5	0.01	GHE-P 3231
ERC 92.30	1992	Peas-whole plant	FPD	0.01-1.0	95 ± 7	0.01	GHE-P 3232
		Peas-rest of plant	FPD	0.01-1.0	96 ± 6	0.01	GHE-P 3232
		Peas	FPD	0.01-1.0	98 ± 7	0.01	GHE-P 3232
Leafy vegetables							
ACR 84.4	1984	Leaf lettuce	FPD	0.01-5.0	88 ± 12	0.02	GH-C 1696
		Head lettuce	FPD	0.01-10.0	94 ± 10	0.01	GH-C 1696
Fruiting vegetables							
ACR 76.3.S1	1976	Whole tomatoes	FPD	0.01-10.0	87 ± 4	0.02	GH-C 1282
		Juice	FPD	0.01-0.10	100 ± 18	0.01	GH-C 1282
		Tomato less peel	FPD	0.01-0.50	94 ± 8	0.01	GH-C 1282
		Purée	FPD	0.01-0.10	92 ± 15	0.01	GH-C 1282
		Seeds/peelings	FPD	0.01-1.5	90 ± 9	0.01	GH-C 1282
ACR 76.3.S1	1976	Tomatoes	FPD	0.01-0.50	88 ± 6	0.01	GH-C 1372
ACR 76.3.S1	1976	Tomatoes	FPD	0.01-5.0	89 ± 5	0.02	GH-C 1641
ACR 76.9	1976	Tomatoes	FPD	0.01-0.50	94 ± 4	0.01	GH-C 952
ACR 84.4	1984	Peppers	FPD	0.01-2.0	86 ± 9	0.01	GH-C 1757
		Tomatoes	FPD	0.01-0.50	94 ± 12	0.01	GH-C 1757
Bulb vegetables							
ACR 84.4	1984	Onions	FPD	0.01-0.04	87 ± 5	0.01	GH-C 1848
ERC 92.28	1992	Onions	FPD	0.01-1.0	100 +/-6	0.01	GHE-P 3466
Root crops							
ACR 72.15	1972	Sugar beet leaves	FPD	0.01-1.0	89 ± 6	0.01	GH-C 729
ACR 73.5	1973	Sugar beet roots	FPD	0.01-1.0	87 ± 4	0.01	GH-C 729
		Wet pulp	FPD	0.01-1.0	90 ± 6	0.01	GH-C 729
		Dry pulp	FPD	0.01-1.0	100 ± 4	0.01	GH-C 729
		Lime cake	FPD	0.01-1.0	99 ± 4	0.01	GH-C 729
ACR 73.6	1973	Diffusion juice	FPD	0.01-1.0	103 ± 5	0.01	GH-C 729
		Thin juice	FPD	0.01-1.0	100 ± 2	0.01	GH-C 729
		Thick juice	FPD	0.01-1.0	106 ± 6	0.01	GH-C 729
ACR 84.4.S3	1984	Sugar beet roots	FPD	0.01-1.0	71 ± 4	0.01	GH-C 4223
		Sugar beet tops	FPD	0.01-10.0	80 ± 8	0.01	GH-C 4223
ERC 90.13	1990	Sugar beet leaves	FPD	0.01-10.0	92 +/-7	0.01	GHE-P 2467

Method no.	Date	Sample	Detector	Fortification, mg/kg	Mean recovery	LOQ, mg/kg	Reference
		Sugar beet roots	FPD	0.01-10.0	100 +/-7	0.01	GHE-P 2467
ERC 87.05	1987	Sugar beet leaves	ECD	0.01-0.5	70 ± 4	0.01	GHE-P 1709
		Sugar beet roots	ECD	0.01-0.5	73 +/-8	0.01	GHE-P 1709
ERC 96.04	1996	Carrots	FPD	0.01-10.0	88 ± 6	0.01	GHE-P 5473
Cereal grains and animal feeds							
Alfalfa							
ACR 78.10	1978	Alfalfa forage	FPD	0.50-2.0	95 ± 4	0.50	GH-C 1610
		Alfalfa hay	FPD	0.50-2.0	94 ± 4	0.50	GH-C 1610
ACR 78.10	1978	Alfalfa forage	FPD	0.50-5.0	96 ± 4	0.50	GH-C 2288
ACR 78.10	1978	Alfalfa forage	FPD	0.50-5.0	94 ± 6	1.0	GH-C 2294
ACR 78.10	1978	Alfalfa forage	FPD	0.5-100.0	97 ± 6	1.0	GH-C 2334
		Alfalfa hay	FPD	0.5-100.0	107 ± 7	1.0	GH-C 2334
ACR 84.4	1984	Alfalfa seed	FPD	0.10-0.50	96 ± 7	0.02	GH-C 1803
ACR 84.4S1	1984	Alfalfa forage	FPD	0.01-10.0	84 ± 10	0.01	GH-C 4198
		Alfalfa hay	FPD	0.01-20.0	84 ± 10	0.01	GH-C 4198
ACR 84.4.S3	1984	Alfalfa forage	FPD	0.01-20.0	84 ± 7	0.01	GH-C 2752
		Alfalfa hay	FPD	0.01-50.0	89 ± 11	0.01	GH-C 2752
Sweet corn and maize (field corn)							
ACR 71.18	1971	Field corn forage	FPD	0.01-1.0	92 ± 5	0.01	GH-C 530
		Field corn grain	FPD	0.01-1.0	83 ± 6	0.01	GH-C 530
		Field corn stover	FPD	0.01-1.0	93 ± 5	0.01	GH-C 530
ACR 72.9	1972	Sweet corn forage	FPD	0.01-1.0	97 ± 6	0.01	GH-C 664
		Kernels	FPD	0.01-1.0	94 ± 5	0.01	GH-C 664
		Kernels plus cob	FPD	0.01-1.0	95 ± 5	0.01	GH-C 664
		Cobs plus husks	FPD	0.01-1.0	101 ± 4	0.01	GH-C 664
		Husks	FPD	0.01-1.0	82 ± 7	0.01	GH-C 664
ACR 73.5.S1	1973	Field corn forage	FPD	0.05-1.0	81 ± 3	0.05	GH-C 1284
		Fodder	FPD	0.05-1.0	84 ± 2	0.01	GH-C 1284
		Grain	FPD	0.01-1.0	93 ± 5	0.01	GH-C 1284
ACR 73.5.S1	1973	Field corn forage	FPD	0.01-.10	84 ± 5	0.01	GH-C 1068
		Field corn fodder	FPD	0.01-0.10	83 ± 6	0.01	GH-C 1068
		Field corn grain	FPD	0.01-0.10	85 ± 4	0.01	GH-C 1068
ACR 73.5.S1	1973	Field corn forage	FPD	0.50-50.0	89 ± 8	1.0	GH-C 1440
		Fodder	FPD	0.50-10.0	91 ± 5	1.0	GH-C 1440
		Grain	FPD	0.01-1.0	82 ± 6	0.01	GH-C 1440
ACR 84.4	1984	Sweet corn forage	FPD	0.01-2.0	91 ± 9	0.01	GH-C 2569
		Sweet corn ears	FPD	0.01-0.10	92 ± 11	0.01	GH-C 2569
ACR 84.4	1984	Sweet corn forage	FPD	0.01-10.0	91 ± 4	0.01	GH-C 1797
ACR 84.4.S3	1984	Field corn grain	FPD	0.01	88 ± 20	0.01	GH-C 2878
		Grits	FPD	0.01-0.10	77 ± 14	0.01	GH-C 2878
		Meal	FPD	0.01-1.0	83 ± 8	0.01	GH-C 2878
		Flour	FPD	0.01-0.10	84 ± 9	0.01	GH-C 2878
		Gluten	FPD	0.01-0.50	97 ± 6	0.01	GH-C 2878
		Starch	FPD	0.01-0.05	84 ± 10	0.01	GH-C 2878
		Screenings	FPD	0.10-2.0	107 ± 12	0.10	GH-C 2878
ACR 90.2	1990	Field corn oil	FPD	0.01-0.10	71 ± 13	0.02	GH-C 2878
Sorghum							
ACR 73.5	1973	Sorghum forage	FPD	0.01-5.0	93 ± 4	0.01	GH-C 900
		Sorghum silage	FPD	0.01-1.0	94 ± 8	0.01	GH-C 900
ACR 76.3	1976	Sorghum silage	FPD	0.01-1.0	78 ± 6	0.01	GH-C 900
		Sorghum grain	FPD	0.01-1.0	84 ± 3	0.01	GH-C 900

Method no.	Date	Sample	Detector	Fortification, mg/kg	Mean recovery	LOQ, mg/kg	Reference
ACR 76.3	1976	Sorghum grain	FPD	0.01-0.50	84 +/-3	0.01	GH-C 998
		Sorghum stover	FPD	0.01-3.0	78 ± 4	0.01	GH-C 998
ACR 76.3	1976	Sorghum grain	FPD	0.02-0.50	85 ± 6	0.02	GH-C 1109
		Flour	FPD	0.02-0.10	79 ± 13	0.02	GH-C 1109
		Shorts	FPD	0.02-0.10	92 ± 4	0.02	GH-C 1109
		Middlings	FPD	0.02-0.10	88 ± 16	0.02	GH-C 1109
		Screenings	FPD	0.02-0.20	82 ± 10	0.02	GH-C 1109
ACR 76.3.S1	1976	Sorghum bran	FPD	0.02-0.50	90 ± 14	0.02	GH-C 1109
		Sorghum germ	FPD	0.05-0.40	77 ± 1	0.05	GH-C 1109
ACR 84.4	1984	Sorghum forage	FPD	0.05-5.0	85 ± 11	0.05	GH-C 1813
		Sorghum fodder	FPD	0.05-1.0	87 ± 10	0.05	GH-C 1813
		Sorghum grain	FPD	0.01-0.05	89 ± 13	0.01	GH-C 1813
ACR 84.4	1984	Sorghum grain	FPD	0.01-0.50	92 ± 17	0.02	GH-C 2555
		Sorghum fodder	FPD	0.01-1.0	100 ± 11	0.02	GH-C 2555
ACR 84.4.S3	1984	Sorghum grain	FPD	0.01-0.50	83 ± 7	0.01	GH-C 3226
		Sorghum forage	FPD	0.01-0.50	82 ± 4	0.01	GH-C 3226
Wheat							
ACR 73.5.S1	1973	Wheat grain	FPD	0.01-1.0	92 ± 8	0.02	GH-C 1346
		Wheat straw	FPD	0.01-2.0	90 ± 4	0.01	GH-C 1346
		Wheat bran	FPD	0.05-2.0	86 ± 1	0.05	GH-C 1346
		Wheat flour	FPD	0.05-2.0	76 ± 13	0.05	GH-C 1346
		Break shorts	FPD	0.05-2.0	86 ± 1	0.05	GH-C 1346
ACR 73.5.S1	1973	Reduction shorts	FPD	0.05-2.0	84 ± 6	0.05	GH-C 1346
		Red dog	FPD	0.05-2.0	86 ± 2	0.05	GH-C 1346
		Bread	FPD	0.05-2.0	84 ± 1	0.05	GH-C 1346
ACR 73.5.S1	1973	Wheat grain	FPD	0.01-1.0	98 ± 9	0.02	GH-C 1639
		Wheat straw	FPD	0.05-5.0	97 ± 6	0.02	GH-C 1639
		Wheat forage	FPD	0.05-20.0	93 ± 9	0.04	GH-C 1639
ACR 84.4	1984	Wheat grain	FPD	0.01-0.10	90 ± 0	0.01	GH-C 1790
		Wheat straw	FPD	0.01-5.0	88 ± 7	0.01	GH-C 1790
		Wheat forage	FPD	0.01-2.0	91 +/-5	0.01	GH-C 1790
ACR 84.4	1984	Wheat grain	FPD	0.01-1.0	95 ± 12	0.01	GH-C 1804
ERC 90.13	1990	Wheat grain	FPD	0.01-1.0	92 +/-9	0.01	GHE-P 3720
		Wheat straw	FPD	0.01-2.0	92 +/-6	0.01	GHE-P 3720
Nuts and seeds							
Almonds							
RAM 1312	1987	Kernels	FPD	0.01-8.0	86 ± 4	0.01	GH-C 2180
		Hulls	FPD	0.01-4.0	84 ± 6	0.01	GH-C 2180
Cotton seed							
ACR 73.5.S1	1973	Cotton seed	FPD	0.01-1.0	86 ± 6	0.01	GH-C 1893
ACR 74.4	1974	Cotton seed	FPD	0.01-0.10	93 ± 10	0.01	GH-C 840
		Gin trash	FPD	0.01-1.0	88 ± 18	0.03	GH-C 840
		Hulls	FPD	0.10	66 ± 9	0.10	GH-C 840
		Linters	FPD	0.01	85 ± 15	0.02	GH-C 840
		Meal	FPD	0.01-0.10	97 ± 7	0.01	GH-C 840
ACR 75.1	1975	Oil	FPD	0.01-0.20	78+/- 8	0.01	GH-C 840
ACR 76.3.S1	1976	Cotton seed	FPD	0.01-0.50	87 ± 8	0.01	GH-C 1658
ACR 76.3.S1	1976	Cotton seed	FPD	0.01-0.10	87 ± 5	0.01	GH-C 1879
BRC 93.1	1993	Cotton seed	ECD	0.01-1.0	81 ± 3	0.01	GHB-P 195
Coffee							
ACR 76.3.S1	1976	Coffee beans	FPD	0.01-0.10	88 ± 5	0.01	GH-C 1462

Method no.	Date	Sample	Detector	Fortification, mg/kg	Mean recovery	LOQ, mg/kg	Reference
Peanuts							
ACR 76.3.S1	1976	Peanut forage	FPD	0.05-100.0	79 ± 3	0.05	GH-C 1071
		Kernels	FPD	0.01-0.50	84 ± 3	0.01	GH-C 1071
		Hulls	FPD	0.01-0.10	87 ± 6	0.01	GH-C 1071
		Hay	FPD	0.05-5.0	89 ± 10	0.05	GH-C 1071
ACR 76.3.S1	1976	Nut meats	FPD	0.02	90 (2)	0.02	GH-C 1199
		Press cake	FPD	0.05	98 (2)	0.05	GH-C 1199
		Pressed oil	FPD	0.05	86 (2)	0.05	GH-C 1199
ACR 76.3.S1	1976	Peanut oil	FPD	0.01-0.25	91 ± 9	0.01	GH-C 1278
		Soapstock	FPD	0.01-.020	91 ± 6	0.02	GH-C 1278
ACR 84.4	1984	Peanut kernels	FPD	0.01-0.50	79 ± 8	0.01	GH-C 2665
		Hulls	FPD	0.01-2.0	106 ± 28	0.03	GH-C 2665
Sunflower							
ACR 73.5.S1	1973	Sunflower seed		0.01-1.0	92 ± 8	0.01	GH-C 1180
ACR 76.3.S1	1976	Sunflower forage	FPD	0.01-4.0	87 ± 6	0.02	GH-C 1371
		Seed	FPD	0.01-0.50	92 ± 5	0.01	GH-C 1371
ACR 76.3.S1	1976	Sunflower seed	FPD	0.01-0.05	91 ± 9	0.01	GH-C 1468
		Meal	FPD	0.01-0.05	77 ± 5	0.01	GH-C 1468
		Hulls	FPD	0.01-0.05	66 ± 34	0.01	GH-C 1468
		Oil	FPD	0.01-0.05	64 ± 14	0.01	GH-C 1468
		Soapstock	FPD	0.01-0.05	81 ± 19	0.01	GH-C 1468
ACR 90.2	1990	Sunflower seed	FPD	0.01-0.10	78 ± 6	0.01	GH-C 2683
ACR 90.2	1990	Sunflower seed	FPD	0.01-0.50	86 ± 9	0.01	GH-C 3239
		Sunflower hulls	FPD	0.01-0.50	97 ± 12	0.01	GH-C 3239
Animal products							
ACR 71.1	1971	Milk	FPD	0.01-0.10	86 ± 4	0.01	GH-C 533
		Cream	FPD	0.01-0.10	87 ± 16	0.01	GH-C 533
Claborn & Ivey	1971	Bovine muscle	FPD	0.01-0.10	86 ± 2	0.01	GH-C 566
		Liver	FPD	0.01-0.08	78 ± 5	0.01	GH-C 566
		Kidney	FPD	0.01-0.03	74 ± 3	0.01	GH-C 566
		Omental fat	FPD	0.01-0.10	88 ± 5	0.01	GH-C 566
		Renal fat	FPD	0.01-0.05	90 ± 4	0.01	GH-C 566
		Subcutaneous fat	FPD	0.01	87 ± 7	0.01	GH-C 566
ACR 72.1	1972	Pig muscle	FPD	0.01-1.0	88 ± 5	0.01	GH-C 549
		Liver	FPD	0.01-1.0	90 +/-9	0.01	GH-C 549
		Kidney	FPD	0.01-1.0	88 ± 5	0.01	GH-C 549
		Fat	FPD	0.01-1.0	83 ± 4	0.01	GH-C 549
ACR 72.3	1972	Chicken muscle	FPD	0.01-1.0	98 ± 7	0.01	GH-C 555
		Liver	FPD	0.01-1.0	90 ± 7	0.01	GH-C 555
		Kidney	FPD	0.01-1.0	91 ± 6	0.01	GH-C 555
		Fat	FPD	0.01-1.0	83 ± 6	0.01	GH-C 555
		Eggs	FPD	0.01-1.0	94 ± 5	0.01	GH-C 555
Soil and water samples							
ACR 77.7	1977	Soil	FPD	0.01-10.0	96 +/-3	0.01	
ERC 90.13	1990	Soil	FPD	0.01-1.0	98 +/-9	0.01	
ACR 71.21	1971	Water	FPD	0.001-1.0	92 +/-5	0.001 ppm	
ACR 71.21.S1	1971	Water	FPD	1 ppb	98 +/-4	1.0 ppb	
ERC 78.3	1978	Water	FPD	0.01-5.0 ppb	92 +/-6	0.01 ppb	

Method no.	Date	Sample	Detector	Fortification, mg/kg	Mean recovery	LOQ, mg/kg	Reference
ACR 79.8	1979	Water	FPD	1.0-10.0 ppb	98 +/-2	1.0 ppb	
ACR 86.5	1986	Water	FPD	0.25-25 ppb	94 +/-9	0.25 ppb	

Stability of pesticide residues in stored analytical samples

Stability trials were conducted with various crop samples fortified with 0.1 and 1.0 mg/kg chlorpyrifos and stored frozen. The samples were analysed periodically by a gas chromatographic method with flame photometric detection with a validated LOQ of 0.01 mg/kg. The results are shown in Table 22. Some samples were heated with alcoholic sodium hydroxide before extraction, which converted chlorpyrifos to the pyridinol and allowed determination of the total residue. In these cases, TCP was determined by GLC with EC detection to a validated level of 0.05 mg/kg (Wetters, 1990a).

Table 22. Stability of chlorpyrifos in various substrates stored at -18°C.

Sample	Container	Storage period, days	Fortification, mg/kg	% remaining
Alfalfa forage	glass	327 340	1.0 0.97	100 97
Alfalfa hay	glass	327 340	1.0 1.0	110 100
Almond hulls	glass	258	0.10	57 [1]
Almond kernels	glass	258	0.10	82 [1]
Apple	glass	172 271	0.10 0.10	93 90
Apple	polyethylene	1351 1533	1.0 1.0	90 80
Apple	glass	258	0.10 0.10	93 90
Apricots	glass	258	0.10	84 [1]
Cherries	glass	260 272	0.10	102 [1]
Maize, cobs	glass	30 150	0.10 0.10	91 74
Maize, grain	glass	30 150 810 810	0.10 0.10 0.10 1.0	81 82 85 70
Maize, green plant	glass	30 30 150 150 810 810	0.10 0.10 0.10 0.10 0.10 1.0	82 89 83 84 81 73
Maize, stalks	glass	30 150 810 810	0.10 0.10 0.10 1.0	86 85 104 76
Orange juice	glass	162	0.10	79
Orange peel + pulp	glass	162	0.10	103
Oranges	glass	162 172	0.10 0.10	78 79
Peaches	glass	258	0.10	73 [1]
Pears	glass	258	0.10	75 [1]
Plums	glass	258	0.10	98 [1]
Sorghum, dry plant	glass	61	1.0	83
Sorghum, fodder	polyethylene	1679	1.0	92
Sorghum, grain	glass	65	1.0	77
Sorghum, grain	polyethylene	1679	1.0	76
Sorghum green	glass	65	1.0	77

Sample	Container	Storage period, days	Fortification, mg/kg	% remaining
plant (silage stage)				
Sorghum, green plant	glass	61	1.0	88
Sugar beet roots	polyethylene	1369	1.0	82 [1]
Sugar beet lime cake	glass	68 75	1.0 1.0	53 38
Sugar beet tops	polyethylene	1369	1.0	91 [1]
Sugar beet dry pulp	glass	68	1.0	88
Sugar beet wet pulp	glass	68	1.0	91
Sugar beet leaves	glass	48 147 151 151	0.10 0.10 0.10 1.0	88 90 69 85
Sugar beet roots	glass	48 147 151 151	0.10 0.10 0.10 1.0	74 89 73 63
Sugar beet thin juice	glass	69	1.0	92
Sugar beet diffusion juice	glass	69	1.0	93
Sugar beet thick juice	glass	69	1.0	90
Sweet corn, kernels	glass	30 150	0.10 0.10	97 84
Sweet corn, green plant	glass	30 30 150 150	0.10 0.10 0.10 0.10	96 90 84 76
Sweet corn, kernels + cobs	glass	30 150	0.10 0.10	96 80
Sweet corn, husks	glass	30 150	0.10 0.10	93 79
Sweet corn, cobs + husks	glass	30 150	0.10 0.10	95 80
Sweet potatoes	glass	104	0.10	72
Tomatoes	glass	51 175 175	0.10 0.10 0.10	70 90 91
Walnuts	glass	258	0.10	77 [1]

[1] Determined as TCP after alkaline hydrolysis

In a follow-up study in 1995, sets of fourteen 10-g replicate samples of bananas, beans, cauliflower, peaches and onions were weighed into polyethylene sample containers, fortified with 0.5 mg/kg chlorpyrifos and stored at -18°C until analysed. The results are shown in Table 23 (Khoshab and Bolton, 1995).

Table 23. Stability of chlorpyrifos in fortified substrates stored at -18°C in polythene containers.

Sample	Storage period, days	Chlorpyrifos	
		Fortification, mg/kg	% remaining
Banana peel	34 126 247 370	0.5 0.5 0.5 0.5	92 92 83 96
Banana pulp	34 126 247 370	0.5 0.5 0.5 0.5	92 126 93 93
Onion	31 123 245 367	0.5 0.5 0.5 0.5	101 88 96 99
Peach	31 123	0.5 0.5	95 82

	245	0.5	95
	367	0.5	99
Cauliflower curd	31	0.5	102
	123	0.5	96
	245	0.5	102
	367	0.5	99
Field beans	28	0.5	94
	120	0.5	101
	242	0.5	101
	364	0.5	97

In a study of the stability of incurred chlorpyrifos residues in animal commodities (McCollister, 1973) samples of subcutaneous fat, kidney, liver and muscle from an animal feeding study were stored at -18°C for 41, 36, 37 and 38 months respectively, and the remaining residue was determined. The percentages remaining were liver 100-150, kidney 33-130, muscle 70-193 and fat 60-86. Milk was fortified with 0.01, 0.10 and 1.0 mg/kg chlorpyrifos and stored frozen for 49 months, and the remaining residues were 69%, 74% and 74% respectively. No experimental details were reported.

Definition of the residue

Studies on plant and animal metabolism as well as on environmental fate indicate that the use of chlorpyrifos could leave residues of the parent compound and the main metabolite 3,5,6-trichloro-2-pyridinol (TCP) in plant and animal commodities. The 1999 JMPR considered the TCP metabolite during its deliberations, but established an ADI and an acute RfD only for the parent compound. Recent regulatory evaluations of chlorpyrifos in the USA, Australia and the EU have been consistent in the recognition of chlorpyrifos as the sole component of the residue. Analytical methods for enforcement purposes are available for the determination of chlorpyrifos residues in plant and livestock commodities, soil and water. The Meeting concluded that the residue should be defined as chlorpyrifos both for compliance with MRLs and for the estimation of dietary intake.

The octanol/water partition coefficient of chlorpyrifos, log P_{ow} = 4.7, indicates that chlorpyrifos is fat-soluble. This is confirmed by the results of studies on goats and poultry, in which the concentration of labelled material in fat was up to 10 times that in muscle. The Meeting concluded that the residue should be described as fat-soluble.

USE PATTERN

Chlorpyrifos is an insecticide used as a soil treatment (pre-plant and at planting), a seed treatment, and as a foliar spray, directed spray and dormant spray.

Registered uses of chlorpyrifos are shown in Table 24. The manufacturer submitted product labels for many countries (with English translations in most instances), but only summarized information without labels for Belgium, England, Germany, France and Portugal. Such entries are noted as "Summary only". The governments of Australia, Germany, The Netherlands, Poland, the USA and Thailand provided information on GAP or labels. The government of The Netherlands reported that it has not authorized the use of the compound on agricultural crops since 1-12-1999, and the government of the USA that the active ingredient is not authorized for use on tomatoes, and that use on apples is limited to pre-bloom dormant stages. Values in parentheses are (maximum rates) calculated from the available information.

Table 24. Registered uses of chlorpyrifos.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Agricultural crops	France	Bait	20 g/kg	Broadcast	Pre-plant	1			1.0		Summary only
Agricultural crops (general treatment)	France	G	50 g/kg	Broadcast	Pre-plant	1			5.0		Summary only
Alfalfa	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	0.40 l/ha (0.19)	7	20 day grazing restriction
Alfalfa	Mexico	EC	480 g/l or 445 g/kg	Foliar spray					1.0 l/ha (0.48)	21	Max rate is 0.7 l/ha if alfalfa is to be cut for green forage immediately after 21 days.
Alfalfa	Spain	EC	480 g/l	Foliar spray			0.096			21	
Alfalfa	Spain	WP	250 g/kg	Foliar high volume	Early stage	1	0.10	600		21	Summary only
Alfalfa	Spain	EC	480 g/l	Foliar spray high volume	Early stages	1	0.096	600		21	Summary only.
Alfalfa	Uruguay	EC	500 g/l	At plant				80 ground 25 aerial	0.3 l/ha (0.15)		Formulation includes cypermethrin (50 g/l)
Alfalfa	USA	EC	4 lb/gal (480 g/l)	Foliar spray, broadcast		1 per cutting ; 4 /yr		2 aerial 20 ground	2 pt/a (1.1)	21 @ >1 pt 14 @ 1 pt 7 @ 1/2 pt	May be applied through irrigation systems
Almond	Argentina	EC	480 g/l	Spray to run-off; high volume			0.16 l/100 l water (0.08)	80-100		21	
Almond	Chile	WP	500 g/kg	Spray			0.12 l/hl			14	
Almond	USA	EC	4 lb/gal (480 g/l)	Spray	Dormant	1	1 pt/100 gal (0.06)	200 gal (760) 250 gal Cali-fornia	4 pt/a (2.2)		Grazing restriction
Almond	USA	EC	4 lb/gal (480 g/l)	Foliar spray		3			4 pt/a (2.2)	14	Grazing restriction. Use dilute or concentrate spray.
Almond	USA	EC	4 lb/gal (480 g/l)	Orchard floor spray				25 gal/a (230)	8 pt/a (4.5)	14	Do not exceed 16 pt/a/season. Foliar applications may also be made.
Almond	USA	WP	500 g/kg	Spray		4	4 lb/100 gal (0.24)		8 lb/a (4.5)	14	One dormant + 3 foliar
Apple	Argentina	EC	480 g/l	Spray to run-off; high volume			0.15 l/ 100 l water (0.07)	80-100		30	
Apple	Argentina	WP	500 g/kg	Spray to cover total foliage			0.12 kg/ 100 l water (0.06)			30	
Apple	Australia	WP	500 g/kg	Spray, thorough coverage	Up to late pink (balloon) and at end of flowering		0.05			7	Do not apply for a minimum of 3 days before bees are actively foraging.
Apple	Australia	WP	500 g/kg	Spray, thorough coverage	After petal fall	Two week interva ls	0.025			7	

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Apple	Australia	EC	500 g/l	Spray. thorough coverage of branches, foliage, fruit	mid-late November and later		0.05	10-50 aerial		14	
Apple	Belgium	EC	480 g/l	Foliar spray	Before flower	1	0.038 alt label		0.72	35	Summary only.
Apple	Belgium	WP	250 g/kg	Foliar spray	Before flower	1	0.15			35	Summary only.
Apple	Chile	WP	500 g/kg	Foliar spray	November and January		0.12 l/hl (0.06)			28	
Apple	France	EC	278 g/l	Low volume spray	BCCH 51-79	2	0.0348	400		30	If spray volume is less than 1000 l/ha, adjust concentration to ensure 0.35 g ai/ha
Apple	Italy	EC	480 g/l 225 g/l	Foliar spray			0.11 l/hl (0.053)	1500	(0.84)	30	
Apple	India	EC	200 g/kg				0.05% (w/w)		(0.010 kg/tree)		Apply 10 -20 l of a 0.05% solution per tree. 11 day PHI pending
Apple	Japan	WP	250 g/kg	Foliar spray		2	0.025			14	
Apple	Korea	WP	250 g/kg	Foliar spray	Before bloom and 20 days after petal fall (late June-early Aug)	<6	0.025			3	
Apple	Mexico	EC	480 g/l or 445 g/kg	Foliar spray		1	2 l/hl (0.96)			30	
Apple	Mexico	WP	500 g/kg	Foliar spray		8	0.18	1000		28	
Apple	New Zealand	WP	500 g/kg	Foliar spray	At bud movement and at 2 week intervals at petal fall	Repeat	0.025-0.038		1 minimum	14	
Apple	New Zealand	EC	400 g/l	Foliar spray	At bud movement and 10-12 days later		0.1 l/hl (0.04)		3 l/ha minimum (1.2)		Do not use after flowering starts.
Apple	Portugal	EC	480 g/l	Foliar spray high volume	fruiting	5	0.096	1000		14	Summary only
Apple	South Africa	EC	480 g/l	Spray	3 weeks before bud swell; bud swell green tip	2	0.048	High volume		40	
Apple	Uruguay	WP	500 g/kg	Foliar spray		20-25 day repeat interval	0.06			28	
Apple	Uruguay	EC	480 g/l	Foliar spray			0.058	35 ground 25 aerial		15	
Apple	UK	EC	480 g/l	Foliar spray	April to August	5		250	0.96	14	Summary only
Apple	USA	EC	4 lb/a (480 g/l)	Spray	Dormant/ Delayed dormant	1	1 pt/100 gal (0.06)	200 - 600 gal/a (760-2300) 250	6 pt/a (3.4)	70-200 variety dependent	Grazing restriction. Ground equipment only.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
								gal/a California			
Apricot	Argentina	EC	480 g/l	Spray to run-off; high volume			0.16 l/ 100 l water (0.08)	80-100		21	
Apricot	South Africa	EC	480 g/l	Spray	Dormant. Before and after pruning.		0.036	High volume			
Artichokes	Spain	GR	50 g/kg	Row or broadcast incorporated	Pre-plant At planting	1			0.75 row 4 broadcast		Summary only.
Artichokes	Spain	WP	250 g/kg	Foliar high volume	Early stage		0.10	600		21	Summary only.
Artichokes	Spain	EC	480 g/l	Foliar spray high volume	Early stages and close to harvest		0.096	500		21	Summary only.
Asparagus	Italy	EC	225 g/l	Broadcast		1		800	0.56	15	Summary only
Asparagus	Spain	EC WP	480 g/l 250 g/kg	Foliar spray, medium /high volume			0.10	300		21	
Asparagus	Spain	GR	50 g/kg	Broadcast or row, incorporated	Pre-plant At planting	1			4.0 broadcast 0.75 row		Summary only
Asparagus	USA	EC	4 lb/gal (480 g/l)	Foliar spray		1 pre-harvest, 2 post-harvest in fern stage			1 pt/a (1.1)	1	Use limited to Midwest and Pacific Northwest
Avocado	Australia	WP	500 g/kg	Spray strip, applied low on tree, avoid contacting fruit.		Every 7 days	0.2	50-100 ml of water mixture per tree		7	Applied as a mixture with yeast hydrolysate
Avocado	Australia	EC	500 g/l	Spray		Repeat as needed	0.05		2 l/ha (1)	7	Tank mix with dichlorvos
Avocado	New Zealand	EC	480 g/l	Foliar spray	Pre-blossom, complete petal fall, then 21 day intervals	Repeat	0.038 high volume to run-off		1 aerial	14	
Avocado	New Zealand	EC	400 g/l	Foliar spray to run-off	Pre-blossom, at complete petal fall and then at 21 day intervals.	Repeat	0.09 high volume		2 l/ha aerial (0.80)	14	
Banana	Australia	WP	500 g/kg	Foliar spray	From flowers to first fingers		0.1	500-1000 l (air blast)	1 (air blast)	7	Air blast or knapsack
Banana	Australia	WP	500 g/kg	Soil around base	Spring	1	0.25	0.6 per plant in 30 cm band			May also be applied as a mixture with sand (0.25 kg ai/4 kg), 30 g per plant
Banana	Australia	EC	500 g/l	Foliar spray	From first flower bell to finger	Repeat as needed	0.10	500 min 10	2 l/ha (1)	14	Ground only in NSW.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
					exposure			aerial			
Banana	Australia	EC	500 g/l	Butt and soil spray	Sept-Nov (1) Feb-Apr (2)	2	0.9 (1) 0.5 (2)			14	Apply 700 ml of spray to the lower 30 cm of butt and to the surrounding soil (30 cm radius).
Banana	Columbia	IPE	10 g/kg poly-ethylene	Impregnated polyethylene shrouds	After fruit bunch formation	1					Remove bags at normal harvest and destroy
Banana	Philippines	IPE	10 g/kg poly-ethylene	Impregnated polyethylene shrouds	After fruit bunch formation	1					Remove bags at normal harvest and destroy
Banana	Spain	EC	480 g/l	Foliar spray			0.12 l/hl (0.06) 0.1 alt label	1000 alt label		21	
Banana	Spain	WP	250 g/kg	Foliar spray			0.10	500 1000 alt label		21	Summary only.
Banana	Spain	EC	480 g/l	Foliar spray high volume	Fruiting	1	0.096	500		21	Summary only.
Banana	South Africa	EC	480 g/l	Foliar spray, high volume	July-Feb	4 week interval repeat	0.036			28	
Barley	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	1.60 l/ha (0.77)	30	1.60 is for early post-emergence. 0.90 lt/ha otherwise
Barley	Australia	EC	500 g/l	Soil spray	Pre-emergence				0.3 l/ha (0.15)	10	
Barley	Brazil	EC	480 g/l	Foliar spray		2			0.7 l/ha (0.34)	14	
Barley	Canada	EC	480 g/l	Foliar spray		5		50-200 (ground) 10-30 (aerial)	1.2 l/ha (0.58)		Max seasonal rate is 5.275 l/ha. One application may be to the soil.
Barley	India	EC	200 g/kg	Seed treatment					1.2 g/kg seed		
Barley	India	EC	200 g/kg	Foliar spray				500	0.375		30 day PHI pending
Barley	UK	EC	480 g/l	Overall volume spray				200	0.72	14	Summary only
Barley	Uruguay	EC	480 g/l	Foliar spray		Repeat interval 15-20 days		35 ground 25 aerial	0.4 l/ha (0.19)	30	20 day grazing restriction
Beans	Australia	EC	500 g/l	Band over plants and adjacent row	Young plants				0.8 l/ha (0.40)		
Beans	Australia	EC	500 g/l	Foliar spray			0.025		0.5 l/ha (0.25)		
Beans	Australia	EC	500 g/l	Soil spray	Pre-emergence	1			0.3 l/ha (0.15)		
Beans	Brazil	EC	480 g/l	Foliar spray		2			1.25 l/ha (0.6)	21	
Beans	Chile	EC	500 g/l	foliar spray					0.6 l/ha (0.3)	14	Formulation is a mix with cypermethrin (50 g/l).
Beans	Chile	G	150 g/kg	Broadcast or band (15-18 cm)	Pre-plant/ At planting				3		
Beans	France	G	50 g/kg	Broadcast	Pre-plant	1			4.0		Summary only
Beans	Italy	EC	480 g/l 225 g/l	Foliar spray				600	1.1 l/ha (0.53)	15	
Beans	Italy	G	75 g/kg	Row localized. Broadcast	At planting At-transplant	1			1.2; 3 broadcast	15	Summary only.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
					At earthing up						
Beans	India	EC	200 g/kg	Foliar spray				500	0.60		30 day PHI pending
Beans	Mexico	EC	480 g/l or 445 g/kg	Foliar spray					1.75 l/ha (0.84)		
Beans	Poland	EC	500 g/l	Foliar spray		2	0.12 l/hl (0.06)	200	0.25 l/ha (0.12)	21	Formulation with cypermethrin (50 g/l).
Beans	Portugal	GR	50 g/kg	Broadcast incorporated	Pre-plant	1			4.0		Summary only.
Beans	Spain	WP	250 g/l	Foliar spray, medium/ high volume			0.10	300		21	Summary only. See legumes.
Beans	Spain	GR	50 g/kg	Broadcast row	At planting	1			3 (4 alt label) 0.75 row	-	Summary only.
Beans	USA	WP (SL)	50 g/ 100 g	Seed treatment		1			2 oz (1 oz ai) per 100 lb seed (0.062 kg/ 100 kg seed)		Do not graze or feed hay from treated seed. Field, green, snap, kidney, lima, navy, string, wax.
Beans, green	Columbia	EC	400 g/l						1.0 l/ha (0.4)	15	
Beet	Belgium	EC	480 g/l	Foliar spray	Up to 10 leaves	1			0.72		Type of beet not specified. Summary only.
Beetroot	Australia	EC	500 g/l	Band over plants and adjacent row	Young plants				0.8 l/ha (0.40)		
Beetroot	Australia	EC	500 g/l	Foliar spray			0.025		0.5 l/ha (0.25)		
Beetroot	Greece	GR	50 g/kg	Broadcast or in-line furrows or planting holes					0.5 furrow 1.25 broadcast	20	Summary only
Brassica (cole)	Australia	EC	500 g/lg	Foliar spray		10-14 day interval	0.2 l/hl (0.1)		1.0		Also a boom spray after planting (cabbage and cauliflower only) in NSW.
Brassica, head	Greece	EC WP	480 g/l 250 g/kg	Soil band, or broadcast incorporated	Pre-plant	1		1000 broadcast	0.96 band 2.5 broadcast	20	Summary only
Brassica, head	Greece	GR	50 g/kg	Broadcast or in line furrows, or planting holes	Pre-plant At planting	1			0.5 furrow 1.25 broadcast	20	Summary only.
Brassica, head	Greece	EC WP	480 g/l 250 g/kg	Foliar spray, high volume		2	0.12 0.09 WP	1000	1.2 0.9 WP	20	Summary only.
Brassica, head	Greece	EC WP	480 g/l 250 g/kg	Bait		1			0.96 0.5 WP	20	Bait = 30 kg bran + 10 l water/ha. Summary only.
Brassica, flowering	Greece	EC WP	480 g/l 250 g/kg	Foliar spray Before flowering		2	0.12	1000	1.2	20	Summary only
Brassica, flowering	Greece	GR	50 g/kg	Broadcast or in lines, furrows, or planting holes	Pre-plant At planting	1			0.5 furrow 1.25 broadcast	20	Summary only.
Brassica, flowering	Greece	EC WP	480 g/l 250 g/kg	Broadcast to soil or band, incorporated	Pre-plant	1			1.25 band (1 WP) 2.5 broadcast	20	Summary only.
Brassica, flowering	Greece	EC	480 g/l	Bait		1			0.48	20	Bait = 30 kg bran + 10 l water/ha. Summary only.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Brassica	Spain	WP	250 g/kg	Foliar high volume	Early stage	1	0.10	600		21	Summary only.
Brassica	Spain	EC	480 g/l	Foliar spray high volume	Early stages	1	0.096	500		21	Summary only.
Brassica	UK	EC	480 g/l	Plant or module drench	Transplant At planting	1	0.048 transplant 0.19 module			21	70 ml mix to base of each transplant. 1 hl mix to each 20,000 modules before planting. Summary only.
Brassica	UK	EC	480 g/l	Foliar spray		1		600	0.72	21	Summary only
Brassica (cole)	USA	G	15 g/100 g	T-band	At planting	1			9.2 oz per 1000 ft row. 15 lb/a (2.5) for 20 in row, 7.5 lb/a for 40 in row, etc		Do not use rutabaga tops for food or feed. Specifies: bok choy, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, Chinese broccoli, Chinese cabbage, collards, kale, kohlrabi, rutabaga, turnips
Broad bean	Australia	EC	500 g/l	Soil spray	Pre-emergence				0.3 l/ha (0.15)	10	
Broccoli	Canada	G	15%	In-furrow	At planting	1			1.4		For 105 cm row spacing. Rate is 150 g ai/1000 m row
Broccoli	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	32	
Broccoli	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	32	
Broccoli	Canada	EC	480 g/l	Soil spray, drench	7-10 days and 28 days post-seed or 3 and 21 days post-transplant	2	1.68 l/10 hl (0.08)	1000	210 ml of EC /1000 m row (0.10 g ai/1000 m row) 7.0 l/ha (3.36) for 30 cm row space	32	Apply 12.5 l of solution per 100 m of row on soil, 10 cm on each side of the plant. Do not apply to harvestable portions.
Broccoli	Canada	WP	50%	Spray	2-5 leaf seedling			400	1.125	32	
Broccoli	South Africa	EC	480 g/l	Foliar spray		As needed	0.02	500		7	
Broccoli	USA	EC	4 lb/gal (480 g/l)	Spray band 4 in incorporated for direct seeded or spray directed to the base of new transplants.	At planting	1			4.5 pt/a (2.5) 2.75 fl oz/1000 linear ft of row for 20 inch row spacing, 0.267 ml ai/m.		Do not exceed 2.6 pt/a. for 40 in; 20 in, 4.5 pt/a. Do not apply to foliage. CA only.
Broccoli	USA	EC	4 lb/gal (480 g/l)	Inject as sidedress on each side of row	Established plants	1		15 gal/a (140)	1.2 fl oz/1000 linear feet of row (0.116 ml ai/m). 1.1 kg ai/ha	30	Double application rate for double row plantings, or 2.2 kg ai/ha.
Broccoli	USA	WP	500 g/kg	Foliar		6			1.1	21	CA and AZ only.
Brussels sprouts	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	32	
Brussels sprouts	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	32	
Brussels sprouts	Canada	EC	480 g/l	Soil spray,	7-10 and	3	1.68	1000	210	32	Apply 12.5 l solution per

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
				drench	28 days post-seed or 3 and 21 days post-transplant.		l/10 hl (0.08)		ml/1000 m row (0.10 g ai/1000 m row) 7.0 l/ha (3.36) for 30cm row space		100 m row on soil, 10 cm on each side of plant. Do not apply to harvestable portions. Do not make first application if G applied At planting.
Brussels sprouts	Canada	WP	50%	Spray	2-5 leaf seedling	1		400	1.125	32	
Brussels sprouts	Germany	G	10 g/kg	Spreading with incorpo-ration	Pre-plant	1			1		
Brussels sprouts	Germany	G	10 g/kg	Spreading at root collar	Post-plant	1			0.005 g/plant		Single plant treatment
Brussels sprouts	South Africa	EC	480 g/l	Foliar spray		As needed	0.024	500		7	
Brussels sprouts	UK	EC	480 g/l	Overall volume spray				200	0.48	21	
Brussels sprouts	USA	EC	4 lb/a (480 g/l)	Spray band 4 in incorporated for direct seeded or spray directed to the base of new transplants.		1			4.5 pt/a (2.5) 2.75 fl oz/1000 linear ft of row		Do not exceed 2.6 pt/a.; 20 in, 4.5 pt. Do not apply to foliage.
Brussels sprouts	USA	EC	4lb/a (480 g/l)	Foliar spray		6		20 gal/a (190)	2 pt/a (1.1)	21	
Cabbage	Australia	EC	500 g/l	Boom spray, 10 cm band	At or immedi-ately after planting			500-1000	2 l/ha (1)	5	
Cabbage	Australia	EC	500 g/l	Drench to plant base			0.15			5	100 ml per plant
Cabbage	Belgium	EC	480 g/l	Drench to plant base	At or just after plant	1	0.096				100 ml per plant
Cabbage	Brazil	EC	480	Foliar spray		2	60 ml/hl (0.03)	1000		21	
Cabbage	Canada	G	15%	In-furrow	At planting	1			1.4		For 105 cm row spacing. Rate is 150 g ai per 1000 m row.
Cabbage	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	32	
Cabbage	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	32	
Cabbage	Canada	EC	480 g/l	Soil spray, drench	7-10 days and 28 days post-seed or 3 and 21 days post-transplant.	2	1.68 l/10 hl (0.08)	1000	210 ml/1000 m row (0.10 g ai/1000 m row) 7.0 l/ha (3.36) for 30 cm row space	32	Apply 12.5 l solution per 100 m row on soil, 10 cm on each side of plant. Do not apply to harvestable portions.
Cabbage	Canada	WP	50%	Spray	2-5 leaf seedling	1		400	1.125	32	
Cabbage	Canada	WP	50%	Water treatment	Transplant	1	0.0162	0.2 l mix/pl ant		32	Mix 65g (32.5 g ai) in 200 l of water; apply 200 ml with each plant. Do not use lindane or starter fertilizer.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Cabbage	Germany	G	10 g/kg	Spreading with incorpo-ration	Pre-plant	1			1		Savoy, white, red.
Cabbage	Germany	G	10 g/kg	Spreading at root collar	Post-plant	1			0.005 g/plant		Single plant treatment. Savoy, white, red.
Cabbage	Italy	EC	480 g/l 225 g/l	Foliar spray				600	1.1 l/ha (0.53)	30	
Cabbage	India	EC	200 g/kg					500	0.20		7 day PHI pending.
Cabbage	Italy	G	75 g/kg	Row localized. broadcast	At planting At-transplant At earthing up	1			1.2; 3 broadcast	30	Summary only.
Cabbage	Korea	WP	250 g/kg	Foliar spray		<4	0.025			8	
Cabbage	Poland	EC	480 g/l	Foliar spray		2	0.36 l/hl (0.17)	200	0.72 l/ha (0.34)	21	
Cabbage	Poland	EC	500 g/l	Foliar spray		2	0.15 l/hl (0.08)	200	0.31 l/ha (0.016)	21	Formulation with cypermethrin
Cabbage	South Africa	EC	480 g/l	Foliar spray		As needed	0.024	500		7	
Cabbage	Spain	EC WP	480 g/l 250 g/kg	Foliar spray, medium/ high volume			0.10	300		21	
Cabbage	Spain	GR	50 g/kg	Row or broadcast, incorporated	Pre-plant At planting	1			0.75 row 4 broadcast		Summary only
Cabbage	UK	EC	480 g/l	Overall volume spray			(0.12)	600	0.72	21	Summary only
Cabbage	USA	EC	4 lb/gal (480 g/l)	Spray band 4 in incorporated for direct seeded or spray directed to the base of new transplants.	At planting	1			4.5 pt/a (2.5) 2.75 fl oz/1000 linear ft of row		Do not exceed 2.6 pt/a. for 40 in rows; 20 in, 4.5 pt. Do not apply to foliage
Cabbage	USA	EC	4 lb/a (480 g/l)	Inject as sidedress on each side of row	Establi-shed plants	1		15 gal/a (140)	1.2 fl oz/1000 linear feet of row (0.116 ml/m; 1.1 kg ai/ha)	30	Double rate for double row planting (2.2 kg ai/ha).
Cabbage	USA	WP	500 g/kg	Broadcast foliar		6			1.1	21	
Canola	Australia	EC	500 g/l	Spray to soil, broadcast or in-furrow	Pre-plant At planting			30 (in-furrow)	1.5 l/ha for 1 m row spacing (0.75)		
Canola	Canada	EC	480 g/l	Foliar spray		4		50-200 (groun d) 10-40 (aerial)	1.5 l/ha (0.72)	21	One application may be to the soil.
Carrots	Australia	EC	500 g/l	Foliar spray					0.35	-	
Carrots	Australia	EC	500 g/l	Band over plants and adjacent row	Young plants				0.8 l/ha (0.40)		
Carrots	Canada	EC	480 g/l	Soil spray	Pre-plant	1		400	4.8 l/ha (2.3)	60	
Carrots	Canada	WP	50%	Spray	Seedling	1		400	2.25	60	

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Carrots	Germany	G	10 g/kg	Spreading with incorpo-ration	Pre-plant	1			0.75		
Carrot	Italy	EC	480 g/l	Foliar spray				600	1.0 l/ha (0.48)	21	
Carrots	Italy	G	75 g/kg	Broadcast	At planting At earthing up	1			3	21	Summary only.
Carrots	Poland	EC	480 g/l	Foliar spray		2	0.36 l/hl (0.17)	3200	0.72 l/ha (0.34)	14	
Carrots	Poland	EC	500 g/l	Foliar spray		2	0.12 l/hl (0.06)	200	0.25 l/ha (0.12)	14	Formulation with cypermethrin (50 g/kg)
Carrots	South Africa	EC	480 g/l	Spray	At emergence of plants	2-3 week repeat	(0.096)	500	0.48	21	
Carrots	UK	EC	480 g/l	Overall volume spray				200	0.96	14	Summary only
Cassava	Australia	EC	500 g/l	Foliar spray	seedlings				0.35	-	
Cauliflower	Australia	EC	500 g/l	Drench to plant base			0.15			5	100 ml per plant
Cauliflower	Canada	G	15%	In-furrow	At planting	1			1.4		For 105 cm row spacing. Rates is 150 g ai per 1000 m row.
Cauliflower	Canada	EC	480 g/l	Soil spray, drench	7-10 days and 28 post-seed or 3 and 21 days post-transplant.	2	1.68 l/10 hl (0.08)	1000	210 ml EC /1000 m row (0.10 g ai/1000 m row). 7.0 l/ha (3.36) for 30 cm row space	32	Apply 12.5 l solution per 100 m row on soil, 10 cm on each side of plant. Do not apply to harvestable portion
Cauliflower	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	32	
Cauliflower	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	32	
Cauliflower	Canada	WP	50%	Spray	2-5 leaf seedling	1		400	1.125	32	
Cauliflower	Germany	G	10 g/kg	Spreading with incorpo-ration	Pre-plant	1			1		
Cauliflower	Germany	G	10 g/kg	Spreading at root collar	Post-plant	1			0.005 g/plant		Single plant treatment
Cauliflower	India	EC	200 g/l	Foliar spray				500	0.4		7 day PHI pending.
Cauliflower	Spain	EC WP	480 g/l 250 g/kg	Foliar spray, medium/ high volume			0.10	300		21	Summary only
Cauliflower	Spain	GR	50 g/kg	Broadcast or row, incorporated	Pre-plant At planting				0.75 row 4 broadcast		Summary only
Cauliflower	South Africa	EC	480 g/l	Foliar spray		As needed	0.024	500		7	
Cauliflower	UK	EC	480 g/l	Overall volume spray				200	0.48	21	
Cauliflower	USA	EC	4 lb/a (480 g/l)	Band 4 in incorporated for direct seeding or spray directed to	At planting	1			2.4 fl oz/1000 linear feet or row. 4 pt/a (1.9)		Do not apply to foliage.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
				base of new transplants							
Celery	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	70	
Celery	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	70	
Celery	Canada	WP	50%	Spray	2-5 leaf seedling	1		400	1.125	70	
Celery	Spain	EC WP	480 g/l 250 g/kg	Foliar spray, medium/ high volume			0.10	300		21	Summary only
Celery	Spain	GR	50 g/kg	Row or broadcast, incorporated	Pr-plant At planting	1			0.75 row 4 broadcast		Summary only.
Cereal grains	Argentina	EC	480 g/l	Soil treatment; incorpo-rated 5-10 cm	Pre-plant			100-150	6.0 l/ha (2.9)		4.0 l/ha for winter grains, incorporated 3-4 cm.
Cereals	Australia	EC	500 g/l	Foliar spray					1.5 l/ha (0.75)	10	2 day gazing restriction.
Cereals	Australia	EC	500 g/l	Seed treatment					120 ml (0.06 kg ai)/100 kg seed		Apply to seed just before sowing.
Cereals	Chile	G	150 g/kg	Broadcast or band (15-18 cm)	Pre-plant/ At planting				3		
Cereals	Chile	D	120 g/kg	Mix with fertilizer					0.36		
Cereals	Chile	WP	250 g/kg	In-furrow or broadcast	At planting				2.3		
Cereals	Portugal	GR	50 g/kg	Row or broadcast, incorporate	Pre-plant At planting	1			0.4 row 3.0 broadcast		Summary only.
Cereals	Spain	DP	30 g/kg	Dusting	Earing	1			0.9	15	Summary only.
Cereals	Spain	GR	50 g/kg	Row incorporated Broadcast incorporated	At planting	1			0.75 row 4.0 broadcast	-	Summary only
Cereals	UK	EC	480 g/l	Foliar spray		3		200	0.34 0.48 0.72	14	Summary only. Information incomplete. Specified whet, barley, oats
Cherries	Argentina	EC	480 g/l	Spray to run-off; high volume			0.16 l/ 100 l water (0.08)	80-100		21	
Cherries	Chile	WP	500 g/kg	Spray			0.12 l/hl			14	
Cherries	Greece	EC WP	480 g/l 250 g/kg	Foliar spray, high volume	Flowering or fruit setting	2	0.075	1500	1.9 2.1 WP	20	Summary only.
Cherries	USA	EC	4 lb/gal (480 g/l)	Coarse, low pressure spray to trunk and lower branches		2 prehar-vest 1 post-harvest	3 qt/100 gal (0.36)			6	Avoid contact with foliage in sweet cherries. Grazing prohibited.
Cherries, sour	USA	WP	500 g/kg	Foliar spray		8	3 lb/100 gal (0.18)		8 lb/a (4.5)	14	
Cherries, sweet	USA	WP	500 g/kg	Spray to trunk and lower limbs		3	2 lb/a00 gal (0.12)		8 lb/a (4.5)	6	Do not contact foliage
Chick peas	Australia	EC	500 g/l	Soil spray	Pre-				0.3 l/ha	10	

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
					emergence				(0.15)		
Chick peas (Bengal gram)	India	EC	200 g/l	Foliar spry				500	0.6		30 day PHI pending
Chinese cabbage	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	15	
Chinese cabbage	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	15	
Chinese cabbage	Canada	EC	480 g/l	Soil spray, drench	7-10 days post-seed or 3 days post-transplant.	2	1.68 l/10 hl (0.08)	1000	210 ml/1000 m row (0.10 g ai/1000 m row) 7.0 l/ha (3.36) for 30 cm row space	15	Apply 12.5 l solution per 100 m row on soil, 10 cm on each side of the plant. Do not apply to harvestable portions.
Chinese cabbage	Canada	WP	50%	Spray	2-5 leaf seedling	1		400	1.125	32	
Chinese cabbage	Korea	WP	250 g/kg	Foliar spray		<4	0.025			8	
Chinese cabbage	USA	EC	4 lb/a (480 g/l)	Spray band 4 in incorporated for direct seeded or spray directed to the base of new transplants.	At planting	1			4.5 pt/a (2.2) 2.75 fl oz/1000 linear ft of row		Do not exceed 2.6 pt/a.; 20 in, 4.5 pt. Do not apply to foliage.
Citrus	Argentina	EC	480 g/l	Spray to run-off; high volume			0.12 l/100 l water (0.06)	80-100		21	
Citrus	Australia	WP	500 g/kg	Spray strip low on tree. Avoid fruit contact.		Every 7-10 days	0.2		50-100 ml per tree (0.0002 kg ai per tree)	7	
Citrus	Australia	EC	500 g/kg	High volume foliar spray to run-off	Nov-Mar	2	0.05			14	
Citrus	Australia	EC	500 g/kg	Ground and butt spray		2	0.2 l/hl (0.1)		2.0 l/ha (1)	14	
Citrus	Brazil	EC	480	Foliar spray		3	0.2 l /hl (0.1)	500		21	
Citrus	Italy	EC	480 g/l 225 g/l	Foliar spray			0.22 l/hl (0.11)	1000	(1.1)	60	225 g/l summary only states soil application.
Citrus	Italy	EC	225 g/l	Foliar spray		2	0.056	1500	0.84	60	Summary only
Citrus	India	EC	200 g/kg	Foliar spray			0.02 % solution (w/w)		0.004 kg/tree		Apply 20 l of a 0.02% solution per tree.
Citrus	Korea	WP	250 g/kg	Foliar spray		<3	0.031			15	
Citrus	Mexico	EC	480 g/l or 445 g/kg	Foliar spray			0.001 l/ha (0.0005)			34	
Citrus	New Zealand	WP	500 g/kg	Foliar spray, to run-off.	Pre-flower, monthly intervals from petal fall.	Repeat	0.038		0.75 minimum	14	If used alone, add a nonionic surfactant
Citrus	Portugal	EC	480 g/l	Foliar spray,	Fruiting	2	0.096	2500	(2.4)	28	Summary only.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
				high volume				(1000 alt label)			
Citrus	Spain	WP	240 g/kg	Foliar spray high volume	Fruiting	1	0.072	2500		21	Formulation with carbonyl (375 g/kg). Summary only.
Citrus	Spain	EC	260 g/l	Foliar spray high volume	Fruiting	1	0.072	2500		21	Formulation with cypermethrin (50 g/kg). Summary only.
Citrus	Spain	WP	250 g/kg	Foliar spray	Fruiting	1	0.10	2500 (3000 alt label)		21	
Citrus	Spain	EC	480 g/l	Foliar spray high volume	Fruiting	1	0.096	2500 (3000 alt label)		21	Summary only.
Citrus	South Africa	EC	480 g/l	Foliar spray, full cover	80-100% pedal fall; 5-8 weeks later	2	0.048			60	
Citrus	South Africa	EC	480 g/l	Foliar spray, light cover		As needed	0.029			60	
Citrus	Thailand	EC	200 g/l	Foliar spray, high volume			0.06	1400	0.84	7	
Citrus	Uruguay	EC	480 g/l	Foliar spray			0.048	35 ground 25 aerial		21	
Citrus	USA	EC	4 lb/gal (480 g/l)	Foliar spray		2		100 gal/a (935) ground 15 gal/a (140) @ 7 pt/a in California and Arizona-aerial. 20 gal/a (187) @ 7 pt/a in Florida-aerial	12 pt/a (6.7)	21 @ 7 pints 35 @>7 pts/ a	30 day retreatment interval; 7.5 lb ai/a/yr max (8.4). Worker reentry 2 days. Grazing prohibited. Minimum concentration is 0.5 pt per 100 gal of water per acre
Citrus	USA	EC	4 lb/gal (480 g/l)	Ground spray		Multiple	0.5	25 gal/a (230)	1 qt/a (1.1)	28 14 @ ≤ 3qt/a/ season (3.40)	Maximum of 10 qt/a/season (11.2), except Florida, 3 qt/a/season (3.4). May be applied with sprinkler irrigation systems. Foliar applications of EC may also be made.
Citrus	USA	WP	500 g/kg	Foliar spray		2	4 lb/100 gal (0.24)		8 lb/a (4.5)		Do not apply to flowering trees. 30 day minimum retreatment interval
Citrus	USA	G	15 g/100g	Broadcast to ground					6.7 lb/a (1.1)	28	67 lb/a/season (11 kg ai/ha/season). Grazing restriction.
Clover	Australia	EC	500 g/l	Soil spray	Pre-emergence				0.3 l/ha (0.15)	10	
Coconut	India	EC	200 g/kg	Soil drench			1 g/tree				30 day PHI pending.
Coffee	Brazil	EC	480 g/l	Foliar spray		2			1.5 l/ha (0.72)	21	

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Coffee	Columbia	EC	400 g/l						3.5 l/ha (1.4)	21	Summary of label only.
Coffee	Australia	EC	500 g/l	Spray to ground and base	Non-bearing seedlings	0.1					
Coffee	Tanzania	EC	480 g/l	Foliar spray		0.96				7	
Cole crops	Australia	EC	500 g/l	Foliar spray		10-14 day interval	0.1	2		5	Includes cabbage, cauliflower, Brussels sprouts, broccoli
Collards	USA	EC	4 lb/a (480 g/l)	Spray band 4 in incorporated for direct seeded or spray directed to the base of new transplants.	At planting	1			4.5 pt/a (2.5) 2.75 fl oz/1000 linear ft of row		Do not exceed 2.6 pt/a.; 20 in, 4.5 pt. Do not apply to foliage.
Cotton	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	2.00 l/ha (0.96)	21	
Cotton	Australia	EC	500 g/l	Foliar spray		Repeat as needed			1.5 l/ha (075)		Also used in-furrow, row spacing 1 m (QLD, NSW)
Cotton	Brazil	EC	480 g/l	Foliar spray		3			2 l/ha (0.96)	21	
Cotton	Columbia	EC	400 g/l						2.0 l/ha (0.8)	14	Summary of label only
Cotton	India	EC	200 g/kg	Foliar spray				500	0.45		12 day PHI pending
Cotton	India	EC	200 g/kg	Soil spray				1000	0.75		12 day pending PHI
Cotton	Mexico	EC	480 g/l or 445 g/kg	Foliar spray			0.35 l/hl (0.17)		2.0 l/ha (0.96)	21	
Cotton	Spain	EC	480 g/l	Foliar spray			0.096			21	
Cotton	Spain	WP	250 g/kg	Foliar high volume	Early stage	1	0.10	600 (300 alt label)		21	Summary only.
Cotton	Spain	EC	480 g/l	Foliar spray high volume	Flowering	1	0.096	600		21	Summary only.
Cotton	Spain	EC	260 g/l	Foliar spray high volume	Flowering	1	0.072	500		21	Formulation with cypermethrin (50 g/kg). Summary only.
Cotton	Spain	DP	30 g/kg	Dusting	Flowering	1			0.9	-	Summary only.
Cotton	Spain	GR	50 g/kg	Row Broadcast and incorporated	At planting	1			0.75 row 4.0 broadcast	-	Summary only
Cotton	USA	EC	4 lb/gal (480 g/l)	Foliar spray		6		1 gal/a (9.4) aerial	2 pt/a (1.1)	14	Grazing restriction. Do not feed gin trash. May be applied through irrigation sprinklers.
Courgette	France	G	50 g/kg	Broadcast	Pre-plant	1			1.0		
Cranberries	USA	EC	4 lb/gal (480 g/l)	Foliar spray broadcast	Flower develop-ment. After 100% bloom	2		15 gal/a (140) ground 5 gal /a (47) aerial	3 pt/a (1.7)	60	No applications when bog flooded. May be applied via irrigation systems.
Cruciferae	Belgium	EC	480 g/l	Spray	Post-plant	1			0.72	42	Summary only.
Cruciferae	Belgium	GR	50 g/kg	Spray	Post-plant	1			0.72	-	Summary only.
Cucumber	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	60	
Cucumber	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	60	

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Cucumber	Canada	WP	50%	Spray	Seedling 2-5 leaf	1		400	1.125	60	
Cucumber	Italy	G	75 g/kg	Row localized. Broadcast	At planting At-transplant At earthing up	1			1.2; 3 broadcast	15	Summary only.
Cucumber	Mexico	EC	445 g/kg or 480 g/l	Foliar spray					2 l/ha (0.96)	7	
Cucumber	USA	WP (SL)	50 g/ 100 g	Seed treatment		1			2 oz per 100 lb seed (0.062 kg/ 100 kg seed)		
Cucurbits	Australia	EC	500 g/l	Foliar spray		10-14 day interval	0.05			5	Includes chokos, cucumbers, gherkin, marrow, melon, pumpkin, squash.
Currants	UK	EC	480 g/l	Foliar spray	Flowering	3		1000	0.72	14	Summary only. Black, red and white currants
Custard apple	Australia	EC	500 g/l	Ground and trunk spray		2	2 l/hl (1)		10	14	
Egg plant	India	EC	200 g/kg	Foliar spray				500	0.2		3 day PHI pending
Egg plant	Australia	EC	500 g/l	Band over and adjacent soil	Young plants		0.40				
Egg plant	Australia	EC	500 g/l	Foliar spray			0.025		0.25		
Egg plant (Aubergine)	Italy	EC	225 g/l	Foliar broadcast	Swelling	1		800	0.56	15	Summary only
Egg plant (Aubergine)	Italy	G	75 g/kg	Ground	Transplant or earthing up	1			1.2	15	Summary only
Field peas	Australia	EC	500 g/l	Soil spray	Pre-Emer-gence				0.3 l/ha (0.15)	10	
Figs	USA	EC	4 lb/gal (480 g/l)	Soil spray incorporated 3 inc.	Dormant	1			2 qt/a (1.9)	7 mo	California only
Filberts (Hazelnuts)	Spain	WP	250 g/kg	Foliar spray high volume	Fruiting		0.10	1500		21	Summary only.
Filberts (Hazelnuts)	Spain	DP	30 g/kg	Dusting	Fruiting	1			0.9	15	Summary only.
Filberts (Hazelnuts)	USA	WP	500 g/kg	Foliar spray		3	4 lb/100 gal (0.24)		8 lb/a (4.5)	14	
Filberts (Hazelnuts)	USA	EC	4 lb/gal (480 g/l)	Foliar spray		3			4 pt/a (2.2)	14	Grazing restriction. Use dilute or concentrate spray.
Flax	Argentina	EC	480 g/l	Soil treatment, incorporated	pre-plant			100-150	6 l/ha (2.9)		30 day grazing restriction
Flax	Canada	EC	480 g/l	Foliar spray		2		50-200 (ground) 10-30 (aerial)	1.2 l/ha (0.58)	21	One application may be to the soil.
Fodder beet	Poland	EC	278 g/kg	Foliar high volume		1	0.28 l/hl (0.08)	150	0.42 l/ha (0.12)	30	Formulation with dimethoate (22.2%)
Fodder beet	Poland	EC	480 g/l	Spray to ground, high volume	3-4 days pre-plant	1	0.80 l/hl (0.38)	150	1.20 l/ha (0.58)	30	
Fodder beet	Poland	EC	480 g/l	Foliar high volume	After sprouting	1	0.48 l/hl (0.23)	150	0.72 l/ha (0.34)	30	

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Fodder beet	Poland	EC	500 g/l	Foliar spray		2	0.23 l/hl (0.12)	150	0.35 l/ha (0.18)	30	Formulation with cypermethrin (50 g/l).
Forage crops	Australia	EC	500 g/l	Foliar spray					0.9 l/ha (0.45)	10	2 day grazing restriction
Fruit	Chile	EC	480 g/l	Tree spray	Dormant; end of winter		0.1 l/hl (0.048)			-	
Fruit (trees)	Poland	EC	278 g/kg	Foliar high volume		2	0.081 l/hl (0.022)	500	0.42 (0.12 l/ha)	30	Formulation with dimethoate (22.2%)
Fruit, small	Poland	EC	278 g/kg	Foliar high volume	14 days before blooming and after harvest	2	0.06 l/hl (0.02)	750	0.42 l/ha (0.12)	30	Formulation with dimethoate (22.2%)
Fruit (trees); Fruit, small	Poland	EC	480 g/l	Spray to ground	Before planting	1	0.32 l/hl ((0.15)	750	2.4 l/ha (1.2)	-	
Fruit (trees)	Poland	EC	500 g/l	Foliar spray		2	0.15 l/hl (0.08)	500	0.75 l/ha (0.38)	30	Formulation with cypermethrin (50 g/l)
Fruit, small	Poland	EC	500 g/l	Foliar spray		2	0.10 l/hl (0.05)	750	0.75 l/ha (0.38)	30	Formulation with cypermethrin (50 g/l)
Garlic	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	1.50 l/ha (0.72)	21	
Garlic	Argentina	EC	480 g/l	Broadcast	Post-emergence		0.16 l/100 l water (0.08)	80-100 10 aerial		21	Mix with cyper-methrin
Garlic	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	50	
Garlic	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	50	
Garlic	Canada	EC	480 g/l	Ground drench over the row		1		1000	3.5 l/ha (1.69)	50	
Gentian	Japan	WP	250 g/kg	Foliar spray		2	0.025			2	
Gherkin	France	G	50 g/kg	Broadcast	Pre-plant	1			1.0		
Ginger	Australia	WP	500 g/kg	Spray	First shoot or first leaf.				0.45		
Ginger	Australia	EC	500 g/l	Spray	First shoot or first leaf				0.45		
Gooseberries	UK	EC	480 g/l	Foliar spray		2		1000	0.72	14	Summary only
Grapes	Australia	WP	500 g/kg	Foliar spray	berry set and later		0.025		0.25	7	
Grapes	Australia	EC	500 g/kg	Foliar spray	Berry set and later		0.025		0.25	14	
Grapes	Australia	EC	500 g/kg	Spray	Dormant, post-pruning		0.05				
Grapes, table	Chile	WP	500 g/kg	Foliar spray			0.12 l/ha			20	
Grapes	France	EC	228 g/l	Low volume row	BBCH 41-85			200	0.34	21	
Grapes	Italy	EC	480 g/l; 225 g/l	Foliar spray	Cluster closing	2	0.11 l/ha (0.05)	1000		30	Label designates "vines" as the crop.
Grapes	India	EC	200 g/kg	Soil drench			2 g/plant				Drench at base of plant. 11 day PHI pending.
Grapes	Japan	EC	400 g/l	Spray	Dormant	1	0.4				
Grapes	New Zealand	WP	500 g/kg	Foliar spray	At bud swell, at pre-	Repeat	0.038		0.5 minimum	14	

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
					flower, at post-flower and 14 days later and then at 3 week intervals						
Grapes	New Zealand	EC	400 g/l	Foliar spray	At bud swell, pre-flower, post-flower and 14 days later, then at 3 week intervals	Repeat	0.036		1.2 l/ha minimum (0.48)	14	Not table grapes
Grapes	Portugal	EC	480 g/l	Foliar spray, high volume	Fruiting	2	0.096	500 (1000 alt label)		56	Summary only
Grapes (wine)	South Africa	EC	480 g/l	Spray	Dormant. Before bud burst	2	0.096	High volume			
Grapes (wine)	South Africa	EC	480 g/l	Foliar spray	Four weeks after budding, 21 day repeat	Multiple	0.036	High volume		28	
Grapes	Spain	EC	480 g/l	Foliar spray			0.096			21	
Grapes	Spain	WP	250 g/l	Foliar spray	Fruiting	1	0.10	600		21	Summary only.
Grapes	Spain	WP	240 g/kg	Foliar spray high volume	Fruiting	1	0.048	500		21	Formulation with carbaryl (375 g/kg). Summary only.
Grapes	Spain	EC	480 g/l	Foliar spray high volume	Fruiting	1	0.096	500		21	Summary only.
Grapes	Spain	DP	30 g/kg	Dusting	fruiting	1			0.9	15	Summary only
Grapes (table)	South Africa	EC	480 g/l	Spray	Dormant. Before any signs of green material	1 or 2	2X0.096 or 1X0.19	High volume			Minimum of 4 l of spray mixture per vine
Grapes	USA	EC	4 lb/gal (480 g/l)	Soil spray, 15 sq ft about base of each vine		1	4.5 pt/100 gal (0.27)		2 qt of mixture per vine (0.005 kg/vine or 15 sq ft; $7X10^{-7}$)	35	Do not contact fruit or foliage with spray. States East of the Rocky Mountains only.
Hops		EC	500 g/l	Foliar spray		1	0.05 l/hl (0.025)	1500	1.5 l/ha (0.75)	30	Formulation with cypermethrin (50 g/l).
Hops	South Africa	EC	480 g/l	Row spray	At plant emergence		0.036	500			
Hops	Australia	EC	500 g/l	Foliar spray			0.05				
Horseradish	Poland	EC	500 g/l	Foliar spray		2	0.15 l/hl (0.08)	200	0.31 l/ha (0.16)	14	Formulation with cypermethrin (50 g/l)
Horticultural crops	Argentina	EC	480 g/l	Broadcast			0.16 l/ 100 l water (0.08)	80-100		21	Mix with cyper-methrin
Horticultural crops	Argentina	EC	480 g/l	Soil treatment; incorp-orated	Pre-plant			100-150	6.0 l/ha (2.9)		
Kale	UK	EC	480 g/l	Overall volume spray				200	0.72	21	

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Kale	USA	EC	4 lb/a (480 g/l)	Spray band 4 in incorporated for direct seeded or spray directed to the base of new transplants.	At planting	1			4.5 pt/a (2.2) 2.75 fl oz/1000 linear ft of row		Do not exceed 2.6 pt/a.; 20 in, 4.5 pt. Do not apply to foliage.
Kiwifruit	Australia	WP	500 g/kg	Foliar spray	Green-tip, pre-blossom or post-blossom and later	14 day, then 21- 28 day intervals	0.025		0.5	7	
Kiwifruit	Australia	EC	500 g/l	Foliar spray	Green-tip and pre-blossom. Do NOT apply post-blossom		0.025		0.5	14	
Kiwifruit	Chile	WP	500 g/kg	Spray			0.12 l/hl			14	
Kiwifruit	New Zealand	WP	500 g/kg	Foliar spray	Pre-blossom at green tip and before bloom. Post-blossom at 21-28 day intervals from 14 Feb or 60 days after complete petal fall	Repeat	0.025		0.5	14	
Kiwifruit	New Zealand	EC	400 g/l	Foliar spray	Pre-blossom in Oct and 7 days before introduction; post-blossom after Mar 1, 2 applications	Repeat	0.06 l/hl (0.024)		1.2 l/ha minimum (0.48)	14	
Kohlrabi	USA	EC	4 lb/a (480 g/l)	Spray band 4 in incorporated for direct seeded or spray directed to the base of new transplants.	At planting	1			4.5 pt/a (2.5) 2.75 fl oz/1000 linear ft of row		Do not exceed 2.6 pt/a.; 20 in, 4.5 pt. Do not apply to foliage.
Kohlrabi	Chile	D	120 g/kg	Mix with fertilizer					0.12		
Kohlrabi	Germany	G	10 g/kg	Spreading with incorpo-ration	Pre-plant	1			1		
Kohlrabi	Germany	G	10 g/kg	Spreading at root collar	Post-plant	1			0.005 g/plant		Single plant treatment.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Leafy Crucifers	Australia	EC	500 g/l	Foliar spray					0.15		Includes chou moullier, kale, mustard, canola
Leafy Crucifers	Australia	EC	500 g/l	Spray over plants and adjacent row	Young plants				0.8 l/.ha (0.40)		
Leeks	France	G	50 g/kg	Broadcast	Pre-plant	1			3.0		Summary only
Leeks	Poland	EC	500 g/l	Foliar spray		2	0.12 l/ha (0.06)	200	0.25 l/ha (0.12)	21	Formulation with cypermethrin (50 g/l).
Legumes	Greece	EC WP	480 g/l 250 g/l	Foliar spray, high volume		2			1.2 0.9 WP	20	Summary only.
Legumes	Greece	EC	480 g/l	Broadcast to soil or band, incorporate	Pre-plant	1			2.5 broadcast 0.96 band	20	Summary only.
Legumes	Greece	GR	50 g/kg	Broadcast or in line furrows or planting holes, incorporated	Pre-plant	1			1.25 broadcast 0.5 furrow	20	Summary only.
Legumes	Greece	EC	480 g/l	Bait		1			0.45	20	Bait = 30 kg bran + 10 l water/ha. Summary only.
Legumes	Spain	EC	480 g/l	Foliar spray high volume		1	0.096	500		21	Summary only.
Lettuce	Australia	EC	500 g/l	Foliar spray					0.3 l/ha (0.15)	7	
Lettuce	Australia	EC	500 g/l	Band over plants and adjacent soil	Young plants				0.8 l/ha (0.40)		
Lettuce	Greece	EC WP	480 g/l 250 g/kg	Foliar spray, high volume		2		600 EC	1.2 0.9 WP	20	Summary only.
Lettuce	Greece	EC	480 g/l	Broadcast to soil or band, incorporate	Pre-plant	1			2.5 broadcast 0.96 band	20	Summary only
Lettuce	Greece	GR	50 g/kg	Broadcast, incorporate	Pre-plant	1			1.25	20	Summary only.
Lettuce	South Africa	EC	480 g/l	Spray	At emergence of plants	7-14 day repeat	0.48	500		21	Western Cape only.
Lettuce	Spain	EC WP	480 g/l 250 g/kg	Foliar spray, medium/ high volume			0.10	300		21	Summary only.
Lettuce	Spain	GR	50 g/kg	Broadcast or row, incorporated	Pre-plant At planting	1			0.75 row 4 broadcast		Summary only.
Lentils	Canada	EC	480 g/l	Foliar spray (boom)	Seedling stage; Flowering to early podding	2		200 (ground) 20 or 30 (aerial)	1.2 l/ha (0.58)	60	20 day PHI if rate not greater than 875 ml/ha
Lucerne	Australia	EC	500 g/l	Soil spray	Pre-emergence				0.3 l/ha (0.15)	10	
Lucerne	Australia	EC	500 g/l	Foliar spray				100	0.9 l/ha (0.45)	2	2 day grazing restriction
Lupin	Australia	EC	500 g/l	Soil spray	Pre-emergence				0.3 l/ha (0.15)	10	
Maize	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	1.60 l/ha (0.77)	30	1.60 for early post-emergence only. Otherwise, 0.35 l/ha
Maize	Argentina	EC	480 g/l	Soil treatment, incorporated	Pre-plant			100-150	4.0 l/ha (1.9)		
Maize	Australia	EC	500 g/l	Band spray to soil	At sowing	1			2 l/ha (1) for 1 m row spacing or 20 ml/100 m of row		
Maize	Australia	EC	500 g/l	In-furrow	At	1			1.5 l/ha		

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
					planting				(0.75) for 1 m row spacing		
Maize	Australia	EC	500 g/l	Bait	At planting	1			0.1 l per 2.5 kg bait/ha		Bait is sorghum or wheat
Maize	Brazil	EC	480	Foliar spray	Sprouting to 35 cm or 30 days	2			1 l/ha (0.48)	21	
Maize	Brazil	EC	480	Foliar spray	Sprouting to 60 days	3			0.6 l/ha (0.29)	21	
Maize	Canada	G	15%	Band (row), incorporated, 2.5 cm	At planting	1			1.5		For 76 cm row spacing. All spacings use 15 grams (2.25 g ai) per 100 m of row.
Maize	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	70	
Maize	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	70	
Maize	Canada	WP	50%	Spray	Seedling 2-5 leaf	1		400	1.125	70	
Maize	Chile	EC	480 g/l	Ground spray	Pre-plant, incorpo-rated 10 cm	1			5 l/ha (2.4)	30	
Maize	Chile	EC	480 g/l	Spray, directed to base of plants					2 l/ha (0.96)	30	
Maize	Chile	G	150 g/kg	Broadcast or band (15-18 cm)	Pre-plant/ At planting				3		
Maize	Chile	WP	250 g/kg	In-furrow or broadcast	At planting				1.1		
Maize	Chile	D	120 g/kg	Mix with fertilizer					0.12		
Maize	Columbia	EC	400 g/l						1.0 l/ha (0.4)	14	Summary of label only
Maize	France	G	15 g/kg	Broadcast, aerial	51. Panicle appea-rance in shaft	2			0.375		Summary only.
Maize	France	G	50 g/kg	Broadcast	Pre-plant	1			0.5		Summary only
Maize	France	EC	300 g/l	Low volume broadcast, incorporate	Pre-plant		1	150	1.5		
Maize	Italy	EC	480 g/l	Foliar spray	60-100 cm ht (1) end of Jul-Aug (2)	2		600	1.2 l/ha (0.58) (1) 1.7 l/ha (0.82) (2)	30	
Maize	Italy	EC	225 g/l	Foliar spray	Flowering	2		600 1000	0.45 (1) 0.56 (2)	30	Summary only
Maize	Italy	G	75 g/kg	Row localized. broadcast	At planting At-transplant At earthing up	1			1.2; 3 broadcast	30	Summary only.
Maize	Mexico	G	50 g/kg	Band treatment, soil	At planting				1.0		
Maize	Mexico	EC	480 g/l or 445 g/kg	Foliar spray					1.5 l/ha (0.72)	21	
Maize	Portugal	WP	50 g/kg	Row or broadcast	Pre-plant At	1			0.5 row 5.0		Summary only.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
				incorporate	planting				broadcast		
Maize	South Africa	EC	480 g/l	Row, incorporated	At planting	1	(0.16)				10 ml/100 m row in 3 l water
Maize	South Africa	EC	480 g/l	Broadcast to soil, incorporated (100 mm)	At planting	1		200	1 l/ha (0.48)		
Maize	South Africa	EC	480 g/l	Broadcast	Post planting, 30-35 after and 44-49 days after	2	(0.055)			32	3.5 ml/100 m row in 3 l water
Maize	Spain	EC	480 g/l	Foliar spray			0.096	500	(0.45)	21	
Maize	Spain	GR	50 g/kg	Row	At planting	1			0.75	-	Summary only
Maize	Spain	WP	250 g/kg	Foliar high volume	Early stage	1	0.10	600		21	Summary only
Maize	Spain	EC	480 g/l	Foliar spray high volume	Early stages to 2 m high	1	0.096	600		21	Summary only.
Maize	Spain	GR	50 g/kg 15 g/kg	Row	50 cm high	1			0.45		Summary only.
Maize	Uruguay	EC	480 g/l	Foliar spray		15-20 day repeat interval		35 ground 25 aerial	1.2 l/ha (0.58)	30	20 day grazing restriction
Maize	UK	EC	480 g/l	Foliar spray	Emergence to 2 leaves	1		200	0.72	21	Summary only
Maize	UK	EC	480 g/l	Overall volume spray				200	0.72	14	Summary only
Maize	USA	EC	4 lb/gal (480 g/l)	Broadcast spray to the ground	Pre-plant, incoropo-rate 2-4 inches	1		10 gal/a (94)	6 pt/a (3.4)		Total use not to exceed 15 pt/a/season.
Maize	USA	EC	4 lb/gal (480 g/l)	Conser-vation Tillage: T-band in open seed furrow. Broadcast to surface trash and exposed soil.	At planting Pre-plant			20 gal/a (190) 5 gal/a (47) for T-band	2 pt/a (1.12) broadcast or for 40 in row spacing. 2.6 pt/a for 30 in row spacing		Total use not to exceed 15 pt/a/season.
Maize	USA	EC	4 lb/gal (480 g/l)	Both sides of row basal treatment, ahead of cultivator	Cultivation time				2 pt/a (1.12)		Total use not to exceed 15 pt/a/season. Cultivation application may be made in addition to use of 15G formulation
Maize	USA	EC	4 lb/gal (480 g/l)	Foliar spray or band over row (6 in ht) or drop nozzles directed to base of plants		Multiple		2 gal/a (19) aerial 20 gal/a (190) ground	3 pt/a (1.7)	35	May be applied through sprinkler irrigation. Total use not to exceed 15 pt/a/season. 14 day grazing restriction. 35 day fodder restriction.
Maize	USA	G	15 g/100g	Banded or broadcast	Pre-plant At planting Postplant at cultivation Postplant broadcast				12 oz /1000 ft row (0.17 kg ai/km) or 13.1 lb/a (2.2) for 30 in row spacing	35	For soil insect control, do not exceed 13.5 lb/a/season (2.3 kg ai/ha/season) or 16 oz per 1000 feet of row. For foliar insect control, do not exceed 13 lb/a/season (2.2 kg ai/ha/season) or 16 oz per

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
									(banded At planting or post-plant) 13.5 lb/acre (2.3) (pre-plant broadcast) 6.5 lb/acre (1.1) (aerial or ground broadcast, postplant)		1000 feet of row. 14 day grazing restriction.
Maize	USA	WP (SL)	50 g/ 100 g	Seed treatment		1			2 oz per 100 lb seed (0.062 kg/ 100 kg seed)		Summary only
Mango	Australia	EC	500 g/l	Foliar spray, thorough coverage of all branches, foliage and fruit			0.05			21	
Melon	India	EC	200 g/kg	Foliar spray				500	0.1		
Milo	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	1.60 l/ha (0.77)	30	1.60 for early post-emergence only. Otherwise, 0.35 l/ha
Milo	Uruguay	EC	480 g/l	Foliar spray		15-20 day repeat interval		35 ground 25 aerial	0.35 (0.14)	20	
Mint	USA	EC	4 lb/gal (480 g/l)	Foliar spray, broadcast		2			4 pt/a (2.2)	90	One application is post-harvest Only one application during growing season.
Mung bean (Green gram)	India	EC	200 g/kg	Foliar spray				500	0.60		30 day PHI pending
Mustard	India	EC	200 g/kg	Foliar spray				500	0.10		15 day PHI pending
Nectarine	Argentina	EC	480 g/l	Spray to run-off; high volume			0.16 l/100 l water (0.08)			21	
Nectarine	Chile	WP	500 g/kg	Spray	Oct-Nov		0.12 l/hl			45	
Nectarine	Uruguay	WP	500 g/kg	Foliar spray		20-25 day repeat interval	0.06				
Nectarine	USA	EC	4 lb/gal (480 g/l)	Coarse spray to trunk		1	3 qt/100 gal (0.36)			14	Grazing restriction. Cover bark from ground level to scaffold limbs.
Nectarine	USA	EC	4 lb/a (480 g/l)	Spray	Dormant	1	1 pt/100 gal (0.06)	200 gal (760) 250 gal California	4 pt/a (2.2)		Grazing restriction
Nectarine	USA	WP	500 g/kg	Spray to trunk		1			8 lb/a (4.5)	14	Do not contact fruit with spray
Oats	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	1.60 l/ha (0.77)	30	1.6 early post-emergence only, 0.90 otherwise
Oats	Australia	EC	500 g/l	Soil spray	Pre-				0.3 l/ha	10	

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
					emergence				(0.15)		
Oats	Canada	EC	480 g/l	Foliar spray		5			1.2 l/ha (0.58)		Max seasonal rate is 5.275 l/ha. One application may be to the soil.
Oats	Chile	EC	400 g/l	Spray					0.4 l/ha (0.19)	30	
Oats	UK	EC	480 g/l	Overall volume spray				200	0.72	14	Summary only
Oats	Uruguay	EC	480 g/l	Foliar spray				35 ground 25 aerial	0.4 l/ha (0.19)	30	20 day grazing restriction
Oil seeds	Australia	EC	500 g/l	Foliar spray	Young plants	As needed	0.9 l/ha (0.45)			10	Grazing restriction 2 days. Specifies: cotton, mustard, linseed, peanut, poppy, canola, safflower, sunflower
Olive	Argentina	EC	480 g/l	Spray to run-off; high volume			0.12 l/100 l water (0.06)	80-100		21	
Olive	Greece	EC WP	480 g/l 250 g/kg	Foliar spray, high volume	End of July	1	0.06	1500	1.8		Summary only
Olive	Spain	DP	30 g/kg	Dusting	Flowering	1			0.9	-	Summary only.
Onions	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	1.50 l/ha (0.72)	21	
Onions	Argentina	EC	480 g/l	Broadcast	Post-emergence		0.16 l/100 l water. (0.08)	80-100 10 aerial		21	160 cc/100 l water in a mix with cyper-methrin
Onions	Australia	EC	500 g/l	Foliar spray, band					0.4		
Onions	Canada	G	15%	In-furrow	At planting	1		35 ground 25 aerial	2.4	97 (pickling) 109 (dry)	For 10 cm furrow width, 64 g (9.6 g ai) per 100 m. For 5 cm furrow width, 32 g per 100 m, or 1.2 kg ai/ha.
Onions (bulb)	Canada	EC	480 g/l	Soil treatment, spray	Pre-plant	1		400	4.8 l/ha (2.3)	60	
Onions	Canada	WP	50%	Spray	Seedling	1		400	2.25	60	Do NOT use on bunching onions.
Onions	Columbia	EC	400 g/l						1.0 l/ha (0.4)	15	Summary of label only.
Onions	France	G	50 g/kg	Broadcast	Pre-plant	1			3.0		Summary only
Onions	Germany	G	10 g/kg	Spreading as drill treatment with soil covering	At sowing	1			0.01 g/m row		
Onions	Greece	EC	480 g/l	Foliar spray, high volume		3		400	2.5 l/ha (1.2)	7 (20 alt label)	
Onions	Greece	EC	480 g/l	Broadcast to soil or band		1			2.5 broadcast 0.96 band	20	Summary only
Onions	Greece	G	50 g/kg	Broadcast to soil					3.0		
Onions	Greece	G	50 g/kg	In-furrow	At planting				0.5	21	
Onions	Greece	WP	250 g/kg	Foliar spray	At infestation	2 week repeat		400	0.88	20	
Onions	Greece	WP	250 g/kg	Dust or spray to ground; broadcast or	Pre-plant	1			2.5 broadcast 1.25 in-furrow		

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
				in furrow. Soil incorpo-rate, 5-10 cm							
Onions	Greece	WP	250 g/kg	Spray or dust	At planting; Post-planting				0.75 At planting 1.0 post-planting (0.5 in line)		
Onions	Greece	G	50 g/kg	Broadcast or in lines, furrows, or planting holes	Pre-plant At planting				0.5 furrow 1.25 broadcast	20	Summary only.
Onions	Greece	WP	250 g/kg	Bait					0.5	20	2 kg WP + 30 kg bran + 10 l water, per ha.
Onions	Italy	EC	480 g/l 225 g/l	Foliar spray				600	1.1 l/ha (0.53)	21	
Onions	Italy	G	75 g/kg	Broadcast	At planting At earthing up	1			3	21	Summary only.
Onions	India	EC	200 g/kg	Foliar spray				1000	1.0		35 day PHI pending
Onions	Poland	EC	500 g/l	Foliar spray		2	0.12 l/ha (0.06)	200	0.25 l/ha (0.12)	21	Formulation with cypermethrin (50 g/l).
Onions	Portugal	G	50 g/kg	broadcast, incorporate	Pre-plant	1			3.0		Summary only.
Onions	Spain	WP	250 g/kg	Foliar spray	Early and later	1	0.10	500		21	Summary only.
Onions	Spain	EC	480 g/l	Foliar spray high volume	Early stages and later	1	0.096	500		21	Summary only.
Onions	Spain	G	50 g/kg	Broadcast	At planting	1			3 (4 alt label)	-	Summary only
Onions	Uruguay	EC	480 g/l	Foliar spray					0.1 l/ha (0.048)	15	
Onions, dry bulb	USA	G	15 g/100 g	In-furrow	At planting	1			3.7 oz/1000 feet row, 6.7 lb/a (1.1)		
Orange, Mandarin	Japan	EC	400 g/l	Foliar spray		3	0.04			30	
Orange, Mandarin	Japan	EC	400 g/l	Spray to trunk		3	0.4			30	
Pak-choi	Canada	EC	480 g/l	Ground spray, drench	7-10 an 28 days post-seed or 3 and 21 days post-transplant.	2	1.68 l/10 hl (0.08)	1000	210 ml/1000 m row (0.10 g ai/1000 m row). 7.0 l/ha (3.36) for 30 cm row space.	15	Apply 12.5 l solution per 100 m row on soil, 10 cm on each side of plant. Do not apply to harvestable portion.
Parsnip	Australia	EC	500 g/l	Band over plants and adjacent soil	Young plants				0.8 l/ha (0.40)		
Passion fruit	Australia	WP	500 g/kg	Spray strip at bottom of vines. Avoid fruit contact.		Repeat 7-10 day interva l	0.034	30	(1.02)	7	Apply as a mixture with yeast hydrolysate. Fruit fly control.
Pasture	Australia	EC	500 g/l	Foliar spray					0.9 l/ha (0.45)		2 day grazing restriction
Pasture	Belgium	EC	480 g/l	Foliar spray		1			0.72	21	Summary only.
Pasture	Brazil	EC	480 g/l	Foliar spray		2			1 l/ha (0.48)		7 day grazing restriction
Pasture	Chile	EC	480	Spray					1.2 l/ha		3 day grazing restriction

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
									(0.58)		
Pasture	Columbia	EC	400 g/l						3.5 l/ha (1.4)		15 day grazing restriction. Summary of label only.
Pasture	Germany	EC	480 g/l	Spray broadcast		1	0.12	400	0.48	28	
Pasture	Mexico	EC	480 g/l or 445 g/kg	Foliar spray					1.5 l/ha (0.72)		21 day grazing restriction
Pasture	South Africa	EC	480 g/l	Spray				200	0.25 l/ha (0.12)		14 day grazing restriction. Summary only.
Pasture	Spain	WP	250 g/kg	Foliar spray high volume	Early	1	0.10	40			Summary only.
Pasture (grassland)	UK	EC	480 g/l	Foliar spray		1		200	0.72	14 (hay)	14 day grazing restriction
Peach	Argentina	EC	480 g/l	Spray to run-off; high volume			0.16 l/100 l water (0.08)	80-100		21	
Peach	Chile	WP	500 g/kg	Spray	Oct-Nov		0.06			45	
Peach	France	EC	228 g/l	Low volume foliar	BBCH 69-79	3	0.05	400		30	If spray volume is less than 1000 l/ha, the conc. Is adjusted to ensure 0.5 g ai/ha. Summary only.
Peach	Greece	EC WP	480 g/l 250 g/kg	Foliar spray, high volume	Flowering; green stage	2	0.075	1500	1.9 2.1 WP	20	Summary only.
Peach	Italy	EC	480 g/l 225 g/l	Foliar spray	Swelling	2	0.11 l/hl (0.053)	1500	(0.80)	30	225 g/l was summary only.
Peach	Japan	WP	250 g/kg	Foliar spray		5	0.025			14	
Peach	Korea	WP	250 g/kg	Foliar spray	From early June	<5	0.041			14	
Peach	South Africa	EC	480 g/l	Spray	Dormant, before and after pruning	2	0.03	High volume			
Peach	Uruguay	WP	500 g/kg	Foliar spray		20-25 day repeat interval	0.06			45	
Peach	Uruguay	Foliar spray	480 g/l	Foliar spray			0.058	35 ground 25 aerial		15	
Peach	USA	EC	4 lb/gal (480 g/l)	Coarse spray to trunk		1	3 qt/100 gal (0.36)			14	Grazing restriction. Cover bark from ground level to scaffold limbs.
Peach	USA	EC	4 lb/a (480 g/l)	Spray	Dormant	1	1 pt/100 gal (0.06)	200 gal (760) 250 gal California	4 pt/a (2.2)		Grazing restriction
Peach	USA	WP	500 g/kg	Spray to trunk		1			8 lb/a (4.5)	14	Do not contact fruit with spray
Peanut (Groundnut)	India	EC	200 g/l	Foliar spray				500	0.20		30 day PHI pending.
Peanut (Groundnut)	India	EC	200 g/kg	Soil spray				1000	0.225		30 day PHI pending.
Peanut	Thailand	EC	200 g/l	Soil spray between plants	30-35 days post-plant	2			0.94		
Peanut	USA	EC	4 lb/gal (480 g/l)	Soil broadcast spray, incorporate 3-4 in.	pre-plant	1		10 gal/a (94)	4 pt/a (2.2)	21	Do not feed treated peanut forage or hay to dairy or meat animals. Combined total use of chlorpyrifos (EC and G)

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
											not to exceed 4 lbs ai/a/season
Peanut	USA	EC	1 lb/gal (120 g/l)	Directed Foliar spray		1			2 lb ai/a (2.2)	21	
Peanut	USA	G	15g/100g	Band Or aerial broadcast	Pre-plant At planting Post-plant	Early flower-ing to peggin g for band postpla nt Broad-cast at peggin g			15 oz/1000 feet row (banded at plant or postplant). 13.3 lb/a (2.2) broadcast	21	Do not apply more than 30 oz/1000 ft row/season or 26.6 lb/a/season (4.5). Total of pre-plant and postplant applications not to exceed 26.6 (4 lb ai)lbs/a/season (4.5).
Pear	Argentina	EC	480 g/l	Spray to run-off; high volume			0.15 l/100 l water (0.07)			30	
Pear	Argentina	WP	500 g/kg	Spray to cover total foliage			0.12 g/100 l water (0.06 g ai/100 l water)			30	
Pear	Australia	WP	500 g/kg	Foliar spray	After pedal fall	Two week repeat interva l	0.025			7	
Pear	Australia	EC	500 g/l	Spray, thorough coverage of branches, foliage, fruit.	mid-late November and later		0.05	10-50 aerial		14	
Pear	Belgium	EC	480 g/l	Foliar spray	Before flower	1	0.038 alt label		0.72	35	Summary only.
Pear	Belgium	WP	250 g/kg	Foliar spray	Before flower.	1	0.15			35	Summary only.
Pear	Chile	WP	500 g/kg	Spray			0.12 l/ha			45	
Pear	Italy	EC	480 g/l 225 g/l	Foliar spray	Swelling	2	0.11 l/ha (0.053)	1500		30	
Pear, Japanese	Japan	WP	250 g/kg	Foliar spray		3	0.025			21	
Pear	New Zealand	WP	500 g/kg	Foliar spray	At bud movement and then at 2 week intervals from petal fall	Repeat	0.038		1.5 minimum	14	
Pear	Korea	WP	250 g/kg	Foliar spray		<3	0.025			21	
Pear	Portugal	EC	480 g/l	Foliar spray, high volume		5	0.096			14	Summary only.
Pear	New Zealand	EC	400 g/l	Foliar spray	At bud movement and 10-12 days later	Repeat	0.1		3 l/ha minimum (1.2)		Do not use after flowering starts.
Pear	South Africa	EC	480 g/l	Foliar	3 weeks before bud swell; bud swell green tip	2	0.048	High volume			
Pear	UK	EC	480 g/l	Foliar spray	April to August	5		250	0.96	14	Summary only

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Pear	USA	EC	4 lb/a (480 g/l)	Spray	Dormant	1	1 pt/100 gal (0.06)	200 gal (760) 250 gal California	4 pt/a (2.2)		Grazing restriction
Pear	Uruguay	WP	500 g/kg	Foliar spray		20-25 day repeat interval	0.06			45	
Pear	Uruguay	EC	480 g/l	Foliar spray			0.058	35 ground 25 aerial		15	
Peas	Australia	EC	500 g/l	Band over plants and adjacent row	Young plants				0.8 l/ha (0.40)		
Peas	Australia	EC	500 g/l	Foliar spray			0.025		0.5 l/ha (0.25)		
Peas	Australia	EC	500 g/l	Soil spray	Pre-emergence	1			0.3 l/ha (0.15)		
Peas	Italy	EC	480 g/l 225 g/l	Foliar spray				600	1.1 l/ha (0.53)	15	
Peas	Italy	G	75 g/kg	Row localized. Broadcast	At planting At-transplant At earthing up	1			1.2; 3 broadcast	15	Summary only.
Peas	UK	EC	480 g/l	Spray	Preemer-gence Early post-emergence	2		200	0.72	21	Summary only
Peas	USA	EC	1 lb/gal (120 g/l)	Foliar spray		5	0.12		1.12	28	Grazing restriction.
Pecan	USA	EC	4 lb/gal (480 g/l)	Foliar spray		5		100 gal/a (940) ground 5 gal/a (47) aerial	4 pt/a (2.2)	28	Do not exceed 20 pt/a/season. Grazing restriction.
Pecan	USA	WP (SL)	500 g/kg	Seed treatment slurry	Seed	1	1 oz ai/cwt				Blackeyed, field, garden.
Pecan	USA	WP	500 g/kg	Foliar spray		5	2 lb/100 gal (0.12)		8 lb/a (4.5)	28	
Pepper, Bell	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	1.50 l/ha (0.72)	21	
Pepper, Bell (capsicum)	Australia	EC	500 g/l	Spray to soil on either side of plant row		As needed	0.035		0.35		
Pepper, Bell (capsicum)	Australia	EC	500 g/l	Foliar spray			0.025		0.50		
Pepper, Bell	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	40	
Pepper, Bell	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	40	
Pepper, Bell	Canada	WP	50%	Spray	Seedling 2-5 leaf	1		400	1.125	40	
Pepper	Italy	EC	225 g/l	Broadcast		1		800	0.56	15	Summary only
Pepper	Italy	G	75 g/kg	Row	At	1			1.2; 3	21	Summary only.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
				localized. Broadcast	planting At-transplant At earthing up				broadcast		
Pepper, Bell	Mexico	EC	480 g/l or 445 g/kg	Foliar spray					1.5 l/ha (0.72)	7	
Pepper, Bell	Mexico	WP	500 g/kg	Foliar spray					1.0	7	
Pepper	Spain	WP	250 g/kg	Foliar spray high volume	Fruiting	2	0.10	600-1200		7	Summary only.
Pepper	Spain	EC	260 g/l	Foliar spray high volume	Fruiting	3	0.072	500		21	Formulation with cypermethrin (50 g/kg). Summary only.
Pepper	Spain	EC	480 g/l	Foliar spray high volume	Fruiting and early stages	3	0.096	500-1200	(1.15)	7	Summary only.
Pepper	Spain	GR	50 g/kg	Broadcast or row incorporated	Pre-plant At planting	1			0.75 row 4 broadcast		
Pepper	Spain	DP	30 g/kg	Dusting	Fruiting	2			0.9	15	Summary only.
Pepper	USA	WP	500 g/kg	Foliar spray broadcast		8		50 gal/a (470)	2 lb/a (1.1)	7	Do not apply within 10 days of transplanting. Do not apply through any type of irrigation system.
Pineapple	Australia	EC	500 g/l	Foliar spray		90 day interval	0.05		3000 l spray/ha (1.5)	14	
Pineapple	Australia	EC	500 g/l	Pre-plant to soil, incorporated 10 cm.		1			5 l/ha (2.5)		
Pineapple	Columbia	EC	400 g/l						2.0 l/ha (0.8)	21	
Plums	Argentina	EC	480 g/l	Spray to run-off; high volume			0.16 l/100 l water (0.08)	80-100		21	
Plums	Chile	WP	500 g/kg	Spray	Oct-Nov		0.12 l/hl (0.06)			45	
Plums, Japanese	Japan	WP	250 g/kg	Foliar spray		2	0.025			2	
Plums	South Africa	EC	480 g/l	Spray	Dormant; before and after pruning	2	0.036	High volume			
Plums	Uruguay	WP	500 g/kg			20-25 day repeat interval					
Plums	UK	EC	480 g/l	Foliar spray	April-August	5		250	0.96	14	Summary only
Plums	USA	EC	4 lb/a (480 g/l)	Spray	Dormant	1	1 pt/100 gal (0.06)	200 gal (760) 250 gal California	4 pt/a (2.2)		Grazing restriction. Includes prune plums.
Pome fruit	Australia	EC	500 g/l	Ground spray			0.025	0.5		14	Spray areas infested with grasshoppers.
Pome fruit	Australia	EC	500 g/l	Directed spray			0.2		0.06 or 100 ml mix per tree in a strip or patch low on tree.	14	Do not contact fruit.
Pome fruit	Germany	EC	480 g/l	Broadcast	Preflower	4	0.048	1500	0.723	14-28	Summary only. Apple

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
				foliar	Post flower						PHI is 28 days.
Pome fruit	Italy	EC	420 g/l	Overall spray, high volume		1	0.052			30	Summary only.
Pome fruit	Spain	WP	250 g/kg	Foliar spray high volume	Fruiting	1	0.10	1500 (1000 alt label)		21	Summary only
Popcorn	USA	EC	4 lb/gal (480 g/l)	Broadcast spray to the ground	Pre-plant, incorpo-rate 2-4 inches	1		10 gal/a (94)	6 pt/a (3.4)		Total use not to exceed 15 pt/a/season.
Popcorn	USA	EC	4 lb/gal (480 g/l)	Conser-vation Tillage: T-band in open seed furrow. Broadcast to surface trash and exposed soil.	At planting Pre-plant			20 gal/a (190) 5 gal/a (47) for T-band	2 pt/a (1.1) broadcast or for 40 in row spacing. 2.6 pt/a for 30 in row spacing		Total use not to exceed 15 pt/a/season.
Popcorn	USA	EC	4 lb/gal (480 g/l)	Both sides of row basal treatment, ahead of cultivator	Cultivation time				2 pt/a (1.1)		Total use not to exceed 15 pt/a/season. Cultivation application may be made in addition to use of 15G formulation
Popcorn	USA	EC	4 lb/gal (480 g/l)	Foliar spray or band over row (6 in ht) or drop nozzles directed to base of plants		Multiple		2 gal/a (19) aerial 20 gal/a (190) ground	3 pt/a (1.7)	35	May be applied through sprinkler irrigation. Total use not to exceed 15 pt/a/season. 14 day grazing restriction. 35 day fodder restriction.
Popcorn	USA	G	15 g/100g	Banded or broadcast	Pre-plant At planting Postplant at cultivation Postplant broadcast				12 oz /1000 ft row (0.17 kg ai/km) (banded At planting or post-plant) 13.5 lb/acre (2.3) (pre-plant broadcast) 6.5 lb/acre (1.1) (aerial or ground broadcast, postplant)	35	For soil insect control, do not exceed 13.5 lb/a/season (2.3 kg ai/ha/season) or 16 oz per 1000 feet of row. For foliar insect control, do not exceed 13 lb/a/season (2.2 kg ai/ha/season) or 16 oz per 1000 feet of row. 14 day grazing restriction.
Potatoes	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	1.50 l/ha (0.72)	21	
Potatoes	Argentina	EC	480 g/l	Soil treatment, incorporated	Pre-plant			100-150	6 l/ha (2.9)		
Potatoes	Argentina	EC	480 g/l	Soil treatment, incorpo-rated	Preplant and immediate-ly after hilling up	2		100-150	4 l/ha (1.9) 2 l/ha (1.0)		
Potatoes	Australia	EC	500 g/l	Soil treatment	Pre-plant, incorpo-rated; at hilling-up	2			6 l/ha (3); 1 l/ha (0.5)		

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Potatoes	Australia	EC	500 g/l	Foliar spray			0.025		0.5 l/ha (0.25)		
Potatoes	Brazil	EC	480	Foliar spray		2			1.5 l/ha (0.72)	21	
Potatoes	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	7	
Potatoes	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	7	
Potatoes	Canada	EC	480 g/l	Foliar spray		9		400-800	1.0 l/h (0.48)	7	
Potatoes	Canada	WP	50%	Spray	Seedling 2-5 leaf	1		400	1.125	7	
Potatoes	Chile	EC	500 g/l	Foliar spray					0.4 l/ha (0.2)	14	Formulation is a mix with cypermethrin (50 g/l).
Potatoes	Chile	G	150 g/kg	Broadcast or band (15-18 cm)	Pre-plant/ At planting				3		
Potatoes	Chile	D	120 g/kg	Mix with fertilizer					0.12		
Potatoes	Columbia	EC	400 g/kg						4.0 l/ha (1.6)	15	Summary of label only.
Potatoes	France	G	50 g/kg	Broadcast	Pre-plant	1			1.25		Summary only
Potatoes	Italy	EC	480 g/l	Foliar spray		Repeat as needed		600	1.6 l/ha (0.77)	15	
Potatoes	Italy	EC	225 g/l	Foliar spray	Post-flowering	2		600	0.56	30	Summary only
Potatoes	India	EC	200 g/kg	Foliar spray				500	0.50		35 day PHI pending.
Potatoes	Poland	EC	268 g/kg	Foliar, high volume		2	0.28 l/hl (0.075)	150	0.42 l/ha (0.11)	30	Formulation with dimethoate (22.2%)
Potatoes	Poland	EC	500 g/l	Foliar spray		2	0.20 l/hl (0.1)	150	0.3 l/ha (0.15)	30	Formulation with cypermethrin (50 g/kg).
Potatoes	Portugal	EC	480 g/l	Foliar spray, high volume	Fruiting	2	0.096	500 (1000 alt label)		14	Summary only.
Potatoes	Portugal	GR	50 g/kg	Broadcast or in-row	At planting	1		5.0 broadcast 1.25 in-row			Summary only.
Potatoes	South Africa	EC	480 g/l	Spray, with good ground coverage	Pre-plant; Post-plant	1 pre; multiple post at 2-3 week intervals	(0.24)pre-plant	500 post	(0.72) pre-plant for 1 m row spacing. 0.5 l/ha post plant (0.24)	7	Apply pre-plant in a 100 mm band just before closing furrows, 15 ml/100 m row length in 3 l water.
Potatoes	South Africa	EC	480 g/l	Spray	Immediate-ly before tuber initiation and at 2 week intervals	Multiple		500 increase with crop density	1l/ha (0.48)	7	
Potatoes	Spain	EC	480 g/l	Foliar spray			0.096	300		21	
Potatoes	Spain	EC	260 g/l	Foliar spray high volume	40 cm high	1	0.072	500		21	Formulation with cypermethrin (50 g/kg). Summary only.
Potatoes	Spain	WP	250 g/kg	Broadcast spray, high volume			0.10	300		21	Summary only.
Potatoes	Spain	WP	240 g/kg	Foliar high volume	40 cm high	1	0.048	750		21	Formulation with carbaryl (375 g/kg). Summary.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Potatoes	Spain	EC	480 g/l	Foliar spray high volume	20-40 cm high	1	0.096	500		21	Summary only.
Potatoes	Spain	GR	50 g/kg	Row Broadcast	At planting	1			1.5 row 5 broadcast	-	Summary only.
Potatoes	UK	EC	480 g/l	Overall volume spray				200	0.72	21	Summary only.
Potatoes	Uruguay	EC	480 g/l	Soil treatment, band/furrow	At planting				1.5 l/ha (0.72)		
Potatoes	Uruguay	EC	480 g/l	Broadcast soil treatment, incorporate 10 cm	Pre-plant				3.5 l/ha (1.7)		
Potatoes	Uruguay	EC	480 g/l	Foliar spray		15-20 day repeat interval			1.5 l/ha (0.72)		
Pumpkin	USA	WP (SL)	50 g/ 100 g	Seed treatment		1			2 oz per 100 lb seed (0.062 kg/ 100 kg seed)		
Quince	Uruguay	WP	500 g/kg	Foliar spray		20-25 day repeat interval	0.06				
Quince	Uruguay	EC	480 g/l	Foliar spray		15-20 day repeat interval	0.058	35 ground 25 aerial		15	
Radish	Australia	EC	500 g/l	Foliar spray			0.025		0.5 l/ha (0.25)		
Radish	Australia	EC	500 g/l	Band over plants and adjacent soil	Young plants				0.8 l/ha (0.40)		
Radish	USA	EC	4 lb/gal (480 g/l)	Soil treatment drench in the seed furrow	At planting	1		40 gal/a (370)	5.5 pt/a (3.1). 1.0 fl oz /1000 ft of row		
Radish	USA	G	15 g/100 g	In-furrow	At planting	1			3.3 oz per 1000 ft row, 18.3 lb/a (3.1)		
Rape seed	Australia	EC	500 g/l	Soil spray	Pre-emergence				0.3 l/ha (0.15)	10	
Rape seed	Australia	EC	500 g/l	Broadcast spray					1.5 l/ha (0.75)		Label is unclear. Implies soil application.
Rape	Poland	EC	500 g/l	Foliar spray	2		0.20 l/hl (0.10)	150	0.31 l/ha (0.03)	21	Formulation with cypermethrin (50 g/l).
Rape seed (oilseed rape)	UK	EC	480 g/l	Overall volume spray				200	0.72		
Raspberries	UK	EC	480 g/l	Foliar spray	May-June	2		500	0.72	7	Summary only
Rhubarb	UK	EC	480 g/l	Foliar spray	Before stem extension	1		1000	0.96	21	Summary only
Rice	Australia	EC	500 g/l	Foliar spray					1.5 l/ha (0.75)	10	Maximum rate when water >15 cm or high amount of decaying material.
Rice	Columbia	EC	400 g/l						2.0 l/ha (0.8)	15	Summary of label only

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
Rice	India	EC	200 g/kg	Foliar application				500	0.375		30 day PHI pending
Rice	India	EC	200 g/kg	Seedling dip			0.02% solution				
Rice	Mexico	EC	480 g/l or 445 g/kg	Foliar spray				250 ground 50 aerial	1.25 l/ha (0.6)		21 day grazing restriction
Rice	Philippines	EC	300 g/l	Foliar		3		160-192	0.3	7	
Rice	Thailand	EC	200 g/l	Foliar spray, high volume			0.08	500	0.4	7	
Rutabaga	Canada	G	15%	In-furrow	At planting	1			1.4		For 105 cm row spacing. Rate is 150 g ai/1000 m row.
Rutabaga	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	30	
Rutabaga	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	30	
Rutabaga	Canada	EC	480 g/l	Soil spray, drench	7-10, 28, 49 and 70 days post-seed.	4	1.68 l/ 10 hl (0.08)	1000	210 ml/1000 m row (0.10 g ai/1000 m row) 7.0 l/ha (3.36) for 30 cm row space	30	Apply 12.5 l solution per 100 m row on soil, 10 cm on each side of plant. Do not apply to harvestable portions. Do not use first treatment if G used at planting.
Rutabaga	Canada	WP	50%	Spray	Seedling 2-5 leaf	1		400	1.125	30	
Rutabaga	USA	EC	4 lb/a (480 g/l)	Band 4 in spray over row, shallow incorpo-ration	At planting	1		40 gal/a (370)	4.5 pt/a (2.5). 3.3 fl oz/1000 linear ft of row		Do not use rutabaga tops for food or feed.
Rye	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	1.60 l/ha (0.77)	30	1.6 early post-emergence only, otherwise 0.90 l/ha.
Rye	Australia	EC	500 g/l	Soil spray	Pre-emergence				0.3 l/ha (0.15)	10	
Rye	Uruguay	EC	480 g/l	Foliar spray		15-20 day repeat interval		35 ground 25 aerial	0.4 l/ha (0.19)	30	20 day grazing restriction
Safflower	Australia	EC	500 g/l	Soil spray	Pre-emergence				0.3 l/ha (0.15)	10	
Safflower	Australia	EC	500 g/l	Spray to soil, broadcast or in-furrow	Pre-plant At planting			30 (in-furrow)	1.5 l/ha for 1 m row spacing (0.75)		
Shallot	Australia	EC	500 g/l	Foliar spray, band					0.4		
Shallot	France	G	50 g/kg	Broadcast	Pre-plant	1			3.0		Summary only
Silver beet	Australia	EC	500 g/l	Foliar spray					0.3 l/ha (0.15)		
Sorghum	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	1.60 l/ha (0.77)		1.6 for early post-emergence only. Otherwise, 0.35 l/ha
Sorghum	Argentina	EC	480 g/l	Soil treatment, incorp-orated	Pre-plant			100-150	4.0 l/ha (1.9)	30	
Sorghum	Australia	EC	500 g/l	Foliar spray					1.5 l/ha (0.75)	2	Do NOT use on Sugar Drip or Alpha sorghum
Sorghum	Australia	EC	500 g/l	Soil, in-	At			30	1.5 l/ha		

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
				furrow	planting				(0.75) or 15 ml per 100 m row, 1 m row spacing		
Sorghum	Australia	EC	500 g/l	Bait	At plant				100 ml/2.5 kg bait/ha		Bait is wheat or sorghum
Sorghum	Brazil	EC	480 g/l	Foliar spray	Sprouting to 70 days	2			0.75 l/ha (0.36)	21	
Sorghum	Mexico	G	50 g/kg	Band treatment, soil.	At planting				1.0		
Sorghum	Mexico	EC	480 g/l or 445 g/kg	Foliar spray					1.5 l/ha (0.72)		
Sorghum, grain	South Africa	EC	480 g/l	Row or overall, incorporate (100 mm)	Pre-plant	1	0.16 row	200 overall	1l/ha (0.48)	32	For row application, 10 ml/100 m row in 3 l water
Sorghum	Spain	EC WP	480 g/l 250 g/kg	Broadcast spray, high volume			0.10	500		21	Summary only.
Sorghum	Spain	GR	1.5 k/kg	Row					0.45	21	Summary only.
Sorghum, grain	USA	EC	4 lb/gal (480 g/l)	Foliar spray, broadcast or band (8-12 in).					2 pt/a (1.1)	30 @ 1pt/a 60 @ >1pt/a	Do not exceed 3 pints/a/season. Do not treat sweet varieties of sorghum. Do not reduce dosage for banded or directed application.
Sorghum (Milo)	USA	G	15 g/100 g	Band incorporate	At planting	1			12 oz per 1000 feet row, or 13.1 lb/a (2.0) for 30 in row spacing		
Soya beans	Australia	EC	500 g/l	Bait	At planting				0.1 l per 2.5 kg bait/ha		Bait is sorghum or wheat
Soya beans	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	2.0 l/ha (0.96)	45	
Soya beans	Brazil	EC	480 g/l	Foliar spray		2			1.0 l/ha (0.48)	21	
Soya beans	France	EC	300 g/l	Low volume broadcast, incorporate	Pre-plant	1		150	1.5		Summary only
Soya beans	Italy	EC	480 g/l 225 g/l	Foliar spray	Milky ripe			800	1.2 l/ha (0.58)	120	
Soya beans	Italy	G	75 g/kg	Row localized. Broadcast	At planting At-transplant At earthing up	1			1.2; 3 broadcast	120	Summary only.
Soya beans	Mexico	EC	480 g/l or 445 g/kg	Foliar spray					1.5 l/ha (0.72)	21	
Soya beans	Thailand	EC	200 g/l; 400 g/l	Foliar spray, high volume		3	0.12	625	0.75	7	10 day retreatment interval. 14 day PHI for undefined conditions.
Soya beans	Uruguay	EC	500 g/l	Foliar spray		15-20 day repeat interval		80 ground 25 aerial	0.75 l/ha (0.38)	45	Formulation includes cypermethrin (50 g/l)
Soya beans	USA	EC	4 lb/gal	Soil spray.	Pre-plant	1		10	2 pt/a		Do not apply in-furrow.

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
			(480 g/l)	Band 4-6 in At planting; 9-12 in post-emergence.	through post-emergence			gal/a (94)	(1.1)		36 in row spacing requires 8.8 oz of spray per 100 feet or row.
Soya beans	USA	EC	4 lb/a (480 g/l)	Foliar spray, broadcast					2 pt/a (1.1)	28	Last two treatments must be a minimum of 14 days apart. Do not exceed 6 pt (3 lb ai) per acre per season. Grazing /feeding restriction. Only 1 application after pod set on determinate soya. May be applied with sprinkler irrigation.
Soya beans	USA	G	15 g/100 g	Band incorporate	At planting Post-plant	1			8 oz per 1000 ft row, 8.7 lb/a (1.5) for 30 in row spacing.		Do not apply as an in-furrow treatment.
Spinach	France	G	50 g/kg	Broadcast	Pre-plant	1			1.0		
Stone fruit	Australia	WP	500 g/kg	Foliar spray	After petal fall	Two week repeat interval	0.025			14	
Stone fruit	Australia	WP	500 g/kg	Spray strip low on tree. Avoid fruit contact.		7 day repeat interval	0.2		0.05-0.1 0 per tree	14	Applied as a mixture with yeast hydrolysate
Stone fruit	Australia	EC	500 g/l				100 ml/hl (0.05)	2000	2 l/ha (1)	14	
Stone fruit	Australia	EC	500 g/l	Bait	Spring		200 ml (0.20 kg ai) + 250 ml sunflower oil per 5 kg cracked bait			14	Wheat or sorghum used as bait.
Stone fruit	Australia	EC	500 g/l	Foliar spray, with thorough coverage of branches, foliage and fruit		Repeat	0.1 l/hl (0.05)			14	
Stone fruit	New Zealand	EC	480 g/l	Foliar spray	Petal fall and 2 week intervals	Repeat	0.038		1 minimum	28	
Stone fruit	New Zealand	EC	400 g/l	Foliar spray	Early bud movement		0.1		3 l/ha minimum (1.2)		Do not use after flowering starts.
Strawberries	Australia	EC	500 g/l	Bait, broadcast to plant bases and inter-rows.	Recently ratooned or newly planted runners		100 ml per 10 kg bran bait				
Strawberries	Belgium	GR	50 g/kg	Post-plant	1				2	42	Summary only.
Strawberries	Canada	EC	480 g/l	Foliar spray	Jun 1-June 15	1		2000	1.2 l/ha (0.58)	20	
Strawberries	Canada	WP	50%	Foliar spray	June 1-June 15	1		2000	0.56	20	
Strawberries	Poland	EC	480 g/l	Foliar spray	After harvest		0.19 l/hl	750	1.44 l/ha (0.69)	-	

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
							(0.09)				
Strawberries	Spain	EC	480 g/l	Foliar spray			0.096			21	
Strawberries	Spain	WP	250 g/kg	Foliar spray	Fruiting	1	0.10	600		21	Summary only
Strawberries	Spain	EC	480 g/l	Foliar spray high volume	Fruiting	1	0.096	500		21	Summary only.
Strawberries	UK	EC	480 g/l	Foliar spray	Mar-May	3		1000	0.72	7	Summary only
Strawberries	UK	EC	480 g/l	Foliar spray	Post-harvest to vines	1	0.096				
Strawberries	USA	EC	4 lb/gal (480 g/l)	Foliar spray broadcast	Budding	2		40 gal/a (370)	1 qt/a (1.1)	21	Pre-bloom use only. Do not use when berries are forming or present.
Sugar beet	Canada	EC	480 g/l	Soil OR foliar spray		1		200	2.4 l/ha (1.2)	90	
Sugar beet	Chile	EC	480 g/l	Ground spray	Pre-plant, incorpo-rated to 10 cm	1			5 l/ha (2.4)	30	
Sugar beet	Chile	E C	480 g/l	Spray					2 l/ha (0.96)	30	
Sugar beet	Chile	EC	150 g/kg	Broadcast or band (15-18 cm)	Pre-plant/ At planting				3		
Sugar beet	Chile	D	120 g/kg	Mix with fertilizer					0.12		
Sugar beet	Chile	WP	250 g/kg	In-furrow or broadcast	At planting				1.1		
Sugar beet	France	EC	300 g/l	Low volume broadcast, incorporate	Pre-plant	1		150	1.5		Also fodder beet. Summary only.
Sugar beet	Germany	EC	480 g/l	Spray to soil, incorporate	Pre-plant	1	(0.24)	400	0.96		
Sugar beet	Italy	EC	480 g/l 225 g/l	Foliar spray				600	1.1 l/ha (0.53)	60	225 g/l summary only stated 120 day PHI
Sugar beet	Italy	G	75 g/kg	Row localized. Broadcast	At planting At-transplant At earthing up	1			1.2; 3 broadcast	60	Summary only
Sugar beet	Poland	EC	278 g/l	Foliar, high volume		1	0.28 l/hl (0.078)	150	0.42 l/ha (0.12)	30	Formulation with dimethoate (22.2%).
Sugar beet	Poland	EC	480 g/l	Spray to ground, high volume	3-4 days pre-plant	1	0.80 l/hl (0.38)	150	1.20 l/ha (0.58)	30	
Sugar beet	Poland	EC	480 g/l	Foliar high volume	After sprouting	1	0.48 l/hl(0.23)	150	0.72 l/ha (0.34)	30	
Sugar beet	Poland	EC	500 g/l	Foliar spray		2	0.23 l/hl (0.12)	150	0.35 l/ha (0.18)	30	Formulation with cypermethrin (50 g/l).
Sugar beet	Spain	WP	250 g/kg	Foliar spray high volume	Early stage and later.	1	0.10	400		21	Summary only
Sugar beet	Spain	WP	240 g/kg	Foliar spray high volume	6 leaves	1	0.048	400		21	Summary only. Formulation with carbaryl (375 g/kg).
Sugar beet	Spain	EC	480 g/l	Foliar spray high volume	Several leaves and later		0.096	400		21	Summary only.
Sugar beet	Spain	GR	50 g/kg	Row, broadcast and incorporated	At planting	1			0.75 row 4.0 broadcast	-	Summary only
Sugar beet	Uruguay	EC	480 g/l	Soil	Pre-plant				3.5 l/ha		

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
				treatment, incorporate 2.5-5.0 cm					(1.7)		
Sugar beet	Uruguay	EC	480 g/l	Foliar spray		15-20 day repeat interval		35 ground 25 aerial	1.2 l/ha (0.58)		
Sugar Beet	UK	EC	480 g/l	Foliar spray	1st true leaves to late July	2		200	0.72	21	Summary only
Sugar beet	USA	EC	4 lb/gal (480 g/l)	Spray to soil Incorporated 1-2 in	Pre-plant or At planting	1			1 pt/a (0.56) centered on a 10 in band centered on rows for furrows 30 in apart		Do not apply as in-furrow treatment
Sugar beet	USA	EC	4 lb/gal (480 g/l)	Foliar spray broadcast or band over rows		4		2 gal/a (19) aerial 10 gal/a (94) ground 6.5 gal/a (61) band	2 pt/a (1.1)	30	8 pt/a/season maximum.
Sugar beet	USA	G	15 g/100g	Band incorporate	At planting Post-emergence	1			9 oz/1000 ft row, or 13.5 lb/a (2.3) for a 22 in row spacing		
Sugar cane	Australia	EC	500 g/l	Foliar spray				60	2.0 l/ha (1.0)	7	Grazing restriction 2 days
Sugar cane	Australia	EC	500 g/l	Low pressure spray	At planting	1 or 2			2 l/ha (1) if 1 1.5 l/ha (0.75) if 2		Apply onto the plant set and adjacent to soil. Repeat at 12 weeks.
Sugar cane	India	EC	200 g/kg	In-furrow				1000	1.2		90 day PHI pending
Sugar cane	India	EC	200 g//kg	Foliar spray				500	0.30		90 day PHI pending
Sugar cane	Mexico	EC	480 g/l	Foliar spray					1.75 l/ha (0.84)	60	
Sunflower	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	0.90 l/ha (0.43 kg/ha)	25	.
Sunflower	Argentina	EC	480 g/l	Soil treatment, incorp-orated	Pre-plant			100-150	4.0 l/ha (1.9)	25	
Sunflower	Australia	EC	500 g/l	Bait	At planting				0.1 l/2.5 kg bait/ha		Bait is wheat or sorghum
Sunflower	Australia	EC	500 g/l	Spray to soil, broadcast or in-furrow	Pre-plant At planting			30 (in-furrow)	1.5 l/ha for 1 m row spacing (0.75)		
Sunflower	Canada	EC	480 g/l	Foliar or ground spray		2		2; 200 (ground)	1.2 l/ha (0.58)	42	One application may be to the soil.
Sunflower	France	EC	300 g/l	Low volume broadcast,	Pre-plant	1		150	1.5		Summary only

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
				incorporate							
Sunflower	Italy	EC	225 g/l	Broadcast		1		800	0.56	120	Summary only
Sunflower	Italy	G	75 g/kg	Row localized. Broadcast	At planting At-transplant At earthing up	1			1.2; 3 broadcast	120	Summary only.
Sunflower	Spain	GR	50 g/kg	Row	At planting	1			0.75	-	Summary only
Sunflower	Spain	EC WP	480 g/l 250 g/kg	Foliar spray, high volume		0.10	300			21	Summary only.
Sunflower	Spain	GR	50 g/kg	Broadcast or row, incorporated	Pre-plant At planting				4.0 broadcast 0.75 row		Summary only.
Sunflower	Uruguay	EC	500 g/l	Foliar spray		15-20 day repeat interval		80 ground 25 aerial	0.45 l/ha (0.22)		Formulation includes cypermethrin (50 g/l)
Sunflower	USA	EC	4 lb/gal (480 g/l)	Spray to soil incorporate 2-4 in.	Pre-plant	1		10 gal/a (94)	4 pt/a (2.2)		
Sunflower	USA	EC	4 lb/gal (480 g/l)	Foliar spray broadcast	Post-emergence	3			3 pt/a (1.7)	42	Do not apply more than 9 pt/a/season (5.0 kg ai/ha/season). Grazing restriction.
Sunflower	USA	G	15 g/100 g	Band incorporate	At planting	1			8 oz/1000 ft row, or 14.5 lb/a (2.4) for 18 in row spacing.		
Swede	UK	EC	480 g/l	Overall volume spray				200	0.72	21	
Sweet corn	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	1.50 l/ha (0.72)	21	
Sweet corn	Canada	G	15%	Band (row), incorporated 2.5cm	At planting	1			1.5		For 76 cm row spacing. Rate is 15 g (2.25 g ai) per 100 m of row for all spacings.
Sweet corn	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)	70	
Sweet corn	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)	70	
Sweet corn	Canada	WP	50%	Spray	Seedling 2-5 leaf	1		400	1.15	70	
Sweet corn	UK	EC	480 g/l	Foliar spray	Emergence to 2 leaves	1		200	0.72	21	Summary only
Sweet corn	UK	EC	480 g/l	Overall volume spray				200	0.72	14	Summary only
Sweet corn	USA	EC	4 lb/gal (480 g/l)	Broadcast spray to the ground	Pre-plant, incorpo-rate 2-4 inches	1		10 gal/a (94)	6 pt/a (3.4)		Total use not to exceed 15 pt/a/season.
Sweet corn	USA	EC	4 lb/gal (480 g/l)	Conser-vation Tillage: T-band in open seed furrow. Broadcast to surface trash	At planting Pre-plant			20 gal/a (190) 5 gal/a (47) for T-band	2 pt/a (1.1) broadcast or for 40 in row spacing. 2.6 pt/a for 30 in		Total use not to exceed 15 pt/a/season (8.4 kg ai/ha/season)

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
				and exposed soil.					row spacing		
Sweet corn	USA	EC	4 lb/gal (480 g/l)	Both sides of row basal treatment, ahead of cultivator	Cultivation time				2 pt/a (1.1)		Total use not to exceed 15 pt/a/season. Cultivation application may be made in addition to use of 15G formulation
Sweet corn	USA	EC	4 lb/gal (480 g/l)	Foliar spray or band over row (6 in ht) or drop nozzles directed to base of plants		Multiple		2 gal/a (19) aerial 20 gal/a (190) ground	3 pt/a (1.7)	35	May be applied through sprinkler irrigation. Total use not to exceed 15 pt/a/season. 14 day grazing restriction. 35 day fodder restriction.
Sweet corn	USA (Florida and Georgia only)	EC	4 lb/gal (480 g/l)	Broadcast foliar spray		11		2 gal/a (19) aerial	1 pt/a (1.1)	21	May be applied through sprinkler irrigation. Do not use in conjunction with postplant application of G.
Sweet corn	United State (Delaware only)	EC	4 lb/gal (480 g/l)	Broadcast foliar spray		13			0.5	7	
Sweet corn	USA	G	15 g/100g	Banded or broadcast	Pre-plant At planting Postplant at cultivation Postplant broadcast				12 oz /1000 ft row (0.17 kg ai/km) (banded At planting or post-plant) 13.5 lb/acre (2.3) (pre-plant broadcast) 6.5 lb/acre (1.1) (aerial or ground broadcast, postplant)	35	For soil insect control, do not exceed 13.5 lb/a/season (2.3 kg ai/ha/season) or 16 oz per 1000 feet of row. For foliar insect control, do not exceed 13 lb/a/season (2.2 kg ai/ha/season) or 16 oz per 1000 feet of row. 14 day grazing restriction.
Sweet corn	USA	WP	500 g/kg	Seed treatment		1	1oz ai/cwt (0.062 kg ai/100 kg seed)				
Sweet potato	Australia	EC	500 g/l	Foliar spray			0.015		0.3 l/ha (0.15)		
Sweet potato	Australia	EC	500 g/l	Band over plants and adjacent soil	Young plants				0.8 l/ha (0.40)		
Sweet potato	Thailand	EC	200 g/l	Foliar spray, high volume			0.075	1000	0.75	7	
Sweet potato	USA	EC	4 lb/gal (480 g/l)	Broadcast to soil, incorporate 4-6 in	pre-plant	1			4 pt/a (2.2)	125	Plant crop within 14 days of treatment
Sweet potato	USA	G	15 g/ 100 g	Broadcast to soil, incorporate	Pre-plant	1	`		13.5 lb/a (2.3)	125	
Tea	India	EC	200 g/kg	Foliar spray				500	0.15		7 day PHI pending.
Tea	Japan	EC	400 g/l	Foliar spray		2	0.04			21	
Tobacco	Argentina	EC	480	Soil treatment, incorp-	Pre-plant			100-150	6.0 l/ha (2.9)		

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
				orated							
Tobacco	Argentina	EC	300 g/l	spray		2	0.4% (0.04 l/10 l water)	250	1 l/ha (0.3)		
Tobacco	Australia	EC	500 g/l	Spray to soil	Pre-plant				3 l/ha (1.5)		
Tobacco	India	EC	200 g/kg	Foliar spray				500	0.35		30 day PHI pending.
Tobacco	Japan	EC	400 g/l	Foliar spray		2	0.04				
Tobacco	South Africa	EC	480 g/l	Spray to stem and soil		Repeat	0.096				30 ml per plant
Tobacco	Spain	GR	50 g/kg	Row	At planting	1			0.75	-	Summary only
Tobacco	USA	EC	4 lb/a (480 g/l)	Broadcast spray to soil, incorporate 4 in	Pre-transplant	1			5 qt/a (5.6)		
Tobacco	USA	G	15 g/ 100g	Broadcast to soil, incorporate	Pre-plant	1			20 lb/a (3.4)		
Tomatoes	Argentina	EC	480 g/l	Broadcast	Post-emergence			80-100 10 aerial	1.50 l/ha (0.72)	21	
Tomatoes	Argentina	EC	480 g/l	Spray to run-off; high volume				80-100	0.16 l/ 100 l water (0.08)	21	Mix with cyper-methrin
Tomatoes	Australia	EC	500 g/l	Foliar spray	At flowering and later	7 to 10 day interval	0.2 l/hl (0.1)		2 l/ha (1)	3	
Tomatoes	Australia	EC	500 g/l	Band spray to open furrow	At planting		5 l/ha (2.5)				
Tomatoes	Australia	EC	500 g/l	Boom spray; Drench	At planting; Not specified		0.3 l/hl (0.15)	1000 0.1 l to base of each plant	2 l/ha (1)		
Tomatoes	Brazil	EC	480 g/l	Foliar spray	Small fruit	7			1.5 l/ha (0.72)	21	
Tomatoes	Canada	EC	480 g/l	Ground spray, no incorpo-ration	Pre-transplant	1		200	2.4 l/ha (1.15)		
Tomatoes	Canada	EC	480 g/l	Ground spray	2-5 leaf	1		400	2.4 l/ha (1.15)		Formulation is a mix with cypermethrin (50 g/l)
Tomatoes	Canada	WP	50%	Spray	Seedling 2-5 leaf	1		400	1.125	70	
Tomatoes	Chile	EC	500 g/l	Foliar spray					0.4 l/ha (0.2)	14	
Tomatoes	Columbia	EC	400 g/l						1.0 l/ha (0.4)	21	Summary of label only.
Tomatoes	Italy	EC	480 g/l 225 g/l	Foliar spray				600	1.1 l/ha (0.53)	21	
Tomatoes	Italy	G	75 g/kg	Row localized. Broadcast	At planting At-transplant At earthing up	1			1.2; 3 broadcast	21	Summary only.
Tomatoes	Mexico	EC	480 g/l or 445 g/kg	Foliar spray					2.0 l/ha (0.96)	1	
Tomatoes	Mexico	WP	500 g/kg	Foliar spray					1.0	1	
Tomatoes	Poland	EC	500 g/l	Foliar spray		2	0.12 l/hl	200	0.25 l/ha (0.12)	21	Formulation with cypermethrin (0.50 g/l).

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
							(0.06)				
Tomatoes	Portugal	EC	480 g/l	Foliar spray high volume	Fruiting	2	0.096	500-1000		14	Summary only.
Tomatoes	Portugal	GR	50 g/kg	Broadcast or in row	Pre-plant	1			5.0 broadcast 1.25 in row		Summary only.
Tomatoes	South Africa	EC	480 g/l	Foliar spray, full cover		Multiple, 7 day interval	0.096			4	
Tomatoes	Spain	WP	250 g/kg	Foliar spray High volume	fruiting	2	0.10	600-1200		7	Summary only.
Tomatoes	Spain	EC WP	480 g/l 250 g/l	Foliar spray high volume	Early stages and fruiting	3	0.096	500-1200		7	Summary only.
Tomatoes	Spain	EC	260 g/l	Foliar spray high volume	Fruiting	3	0.072	500-1200		21	Formulation with cypermethrin (50 g/kg). Summary only.
Tomatoes	Spain	DP	30 g/kg	Dusting	Fruiting	2			0.9	15	Summary only.
Tomatoes	Spain	GR	50 g/kg	Row broadcast	At planting	1			0.5 row (0.75 alt label) 5 broadcast (4 alt label)	-	Summary only.
Tomatoes	Uruguay	EC	500 g/l	Foliar spray		15-20 day repeat interval	0.075	80 ground 25 aerial		14	
Turnips	Australia	EC	500 g/l	Foliar spray			0.015		0.3 l/ha (0.15)		
Turnips	Australia	EC	500 g/l	Band over plants and adjacent soil	Young plants				0.8 l/ha (0.40)		
Turnips	Italy	EC	225 g/l	Broadcast		1		600	0.56	21	Summary only
Turnips	Italy	G	75 g/kg	Broadcast	At planting At earthing up	1			3	21	Summary only.
Turnips	UK	EC	480 g/l	Overall volume spray				200	0.72	21	Summary only
Turnips	USA	EC	4 lb/a (480 g/l)	Spray band 4 in incorporated for direct seeded or spray directed to the base of new transplants.		1			4.5 pt/a (2.5) 2.75 fl oz/1000 linear ft of row		Do not exceed 2.6 pt/a.; 20 in, 4.5 pt. Do not apply to foliage.
Urd bean (Black gram)	India	EC	200 g/kg	Foliar spray				500	0.60		30 day PHI pending
Vegetables	Australia	EC	500 g/l	Foliar spray					0.8 l/ha (0.4)	3 tomato 5 cole 14 asparagus	Includes asparagus, beans beetroot, broccoli, Brussels sprouts, cabbage, cauliflower, pepper, carrot, celery, egg plant, onion, peas, potato, radish, rhubarb, shallot, sweet potato, tomato turnip
Vegetables	Belgium	GR	50 g/kg	Post-plant	1				2	90	Summary only.
Vegetables	Belgium	EC	480 g/l	Foliar					0.72	42	
Vegetables	Chile	EC	500 g/l	Foliar spray					0.8 l/ha	14	Formulation is a mix

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
(garden)									(0.4)		with cypermethrin (50 g/l).
Vegetables (garden)	Chile	G	150 g/kg	Broadcast or band (15-18 cm)	Pre-plant/ At planting				3		
Vegetables (garden)	Germany	G	2 g/100g	Dusting drench	1						Summary only
Vegetables (garden)	Germany	G	1 g/100 g	Soil to row	Pre-plant Pre-emergence	1			1.0		Summary only
Vegetables (various species)	Poland	EC	500 g/l	Foliar spray		2	0.12 l/hl (0.06)	200	0.25 l/ha (0.12)	21	Formulation with cypermethrin (0.50 g/l).
Vegetables (garden)	Spain	EC	480 g/l	Foliar spray			0.096			21 7 tomato 7 pepper	
Vegetables	Spain	GR	50 g/kg	Row Broadcast	At planting	1			1 row 4 broadcast	-	Summary only
Vegetables	UK	EC	480 g/l	Foliar spray	June- July	2 (1 lettuce)		600	0.96	21 (14 carrots)	Summary only. Potatoes, beet root, lettuce, leeks, onions, parsnips, celery, brassica, carrots.
Vegetables, stalk and stem	Australia	EC	500 g/l	Band over plants and adjacent row	Young plants				0.8 l/ha (0.40)	14 asparagus	Includes asparagus, celery and rhubarb
Vegetables, stalk and stem	Australia	EC	500 g/l	Foliar spray			0.025		0.5 l/HA (0.25)		Includes asparagus, celery and rhubarb.
Vegetables, stem	Greece	EC WP	480 g/l 250 g/l	Foliar spray, high volume		2	0.12 0.09 WP	1000	1.2 0.9 WP	20	Summary only. Includes celery, .fennel, asparagus, glove artichokes, leeks.
Vegetables, stem	Greece	EC WP	480 g/l 250 g/kg	Broadcast to soil or band incorporated	Pre-plant	1			2.5 broadcast 0.96 band	20	Summary only. Includes celery, .fennel, asparagus, glove artichokes, leeks
Vegetables, stem	Greece	GR	50 g/kg	Broadcast to soil or in-line furrows or planting holes	Pre-plant At planting	1			0.5 furrow 1.5 broadcast	20	Summary only. Includes celery, .fennel, asparagus, glove artichokes, leeks
Vegetables, stem	Greece	EC WP	480 g/l 250 g/kg	Bait		1		10	0.45	20	Bait = 30 kg bran + 10 l water/ha. Summary only. Includes celery, .fennel, asparagus, glove artichokes, leeks
Vegetables, root and tuber	Greece	EC WP	480 g/l 250 g/kg	Foliar spray, high volume		2		500	1.2 0.9 WP	20	Summary only. Includes beetroot and carrots.
Vegetables, root and tuber	Greece	EC WP	480 g/l 250 g/kg	Soil band or broadcast, incorporate	Pre-plant	1			2.5 broadcast 0.96 band	20	Summary only. Includes beetroot and carrots.
Walnut	Chile	WP	500 g/kg	Spray			0.12 l/hl			14	
Walnut	USA	WP	500 g/kg	Foliar spray		3	4 lb/100 gal (0.24)		2lb ai/a (2.24)	14	1 dormant + 2 foliar
Walnut	USA	EC	4 lb/gal (480 g/l)	Foliar spray		2			4 pt/a (2.2)	14	Grazing restriction. Use dilute or concentrate spray.
Wheat	Argentina	EC	480 g/l	Broadcast	Post-emergence			80 - 100 10 aerial	1.60 l/ha (0.77)	30	1.6 early post-emergence only, otherwise 0.90.
Wheat	Australia	EC	500 g/l	Soil spray	Pre-emergence				0.3 l/ha (0.15)	10	
Wheat	Brazil	EC	480 g/l	Foliar spray		2			1.5 l/ha (0.72)	21	
Wheat	Canada	EC	480 g/l	Foliar spray		5			1.2 l/ha (0.58)	60	Max seasonal rate is 5.275 l/ha. One application may be to the

Crop	Country	Formulation		Application						PHI, days	Comment
		Type	Conc. of ai	Method	Growth stage	No.	kg ai/hl	Water l/ha	kg ai/ha		
											soil.
Wheat	Chile	EC	480 g/l	Spray					0.4 l/ha (0.19)	30	
Wheat	India	EC	200 g/kg	Seed treatment					0.8 g / kg seed		
Wheat	India	EC	200 g/kg	Foliar spray				500	0.6		30 day PHI pending
Wheat	Mexico	EC	480 g/l or 445 g/kg	Foliar spray					1.0 l/ha (0.48)	21	
Wheat	South Africa	EC	480 g/l	Foliar spray		Multiple		200 ground 30 aerial	2.0	32	
Wheat (winter)	UK	EC	480 g/l	Overall volume spray	Pre-emergence	1		200	1.92		Summary only
Wheat (winter)	UK	EC	480 g/l	Overall volume spray		3			0.72	14	Summary only. 2.16 kg ai/ha/season
Wheat (spring)	UK	EC	480 g/l	Overall volume spray				200	0.72	14	Summary only
Wheat	Uruguay	EC	480 g/l	Foliar spray		15-20 day repeat interval		35 ground 25 aerial	0.4 l/ha (0.19)	30	20 day grazing restriction
Wheat	USA	EC	4 lb/gal (480 g/l)	Foliar spray		2		2 gal/a (19)	1 pt/a (0.56)	28	14 day grazing restriction. Ground, aerial, or sprinkler irrigation application.
Wheat	USA	EC (E-SG)	4 lb/gal (480 g/l)	Foliar (aerial, ground, sprinkler irrigation)		2		2 gal/a (19)	0.5 lb/a (0.56)	28	14 day grazing restriction. 28 day feeding (straw)

RESIDUES RESULTING FROM SUPERVISED TRIALS

Residue trials were reported by the manufacturer and by the governments of Germany, Poland and Thailand. The results of the trials are tabulated according to the CCPR Classification as follows.

Commodity	**Table no.**
Mandarin orange	25
Orange	26
Grapefruit	27
Lemon	28
Apple (Chile)	29
Apple (Italy)	30
Apple (New Zealand, Germany, UK)	31
Apple (USA)	32
Apple (Brazil)	33
Pear	34
Peach (Chile)	35
Peach (Greece, Spain, Italy)	36
Peach (USA)	37
Plum	38
Blueberry & Caneberry	39
Raspberry & Gooseberry	40
Strawberry (UK)	41
Strawberry (USA)	42
Grape (France)	43
Grape (Italy, Greece, South Africa)	44
Grape (USA)	45
Banana (Australia, South Africa)	46
Banana (Spain)	47
Banana (Ecuador, Costa Rica, Honduras, Philippines)	48
Kiwifruit	49
Onions (Canada, USA)	50
Onions (Greece)	51
Onions (UK)	52
Broccoli	53
Brussels sprouts	54
Cabbage (Brazil)	55
Cabbage (South Africa)	56
Cabbage (UK)	57
Cabbage USA)	58
Chinese Cabbage	59
Cauliflower	60
Pepper (Spain)	61
Pepper (USA)	62
Tomato (Brazil, Mexico, Spain)	63
Tomato (Australia, South Africa)	64
Tomato (USA)	65
Egg plant	66
Lettuce (Spain)	67
Lettuce (USA)	68
Lettuce (USA)	69
Common bean (Italy)	70
Common bean (USA)	71
Pea (USA)	72
Pea (UK)	73
Soya bean (USA)	74
Soya bean (Thailand)	75
Carrots	76
Potato (Brazil)	77
Potato (Brazil)	78
Potato (Australia, Columbia, Poland)	79

Commodity	**Table no.**
Potato (Canada, South Africa, UK)	80
Sugar beet (France, Germany, UK)	81
Sugar beet (Japan)	82
Sugar beet (Canada, USA)	83
Maize (Brazil)	84
Maize (Brazil)	85
Maize (USA)	86
Sweet corn (Canada, USA)	87
Sweet corn (USA)	88
Rice (Australia, Columbia)	89
Rice (Philippines, Vietnam, Thailand)	90
Rice (India)	91
Sorghum	92
Wheat (Brazil)	93
Wheat (Germany, UK)	94
Wheat (Canada, USA)	95
Alfalfa (USA)	96
Alfalfa (USA)	97
Almond	98
Pecan	99
Walnut	100
Cotton seed	101
Peanut	102
Sunflower	103
Coffee	104

The results are not corrected for recoveries. Double underlined results are from trials according to maximum GAP (±30%) appropriate for the estimation of STMRs and maximum residue levels. Application rates in parentheses are calculated values.

Citrus fruits. Field trials were reported on mandarins/clementines (Italy, Spain), lemons (Spain, USA), oranges/tangelos (South Africa, USA) and grapefruit (USA).

In thirteen supervised trials in Spain from 1992 to 1995 (Khoshab *et al.*, 1993a, Khoshab and Berryman, 1994a, Portwood, and Williams, 1995a-c) mandarin oranges in the maturing stage were treated with EC formulations containing 480 g ai/l and in some cases also with WG 750 g ai/l, at 1.6-3.8 kg ai/ha. In the decline trials, samples were taken from one to 116 days after the last treatment. Whole mandarins were analysed at intervals, and pulp and peel from some samples at harvest. Six trials were conducted in Italy in 1995 (Portwood and Williams, 1996d-f). The results are shown in Table 25.

Table 25. Residues of chlorpyrifos and 3,5,6-trichloropyridinol in mandarin oranges from supervised trials in Spain and Italy.

Location, (variety), year	Application				PHI, days	Residues, mg/kg		Analytical method/ recovery at mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	No.		Chlorpyrifos	TCP		
Spain GAP	EC WP	(3.0) (3.0)	0.10 0.10	1 1	21 21				
Martinez (Clemenules) 1992	EC	(2.88)	0.096	1	1 27 56 89 116	1.4 0.4 0.27 0.17 0.14 (0.43 peel, <0.1 pulp)	1.1 0.4 0.25 0.20 0.12 (0.36 peel, <0.25 pulp)	ERC 92.38. CP: 92% @ 0.1 TCP: 96% @ 0.25	GHE-P 3213

Location, (variety), year	Application				PHI, days	Residues, mg/kg		Analytical method/ recovery at mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	No.		Chlorpyrifos	TCP		
Puzol, Valencia (Hernandina) 1993	EC	(2.9)	0.096	1	22	0.99 0.89 0.75 0.81	-	ERC 92.38 CP: 91% @ 0.01	GHE-P 3733
Puzol, Valencia (Clemenules) 1993	EC	(2.9)	0.096	1	22	1.19	-		
Librilla, Murcia (Nova) 1993	EC	(3.8)	0.096	1	22	0.55	-		
Carcagentes, Valencia (Clementina fina) 1994	WG	1.6	0.094	1	0 3 7 14 21	2.4 1.9 1.2 1.0 0.47	-	ERC 92.38 CP: 96±4% @ 0.01	GHE-P-4516
	WG	0.80	0.047	1	0 3 7 14 21	1.5 1.2 0.84 0.41 0.33	-		
	EC	1.6	0.096	1	0 3 7 14 21	2.1 2.4 1.2 0.82 0.70	-		
Piscasent, Valencia (Marisol) 1995	WG	2.8	0.065	1	0 5 10 15 20	1.4 0.33 0.31 0.26 0.15	-	ERC 92.38 78% @ 0.10	GHE-P-4808
	EC	2.8	0.065	1	0 5 10 15 20	1.6 0.52 0.38 0.37 0.33	-		
Benifayo, Valencia (Marisol) 1995	WG	1.7	0.065	1	20	0.16		ERC 92.38 70% @ 0.10	GHE-P-4809
	EC	1.7	0.065	1	20	0.23			
Sevilla (Navelina) 1995	WG	1.6	0.065	1	0 6 11 16 21	0.48 (0.18) 0.18 0.15 0.07	-	ERC 92.38 104% @ 0.1	GHE-P-4816
	EC	1.6	0.065	1	0 6 11 16 21	0.44 0.28 0.22 0.12 0.16			
Italy GAP	EC	0.84	0.056	2	60				
	WG	1.1	0.11						

Location, (variety), year	Application				PHI, days	Residues, mg/kg		Analytical method/ recovery at mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	No.		Chlorpyrifos	TCP		
Palagonia, Catania (Monreal Clementine) 1995	WG	1.9	0.065	3	0 5 11 16 21	2.7 0.99 0.92 0.84 0.60	-	ERC 92.38 89% @ 0.10	GHE-P-4970R
	EC	1.9	0.065	3	0 5 11 16 21	2.8 1.5 1.4 1.1 0.86	-		
Catania (Navelina Nucellare) 1995	WG	1.9	0.065	1	0 6 11 16 21	0.94 0.24 0.31 0.35 0.25	-	ERC 92.38 92±16% @ 0.01	GHE-P-4969R
	EC	1.9	0.065	1	0 6 11 16 21	1.0 0.49 0.50 0.47 0.43	-		
Catania, C. da Coccumella (Navelina)	WG	1.9	0.065	3	21	0.11	-	ERC 92.38 100% @0.10	GHE-P-5426R
	EC	1.9	0.065	3	21	0.24	-		

Field trials on oranges were reported from the USA. Chlorpyrifos as a 4 lbs/gal EC formulation was applied once or twice in high volume (dilute) and low volume (concentrated sprays at 1.4 to 14 kg ai/ha in 16 trials on oranges, grapefruit, lemons and tangelos in California, Texas and Florida (Wetters, 1981). The high volume sprays contained 0.03-0.06 kg ai/hl at a volume of 2340 to 23400 l/ha and the low 0.20 to 1.5 kg ai/hl at a volume of 700 to 940 l/ha. Whole fruit samples were collected 14-19 and 21-26 days after the last treatment and analysed by gas chromatography with flame photometric detection (ACR 73.5.S1). Recoveries were 91 ± 4.2% at 0.01 mg/kg. Processed fractions were also analysed.

In a single separate trial in California (Robb, 1991a), Valencia oranges were treated by airblast equipment with three foliar sprays an EC formulation at 6.7, 2.2 and 6.7 kg ai/ha, diluted in 940 l/water/ha 325, 80 and 35 days before harvest, and two orchard floor applications with a hydraulic boom sprayer at 5.6 kg ai/ha, totalling 11.2 kg ai/ha, 240 l/water/ha, 88 and 28 days before harvest. Two plots of 4 replicates (each one tree with all quadrants sampled for a total of 30 mature fruit) were treated. Samples of oranges were collected 28 days after the last application and analysed by method ACR 84.4. The mean recovery was 89 ± 4.7% at 0.01 mg/kg.

In 1975 (Wetters, 1977) three trials were carried out in California. In two an EC formulation of chlorpyrifos was applied to duplicated plots as a single high or low volume foliar spray. In the third only a single high volume application was made. The high volume sprays contained 0.09 kg ai/hl applied at 13400 to 18700 l/ha, and the low 1.3 to 1.8 kg ai/hl in 940 l total volume/ha. The calculated application rate was 17 kg ai/ha maximum for both methods. Whole oranges were collected 14 days after treatment and analysed by method ACR 73.5.S1 for chlorpyrifos and ACR 71.19R for 3,5,6-TCP. Recoveries of chlorpyrifos were 90 ± 10% at 0.01 mg/kg and of 3,5,6-TCP 104% at 0.05 mg/kg.

In a trial at an exaggerated application rate in California in 1978 (Wetters, 1978) an EC formulation of 0.06 kg ai/hl was applied with an oscillating boom citrus sprayer at 8.0 or 11 kg ai/ha. The total volume applied was 13400 or 18600 l/ha. Samples were collected 14 and 21 days after treatment and analysed by method ACR 73.5.S1.

In 1984 in California side-by-side trials of low and high volume applications of chlorpyrifos were conducted in two locations (Wetters, 1985). Whole oranges were analysed by method ACR 84.4 for chlorpyrifos and 3,5,6-TCP. Recoveries of chlorpyrifos from whole fruit fortified at 0.01 to 2.0 mg/kg were 88 $\pm$ 5%, n = 11, and of 3,5,6-TCP at 0.05 to 2.0 mg/kg, 95 $\pm$4%, n = 11.

In eight supervised trials in South Africa single high-volume treatments with an EC formulation were applied to Valencia and navel orange trees at 0.05 to 0.10 kg ai/hl (Hollick and Sandenskog, 1976). Each tree was treated with 30 or 60 l of spray solution and samples were taken at intervals of 7 days until about 90 days after application (normal harvest). The oranges were peeled, the weight of pulp and peel recorded and the pulp and peel analysed separately. By method ERC 76.1 Recoveries from pulp fortified at 0.01 mg/kg were 101 $\pm$ 9.2% and from peel at 0.10 mg/kg, 86%. The level of chlorpyrifos in the whole fruit was calculated from these analyses and the relative weights. No residue (<0.01 mg/kg) was found in any pulp sample.

The results of the orange trials are shown in Table 26.

Table 26. Residues of chlorpyrifos and 3,5,6-TCP in whole oranges from the application (foliar except as noted) of a chlorpyrifos EC formulation.

Location, (variety), Year	Application			PHI, days	Residues, mg/kg		Reference/ comment
	kg ai/ha	kg ai/hl	No.		CP	TCP	
South Africa GAP		0.048 0.029	2 as needed	60 60			EC 480 g/l
Nelspruit, SA (Navel) 1975	0.015 kg ai/tree	0.05	1	7 33 62 91	0.21 0.10 <u>0.05</u> 0.03		GHE-P-413
Transval, SA (navel) 1975	0.03 kg ai/tree	0.05	1	7 31 59 92	0.45 0.209 <u>0.12</u> 0.05		
	0.06 kg ai/tree	0.10	1	7 31 59 92	0.59 0.29 0.17 0.12		
Transval, SA (Valencia) 1975	0.03 kg ai/tree	0.05	1	7 31 59 92	0.56 0.32 <u>0.14</u> 0.06		
	0.06 kg ai/tree	0.10	1	7 31 59 92	0.72 0.45 0.27 0.17		
Citrusdal, SA (Valencia) 1975		0.05	1	7 30 58 86	0.37 0.25 <u>0.21</u> 0.13		
		0.10	1	7 30 58 86	0.62 0.54 0.55 0.29		

Location, (variety), Year	Application			PHI, days	Residues, mg/kg		Reference/ comment
	kg ai/ha	kg ai/hl	No.		CP	TCP	
E. Transval, SA (Valencia) 1975		0.05	2	31 61 91 190	0.21 0.19 0.13 0.07		
US GAP	6.7 1.1	0.7 0.5	2 foliar 10 to ground	35 28			
Riverside, California (Valencia) 1978	8.4	0.06 (1500 gal/A)	1	14 21	0.19 0.20 0.15 0.12 0.12 0.09	0.13 0.13 0.14 0.09 0.11 0.09	GH-C 1441
	8.4	0.9 (100 gal/A)	1	14 21	0.65 0.57 0.45 0.34 0.46 0.35	0.43 0.35 0.59 0.29 0.32 0.33	
	14	0.06 (2500 gal/A)	1	14 21	0.29 0.30 0.29 0.16 0.18 0.19	0.23 0.22 0.24 0.15 0.20 0.15	
	14	1.5 (100 gal/A)	1	14 21	2.3 2.1 2.2 1.7 1.9 1.0	1.7 1.7 1.6 0.92 1.5 0.84	
Davis, California (Navel) 1984	6.7	0.05	1	35	0.38 0.41 0.39	0.30 0.24 0.27	GH-C 1724
	6.7	0.7	1	21	1.3 2.2	1.1 1.6	
Solomon, California (Valencia) 1983	6.7	0.05	1	36	0.26 0.093 0.11	0.23 0.13 0.16	
	6.7	0.7	1	21	0.38 0.36	0.28 0.28	
Lake Alfred, Florida (Valencia) 1979	4.4	0.03 (20-22 gal/tree; 1540 gal/A)	2	14	0.30 0.34 0.29 0.31	0.23 0.28 0.21 0.21	
	8.6	0.06 (20-22 gal/tree; 1540 gal/A)	2	14	0.58 0.65 0.77 0.84	0.45 0.58 0.43 0.55	
Lake Alfred, Florida (Orlando tangelo) 1980	4.4	0.03 (20-22 gal/tree; 1540 gal/A)	2	14	0.43 0.50 0.44	0.37 0.35 0.31	
	8.6	0.06 (20-22 gal/tree; 1540 gal/A)	2	14	0.68 0.74 0.60	0.44 0.40 0.40	
Lake Alfred, Florida (Valencia)	4.4	0.03	2	15	0.27	0.20	

Location, (variety), Year	Application			PHI, days	Residues, mg/kg		Reference/ comment
	kg ai/ha	kg ai/hl	No.		CP	TCP	
1979							
	8.6	0.06	2	15	0.51	0.44	
Auburndale, Florida (Orlando tangelo) 1978	4.4	0.03 (800 gal/A)	2	15	0.45	0.28	
	8.6	0.06 (800 gal/A)	2	15	0.59	0.36	
Weslaco, Texas (Valencia) 1978	1.4	0.06 (250 gal/A)	1	13 21	0.06 0.05 0.07 0.04 0.05 0.05 0.1 0.05 0.06 0.05 0.06 0.05	0.05 0.04 0.06 0.03 0.04 0.04 0.05 0.04 0.04 0.04 0.03 0.04	
	1.4	0.20 (75 gal.A)	1	13 21	0.34 0.47 0.45 0.38 0.49 0.34	0.25 0.24 0.32 0.20 0.31 0.21	
Porterville, California (Valencia) 1989-1990	6.7 foliar 5.6 ground 2.2 foliar 6.7 foliar 5.6 ground	0.7 2.4 0.7 0.7 2.4	5	35 foliar 28 ground	0.28 0.33 0.48 0.54 0.66 0.48 0.30 0.38		GH-C 2554/ Each result is from a separate tree. Duplicate plots.
Riverside, California (Valencia) 1975	12	0.09	1	14	0.40 0.55 0.49 0.36	0.31 0.31 0.30 0.21	GH-C 1041
	12	1.3	1	14	1.2 1.0 1.3 1.1	1.2 0.84 0.73 0.89	
Riverside, California (Valencia) 1978	8.0	0.06	1	14	0.30 0.28 0.32 0.33 0.34 0.44 0.35 0.26	0.18 0.20 0.17 0.19 0.16 0.20 0.17 0.15	GH-C 1141/ 4 replicate samples from each of duplicate plots
	11	0.06	1	14	0.59 0.56 0.58 0.46 0.47	0.31 0.26 0.38 0.26 0.24	

Location, (variety), Year	Application			PHI, days	Residues, mg/kg		Reference/ comment
	kg ai/ha	kg ai/hl	No.		CP	TCP	
					0.44 0.44 0.52	0.27 0.26 0.30	

A series of supervised trials and processing studies in the USA on lemons and grapefruits (Wetters, 1981) was reported. Whole grapefruit and lemons were analysed by method ACR 73.5.S1. In a residue decline study in Spain on lemons (Khoshab *et al.*, 1993b) the fruits were separated into peel and pulp and each was analysed by method ERC 92.38. At a fortification level of 0.10 mg/kg, the mean recoveries of chlorpyrifos were 93% (n = 2) from pulp and 94% (n = 2) from peel. The corresponding recoveries of TCP were 100% and 106%. The results are shown in Tables 27 and 28.

Table 27. Residues of chlorpyrifos and TCP in grapefruit from the foliar application of a chlorpyrifos EC formulation in the USA.

Location, (Variety) Year	Application			PHI, days	Residues, mg/kg		Reference
	kg ai/ha	kg ai/hl	No.		CP	TCP	
USA GAP	6.7 1.1	0.7 0.5	2 foliar 10 ground	35 28			
Lake Alfred, Florida (Marsh) 1980	2.9	0.03	2	14	0.38 0.31 0.32	0.21 0.22 0.21	GH-C 1441
	5.9	0.06	2	14	0.52 0.45 0.57	0.32 0.35 0.42	
Lake Alfred, Florida (March) 1979	2.9	0.03	2	15	0.20	0.18	
	5.9	0.06	2	15	0.36	0.29	
Weslaco, Texas (Ruby red) 1978	1.4	0.06	1	13 21	0.032 0.033 0.035 0.067 0.032 0.050	0.038 0.053 0.037 0.053 0.043 0.051	
	1.4	0.20	1	13 21	0.23 0.38 0.27 0.23 0.31 0.31	0.29 0.28 0.30 0.15 0.36 0.26	
Weslaco, Texas (Webb Redblush) 1978	1.4	0.06	1	13 21	0.036 0.048 0.043 0.040 0.039 0.047	0.047 0.050 0.037 0.038 0.029 0.030	
	1.4	0.20	1	13 21	0.26 0.36 0.21 0.34 0.20 0.15	0.22 0.24 0.19 0.23 0.19 0.13	

Table 28. Residues of chlorpyrifos and TCP in lemons from the foliar application of a chlorpyrifos EC formulation in trials in Spain and the USA.

Location, (Variety) Year	Application			PHI, days	Residue, mg/kg		Reference
	kg ai/ha	kg ai/hl	No.		CP	TCP	
Spain GAP	2.4	0.096	1	21			
Alhama, Murcia (Fino) 1992	2.9	0.1	1	0 25 53 77 100	1.2 0.10 0.05 0.05 0.09	0.94 0.14 0.10 0.10 0.18	GHE P 3228
USA GAP	6.7 1.1	0.7 0.5	2 foliar 10 ground	35 28			
Riverside, California (Lupe) 1978	6.7	0.06	1	19 26	0.18 0.094 0.13 0.12 0.12 0.10	0.15 0.10 0.15 0.14 0.15 0.11	GH-C 1441
	6.7	0.7	1	19 26	0.035 0.059 0.062 0.025 0.055 0.039	0.049 0.065 0.077 0.052 0.085 0.065	
	8.4	0.06	1	14 21	0.27 0.30 0.31 0.20 0.21 0.22	0.23 0.21 0.22 0.18 0.21 0.20	
	8.4	0.7	1	14 21	0.16 0.16 0.18 0.14 0.16 0.14	0.13 0.14 0.14 0.13 0.15 0.14	
Indiantown, Florida (Bearss) 1980	5.8	0.03	2	14	0.27 0.28 0.19	0.29 0.26 0.26	
	12	0.06	2	14	0.39 0.31 0.49	0.40 0.36 0.34	
Indiantown, Florida (Bearss) 1978	5.8	0.03	2	14	0.38	0.29	
	12	0.06	2	14	0.20	0.19	

Pome Fruits

Apples. Supervised trials on apples in Chile, Italy, Japan, New Zealand, the UK, the USA, Brazil and Canada were reported. The government of Germany provided summary information on trials in 1983. The results are shown in Tables 29-33.

In Chile, after two applications of “Lorsban” 50WP at 1.5 and 1.6 kg ai/ha during fruit development, samples were collected at intervals up to 28 days later and analysed (Pompeu-Braga, 1982).

Table 29. Residues of chlorpyrifos in apples from supervised trials in Chile.

Year	Application				PHI, days[1,2]	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Chile	50WP		0.06		28		
Chile, 1982	WP	1.5+1.6	0.05	2	7	0.07, 0.12, 0.07, 0.13, 0.09	GHB-P 008
					14	0.14, 0.12, 0.24, 0.14, 0.10	
					21	0.06, 0.08, 0.07, 0.16, 0.07	
					28	0.09, 0.05, 0.07, 0.06	

[1] LOQ 0.01 mg/kg

In four trials in Italy using EC formulation 480 g/l of chlorpyrifos apple trees were treated two or three times at 0.77 or 1.2 kg ai/ha, spray volume 15 l/ha, and samples collected at regular intervals from 0 to 87 days later (Teasdale, 1988a). The results are shown in Table 30.

Table 30. Residues of chlorpyrifos in apples in supervised trials in Italy.

Year	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Italy	EC	(0.84)	0.053		30		
1987	EC	0.77		2	0	1.30	GHE-P 1872
					17	0.28	
					28	0.17	
					37	0.14	
					51	0.10	
					58	0.09	
					87	0.03	
Italy, 1987	EC	1.2		2	0	2.5	GHE-P 1872
					17	0.60	
					28	0.48	
					37	0.22	
					51	0.14	
					58	0.12	
					87	0.07	
Italy, 1987	EC	0.77		3	0	0.84	GHE-P 1872
					9	0.66	
Italy, 1987	EC	0.77	--	3	23	0.28	GHE-P 1872
					30	0.19	
					59	0.12	
Italy, 1987	EC	1.2	--	3	0	1.8	GHE-P 1872
					9	1.2	
					23	0.04	
					30	0.48	
					59	0.36	

[1] LOQ 0.01 mg/kg

Results of supervised trials in New Zealand, Germany and the UK are shown in Table 32. Trials in New Zealand were at a rate of 0.025 kg ai/hl, applied 3 or 7 times at 2-4 week intervals. Samples were collected at regular intervals from 0 to 28 days after treatment (Upritchard *et al.*, 1982).

In trials in Germany plots at seven different locations were treated 4 times with a foliar spray of a WP formulation (250 g/kg) at 0.75 kg ai/ha or 0.05 kg/hl. Fruits were collected at intervals of 0 to 28 days after the last application (growth stage 79) (Federal Biological Research Center for Agriculture and Forestry, Germany, 1999).

In the UK Cox's Orange pippin and Worcester Pearmain apples were treated with chlorpyrifos EC insecticide once at 0.48 kg ai/ha, then three times at 0.96 kg ai/ha. Samples were collected from four trees at random from the treated plots 16 days after the last application (Hollick and Gilmour, 1974).

Table 31. Residues of chlorpyrifos in apples from supervised trials in New Zealand, Germany and the UK.

Country, year	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-New Zealand	50WP	1 minimum	0.025-0.038		14		
New Zealand	50WP		0.025	7	1	0.59, 0.59	GHF-P 230
1972					2	0.45, 0.40	
					7	0.32, 0.32	
					14	0.14, 0.19	
					21	<0.05,<0.05	
New Zealand	50WP		0.025	3	1	0.22, 0.19	GHF-P 230
1980					2	0.36, 0.22	
					4	0.37, 0.10	
					7	0.09, 0.08	
					14	0.09, 0.07, 0.16	
					23	0.19, 0.28	
					28	0.14, 0.14	
GAP-Germany							
NONE (See UK)							
Frankfurt, Germany 1983 (Ontario)	250WP	0.75	0.05	4	0 7 14 21 28	0.72 0.06 0.08 0.05 0.05	Federal Biological Research Center for Agriculture and Forestry, Germany, 1999. Only summary information.
Münster, Germany 1983 (Jonathan)	250WP	0.75	0.05	4	0 7 14 21 28	1.6 0.72 0.53 0.29 0.41	
Dossenheim, Germany 1983 (Cox Orange)	250WP	0.75	0.05	4	0 7 14 21 28	1.2 0.30 0.17 0.08 0.08	
Heidesheim, Germany 1983 (Golden Delicious)	250WP	0.75	0.05	4	0 7 21 28	0.38 0.11 0.06 0.06	
Lanförden Germany 1983	250WP	0.75	0.05	4	0 7	0.88 0.58	

Country, year	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
(James Grieve)					14 21 28	0.43 0.28 0.21	
Jork, Germany 1983 (Gloster)	250WP	0.75	0.05	4	0 7 13	1.1 0.83 0.94	
Saarwellingen, Germany 1983 (Golden Delicious)	250WP	0.75	0.05	4	0 7 14 21 28	0.41 0.32 0.11 0.13 0.12	
GAP-UK	EC	0.96	(0.38)	5	14		
UK, 1974 (Worcester Pearmain)	EC	0.48(1x) + 0.96(3x)		4	16	0.17	GHE-P 195
UK, 1974							
(Cox's Orange Pippin)	EC	0.48(1x) + 0.96(3x)		4	16	0.18	GHE-P 195

[1] LOQ 0.01 mg/kg for New Zealand and the UK, 0.02 mg/kg for Germany.

In California and Washington, USA, chlorpyrifos 50W insecticide was cover-sprayed four times post-petal fall at 1.68 kg ai/ha or a total of 6.7 kg ai/ha per season. In Michigan, New York and Pennsylvania a total of 9.6 kg ai/ha was applied in eight applications during the season, from petal fall to seventh cover. Samples were collected 14, 21 and 28 days after the last application (Wetters and Ervick, 1990a).

In trials in New York, USA, in 1980 seven foliar applications of chlorpyrifos 50W insecticide as a dilute spray of 0.15 kg ai/hl or as a tenfold concentrate were made during the season at 2.24 kg ai/ha, and samples collected 0, 7, 14, 21 and 28 days after the last treatment (Miller, 1980a).

In trials in seven US States, 1973-1976, the trees were foliar-sprayed with chlorpyrifos 25W or 50W formulations at the standard dilution of 0.06 kg ai/hl or at 4-20 times this concentration, and samples were collected 0 to 35 days after treatment (Wetters and Ervick, 1978). The residues found up to 28 days after treatment are shown in Table 32.

In apple trials in 1987 in Ontario and Quebec, Canada, Lorsban 50W was applied five times at 1.7 kg ai/ha during the season at 20-day intervals, beginning approximately 108 days before harvest, with the last application 27 days before harvest, and samples were collected at harvest (Dixon-White, 1991). The results are shown in Table 32.

Table 32. Residues of chlorpyrifos in apples from supervised trials in the USA and Canada.

Location, year	Application				PHI, days	Residues, mg/kg [1]	Reference/ Comment
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-USA	4lb/gal EC	3.4	0.06		70-200 [2]		Limited to pre-bloom, dormant use.
CA, 1988	50W	1.68	0.047	4	14	0.34, 0.21, 0.24, 0.35	GH-C 2397
					21	0.18, 0.20, 0.46, 0.18	
					28	0.17, 0.30, 0.22, 0.34	
CA, 1988	50W	1.68	0.47	4	14	0.52, 0.66, 0.17, 0.53	GH-C 2397
					21	0.45, 0.37, 0.19, 0.23	

Location, year	Application				PHI, days	Residues, mg/kg [1]	Reference/ Comment
	Form.	kg ai/ha	kg ai/hl	No.			
					28	0.49, 0.50, 0.21, 0.19	
WA, 1988	50W	1.68	0.047	4	14	0.21, 0.17, 0.13, 0.14	GH-C 2397
					21	0.13, 0.18, 0.11, 0.13	
					28	0.16, 0.13, 0.08, 0.20	
WA, 1988	50W	1.68	0.47	4	14	0.18, 0.21, 0.33, 0.19	GH-C 2397
					21	0.13, 0.14, 0.17, 0.13	
					28	0.27, 0.27, 0.18, 0.26	
MI, 1988	50W	1.6(x4)+0.8(x4)	0.022-0.047	8	14	0.13, 0.05, 0.11, 0.07	GH-C 2397
MI, 1988	50W	1.6(x4)+0.8(x4)	0.022-0.047	8	21	0.01, 0.01, 0.02	GH-C 2397
					28	0.01	
MI, 1988	50W	1.6(x4)+0.8(x4)	0.22-0.47	8	14	0.15, 0.17, 0.17, 0.12	GH-C 2397
					21	0.04, 0.04, 0.11, 0.15,	
					28	0.05, 0.03, 0.04, 0.19	
MI, 1988	50W	1.6(x4)+0.8(x4)	0.022-0.047	8	14	0.08, 0.06, 0.20, 0.08	GH-C 2397
					21	0.07, 0.05, 0.1, 0.11	
					28	0.04, 0.07, 0.05, 0.13	
MI, 1988	50W	1.6(x4)+0.8(x4)	0.22-0.47	8	14	0.18, 0.13, 0.26, 0.19	GH-C 2397
					21	0.10, 0.12, 0.09, 0.09	
					28	0.04, 0.05, 0.19, 0.13	
NY, 1988	50W	1.6(x4)+0.8(x4)	0.022-0.047	8	14	0.30, 0.74, 0.36, 0.30	GH-C 2397
					21	0.29, 0.37, 0.33, 0.33	
					28	0.57, 0.25, 0.34, 0.38	
NY, 1999	50W	1.6(x4)+0.8(x4)	0.22-0.47	8	14	0.23, 0.10, 0.20, 0.09	GH-C 2397
					21	0.14, 0.17, 0.14, 0.06	
					28	0.15, 0.10, 0.07, 0.1	
PA, 1988	50W	1.6(x4)+0.8(x4)	0.022-0.047	8	14	0.23, 0.20, 0.19, 0.17	GH-C 2397
					21	0.14, 0.12, 0.11, 0.28	
					28	0.17, 0.09, 0.28, 0.26	
PA, 1988	50W	1.6(x4)+0.8(x4)	0.22-0.47	8	14	0.09, 0.05, 0.10, 0.06	GH-C 2397
					21	0.06, 0.10, 0.08, 0.12	
					28	0.04, 0.05, 0.07, 0.06	
NY, 1980	50W	2.24	0.15	7	0	1.3, 1.4, 0.95, 1.62	GH-C 1485
					7	0.58, 0.38, 0.72, 0.68	
					14	0.48, 0.42, 0.48, 0.37	
					21	0.28, 0.21, 0.43, 0.44	
					28	0.30, 0.29, 0.39, 0.35	
NY, 1980	50W	2.24	1.5	7	0	1.23, 1.32, 1.13, 1.5	GH-C 1485
					7	0.35, 0.48, 0.52, 0.57	
					14	0.27, 0.23, 0.25, 0.29	
					21	0.21, 0.31, 0.33, 0.27	
					28	0.22, 0.20, 0.36, 0.33	
CA, 1976							
	50W	4.48	0.06	4	28	0.39, 0.45, 0.27, 0.30	GH-C 1107
		4.48	1.2	4	28	0.49, 0.40, 0.34, 0.33	
WA, 1976	50W	3.36	0.06	5	28	0.52, 0.48, 0.36, 0.19	GH-C 1107
MI, 1976	50W	2.24	0.06	7	28	0.25, 0.52, 0.24, 0.43	GH-C 1107

Location, year	Application				PHI, days	Residues, mg/kg [1]	Reference/ Comment
	Form.	kg ai/ha	kg ai/hl	No.			
MI, 1973	25 WP	0.7	0.06	9	28	0.11, 0.17, 0.11, 0.19	GH-C 1107
NC, 1976	50W	2.24	0.06	9	28	1.1	GH-C 1107
WI, 1976	50W	2.24	0.06	10	28	0.14, 0.13, 0.16, 0.07	GH-C 1107
GAP- Canada NONE							
Canada, 1987							
(Red Delicious)	50 WP	1.7	0.043	5	27	0.21	GH-C 2449
Canada, 1987	50 WP	1.7		5	27	0.30	GH-C 2449
(Macintosh)							
Canada, 1987	50 WP	1.7	0.06	5	27	0.36	GH-C 2449
(Macspur)							
Canada, 1987 (Red Delicious)	50 WP	1.7	0.06	5	27	0.31	GH-C 2449

[1] LOQ 0.01 mg/kg
[2] Variety-dependent.

In a trial in Brazil chlorpyrifos was applied 3 times at different rates at the developmental stage of the fruit (Pinheiro *et al*., 1999), and samples taken 0, 3, 7, 10 and 14 days after the last application. The results are shown in Table 33.

Table 33. Residues of chlorpyrifos in apples from supervised trials in Brazil.

Country, year	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Brazil NONE GAP-Argentina	WP 500 g/kg		0.06		30		
Brazil, 1999	75 WG	0.48	0.048	3	3	0.12, 0.18, 0.11	GHB-P 415
					7	0.13, 0.12, 0.10	
					10	0.14, 0.15, 0.08	
Brazil, 1999	75 WG	0.75	0.075	3	3	0.15, 0.16, 0.19	GHB-P 415
					7	0.14, 0.10, 0.17	
					10	0.11, 0.13, 0.13	
					14	0.08, 0.10, 0.11	
Brazil, 1999	75 WG	0.96	0.096	3	3	0.78, 0.85, 0.33	GHB-P 415
					7	0.17, 0.16, 0.20	
					10	0.14, 0.20, 0.33	
					14	0.16, 0.16, 0.23	
Brazil, 1999	75 WG	1.5	0.15	3	3	0.93, 0.54, 0.66	GHB-P 415
					7	0.66, 0.68, 0.33	
					10	0.20, 0.43, 0.20	
					14	0.28, 0.35, 0.35	

[1] LOQ 0.01 mg/kg

Pears. In eight trials in California, Michigan, New York, Oregon, Pennsylvania and Washington, (the largest US areas of pear production) Lorsban 50W was applied to the trees at 1.6 kg ai/ha as a concentrate or dilute spray. The first applications were made at blossom pink stage and at petal fall, and six more applications at approximately 14-day intervals and samples taken 14 and 28 days after the last application (Miller and McKellar, 1986a).

In trials in Canada five applications were made to the trees during the season at 20-day intervals beginning approximately 108 days before harvest, at 1.7 kg ai/ha (Dixon-White, 1991).

In UK trials on Conference and Comice pears, the trees were treated with Dursban 4E at 0.48 kg ai/ha, followed by three applications at 0.96 kg ai/ha. Samples were collected from four trees at random from the treated plots, 27 days after the last application (Hollick and Gilmour, 1974).

The results are shown in Table 34.

Table 34. Residues of chlorpyrifos in pears from supervised trials in Canada, the USA and the UK.

Location, year (Variety)	Application				PHI, days	Residues, mg/kg[1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP- USA NONE							
CA, 1983	50W	1.6	0.06	8	14	0.23	GH-C 1789
(Bartlett)					28	0.07	
		1.6	0.51	8	14	0.59	
					28	0.59	
OR, 1983	50W	1.6	0.05	8	14	0.31	GH-C 1789
(Bartlett)					28	0.26 [2]	
CA, 1983	50W	1.6	0.43	8	14	0.19	GH-C 1789
(Bartlett)					28	0.034	
		1.6	0.08	8	14	0.14	
					28	0.04	
MI, 1983	50W	1.6	0.34	8	14	0.91	GH-C 1789
(Bartlett)					28	0.43	
		1.6	0.08	8	14	0.72 [3]	
					28	0.16	
MI, 1983	50W	1.6	0.34	8	14	1.8	GH-C 1789
(Bartlett)					28	1.4	
		1.6	0.08	8	14	0.73	
					28	0.37	
NY, 1984	50W	1.6	0.34	8	14	0.53	GH-C 1789
(Bartlett)					28	0.17	
		1.6	0.06	8	14	0.54	
					28	0.25	
PA, 1984	50W	1.6	0.34	8	14	0.35	GH-C 1789
(Bartlett)					27	0.06	
		1.6	0.08	8	14	0.24	
					27	0.06	
WA, 1983	50W	1.6	0.34	8	14	0.63	GH-C 1789
(Bartlett)					28	0.22	
		1.6	0.03	8	14	0.18	
					28	0.13	
GAP- Canada NONE							

Location, year (Variety)	Application				PHI, days	Residues, mg/kg[1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
Canada, 1987	50W	1.7	0.04	5	29	0.16 [3]	GH-C 2449
(Bosc)							
Canada, 1987	50W	1.7	0.04	5	28	0.07[2]	GH-C 2449
(Moonglow)							
UK GAP	EC 480g/l	0.96	(0.38)	5	14		
UK, 1974 (Comice)	EC	0.48(1x) + 0.96(3x)		5	27	0.12	GHE-P 195
UK, 1974 (Conference)	EC	0.48(1x) + 0.96(3x)		5	27	0.10	GHE-P 195

[1] LOQ 0.01 mg/kg
[2] Average of duplicate determinations.
[3] Average of triplicate determinations.

Stone Fruits

Peaches. In three trials in Chile in support of a USA import tolerance a WP formulation was applied to fruit-bearing peach trees and fruits collected 45 days after the treatment. The fruits were washed, brushed and waxed and then frozen pending analysis (Catta-Preta and Rampazzo, 1994).

In another trial in Padre Hurtado, central Chile, a WP formulation was applied to fruit-bearing trees at 120 g/hl and samples taken 0, 14, 25 and 45 days after treatment, stored frozen and analysed (Catta-Preta and Rampazzo, 1995).

In ten further trials in Chile during the 1998-9 season chlorpyrifos was applied once at 1.2 kg ai/ha to five different varieties of tree. Five trials were with the 75 G (water-dispersible granule) formulation containing 750 g ai/kg, and five with the 50WP. Samples were collected at intervals up to 52 days (Do Amaral *et al.*, 1999a,b). The results are shown in Table 35.

Table 35. Residues of chlorpyrifos in peaches in Chile from the foliar application of chlorpyrifos.

Location, Year, (Variety)	Application			PHI, days	Residue, mg/kg	Reference/ comment
	kg ai/ha	kg ai/hl	No.		Chlorpyrifos	
Chile GAP		0.06	3	45		WP
Buin, Chile (Elegant Lady) 1993	(1.4)	0.06	1	45	0.023	GHB-P 212. WP
Padre Hurtado, (O'Henry) 1993	(1.2)	0.06	1	45	0.045	GHB-P 212. WP
Lampa, Chile (O'Henry) 1993	(1.3)	0.06	1	45	0.017	GHB-P 212. WP
Padre Hurtado, Chile (O'Henry) 1993-1994	(1.2)	0.06	1	0 14 25 45	1.3 0.43 0.28 0.04	GHB-P 254 WP
Chile, 1998 (Royal Glory)	(1.2)	0.08	1	0 17 34 45 52	5.4, 3.5 2.8, 1.2 0.42, 0.17 0.25, 0.05 0.13	GHB-P 422 WG

Location, Year, (Variety)	Application			PHI, days	Residue, mg/kg	Reference/ comment
	kg ai/ha	kg ai/hl	No.		Chlorpyrifos	
Chile, 1998 (Iris Rosso)	(1.2)	0.08	1	0 17 34 45	10 1.6 0.34 0.09	GHB-P 422 WG
Chile, 1998 (Rich May)	(1.2)	0.08	1	0 17 34 45	2.8 0.65 0.10 0.05	GHB-P 422 WG
Chile, 1998 (Flavourcrest)	(1.2)	0.8	1	0 17 34 45 52	2.4 0.67 0.20 0.08 0.03, 0.08	GHB-P 422 WG
Chile, 1998 (Red Top)	(1.2)	0.8	1	0 17 34 45 52	3.0 0.58 0.20 0.04 0.02	GHB-P 422 WG
Chile, 1998 (Royal Glory)	(1.2)	0.12	1	0 17 34 45 52	3.6, 2.1 3.1, 0.56 0.20, 0.15 0.13, 0.03 0.02	GHB-P 423 WP
Chile, 1998 (Iris Rosso)	(1.2)	0.12	1	0 17 34 45	0.47 0.85 0.19 0.07	GHB-P 423 WP
Chile, 1998 (Rich May)	(1.2)	0.12	1	0 17 34 45	2.0 0.53 0.13 0.03	GHB-P 423 WP
Chile, 1998 (Flavourcrest)	(1.2)	0.12	1	0 17 34 45 52	4.2 0.79 0.17 0.04 0.01, 0.03	GHB-P 423 WP
Chile, 1998 (Red Top)	(1.2)	0.12	1	0 17 34 45 52	3.7 0.63 0.09 0.04 <0.01	GHB-P 423 WP

The results of supervised trials on peaches in Greece, Italy and Spain are shown in Table 36. In some trials in Greece in 1992, a single application of chlorpyrifos EC (480 g ai/l) diluted to 0.096 kg ai/hl was applied to peach trees when the fruits were 3 cm in diameter at 1.44 kg ai/ha and samples were taken at intervals from 0 to 39 days after treatment (Khoshab, 1993d).

In another trial in Greece, a single application of chlorpyrifos WG formulation (750 g ai/l) diluted to 0.05 kg ai/hl was applied at 0.63 kg ai/ha to peach trees with fruit 4-6 cm in diameter and samples were taken at intervals from 0 to 22 days after application (Portwood and Williams, 1996h).

In a trial in Spain a single application of chlorpyrifos formulation containing 480 g ai/l diluted to 0.096 kg ai/hl was applied at 1.44 kg ai/ha to peach trees with fruit about 3 cm in diameter. Samples were taken at intervals from the day of application to 28 days later (Khoshab, 1993c).

In two trials in Italy in 1992, a single application of chlorpyrifos EC (480 g ai/l) at 0.08 kg ai/hl was applied at 1.2 kg ai/ha to peach trees with fruit 3-4 cm in diameter. Peaches were harvested at intervals from 0 to 40-42 days after treatment (Khoshab, 1993e). In similar trials in 1994, single applications of the WG or EC formulation, diluted to 0.056 kg ai/hl, at 0.85 kg ai/ha were made with fruit 4-5 cm in diameter. A further application of the WG formulation at 0.028 kg ai/hl was made at 0.43 kg ai/ha. Fruits were sampled from 0 to 39 days after treatment (Portwood and Williams, 1995b).

Table 36. Residues of chlorpyrifos in whole peaches from supervised trials in Greece, Spain and Italy.

Country, year	Application				PHI, days	Residues, mg/kg [1]	Reference/comment
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Greece	480 EC	(1.9)	0.08	2	20		
	250 WP	2.1	0.08	2	20		
Greece, 1992	EC	1.44	0.096	1	0	2.5	GHE-P 3139. Plot = 4 trees.
					9	1.0	
					19	<u>0.33</u>	
					29	0.17	
					39	0.10	
Greece, 1995	WG	0.63	0.05	1	0	0.70	GHE-P 4806
					5	0.32	
					10	0.19	
					15	0.12	
					22	0.07	
GAP Spain NONE. GAP Greece.	480 EC	(1.9)	0.08	2	20		
Spain, 1992	EC	1.44	0.096	1	0	2.5	GHE-P 3138. Plot = 4 trees.
					7	0.78	
					14	0.55	
					20	<u>0.04</u>	
					28	0.04	
GAP-Italy	480 EC	0.80	0.053	2	30		
	225 EC	0.80	0.056	2	30		
Ferrara, Italy, 1992	480 EC	1.2	0.08	1	0	2.2	GHE-P 3142. Plot = 6 trees.
					9	1.0	
					20	0.35	
					30	0.07	
					40	0.05	
Verona, Italy, 1992	480 EC	1.2	0.08	1	0	1.2	GHE-P 3142. Plot = 6 trees
					10	0.72	
					20	0.43	
					30	0.19	
					42	0.04	
Italy, 1994	480 EC	0.85	0.056	1	0	0.87	GHE-P 4229
					10	0.42	
					20	0.17	
					31	<u>0.04</u>	

Country, year	Application				PHI, days	Residues, mg/kg [1]	Reference/comment
	Form.	kg ai/ha	kg ai/hl	No.			
					39	0.04	
Italy, 1994	WG	0.85	0.056	1	0	0.75	GHE-P 4229
					10	0.24	
					20	0.09	
					31	0.05	
					39	0.03	
Italy, 1994	WG	0.43	0.028	1	0	0.35	GHE-P 4229
					10	0.13	
					20	0.05	
					31	0.03	
					39	<0.01	

[1] Average of duplicate determinations

The US label only allows for trunk spray or dormant season (winter) applications to peach trees. In trials in Georgia, Arkansas and Mississippi applications of chlorpyrifos EC diluted to 0.36-0.72 kg ai/hl were sprayed on peach tree trunks, wetting the trunk thoroughly. Peaches collected 0 to 30 days after treatment were analysed (McKellar, 1971).

Table 37. Residues of chlorpyrifos in peaches from supervised trials in the USA (trunk spray).

Location, year	Application			PHI, days	Residues, mg/kg [1,2]	Reference
	Form.	kg ai/hl	No.			
GAP-USA	480 EC	0.36	1	14		
Georgia, 1969	EC	0.36	1	0	<0.01, <0.01, <0.01	GH-C 479
Trunk				7	<0.01, <0.01, <0.01, <0.01	
				14	<0.01, <0.01, <0.01, ≤0.01	
				28	<0.01,<0.01, <0.01, <0.01	
Arkansas, 1969	EC	0.36	1	0	0.02, 0.01, 0.04, 0.03, 0.02	GH-C 479
Trunk					0.01, <0.01, 0.011, 0.01	
				7	<0.01, <0.01, <0.01, <0.01	
				14	<0.01, <0.01, <0.01, ≤0.01	
				28	<0.01,<0.01, <0.01	
Arkansas, 1969	EC	0.36	1	0	0.01, 0.03, 0.01, 0.01	GH-C 479
Trunk				7	0.01,0.01, <0.01, <0.01	
				14	<0.01, <0.01, <0.01, <0.01	
				30	0.01, 0.01,<0.01, 0.01, 0.01	
Arkansas, 1969	EC	0.72	1	0	0.06, 0.05, 0.02, 0.01, 0.01	GH-C 479
Trunk				7	<0.01, <0.01, <0.01, <0.01	
				14	<0.01, <0.01, 0.01, <0.01	
				30	0.01, 0.011, 0.021,0.01	
Mississippi, 1969	EC	0.36	1	0	0.01, 0.02, 0.12, 0.03	GH-C 479
Trunk				7	<0.01, 0.01, <0.01, <0.01	
				14	<0.01, <0.01, <0.01, 0.01	
				28	<0.01, <0.01, <0.01, <0.01	
Mississippi, 1969	EC	0.72	1	0	0.05, 0.09, 0.04, 0.04	

Location, year	Application			PHI, days	Residues,	
	Form.	kg ai/hl	No.		mg/kg [1,2]	Reference
Trunk				7	0.01, 0.01, 0.01, 0.01	GH-C 479
				14	<0.01, <0.01, <0.01, ≤0.01	GH-C 479
				28	<0.01,<0.01, <0.01, <0.01	

[1] LOQ 0.01 mg/kg.
[2] Analyses were also conducted for the oxygen analogue and TCP. The former was not found in any sample. TCP was found in two samples, <0.05 mg/kg.

Plums. Results of supervised trials conducted on plums/prunes in Chile, Japan and Germany are shown in Table 38.

Three field trials were conducted in Colina, Padre Hurtado and Buin, representative fruit growing regions in central Chile, to support a US import tolerance. Lorsban 50W was applied to fruiting plum trees at 0.06 kg ai/hl. 45 days after treatment control and treated samples were picked, washed, brushed and waxed by simulated commercial practices (Catta-Preta, 1994).

In trials in Japan the 25 WP formulation at 0.025 kg ai/hl was applied twice at a 7-day interval at 1.0 kg ai/ha, and samples were taken 14, 21 and 30 days after application (Ishikura, 1993).

Trials in Germany were approximately according to UK GAP, because GAP was not then established in Germany. The 25 WP formulation was applied to plums 4 times at three different rates, and the plums were harvested at intervals up to 21 days after the last treatment (Osborne, 1989a).

Table 38. Residues of chlorpyrifos in plums from supervised trials in Chile, Japan and Germany.

Country, year	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP Chile	500 WP		0.06		45		
Chile, 1993	WP	(0.77)	0.06	1	45	0.004, 0.005 [2]	GHB-P 213
Chile, 1993	WP	(1.1)	0.06	1	45	<0.002, ≤0.002 [2]	GHB-P 213
Chile, 1993	WP	(1.0)	0.06	1	45	<0.002, ≤0.002 [2]	GHB-P 213
GAP-Japan	250 WP		0.025	2	14		
Japan	WP	1	0.025	2	14	0.05 [3]	GHF-P 1328
					21	0.02 [3]	
					30	0.01 [3]	
Japan	WP	1	0.025	2	14	0.03 [3]	GHF-P 1328
					21	0.04 [3]	
					30	0.01 [3]	
GAP Germany NONE							
GAP- UK	480 EC	0.96	0.38	5	14		
Germany, 1987	25 WP	0.75	0.1	4	0	0.29	GHE-P 1911
					7	0.12	
					10	0.14	
					14	0.10	
Germany, 1987	WP	0.93	0.05	4	0	0.22	GHE-P 1911
					7	0.14	
					10	0.13	

Country, year	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
					14	0.08	
					21	0.08	
Germany, 1987	WP	0.83	0.15	4	0	0.52	GHE-P 1911
					7	0.28	
					10	0.26	
					14	0.20	
					10	0.13	
					14	0.08	
					21	0.08	
Germany, 1987	WP	0.83	0.15	4	0	0.52	
					7	0.28	
					10	0.26	
					14	0.20	
					21	0.14	
Germany, 1987	25 WP	0.75	0.05	4	0	0.32	GHE-P 1911
					7	0.20	
					10	0.10	
					14	0.04	

[1] Average of duplicate determinations. LOQ 0.02 mg/kg. Recoveries averaged 83%.
[2] LOQ 0.002 mg/kg. Recoveries averaged 91 (± 4)%.
[3] LOQ 0.005 mg/kg (not validated). Recoveries averaged 96%.

Berries and other small fruits

Berries. In caneberry trials in the USA (Wetters and Markle, 1987) a foliar spray of a WP formulation was applied during the growing season, with the last application 14 days before harvest. In seven field trials on blueberries in six States, representing the main blueberry growing regions of the USA, a WP formulation was sprayed on the leaves at 3 x 1.7 kg ai/ha at about 14 day intervals with a 14-day PHI (Wetters, 1986). The conditions and results are shown in Table 39.

Table 39. Residues of chlorpyrifos and TCP in blueberries and caneberries from application of a WP formulation in the USA.

Country, year	Application		PHI, days	Chlorpyrifos, mg/kg	Reference
	kg ai/ha	No.			
No GAP in USA or NAFTA[1] country					
Blueberries					
Michigan 1986	1.7	3	15	0.17	GH-C 1832
			29	0.01	
Michigan, 1986	1.7	3	14	0.09	GH-C 1832
			28	0.04, 0.04, 0.04, 0.05	
New Jersey, 1986	1.7	3	1	1.7	GH-C 1832
			3	1.7	
			7	0.26	
			14	0.99	
			21	0.03	

Country, year	Application		PHI, days	Chlorpyrifos, mg/kg	Reference
	kg ai/ha	No.			
New York, 1986	1.7	3	14	0.02	GH-C 1832
			28	0.02	
Oregon, 1986	1.7	3	15	1.8	GH-C 1832
			29	0.51	
Pennsylvania, 1986	1.7	3	14	0.36	GH-C 1832
			21	0.08	
			28	0.11	
Washington, 1986	1.7	3	14	0.89	GH-C 1832
			28	0.34	
Blackberries					
Maryland, 1984	1.7	3	14	0.08	GH-C 1903
	1.7	4	14	0.16	
Michigan, 1983	1.7	3	14	0.33	GH-C 1903
			28	0.19	
New York, 1984	1.7	3	14	0.14	GH-C 1903
			14	0.25	
Oregon, 1983	1.7	3	15	1.9	GH-C 1903
			29	0.57	
Boysenberries					
Oregon, 1983	1.7	3	15	1.3	GH-C 1903
			29	0.33	
Black raspberries					
Pennsylvania, 1984	1.7	3	14	0.34	GH-C 1903
			21	0.30	
			28	0.13	
Red raspberries					
Maryland, 1984	1.7	3	14	0.12	GH-C 1903
			14	0.14	
Michigan, 1984	1.7	3	14 28	0.58 0.32	GH-C 1903
New York, 1984	1.7	3	14 28	0.45 0.07	GH-C 1903
Oregon, 1983	1.7	3	12 26	1`.8 0.46	GH-C 1903
Washington, 1983	1.7	3	14 28	0.38 0.16	GH-C 1903

[1] North American Free Trade Agreement

In residue trials on raspberries and gooseberries in the UK during 1974 to 1977 a single application of an EC formulation of chlorpyrifos was made at 0.72 kg ai/ha. Samples were collected from 3 to 28 days after treatment and analysed by a gas-chromatographic method sensitive to 0.01 mg/kg (Hollick and Walker, 1976a; Freeman, 1978a). The results are shown in Table 40.

Table 40. Residues of chlorpyrifos in raspberries and gooseberries from supervised trials in the UK.

Country, year	Application				PHI, days	Residue, mg/kg [1]	Reference/ Comments
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-UK	480 EC	0.72	(0.14) (0.07)	2	7 14		Raspberry Gooseberry
1974	EC	0.71		1	13	0.11	GHE-P 435
Raspberries					13	0.07	
					14	0.15	

Country, year	Application				PHI, days	Residue, mg/kg [1]	Reference/ Comments
	Form.	kg ai/ha	kg ai/hl	No.			
1976	EC	0.72		1	7	0.52	GHE-P 435
Raspberries					14	0.18	
1974	EC	0.71		1	28	0.13	GHE-P 435
Gooseberries					26	0.16	
1977	EC	0.71		1	3	0.37	GHE-P 575
Raspberries					7	0.25	
					13	0.21	
					14	0.09	
1977 Gooseberries	EC	0.72		1	14	0.05	GHE-P 575

[1] Average of two determinations. LOQ 0.01 mg/kg

Strawberries. Supervised trials on strawberries were conducted in the UK in 1977, 1992 and 1995. In the 1977 trial a single application of chlorpyrifos EC at 0.71-0.72 kg ai/ha was made and samples were taken 3-14 days after treatment (Freeman, 1978a).

In the later trials multiple applications of chlorpyrifos WG or EC formulations were made at approximately 2-week intervals until harvest. In one 1995 trial a single application was made to each of six separate plots and a seventh plot received 6 applications. A similar trial was conducted in 1992. In two further trials in 1992 there was one application to 5 separate plots and a sixth plot received 5 applications. The formulations were diluted to 0.072 kg ai/hl and applied at 0.72 kg ai/ha. Fruits were sampled at commercial harvest, 7 days after the final application, and at other intervals up to 75 days (Portwood, 1996a).

In two other trials chlorpyrifos WG diluted to 0.072 kg ai/hl and applied at a rate of 0.72 kg ai/ha was applied at 2-week intervals until harvest. In one trial one plot received 6 applications and in the other the plot received 5 applications. Fruits were sampled at commercial harvest, 7 days after final application (Portwood, 1996b).

The results are shown in Table 41.

Table 41. Residues of chlorpyrifos in strawberries from supervised trials in the UK.

Year	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-UK	480 EC	0.72	0.072	3	7		
1977	EC	0.72		1	3	0.08	GHE-P 575
					7	0.09	
					14	0.02	
1977	EC	0.71		1	3	0.08	GHE-P 575
					7	0.04	
					13	0.03	
					14	0.04	
1992	WG	0.72	0.072	6	7	0.09	GHE-P 5492R
		0.72	0.072	1	7	0.06	
				1	21	0.03	
				1	35	0.03	
				1	46	0.02	

Year	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
				1	61	<0.01	
				1	75	<0.01	
1992	EC	0.72	0.072	5	7	0.10	GHE-P 5492R
		0.72	0.072	1	7	0.05	
				1	22	0.02	
				1	38	<0.01	
				1	52	<0.01	
				1	69	<0.01	
1992	WG	0.72	0.072	5	7	0.10	GHE-P 5492R
		0.72	0.072	1	7	0.09	
				1	22	0.02	
				1	38	<0.01	
				1	52	<0.01	
				1	69	<0.01	
1995	WG	0.72	0.072	6	7	0.15	GHE-P 5493R
1995	WG	0.72	0.072	5	7	0.12	GHE-P 5493R
1995	EC	0.72	0.072	6	7	0.14	GHE-P 5492R
	EC	0.72	0.072	1	7	0.07	
				1	21	0.02	
				1	35	0.03	
				1	46	<0.01	
				1	61	<0.01	
				1	75	<0.01	

[1] LOQ 0.01 mg/kg

In trials in Idaho and Oregon, USA, plots of strawberries were treated pre-plant in 1985 with Lorsban 4E insecticide at 2.24 kg ai/ha, and by two foliar sprays the following year at 1.12 kg ai/ha. In a similar trial in California, the plots received only the two foliar sprays. Strawberries were harvested from each trial 21 days after the last application. The results are shown in Table 42 (Wetters, 1987a).

Table 42. Residues of chlorpyrifos in strawberries from supervised trials in the USA.

Location, Year	Application				PHI, days	Residues, mg/kg [1]	Reference/ Comments
	Form.	kg ai/ha	kg ai/hl	No.			
GAP USA	480 g/l	1.12	0.30	2	21		Pre-boom only
CA, 1986	EC	1.12	0.28	2	21	0.06, 0.07, 0.03, 0.04	GH-C 1871
ID, 1986	EC	1.12	0.27	2	21	0.01, 0.01, 0.02, 0.02	GH-C 1871
OR, 1986	EC	1.12	0.27	2	21	0.03, 0.04, 0.03, 0.04	GH-C 1871

[1] LOQ 0.01 mg/kg

Grapes. Supervised trials were conducted in France, Greece, Italy, South Africa and the USA from 1980 to 1995. The results are shown in Tables 43 to 45.

In two trials in Northern France in 1993 (4 replicate plots analysed separately) single applications of chlorpyrifos in an EC formulation contained either 228 g ai/l at 1.5 l/ha or 480 g/l at 0.71 l/ha, both giving rates of 0.34 kg ai/ha. Samples were taken at harvest, 21 days after treatment (Khoshab and Berryman, 1994b).

In two further trials in 1994 in Northern France, single applications of the 228 EC or 480 EC formulations of chlorpyrifos both diluted to 0.16 kg ai/hl were applied at 0.34 kg ai/ha. Grapes were sampled at intervals from 0 to 28 days (Khoshab *et al.*, 1995b).

In two trials in 1995, one in the north and one in the south of France, single applications of either chlorpyrifos WG or 480 EC formulations diluted to 0.065 kg ai/hl at 0.34 kg ai/ha were applied to the vines 28 and 27 days before harvest respectively. Fruits were sampled at intervals from days 0 to 27 (Portwood and Williams, 1996i).

In a trial with four replicate plots, sampled separately, of 12 vines for each treatment, in Southern France in 1994 single applications of either the 228 EC or 480 EC formulation of chlorpyrifos diluted to 0.166 kg ai/hl at 0.34 kg ai/ha were applied and the grapes harvested 24 days after treatment (Khoshab *et al.*, 1995c).

Table 43. Residues of chlorpyrifos in grapes from supervised trials in France.

Year	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-France	EC	0.34	(0.17)		21		
1993	228 EC	0.34	0.134	1	21	0.06, 0.04, 0.04, 0.04	GHE-P 3636
1993	480 EC	0.34	0.134	1	21	0.02, 0.02, 0.01, 0.01	GHE-P 3636
1994	228 EC	0.34	0.16	1	0	0.28	GHE-P 4080
					7	0.16	
					15	0.09	
					22	0.06	
					28	0.07	
1994	480 EC	0.34	0.16	1	0	0.34	GHE-P 4080
					7	0.14	
					15	0.10	
					22	0.04	
					28	0.06	
1994	228 EC	0.34	0.166	1	24	0.06, 0.08, 0.08, 0.08	GHE-P 4082
1994	480 EC	0.34	0.166	1	24	0.07, 0.08, 0.06, 0.08	GHE-P 4082
1995	WG	0.34	0.065	1	0	0.56	GHE-P 4968R
					7	0.21	
					14	0.19	
					22	0.14	
					28	0.08	
1995	480 EC	0.34	0.065	1	0	0.39	GHE-P 4968R
					7	0.16	
					14	0.07	
					22	0.1	
					28	0.03	

Year	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
1995	WG	0.34	0.065	1	0	1.3	GHE-P 4968R
					7	0.36	
					14	0.15	
					20	0.10	
					27	0.12	
1995	480 EC	0.34	0.065	1	0	1.0	GHE-P 4968R
					7	0.17	
					14	0.13	
					20	0.15	
					27	0.11	

[1] LOQ 0.01 mg/kg

In trials in South Africa in 1980 two applications of the EC formulation diluted to 0.036 or 0.072 kg ai/hl were made, with samples taken at intervals from 0 to 35 days (Freeman *et al.*, 1980). In trials at three locations in Italy in 1986, single applications of the EC formulation were made to plots of grape vines at either 0.69 or 0.77 kg ai/ha, and in two other trials two applications at 0.77 kg ai/ha. Samples were taken between 7 and 69 days (Teasdale, 1988b).

In a trial in Greece according to GAP in Italy (Portwood and Williams, 1996j) single applications of either chlorpyrifos WG or 480 EC formulations, diluted to 0.065 kg ai/hl, were made at 0.83 kg ai/ha 28 days before harvest.

The results of all the trials are shown in Table 44.

Table 44. Residues of chlorpyrifos in grapes from supervised trials in Italy, Greece and South Africa.

Country, year	Application				PHI, days	Residues, mg/kg [1]	Reference/ comment
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Italy	EC	(0.5)	0.05	2	30		
Italy, 1986	EC	0.69		1	7	0.17	GHE-P 1818R
					14	0.09	
					33	0.04	
					49	0.06	
Italy, 1986	EC	0.69		1	7	0.50	GHE-P 1818R
					14	0.19	
					33	0.02	
					49	0.03	
Italy, 1986	EC	0.77		1	12	0.69	GHE-P 1818R
					19	0.28	
					38	0.10	
					69	0.05	
Italy, 1986	EC	0.77		2	13	0.50	GHE-P 1818R
Italy, 1986	EC	0.77		2	44	0.26	GHE-P 1818R
GAP-Greece NONE							

Country, year	Application				PHI, days	Residues, mg/kg [1]	Reference/ comment
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Italy							
Greece, 1995	WG	0.54	0.065	1	28	0.09	GHE-P 4967
	EC	0.54	0.065	1	28	0.32	
GAP-SA	480 EC		0.036		28		High volume
South Africa,	EC		0.036	2	0	1.1	GHE-P 792
1980					7	0.92	
					14	0.49	
					21	0.17	
					28	0.13	
					35	0.09	
South Africa,	EC		0.072	2	7	0.93	GHE-P 792
1980					14	0.14	
					21	0.20	
					28	0.28	
					35	0.17	
South Africa,	EC		0.036	2	0	2.2	GHE-P 792
1980					7	0.71	
					14	0.26	
					21	0.24	
					28	0.17	
					35	0.15	
South Africa,	EC		0.072	2	0	3.9	GHE-P 792
1980					7	0.97	
					14	0.42	
					21	0.29	
					28	0.20	
					35	0.24	

[1] LOQ 0.01 mg/kg

In a trial at 12 locations in the USA foliar sprays of both chlorpyrifos 480 EC and 50W were applied to grapes at a total rate of 6.7 kg ai/ha. 480 EC was applied at bud swell, 2.24 kg ai/ha, and 50W approximately 51, 41, 31 and 21 days before normal harvest at 1.12 kg ai/ha. Grapes were sampled 14, 21 and 30 days after the last application (McCormick *et al.*, 1994). The results are shown in Table 45.

Table 45. Residues of chlorpyrifos in grapes from supervised trials in the USA.

Location, year, (variety)	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-USA No foliar. soil spray only about vines. No NAFTA[2] country GAP.	EC		0.27	1	35		
NY, 1993	EC + WP(x4)	2.24 + 1.12(4x)	0.48 + 0.24	1 + 4	14	0.33	GH-C 3272

Location, year, (variety)	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
(Concord)					21	0.31	
					30	0.37	
NY, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.09 + 0.05	1 + 4	14	0.41	GH-C 3272
(Concord)					21	0.38	
					30	0.40	
WA, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.48 + 0.24	1 + 4	14	0.61	GH-C 3272
(Concord)					21	0.71	
					30	0.54	
WA, 1993	EC + WP(x4)	2.24 + 1,12(x4)	0.09 + 0.05	1 + 4	14	0.78	GH-C 3272
(Concord)					21	0.59	
					30	0.65	
NY, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.48 + 0.24	1 + 4	14	0.61	GH-C 3272
(Catawba)					21	0.44	
					30	0.43	
WA, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.48 + 0.24	1 + 4	14	0.71	GH-C 3272
(Chardonnay)					21	0.55	
					30	0.58	
CA, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.48 + 0.24	1 + 4	14	0.19	GH-C 3272
(Thompson)					21	0.08	
					30	0.10	
CA, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.48 + 0.24	1 + 4	14	0.20	GH-C 3272
(Thompson)					21	0.15	
					30	0.05	
CA, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.48 + 0.24	1 + 4	14	0.14	GH-C 3272
(Flame seedless)					21	0.12	
					30	0.05	
CA, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.09 + 0.05	1 + 4	14	0.25	GH-C 3272
(Flame seedless)					21	0.15	
					30	0.11	
CA, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.48 + 0.24	1 + 4	14	0.45	GH-C 3272
(Chenin blanc)					21	0.26	
					30	0.28	
CA, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.09 + 0.05	1 + 4	14	0.31	GH-C 3272
(Chenin blanc)					21	0.22	
CA, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.09 + 0.05	1 + 4	30	0.19	GH-C 3272
(Chenin blanc)							
CA, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.48 + 0.24	1 + 4	14	0.30	GH-C 3272
(Carignane)					21	0.32	
					30	0.36	
CA, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.48 + 0.24	1 + 4	14	0.25	GH-C 3272
(Zinfandel)					21	0.17	
					30	0.14	
CA, 1993	EC + WP(x4)	2.24 + 1.12(x4)	0.48 + 0.24	1 + 4	14	0.35	GH-C 3272
(Riesling)					21	0.17	

Location, year, (variety)	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
					30	0.14	
CA, 1993	EC + WP(x4)	2.24+ 1.12(x4)	0.48 +0.24	1 + 4	14	0.12	GH-C 3272
(Riesling)					21	0.08	
					30	0.08	

[1] LOQ 0.01 mg/kg
[2] North American Free Trade Agreement

Assorted tropical and sub-tropical fruits, inedible peel

Banana. Chlorpyrifos is applied to banana plants as a direct foliar spray, with an EC or WP formulation. Supervised trials were conducted in Australia, South Africa and Spain from 1977 to 1994. The results are shown in Tables 46 and 47.

In Australia, the 500 EC formulation was applied aerially to plants at 0.8 kg ai/ha, and samples analysed 24 hours and 14 days later (Vella, 1981).

In residue trials in South Africa during 1977-1979 bananas were treated with chlorpyrifos at rates of 0.036 and 0.075 kg ai/hl, and samples taken at regular intervals up to 21 days after treatment (Hollick and Walker, 1980).

Table 46. Residues of chlorpyrifos in bananas from foliar application in Australia and South Africa.

Country, year	Application				PHI, days	Residues, mg/kg	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Australia	500 EC	1.0	0.1		14		
	500 WP	1.0	0.1		14		
Australia, aerial 1981							
Peel	EC	0.8		1	0	0.03, 0.04, 0.08, 0.05 [1]	PAU 3183042
					14	0.02, 0.03, 0.03, 0.03 [1]	
Pulp					0	<0.02, <0.02, <0.02, <0.02 [1]	
					14	<0.02, <0.02, <0.02, ≤0.02 [1]	
GAP-South Africa	480 EC		0.036	8	28		
South Africa, 1978							
Peel	EC		0.036	1	0	0.73 [2]	GHE-P 722
					1	0.71 [2]	
					3	0.44 [2]	
					7	0.29 [2]	
					11	0.37 [2]	
					21	0.33 [2]	
Pulp					0	<0.01 [2]	GHE-P 722
					1	<0.01 [2]	
					3	<0.01 [2]	
					7	<0.01 [2]	

Country, year	Application				PHI, days	Residues, mg/kg	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
					11	<0.01 [2]	
					21	<0.01 [2]	
South Africa, 1978	480 EC		0.075	3	0	<0.01	GHE-P 722
Pulp					3	<0.01	
					5	<0.01	
					7	<0.01	
					12	<0.01	

[1]LOQ 0.02 mg/kg
[2] Recoveries averaged 93% (±4%) for banana peel and 97% (±4%) for banana pulp. LOQ 0.01 mg/kg.

In three trials at two locations in Spain during 1992 single applications of chlorpyrifos diluted to 0.096 kg ai/hl were applied at 0.43 kg ai/ha to the plants when the bananas were mature. Fruit were sampled at intervals from one day to 21 days after treatment. The recoveries of chlorpyrifos from whole bananas in two of the trials were 88±11%, n = 9 at 0.01 to 2.0 mg/kg. The results of the third trial were considered invalid owing to unexplained contamination of untreated samples (Khoshab, *et al.*, 1994c).

In trials in four different glasshouses near La Nuncia, Spain, in 1994, single applications of chlorpyrifos EC formulation were made to 4 trees approximately 21 days before harvest. The formulation was diluted to 0.096 kg ai/hl and applied to run-off at a rate of 6.4 or 4.3 kg ai/ha (Trials A and B) and 2.7 kg ai/ha (Trials C and D). The recovery of chlorpyrifos from whole bananas was 88% at 0.1 mg/kg and 94% at 0.25 mg/kg fortification. The fruit were harvested 21 or 22 days after the application. In trial D, each of the four treated trees was sampled and analysed separately (Khoshab and Clements, 1995a).

In a separate glasshouse trial in Spain in 1994, one application of the EC formulation diluted to 0.096 kg ai/hl was made at 2.7 kg ai/ha, and samples were taken at intervals from 0 to 21 days after treatment (Khoshab and Clements, 1995b). The analytical recovery from whole bananas was 95% at 0.10 mg/kg.

Table 47. Residues of chlorpyrifos in bananas from supervised trials in Spain.

Year	Application			No.	PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl				
GAP-Spain	480 EC		0.096	1	21		
	250 WP		0.1	1	21		
1992	EC	0.43	0.096	1	1	1.5	GHE-P 3349
whole fruit					3	1.2	
whole fruit					7	0.73	
whole fruit					14	0.80	
peel					14	2.0	
pulp					14	0.01	
whole fruit					21	0.48	
peel					21	1.3	
pulp					21	0.01	
1992	EC	0.43	0.096	1	1	1.6	GHE-P 3349

Year	Application			No.	PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl				
whole fruit					3	1.1	
whole fruit					7	0.57	
whole fruit					14	0.59	
peel					14	1.4	
pulp					14	<0.01	
whole fruit					21	0.37	
peel					21	0.83	
pulp					21	<0.01	
1994 (Glasshouse) trial A	EC	6.4	0.096	1	21	0.75 whole fruit	GHE-P 4518
(Glasshouse) trial B	EC	4.3	0.096	1	21	1.1 whole fruit	GHE-P 4518
(Glasshouse) trial C	EC	2.7	0.096	1	22	1.1 whole fruit	GHE-P 4518
(Glasshouse) trial D	EC	2.7	0.096	1	22	1.6; 1.5; 1.6; 1.6	GHE-P 4518
(Glasshouse)	EC	2.7	0.096	1	0	1.7 whole fruit	GHE-P 4519
					3	1.2	
					7	0.99	
					14	0.83	
					21	1.6	

[1] LOQ 0.01 mg/kg.

1% chlorpyrifos is also impregnated into plastic resins which are extruded into shrouds to cover the banana bunches. In Latin America trials were conducted in five locations in 1972 in Ecuador, Honduras and Costa Rica. Chlorpyrifos-impregnated bags were prepared by either spraying of pre-formed bags, or extrusion of chlorpyrifos-impregnated polyethylene pellets into roll film which was cut into bags. In the first method polyethylene bags were suspended by clamps from a wire and the exposed surface was sprayed with an airbrush with a solution of chlorpyrifos. The bags were then turned inside out so that the treated area was inside the bag. In the second method chlorpyrifos was blended with low-density polyethylene pellets in a shell blender at 90°C for half an hour. Pellets were tumble-blended with base resin to give a polymer mixture containing 1 and 2% (w/w) chlorpyrifos. The resin samples were then fabricated into a film, with an extruder.

Treated bags were placed over young banana bunches according to conventional practice until harvest (about 1 to 3 months), when samples of fingers selected at random from the top, middle and bottom sections of the shrouded stem were collected (Herman and Dishburger, 1972).

Using similar methods, in a trial in the Philippines to compare slow-release chlorpyrifos IPE with the standard chlorpyrifos IPE, bananas were shrouded weekly with the “Lorsban”-impregnated bags until harvest at 12 weeks (Ling, 1986).

The results are shown in Table 48.

Table 48. Residues of chlorpyrifos in bananas from trials using impregnated IPE bags.

Country, year	Application			PHI, weeks	Residues, mg/kg	Reference
	Form.	g ai/bag	No.			
GAP-Columbia	1% in IPE		1 bag/season	12-13		

Country, year	Application			PHI, weeks	Residues, mg/kg	Reference
	Form.	g ai/bag	No.			
Ecuador, 1972	1% in IPE	0.33	1 bag/season	12-13		
Whole					0.05, 0.06, 0.04	GH-C 603
Peel					0.17, 0.06, 0.04	
Pulp					<0.01, <0.01, ≤0.01	
Costa Rica, 1972	1% in IPE	0.33	1 bag/season	12-13		GH-C 603
Whole					0.04, 0.01, 0.03	
Peel					0.19, 0.02, 0.08	
Pulp					<0.01, <0.01, 0.01	
Costa Rica, 1972	1% in IPE	0.33	1 bag/season	12-13		
Whole					0.01, 0.01, 0.01	GH-C 603
Peel					0.12, 0.04, 0.06	
Pulp					<0.01, <0.01, ≤0.01	
Costa Rica, 1972	1% in IPE	0.66	1 bag/season	12-13		GH-C 603
Whole					0.05, 0.04, 0.04	
Peel					0.14, 0.11, 0.06	
Pulp					<0.01, <0.01, ≤0.01	
Honduras, 1972	1% in IPE	0.25	1 bag/season	12-13		GH-C 603
Whole					0.01, <0.01, 0.01	
Peel					0.02, 0.05, 0.02	
Pulp					<0.01, <0.01, ≤0.01	
Honduras, 1972	1% in IPE	0.5	1 bag/season	12-13		GH-C 603
Whole					0.01, 0.01, <0.01	
Peel					0.03, 0.02, <0.01	
Pulp					<0.01,<0.01, ≤0.01	
Costa Rica, 1972	1% in IPE	0.25	1 bag/season	12-13		GH-C 603
Whole					0.01, 0.02, 0.02	
Peel					0.03, 0.02, 0.05	
Pulp					<0.01, <0.01, ≤0.01	
Costa Rica, 1972	1% in IPE	0.5	1 bag/season	12-13		GH-C 603
Whole					0.08, 0.07, 0.13	
Peel					0.13, 0.06, 0.08	
Pulp					<0.01, <0.01, ≤0.01	
GAP-Philippines	1% in IPE		1 bag/season	12-13		
Philippines, 1983	1% in IPE	0.4	1 bag/season			
Whole				10	0.10, 0.07, 0.11	PM-86-010
Peel					0.08, 0.05, 0.07	
Pulp					0.02, 0.02, 0.04	
Whole				11	0.12, 0.08, 0.08	
Peel					0.08, 0.06, 0.01	
Pulp					0.04, 0.02, 0.07	
Whole				12	0.06, 0.06, 0.13	
Peel					0.01, <0.01, 0.11	
Pulp					0.05, 0.05, 0.02	
Philippines, 1983	1% in IPE	0.4				
Whole				10	0.07, 0.05, 0.07	PM-86-010

Country, year	Application			PHI, weeks	Residues, mg/kg	Reference
	Form.	g ai/bag	No.			
Peel					0.06, <0.01, 0.03	
Pulp					0.01, 0.05, 0.04	
Whole				11	0.02, 0.04, 0.03	
Peel					<0.01, <0.01, 0.02	
Pulp					0.02, 0.02, 0.03	
Whole				12	0.04, 0.21, 0.07	
Peel					<0.01, 0.19, 0.05	
Pulp					0.04, 0.02, 0.02	

Kiwifruit. In New Zealand in a supervised trial in 1978 chlorpyrifos was applied at 0.025 kg ai/hl and fruits were collected at intervals up to 21 days after treatment (MacDairmid and Mercer, 1978). In another trial in 1979, chlorpyrifos was applied at 0.025 kg ai/hl in EC and WP formulations. Three and 9 applications were made and samples taken at intervals from the day after the last application to 21 days (Upritchard, 1980).

In trials in 1985 in New Zealand chlorpyrifos 50W was applied to kiwifruit at 1 kg ai/ha and the mature fruits were harvested 10-39 days after the last application, but necessary details were not reported (Wilson, 1986).

The results of the trials are shown in Table 49.

Table 49. Residues of chlorpyrifos in whole kiwifruit from supervised trials in New Zealand.

Year	Application				PHI, days	Residues, mg/kg[1]		Reference
	Form.	kg ai/ha	kg ai/hl	No.		Whole	Pulp	
GAP-New Zealand	500 WP	0.50	0.025		14			
	400 EC	0.48	0.024		14			
1985[2]	WP	1.0		4	16	0.29		GHF-P 544
					20	0.14		
					39	0.09		
1985[2]	WP	1.0		5	10	0.91		
					12	0.27, 0.37		GHF-P 544
					13	1.6		
					16	0.30		
					21	0.37		
					24	0.67		
1985[2]	WP	1.0		6	11	0.55		GHF-P 544
					13	0.54		
					16	0.66		
					17	0.62		
					25	0.26, 0.37		
		1.0	-	7	11	0.37		GHF-P 544
1977	WP		0.025 or 0.09	1	0	0.25	<0.05	GHF-P 086. Conflicting rates reported. Whole fruit calculated.
.					1	0.08	<0.05[3]	Whole fruit calculated.
					2	0.08	<0.05	
					4	0.08	<0.05	

Year	Application				PHI, days	Residues, mg/kg[1]		Reference
	Form.	kg ai/ha	kg ai/hl	No.		Whole	Pulp	
					7	0.07	<0.05	
					14	<0.05	<0.05	
					21	<0.05	<0.05	
1979	WP	1.0	0.025	4	1	0.96	<0.05	GHE-P 147
					2	0.79		
					4	0.51		
					7	0.49		
					14	0.26	<0.05	
					21	0.40		
1979	WP	1.0	0.025	9	1	1.5	0.10[4]	GHE-P 147. Whole fruit calculated.
					2	1.1	0.08	
					4	1.7	0.13	
					7	1.2	0.07	
					14	1.9	0.08	
					21	0.48	0.08	
1979	EC	1.0	0.025	4	1	0.83	<0.05	GHE-P 147
.					2	0.93		
					4	1.0		
					7	0.85		
					14	0.75	<0.05	
					21	0.59		
1979	EC	1.0	0.025	9	1	2.2	0.05	GHE-P 147. Whole fruit calculated.
.					2	2.2	0.09	
					4	1.6	0.07	
					7	1.4	0.11	
					14	1.0	0.14	
					21	0.71	0.15	

[1] LOQ 0.01 mg/kg
[2] Each result is from a different field.
[3] Recovery from pulp was 94% at 0.05 mg/kg fortification of control samples.
[4] Recovery from pulp was 97% at 0.1 mg/kg fortification of control samples.

Bulb Vegetables

Onions. An at-plant treatment was reported from the USA (Doom, 1986). G and EC formulations were tested in separate plots, at the rate of 1.12 kg ai/ha. They were applied to onions as a drench and 4.5 kg samples were collected at the regular harvest time of 182 or 210 days after application. Additional trials were reported from Canada, where a G formulation was applied with onion seeds in the seed furrow at the rate of 1.1 kg ai/ha. Samples were collected 80, 109 and 121 days after treatment and analysed (Plaumann *et al.*, 1982). The findings are shown in Table 50.

Table 50. Residues of chlorpyrifos in onions from the at-planting application of G or EC formulations.

Location, (Variety) Year	Application		PHI, days	Residue, mg/kg		Reference/Comment
	kg ai/ha	No.		Chlorpyrifos	TCP	
USA GAP	1.1	1				G. In-furrow

Location, (Variety) Year	Application		PHI, days	Residue, mg/kg		Reference/Comment
	kg ai/ha	No.		Chlorpyrifos	TCP	
Canada GAP	2.4	1				G. In-furrow. For 5 cm furrow width, 1.12 kg ai/ha
Selema, California USA (Stockton Early Yellow) 1985-1986	15.7 g ai/1000ft 1.12	1	210	0.019, 0.017, 0.016, 0.012	0.053, 0.012, 0.025, 0.008	GH-C 1848 G
				0.024, 0.031, 0.016, 0.007	0.062, 0.054, 0.034, <0.01	EC. 374 l/ha
Imperial Valley, California, USA (Colossal) 1985-1986	15.7 g ai/1000 ft 1.12	1	182	≤0.01	<0.01	G
				≤0.01	<0.01	EC. 355 l/ha
Canada 1982	1.1	1	80 109 121	0.14, 0.12, 0.10, 0.11 0.04, 0.05, 0.04, 0.05 0.03, 0.05, 0.06, 0.05		GHS-C 43

Seven supervised trials on onions were carried out in Greece in 1993-1995. In the 1993 trials two foliar applications of chlorpyrifos EC at 0.96 kg ai/ha were made to the plants at the 6-7 leaf growth stage 41 and 21 days before harvest. Whole onions were sampled at harvest and all replicates analysed separately (Khoshab and Koliopanos, 1994).

In the two trials in 1994 single applications of EC formulation at a spray concentration of 0.24 kg ai/hl was sprayed on bulb onion plants at 0.96 kg ai/ha 40 days before normal harvest. Whole plant samples were taken at intervals from the day of application to harvest (Khoshab, 1996a). Similar trials were conducted in 1995 using either the EC or WG (750 g ai/l) formulation (Portwood and Williams, 1996k).

The results are shown in Table 51.

Table 51. Residues of chlorpyrifos in onions from supervised trials in Greece (foliar application).

Year	Application				PHI, days	Residues, mg/kg [1,2]	Reference/ Comment
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Greece	480 EC	1.20 2.5 (0.96 band)	0.3	3 1	7, 20		Foliar Broadcast soil/band Labels have conflicting PHIs
	250 WP	2.5 1.25 0.88		1-2	20		Pre-plant At planting Post-planting foliar
	50 G	3.0					
1993	EC	0.96		2	20	0.03, 0.02, 0.02, 0.01	GHE-P 3466
1994	EC	0.96	0.24	1	0	9.1	GHE-P 4514
					10	0.03	
					20	≤0.01	
					30	<0.01	
					40	ND [3]	
1994	EC	0.96	0.24	1	0	11.0	GHE-P 4514
					10	0.03	
					20	≤0.01	
					30	<0.01	

Year	Application				PHI, days	Residues, mg/kg [1,2]	Reference/ Comment
	Form.	kg ai/ha	kg ai/hl	No.			
					40	ND [4]	
1995	EC	0.96	0.24	2	0	6.1	GHE-P 4807
					5	0.24	
					10	0.13	
					15	0.03	
					20	0.05	
1995	WP	0.96	0.24	2	0	7.9	GHE-P 4807
					5	0.17	
					10	0.07	
					15	0.04	
					20	0.02	
1995	EC	0.96	0.24	2	0	5.8	GHE-P 4807
					5	0.09	
					10	0.04	
					15	0.03	
1995	EC	0.96	0.24	2	20	0.02	GHE-P 4807
1995	WP	0.96	0.24	2	0	9.2	GHE-P 4807
					5	0.33	
					10	0.16	
					15	0.06	
					20	0.05	

[1] All results averages of duplicate determinations
[2] LOQ 0.01 mg/kg
[3] ND = less than 20% of LOQ

In four trials at different locations in the UK in 1993 single applications of EC were applied to the plants at 0.96 kg ai/ha. Whole onions were sampled at harvest after 21-23 days (Khoshab *et al.*, 1994d). The results are shown in Table 52.

Table 52. Residues of chlorpyrifos in onions from supervised trials in the UK (foliar application).

Year	Application				PHI, days	Residues, mg/kg [1]	Reference/ Comment
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-UK	480 EC	0.96	0.16	1-2	21		Specific commodity under Vegetables on label
1993	EC	0.96	0.16	1	23	0.04	GHE-P 3488
1993	EC	0.96	0.16	1	22	0.05, 0.03, 0.08, 0.08	GHE-P 3488
1993	EC	0.96	0.16	1	21	0.06	GHE-P 3488
1993	EC	0.96	0.16	1	23	0.07	GHE-P 3488

[1] LOQ, 0.01 mg/kg.

Brassica vegetables

Broccoli. In nine supervised trials in main US broccoli growing areas in 1983–1984 multiple applications of chlorpyrifos 50W were made at 1.12 kg ai/ha, alone or following application at transplant of the EC formulation at 0.8 to 2.2 kg ai/ha. Sample of heads with 2-3 inches of stems were collected at random 14-15 days and 21 days after the last application (Miller *et al.*, 1986a).

In a trial in California in 1986 EC was applied to broccoli twice during the season at 1.68 kg ai/ha, at planting and 30 days later. Samples were collected at normal harvest (McKellar and Ordiway, 1986a). The results are shown in Table 53.

Table 53. Residues of chlorpyrifos in broccoli from supervised trials in the USA.

Country, year	Application			PHI, days	Residues, mg/kg [1]	Reference/ Comment
	Form.	kg ai/ha	No.			
GAP-USA	480 EC	2.5 at planting	1			Total EC use not to exceed 2.9 kg ai/ha/season. At planting use limited to CA
		1.1 directed post plant	1	30		
	50% WP	1.1 foliar	6	21		AZ and CA only
CA, 1983	WP	2.2	9	7	0.28	GH-C 1788
				14	<0.01	
				21	<0.01	
FL, 1983	EC + WP	2.1 + 1.1(x7)	8	7	0.03	GH-C 1788
				14	<0.01	
				21	<0.01	
FL, 1984	EC + WP	1.5 + 1.1(x7)	8	7	2.17	GH-C 1788
				14	0.65	
				21	0.07	
IL, 1983	EC + WP	1.5 + 1.1(x6)	7	7	0.08	GH-C 1788
				14	<0.01	
				21	<0.01	
MA, 1983	EC + WP	0.8 + 1.1(x4)	5	7	0.16	GH-C 1788
				14	0.05	
				21	0.01	
MI, 1983	EC + WP	1.2 + 1.1(x9)	10	7	0.66	GH-C 1788
				14	0.9	
				21	0.05	
MI, 1983	EC + WP	1.7 + 1.1(x6)	7	7	0.19	GH-C 1788
				15	0.05	
				21	<0.01	
NJ, 1983	EC + WP	0.8 + 1.1(10)	11	7	4.5	GH-C 1788
				14	1.7	
				21	1.4	
OR, 1983	EC + WP	1.5 + 1.1(8)	9	7	0.86	GH-C 1788
				14	0.07	
				21	0.03	
CA, 1986	EC	1.68	2	103	<0.01, <0.01, <0.01, <0.01	GH-C 1802

[1] LOQ 0.01 mg/kg

Brussels sprouts. In a similar trial to the last, also in California in 1986, chlorpyrifos EC was applied to Brussels sprouts twice during the season at a rate of 1.68 kg ai/ha, at planting and 30 days later. Samples were collected at normal harvest (McKellar and Ordiway, 1986a). The results are shown in Table 54.

Table 54. Residues of chlorpyrifos in Brussels sprouts from supervised trials in the USA.

Year	Application				PHI,	Residues,	Reference
	Form.	kg ai/ha	kg ai/hl	No.	Days	mg/kg [1, 2]	
GAP-USA: Brussels sprouts	EC	2.5 at planting 1.1 foliar spray	(0.58)	1 6	21		
CA, 1986 Brussels sprouts	EC	1.68		2	139	<0.01, <0.01, <0.01, <0.01	GH-C 1802

[1] LOQ 0.01 mg/kg

Cabbage. In Brazil an EC formulation was applied three times to cabbages at 0.72 or 1.4 kg ai/ha near maturity (Balderrama and Matos, 1994a,b).

Table 55. Residues of chlorpyrifos from the application of an EC formulation to cabbages in Brazil.

Location, (Variety) Year	Application			PHI, days	Residue	Reference/ Comment
	kg ai/ha	kg ai/hl	No.		Chlorpyrifos, mg/kg	
Brazil GAP	(0.3)	0.03	2	21		Manufacturer applied GAP for Germany.
Mogi-Mirim (Georgia Agroc) 1992	0.72	0.24 0.24 0.08	3	3 7 14 21	2.9 0.92 0.06 0.01	GHB-P 192
	1.4		3	3 7 14 21	7.6 2.0 0.32 0.05	GHB-P 192
Mori-Mirim, (Chato de Quintal Ag, Savoy) 1992	0.72	0.24 0.24 0.08	3	3 7 14 21	0.02 0.02 <0.01 <0.01	GHB-P 193.
	1.4		3	3 7 14 21	0.08 0.05 0.01 <0.01	GHB-P 193

In trials in South Africa in 1977 single spray applications of an EC formulation were made at 0.08 to 0.22 kg ai/ha, 0.01 to 0.024 kg ai/hl. Samples were collected at intervals from 0 to 35 days (Freeman, 1978b). The results are shown in Table 56.

Table 56. Residues of chlorpyrifos in head cabbages from supervised trials in South Africa.

Year	Application				PHI, days	Residues, mg/kg [1,2]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-SA	480 EC	(0.12)	0.024		7		
1977	EC	0.17	0.019	1	1	1.2	GHE-P 585
					3	0.75	
					7	0.21	
					14	0.08	

Year	Application				PHI, days	Residues, mg/kg [1,2]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
					21	0.01	
					28	<0.01	
1977	EC	0.22	0.024	1	1	1.4	GHE-P 585
					3	0.56	
					7	0.22	
					14	0.09	
					21	0.01	
					28	0.02	
1977	EC	0.08	0.01	1	2	0.01	GHE-P 585
					4	0.01	
					7	0.02	
					14	0.01	
					21	<0.01	
					28	<0.01	
					35	<0.01	
1977	EC	0.19	0.024	1	2	0.01	GHE-P 585
					4	0.02	
					7	0.01	
					14	<0.01	
					21	<0.01	
					28	<0.01	
					35	<0.01	

[1] Average of duplicate analyses
[2] LOQ 0.01 mg/kg

In two trials in the UK in 1976 an EC formulation was applied either as a single foliar application at 0.72 kg ai/ha with samples taken after 20 days, or as a soil drench with 2 treatments at 0.024 kg ai/hl and samples taken after 20 and 59 days (Hollick and Walker, 1976b).

In 1993 immature cabbage plants were treated with an EC formulation at 0.96 and 0.48 kg ai/ha at the 2-4 leaf and 10 leaf growth stages, and samples taken at intervals up to 28 days after the second application (Khoshab and Hastings, 1994a).

In another trial in 1993 cabbage plants were treated at the 2-leaf and heart-forming growth stages with an EC formulation at 0.96 and 0.48 kg ai/ha respectively. Samples were taken at harvest 21 days after the second application (Khoshab and Hastings, 1994b).

In trials in 1994 two applications of EC or WG formulations were made to cabbages at 0.96 kg ai/ha and 0.08 kg ai/hl (1st application) and 0.72 kg ai/ha and 0.06 kg ai/hl (2nd). In a third trial the WG formulation was applied twice, firstly at 0.48 kg ai/ha and 0.08 kg ai/hl, then at 0.36 kg ai/ha and 0.06 kg ai/hl. Samples were collected at intervals up to 21 days after the last application (Portwood and Williams, 1995c).

In a further trial in the UK in 1994 two applications (0.96 and 0.72 kg ai/ha) of chlorpyrifos EC were made at the 6-leaf growth stage and 21 days before harvest and samples taken at harvest (Khoshab, 1995a). In another trial under similar conditions samples were taken at intervals up to 21 days after application (Khoshab, 1995b).

The results are shown in Table 57.

Table 57. Residues of chlorpyrifos in cabbages from supervised trials in the UK.

Country, year	Application				PHI, days	Residues, mg/kg [1,2]	Reference/ Comment
	Form.	kg ai/ha	kg ai/hl	No.			
GAP- UK	EC	0.72	(0.12)		21		
1976	EC	0.72		1	20	0.01	GHE-P 438
							Foliar
1976	EC		0.024	2	20	<0.01	GHE-P 438
					59	<0.01	Soil drench
1993	EC	0.96 + 0.48	0.08 + 0.16	2	0	17	GHE-P 3634
					7	0.62	Early foliar
					14	0.04	
					21	0.03	
					28	0.01	
1993	EC	0.96 + 0.48	0.16 + 0.08	2	21	0.05, 0.05, 0.05, 0.07	GHE-P 3635
							Early foliar
1994	EC	0.96 + 0.72	0.16 + 0.12	2	0	1.5	GHE-P 4355
					6	0.72	Foliar
					9	0.41	
					15	0.21	
					21	0.10	
1994	WG	0.96 + 0.72	0.16 + 0.12	2	0	2.4	GHE-P 4355
					6	0.75	Foliar
					9	0.45	
					15	0.25	
					21	0.15	
1994	WG	0.48 + 0.36	0.08 + 0.06	2	0	1.11	GHE-P 4355
					6	0.39	Foliar
					9	0.20	
					15	0.12	
					21	0.05	
1994	EC	0.96 + 0.72	0.12 + 0.16	2	21	0.26	GHE-P 4513
							Foliar
1994	EC	0.96 + 0.72	0.12 + 0.16	2	6	0.32	GHE-P 4512
					12	0.22	Foliar
					15	0.28	
					21	0.02	

[1] Average of duplicate analyses
[2] LOQ 0.01 mg/kg

In supervised trials on cabbages in the USA in 1983 and 1984 multiple applications of chlorpyrifos 50WP were made at 1.12 kg ai/ha, alone or after EC applications of 0.84–2.1 kg ai/ha at planting. Samples were collected at random 14-15 and 21 days after the last application, and quartered cabbage heads including the wrapper leaves analysed (Miller, *et al.*, 1986a). The results are shown in Table 58.

Table 58. Residues of chlorpyrifos in cabbages from supervised trials in the USA (foliar or at planting plus foliar applications).

Location, year	Application			PHI, days	Residues, mg/kg [1]	Reference/ Comment
	Form.	kg ai/ha	No.			
GAP-USA	480 EC	2.5	1	30		At-seeding, incorporated; sidedress after transplant
	500WP	1.12	6	21		Broadcast foliar.
CA, 1983	WP	1.12	9	7	0.9	GH-C 1788
				14	0.05	
				21	<0.01	
TX, 1983	WP	1.12	10	7	0.12	GH-C 1788
				14	0.4	
				21	0.4	
FL, 1984	EC + WP	1.5 + 1.1(x8)	9	7	1.4	GH-C 1788
				14	0.51	
				21	0.50	
IL, 1983	EC + WP	1.5 + 1.1(x6)	7	7	0.02	GH-C 1788
				14	0.04	
				21	<0.01	
MA, 1983	EC + WP	0.8 + 1.1(x5)	6	7	0.86	GH-C 1788
				14	0.33	
				21	0.15	
MI, 1983	EC + WP	1.5+ 1.1(x7)	8	7	0.04	GH-C 1788
				14	0.07	
				21	<0.01	
NJ, 1983	EC + WP	0.8 + 1.1(8)	9	7	2.1	GH-C 1788
				14	2.8	
				21	0.94	
FL, 1983	EC + WP	2.1 + 1.1(7)	8	7	1.4	GH-C 1788
				14	0.23	
				21	0.22	
				7	0.12	
				14	0.02	
				21	0.03	
				7	0.29	
				14	0.01	
				21	0.03	
MI, 1983	EC + WP	1.2 + 1.1(9)	10	7	1.4	GH-C 1788
				14	0.12	
				21	0.26	
				7	0.23	
				14	0.02	
				21	0.01	
				7	0.22	

Location, year	Application			PHI, days	Residues, mg/kg [1]	Reference/ Comment
	Form.	kg ai/ha	No.			
				14	0.03	
				21	0.03	
IL, 1983	EC + WP	1.7 + 1.1(9)	10	7	1.0	GH-C 1788
				14	0.21	
				21	0.22	
				7	4.2	
				14	0.88	
				21	0.71	

[1] LOQ 0.01 mg/kg

Chinese cabbage. Three residue trials were conducted at different locations in the UK during 1993. A single spray of EC containing 480 g ai/l was applied at 0.16 kg ai/hl and 0.96 kg ai/ha to plants at growth stages between 5 and 18 leaves. The plants were harvested from 0 to 37 days after application. In two of the trials replicate samples were bulked in the field, and in the third analysed separately (Khoshab *et al.*, 1993f). The results are shown in Table 59.

Table 59. Residues of chlorpyrifos in Chinese cabbage from supervised trials in the UK.

Location, year	Application				PHI, days	Residues, mg/kg [1,2]	Reference/Comment
	Form.	kg ai/ha	kg ai/hl	No.			
GAP- UK	EC	0.96	0.16	2	21		Specified on label as brassica
Bray, Berkshire, 1993	EC	0.96	0.16	1	0	35, 39, 3, 34, 30	GHE-P 3252
					8	2.6, 3.0, 3.3, 2.9	
					16	0.71, 0.50, 0.75, 0.56	
					24	0.19, 0.15, 0.15, 0.11	
					37	ND, ND, ND, ND	
Bray, Berkshire, 1993	EC	0.96	0.16	1	0	31, 31, 36, 27	GHE-P 3252 Replicate plot
					8	1.0, 2.5, 2.6, 2.2	
					16	0.70, 0.47, 0.56, 0.52	
					24	0.17, 0.10, 0.10, 0.16	
					37	<0.01, <0.01, <0.01, <0.01	
Methwold Hythe, Thetford, 1993	EC	0.96	0.16	1	0	35	GHE-P 3252
					6	5.4	
					12	1.8	
					18	0.60	
					24	0.18	
Methwold Hythe, Thetford, 1993	EC	0.96	0.16	1	0	28	GHE-P 3252 Replicate plot
					6	4.2	
					12	1.4	
					18	0.34	
					24	<0.01	
Derbyshire, 1993	EC	0.96	0.16	1	0	64	GHE-P 3252

Location, year	Application				PHI, days	Residues, mg/kg [1,2]	Reference/Comment
	Form.	kg ai/ha	kg ai/hl	No.			
					7	0.87	
					14	0.12	
					21	0.04	
					28	<0.01	
Derbyshire, 1993	EC	0.96	0.16	1	0	67	GHE-P 3252 Replicate plot
					7	0.90	
					14	0.16	
					21	0.04	
					28	<0.01	

[1] Average of two analyses
[2] LOQ 0.01 mg/kg

Cauliflower. All the ten supervised trials were carried out in the UK from 1992 to 1995. In two in 1992 single applications of EC formulation were sprayed on plants at the 10-15 cm or 20-30 cm height stages at 0.16 kg ai/hl and 0.96 kg ai/ha. The plants were harvested from 0 to 28 days after treatment (normal harvest). Whole plants taken up to 21 days after treatment were analysed, but the curd and the rest of plant were analysed separately in the samples taken at harvest (Khoshab *et al.*, 1993g).

In a trial in 1993 a single application of EC formulation was sprayed at growth stage 12-20 true leaves at 0.16 kg ai/hl, 0.96 kg ai/ha. Samples were harvested 21 and 34 days after application (Khoshab and Berryman, 1994d).

In another two trials in 1993, two applications of EC formulation were made at 0.89 and 0.48 kg ai/ha or 0.96 and 0.48 kg ai/ha at the 4-leaf and small curd growth stages. Samples were taken at harvest, 21 days after the last application (Khoshab and Berryman, 1994c).

In a further trial in 1994 two applications of EC or WG formulations were made to cabbages at 0.96 kg ai/ha and 0.08 kg ai/hl (1st application) and 0.72 kg ai/ha and 0.06 kg ai/hl (2nd). In a third trial the WG formulation was applied twice, firstly at 0.48 kg ai/ha and 0.08 kg ai/hl, then at 0.36 kg ai/ha and 0.06 kg ai/hl.

In trials in 1994 two applications of WG or EC formulations were made to plants at the 50-cm stage (no hearts visible) at 0.16 and 0.12 kg ai/hl, applied at 0.96 and 0.72 kg ai/ha respectively. In a third trial the WG formulation was applied at 0.08 kg ai/hl and 0.48 kg ai/ha (1st application) and 0.36 kg ai/ha 0.06 kg ai/hl (2nd) for the WG formulation. The plants were sampled at intervals up to harvest 22 days after treatment. On the day of harvest, leaves and curd were also analysed (Portwood and Williams, 1995d).

In another trial in 1994 two applications of EC were made to cauliflower plants post-emergence and 21 days before harvest, firstly at 0.96 kg ai/ha and then at 0.72 kg ai/ha. Whole plants were sampled at intervals up to 15 days, and curd and leaves at harvest 21 days after the second application (Khoshab, 1995c).

In 1995 trials two applications of chlorpyrifos EC or WG formulations were made to cauliflowers at crop growth stages BBCH 103 and 41 at 0.16 kg ai/hl and 0.12 kg ai/hl and applied at 0.96 kg and 0.72 kg ai/ha respectively. Plants were sampled at intervals from the day of final application to 36 days after treatment (normal harvest), when curd was analysed (Portwood and Williams, 1996l).

In a further trial in 1995 two applications of chlorpyrifos WG were made to cauliflower plants when hearts were 1 inch across at 0.16 and 0.12 kg ai/hl, applied at 0.96 kg ai/ha and 0.72 kg ai/ha respectively. The curds were sampled at harvest, 21 days after treatment (Portwood, 1996e).

The results are shown in Table 60.

Table 60. Residues of chlorpyrifos in cauliflowers from supervised trials in the UK (foliar applications).

Year, sample	Application				PHI, days	Residues, mg/kg [1,2]	Reference/ Comment
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-UK	480 EC	0.48	(0. 24)		21		Conflicting information.
		0.72	(0.12)	1	21		
		0.96	(0.16)	2	21		Specified as brassica on label.
1992	480 EC	0.96	0.16	1	0	31	GHE-P 3212
Whole plant					7	1.5	
					14	0.53	
					21	0.11	
Plant except curd					28	0.03	
Curd					28	<0.01	
1992	480 EC	0.96	0.16	1	0	54	GHE-P 3212
Whole plant					7	0.82	
					14	0.04	
					22	0.01	
1993	480 EC	0.96	0.16	1	21	<0.01	GHE-P 3633
Curd					34	<0.01, <0.01, <0.01, <0.01	
1993 Curd	480EC	0.89 + 0.48	0.15 + 0.09	2	21	<0.01, <0.01, <0.01, <0.01	GHE-P 3506
1993 Curd	480 EC	0.96 + 0.48	0.16 + 0.09	2	21	<0.01, <0.01, <0.01, <0.01	GHE-P 3506
1994 Whole plant	480 EC	0.96 + 0.72	0.16 + 0.12	2	0	6.1	GHE-P 4354
					5	1.6	
					12	0.66	
					15	0.31	
Leaves					22	0.25	
Curd					22	<0.01	
1994 Whole plant	WG	0.96 + 0.72	0.16 + 0.12	2	0	7.0	GHE-P 4354
					5	1.3	
					12	0.62	
					15	0.31	
Leaves					22	0.17	
Curd					22	<0.01	
1994 Whole plant	WG	0.48 + 0.36	0.08 + 0.06	2	0	2.7	GHE-P 4354
					5	0.67	
					12	0.21	
					15	0.14	
Leaves					22	0.10	
Curd					22	<0.01	

Year, sample	Application				PHI, days	Residues, mg/kg [1,2]	Reference/ Comment
	Form.	kg ai/ha	kg ai/hl	No.			
1994 Whole plant	EC	0.96 + 0.72	0.16 + 0.12	2	0	13	GHE-P 4511
					6	1.5	
					12	0.47	
					15	0.27	
Leaves					21	0.33	
Curd					21	0.01	
1995 Whole plant	EC	0.96 + 0.72	0.16 + 0.12	2	0	12	GHE-P 5450
					3	5.5	
					9	1.1	
					16	0.23	
Curd					36	<0.01	
1995 Whole plant	WG	0.96 + 0.72	0.16 + 0.12	2	0	10	GHE-P 5450
					3	4.8	
					9	2.1	
					16	0.24	
Curd					36	<0.01	
1995 Whole plant	WG	0.96 + 0.72	0.16 + 0.12	2	0	12	GHE-P 5450
					3	5.5	
					9	1.1	
					16	0.42	
Curd					36	<0.01	
1995 Whole plant	WG	0.96 + 0.72	0.16 + 0.12	2	0	14	GHE-P 5450
					3	5.7	
					9	1.7	
					16	0.28	
Curd					36	<0.01	
1995 Whole plant	WG	0.96 + 0.72	0.16 + 0.12	2	0	14	GHE-P 5450
					3	5.5	
					9	1.43	
					16	0.31	
Curd					36	<0.01	
1995 Whole plant	WG	0.96 + 0.72	0.16 + 0.12	2	0	17	GHE-P 5450
					3	2.3	
					9	0.37	
					16	0.18	
Curd					36	<0.01	
1995 Curd	WG	0.96 + 0.72	0.16 + 0.12	2	21	0.02	GHE-P 5451

[1] Average of two determinations
[2] LOQ 0.01 mg/kg

Fruiting vegetables, other than cucurbits

Peppers. In three trials in Spain in 1988 EC (480 g ai/l) was applied twice, at 1.15 kg ai/ha and 1.44 kg ai/ha at a concentration of 0.096 kg ai/hl. Samples were harvested at intervals up to 28 days after the final application. Bulk samples were prepared by combining replicate samples (Osborne, 1989b).

The results are shown in Table 61.

Table 61. Residues of chlorpyrifos in peppers from supervised trials in Spain.

Year	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Spain	480 EC	(1.15)	0.096	3	7		
	250 WP	(1.2)	0.1	2	7		
1988	EC	1.15 + 1.44	0.096	2	4	0.28 [2]	GHE-P 1990
					7	0.37 [2]	
					14	0.30 [2]	
					21	0.36 [2]	
					28	0.30 [2]	
1988	EC	1.06 + 1.25	0.096	2	4	0.52, 0.53, 0.32, 0.26	GHE-P 1990
					7	0.37, 0.47	
					14	0.22, 0.19, 0.11, 0.13	
					22	0.37, 0.33, 0.20, 0.14	
					28	0.35, 0.24	
1988	EC	1.15 + 1.34	0.096	2	7	0.45 [2]	GHE-P 1990
					14	0.19 [2]	
					21	0.12 [2]	
					28	0.06 [2]	

[1] LOQ 0.01 mg/kg
[2] Average of two analyses

Several supervised trials on bell peppers were conducted in seven US States during 1982-1984, with the WP formulation applied as a multiple foliar spray at 10 -14 day intervals, at 1.12 kg ai/ha. Samples were collected 7, 14 and 21 days after the final application (Miller *et al.*, 1985b). The results are shown in Table 62.

Table 62. Residues of chlorpyrifos in bell peppers from supervised trials in the USA.

Location, year (Variety)	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-US	WP	1.12	(0.23)	8	7		
CA, 1983	WP	1.12	0.17	7	7	0.01	GH-C 1757
(Serrano)					14	0.04	
					21	0.01	
FL, 1983	WP	1.12	0.16	5	7	0.27	GH-C 1757
(Hungarian Wax)					14	0.01	
					21	0.01	
FL, 1983	WP	1.12		8	7	0.60	GH-C 1757
(Jalapeño)					14	0.13	
					21	0.02	
MI, 1983	WP	1.12		7	7	0.39	GH-C 1757
(Small fry)					14	0.15	
					21	0.02	
MS, 1983	WP	1.12		10	7	1.4	GH-C 1757

Location, year (Variety)	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
(Red Cayenne))					14	0.90	
					21	0.27	
NJ, 1983	WP	1.12		8	7	0.40	GH-C 1757
(Vineland Special)					14	0.14	
					21	0.16	
NY, 1983	WP	1.12		8	7	0.52	GH-C 1757
(Hungarian Wax)					14	0.16	
					21	0.13	
OR, 1983	WP	1.12		8	7	0.13	GH-C 1757
(Anaheim)					14	0.14	
					21	0.04	
CA, 1983	WP	1.12		10	7	0.23, 0.27	GH-C 1757
(Sweet Pimiento)					14	0.22, 0.18	
					21	0.10, 0.09	
CA, 1983	WP	1.12		7	7	0.10	GH-C 1757
(Bell)					14	0.05	
					21	0.01	
FL, 1983	WP	1.12		10	0	0.27, 0.13, 0.12, 0.10	GH-C 1757
(Early CA Wonder)					7	0.13, 0.07, 0.10, 0.08	
					14	0.13, 0.08, 0.06, 0.03	
					21	0.04, 0.02, 0.04, 0.02	
Fl, 1983	WP	1.12		10	0	0.89, 0.78, 0.90, 0.63	GH-C 1757
(Early CA Wonder)					7	0.47, 0.52, 0.60, 0.35	
					14	0.33, 0.47, 0.33, 0.33	
					21	0.38, 0.32, 0.19, 0.10	
MS, 1984	WP	1.12		10	7	0.06	GH-C 1757
(Yolo Wonder)					14	0.02	
					21	0.01	
NJ, 1983	WP	1.12		10	7	0.81	GH-C 1757
(Yolo Wonder L)					14	0.43	
					21	0.18	
NY, 1982	WP	1.12		8	8	0.30	GH-C 1757
(Skipper)					15	0.12	
					22	0.10	
OR, 1983	WP	1.12		8	7	0.48	GH-C 1757
(California Wonder)					14	0.39	
					21	0.16	
CA, Davis, 1983	WP	1.12		7	7	0.04, 0.10	GH-C 1757
(Yolo Wonder)					14	0.02, 0.07	
					21	0.01, 0.01	

[1] LOQ 0.01 mg/kg

Tomatoes. Supervised trials were carried out in Australia, Brazil, Mexico, Spain and the USA from 1975 to 1995.

In a trial in Brazil, tomatoes were treated 6 times at 0.72 or 1.4 kg ai/ha with an EC formulation and harvested 3-21 days after the final application (Pinto and Gagnotto, 1994).

Tomatoes in Mexico were treated three times with EC at 0.96 kg ai/ha at weekly intervals by ground and aerial applications and samples were taken one day after each application and 3, 7 and 14 days after the last application (Miller and Ervick, 1976).

In trials in Spain in 1995 the WG 750 or EC 480 formulation was applied once to tomatoes 7 days before normal harvest at 0.065 kg ai/hl and 0.695 kg ai/ha and samples taken 0 to 7 days after treatment (Portwood, 1996c).

Table 63. Residues of chlorpyrifos in tomatoes after foliar application of an EC Formulation in Brazil, Mexico and Spain.

Location, (Variety) Year	Application			PHI, days	Chlorpyrifos, mg/kg[1]	Reference/comment
	kg ai/ha	kg ai/hl	No.			
GAP- Brazil	0.72		7	21		480 g/l EC
Mogi Mirim (Peixe) 1992	0.72		6	3 7 14 21	0.18, 0.30, 0.24 0.12, 0.09, 0.18 0.03, 0.03, 0.02 0.02, 0.03, 0.01	GHB-P 159. 300l/ha for first two applications; 900 l/ha for last 4 applications.
	1.4		6	21	0.03, 0.03, 0.06	
GAP- Mexico	1.0 0.96			1 1		500 WP 480 g/l EC
Mexico, 1976	0.96		1 2 3 3 3 3	1 1 1 3 7 14	0.01, 0.01, 0.01, <0.01 0.02, 0.01, 0.01, 0.01 0.02, 0.06, 0.04, 0.01 0.01, 0.02, 0.01, 0.01 0.01, 0.02, 0.01, 0.01 0.01, 0.01, 0.01, <0.01	GH-C 952 EC
Mexico, 1976	0.96		1 2 3 3 3 3	1 1 1 3 8 15	0.07, 0.19, 0.16, 0.13 0.12, 0.08, 0.15, 0.19 0.17, 0.11, 0.03, 0.13 0.07, 0.07, 0.07, 0.06 0.04, 0.02, 0.03.0.04 0.05, 0.03, 0.04, 0.02	GH-C 952 EC
Mexico, 1976	0.96		1 2 3 3 3 3	1 1 1 3 8 15	0.13, 0.12, 0.08, 0.22 0.13, 0.14, 0.33, 0.13 0.24, 0.08, 0.20, 0.07 0.10, 0.16, 0.12, 0.15 0.06, 0.17, 0.03, 0.03 0.23, 0.04, 0.03, 0.02	GH-C 952 EC
GAP- Spain	(1.2) (1.2)	0.10 0.096	2 3	7 7		WP 250g/kg EC 480 g/l
Spain, 1995		0.065	1	0 3 5 7	0.27[2] 0.11[2] 0.09[2] 0.06[2]	GHE-P 5495 WG
Spain, 1995		0.065	1	0 3 5 7	0.27[2] 0.12[2] 0.12[2] 0.08[2]	GHE-P 5495 EC

[1] LOQ 0.01 mg/kg in all trials. Recoveries averaged 94% from the Mexican trials, 92% from the Brazilian trials and 103% from the Spanish trials.
[2] Average of duplicate analyses

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Two trials in Australia (1975) were at 0.05 kg ai/hl and 0.10 kg ai/hl, each in triplicate. The plants received seven treatments. Tomato samples were taken at intervals up to 21 days after the last treatment (Tucker, 1975).

Four decline trials were carried out during 1978 in South Africa, with single applications at rates of 0.048, 0.072, 0.096 and 0.192 kg ai/hl and samples taken at intervals up to 29 days after treatment (Iosson, 1979).

Table 64. Residues of chlorpyrifos in tomatoes from supervised trials in Australia and South Africa.

Country, year	Application				PHI, days	Residues, mg/kg [1,2]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Australia	500 EC	(1.0)	0.10	7-10	3		Foliar
Australia, 1975	EC		0.05	7	0	0.20, 0.23, 0.26	GHF-P 030
					1	0.07, 0.10, 0.05	
					3	0.01, 0.02, 0.01	
					10	<0.01, <0.01, <0.01	
					14	<0.01, <0.01, <0.01	
					21	<0.01, <0.01, <0.01	
Australia, 1975	EC		0.10	7	0	0.25, 0.37, 0.27	GHF-P 030
					1	0.13, 0.24, 0.26	
					3	0.12, 0.13, 0.06	
					10	0.02, 0.02, 0.01	
					14	<0.01, <0.01, <0.01	
					21	<0.01, <0.01, <0.01	
GAP-S. Africa	EC		0.096	multiple	4		
South Africa,	EC		0.048	1	0	0.12 [3]	GHE-P 664
1978					1	0.10 [3]	
					4	0.12 [3]	
					7	0.06 [3]	
					14	0.05 [3]	
					20	0.03 [3]	
					29	<0.01 [3]	
South Africa,	EC		0.072	1	0	0.22 [3]	GHE-P 664
1978					1	0.18 [3]	
					4	0.19 [3]	
					7	0.23 [3]	
					14	0.07 [3]	
					20	0.01 [3]	
					29	0.01 [3]	
South Africa,	EC		0.096	1	0	0.16 [3]	GHE-P 664
1978					1	0.24 [3]	
					4	0.19 [3]	
					7	0.23 [3]	

Country, year	Application				PHI, days	Residues, mg/kg [1,2]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
					14	0.10 [3]	
					20	0.03 [3]	
					29	0.02 [3]	
South Africa,	EC		0.192	1	0	0.75 [3]	GHE-P 664
1978					1	1.1 [3]	
					4	0.89 [3]	
					7	0.59 [3]	
					14	0.26 [3]	
					20	0.06 [3]	
					29	0.05 [3]	

[1] LOQ 0.01 mg/kg
[2] Recoveries averaged 96% from the Australian trials and 97% from the South African trials
[3] Average of duplicate analyses

Chlorpyrifos EC was applied as a directed ground application in two trials in the USA (1979) at 1.12 kg ai/ha. Six or seven applications were made following a weekly or biweekly schedule during the fruiting season and samples were collected 3, 7 and 14 days after the last application (Miller, 1980b).

In another US trial in 1982 at 12 locations ten weekly applications of EC formulation were made to tomatoes during the vegetative and reproductive stages at 1.12 kg ai/ha and samples taken 0, 7, 14 and 21 days after the last application (Miller, 1983a).

In thirteen trials in seven US States in 1983 the 50W or 4E formulation was applied to the tomatoes at 1.12 kg ai/ha. The first application was made after transplant and the subsequent 7-12 sprays were applied at 10-14 day intervals with samples taken 7, 14 and 21 days after the last application (Miller, 1985b).

Table 65. Residues of chlorpyrifos in tomatoes from supervised trials in the USA.

Location, year	Application			PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	No.			
GAP-USA NONE						
GAP-Mexico[2]	EC 480 g/l WP 500 g/kg	0.96 1.0		1 1		
GA, 1979	EC	1.12	7	0	0.11, 0.22, 0.20, 0.15	GH-C 1372
				7	0.10, 0.06, 0.09, 0.10	Directed ground
				14	0.03, 0.02, 0.03, 0.02	
OH, 1979	EC	1.12	6	0	0.14, 0.23,,	GH-C 1372
				7	0.12, 0.17, 0.21, 0.13	Directed ground
				14	0.14, 0.13, 0.14, 0.09	
FL, 1982	EC	1.12	10	0	0.08	GH-C 1641
Floradale)				7	0.24	Foliar
				14	0.03	
				21	0.03	
FL, 1982	EC	1.12	9	0	0.17	GH-C 1641

Location, year	Application			PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	No.			
(Burgis)				7	0.3	Foliar
				14	0.02	
				21	0.04	
FL, 1982	EC	1.12	10	0	0.10	GH-C 1641
(Floradale)				7	0.19	Foliar
				14	0.02	
				21	0.05	
MI, 1982	EC	1.12	10	0	0.14	GH-C 1641
(G-465)				7	0.09	Foliar
				14	0.11	
				21	0.02	
SC, 1982	EC	1.12	10	0	0.43	GH-C 1641
(Floradale)				7	0.11	Foliar
				14	0.10	
				21	0.18	
IL, 1982	EC	1.12	10	0	0.41	GH-C 1641
(Campbell C-28)				7	0.24	Foliar
				14	0.31	
				21	0.22	
IN, 1982	EC	1.12	10	0	0.24	GH-C 1641
(Campbell C-28)				7	0.14	Foliar
				14	0.06	
				21	0.09	
CA, 1982	EC	1.12	10	0	0.49	GH-C 1641
(Ace)				7	0.07	Foliar
				14	0.06	
				21	0.02	
NY, 1982	EC	1.12	10	0	0.70	GH-C 1641
(Jet Star)				7	0.81	Foliar
				14	0.56	
				21	0.36	
PA, 1982	EC	1.12	10	0	1.5	GH-C 1641
(Floradale)				7	0.82	Foliar
				14	0.84	
				21	0.30	
GA, 1982	EC	1.12	10	0	0.57	GH-C 1641
(Walter)				7	0.08	Foliar
				14	0.25	
MA, 1982	EC	1.12	10	0	0.28	GH-C 1641
(Jet Star)				1	0.12	Foliar
				7	0.04	
				14	0.03	
				21	0.02	
FL, 1983	WP	1.12	8	7	0.12	GH-C 1757

Location, year	Application			PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	No.			
(Floradale)				14	0.06	Foliar
				21	0.08	
IL, 1983	WP	1.12	10	7	0.02	GH-C 1757
(Golden Boy)				14	0.01	Foliar
				21	0.02	
MI, 1983	WP	1.12	9	7	0.01	GH-C 1757
(Glamour)				14	0.01	Foliar
				21	<0.01	
MS, 1984	WP	1.12	10	7	0.05	GH-C 1757
(Floradale)				14	0.04	Foliar
				21	0.01	
NJ, 1983	WP	1.12	10	7	0.32	GH-C 1757
(1327)				14	0.05	Foliar
				21	0.02	
OR, 1983	WP	1.12	10	7	0.05	GH-C 1757
(Willamette)				14	0.07	Foliar
				21	0.01	
CA, 1983	WP	1.12	10	7	0.02	GH-C 1757
(Ace 55)				14	0.02	Foliar
				21	0.01	
CA, 1983	EC (4E)	1.12	10	7	0.10	GH-C 1757
(Ace 55)				14	0.10	Foliar
				21	0.06	
CA, 1983	EC (1E)	1.12	10	7	0.11	GH-C 1757
(Ace 55)				14	0.04	Foliar
				21	0.01	
FL, 1983	WP	1.12	9	7	0.12	GH-C 1757
(Sunny)				14	0.03	Foliar
				21	0.03	
FL, 1983	EC (1E)	1.12	9	7	0.11	GH-C 1757
(Sunny)				14	0.05	foliar
				21	0.02	
MI, 1983	WP	1.12	7	7	0.04	GH-C 1757
(Pik Red)				14	0.10	Foliar
				21	0.02	
MI, 1983	EC(1E)	1.12	7	7	0.39	GH-C 1757
(Pik Red)				14	0.14	Foliar
				21	0.01	

[1] LOQ 0.01 mg/kg
[2] None of the trials were in geographic zones corresponding to those of Mexico

Egg plant. In a trial in 1972 in Turkey chlorpyrifos was applied as a directed spray to egg plants and other fruiting vegetables at 0.96 kg ai/ha. Samples were collected 0, 7 and 14 days after application. The results for egg plants are shown in Table 66 (Hollick and Collison, 1972).

Table 66. Residues of chlorpyrifos in egg plant from supervised trials in Turkey.

Year	Application				PHI, days	Residues, mg/kg	References
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Turkey NONE							
1972	EC	0.96		3	0	0.33	GHE-P 101
					7	0.03	
					14	0.02	

Leafy vegetables

Lettuce. Two trials were reported from Spain. Immature head lettuce at the 6-8 leaf stage were treated with an EC formulation (Butcher and Teasdale, 1990).

Table 67. Residues of chlorpyrifos and TCP in head lettuce from the foliar application of an EC formulation in Spain.

Location, (Variety) Year	Application			PHI, days	Residue, mg/kg		Reference
	kg ai/ha	kg ai/hl	No.		CP	TCP	
GAP- Spain	(0.3)	0.10		21			
S Jaume D'enveja, Spain (Eugenia) 1989	0.48		2	19 25	0.10 <0.02	0.25 <0.05	GHE-P 2194
Amposta, Spain (Ruver) 1989	0.48		2	19 25	0.23 0.08	0.22 0.13	

Several supervised trials in the USA were carried out to establish MRLs for head and leaf lettuce. Proposed GAP is eight applications as a directed spray at 1.12 kg ai/ha and a PHI of 21 days, the first application to be made within three weeks of planting and subsequent applications at 4- to 14-day intervals (Woods, 1984).

The results are shown in Tables 68 and 69.

Table 68. Residues of chlorpyrifos in head lettuce from supervised trials in the USA.

Location, year (Variety)	Application			PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	No.			
GAP-USA NONE						
CA, 1983	WP	1.12	7	7	1.8	GH-C 1696
				14	0.20	
				21	0.02	
CA, 1983	EC (4E)	1.12	8	7	0.63	GH-C 1696
(Great Lakes)				14	0.42	
				21	0.27	
CA, 1983	WP	1.12	8	7	0.53	GH-C 1696

Location, year (Variety)	Application			PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	No.			
(Great lakes)				14	0.77	
				21	0.33	
CA, 1983	WP	1.12	6	7	0.12, 0.09, 0.10, 0.17	GH-C 1696
(Iceberg)				13	0.03, 0.08, 0.05, 0.01	
				21	0.03, 0.01, 0.01, 0.06	
CA, 1982	WP	1.12	10	7	<0.01, 0.01, 0.03, 0.05	GH-C 1696
(Iceberg)				14	0.02, 0.04, 0.03, 0.03	
				21	<0.01, 0.01, 0.01, 0.02	
FL, 1982	WP	1.12	4	7	2.6, 1.2, 1.6, 3.7	GH-C 1696
(Great Lakes)				14	0.03, 0.05, 0.40, 0.07	
				21	0.01, 0.01, 0.01, 0.01	
FL, 1983	EC (4E)	1.12	7	7	0.35	GH-C 1696
(Mesa 654)				14	0.25	
				21	0.13	
FL, 1983	WP	1.12	7	7	0.66	GH-C 1696
(Mesa 654)				14	0.32	
				21	0.15	
FL, 1983	1 E	1.12	7	7	0.53	GH-C 1696
(Mesa 654)				14	0.13	
				21	0.12	
FL, 1983	WP	1.12	5	7	0.55	GH-C 1696
(Iceberg)				14	0.02	
				21	<0.01	
IL, 1983	WP	1.12	5	7	0.01	GH-C 1696
(Iceberg)				14	0.01	
				21	0.01	
MI, 1983	WP	1.12	5	7	0.49	GH-C 1696
				14	0.36	
				22	0.03	
MI, 1983	EC (4E)	1.12	7	7	0.12	GH-C 1696
(Ithaca)				14	0.05	
				21	0.04	
MI, 1983	WP	1.12	7	7	0.14	GH-C 1696
				14	0.04	
				21	0.06	
MI, 1983	1 E	1.12	7	7	0.15	GH-C 1696
				14	0.03	
				21	0.06	
OR, 1983	WP	1.12	8	7	0.17	GH-C 1696
(Great Lakes)				14	0.33	
				21	0.09	

[1] LOQ 0.01 mg/kg

Table 69. Residues of chlorpyrifos in leaf lettuce from supervised trials in the USA.

Location, year (Variety)	Application			PHI, days	Residues, mg/kg[1]	Reference
	Form.	kg ai/ha	No.			

Location, year (Variety)	Application			PHI, days	Residues, mg/kg[1]	Reference
	Form.	kg ai/ha	No.			
GAP-USA NONE						
CA, 1983	WP	1.12	7	7	0.57	GH-C 1696
				14	0.06	
				21	0.07	
CA, 1983	EC	1.12	8	7	3.6	GH-C 1696
(Royal Oak Leaf)				14	0.32	
				21	0.84	
CA, 1983	WP	1.12	8	7	2.7	GH-C 1696
(Royal Oak Leaf)				14	0.81	
				21	0.64	
CA, 1983	WP	1.12	5	9	0.43	GH-C 1696
(Paris Island)				14	0.19	
				21	0.03	
FL, 1983	WP	1.12	5	7	0.95	GH-C 1696
(Valmaine)				14	0.35	
				21	0.07	
FL, 1983	WP	1.12	5	7	5.6	GH-C 1696
(Boston)				14	0.29	
				21	0.09	
IL, 1983	WP	1.12	5	7	1.8	GH-C 1696
(Black Seeded Simpson)				14	0.05	
				21	0.02	
MA, 1983	WP	1.12	4	7	7.0	GH-C 1696
(Salad Bowl)				14	0.01	
				21	0.07	
MI, 1983	WP	1.12	5	7	1.1	GH-C 1696
Leaf Lettuce				14	0.17	
				21	0.04	
MI, 1983	WP	1.12	5	7	0.08	GH-C 1696
(Grand Rapids)				14	0.17	
				22	0.01	
OR, 1983	WP	1.12	6	7	2.2	GH-C 1696
(Chicken)				14	0.06	
				21	0.02	
TX, 1983	WP	1.12	9	7	0.42	GH-C 1696
(Black Seeded Simpson)				14	0.11	
				21	0.05	

[1] LOQ 0.01 mg/kg

Legumes

Common beans. Supervised trials were conducted in Italy from 1992 to 1994 and in the USA from 1969 to 1972. The results are shown in Tables 70 and 71 respectively.

In three residue trials at different locations in Italy single applications of EC (228 g ai/l) was made to field bean plants at the flowering stage at a spray concentration of 0.14 kg ai/hl, 0.57 kg ai/ha.

Whole plant samples were taken at intervals for 9 days. Beans with pods and the rest of the plant were sampled separately at normal harvest after 15 days (Khoshab *et al.*, 1993h).

In a trial in Italy in 1994 single applications of EC (480 g ai/l) were sprayed on field bean plants at flowering stage at 0.57 kg ai/ha, 0.14 kg ai/hl. Whole plants were sampled 0, 5, 10 and 14 days after application, and pods and the rest of the plant separately at normal harvest 20 days after application (Khoshab, 1995d).

Table 70. Residues of chlorpyrifos in common beans from supervised trials in Italy.

Year, sample	Application				PHI, days	Residues, mg/kg [1,2]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Italy	EC	0. 53	(0.09)		15		
1992	EC	0.57	0.14	1	0	23	GHE-P 3231
whole plant					5	2.8	
whole plant					9	1.3	
beans with pods					15	0.05	
rest of plant					15	0.53	
1992	EC	0.57	0.14	1	0	45	GHE-P 3231
whole plant					6	1.6	
whole plant					10	0.52	
beans with pods					15	<0.01	
rest of plant					15	0.09	
1992	EC	0.57	0.14	1	0	35	GHE-P 3231
whole plant					4	5.4	
whole plant					10	0.78	
beans with pods					15	<0.01	
rest of plant					15	0.14	
1994	EC	0.57	0.14	1	0	20	GHE-P 4515
whole plant					5	2.3	
whole plant					10	0.59	
whole plant					14	0.15	
pods					20	<0.01	
rest of plant					20	0.04	

[1] Average of duplicate analyses
[2] LOQ 0.01 mg/kg

In trials in several US States in 1969-1972, snap bean seeds were treated before planting with WP slurries containing 25% or 50% ai, at 0.63 to 1.9 g ai/kg seeds. Green plant samples were collected at various stages of growth, and beans at harvest (McKellar and Dishburger, 1973).

Similar trials were carried out on field and kidney beans during 1972-1976. The seeds were treated with chlorpyrifos at rates up to 2.5 g ai/kg of seeds before planting. Beans, pods and vines were collected at normal harvest time, and whole plants 4 and 6 weeks after planting (Norton, 1978).

The results are shown in Table 71.

Table 71. Residues of chlorpyrifos from seed treatment of common beans in supervised trials in the USA.

Location, Year, Sample	Application			PHI, days	Residues, mg/kg [1,2]	Reference/ Comments
	Form.	g ai/ kg	No.			
GAP-USA	WP (SL)	0.62	1	NA		Seed treatment
MS, 1972						
Kidney beans, shelled	WP	1.9	1	93	<0.01, 0.01, 0.01, <0.01	GH-C 1157
Kidney bean pods	WP	1.9	1	93	0.01, 0.01, 0.02, 0.01	
Kidney bean vines	WP	1.9	1	93	0.02, 0.02, 0.02, 0.01	
IL, 1973						
Kidney beans & pods	WP	1.9	1	117	0.01, 0.01, 0.01	GH-C 1157
Kidney bean vines	WP	1.9	1	117	0.01, 0.01, 0.01	
MS, 1973						
Kidney beans & pods	WP	1.9	1	106	0.03, 0.02, 0.08	GH-C 1157
Kidney bean vines	WP	1.9	1	106	0.07, 0.04, 0.06	
NY, 1973						
Kidney beans & pods	WP	1.9	1	75	<0.01, 0.01, <0,01	GH-C 1157
Kidney bean vines	WP	1.9	1	75	<0.01, <0.01, <0.01	
NY, 1974						
Kidney beans & pods	WP	1.2	1	105	0.01, 0.01, 0.01, 0.01	GH-C 1157
Whole plant	WP	1.2	1	28	0.05, 0.09,0.03, 0.03	
Whole plant	WP	1.2	1	41	0.09, 0.18, 0.03, 0.07	
Kidney bean vines	WP	1.2	1	105	0.26, 0.03, 0.03, 0.02	
CA, 1976						
Kidney beans	WP	1.2	1	161	0.01	GH-C 1157
Kidney bean vines	WP	1.2	1	161	0.01, 0.14	
MI, 1972						
Field beans	WP	0.63	1	114	0.01	GH-C 1157
		1.2	1	114	0.01	
		2.5	1	114	0.02	
Field bean vines	WP	0.63	1	114	0.05	
		1.2	1	114	0.02	
		2.5	1	114	0.86	
WI, 1971						
Snap bean plant	WP	0.63	1	16	≤0.01	GH-C 660
		0.63	1	28	<0.01	
		0.63	1	58	<0.01	
Snap bean plants	WP	1.9	1	16	0.01	GH-C 660
		1.9	1	28	0.01	
		1.9	1	58	<0.01	
Beans (with pod)	WP	0.63	1	58	≤0.01	
		1.9	1	58	<0.01	
NY, 1971	WP	0.63	1	31	<0.01	GH-C 660
Snap bean plant		0.63	1	31	0.03	
		0.63	1	46	<0.01	
		0.63	1	58	0.01	
Snap bean plant	WP	1.9	1	31	0.22	
		1.9	1	46	<0.01	

Location, Year, Sample	Application			PHI, days	Residues, mg/kg [1,2]	Reference/ Comments
	Form.	g ai/ kg	No.			
		1.9	1	58	<0.01	
Beans (with pod)	WP	0.63	1	58	≤0.01	
		1.9	1	58	<0.01	
MS, 1971	WP	0.63	1	28	0.04, 0.05, 0.06, 0.06	GH-C 660
Green plant		0.63	1	43	0.01, 0.01, <0.01, <0.01	
		0.63	1	59	0.01, 0.01, 0.04, 0.03	
Green plant	WP	1.9	1	28	0.28, 0.07, 0.16, 0.41	
		1.9	1	43	0.01, 0.01, 0.02, 0.01	
		1.9	1	59	0.14, 0.18, 0.17, 0.05	
Beans (with pod)	WP	0.63	1	58	<0.01, <0.01, <0.01,<0.01	
		1.9	1	58	<0.01, <0.01, <0.01, 0.01	
FL, 1972	WP	0.63	1	28	0.01, 0.01, 0.01, 0.01	GH-C 660
Green Plant		0.63	1	41	0.01, <0.01, 0.01, <0.01	
		0.63	1	57	<0.01, <0.01, <0.01, 0.01	
Green Plant	WP	1.9	1	28	0.03, 0.04, 0.02, 0.02	
	WP	1.9	1	41	0.01, 0.02, 0.02, 0.02	
	WP	1.9	1	57	0.01, 0.01, 0.01, 0.02	
Beans (with pod)	WP	0.63	1	57	<0.01, <0.01, <0.01, 0.01	GH-C 660
	WP	1.9	1	57	<0.01, <0.01, <0.01, 0.01	
OR, 1971	WP	0.63	1	48	0.24, 0.59, 0.45, 0.29	GH-C 660
Green Plant	WP	0.63	1	61	<0.01, <0.01, <0.01, ≤0.01	
	WP	1.9	1	48	1.4, 1.4, 1.1, 1.3	
	WP	1.9	1	61	0.01, <0.01, 0.01, 0.07	
IL, 1969	WP	1.2	1	55	<0.01	GH-C 660
Green plant				57	<0.01	
				59	<0.01, <0.01	
				60	<0.01, <0.01	
Beans (with pod)	WP	1.2	1	55	<0.01	GH-C 660
				57	<0.01	
				59	<0.01, <0.01	
				60	<0.01, <0.01	
				61	<0.01, <0.01, <0.01	

[1] LOQ 0.01 mg/kg
[2] Recoveries averaged 92% from snap beans, 98% from kidney beans and pods, 91% from kidney bean vines and whole plants, 88% from field beans and 89% from field beans and vines

Peas. Supervised trials on peas were carried out in the USA, 1972-1976, and in the UK in 1975 and 1992-1993. The results are shown in Tables 72 and 73.

In the US trials seeds were treated before planting with a slurry of chlorpyrifos (25% or 50% WP) at 0.63 to 1.9 g ai/ kg seeds. Samples of peas, pods and vines were collected at normal harvest, and whole plants from one location four and six weeks after planting (Norton, 1979).

Table 72. Residues of chlorpyrifos from seed treatment of peas in supervised trials in the USA.

Location, Year	Application			PHI, days	Residues, mg/kg [1]	Reference/ Comment
	Form.	g ai/kg	No.			
GAP-USA	WP (SL)	0.62	1	NA		Seed treatment
IL, 1972						
peas + pods	WP	0.63	1	61	0.01	GH-C 1158
				64	0.01	
				68	0.01	
				70	<0.01	
				77	0.01, 0.01	
vines	WP	0.63	1	61	0.01	
				68	0.01	
MS, 1972						
peas (shelled)	WP	1.9	1	46	0.15	GH-C 1158
vines				46	1.1	
MS, 1973						
peas (shelled)	WP	1.9	1	52	0.01	GH-C 1158
IL, 1974						
peas + pods	WP	0.63	1	58	<0.01, <0.01, ≤0.01	GH-C 1158
vines	WP	0.63	1	58	0.02, 0.01, 0.01	
IL, 1975						
peas + pods	WP	1.2	1	59	<0.01, <0.01, 0.01, <0.01	GH-C 1158
vines	WP	1.2	1	59	0.01, 0.01, 0.01, 0.03	
WA, 1975						
peas + pods	WP	0.63	1	73	0.01, 0.01, 0.01, 0.01	GH-C 1158
vines	WP	0.63	1	73	0.03, 0.04, 0.05, 0.10	
NY, 1976						
peas + pods	WP	0.63	1	68	0.01, 0.01, 0.01, 0.01	GH-C 1158
vines	WP	0.63	1	68	0.09, 0.09, 0.09, 0.17	

[1] LOQ was 0.05 mg/kg with recoveries averaging 81% from peas and pods and 82% from plants and vines.

In three trials (two on vining peas and one on edible podded peas) at different locations in the UK in 1992 single applications of EC was sprayed onto the plants at 0.36 kg ai/hl, 0.72 kg ai/ha. Whole plant samples were taken at intervals until harvest when peas were sampled separately (Khoshab *et al.*, 1993i).

Two other trials in 1993 were similar to the above. Samples of peas were taken at harvest (69 or 75 days after application). Each sample consisted of four replicates which were analysed separately (Khoshab and Berryman, 1994e).

In 1975 in two trials in the UK, peas were treated at 0.75 kg ai/ha and sampled approximately 30 days later (Hollick and Walker, 1976c).

The results of trials in the UK are shown in Table 73.

Table 73. Residues of chlorpyrifos in peas from supervised trials in the UK (foliar application).

Year, Sample	Application				PHI, days	Residues, mg/kg[1,2]	Reference/ Comment
	Form.	g ai/ha	kg ai/ hl	No.			

Year, Sample	Application				PHI, days	Residues, mg/kg[1,2]	Reference/ Comment
	Form.	g ai/ha	kg ai/ hl	No.			
GAP-UK	480 EC	0.72	(0.36)	2	21		Foliar treatment
1992							
whole plant	EC	0.72	0.36	1	0	22	GHE-P 3232
					21	0.07	
					48	0.03	
					57	0.03	
rest of plant					78	<0.01, <0.01	
pods + peas					78	<0.01, <0.01	
1992							
whole plant	480 EC	0.72	0.36	1	0	39	GHE-P 3232
					21	0.04	
					48	<0.01	
rest of plant					59	<0.01, <0.01	
pods + peas					59	<0.01, <0.01	
1992							GHE-P 3232
whole plant	480 EC	0.72	0.36	1	0	47	
					21	0.02	
					48	<0.01	
rest of plant					64	0.01	
peas					64	<0.01	
1993							
peas	480 EC	0.72	0.36	1	75	<0.01, <0.01,	GHE-P 3487
						<0.01, <0.01	
1993							
peas	480 EC	0.72	0.36	1	69	<0.01	GHE-P 3487
1975 peas	480 EC	0.75	0.13	1	33	<0.01	GHE-P 437
1975 peas	480 EC	0.75	0.13	1	30	<0.01	GHE-P 437

[1] Average of duplicate analyses
[2] LOQ 0.01 mg/kg

Soya beans. Supervised trials on soya beans in 1975 and 1976 in seven locations in the midwest, south and southwestern States of the USA were reported. EC was applied as a broadcast directed spray at emergence followed by 3 or 4 foliar applications during the growing season at rates ranging from 0.56 to 2.2 kg ai/ha at emergence and 0.56 to 1.1 kg ai/ha at each foliar treatment and total rates of 3.36 to 5.5 kg ai/ha. Samples of green forage were taken at intervals from 0 to 22 days after the last application and straw and beans at normal harvest (28-51 days after the last treatment) as shown in Table 74 (Miller, 1979a).

Table 74. Residues of chlorpyrifos in soya beans from supervised trials in the USA (foliar application).

Location, year	Application			PHI, days	Residues, mg/kg[1,2]	Reference/ Comment
	Form.	kg ai/ha	No.			
GAP-USA	EC	1.1		NA		Pre-plant through post-emergence
	EC	1.1	3	28		Foliar broadcast
	G	1.5 (30 inch row space)	1	NA		At planting, post-plant, incorporated.
IL, 1975						
Green forage	EC	2.2 + 0.56 (x2) + 1.1	4	1	39, 21, 45	GH-C 1224
				7	7.8, 6.4, 6.3	
				14	5.5, 3.4, 3.5	
				22	3.6, 1.4, 1.7	
Straw	EC	2.2 + 0.56 (x2) + 1.1	4	51	12, 6.7, 2.9	
Soya beans	EC	2.2 + 0.56 (x2) + 1.1	4	51	0.02, 0.01, 0.01	
MS, 1975						
Green forage	EC	0.56 (x2) + 1.12 (x2)	4	0	35, 52, 62	GH-C 1224
				7	11, 12, 8.9	
				14	2, 1.4, 1.4	
				21	0.38, 0.01, 0.20	
Straw	EC	0.56 (x2) + 1.12 (x2)	4	28	1.5, 7.6, 1.4	
MS, 1975						
Soya beans	EC	0.56 (x2) + 1.12 (x2)	4	28	<0.01, <0.01, ≤0.01	GH-C 1224
GA, 1975						
Straw	EC	2.2 + 0.56 (x2) + 1.1	4	30	1.6, 1.6, 1.8	GH-C 1224
Soya beans	EC	2.2 + 0.56 (x2) + 1.1	4	30	<0.01, <0.01, ≤0.01	
IL, 1976						
Straw	EC	2.2 + 0.56 (x2) + 1.1 (x2)	5	28	0.87, 0.27, 0.45	GH-C 1224
Soya beans	EC	2.2 + 0.56 (x2) + 1.1 (x2)	5	28	0.01, 0.01, <0.01	
IA, 1975						
Straw	EC	2.2 + 0.56 (x2) + 1.1 (x2)	5	30	1.1, 0.70, 0.70	GH-C 1224
Soya beans	EC	2.2 + 0.56 (x2) + 1.1 (x2)	5	30	0.02, 0.05, 0.02	
NE, 1975						
Straw	EC	2.2 + 0.56 (x2) + 1.1 (x2)	5	31	0.47, 0.51, 0.45	GH-C 1224
Soya beans	EC	2.2 + 0.56 (x2) + 1.1 (x2)	5	31	0.01, 0.01, 0.01	
NC, 1975						
Straw	EC	2.2 + 0.56 (x2) + 1.1 (x2)	5	38	2.1, 2.2, 1.6	GH-C 1224
Soya beans	EC	2.2 + 0.56 (x2) + 1.1 (x2)	5	38	0.01, 0.24, 0.14	

[1] LOQ 0.01 mg/kg
[2] Recoveries averaged 89% from green forage, 85% from straw and 88% from soya beans

The Government of Thailand reported four field trials conducted in 1988, 1995 and 1996. In the first two trials an EC formulation was applied 9 times at 0.94 or 1.9 kg ai/ha. In the 1995 trial an EC formulation was applied 4 times at 0.12 or 0.24 kg ai/ha and samples taken 7, 14 and 21 days after the final application. In the 1996 trial, an EC formulation was applied 4 times at 0.12 or 0.24 kg ai/ha and dry seeds were sampled 8, 15 and 22 days after the last application. The pods were dried in the sun before removing the seeds. Samples were analysed by The Netherlands multi-residue method. No recoveries were reported (Thai Industrial Standards Institute, Bangkok, Thailand). The conditions and findings are shown in Table 75.

Table 75. Residues of chlorpyrifos in soya beans from foliar applications of an EC Formulation in field trials in Thailand.

Location, Year	Application			PHI, days	Residue, mg/kg[1]	Reference/ Comment
	kg ai/ha	kg ai/hl	No.			
GAP- Thailand	0.75	0.12		7		EC 200 g/l
Nakronsawan Field Crop Research Center, 1988	0.94	0.12	9	15	<0.01	Govt of Thailand EC 200 g/l 4 replicate plots, each 5 x 8 m.
	1.9	0.24	9	15	<0.01	
Nakronsawan Crop Research Center, 1988	0.44	0.12	9	14	<0.01	Govt of Thailand EC 200 g/l 4 replicate plots, each 5 x 8 m.
	1.9	0.24	9	14	<0.01	
Saraburi Province, 1995	0.75	0.12	4	7 14 21	0.23 0.06 0.02	Govt of Thailand EC 400 g/l 4 replicate plots, each 6 x 12 m.
	1.5	0.24	4	7 14 21	0.32 0.06 0.11	
Chainat Province, 1996	0.75	0.12	4	8 15 22	1.6 0.97 0.09	Govt of Thailand EC 400 g/l 4 replicate plots, each 8 x 8 m
	1.5	0.24	4	8 15 22	2.9 1.4 0.82	

[1] Reported limit of detection 0.001 mg/kg.

Root and tuber vegetables

Carrots. Supervised trials were conducted in South Africa in 1976, in the UK in 1976-1977 and 1995 and in The Netherlands in 1995. The results are shown in Table 77.

In two trials in South Africa carrots were treated four times at approximately monthly intervals with an EC formulation at 0.48 kg ai/ha (GAP) and 0.72 kg ai/ha. Samples from both trials were taken 1, 3, 7, 21 and 28 days after the last application (Hollick and Walker, 1978a).

Three trials were carried out in the UK in 1975-1976. In one carrots were treated at 1.44 kg ai/ha with samples taken 49 days after treatment, and in the other two at 1.2 and 0.96 kg ai/ha with samples taken 15, 24 and 30 days after application (Hollick and Walker, 1977).

In two late-season trials in the UK in 1995 two applications of chlorpyrifos WG (750 g ai/kg) formulation were sprayed on carrots at 0.96 kg ai/ha and 0.16 kg ai/hl. The carrots were sampled at harvest 14 days after the last application (Portwood and Williams, 1996n).

In two trials at different locations in The Netherlands in 1995 chlorpyrifos was sprayed twice at 21-day intervals at 0.96 kg ai/ha and 0.48 kg ai/hl, and samples were taken from 0 to 14 days after the final application (Portwood, 1996d).

Table 76. Residues of chlorpyrifos in carrots from supervised trials in the UK, The Netherlands and South Africa (foliar application).

Country, Year	Application				PHI, days	Residues, mg/kg [1,2,3]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-South Africa	480 EC	0.48	(0.096)		21		
South Africa, 1976	EC	0.48		4	1	0.08	GHE-P 542
					3	0.09	
					7	0.08	
					21	0.05	
					28	0.05	
South Africa, 1976	EC	0.72		4	1	0.31	GHE-P 542
					3	0.10	
					7	0.14	
					21	0.09	
					28	0.07	
South Africa, 1976	EC	0.72		4	1	0.31	GHE-P 542
					3	0.10	
					7	0.14	
					21	0.09	
					28	0.07	
UK	480 EC	0.96	0.48		14		
UK, 1976	EC	0.96		2	15	0.02	GHE-P 439
					24	0.03	
					30	0.02	
UK, 1976	EC	1.2		2	15	0.03	GHE-P 439
					24	0.03	
					30	0.03	
UK, 1975	EC	1.44		2	49	0.03	GHE-P 439
UK, 1995	WG	0.96	0.16	2	14	<0.01, <0.01	GHE-P 5473
GAP -Netherlands NONE. See UK.							
Netherlands, 1995	WG	0.94 + 0.97	0.48	2	0	13	GHE-P 5491
					4	2.18	
					9	1.03	
					14	0.01	
Netherlands, 1995	WG	0.98 + 0.95	0.48	2	0	17.5	GHE-P 5491
					4	2.97	
					9	0.56	
					14	0.03	

[1] Average of duplicate analyses
[2] LOQ 0.01 mg/kg
[3] Recoveries 88% from the 1995 trials and 101% from those in 1975-1977

Potatoes. Two residue field trials were reported from Brazil, where a granular formulation was applied to the furrow at planting. Potato samples were taken at normal harvest, about 100 days after planting (Balderrama and Matos, 1994c). In separate studies at two sites 3-4 applications were made with EC formulations (Balderrama and Matos, 1994d,e). During the 1994-95 season two trials were carried out in Brazil with the EC formulation applied once at planting in furrow according to GAP for the 10G formulation. Samples were collected 103 to 105 days after treatment (Do Amaral, 1999).

Table 77. Residues of chlorpyrifos in potato tubers from the at-planting application to potato fields of a granular formulation.

Location, (Variety) Year	Application		PHI, days	Residue, mg/kg[1]	Reference/ Comment
	kg ai/ha	No.			
GAP- Brazil NONE GAP- Chile GAP-Argentina	 3 2.9	 1 1			 G EC
Mogi-Mirim, Brazil (Achat) 1993	1.5	4	124	0.20;0.03;0.19	GHB-P 218
	3.0	4	124	0.29;0.10;0.14	
	6.0	4	124	0.29;0.08;0.05	
Ouro Fino, Brazil	1.5	4	105	0.17;0.13;0.07	
	3.0	4	105	0.12;0.51;0.23	
	6.0	4	105	0.96;0.66;0.46	
Mogi-Mirim, Brazil (Achat) 1994	0.90	3	21	<0.01	GHB-P 224. Spray volume 400 l/ha
	1.8	3	21	<0.01	
Ouro Fino, Brazil (Chatti) 1994	0.90	4	21	<0.01	GHB-P 224. Spray volume 400 l/ha.
	1.8	4	21	<0.01	
Brazil, 1994	2.9	1	103	0.03, 0.13, 0.08	GHB-P 349 EC formulation
	5.9	1	103	0.27, 0.18, 0.22	
Brazil, 1994	2.9	1	105	0.02, <0.01, 0.02	GHB-P 349 EC formulation
	5.9	1	105	0.03, 0.06, 0.01	

[1] LOQ 0.01 mg/kg.

Table 78. Residues of chlorpyrifos in potato tubers from the foliar application of an EC formulation in Brazil.

Location, (Variety) Year	Application		PHI, days	Residue, mg/kg	Reference
	kg ai/ha	No.			
Brazil GAP	0.72	2	21		
Mogi-Mirim, Brazil (Achat) 1992	0.72	4	21	0.01	GHB-P 194
	1.4	4		0.02	
Guarapuava, Brazil (Bintje)1993	0.72	4	36	0.02	

Location, (Variety) Year	Application		PHI, days	Residue, mg/kg	Reference
	kg ai/ha	No.			
	1.4	4	36	0.03	

In two trials in Australia in 1982 an EC formulation was applied at 3.0 or 1.5 kg ai/ha pre-planting and 0.45 kg ai/ha pre-emergence, and samples taken at harvest 165 days after the pre-emergence application (Vella, 1983).

In trials in Columbia in 1982, potatoes were treated two or three times during the season with the 480 EC formulation at 1.44 and 1.92 kg ai/ha. The tubers were collected from all plots 127 days after the last application (Hollick, 1983).

The government of Poland submitted summary information on two 1994 trials. A foliar application of an EC formulation was made to vines at 0.42 kg ai/ha (Institute of Plant Protection, Poland, 1999).

Table 79: Residues of chlorpyrifos in potatoes from supervised trials in Australia, Columbia and Poland.

Location, year	Application				PHI, days	Residues, mg/kg [1,2,3]	Reference/ comments
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Australia	500 EC	3.0 pre-plant 0.5 hilling up		2			Soil treatment
Australia, 1982	EC	3 + 0.45		2	165	<0.01, <0.01, <0.01, <0.01	PAU 3183 068
Australia, 1982	EC	1.5 + 0.45		2	165	<0.01, <0.01, <0.01, <0.01	PAU 3183 068
GAP-Columbia	480 EC	1.6		2-4	15		
Columbia, 1982	480 EC	1.44		2	127	0.02	GHB-P 013
				3	127	0.03	
Columbia, 1982	480 EC	1.92		2	127	0.02	GHB-P 013
Columbia, 1982				3	127	0.04	
GAP- Poland	268 EC	0.42	0.28	2	30		
Bonin, Poland 1994 (Aster)	278 g/l EC	0.42		1	3 7 14	<0.02 <0.02 <0.02	Institute of Plant Protection, Poland, 1999
Bonin, Poland 1994 (Bogna)	278 g/l EC	0.42		1	49	<0.02	

[1] Average of duplicate analyses
[2] LOQ 0.01 mg/kg for Australia and Columbia, 0.02 mg./kg for Poland.
[3] Recoveries 88-101%

In a trial in South Africa in 1976, foliar applications were made to potatoes three times at 0.72 kg ai/ha, and samples taken at intervals of 1, 3, 7, 14, 21 and 28 days after the last treatment (Freeman, 1976).

In two trials in the UK in 1977, potatoes were treated once or twice with the 480 EC formulation at 0.96 kg ai/ha, and samples taken at normal harvest 34 or 60 days later (Hollick and Walker, 1978b).

Potatoes in Ontario, Canada, were treated with the 480 EC formulation at 0.5 kg ai/ha in nine successive weekly applications, with samples taken 7, 14 and 20 days after the last (Fairbairn and McKellar, 1980).

Table 80. Residues of chlorpyrifos in potatoes from supervised trials in South Africa, the UK and Canada (foliar application).

Country, year	Application				PHI, days	Residues, mg/kg [1,2]	Reference/Comments
	Form.	kg ai/ha	kg ai/hl	No.			
GAP- South Africa	480 EC	0.72 0.48	(0.096)	1	7		Pre-plant 1 m row space. Foliar
South Africa, 1976	480 EC	0.72		3	1	<0.01	GHE-P 560
					3	<0.01	
					7	0.01	
					14	0.01	
					21	0.02	
					28	<0.01	
GAP-UK	480 EC	0.72	(0.36)		21		
UK, 1977	480 EC	0.96		2	34	<0.01	GHE-P 572
UK, 1977	480 EC	0.96		1	60	<0.01	GHE-P 572
GAP-Canada	500 WP	1.1	(0.28)	1	7		
	480 EC	0.48	(0.12)	9	7		
Canada, 1977	EC	0.5		9	7	0.01, <0.01, <0.01	GHS-C-12
					14	<0.01, <0.01, <0.01	
					20	<0.01, <0.01, <0.01	

[1] All results averages of duplicate analyses.
[2] LOQ 0.01 mg/kg.

Sugar beet. Supervised trials on sugar beet were conducted in the UK, France and Germany in 1975, 1980 and 1990 respectively. The trials in the UK were with an EC formulation at 1.44 kg ai/ha and samples were taken approximately 120 days after application (Hollick and Walker, 1977).

In a trial in France during 1986 a latex suspension concentrate containing 300 g/l chlorpyrifos was applied pre-sowing to some plots. Others were treated with a liquid form containing 300 g chlorpyrifos + 160 g lindane/l for comparison. Samples of sugar beet were taken at harvest and frozen before the roots and tops were analysed separately (Day, 1987a).

In trials in Germany in 1990, the 480 EC formulation was applied to plots of immature sugar beet at 0.72 kg ai/ha. Samples of the whole plant were taken 1 day after application, roots and leaves were then sampled separately at various growth stages up to and including normal harvest (Khoshab *et al.*, 1991).

The results are shown in Table 81.

Table 81. Residues of chlorpyrifos in sugar beet from supervised trials in the UK, France and Germany (pre-plant or foliar applications).

Country, year	Application				PHI, days	Residues, mg/kg[1,2,3]	Reference/ Comments
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-UK	EC	0.72	(0.36)	2	21		
UK, 1975							GHE-P 439
roots	EC	1.44		1	117	<0.01	Foliar
tops	EC	1.44		1	117	<0.01	

Country, year	Application				PHI, days	Residues, mg/kg[1,2,3]	Reference/ Comments
	Form.	kg ai/ha	kg ai/hl	No.			
UK, 1975							GHE-P 439
roots	EC	1.44		1	123	<0.01	
tops	EC	1.44		1	123	<0.01	
GAP-France	300 SC	1.5	(1)	1			Pre-plant
France, 1986							
tops	300 SC	3		1		<0.01, <0.01, <0.01, <0.01	GHE-P 1709
	Liquid mix	1.5		1		<0.01, <0.01, <0.01, <0.01	Pre-plant
roots	300 SC	3		1		<0.01, <0.01, <0.01, <0.01	
	Liquid mix	1.5		1		<0.01, <0.01, <0.01, <0.01	
GAP-Germany	480 EC	0.96	(0.24)	1			Pre-plant
Germany, 1990							
tops	EC	0.72		1	16	0.26	GHE-P 2467
					37	0.01	Foliar
					74	<0.01	
					126	<0.01	
roots	EC	0.72		1	16	0.04	
					37	<0.01	
					74	<0.01	
					126	<0.01	
Germany, 1990							
tops	EC	0.72		1	20	0.16	GHE-P 2467
					56	<0.01	
					90	<0.01	
					138	<0.01	
roots	EC	0.72		1	20	0.04	
					56	<0.01	
					90	<0.01	
					138	<0.01	
Germany, 1990							GHE-P 2467
tops	EC	0.72		1	7	2.6	
					48	0.01	
					79	<0.01	
					122	<0.01	
					150	<0.01	
roots	EC	0.72		1	7	0.06	
					48	<0.01	
					79	<0.01	
					122	<0.01	
					150	<0.01	
Germany, 1990							GHE-P 2467
tops	EC	0.72		1	9	1.8	
					35	<0.01	
					71	<0.01	
					118	<0.01	
roots	EC	0.72		1	9	0.04	
					35	0.02	
					71	<0.01	
					118	<0.01	

[1] Average of duplicate analyses
[2] LOQ 0.01 mg/kg
[3] Recoveries 85% to 101% from the roots and from 84% to 92% from the tops

In supervised trials in Japan the EC formulation containing 400 g ai/l was applied twice at 0.32 kg ai/ha at 10-day intervals. Samples were taken 30, 45 and 60 days after the last application and the roots analysed (Ishikura, 1996). The results are shown in Table 82.

Table 82. Residues of chlorpyrifos in sugar beet from supervised trials in Japan.

Country, year	Application				PHI, days	Residues, mg/kg[1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Japan NONE							
1995	EC	0.32	0.027	2	30	0.05	GHF-P 1491
				2	45	0.02	
				2	60	<0.01	
1995	EC	0.32	0.027	2	30	<0.01	GHF-P 1491
				2	45	<0.01	
				2	60	<0.01	
1995	EC	0.32	0.027	2	30	<0.01	GHF-P 1491
				2	45	0.01	
				2	60	0.01	
1995	EC	0.32	0.027	2	30	0.01	GHF-P 1491
				2	45	<0.01	
				2	60	0.013	
1995	EC	0.32	0.027	2	30	0.01	GHF-P 1491
				2	45	<0.01	
				2	60	0.01	

[1]LOQ 0.01 mg/kg. Recoveries averaged 87%.

In a Canadian trial a single foliar application of the 480 EC formulation was made at the 5-leaf growth stage at 1.12 kg ai/ha, and samples of roots and tops were taken after 87 days at normal harvest (Wetters and Fairbairn, 1980).

In field trials on sugar beet in four US States the WG formulation of chlorpyrifos was compared with the commercial EC formulation. Four applications of 1.12 kg ai/ha each were made at approximately 60, 40, 35 and 30 days before harvest, the crop was divided into roots and tops and analysed for residues (McCormick and Bormett, 1996a).

The results are shown in Table 83.

Table 83. Residues of chlorpyrifos in sugar beet from supervised trials in Canada and the USA (foliar application).

Country, year	Application				PHI, days	Residues mg/kg [1,2]	Reference/ Comments
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Canada	480 EC	1.2	0.6	1	90		Soil or foliar
Canada, 1977							
roots	EC	1.12		1	87	<0.01, <0.01, <0.01, <0.01	GHS-C 10
tops	EC	1.12		1	87	<0.01, <0.01, <0.01, <0.01	

Country, year	Application				PHI, days	Residues mg/kg [1,2]	Reference/ Comments
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-USA	EC	1.1	1.2	4	30		
	G	2.3		1	NA		At planting
CA, 1995							
roots	EC	1.18	0.4	4	30	0.02, 0.02	GH-C 4223
tops						0.26, 0.68	
roots	WG	1.15	0.4	4	30	0.02, 0.02	
tops						0.15, 0.15	
ND, 1995							
roots	EC	1.12	0.5	4	29	0.03, 0.01	GH-C 4223
tops						6.6, 4.6	
roots	WG	1.16	0.6	4	29	0.02, 0.02	
tops						3.1, 2.8	
TX, 1995							
roots	EC	1.11	0.6	4	30	<0.01, 0.01	GH-C 4223
tops						0.24, 0.44	
roots	WG	1.12	0.5	4	30	0.01, 0.01	
tops						0.21, 0.42	
WA, 1995							
roots	EC	1.12	0.5	4	30	0.01, 0.01	GH-C 4223
tops						1.3, 1.2	
roots	WG	1.12	0.5	4	30	0.01, 0.01	
tops						0.82, 1.4	

[1] In the US trials, the limit of detection was 0.003 mg/kg and the LOQ 0.01 mg/kg. Recoveries averaged 80% from tops and 71% from roots.
[2] In the Canadian trials, the LOQ was 0.01 mg/kg. Recoveries averaged 88%

Cereal grains and animal feed commodities

Maize (field corn). The results of residue trials with a G formulation (at planting) and an EC formulation (foliar) applied to maize were reported from Brazil (Balderrama and Matos, 1994f,g). The results are shown in Tables 84 and 85.

Table 84. Residues of chlorpyrifos from single at-planting applications of a G formulation to maize.

Location, Year	Application	PHI, days	chlorpyrifos, mg/kg	Reference/Comment
	kg ai/ha			
Chile GAP Argentina-GAP	3 (G) broadcast 1.9 (EC) soil incorp			No GAP for Brazil
Londrina, Brazil (AG-122) 1993-1994	1.1	123	<0.01	GHB-P 217
	2.2	123	≤0.01	
Rio Verde, Brazil (BR-201) 1993-1994	1.1	125	<0.01	
	2.2	125	≤0.01	

Table 85. Residues of chlorpyrifos from the foliar application of an EC formulation to maize in Brazil.

Location, Year	Application		PHI, days	chlorpyrifos, mg/kg	Reference
	kg ai/ha	No.			
Brazil GAP	0.48	2-3	21		
Mogi-Mirim, (Dina 50) 1992-1993	0.29	3	20	<0.01	GHB-P 185. 300 l/ha.
	0.58	3	20	≤0.01	
Cascavel, (Cargil 606) 1992-1993	0.29	3	115	<0.01	GHB-P 185. 300 l/ha.
	0.58	3	115	<0.01	

In a set of US trials in four States, surface band or seed furrow applications of chlorpyrifos were applied at planting. A granular formulation was used for the surface band applications at 1.12 to 3.36 kg ai/ha and a ULV EC formulation at 1.12 kg ai/ha for the seed furrow directed sprays. Green forage samples were collected either at monthly intervals or the silage stage, and grain and stover samples at normal harvest. Samples were twenty immature or 10 mature plants taken at random from the centre in each replicate, and chopped, mixed and sub-sampled. 1.4 to 2.3 kg of grain were collected. All samples were stored frozen before analysis (McKellar, 1972).

In another set of trials, plots of field corn in Illinois, Michigan, Mississippi and Missouri were treated with EC formulation at 1.12 or 1.68 kg ai/ha during the 2 to 6-leaf stage by ground or aerial spray. The Michigan and Missouri plots were also treated at planting with 1.2 or 1.5 kg ai/ha of a granular formulation. Samples of green forage were taken at the silage stage (47 to 102 days after the last application) and grain and fodder at normal harvest 104 to 127 days after the last application (Wetters *et al.*, 1977).

In two trials in 1979 chlorpyrifos was applied to plots of field corn at two locations, either as a pre-plant broadcast and incorporated application of a granular formulation or of the EC formulation, both at 3.36 kg ai/ha. In one trial in Michigan, the EC treatment was followed by post-emergence foliar applications at 1.68 kg ai/ha at the 5-leaf stage and then again 7 days later. Samples of green forage were collected at the silage stage 44 to 105 days after the last application and fodder and grain at normal harvest 143 to 176 days after the last application (Norton, 1980a).

Trials in four US States in 1979 were with multiple applications of chlorpyrifos 15 G and EC formulations were made. At three of the locations, 5 or 6 ground applications were made to separate plots. Five aerial treatments were applied at the fourth site. Field corn was treated at planting with the granular formulation followed by foliar treatments with the EC formulation plus either two applications of granular or three applications of EC. A total of 6.6 to 9.9 kg ai/ha was applied. Samples of green forage were taken 0 to 20 days after the last application and fodder and grain at normal harvest (Norton, 1981).

The results are shown in Table 86.

Table 86. Residues of chlorpyrifos in field corn from supervised trials in the USA.

Location, year	Application				PHI, days	Residues, mg/kg [1,2]	Reference/ comment
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-USA	EC	1.7 foliar 3.4 pre-plant incorp 1.12 soil pre-emergence		5	35 grain 14 silage 35 fodder		
	15 G	1.1 broadcast (ground/aerial) 2.2 soil incorp pre-plant		1			

Location, year	Application				PHI, days	Residues, mg/kg [1,2]	Reference/ comment
	Form.	kg ai/ha	kg ai/hl	No.			
	50 WP	62g ai/ 100 kg seeds		1	NA		
Nebraska, 1970							
Green forage	10 G	1.12		1	27	<0.01, <0.01, <0.01	GH-C 530 At planting
					57	<0.01, 0.01, <0.01	
					87	<0.01, <0.01, <0.01	
					112	<0.01, <0.01, <0.01	
	10 G	3.36		1	112	<0.01, <0.01, <0.01	
Grain	10 G	1.12		1	149	<0.01, <0.01, <0.01	
		3.36		1	149	<0.01, <0.01, <0.01	
Stover	10 G	1.12		1	149	<0.01, <0.01, <0.01	
		3.36		1	149	<0.01, <0.01, <0.01	
Nebraska, 1970							
Green forage	EC	1.12	23	1	27	<0.01, <0.01, 0.01	GH-C 530 At planting
					57	<0.01, <0.01, <0.01	
					87	<0.01, <0.01, <0.01	
					112	<0.01, <0.01, <0.01	
Grain	EC	1.12	23	1	149	<0.01, <0.01, <0.01	
Stover	EC	1.12	23	1	149	<0.01, <0.01, <0.01	
Illinois, 1970							
Green forage	G	1.12		1	27	<0.01, <0.01, <0.01	GH-C 530 At planting
					59	<0.01, <0.01, <0.01	
					89	<0.01, <0.01, <0.01	
					100	0.01, <0.01, 0.01	
	G	3.36		1	100	0.01, <0.01, <0.01	
Grain	G	1.12		1	130	<0.01, <0.01, <0.01	
		3.36		1	130	<0.01, <0.01, <0.01	
Stover	G	1.12		1	130	<0.01, <0.01, 0.01	
		3.36		1	130	<0.01, <0.01, <0.01	
Illinois, 1970							
Green forage	EC	1.12	23	1	27	0.01, 0.01, <0.01	GH-C 530 At planting
					59	<0.01, <0.01, <0.01	
					89	<0.01, <0.01, <0.01	
					100	<0.01, <0.01, <0.01	
Grain	EC	1.12	23	1	130	<0.01, <0.01, <0.01	
Stover	EC	1.12	23	1	130	0.01, <0.01, 0.01	
Ohio, 1970							
Green forage	G	1.12		1	117	<0.01, <0.01, <0.01, <0.01	GH-C 530 At planting
						<0.01, <0.01, <0.01, <0.01	
Grain	G	1.12		1	159	<0.01, <0.01, <0.01, <0.01	
Stover	G	1.12		1	159	<0.01, <0.01, <0.01, <0.01	

Location, year	Application				PHI, days	Residues, mg/kg [1,2]	Reference/ comment
	Form.	kg ai/ha	kg ai/hl	No.			
Kansas, 1970							
Green forage	G	1.12		1	52	<0.01	GH-C 530 At planting
Grain	G	1.12		1	170	<0.01	
Stover	G	1.12		1	170	<0.01	
Illinois, 1977	4 E						GH-C 1068
Green forage	4 E	1.12		1	102	<0.01, <0.01, <0.01, <0.01	Foliar, ground
Green forage	4 E	1.12		1	102	<0.01, <0.01, <0.01, <0.01	GH-C1068 Foliar, aerial
Fodder	4 E	1.12		1	127	<0.01, <0.01, <0.01, <0.01	Ground
Fodder	4 E	1.12		1	127	0.01, <0.01, <0.01, <0.01	Aerial
Grain	4 E	1.12		1	127	<0.01, <0.01, <0.01, <0.01	Ground
Grain	4 E	1.12		1	127	<0.01, <0.01, <0.01, <0.01	Aerial
Michigan, 1977							
Green forage	G + EC	1.5 + 1.12		2	89	<0.01, <0.01, <0.01, 0.01	GH-C 1068 Foliar
Fodder	G + EC	1.5 + 1.12		2	114	<0.01, <0.01, <0.01, 0.01	
Fodder	G + EC	1.5 + 1.68		2	114	0.01, <0.01, <0.01, <0.01	
Grain	G + EC	1.5 + 1.12		2	114	<0.01, <0.01, <0.01, 0.01	
	G + EC	1.5 + 1.68		2	114	<0.01, <0.01, <0.01, 0.01	
Mississippi, 1977							
Green forage	EC	1.12		1	47	0.01, <0,01, <0,01, 0.01	GH-C 1068
Grain	EC	1.12		1	104	<0.01, <0.01, <0.01	Foliar
Mississippi, 1977							
Green forage	EC	1.12		1	66	0.01, 0.01, 0.02, 0.02	GH-C 1068
Grain	EC	1.12		1	109	<0.01, <0.01, <0.01, 0.01	Foliar
Missouri, 1977							
Green forage	G + EC	1.23 + 1.12		2	63	<0.01, <0.01, <0.01, 0.01	GH-C 1068
Fodder	G + EC	1.23 + 1.12		2	126	<0.01, <0.01, <0.01, 0.01	Foliar
Grain	G + EC	1.23 + 1.12		2	126	<0.01, <0.01, <0.01, 0.01	
Illinois, 1978							
Green forage	G	3.36		1	105	0.02, 0.01, 0.01	GH-C 1284
	EC	3.36		1	105	0.01, 0.01, 0.01	Pre-plant
Fodder	G	3.36		1	151	0.01, 0.01, 0.01	
	EC	3.36		1	151	0.01, 0.01, 0.01	
Grain	G	3.36		1	151	<0.01, <0.01, <0.01	
	EC	3.36		1	151	<0.01, <0.01, <0.01	
Michigan, 1978							
Green forage	G	3.36		1	77	0.01, 0.01, <0.01, <0.01	GH-C 1284

Location, year	Application				PHI, days	Residues, mg/kg [1,2]	Reference/ comment
	Form.	kg ai/ha	kg ai/hl	No.			
	EC	3.36 + 1.68 (x 2)		3	44	0.01, <0.01, <0.01, <0.01	Pre-plant
Fodder	G	3.36		1	176	0.01, 0.01, 0.01, 0.01	
	EC	3.36 + 1.68 (x 2)		3	143	0.01, 0.02, 0.01, 0.01	
Grain	G	3.36		1	174	<0.01, <0.01, <0.01, 0.01	
	EC	3.36 + 1.68 (x 2)		3	141	<0.01, <0.01, <0.01, 0.01	
Illinois, 1979							
Green forage	G + EC	1.22 (x 3) + 1.68 (x 2)		5	0	2.4, 1.9, 0.71, <0.01	GH-C 1440
					6	2.3, 1.9, 0.27, <0.01	At planting + foliar
					13	2.8, 0.72, 0.31, 2.5	
					20	1.5, 2.0, 0.33, 0.32	
Illinois, 1979							
Green forage	G + EC	1.22 + 1.68 (x 5)		6	0	2.05, 22.6, 17.7, 19	GH-C 1440
					6	1.6, 3.4, 3.4, 3.1	At planting + foliar
					13	2.0, 1.3, 5.5, 2.6	
					20	2.5, 1.1, 2.1, 3.9	
Fodder	G + EC	1.22 (x 3) + 1.68 (x 2)		5	34	1.1, 0.21, 3.4, 5.9	
Fodder	G + EC	1.22 + 1.68 (x 5)		6	34	2.3, 0.67, 0.25, 0.92	
Grain	G + EC	1.22 (x 3) + 1.68 (x 2)		5	20	<0.01, <0.01, 0.01, <0.01	
					34	0.04, 0.01, 0.01, 0.03	
Grain	G + EC	1.22 + 1.68 (x 5)		6	20	<0.01, <0.01, 0.01, 0.01	
					34	0.02, 0.03, 0.02, 0.02	
Michigan, 1979							
Green Forage	G + EC	1.46 (x 3) + 1.68 (x 2)		5	0	6.1, 1.5, 0.14, 3.1	GH-C 1440
					4	3.4, 2.85, 6.93, 4.4	At planting + foliar
					11	1.7, 0.40, 2.92, 3.0	
					18	0.83, 0.66, 7.2, 1.5	
Michigan, 1979							
Green Forage	G + EC	1.46 + 1.68 (x 5)		6	0	27, 26, 18, 23	GH-C 1440
					4	7.8, 9.3, 5.5, 8.0	At planting + foliar
					11	2.2, 1.9, 3.0, 2.2	
					18	1.3, 1.5, 1.3, 0.65	
Fodder	G + EC	1.46 (x 3) + 1.68 (x 2)		5	32	1.4, 1.6, 1.9, 3.1	
Fodder	G + EC	1.46 + 1.68 (x 5)		6	32	1.0, 1.1, 1.5, 1.6	
Grain	G + EC	1.46 (x 3) + 1.68 (x 2)		5	32	<0.01, <0.01, 0.01, 0.01	
Grain	G + EC	1.46 + 1.68 (x 5)		6	32	<0.01, <0.01, <0.01, 0.01	
Mississippi, 1979							
Green forage	G + EC	1.09 (x 3) + 1.68 (x 2)		5	0	2.2, 1.7, 2.2, 3.2	GH-C 1440
					8	1.8, 1.2, 1.9, 1.4	At planting + foliar
					11	1.1, 1.4, 1.0, 1.4	
					17	1.5, 1.4., 2.1, 1.6	

Location, year	Application				PHI, days	Residues, mg/kg [1,2]	Reference/ comment
	Form.	kg ai/ha	kg ai/hl	No.			
Mississippi, 1979							
Green forage	G + EC	1.09 + 1.68 (x 5)		6	0	11, 7.8, 9.0, 7.5	GH-C 1440
					8	2.9, 4.4, 2.9, 2.9	At planting + foliar
					11	2.7, 1.6, 2.0, 1.7	
					17	3.0, 3.4, 3.6, 2.9	
Fodder	G + EC	1.09 (x 3) + 1.68 (x 2)		5	31	1.7, 1.3, 1.7, 1.5	
Fodder	G + EC	1.09 + 1.68 (x 5)		6	31	0.87, 1.6, 1.4, 2.0	
Grain	G + EC	1.09 (x 3) + 1.68 (x 2)		5	17	0.06, 0.02, 0.01, 0.02	
					31	0.02, 0.02, 0.03, 0.01	
Grain	G + EC	1.09 + 1.68 (x 5)		6	17	0.03, 0.02, 0.02, 0.02	
					31	0.02, 0.01, 0.01, 0.01	
Nebraska, 1979							
Green forage	G + EC	G=1.46 + 1.09 (x 2)+					GH-C 1440
		EC=1.68 (x 2)		5	0	2.2, 4.0, 6.3, 1.6	At planting + foliar
Fodder	G + EC	G=1.46 + 1.09 (x 2)+					
		EC=1.68 (x 2)		5	35	6.0, 3.6, 7.2, 5.7	
Grain	G + EC	G=1.46 + 1.09 (x 2)+					
		EC=1.68 (x 2)		5	35	<0.01, <0.01, <0.01, 0.01	

[1] LOQ 0.01 mg/kg.
[2] Recoveries 81% to 92% from green forage, 82% to 84% from fodder and 83% to 93% from grain.

Sweet corn. Supervised trials were conducted in Canada and the USA. The results are shown in Tables 87 and 88.

Sweet corn in Ontario, Canada, in 1977 received a single foliar treatment of an EC formulation at 1.12 kg ai/ha at the seedling stage. Samples of kernels + cob with husk removed were taken 73 and 85 days after treatment (Fairbairn and Norton, 1980).

In US trials in 1983 12 to 23 foliar applications of 50W formulation were made to sweet corn at 1.12 kg ai/ha. One additional plot in California was treated with 21 foliar sprays of the EC formulation at the same rate. Samples of the ears (kernel + cob) and green forage were collected for analysis 7-8, 14-15 and 21-22 days after the last application (Wetters *et al.*, 1986).

Multiple ground applications of the EC formulation were made in trials in California, Florida, Georgia, Minnesota and Wisconsin, and aerial applications in Florida and Georgia only. Ground applications were 5 x 1.67 kg ai/ha and aerial 11 x 1.12 kg ai/ha. Samples of ears and forage from each plot were analysed (Nugent and Schotts, 1991).

Table 87. Residues of chlorpyrifos in sweet corn from supervised trials in Canada and the USA.

Country, year	Application				PHI, days	Residues, mg/kg [1]	Reference/ comment
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Canada	500 WP	1.15	(0.29)	1	70		
Canada, 1977	EC	1.12	0.14	1	73	<0.01, <0.01, ≤0.01	GHS-C 13
Grain + cob					85	<0.01, <0.01, <0.01	

Country, year	Application				PHI, days	Residues, mg/kg[1]	Reference/ comment
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-USA	EC	3.4 broadcast soil incorp pre-plant 1.1 directed at cultivation 1.7 foliar 1.1 foliar (FL and GA) 0.5 foliar (DE)		1 pre-plant	35 grain 35 fodder 14 silage		Grain PHI is 21 days FL and GA and 7 days DE (for special rates)
	15 G	2.3 pre-plant, at planting 1.1 foliar and post plant		1			
	50 WP	62 g ai/ 100 kg seeds		1			
CA, 1983							
Forage	50 WP	1.12		12	7	0.21	GH-C 1797
					14	0.11	
DE, 1983							
Forage	50 WP	1.12		17	7	1.3	GH-C 1797
					14	0.38, 0.23	
					21	0.66	
FL, 1983							
Forage	50 WP	1.12		17	7	3.5	GH-C 1797
					14	1.2	
					21	2.0	
FL, 1983							
Forage	50 WP	1.12		15	7	2.9	GH-C 1797
					14	1.2	
					21	0.77	
IL, 1983							
Forage	50 WP	1.12		19	7	1.3	GH-C 1797
					14	1.1	
					21	0.31	
MI, 1983							
Forage	50 WP	1.12		14	8	0.4	GH-C 1797
					15	0.11	
					22	0.04	
OR, 1983							
Forage	50 WP	1.12		17	7	6.27, 6.51, 8.56, 6.03	GH-C 1797
					14	3.4	
					21	3.0	
TX, 1983							
Forage	50 WP	1.12		23	7	1.3	GH-C 1797
					14	0.81	
					21	0.78	
CA, 1983							
Forage	50 WP	1.12		21	7	1.0	GH-C 1797
					14	0.24	
					21	0.48	
CA, 1983							
Forage	EC	1.12		21	7	1.8	GH-C 1797
					14	0.64	

Country, year	Application				PHI, days	Residues, mg/kg[1]	Reference/ comment
	Form.	kg ai/ha	kg ai/hl	No.			
					21	0.15	
CA, 1990							
Ears	EC	1.67		5	35	<0.01, <0.01, <0.01, ≤0.01	GH-C 2569
Fodder	EC	1.67		5	35	0.13, 0.09, 0.15, 0.23	
FL, 1990							
Ears	EC	1.68		5	35	<0.01, <0.01, <0.01, ≤0.01	GH-C 2569
Fodder	EC	1.68		5	35	0.06, 0.03, 0.06, 0.04	
Ears	EC	1.12		11	21	<0.01, <0.01, <0.01, ≤0.01	
Fodder	EC	1.12		11	21	0.05, 0.04, 0.06, 0.16	
GA, 1990							
Ears	EC	1.68		5	35	<0.01, <0.01, <0.01, <0.01	GH-C 2569
Fodder	EC	1.68		5	35	0.28, 0.08, 1.3, 0.35	
Ears	EC	1.12		11	21	<0.01, <0.01, <0.01, ≤0.01	
Fodder	EC	1.12		11	21	0.10, 0.14, 0.11, 0.14	
MN, 1990							
Ears	EC	1.68		5	35	<0.01, <0.01, <0.01, ≤0.01	GH-C 2569
Fodder	EC	1.68		5	35	0.39, 0.52, 0.68, 0.77	
WI, 1990							
Ears	EC	1.68		5	35	<0.01, <0.01, <0.01, ≤0.01	GH-C 2569
Fodder	EC	1.68		5	35	1.6, 1.3, 0.75, 0.26	

[1] LOQ 0.01 mg/kg

In trials in six US States in 1972, sweet corn seeds were treated before planting with WP slurry formulations containing 25% or 50% ai at 0.63 to 1.9 g ai/100 kg seeds. Green plant samples were collected at intervals, and kernels, kernels + cobs, cobs + husks and husks were collected at normal harvest (Wetters, 1973). The results are shown in Table 88.

Table 88. Residues of chlorpyrifos in sweet corn grown from treated seed in supervised trials in the USA.

Location, Year	Application			PHI, days	Residues, mg/kg [1]	Reference
	Form.	g ai/100kg	No.			
GAP-USA	WP	62	1	NA		
FL, 1972	WP	190	1			GH-C 664
Green plant				28	<0.01, 0.01, 0.01, <0.01	
				42	0.01, 0.01, <0.01, <0.01	
				83	<0.01, <0.01, <0.01, <0.01	
Kernel + cob	WP	190	1	83	<0.01, <0.01, <0.01, ≤0.01	
Husks	WP	190	1	83	<0.01, <0.01, <0.01, <0.01	
MS, 1971	WP	190	1			GH-C 664

Location, Year	Application			PHI, days	Residues, mg/kg [1]	Reference
	Form.	g ai/100kg	No.			
Green plant				28	<0.01, <0.01, 0.01, 0.01	
				41	<0.01, <0.01, <0.01, <0.01	
				72	<0.01, 0.01, <0.01, <0.01	
Kernels	WP	190	1	72	<0.01, <0.01, <0.01, 0.01	
Kernels + cobs	WP	190	1	72	<0.01, 0.01, <0.01, <0.01	
Cobs + husk	WP	190	1	72	<0.01, 0.01, <0.01, <0.01	
OR, 1971	WP	190	1			GH-C 664
Green plant				48	<0.01, 0.01, <0.01, <0.01	
				61	<0.01, <0.01, <0.01, <0.01	
				126	<0.01	
Kernels	WP	190	1	126	<0.01, <0.01, <0.01, <0.01	
Kernels + cob	WP	190	1	126	<0.01, <0.01, <0.01, <0.01	
Cobs + husks				126	<0.01, <0.01, <0.01, <0.01	
IL, 1969	WP	63	1			GH-C 664
Green plant				80	<0.01	
				81	<0.01	
				85	<0.01	
Kernels	WP	63	1	80	<0.01	
				81	<0.01	
				85	<0.01	
NY, 1971						GH-C 664
Green plant	WP	190	1	46	<0.01	
				106	<0.01	
Kernels	WP	190	1	106	<0.01	
Kernels + cobs	WP	190	1	106	<0.01	
Cobs + husks	WP	190	1	106	<0.01	
WI, 1971						GH-C 664
Green plant	WP	190	1	29	<0.01	
				45	<0.01	
				108	<0.01	
Kernels	WP	190	1	108	<0.01	
IA, 1971						GH-C 664
Green plant	WP	120	1	31	<0.01, <0.01, <0.01	
				90	<0.01, <0.01, <0.01	
Green plant	WP	190	1	31	<0.01, <0.01, <0.01	
				90	<0.01, <0.01, <0.01	

[1] LOQ 0.01 mg/kg. Recoveries averaged 97% from green plants, 94% from kernels, 95% from kernels + cobs, 101% from cobs + husks and 82% from husks, over the range 0.01 to 1.0 mg/kg.

Rice. Supervised trials on rice were conducted in 1998 in Australia, Columbia, the Philippines, Thailand and Vietnam. The results are shown in Tables 89 and 90.

In the trials in Australia, the 500 EC formulation was applied once at 0.45 kg ai/ha 10 days before harvest, and samples of grain and straw taken randomly were analysed (Cowles *et al.*, 1999a).

In two trials in Columbia according to current GAP, chlorpyrifos was applied 3 times to paddy at 0.96 kg ai/ha, followed 15 days later with an application of 0.79 kg ai/ha and another of 0.38 kg ai/ha 20-21 days before harvest. Threshed samples were taken for analysis (Pinheiro and De Vito, 1999).

In the two trials in the Philippines the 3 E formulation at 0.30 kg ai/ha was applied 25 and 40 days after transplanting and 25 days before harvest (Cowles *et al.*, 1999b). In the trials in Vietnam one application of the 30 EC formulation was made 10 days before harvest at 0.42 kg ai/ha (Cowles *et al.*, 1999c). In the trials in Thailand only one application of 40 EC formulation at 0.4 g ai/ha was made 44 days before harvest in one trial and 62 days before harvest in the other (Cowles *et al.*, 1999d).

Table 89. Residues of chlorpyrifos in rice from supervised trials in Australia and Colombia.

Country, year	Application			PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	No.			
GAP-Australia	500 EC	0.75		10		
Australia, 1998						
Rice grain	500 EC	0.45	1	10	0.17	GHF-P 1790
					0.13	
Rice straw, dry weight	500 EC	0.45	1	10	1.26	
					1.25	
GAP-Columbia	480 EC	0.8		15		
Colombia, 1998						
Rice grain	480EC	0.96+0.72+ 0.38	3	20	0.09, 0.09, 0.19	GHB-P 406
					0.08,0.08, 0.07	

[1] LOQ 0.01 mg/kg in both trials. Recoveries were 92% and 89%, from grain and straw, respectively, in Australia and 81% from grain in Colombia.

Table 90. Residues of chlorpyrifos in rice from supervised trials in the Philippines, Vietnam and Thailand.

Country, year	Application			PHI, days	Residues, mg/kg [1]	Reference/ Comments
	Form.	kg ai/ha	No.			
GAP- Philippines	300 EC	0.30	3	7		160-192 l water/ha
Philippines, 1998						
Rice grain	300 EC	0.30	3	25	0.02	GHF-P 1791
					0.06	
Rice straw, dry weight	300 EC	0.30	3	25	0.19	
					0.45	
GAP-Vietnam- NONE						
Vietnam, 1998						
Rice grain	300 EC	0.42	1	10	0.15	GHF-P 1792
					0.28	
Rice straw, dry weight	300 EC	0.42	1	10	1.83	
					2.33	
GAP-Thailand	200 EC	0.4		7		
Thailand, 1998						
Rice grain	400 EC	0.4	1	44	<0.01, <0.01	GHF-P 1793
				62	<0.01, <0.01	

Country, year	Application			PHI, days	Residues, mg/kg [1]	Reference/ Comments
	Form.	kg ai/ha	No.			
Rice straw, dry weight	400 EC	0.4	1	44	0.08, 0.06	
				62	0.17, 0.13	

[1] LOQ 0.01 g/kg in all trials. Recoveries were 91% and 96% from grain and straw respectively in all trials.

A trial in India in 1978 was reported. Proposed GAP in India requires 0.1-0.375 ka ai/ha with a 30-day PHI. Chlorpyrifos residues were determined in brown rice grain and straw harvested after treatment with the 20 EC formulation at 0.19 and 0.38 kg ai/ha. Samples were harvested 1, 7, 14 and 21 days after the last application (Leung, 1978). The results are shown in Table 91.

Table 91. Residues of chlorpyrifos in brown rice from supervised trials in India.

Location, year	Application				PHI, days	Residues, mg/kg [1,2]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-India	200 EC	0.38	0.08		30		PHI proposed .
Delhi, 1978							
Grain	200 EC	0.19		3	1	0.62, 0.37, 0.45	GHF-P 084
					7	0.28, 0.26, 0.34	
					14	0.33, 0.17, 0.18	
					21	0.11, 0.17, 0.08	
Straw	200 EC	0.19		3	1	0.47 0.52, 0.41	GHF-P 084
					7	0.23, 0.27, 0.34	
					14	0.39, 0.31, 0.34	
					21	0.08, 0.15, 0.11	
1978							
Grain	200 EC	0.38		3	1	0.77, 0.62, 0.78	GHF-P 084
					7	0.45, 0.54, 0.39	
					14	0.20, 0.34, 0.40	
					21	0.23, 0.11, 0.25	
Straw	200 EC	0.38		3	1	0.62, 0.76, 0.56	GHF-P 084
					7	0.28, 0.63, 0.42	
					14	0.27, 0.20, 0.32	
					21	0.15, 0.25, 0.22	

[1] LOQ 0.01 mg/kg. Recoveries were 94% and 89% from grain and straw respectively
[2] Sample storage period from harvest to analysis not indicated.

Sorghum. Supervised trials on sorghum were conducted with EC formulations in Australia, Brazil and the USA. The results are shown in Table 92.

In trials in Australia, sorghum plots were hand-sprayed with EC formulation diluted to 0.05 to 0.1 kg ai/hl at rates of 0.14 and 0.28 kg ai/ha. Heads were randomly picked from each of the treated plots 1 and 7 days after treatment, sealed in paper bags and forwarded for analysis. On receipt, the grain was separated from the heads, ground and stored frozen before analysis (Tucker, 1974).

In two trials in Brazil chlorpyrifos was applied three times at 0.36 or 0.72 kg ai/ha to plants near the final crop stage. Sampling was made at 21 days after the last application (Balderrama and De Vito, 1994).

In a trial in Kansas, USA, a broadcast band application of the 15 G formulation at 2.2 kg ai/ha at planting was followed by three broadcast foliar sprays of the EC formulation at 0.28 kg ai/ha, made at 3-day intervals with the last application 63 days before harvest. Samples of green forage were collected at the silage stage, 14 days after the last application, and grain and fodder at normal harvest (Miller and McKellar, 1986b).

In trials in 1993 in Kansas and Texas, plants received a total of 1.68 kg ai/ha of chlorpyrifos with separate plots for two different treatment modes at each location the first being three foliar applications of 0.56 kg ai/ha at 44, 36-37 and 30 days before harvest and the second two foliar applications of 0.56 and 1.12 kg ai/ha at 67 and 60 days before harvest respectively. Samples of sorghum grain, green forage and fodder were analysed (Robb, 1994). The water content of the forage and fodder was not reported.

Sorghum plots were treated with three aerial or ground applications of an EC formulation applied at 0.56 kg ai/ha, in trials in the mid-United States in 1975-6. The applications were made at two-week intervals with the last application two weeks before harvest. Grain and stover samples were analysed (Miller and Ervick, 1977).

Trials at three locations in the USA were with three applications of chlorpyrifos at 0.28 kg ai/ha at 3-day intervals. Samples of green plant were collected at 0, 7, and 14 days after the last treatment and at the silage stage if the sorghum was of a silage variety. Samples of dry plant and grain were taken at normal harvest (Wetters and Dishburger, 1976).

Sorghum grown in Kansas and Texas was treated in two ways with an EC formulation at both locations: three foliar applications of 0.56 kg ai/ha with samples collected 30 days after the last application, and two foliar applications of 0.56 and 1.12 kg ai/ha with samples collected 60 days after the second application (Robb, 1991b).

Table 92. Residues of chlorpyrifos in sorghum from supervised trials in Australia, Brazil and the USA.

Country, year, sample	Application				PHI, days	Residues, mg/kg [1]	Reference/ Comments
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-Australia	500 EC	0.75		2	2		
Australia, 1974	EC	0.05		1	1	0.87	GHF-P 019
Grain					7	0.10	
Australia, 1974	EC	0.10		1	1	1.0	GHF-P 019
Grain					7	0.17	
GAP-Brazil	480 EC	0.36	2		21		
Mogi Mirim, Brazil, 1992 (BR301)	EC	0.36		3	21	0.06, 0.05, 0.07	GHB-P 188
	EC	0.72		3	21	0.07, 0.17, 0.06	GHB-P 188
GAP-USA	480 EC	1.1			30 @ 0.56 60 @ 1.1		1.7 kg ai/ha/season max
	15 G	2.0		1			At planting
KS, 1985							
Green forage	G + EC	2.24 + 0.28(x3)		4	14	0.48, 0.63, 0.42, 0.55	GH-C 1813
Fodder	G + EC	2.24 + 0.28(x3)			63	0.15, 0.35, 0.2,0.25	
Grain	G + EC	2.24 + 0.28(x3)			63	0.02, 0.02, 0.02, 0.02	

Country, year, sample	Application				PHI, days	Residues, mg/kg [1]	Reference/ Comments
	Form.	kg ai/ha	kg ai/hl	No.			
KS, 1993							
Grain	EC	0.56		3	30	0.20	GH-C 3226
	EC	0.56 + 1.12		2	60	<0.01	
Green forage	EC	0.56		3	30	0.14	
	EC	0.56 + 1.12		2	60	0.04	
Fodder	EC	0.56		3	30	1.3	
	EC	0.56 + 1.12		2	60	0.34	
TX, 1993							
Grain	EC	0.56		3	30	0.02	GH-C 3226
		0.56 + 1.12		2	60	<0.01, <0.01	
Green forage	EC	0.56		3	30	0.03	
	EC	0.56 + 1.12		2	60	0.01	
Fodder	EC	0.56		3	30	0.17	
	EC	0.56 + 1.12		2	60	0.08	
IL, 1976							
Grain	EC	0.56		3	14	0.03, 0.08, 0.06, 0.03	GH-C 998
Stover	EC	0.56		3	14	0.07, 0.05, 0.05, 0.05	
KS, 1976							
Grain	EC	0.56		3	15	0.32, 0.58, 0.42, 0.28	GH-C 998
Stover	EC	0.56		3	15	0.70, 0.2, 0.7, 0.83	
TX, 1976							
Grain	EC	0.56		3	14	0.25, 0.27, 0.31, 0.28	GH-C 998
Stover	EC	0.56		3	14	2.0, 2.3, 2.2, 1.15	
NE, 1975							
Grain	EC	0.56		3	14	0.27, 0.27, 0.17, 0.13	GH-C 998
Stover	EC	0.56		3	14	1.1, 0.90, 0.91, 1.0	
MS, 1975							
Grain	EC	0.56		3	14	0.31, 0.41, 0.57, 0.70	GH-C 998
Stover	EC	0.56		3	14	1.2, 1.7, 2.5, 2.4	
MS, 1974							
Green plant	EC	0.28		3	0	2.1, 2.4, 1.8, 4.1	GH-C 900
					7	0.24, 0.46, 0.52, 0.38	
					14	0.21, 0.17, 0.17, 0.17	
Fodder	EC	0.28		3	47	0.46, 1.2, 0.35, 0.76	
Grain	EC	0.28		3	47	0.02, 0.01, 0.01, 0.01	
TX, 1974							
Green plant	EC	0.28		3	0	2.2, 2.0, 3.0, 3.4	GH-C 900
					7	0.27, 0.16, 0.27, 0.36	
					14	0.06, 0.02, 0.03, 0.04	
Fodder	EC	0.28		3	38	0.02, 0.02, 0.02, 0.10	
Grain	EC	0.28		3	38	<0.01, <0.01, <0.01, 0.01	
MS, 1974							
Green plant	EC	0.28		3	8	0.70, 0.76, 0.98, 0.91	GH-C 900
					15	0.63, 0.66, 0.56, 0.69	
Forage	EC	0.28		3	29	0.24, 0.15, 0.26, 0.34	

Country, year, sample	Application				PHI, days	Residues, mg/kg [1]	Reference/ Comments
	Form.	kg ai/ha	kg ai/hl	No.			
Fodder	EC	0.28		3	72	0.17, 0.29, 0.25, 0.38	
Grain	EC	0.28		3	72	<0.01, <0.01, <0.01, 0.01	
KS, 1990							
Grain	EC	0.56		3	29	0.27, 0.20, 0.26, 0.26	GH-C 2555
	EC	1.12 + 0.56		2	60	0.09, 0.09, 0.17, 0.21	
Fodder	EC	0.56		3	29	0.28, 0.39, 0.38, 0.36	
	EC	1.12 + 0.56		2	60	0.06, 0.06, 0.04, 0.15	
TX, 1990							
Grain	EC	0.56		3	30	0.04, 0.03, 0.03, 0.04	GH-C 2555
	EC	1.12 + 0.56		2	60	0.01, 0.01, 0.03, 0.01	
Fodder	EC	0.56		3	30	0.01, 0.01, 0.01, 0.01	
	EC	1.12 + 0.56		2	60	0.01, 0.02, 0.01, 0 01	

[1] LOQ 0.01 mg/kg. Recoveries 83% to 92% from grain, 84% to 87% from fodder and 82% to 93% from green forage at the 95% confidence limit of the mean

Wheat. In residue trials in Brazil in 1992, 1993 and 1997 an EC formulation was applied once or three times at PHIs of 17 or 72 days (Balderrama, 1994), once or twice at rates up to 1.4 kg ai/ha (Balderrama and Matos, 1994j), or in single applications from 0.24 to 1.4 kg ai/ha (Do Amaral and De Vito, 1999). The results are shown in Table 93.

Table 93. Residues of chlorpyrifos in wheat grain in Brazil. EC formulation.

Location, Year	Application			PHI, days	Residue, mg/kg	Reference
	kg ai/ha	kg ai/hl	No.			
Brazil GAP	0.72		2	21		
Guarapuava (BR-28) 1992	0.48		1	72	0.02	GHB-P 197
	0.72		3	17	0.30	
	0.96		1	72	0.02	
	1.4		3	17	0.35	
Cruz Alta (BR-34) 1993	0.72 0.19		2	20	<0.01	GHB-P 200
	1.4 0.38		2	20	0.02	
	0.48		1	29	<0.01	
	0.96		1	29	0.01	
Mogi Mirim (IAC-5) 1997	0.24		1	21	<0.01	GHB-P 411
	0.48		1	21	0.03	
	0.72		1	21	0.04	
	0.96		1	21	0.06	
	1.4		1	21	0.17	

In a trial in the UK in 1992 three applications of the EC formulation containing 480 g ai/l were applied to winter wheat plants at various growth stages at rates of 0.72 kg ai/ha for the 1st and 2nd applications and 0.34 kg ai/ha for the 3rd. Grain and straw were sampled at harvest 18 days after application (Khoshab and Berryman, 1994f).

In two trials on winter wheat in the UK in 1995 three treatments with the 480 EC formulation were applied at growth stages Zd 12 or Zd 25 (autumn applications), 14-27 (winter applications) and 83-85 (summer applications) at 0.72 kg ai/ha for the 1st and 2nd applications and 0.34 kg ai/ha for the 3rd. Whole plants were sampled at intervals, and grain and straw at harvest 24 or 31 days after the last application (Khoshab, 1996).

In two trials on winter wheat in the UK in 1994-1995, chlorpyrifos WG formulation containing 750 g ai/kg was applied three times at 0.72 g ai/ha for the 1st and 2nd applications and 0.34 kg ai/ha for the 3rd, and the wheat sampled at intervals from 0 to 24 or 31 days after treatment (Portwood and Williams, 1996).

In a trial in Germany in 1995 plots of winter wheat were treated with three applications of the 480 EC formulation at 0.72 kg ai/ha for the 1st and 2nd and 0.34 kg ai/ha for the 3rd, and immature plants were sampled immediately before the 3rd application and as soon as the spray had dried. Further plant samples were taken 6 and 11 days later, and grain and straw were sampled at harvest 17 days after the last application (Teasdale, 1997).

Table 94. Residues of chlorpyrifos in wheat from supervised trials in the UK and Germany.

Country, year	Application				PHI, days	Residues, mg/kg [1,2,3]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-UK	480 EC	0.72 spring 0.72 winter	0.36	3 3	14 14		
UK, 1992	EC						
Straw		0.72 + 0.72 + 0.34		3	18	0.07	GHE-P 3720
Grain					18	<0.01	
UK, 1995							
Whole plant	EC	0.72 + 0.72 + 0.34		3	0	2.6	GHE-P 5204
Whole plant					8	0.64	
Whole plant					16	0.50	
Straw					24	0.48	
Grain					24	0.02	
UK, 1995							
Whole plant	EC	0.72 + 0.72 + 0.34		3	0	9.7	GHE-P 5204
Whole plant					7	1.7	
Whole plant					12	1.81	
Straw					31	1.1	
Grain					31	0.11	
UK, 1995	WG						
Whole plant		0.72 + 0.72 + 0.34		3	0	3.1	GHE-P 5471
Whole plant					8	1.0	
Whole plant					16	0.97	
Grain					24	0.03	
Straw					24	0.88	
UK, 1995	WG						
Whole plant		0.72 + 0.72 + 0.34		3	0	5.0	GHE-P 5471
Whole plant					7	0.89	

Country, year	Application				PHI, days	Residues, mg/kg [1,2,3]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
Whole plant					12	0.63	
Grain					31	0.03	
Straw					31	0.48	
GAP-Germany NONE							
Germany, 1995							
Whole plant		0.72 + 0.72		2	0[4]	<0.01	GHE-P 4834
Whole plant		0.72 + 0.72 + 0.34		3	0	3.7	
Whole plant					6	1.1	
Whole plant					11	1.0	
Grain					17	0.04	
Straw					17	0.76	

[1] All results are averages of duplicate analyses
[2] LOQ 0.01 mg/kg
[3] Recoveries were 86% to 92% from whole plant, 76% to 91% from grain and 82 to 102% from straw
[4] Immediately before 3rd application

In the USA multiple aerial or single ground applications of EC formulation were made at 0.56 or 1.12 kg ai/ha per application to winter or spring wheat plots at various locations (total 1.12, 1.68, or 2.8 kg ai/ha per season). Grain and straw samples were collected 25-31 days after the last of the multiple applications, and green forage at 7 and 14-15 days after the five single ground applications at 1.12 kg ai/ha (Norton and Wetters, 1983). The moisture content of the green forage was not reported.

Samples of grain and straw were collected from 10 trials in the main wheat growing areas of the USA. Chlorpyrifos was applied by air twice, at 1.12 kg ai/ha 41 to 57 days and at 0.56 kg ai/ha 15 to 35 days before harvest. Green forage was collected 14 or 15 days after treatment in eight other trials at some of the same locations, in which the EC formulation was applied once at 1.12 kg ai/ha as a broadcast ground application when the plants were 15 to 20 cm tall (Miller and McKellar, 1986c).

In trials in Canada EC was applied once at 0.375 kg ai/ha to each of four wheat plots 7, 16-19, 26-29 and 36-40 days before normal harvest. All the plots were harvested at the same time and only grain samples were collected (McKellar and Ordiway, 1986b).

The results of all the trials are shown in Table 95.

Table 95. Residues of chlorpyrifos in wheat from supervised trials in the USA and Canada.

Country, year, sample	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-USA	480 EC	0.56	(2.9)	2	28 grain		
					14 forage/hay		
IL, 1980	EC	1.12 + 1.12 + 0.56		3			
Grain					25	0.01, 0.01, 0.02, 0.02	GH-C 1639
Straw					25	0.08, 0.28, 0.28, 0.39	
IL, 1980	EC	1.12 + 1.12 + 0.56		3			
Grain					26	0.01, <0.01, <0.01, 0.01	GH-C 1639
Straw					26	0.09, 0.05, 0.07, 0.04	

Country, year, sample	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
ID, 1982	EC	1.12 + 0.56		2			
Grain					27	0.02, 0.05	GH-C 1639
Straw					27	2.1, 1.4	
ID, 1981	EC	1.12 + 0.56		2			
Grain					28	0.19	GH-C 1639
Straw					28	1.2	
KS, 1980	EC	1.12 + 0.56		2			
Grain					31	0.01, 0.01, 0.01, 0.01	GH-C 1639
Straw					31	0.32, 0.38, 0.37, 0.48	
KS, 1980	EC	1.12 + 0.56		2			
Grain					27	0.01, 0.01, 0.01, 0.01	GH-C 1639
Straw						0.44, 0.39, 0.42, 0.47	
ND, 1982	EC	1.12 + 0.56		2			
Grain					28	<0.01	GH-C 1639
Straw					28	0.2	
TX, 1981	EC	1.12 + 0.56		2			
Grain					28	0.03	GH-C 1639
Straw					28	1.20	
OR, 1981	EC	1.12 + 0.56		2			
Grain					28	0.23	GH-C 1639
Straw					28	4.1, 3.2	
TX, 1981	EC	1.12 + 0.56		2			
Grain					28	0.02	GH-C 1639
Straw					28	0.63	
TX, 1981	EC	1.12 + 0.56		2			
Grain					28	0.02	GH-C 1639
Straw					28	0.64	
WA, 1981	EC	1.12 + 0.56		2			
Grain					28	0.03, 0.03	GH-C 1639
Straw					28	0.23, 0.21	
CA, 1982	EC	1.12		1			
Green forage					7	18, 1.4, 1.6, 2.6	GH-C 1639
Green forage					14	0.58, 0.51, 0.28, 0.31	
IL, 1981	EC	1.12		1			
Green forage					7	1.1, 0.71, 0.63, 1.1	GH-C 1639
Green forage					14	0.17, 0.08, 0.04, 0.07	
MI, 1981	EC	1.12		1			
Green forage					7	0.96, 1.1, 0.54, 0.91	GH-C 1639
Green forage					15	0.11, 0.06, 0.08, 0.08	
OK, 1981	EC	1.12		1			
Green forage					7	3, 15., 9.1, 2.8	GH-C 1639
Green forage					14	1.6, 15, 9.0, 12	
TX, 1981	EC	1.12		1			
Green forage					7	4.9, 5.9, 5.0, 4.0	GH-C 1639
Green forage					14	1.6, 1.7, 2.0, 2.1	

Country, year, sample	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
AL, 1983	EC	1.12 +.0.56		2			
Grain					35	0.01	GH-C 1790
Straw					35	0.03	
CA, 1984	EC	1.12 + 0.56		2			
Grain					28	0.05, 0.07, 0.08, 0.06	GH-C 1790
Straw					28	2.6, 1.9, 2.4, 2.3	
CO, 1983	EC	1.12 + 0.05		2			
Grain					30	--	GH-C 1790
Straw					30	0.16	
MN, 1984	EC	1.12 + 0.56		2			
Grain					27	<0.01	GH-C 1790
Straw					27	2.2	
MS, 1983	EC	1.12 + 0.56		2			
Grain					27	<0.01, <0.01, <0.01, 0.01	GH-C 1790
Straw					27	0.53, 0.51, 0.85, 0.96	
MO, 1983	EC	1.12 + .0.56		2			
Grain					29	0.01	GH-C 1790
Straw					29	0.11	
NE, 1983	EC	1.12 + 0.56		2			
Grain					15	<0.01	GH-C 1790
Straw					15	1.9	
NY, 1983	EC	1.12 + 0.56		2			
Grain					28	0.01	GH-C 1790
Straw					28	0.60	
NC, 1983	EC	1.12 + 0.56		2			
Grain					23	--	GH-C 1790
Straw					23	0.01	
OH, 1984	EC	1.12 + 0.56		2			
Grain					29	<0.01	GH-C 1790
Straw					29	0.48	
AL, 1983	EC	1.12		1			
Green forage					14	0.71	GH-C 1790
CO, 1983	EC	1.12		1			
Green forage					14	0.31	GH-C 1790
MN, 1984	EC	1.12		1			
Green forage					14	0.05	GH-C 1790
MS, 1983	EC	1.12		1			
Green forage					14	0.30, 0.33, 0.30, 0.28	GH-C 1790
MO, 1983	EC	1.12		1			
Green forage					15	0.05	GH-C 1790
NE, 1983	EC	1.12		1			
Green forage					14	0.29	GH-C 1790
NY, 1983	EC	1.12		1			
Green forage					14	0.15	GH-C 1790
NC, 1983	EC	1.12		1			

Country, year, sample	Application				PHI, days	Residues, mg/kg [1]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
Green forage					14	0.87	GH-C 1790
GAP- Canada	EC 480 g/l	0.58		5	60		
Canada, 1985	EC	0.38		1	7	0.12, 0.13, 0.11, 0.09	GH-C 1804
Grain					16	0.10, 0.09, 0.13, 0.10	
					26	0.03, 0.03, 0.02, 0.03	
					36	0.01, 0.01, 0.01, 0.02	
Canada, 1985	EC	0.36		1	29	0.01, 0.02, 0.02, 0.03	GH-C 1804
Grain					39	0.01, <0.01, <0.01, 0.01	
					49	<0.01, <0.01, <0.01, <0.01	
Canada, 1985	EC	0.36		1	7	0.11, 0.12, 0.13, 0.17	GH-C 1804
Grain					19	0.03, 0.02, 0.01, 0.01	
					29	0.01, 0.02, 0.01, 0.01	
					40	<0.01, <0.01, 0.01, <0.01	

[1] LOQ 0.01 mg/kg. Recoveries 91% to 93% from forage, 90% to 91% from grain and 85% to 88% from straw

Grasses

Alfalfa. Several supervised trials were conducted in the USA from 1982 to 1995, with the results shown in Tables 96 and 97.

In four trials at different locations in 1982, EC formulation was applied as a single foliar spray with ground equipment at 0.28 kg ai/ha 7-8 days before cutting, and samples of green forage were collected 7-8 days and cured alfalfa hay 9-14 days after application (Miller, 1983b).

In trials in California, Michigan and Illinois in 1984 an EC formulation was applied to plots according to two treatment schedules. In the first applications were made before each of four separate cuttings during the season: 28 days before the first cutting, 21 days before the second, 14 days before the third and 7 days before the fourth at 1.12, 1.12, 0.56 and 0.28 kg ai/ha respectively. The second set of plots was treated with single applications of 0.56 kg ai/ha seven days before each of four cuttings during the season. Samples of green forage were collected seven days after the fourth application and cured hay 7-14 days later (Wetters, 1990b).

In a trial in California in 1985 EC formulation was applied at 1.12 kg ai/ha and seed samples were collected after 15 and 22 days (McKellar and Ordiway, 1986c).

In California, Illinois and Michigan alfalfa plots were treated with single applications of chlorpyrifos at 1.12 kg ai/ha, followed by post-plant applications at 1.12 kg ai/ha before each of 3 or 4 cuttings. Four replicate samples of green forage and hay cut 21 and 28 or 29 days after the last application respectively were analysed. The hay samples were field- or greenhouse-cured for 7-8 days (Deubelbeis, 1990).

Chlorpyrifos EC was applied to plots of alfalfa in Illinois, Michigan and Mississippi at 0.80 kg ai/ha 12 to 14 days before each of four cuttings. Samples of green forage and cured hay were collected from the fourth cutting only (Wetters and Ervick, 1990b).

Four applications of chlorpyrifos EC formulation corresponding to four cuttings of the crop were made in California, Illinois, New York and Wisconsin. Residues were determined in samples taken at the fourth cutting after 0.56 kg ai/ha had been applied 7 days, and 1.12 kg/ha 7 or 14 days before harvest (Robb and Schotts, 1993a).

In trials in Colorado, Ohio, North Dakota and Washington, the EC and WG formulations were compared at both 0.28 and 1.12 kg ai/ha. The WG was applied 21 days and the EC 7 days before each cutting. Three cuttings were obtained from Colorado and four from the other sites, and forage and hay samples were taken each time. Only samples from the last cutting were analysed except in North Dakota, where those from the third cutting were also analysed (McCormick and Bormett, 1996b).

Table 96. Residues of chlorpyrifos in alfalfa from supervised trials in the USA (1982-1986).

Country, year, sample	Application			PHI, days	Chlorpyrifos, mg/kg[1]	Reference/ Comment
	Form.	kg ai/ha	No.			
GAP-USA	480 EC	0.28	4	7		One application per cutting cycle.
		0.56	4	14		
		>0.56-1.12	4	21		
	240 EC	0.56	4	4		CA and AZ only. One application per cutting cycle.
California, 1982						
Green forage	EC	0.28	1	7	0.22, 0.16, 0.05, 0.15	GH-C 1610
Hay	EC	0.28	1	7+7	0.74, 0.45, 0.92, 0.40	
Illinois, 1982						
Green forage	EC	0.28	1	7	0.23, 0.20, 0.10, 0.25	GH-C 1610
Hay	EC	0.28		7+3	0.33, 0.29, 0.43, 0.32	
Michigan, 1982						
Green forage	EC	0.28	1	8	0.09, 0.20, 0.17, 0.10	GH-C 1610
Hay	EC	0.28		8+5	0.40, 0.43, 0.37, 0.36	
Mississippi, 1982						
Green forage	EC	0.28	1	7	0.65, 0.45, 0.57, 0.35	GH-C 1610
Hay	EC	0.28		7+2	1.8, 1.3, 1.4, 1.3	
California, 1984						
Green forage	EC	1.12(x2) + 0.56 + 0.28	4	7	0.65, 0.81, 0.72, 0.90	GH-C 2334
Hay	EC	1.12(x2) + 0.56 + 0.28		7 + 14	1.3, 1.3, 1.2, 1.2	
Illinois, 1984						
Green forage	EC	1.12(x2) + 0.56 + 0.28	4	7	0.40, 0.49, 0.62, 0.62	GH-C 2334
Hay	EC	1.12(x2) + 0.56 + 0.28		7 + 10	1.2, 1.0, 0.92, 0.95	
Michigan, 1984						
Green forage	EC	1.12(x2) + 0.56 + 0.28	4	7	0.85, 1.3, 1.1, 1.0	GH-C 2334
Hay	EC	1.12(x2) + 0.56 + 0.28		7 + 7	2.3, 2.3, 2.6, 3.1	
California, 1984						
Green forage	EC	0.56	4	7	2.1, 2.5, 2.0, 2.4	GH-C 2334
Hay	EC	0.56		7 + 14	4.8, 5.7, 6.4, 4.6	
Illinois, 1984						
Green forage	EC	0.56	4	7	0.79, 0.72, 0.69, 0.95	GH-C 2334
Hay	EC	0.56		7 + 10	1.7, 1.9, 2.3, 2.5	

Country, year, sample	Application			PHI, days	Chlorpyrifos, mg/kg[1]	Reference/ Comment
	Form.	kg ai/ha	No.			
Michigan, 1984						
Green forage	EC	0.56	4	7	2.2, 2.3, 1.8, 2.0	GH-C 2334
Hay	EC	0.56		7 + 7	7.0, 7.2, 6.8, 6.2	
California, 1985	EC	1.12	1	15	0.06, 0.05, 0.07, 0.12	GH-C 1803
Seed				22	0.46, 0.23, 0.23, 0.37	
California, 1985						
Green forage	EC	1.12 + 1.12/cutting	5	21	0.61, 0.77, 0.89, 0.85	GH-C 2288
Cured hay	EC	1.12+ 1.12/cutting		21 + 8	1.3, 1.4, 1.2, 1.7	
Illinois, 1985						
Green forage	EC	1.12 + 1.12/cutting	4	21	2.7, 1.7, 1.6, 1.5	GH-C 2288
Cured hay	EC	1.12 + 1.12/cutting		21 + 7	1.1, 0.99, 0.32, 0.18	
Michigan, 1985						
Green forage	EC	1.12 + 1.12/cutting	4	21	3.6, 4.4, (4.9), 4.0	GH-C 2288
Cured hay	EC	1.12 + 1.12/cutting		21 + 8	19, (23), 21, 20	
Illinois, 1986						
Green forage	EC	0.80	5	14	0.32, 0.32, 0.29, 0.32	GH-C 2294
Cured hay	EC	0.80		14 + 10	0.52, 0.55, 0.57, 0.56	
Michigan, 1986						
Green forage	EC	0.80	4	12	9.3, 10, 10, 10	GH-C 2294
Hay	EC	0.80		12 + 2	21, 29, 30, 31	
Mississippi, 1986						
Green forage	EC	0.80	4	14	0.63, 0.83, 0.77, 0.31	GH-C 2294
Cured hay	EC	0.80		14 + 2	1.7, 1.9, 2.2, 2.0	

[1] LOQ 0.05 mg/kg in all trials. Recoveries were 94% to 97% from forage and 94% to 107% from hay

Table 97: Residues of chlorpyrifos in alfalfa from supervised trials in the USA, 1991-1995.

Location, year	Application			PHI, days	Chlorpyrifos, mg/kg[1]	Reference/ Comment
	Form.	kg ai/ha	No.			
GAP-USA	480 EC	0.28	4	7		One application per cutting cycle
		0.56	4	14		
		>0.56-1.12	4	21		
	240 EC	0.56	4	4		One application per cutting cycle. AZ and CA only
California, 1991						
Green forage	EC	0.56	4	7	1.0, 0.48, 0.75, 0.51	GH-C 2752R
	EC	1.12	4	7	2.9, 3.0, 1.4, 4.3	
	EC	1.12	4	14	0.31, 0.21, 0.30, 0.27	
Cured Hay	EC	0.56	4	7	1.8, 2.6, 2.1, 2.2	
	EC	1.12	4	7	3.1, 5.1, 4.3, 4.6	
	EC	1.12	4	14	1.4, 1.2, 1.5, 2.3	
Illinois, 1991						
Green forage	EC	0.56	4	7	1.6, 1.5, 1.8, 2.2	GH-C 2752R
	EC	1.12	4	7	5.7, 4.4, 5.0, 5.5	

Location, year	Application			PHI, days	Chlorpyrifos, mg/kg[1]	Reference/ Comment
	Form.	kg ai/ha	No.			
	EC	1.12	4	14	1.8, 1.7, 1.7, 2.3	
Illinois, 1991						GH-C 2752R
Cured hay	EC	0.56	4	7	5.7, 8.4, 7.4, 8.2	
	EC	1.12	4	7	19, 21, 21, 26	
	EC	1.12	4	14	8.7, 7.8,10, 9.4	
New York, 1991						
Green forage	EC	0.56	4	7	4.0, 3.3, 3.9, 3.5	GH-C 2752R
	EC	1.12	4	7	11, 11, 13, 14	
	EC	1.12	4	14	8.3, 7.6, 8.0, 8.3	
Cured hay	EC	0.56	4	7	16, 17, 16, 15	GH-C 2752R
	EC	1.12	4	7	33, 25, 28, 25	
	EC	1.12	4	14	30, 37, 28, 21	
Wisconsin, 1991						
Green forage	EC	0.56	4	7	5.3, 5.3, 5.0, 5.2	GH-C 2752R
	EC	1.12	4	7	9.3, 14, 11, 6.7	
	EC	1.12	4	14	2.8, 5.9, 4.0, 2.6	
Cured hay	EC	0.56	4	7	9.2, 17, 18, 13	GH-C 2752R
	EC	1.12	4	7	37, 51, 41, 24	
	EC	1.12	4	14	5.1, 16, 9.2, 17	
Colorado, 1995						
Green forage	EC	0.28	3	8	0.32, 0.45	GH-C 4198
	WG	0.28	3	8	0.19, 0.30	
	EC	1.12	3	23	0.06, 0.05	
	WG	1.12	3	23	0.04, 0.06	
Hay	EC	0.28	3	8	1.0, 0.84	GH-C 4198
	WG	0.28	3	8	1.2, 1.2	
	EC	1.12	3	23	0.45, 0.31	
	WG	1.12	3	23	0.23, 0.28	
North Dakota, 1995						
Green forage	EC	0.28	3	7	0.43, 0.40	GH-C 4198
	WG	0.28	3	7	0.42, 0.33	
	EC	1.12	3	21	0.27, 0.18	
	WG	1.12	3	21	0.08, 0.08	
Hay	EC	0.28	3	7	0.46, 0.22	GH-C 4198
	WG	0.28	3	7	0.56, 0.59	
	EC	1.12	3	21	0.43, 0.78	
	WG	1.12	3	21	0.27, 0.35	
North Dakota, 1995						
Green forage	EC	0.28	4	9	1.4, 1.2	GH-C 4198
	WG	0.28	4	9	1.5, 1.1	
	EC	1.12	4	23	4.3,(5.6)	
	WG	1.12	4	23	2.2, 0.12	
Hay	EC	0.28	4	9	2.1, 2.3	
	WG	0.28	4	9	2.0, 1.5	
	EC	1.12	4	23	(12,) 11	

Location, year	Application			PHI, days	Chlorpyrifos, mg/kg[1]	Reference/ Comment
	Form.	kg ai/ha	No.			
	WG	1.12	4	23	1.8, 1.7	
Ohio, 1995						
Green forage	EC	0.28	4	7	0.31, 0.38	GH-C 4198
	WG	0.28	4	7	0.57, 0.55	
	EC	1.12	4	21	0.17, 0.17	
	WG	1.12	4	21	0.43, 0.41	
Hay	EC	0.28	4	7	0.40, 0.66	
	WG	0.28	4	7	0.90, 0.93	
	EC	1.12	4	21	0.36, 0.31	
	WG	1.12	4	21	0.59, 0.63	
Washington, 1995						
Green forage	EC	0.28	4	7	0.18, 0.21	GH-C 4198
	WG	0.28	4	7	0.09, 0.12	
	EC	1.12	4	21	<0.01, <0.01	
	WG	1.12	4	21	0.01, 0.01	
Hay	EC	0.28	4	7	0.64, 0.42	
	WG	0.28	4	7	0.40, 0.37	
	EC	1.12	4	21	0.04, 0.02	
	WG	1.12	4	21	0.02, 0.02	

[1] LOQ 0.01 mg/kg. Recoveries 84% to 90% from forage and 84% to 89% from hay

In the trials in Michigan (GH-C 2288; GH-C 2294) residues were much higher from the Midland site than from other locations. According to the manufacturer, a possible explanation is that the Midland alfalfa was very sparse and small because of the colder climate and shorter growing season in mid-Michigan, where only the first two cuttings produce adequate forage for commercially acceptable hay. In an unusual year a third cutting may be taken, but very seldom are four commercially acceptable cuttings taken. Fourth cutting samples are therefore not typical of Michigan cultural practices and the residues are not representative.

Tree nuts

Almonds. Plots of trees in Fresno Country, California, USA, were foliar-sprayed three times with an EC formulation and once or twice with a soil application about the trees (Wetters and McKellar, 1989). Almonds were shaken from the trees 14 days after the last application and left to dry on the ground for 7 days. Kernels were separated from the hulls and both were analysed for chlorpyrifos and TCP. In another trial in California, dormant spray applications were made and almonds collected at normal harvest were analysed for chlorpyrifos plus TCP, determined as TCP (Wetters and Dishburger, 1975). The results are shown in Table 98.

Table 98. Residues of chlorpyrifos and TCP in almond kernels and hulls from the foliar and ground application of an EC formulation in the USA.

Location, Year	Application			PHI, days	Residue, mg/kg		Reference/ Comment
	kg ai/ha	kg ai/hl	No.		Chlorpyrifos	TCP	
USA GAP	2.2 foliar 4.5 ground		3	14			

Location, Year	Application			PHI, days	Residue, mg/kg		Reference/ Comment
	kg ai/ha	kg ai/hl	No.		Chlorpyrifos	TCP	
Fresno, California 1987	2.2 foliar 4.5 ground 2.2 foliar 2.2 foliar 4.5 ground	0.06 1.2	5	14	0.010 kernel 2.3 hull	0.056 kernel 2.2 hull	GH-C 2180. Foliar and ground applications were on the same day. Foliar 3700 l/ha. Ground 370 l/ha. Plot = 1 tree.
Fresno, California 1987	2.2 foliar 2.2 foliar 2.2 foliar 4.5 ground	0.06 1.2	4	14	≤0.01 kernel 1.9 hull	0.043 kernel 1.4 hull	GH-C 2180. Foliar and ground applications were on the same day. Foliar 3700 l/ha. Ground 370 l/ha. Plot = 1 tree
Fresno, California 1987	2.2 foliar 4.5 ground 2.2 foliar 2.2 foliar	0.06 1.2	4	14	0.010 kernel 3.2 hull	0.066 kernel 2.8 hull	GH-C 2180. Foliar and ground applications were on the same day. Foliar 3700 l/ha. Ground 370 l/ha. Plot = 1 tree
US GAP	Dormant EC: 2.2 WP: 4.5	 0.06 0.24	 1 1	 - -	Total		
Fresno, California 1972	2.2	0.06	1	204	≤0.05 nut ≤0.05 hull		GH-C 783. EC formulation. Total residue determined.
	2.2	0.06	1	191	0.05 nut 0.07 hull		GH-C 783. EC formulation. Total residue determined.
	2.2	0.06	1	185	≤0.05 nut ≤0.05 hull		GH-C 783 EC formulation. Total residue determined
	2.2	0.06	1	185	≤0.05 nut ≤0.05 hull		GH-C 783 WP formulation. Total residue determined.

Pecans. Five foliar sprays of an EC formulation were applied to pecan trees in Mississippi, USA (Wetters, 1989). Samples were harvested 28 days after the last application and stored frozen. Before analysis, the kernels were separated from the shells. The recovery of chlorpyrifos from fortified kernels at 0.01 mg/kg (method ACR 73.5.S1) was 96±7%, n = 9, and that of TCP at 0.05 mg/kg (method ACR 71.19R.S6) was 110 ± 15%, n = 4. The conditions and results are shown in Table 99.

In earlier trials in 1982 in the USA, 5-8 foliar applications of an EC formulation were made to pecan trees at 0.12 kg ai/hl. Kernels were analysed for total residue, chlorpyrifos plus TCP (Miller, 1983c).

The results are shown in Table 99.

Table 99. Residues of chlorpyrifos and TCP in pecans from the application of EC to trees in the USA.

Location, year, (Variety)	Application			PHI, days	Residue, mg/kg[1]		Reference/ Comment
	kg ai/ha	kg ai/hl	No.		chlorpyrifos	TCP	
USA GAP	2.2 foliar 1.1 foliar	(0.23) 0.12	5 5	28 28			480 g/l EC 120 g/l EC
Helm, Mississippi 1985 (Stewart)	1.1		5	28	≤0.01	<0.05	GH-C 2195. 50 or 100 l/ha. Plot = 1.6 ha.
Leland, Mississippi 1985 (Stewart)	1.1		5	28	≤0.01	<0.05	GH-C 2195. 50 or 100 l/ha. Plot = 1.6 ha
					Total		

Location, year, (Variety)	Application			PHI, days	Residue, mg/kg[1]		Reference/ Comment
	kg ai/ha	kg ai/hl	No.		chlorpyrifos	TCP	
South Carolina 1982	0.05 kg/tree	0.12	5	30	≤0.05[3]		GH-C 1652 Plot=2 trees
New Mexico 1982	0.11 kg/tree	0.12	5	31	≤0.05		GH-C 1652 Plot= 1 tree Duplicate plots.
Texas 1982	4	0.12	5	31	≤0.05		GH-C 1652 Plot=1 tree
Mississippi 1982	0.014 kg/tree	0.12	5	30	≤0.05		GH-C 1652 Plot=3 trees
Mississippi 1982	0.023 kg/tree	0.12	5	30	≤0.05		GH-C 1652 Plot=3 trees
Mississippi 1982	0.023 kg/tree	0.12	5	30	≤0.05		GH-C 1652 Plot=2 trees
Georgia 1981	0.057 kg/tree (0.7)	0.15	6	14	<0.05		GH-C 1652 Plot= 8 trees with 12 trees/A
Georgia 1982	0.028 kg/tree (0.34)	0.08	8	21	0.17		GH-C 1652 Plot=8 trees with 12 trees/A

[1] LOQ 0.01 mg/kg for chlorpyrifos, 0.05 mg/kg for TCP. Recoveries averaged 94% from GH-C 2195 and 82% from GH-C 1652.

Walnuts. In supervised trials in California, USA, three applications of chlorpyrifos were made either as a dilute or concentrated spray, at 2.2 to 2.8 kg ai/ha. Samples were collected at normal harvest, 12-17 days after the last application. Kernels were analysed for total residues (chlorpyrifos + TCP) measured as TCP (Miller, 1982). The results are shown in Table 100.

Table 100: Residues of chlorpyrifos in walnut kernels from supervised trials in California, USA.

Country, year	Application				PHI, days	Residues, mg/kg[1,2]	Reference
	Form.	kg ai/ha	kg ai/hl	No.			
GAP-USA	50 WP	2.24	0.24	1	14		
	4 EC	2.24	0.24	2	14		
1977	WP+EC	2.2	0.06	3	12	<0.05, <0.05, <0.05, ≤0.05	GH-C 1579
	WP+EC	2.2	0.60	3	12	<0.05, <0.05, <0.05, ≤0.05	
1979	EC	2.2	0.06	3	14	<0.05, <0.05, <0.05, ≤0.05	GH-C 1579
	EC	2.2	0.06	3	14	<0.05, <0.05, <0.05, ≤0.05.	
1979	EC	2.8	0.06	3	17	<0.05, <0.05, <0.05, ≤0.05	GH-C 1579
1979	EC	2.2	0.06	3	14	<0.05, ≤0.05	GH-C 1579
1972	EC	2.2	0.06	1	216	<0.05, <0.05, <0.05, <0.05	GH-C 783

[1] Total residue (chlorpyrifos + TCP), measured as TCP
[2] LOQ 0.05 mg/kg for total residue. Recoveries averaged 83% to 88%

Oil seeds

Cotton seed. Supervised trials were conducted in Brazil and the USA. In a trial in Brazil in 1992 the EC formulation of chlorpyrifos was applied to plants three times at 0.96 or 1.92 kg ai/ha or once at 0.72 or 1.44 kg ai/ha. Samples were taken 21 days after the last application from 0.96 and 1.92 kg ai/ha plots and 106 days after application from 0.72 and 1.44 kg ai/ha plots (Balderrama and Matos, 1994h).

In a separate trial in Brazil, an EC formulation of chlorpyrifos was applied to plants twice at 0.96 or 1.92 kg ai/ha and once at 0.72 or 1.44 kg ai/ha. Samples were taken from the 0.96 and 1.92 kg treatments 21 days and from the 0.72 and 1.44 kg treatments 85 days after the last application, kept 2 days at 30°C in an oven and 1 day exposed to sunlight, then packed and stored at -20°C before analysis (Balderrama and Matos, 1994i).

In trials in the USA in Arizona, California and Mississippi, ten foliar applications of an EC formulation at 0.56 kg ai/ha were made with aerial or ground equipment, the last 30-33 or 40-41 days before harvest. Samples were harvested at random and ginned, and the seeds stored frozen until analysis. The recoveries of chlorpyrifos from cotton seed fortified at 0.01 mg/kg were 84 ± 5%, n = 5 (Doom, 1987).

In trials in Mississippi EC was applied nine times as a foliar spray at 1.12 or 2.24 kg ai/ha and samples collected at intervals from 0 to 14 days after the last application were ginned and the seed analysed (McKellar and Dishburger, 1974).

In trials in Texas, Mississippi and South Carolina, plants were treated with multiple foliar applications of an EC formulation, using ground and aerial equipment, at 1.12 or 0.28 and 1.12 kg ai/ha. Samples were taken at normal harvest (McKellar, 1975).

In a trial in 1986 in California chlorpyrifos was applied 5 times at 1.12 kg ai/ha. Samples collected 14 days after the last application were mechanically delinted and the seeds collected from the gin chute and stored frozen before analysis (Wetters, 1987b).

Table 101 summarizes the results of all the trials.

Table 101. Residues of chlorpyrifos in cotton seed from supervised trials in Brazil and the USA. Seed analysed.

Location/Year	Application			PHI, days	Residues, mg/kg [1]	Reference/ comment
	Form.	kg ai/ha	No.			
GAP-Brazil	480 EC	0.96	3	21		
Brazil, 1992	EC	0.72	1	106	0.01	GHB-P 195
	EC	0.96	3	21	0.07	
	EC	1.44	1	106	0.02	
	EC	1.92	3	21	0.44	
Brazil, 1992	EC	0.72	1	85	<0.01	GHB-P 196
	EC	0.96	2	21	0.02	
	EC	1.44	1	85	0.02	
	EC	1.92	2	21	0.04	
GAP-USA	480 EC	1.1	6	14		
Mississippi, 1973	EC	1.12	9	0	1.4, 0.94, 0.97, 1.1	GH-C 739
				3	0.28, 0.37, 0.48, 0.47	
				7	0.02, 0.02, 0.02	
				14	0.16, 0.02, 0.03	
Mississippi, 1973	EC	2.24	9	0	3.0, 3.7, 1.8, 2.7	GH-C 739
				3	0.63, 0.54, 0.66, 1.1	
				7	0.07, 0.04, 0.07	
				14	0.05, 0.14, 0.04	
MS, 1980	EC	0.56	2	41	0.01, <0.01, 0.01, 0.01	GH-C 1658
CA, 1982	EC	0.56	4	14	0.08, 0.08, 0.17, 0.25	GH-C 1658
				21	0.08, 0.05, 0.07, 0.04	

Location/Year	Application			PHI, days	Residues, mg/kg [1]	Reference/ comment
	Form.	kg ai/ha	No.			
MS, 1982	EC	0.56	8	14	0.01, 0.01, 0.03, 0.03	GH-C 1658
				21	0.03, 0.03, 0.01, 0.02	
MS, 1982	EC	0.56	8	14	0.03, 0.06, 0.06, 0.02	GH-C 1658
				21	0.12, 0.06, 0.14, 0.15	
CA, 1986	EC	1.12	5	14	0.12, 0.17, 0.15, 0.10	GH-C 1893
Arizona, 1985	EC	0.56	10	30 40	<0.01 <0.01	GH-C 1879 2.3 l/ha
Arizona, 1985	EC	0.56	10	30 40	<0.01 <0.01	GH-C 1879. Aerial 28 l/ha
Arizona, 1985	EC	0.56	10	40	0.010	GH-C 1879. Aerial 28 l/ha
Arizona, 1985	EC	0.56	10	30 40	0.019 <0.01	GH-C 1879. 2.3 l/ha
California, 1985	EC	0.56	10	30 40	<0.01 <0.01	GH-C 1879. Aerial 47 l/ha
California, 1985	EC	0.56	10	31 41	0.040 0.086	GH-C 1879 Aerial 28 l/ha
Mississippi, 1985	EC	0.56	10	33 40	0.018 0.014	GH-C 1879 2.3 l/ha
Texas, 1974	EC	0.28 x 4 1.12 x 13	17	6	0.062, 0.037, 0.015, 0.029	GH-C 840
Mississippi, 1974	EC	0.28 x 4 1.12 x 12	16	15	2.0, 0.92, 1.0, 1.3	GH-C 840
Mississippi, 1974	EC	1.12	11	31	<0.01, <0.01, <0.01, <0.01	GH-C 840
South Carolina, 1974	EC	0.28 x 4 1.12 x 13	17	34	0.13, 0.11, 0.094	GH-C 840
South Carolina, 1974	EC	1.12	13	38	0.055, 0.053, 0.023, 0.038	GH-C 840
Texas. 1974	EC	0.28 x 4 1.12 x 12	16	18	0.12, 0.078, 0.11, 0.098	GH-C 840

[1] LOQ 0.01 mg/kg and mean recoveries 81% for Brazilian trials. LOQ 0.01 mg/kg and recoveries 84% to 87% for US trials.

Peanuts. Residue trials were reported from Georgia and Mississippi, USA, in which a granular formulation was applied at planting and again 30 to 72 days before harvest, and in some trials one or two EC foliar applications between the granular treatments. Peanuts were harvested at normal maturity, separated into hulls and kernels, and analysed for chlorpyrifos and TCP by method ACR 84.4.

Table 102. Residues of chlorpyrifos and TCP in peanuts from soil and foliar applications in the USA.

Location, (Variety) Year	Application			PHI, days	Residue, mg/kg [1]		Reference/comment
	Form.	kg ai/ha	No.		chlorpyrifos	TCP	
USA GAP	G	2.2 broadcast 15 oz/1000 ft row	2	21			All uses not to exceed 4.5 kg ai/ha/season
	EC	2.2 pre-plant (soil); foliar		21			

Location, (Variety) Year	Application			PHI, days	Residue, mg/kg [1]		Reference/comment
	Form.	kg ai/ha	No.		chlorpyrifos	TCP	
Donalson-ville, Georgia (Florunner) 1986	G EC G	2.2 0 2.2	2	30	0.017, 0.011, 0.016, 0.014	0.084, 0.084, 0.093, 0.11	GH-C 2665 The first G application was in an 8 inch band at 15 oz/1000 ft., 36 inch centre. The second G application was an 8 inch band at the rate o f 22.5 oz/1000ft row.
	G EC G	2.2 0 3.4	2	30	0.032, 0.029, 0.034, 0.038	0.13, 0.11, 0.16, 0.18	
	G EC G	2.2 1.1 2.2	3	30	0.037, 0.053, 0.034, 0.028	0.23, 0.22, 0.11, 0.22	EC was broadcast, 187 l/ha
	G EC G	2.2 0 2.2	2	58	0.020, 0.019, 0.035, 0.30	0.16, 0.10, 0.10, 0.20	
	G EC G	2.2 0 3.4	2	58	0.040, 0.044, 0.050, 0.045	0.16, 0.20, 0.17, 0.23	
Wayside, Mississippi (Florunner) 1986	G EC G	2.0 0 2.0	2	41	0.007, 0.010, 0.008, 0.005	0.12, 0.11, 0.094, 0.058	GH-C 2665. First G application at 15 oz/1000ft of row, 40 in centre.
	G EC G	2.0 0 3.1	2	41	0.007, 0.011, 0.009, 0.005	0.10, 0.11, 0.13, 0.072	Second G application at a rate of 22.5 oz/1000ft row, 40 inch centres.
	G EC G	2.0 1.1 2.0	3	41	0.006, 0.004, 0.009, 0.004	0.086, 0.052, 0.078, 0.068	EC was broadcast
	G EC G	2.0 0 2.0	2	72	0.004, 0.002, 0.004, 0.003	0.12, 0.13, 0.12, 0.19	
	G EC G	2.0 0 3.1	2	72	0.004, 0.005, 0.005, 0.002	0.19, 0.13, 0.20, 0.11	
North Carolina 1973	EC EC G	0.28 0.28 2.24	2 2 1				GH-C 1071
Green forage				0 8 15	16, 21, 17, 19 8.6, 8.2, 8.4, 8.8 4.1, 5.4, 5.8, 5.6		
Kernels				15	0.01, 0.01, <0.01, 0.01		
Hay				15	5.1, 5.8, 6.3, 4.2		
Virginia 1974	EC EC G	0.28 1.12 2.24	2 2 1				GH-C 1071
Green forage				0 6 14	74, 42, 56, 52 15, 17, 20, 13 6.0, 7.2, 5.6, 8.6		

Location, (Variety) Year	Application			PHI, days	Residue, mg/kg [1]		Reference/comment
	Form.	kg ai/ha	No.		chlorpyrifos	TCP	
Kernels				14 44	0.01, 0.01, 0.02, 0.01 0.01, 0.01, 0.01, 0.01		
Hay				36	5.5, 5.0, 3.6, 5.6		
Georgia 1974	EC EC G	0.28 1.12 2.24	2 2 1		`		GH-C 1071
Kernels				18	<0.01, <0.01, <0.01, ≤0.01		
Hay				18	<0.01, <0.01, <0.01, ≤0.01		
Georgia 1975	EC EC G	0.28 1.12 2.24	2 2 1				GH-C 1071
Kernels				27	<0.01, <0.01, <0.01, <0.01		
Hay				27	0.01, 0.01, 0.01, 0.01		
Mississippi 1974	EC EC G	0.28 1.12 2.24	2 2 1				GH-C 1071
Kernels				27	<0.01, <0.01, <0.01, <0.01		
Hay				27	1.0		

[1] LOQ 0.01 mg/kg.

Sunflowers. In two supervised trials in the USA chlorpyrifos EC formulation was applied as a band-over-row treatment to plants at cracking to the 4th leaf stage of growth at the broadcast equivalent of 5 or 10 kg ai/ha. Samples of seeds were taken at normal harvest 77 days after treatment (Wetters, 1979).

In four US trials samples of seed and forage were collected after soil incorporation of the 15G formulation at planting at 1.5 kg ai/ha followed by three to five applications of EC at 0.56 to 1.68 kg ai/ha as a broadcast post-emergence spray using aerial or ground equipment. Samples of seed were collected at harvest, 44 to 75 days after the last application, and of forage at the early seed development stage (Miller, 1980c).

Sunflowers in North Dakota were treated with three applications of EC at 1.6 kg ai/ha, and samples collected 42 days after the last application (Robb, 1991c).

In a 1993 trial sunflowers were treated with 3 applications of chlorpyrifos at the maximum label rate of 1.68 kg ai/ha, and samples of whole seeds collected and processed. Residues of chlorpyrifos were determined in forage, seed and hulls (Turner, 1994).

In trials in Michigan, North Dakota and Minnesota in 1979 and 1980 four or six applications of chlorpyrifos 15 G and EC formulations were made to plots of sunflowers. The former was applied at planting, incorporated into the soil at 1.5 kg ai/ha, and the latter twice post-emergence to the leaves at 1.68 kg ai/ha 4 to 8 weeks after planting. The four-treatment schedule concluded with one further application and the six-treatment with three additional applications of EC at 0.56 kg ai/ha 7 to 22 days apart. Seeds were sampled 69 to 71 days after the fourth application and 42 to 46 days after the sixth (Miller, 1981b).

Sunflowers in Canada were treated with a single foliar application of an EC formulation at the 4- to 6-leaf stage at 1.12 kg ai/ha 97 days before harvest, and residues were determined in the seed (Fairbairn *et al.*, 1980).

The results are shown in Table 103.

Table 103: Residues of chlorpyrifos in sunflowers from supervised trials in the USA and Canada.

Location, year, sample	Application			PHI, days	Residues, mg/kg[1,2]	Reference/ Comments
	Form.	kg ai/ha	No.			
GAP-USA	480 EC	2.2 pre-plant 1.7 foliar	1 3	42		5.0 kg ai/ha/season
	15G	2.4 for 18 in row spacing.	1	NA		At planting
MN, 1978						
Seed	EC	1.68	1	77	<0.01, <0.01, <0.01, <0.01	GH-C 1180
	EC	3.36	1	77	<0.01, <0.01, <0.01, <0.01	
ND, 1993						
Forage	EC	1.68	3	42	0.09	GH-C 3239
Seed	EC	1.68	3	42	<u>0.05</u>	
Hulls	EC	1.68	3	42	0.15	
ND, 1990						
Seed	EC	1.68	3	42	0.02[3],0.04, 0.04, <u>0.09</u>[3]	GH-C 2683
MN, 1979						
Seed	G + EC	1.34 + 1.68 (x2) + 0.56	4	59	0.02, 0.03, 0.03, 0.02	GH-C 1371
	G + EC	1.34 + 1.68 (x2) + 0.56 (x3)	6	45	0.05, 0.05, 0.02, 0. 04	
Forage	G + EC	1.34+1.68 (x2)+0.56	4	27	2.1	
	G + EC	1.34 + 1.68 (x2) + 0.56 (x3)	6	13	3.9	
MS, 1979						
Seed	G + EC	1.5 + 1.68 (x2) + 0.56	4	65	0.02[3], 0.01, 0.03, 0.02	GH-C 1371
	G + EC	1.5 + 1.68 (x2) + 0.56 (x3)	6	44	0.04, 0.05[3], 0.06, 0.03	
NE, 1979						
Seed	G + EC	1.5 + 1.68 (x2) + 0.56	4	67	0.05, 0.05, 0.03[3], 0.03	GH-C 1371
	G + EC	1.5 + 1.68 (x2) + 0.56 (x3)	6	46	0.12, 0.12[3], 0.16, 0.11[3]	
ND, 1979						
Seed	G + EC	1.5 + 1.68 (x2) + 0.56	4	75	0.04	GH-C 1371
	G + EC	1.5 + 1.68 (x2) + 0.56 (x3)	6	44	0.10[3]	
MI, 1980						
Seed	G + EC	1.5 + 1.68 (x2) + 0.56	4	69	0.04, 0.04, 0.05, 0.01	GH-C 1468
	G + EC	1.5 + 1.68 (x2) +0.56 (x3)	6	42	0.07, 0.07, 0.07, 0.13	
ND, 1980						
Seed	G + EC	1.5 + 1.68 (x2) + 0.56	4	71	0.06, 0.02, 0.04, 0.01	GH-C 1468
	G + EC	1.5 + 1.68 (x2) + 0.56 (x3)	6	46	0.03, 0.02, 0.01[3], 0.01[3]	
MN, 1979						
Seed	G + EC	1.8 + 1.68 (x2) + 0.56 (x3)	6	45	0.03	GH-C 1468
GAP-Canada	480 EC	0.576	1	42		
Canada, 1977						GHS-C 11

Location, year, sample	Application			PHI, days	Residues, mg/kg[1,2]	Reference/ Comments
	Form.	kg ai/ha	No.			
Seeds	EC	1.12	1	97		

[1] LOQ 0.01 mg/kg
[2] Recoveries 78% to 92% from seeds
[3] Average of duplicate analyses

Seeds for beverages

Coffee. In a trial on the foliar application of an EC formulation to plants in Brazil three treatments were made at 0.72 or 1.4 kg ai/ha and beans sampled 21 days after the final application (Pinto and Matos, 1994). The peel was mechanically separated from the bean (grain).

In a field trial in Brazil in 1994-1995 the EC formulation was applied 3 times to plants at 0.72 and 1.44 kg ai/ha and samples were taken 21 days after the last application (Catta-Preta and Rampazzo, 1997). The beans were processed into roasted beans and instant coffee.

In further trials in Brazil, trees at three different locations were treated at 0.72 kg ai/ha three times during the growing season, with the last application 7 days before normal harvest. Samples of beans were collected 7, 14, 21 and 35-36 days after the last application. Following commercial practice, the beans were de-pulped and sun-dried before analysis (Miller, 1981c).

In field trials in Columbia an EC formulation was applied three times to berry-containing plants at 2.0 or 4.0 l/ha (0.96 kg ai/ha and 1.92 kg ai/ha respectively). Samples were collected at intervals from 0 to 28 days, shelled, soaked in water and dried in the sun. The green beans were stored frozen and sub-samples were processed (Catta-Preta and Rampazzo, 1999).

In a trial in Tanzania during 1986, an EC was applied at rates up to 1.92 kg ai/ha. Samples of beans were taken 1, 8, 15, 22 and 29 days after application and some were processed before analysis (Day, 1987b).

The results are shown in Table 104.

Table 104. Residues of chlorpyrifos in coffee beans from the foliar application of an EC formulation.

Location, (Variety) Year	Application		PHI, days	Residue, mg/kg[1]	Reference/ comment
	kg ai/ha	No.			
Brazil GAP	0.72	2	21		
Campinas, Brazil (Catuai) 1992-1993	0.72	3	21	<u>0.03</u> bean (green) 0.39 peel	GHB-P 201. 400 l/ha
	1.4	3	21	0.11 bean (green) 1.0 peel	
Mogi Mirim, Brazil (Catuai) 1994-1995	0.70	3	21	<u>0.03</u> bean (green)	GHB-P310 400 l/ha
	1.4	3	21	0.12 bean (green)	
Brazil 1979	0.72	3	7 14 21 36	0.01 bean (green) 0.01 <u>0.01</u> 0.01	GH-C 1462
Brazil 1979	0.72	3	7 14 21 35	0.01 bean (green) 0.02 <u>0.01</u> 0.01	GH-C 1462

Location, (Variety) Year	Application		PHI, days	Residue, mg/kg[1]	Reference/ comment
	kg ai/ha	No.			
Brazil 1979	0.72	3	7 14 21 35	0.01 bean (green) 0.02 <u>0.01</u> 0.01	GH-C 1462
GAP- Columbia	1.4	3	21		480 EC
Columbia 1999	0.96	3	0 2 7 14 21 28	1.1, 2.0, 0.84, 2.3 0.29, 0.77, 0.58, 0.58 0.1, 0.29, 0.26, 0.38 0.11, 0.17, 0.14, 0.23 0.05, 0.08, 0.15, 0.05 0.04, 0.04, 0.05, 0.07 bean (green)	GHB-P 413
	1.92	3	0 2 7 14 21 28	2.1, 2.9, 4.0, 3.4 0.85, 2.3, 0.60, 1.7 0.72, 1.4, 0.68, 0.79 0.31, 0.60, 0.44, 0.79 0.22, 0.44, 0.43, 0.38 0.08, 0.20, 0.28, 0.18 bean (green)	
GAP-Tanzania	0.96		7		
Tanzania 1986	0.96 1.44 1.92		8 8 8	<u>0.04</u> 0.13 0.08 green bean	GHE-P 1737
Tanzania 1986	0.96 1.44 1.92		15 15 15	0.07 0.11 0.06 green bean	GHE-P 1737
Tanzania 1986	0.96 1.44 1.92		22 22 22	0.07 0.08 0.08 green bean	GHE-P 1737

[1] LOQ 0.01 mg/kg for GH-C 1462, 0.02 mg/kg for GHB-P 201 and GHE-P 1737. Recoveries 87-88% for GHB-P 201 and GHE-P 1737.

Animal feeding studies

Feeding studies were carried out on cattle, pigs and chickens to determine the potential for residues of chlorpyrifos in meat, milk and eggs. The results are shown in Tables 105 to 110. No corrections were made for recoveries or residues in control samples.

<u>Cattle</u> (Dishburger *et al.*, 1972a). Eighteen Hereford cross-bred heifers were subdivided into 6 groups of 3 according to body weight (158-243 kg). Each group was penned together and allowed to share a conditioning ration containing 50% concentrate and 50% roughage for 36 days. The feed was then changed to 75% concentrate and 25% roughage and doses of chlorpyrifos were administered in capsules by balling gun each day at the equivalent of 0, 3, 10, 30 or 100 ppm in the diet, calculated from each group's average total dry matter intake of the concentrate and roughage. The cattle were slaughtered at the end of the 30-day period without withdrawal and samples of muscle, liver, kidneys, and omental and subcutaneous fat were collected for residue determination. All the cattle, including the control group, gained from 2 to 34 kg during the treatment period. Three other cattle were dosed with the equivalent of 100 ppm chlorpyrifos in the diet for 30 days and then samples of omental fat were collected by surgical biopsy at weekly intervals for 5 weeks.

The results are shown in Tables 105 and 106, and indicate that residues of chlorpyrifos were mainly in the fat, where they ranged from <0.01-0.04 mg/kg in the 3 ppm group to 2.0-4.2 mg/kg in the 100 ppm group with no withdrawals for 30 days. After withdrawal the residues of chlorpyrifos in the omental fat decreased steadily to <0.01-0.03 mg/kg.

Table 105. Residues in the tissues of cattle dosed with chlorpyrifos for 30 days.

Dose, ppm in diet	Chlorpyrifos, mg/kg[1,2,3]						Reference
	Muscle	Liver	Kidney	Omental fat	Renal fat	Subcutaneous fat	
0	0.00	0.00	0.00	0.00	0.00	0.00	GH-C 566
	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	
3	<0.01	<0.01	<0.01	0.01	0.01	0.01	GH-C 566
	<0.01	<0.01	<0.01	0.04	0.03	0.03	
	<0.01	<0.01	<0.01	0.01	0.01	<0.01	
10	0.02	0.02	<0.01	0.10	0.14	0.15	GH-C 566
	<0.01	<0.01	<0.01	0.07	0.09	0.06	
	<0.01	<0.01	<0.01	0.10	0.13	0.07	
30	0.01	<0.01	<0.01	0.38	0.41	0.18	GH-C 566
	0.01	0.01	0.01	0.75	0.99	0.51	
	0.02	<0.01	0.01	0.31	0.42	0.23	
100	0.11	0.01	0.02	2.6	3.1	3.1	GH-C 566
	0.19	0.02	0.01	2.4	4.2	3.8	
	0.29	<0.01	<0.01	2.0	2.4	2.5	

[1] LOQ 0.01 mg/kg
[2] Recoveries averaged 86% from muscle, 78% from liver, 74% from kidney, 88-90% from fat
[3] Analyses were also conducted for TCP and the oxygen analogue of chlorpyrifos. The latter was found only in two omental fat samples from cattle fed at the 100 ppm level, at the LOQ, 0.01 mg/kg.

Table 106. Residues of chlorpyrifos in omental fat of cattle during the withdrawal phase after oral administration of 100 ppm for 30 days.

Period, days	Chlorpyrifos residues, mg/kg[1,2,3]		Reference
	Individual cow	Average	
0	2.6, 2.4, 2.0	2.3	GH-C 566
7	1.0, 0.86, 0.58	0.81	GH-C 566
14	0.59, 0.13, 0.23	0.32	
21	0.51, 0.11, 0.08	0.23	
28	0.13, 0.06, 0.02	0.07	
35	0.03, <0.01	0.02	

[1] LOQ 0.01 mg/kg
[2] Recoveries averaged 88 to 90%
[3] Linear regression correlation coefficient is 0.8447

Dairy cattle. Three dairy cows were fed complete rations containing chlorpyrifos at 0.3, 1, 3, 10 or 30 ppm for 14 days consecutively at each level. At the end of this time, the fortified feed was withdrawn and the animals fed the basal ration for 14 days. A total of 16.3 kg of feed was given to each cow daily, half at each milking. Any feed not eaten between milkings was removed and weighed. All of the feed was consumed most of the time. Milk samples from each cow were taken at intervals by combining equal volumes from the evening and the following morning milkings. All milking was done by machine.

Cream samples were collected only from the morning milk, by pooling 5.6 l of milk from each cow of its group. This was then separated on an electric farm separator adjusted to give medium heavy cream (about 45% butterfat), and samples of milk and cream were stored frozen for analysis (Dishburger *et al.*, 1972b). The results are shown in Table 107. Residues of chlorpyrifos in milk ranged from <0.01 mg/kg for cows fed at the 10 ppm level to 0.02 mg/kg at 30 ppm. In cream the residues ranged from <0.01 at 3 ppm to 0.15 mg/kg at 30 ppm. After withdrawal from the 30 ppm diet, milk and cream showed no detectable residues in the withdrawal period.

Table 107. Residues of chlorpyrifos in milk and cream of cows fed diets containing chlorpyrifos for 14 days.

Chlorpyrifos, ppm in diet	Days fed	Chlorpyrifos, mg/kg [1]		Reference
		Milk	Cream	
3	10	--	0.01	GH-C 533
	11	--	<0.01	
	12	--	<0.01	
	13	--	0.01	
10	3	<0.01, <0.01, <0.01		GH-C 533
	6	<0.01,<0.01, <0.01		
	10	<0.01,<0.01, <0.01	0.03, 0.04	
	11	<0.01,<0.01, <0.01	0.02, 0.03	
	12	<0.01,<0.01, <0.01	0.03, 0.03	
	13	<0.01,<0.01, <0.01	0.03, 0.03	
30	3	0.01, 0.02, 0.01		GH-C 533
	6	0.01, 0.02, 0.01		
	10	<0.01, 0.01, 0.01	0.15	
	11	0.01, 0.01, 0.01	0.12	
	12	0.01, 0.01, 0.01	0.11	
	13	0.01, 0.01, 0.01	0.10	
Withdrawal from	Withdrawal (days)			GH-C 533
30 ppm diet	1	<0.01, <0.01, <0.01		
	3	<0.01, <0.01, <0.01	<0.01	
	4	<0.01, <0.01, <0.01	<0.01	
	5	<0.01, <0.01, <0.01	<0.01	

[1] LOQ 0.01 mg/kg. Recoveries averaged 88% from milk and cream

Pigs. Eighteen weaned Landrace pigs weighing about 23 kg each were divided into 6 treatment groups, each consisting of 2 males and 1 female, placed in separate pens and fed *ad libitum* throughout the trial. Groups were fed the basal ration containing 0, 1, 3 or 10 ppm (3 groups) chlorpyrifos for 30 days. The groups fed 0, 1 and 3 ppm and one of the 10 ppm groups were slaughtered with no withdrawal period. The remaining two 10 ppm groups were put on untreated feed and one group was slaughtered at 7 days and the other after 21 days.

Samples of muscle, liver, kidney, omental fat, renal fat and subcutaneous fat were collected from each pig at slaughter (Dishburger *et al.*, 1972c). The results (Table 106) showed that during the treatment period residues in the fat ranged from <0.01-0.02 mg/kg at the 1 ppm level to 0.05-0.18 mg/kg at the 10 ppm level, and in the muscle 0.01-0.03 mg/kg at the 10 ppm level. After withdrawal the only detectable residues were 0.01-0.03 mg/kg in the fat at 7 days.

Table 108. Residues of chlorpyrifos in tissues of pigs fed diets containing chlorpyrifos for 30 days.

Chlorpyrifos, ppm in diet	Chlorpyrifos, mg/kg [1]						Reference
	Muscle	Liver	Kidney	Omental fat	Renal fat	Subcutaneous fat	
0	0.00	0.00	0.00	0.00	0.01	0.00	GH-C 549
	0.00	<0.01	0.00	0.00	0.01	0.00	
	0.00	0.00	0.00	0.00	0.01	0.00	
1	---	---	---	<0.01	0.02	0.01	GH-C 549
	---	---	---	<0.01	<0.01	<0.01	
	---	---	---	0.01	0.01	0.01	
3	<0.01	<0.01	---	0.01	0.02	0.02	GH-C 549
	<0.01	<0.01	---	<0.01	0.01	0.01	
	<0.01	<0.01	---	0.01	0.04	0.03	
10	0.03	<0.01	<0.01	0.18	0.18	0.18	GH-C 549
	0.02	0.01	<0.01	0.05	0.12	0.12	
	0.01	0.01	<0.01	0.06	0.11	0.12	
Withdrawal from 10 ppm							
7 days	<0.01	<0.01	---	<0.01	0.01	0.01	GH-C 549
	<0.01	<0.01	---	<0.01	0.02	0.03	
	<0.01	<0.01	---	<0.01	<0.01	0.01	
21 days	---	---	---	<0.01	<0.01	<0.01	GH-C 549
	---	---	---	<0.01	<0.01	<0.01	
	---	---	---	<0.01	<0.01	<0.01	

[1] LOQ 0.01 mg/kg. Recoveries averaged 88% from muscle, 90% from liver, 88% from kidney and 83% from fat

Poultry. 288 hens were divided into 8 groups of 36 birds each, kept in certified facilities, and fed chlorpyrifos at 0 (2 groups) 0.3, 1, 3 and 10 (3 groups) ppm in their diet for 30 days. After the 30 days, all the hens in the two control groups and 24 hens from each of 0.3, 1, 3 and 10 (1 group only) ppm groups were killed with no withdrawal. Samples of muscle with fat and skin, liver, kidneys and peritoneal fat, as well as eggs from laying hens fed 10 ppm chlorpyrifos for 45 days, were analysed for residues (Dishburger *et al.*, 1972d). The residues in tissues are shown in Table 109 and in whole eggs in Table 110. Residues were found in peritoneal fat from <0.01 mg/kg at 1 ppm to 0.05 mg/kg at 10 ppm. No residues were detected at 7 days after withdrawal from the 10 ppm dose level. Feed consumption during the 30-day trial was 0.1 kg/hen/day for the control groups, and 0.12 kg/hen/day for the treated groups. Egg production was consistent in all groups (0.62-0.72 egg/hen/day).

Table 109. Residues of chlorpyrifos in tissues of chickens fed diets containing chlorpyrifos for 30 days.

Chlorpyrifos, ppm in diet	Residues, mg/kg [1]				Reference
	Muscle	Liver	Kidney	Peritoneal fat	
0	0.00	0.004	0.00	0.00	GH-C 555
	0.01	0.001	0.00	0.00	

Chlorpyrifos, ppm in diet	Residues, mg/kg [1]				Reference
	Muscle	Liver	Kidney	Peritoneal fat	
	0.001	0.001	0.00	0.00	
	0.00	0.003	0.00	0.00	
	0.00	0.002	0.00	0.00	
	0.00	0.000	0.00	0.00	
0.3	No residues detected				GH-C 555
1.0		---	---	<0.01	GH-C 555
		---	---	<0.01	
		---	---	<0.01	
		---	---	<0.01	
		---	---	<0.01	
		---	---	<0.01	
3		---	---	<0.01	GH-C 555
		---	---	0.01	
		---	---	<0.01	
		---	---	0.01	
		---	---	0.01	
		---	---	0.01	
10	0.01	<0.01	<0.01	0.03	GH-C 555
	<0.01	<0.01	<0.01	0.05	
	<0.01	<0.01	<0.01	0.03	
	<0.01	<0.01	<0.01	0.02	
	<0.01	<0.01	<0.01	0.02	
	<0.01	<0.01	<0.01	0.02	
Withdrawal from 10 ppm feed					
7 days	---	---	---	No residues detected	GH-C 555

[1] LOQ 0.01 mg/kg. Recoveries averaged 98% from muscle, 90% from liver, 91% from kidney, 83% from fat.

Table 110. Residues of chlorpyrifos in whole eggs of chickens fed diets containing chlorpyrifos for 7-45 days.

Chlorpyrifos, ppm in diet	Days feed	Chlorpyrifos, mg/kg [1]	Reference
0	0	0.00, 0.00,	GH-C 555
	10	0.00, 0.00	
10	7	0.01	GH-C 555
	14	0.01	
	21	<0.01	
	28	0.01	
	35	<0.01	
	36	0.01	
	37	<0.01	
	38	0.01	
	39	<0.01	
	40	<0.01	
	41	<0.01	
	42	<0.01	
	43	<0.01	

Chlorpyrifos, ppm in diet	Days feed	Chlorpyrifos, mg/kg [1]	Reference
	44	0.01	
	45	<0.01	

[1] LOQ 0.01 mg/kg. Recoveries averaged 83%

FATE OF RESIDUES IN STORAGE AND PROCESSING

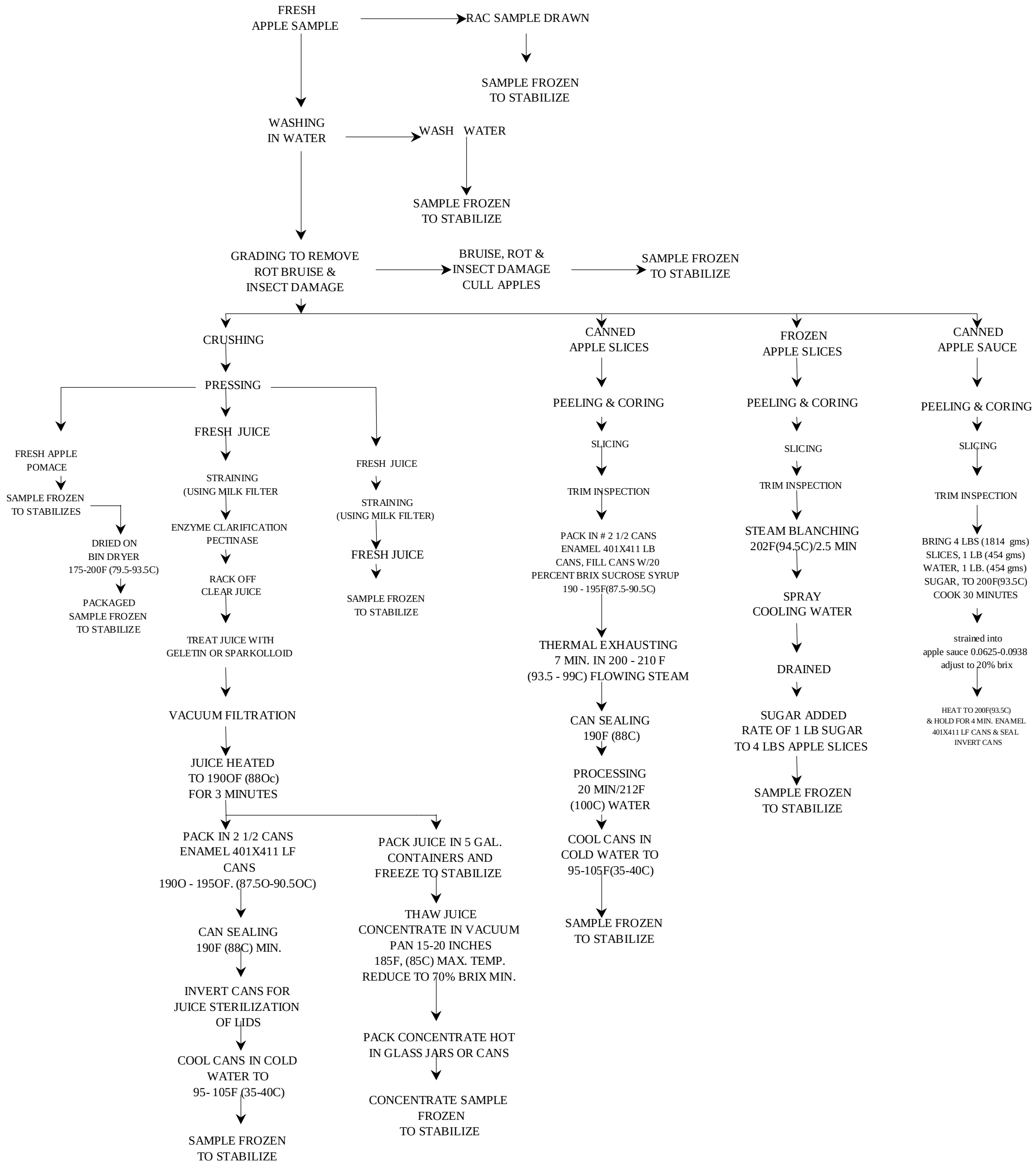
In processing

Processing trials were conducted on apples, citrus, grapes, sugar beet, tomatoes**,** maize, wheat, cotton seed, peanuts, sunflower and coffee. The results are shown in Tables 111-129, where processing factors used in the estimation of STMR-Ps, HRs and/or maximum residue levels are underlined.

None of the results were corrected for recoveries or apparent residues in control samples.

Apples. A typical small-batch apple processing simulating commercial practice is shown in Figure 4. The process involves washing and processing into juice and wet and dry pomace.

Figure 4. Apple processing.



In processing trials in Midland, Michigan in 1976, apple trees received 7 applications of chlorpyrifos 50 WP at the label rate of 2.24 kg ai/ha or 0.06 kg ai/hl. Samples harvested on the day of the last application were processed and residues of chlorpyrifos determined in unwashed, washed, and peeled apples as well as in the peel, juice, and wet and dry pomace (Wetters and Ervick, 1978).

In further processing trials 12 applications of chlorpyrifos 50 WP were made at 2.24 kg ai/ha or 0.12 kg ai/hl, and samples harvested and processed on the last treatment date (0-day PHI). Residues were determined in whole apples, juice, and wet and dry pomace (Miller, 1981a). The results are shown in Table 111.

Table 111. Residues of chlorpyrifos in processed apple fractions, 0-day PHI.

Sample	Application, kg ai/ha	Residues and (mean), mg/kg [1,2]	Processing factor	Reference
Unwashed apples	2.24 x7	4.4, 3.2, 2.1, 2.9 [3] (3.2)		GH-C 1107
	2.24 x12	0.53	1.0	GH-C 1488
Washed apples	2.24 x7	4.0, 3.3, 2.9, 3.6 (3.4)	1.0	GH-C 1107
Peeled apples	2.24 x7	0.52, 0.27, 0.21 0.43 (0.36)	0.11	GH-C 1107
Peels	2.24 x7	17, 17, 11, 16 (15)	4.4	GH-C 1107
Juice	2.24 x7	0.27, 0.40, 0.23, 0.30 (0.30)	<u>0.09</u>	GH-C 1107
	2.24 x12	0.11	<u>0.20</u>	GH-C 1488
Wet pomace	2.24 x7	8.2, 7.9, 7.2, 7.0 (7.6)	<u>2.2</u>	GH-C 1107
	2.24 x12	0.88	<u>1.7</u>	GH-C 1488
Dry pomace	2.24 x12	3.5	<u>6.6</u>	GH-C 1488

[1] LOQ 0.01 mg/kg. Results not corrected for recoveries
[2] Recoveries averaged 92 to 97% from whole apples, 94% from peeled apples, 87% from peel, 87% from pomace and 101% from juice.
[3] Four samples of 20 apples each randomly picked from 10 trees.

<u>Citrus fruit</u>

<u>Oranges</u>. Three processing trials were conducted in California in 1975. In the first chlorpyrifos was applied to fruit at 12 kg ai/ha using low- and high-volume sprays (California, 1975). Samples of whole oranges, peel, peel + pulp and juice were taken after 14 days and residues determined. The juice was extracted with a stainless steel electric juicer. In the second trial, the fruit were treated at 15 kg ai/ha and processed after 14 days, and in the third at 17 kg ai/ha with samples taken 0, 3, 14 and 30 days later (Wetters, 1977a).

In further processing trials chlorpyrifos was applied to oranges at 8 kg ai/ha (Trial 1) and 11 kg ai/ha (Trial 2) and residues were determined 14 and 21 days after treatment respectively in whole oranges, peel, pulp and juice. The oranges were peeled by hand and juice extracted in the laboratory with a Hobart juice extractor (Wetters, 1978). The results are shown in Table 112.

Table 112. Residues in oranges, juice, peel and pulp after foliar applications of chlorpyrifos and subsequent simulated home processing in the USA.

Sample	Application, kg ai/ha	PHI, days	Residues and (mean), mg/kg[1,2]	Processing factor	Reference
Whole oranges (unwashed)	12	14	0.40, 0.55, 0.49, 0.36 (0.45) (13400 l/ha)	1	GH-C 1041
	12	14	1.2, 1.0, 1.3, 1.1, 1.1 (1.1) (935 l/ha)	1	
	15	14	0.86, 0.84, 0.77, 0.80 (0.82) (16800 l/ha)	1	

Sample	Application, kg ai/ha	PHI, days	Residues and (mean), mg/kg[1,2]	Processing factor	Reference
	15	14	0.56, 0.47, 0.24, 0.82 (0.52) (935 l/ha)	1	
Whole oranges (unwashed)	17	0	1.5, 1.6, 1.5, 1.3 (18700 l/ha)		GH-C 1041
	17	3	0.54, 0.60, 0.58, 2.6		
	17	14	0.38, 0.70, 0.52, 0.35 (0.49)		
	17	30	0.21, 0.21, 0.13, 0.18		
Whole oranges (unwashed)	17	0	6.8, 5.0, 7.1, 3.2 (935 l/ha)		GH-C 1041
	17	3	3.8, 3.7, 3.6, 1.8		
	17	14	3.3, 2.0, 2.3, 0.70 (2.1)	1	
	17	30	0.80, 0.69, 0.89, 0.63		
Peel + pulp	12	14	0.52, 0.56, 0.55, 0.51 (0.54)	1.2	GH-C 1041
	12	14	1.6, 1.5, 1.4, 1.3 (1.4)	1.3	
	15	14	1.5, 1.6, 1.5, 1.7 (1.6)	2.0	
	15	14	0.59, 0.85, 0.62, 0.60 (0.66)	1.3	
Juice	12	14	0.01, 0.01, 0.01, 0.01 (0.01)	<u>0.02</u>	GH-C 1041
	12	14	0.07, 0.03, 0.02, 0.02 (0.04)	<u>0.04</u>	
.	15	14	0.01, 0.01, <0.01, 0.01 (0.01)	<u>0.01</u>	GH-C 1041
	15	14	<0.01, <0.01, <0.01, 0.01 (0.01)	<u>0.02</u>	
Peel + pulp	17	0	3.2, 2.4 (18700 l/ha)		
	17	3	1.5, 1.02		
	17	14	0.88, 0.68 (0.78)	1.6	
	17	30	0.40, 0.39		
	17	0	16, 5.4 (935 l/ha)		
	17	3	8.4, 4.6		
	17	14	2.0, 4.9 (3.4)	1.6	
	17	30	1.4, 0.68		
Juice	17	0	0.038, 0.046 (18700 l/ha)		
	17	3	0.018, 0.016		
	17	14	0.013, 0.013 (0.013)	<u>0.03</u>	
	17	30	0.016, 0.011		
	17	0	0.78, 0.071 (935 l/ha)		
	17	3	0.22, 0.22		
	17	14	0.17, 0.062 (0.12)	<u>0.06</u>	
	17	30	0.050, 0.027		
Whole oranges (unwashed)	8	14	0.30, 0.28, 0.33, 0.33 (0.31)	1	GH-C 1141
		21	0.34, 0.44, 0.35, 0.27		
Whole oranges (unwashed)	11	14	0.59, 0.56, 0.58, 0.46 (0.55)	1	GH-C 1141
		21	0.47, 0.44, 0.44, 0.52		
Peel	8	14	1.0, 0.98, 1.0, 1.0 (1.0)	3.2	GH-C 1141
		21	0.97, 0.84, 0.92, 0.89		
Peel	11	14	1.9, 1.9, 2.0, 1.6 (1.8)	3.3	GH-C 1141
		21	2.1, 1.9, 1.7, 1.7		
Pulp	8	14	0.03, 0.02, 0.03, 0.01 (0.02)	0.06	GH-C 1141
		21	0.01, 0.01, 0.01, 0.02		
Pulp	11	14	0.06, 0.03, 0.04, 0.07 (0.05)	0.09	GH-C 1141
		21	0.02, 0.07, 0.02, 0.02		
Juice	8	14	<0.01, 0.01, <0.01, <0.01 (0.01)	<u>0.03</u>	GH-C 1141
		21	<0.01, 0.01, <0.01, 0.01		
Juice	11	14	<0.01, <0.01, <0.01, 0.01 (0.01)	<u>0.02</u>	GH-C 1141

Sample	Application, kg ai/ha	PHI, days	Residues and (mean), mg/kg[1,2]	Processing factor	Reference
		21	0.01, 0.01, 0.01, 0.01		

[1] LOQ 0.01 mg/kg. Results not corrected for recoveries
[2] Recoveries averaged 87 to 88% from whole oranges, 90% from peel + pulp, 86% from peel, 87% from pulp and 87 to 92% from juice.

Batches of 10-15 field boxes of citrus fruit were processed according to the scheme in Figure 5, simulating the commercial process. Residues in the unwashed fruit and fractions through to juices and oils are shown in Table 113 (Wetters, 1981).

Figure 5. Citrus fruit processing.

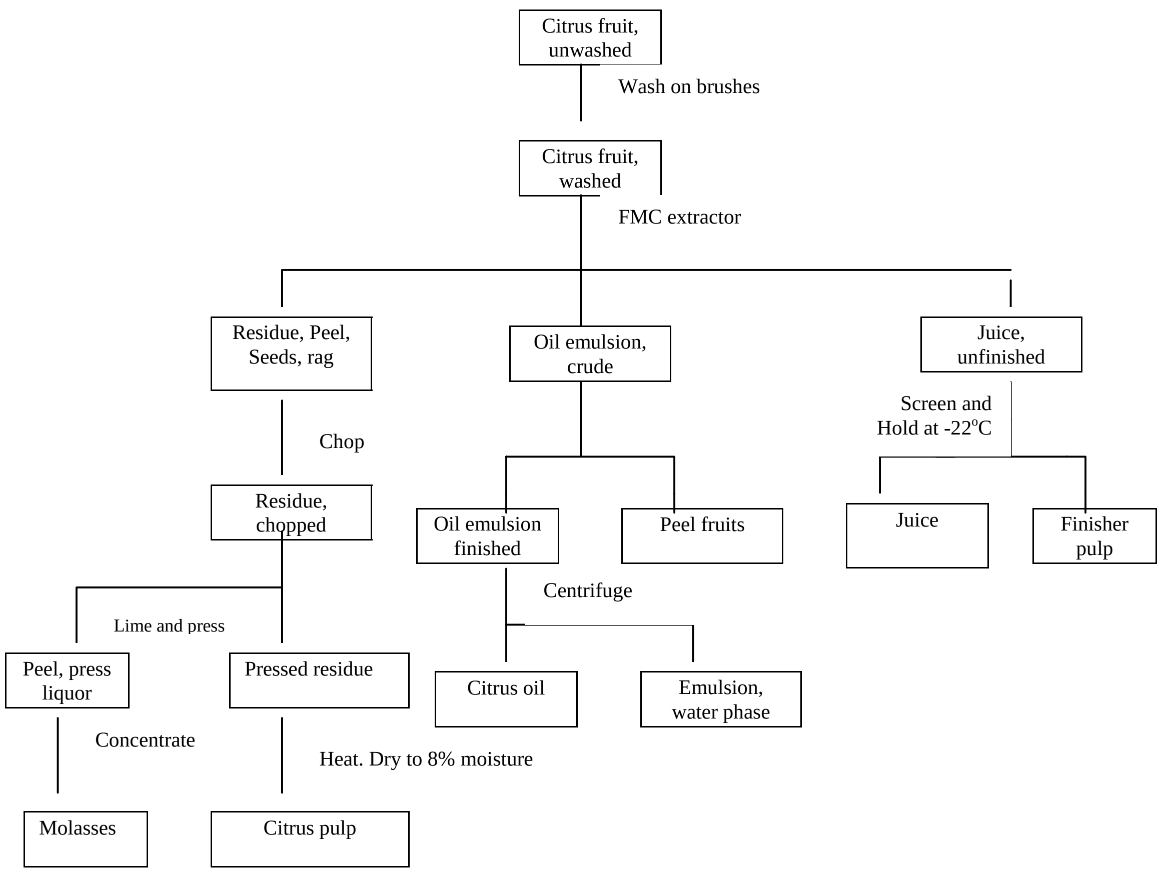


Table 113. Residues of chlorpyrifos in citrus fruit and commercial processed fractions.

Sample	Application, kg ai/ha	PHI, days	Residues, mg/kg[1,2]	Processing factor	Reference
Grapefruit (unwashed)	5.9 x2	15	0.36		GH-C 1441
Grapefruit (washed)	5.9 x2	15	0.29	1	
Dried pulp	5.9 x2	15	1.1	3.8	
Juice	5.9 x2	15	<0.01	0.03	
Peel	5.9 x2	15	1.3	4.5	
Pulp	5.9 x2	15	0.01	0.03	
Oil	5.9 x2	15	6.3	22.	
Lemons (unwashed)	5.8 x2	14	0.38		GH-C 1441
Lemons (washed)	5.8 x2	14	0.31	1	
Dried pulp	5.8 x2	14	0.48	1.5	
Juice	5.8 x2	14	<0.01	0.03	
Peel	5.8 x2	14	0.71	2.3	
Pulp	5.8 x2	14	0.01	0.03	
Oil	5.8 x2	14	1.0	3.2	
Oranges (unwashed)	8.6 x2	15	0.52		GH-C 1441
Oranges (washed)	8.6 x2	15	0.47	1	
Dried pulp	8.6 x2	15	1.2	2.6	
Fruit juice	8.6 x2	15	<0.01	0.02	
Peel	8.6 x2	15	1.5	3.2	
Pulp	8.6 x2	15	0.02	0.04	
Oil	8.6 x2	15	3.0	6.4	
Tangelos (unwashed)	4.5 x2	15	0.59		GH-C 1441
Tangelos (washed)	4.5 x2	15	0.42	1	
Dried pulp	4.5 x2	15	1.7	4.0	
Juice	4.5 x2	15	<0.01	0.02	
Peel	4.5 x2	15	3.6	8.6	
Pulp	4.5 x2	15	0.08	0.20	
Oil	4.5 x2	15	5.6	13.	

[1] LOQ 0.01 mg/kg. Results not corrected for recoveries
[2] Recoveries averaged 86 to 89% from whole fruit and 78 to 79% from the processed fractions

Grapes. Processing trials were conducted in various countries from 1978 to 1988. Processing included drying to raisins and processing to juice, pomace, must and wine. In the USA chlorpyrifos was applied at 1.12 kg ai/ha, and grapes sampled 0 and 3 days after application. A portion of the sample was sun-dried for 14 days on paper-lined trays to produce raisins, and as it was late season the samples had to be put under cover each evening to protect them from dew (Wetters, 1984).

The results are shown in Table 114.

Table 114. Residues of chlorpyrifos in grapes, raisins and raisin waste (USA).

Sample	Application, kg ai/ha	PHI, days	Residues, mg/kg[1,2]	Processing factor	Reference
Grapes	1.12	0	1.3	1	GH-C 1698
		3	0.38	1	
Raisins	1.12	0 + 14	0.28	0.22	GH-C 1698
		3 +14	0.07, 0.08	0.20	
Raisin waste	1.12	0 + 14	0.51	0.39	GH-C 1698
		3 +14	0.26	0.68	

[1] LOQ 0.01 mg/g. Results not corrected for recoveries.
[2] Recoveries averaged 85% from grapes, 91% from raisins and 94% from raisin waste

Chlorpyrifos was applied 3 times at 1.12 kg ai/ha in processing trials in the USA in 1982. Samples were harvested 44 days after the last treatment and processed. Residues of chlorpyrifos were determined in the grapes, juice and pomace (Wetters, 1983). The results are shown in Table 115.

Table 115. Residues of chlorpyrifos in grapes, juice, wet pomace and dry pomace.

Sample	Application, kg ai/ha	PHI, days	Residues and (mean), mg/kg[1,2]	Processing factor	Reference
Grapes	1.12 (x3)	44	0.42, 0.40, 0.49, 0.63 (0.48)	1	GH-C 1611
Juice			0.03	0.06	
Wet Pomace			0.90	1.9	
Dry pomace			1.9	4.0	

[1] LOQ 0.01 mg/kg. Results not corrected for recoveries
[2] Recoveries averaged 89% from grapes, 85% from wet pomace, 92% from dry pomace and 91% from juice

Results of processing trials in which grapes were processed into must and wine are shown in Table 116. The water dispersible granule formulation of chlorpyrifos (WG 750 g ai/kg) was applied four times to wine grapes at 0.34 kg ai/ha in Northern France (Mesland). In a trial on white wine grapes (stages BBCH 65, 79 (2) and 85) and another on red wine grapes (stages BBCH 65, 77, 79 and 83) samples of grapes were taken just before, just after and 7, 14, 21 and 28 days after the last application. At harvest (28-day PHI), separate samples of grapes were taken for residue analysis and for processing to must, pomace, and wine at 2 months and wine at 6 months (Gale, 1999). The recovery of chlorpyrifos from fortified control samples was 81% from grapes (0.05 mg/kg), 106% from pomace (0.01 mg/kg), 102, 104% from must (0.02 mg/kg) and 96, 98% from wine (0.02 mg/kg).

In trials in Italy in 1986 single applications of chlorpyrifos were applied to vines at either 0.69 or 0.77 kg ai/ha. In one trial, a double application at 0.69 kg ai/ha was followed by another double application at 0.77 kg ai/ha. Samples of grapes were taken at intervals after application ranging between 7 and 69 days. At harvest, additional grapes were taken for wine production (Teasdale, 1988b).

In a trial in Israel in 1975 wine grapes were treated with chlorpyrifos at 0.48 kg ai/ha and sampled 0, 7, 14 and 21 days after application. A second trial involved treatment at 0.72 kg ai/ha with grapes sampled on 0 only. Wine was prepared from grapes taken at each sampling interval after which both wine and grapes were analysed for chlorpyrifos residues (Hollick and Iosson, 1978).

Table 116. Residues of chlorpyrifos in grapes, must and wine.

Country, year	Sample	Application, kg ai/ha	PHI, days	Residues, mg/kg [1,2] and (mean)	Processing factor	Reference
Israel, 1975	Grape	0.48	0	3.0, 3.4 (3.2)	1	GHE-P 603
			7	0.90, 0.94 (0.92)	1	
			14	1.1, 1.1 (1.1)	1	
			21	0.48, 0.49 (0.48)	1	
		0.72	0	0.01, 0.01 (0.01)	1	
Israel, 1975	Wine	0.48	0	0.02, 0.02 (0.02)	0.006	GHE-P 603
		0.48	7	0.01, 0.01 (0.01)	0.01	
		0.48	14	0.01, 0.01 (0.01)	0.009	
		0.48	21	<0.01, <0.01 (0.01)	0.02	

		0.72	0	0.01, 0.01 (0.01)	1	
Italy, 1986	Grapes	0.69	7	0.50, 0.49		GHE-P 1818R
			14	0.19, 0.19, 0.03, 0.03		
			33	0.02, 0.02		
			49	0.03, 0.03 (0.03)	1	
Italy, 1986	Grapes	0.77	12	0.71, 0.66		GHE-P 1818R
			19	0.30, 0.26		
			38	0.10, 0.10		
			69	0.05, 0.05 (0.05)	1	
Italy, 1986	Grapes	0.69 x2 + 0.77 x2	13	0.50, 0.50		GHE-P 1818R
			44	0.29, 0.24 (0.26)	1	
Italy, 1986	Must	0.69		<0.01, <0.01, <0.01 (0.01)	0.3	GHE-P 1818R
		0.77		<0.01 (0.01)	0.2	
		0.69 x2 + 0.77 x2		<0.01, <0.01 (0.01)	0.04	
Italy, 1986	Wine	0.69		<0.01, <0.01, <0.01 (0.01)	0.3	GHE-P 1818R
		0.77		<0.01, <0.01 (0.01)	0.2	
		0.69 x2 + 0.77 x2		<0.01, <0.01 (0.01)	0.04	
France, 1996	Grapes (red)	0.34 x4	28	0.33	1	GHE-P 7467
	Must			0.17	0.5	
	Pomace			1.7	5.2	
	Wine			<0.02	0.06	
	Grapes (white)	0.34 x4	28	0.50	1	
	Must			0.06	0.1	
	Pomace			1.3	2.6	
	Wine			<0.02	0.04	

[1] Limit of quantification 0.01 mg/kg, except for GH-C 788, where the limit of determination = 0.001 mg/kg and GHE-P 7467, where the limit of determination (wine) = 0.02 mg/kg.
[2] Recoveries averaged 96% from must, 92 to 98% from wine

Tomatoes. Processing trials on tomatoes were conducted in the USA and Israel. In the US trial tomatoes were treated 5 times with 1.12 kg ai/ha and samples were taken 7 days after the last application for processing (Miller, 1980d). The results, not corrected for recoveries or control, are shown in Table 117.

Table 117. Residues of chlorpyrifos in tomatoes and processed fractions (USA).

Sample	Application, kg ai/ha	PHI, days	Residues, mg/kg[1,2]	Processing factor	Reference
Whole tomatoes	1.12 x5	7	0.33	1	GH-C 1282
Tomato juice			<0.01, <0.01 (0.01)	0.03	
Whole tomato less peel			<0.01, 0.01 (0.01)	0.03	
Purée			0.05, 0.03 (0.04)	0.1	
Seeds and peelings from purée			0.80, 0.43 (0.62)	1.9	
Seeds and peelings from juice			1.4, 0.47 (0.94)	2.8	

[1] LOQ 0.01 mg/kg
[2] Recoveries averaged 87% from whole tomato, 100% from juice, 94% from tomato less peel, 92% from purée and 90% from seeds/peelings.

In processing trials in Israel, tomatoes were treated four times with chlorpyrifos at 0.96 kg ai/ha. Samples were collected at 0, 7, 14 and 21 days after the last treatment. A portion of the fruit collected at each sampling was processed to juice and concentrated to paste. Fresh tomatoes, juice and paste were analysed for residues of chlorpyrifos (Hollick and Iosson, 1977). The results are shown in Table 118.

Table 118. Residues of chlorpyrifos in fresh tomatoes, juice and paste (Israel).

Sample	Application, kg ai/ha	PHI, days	Residues, mg/kg [1,2]	Processing factor	Reference
1975 Trials					
Whole tomatoes	0.96	0	0.36, 0.16, 0.15, 0.11 (0.20)	1	GHE-P 489
		7	0.12, 0.10, 0.10, 0.13 (0.11)	1	
		14	0.10, 0.06, 0.08, 0.06 (0.08)	1	
		21	0.06, 0.05, 0.04, 0.08 (0.06)	1	
Juice	0.96	0	0.04, 0.02, 0.01, <0.01 (0.02)	0.1	GHE-P 489
		7	0.02, 0.02, 0.01, 0.02 (0.02)	0.2	
		14	0.01, 0.01, 0.01, 0.01 (0.01)	0.1	
		21	0.01, <0.01, <0.01, 0.01 (0.01)	0.2	
Paste	0.96	0	0.05, 0.06, 0.03, 0.02 (0.04)	0.2	GHE-P 489
		7	0.04, 0.04, 0.02, 0.03 (0.03)	0.3	
		14	0.03, 0.02, 0.03, 0.02 (0.02)	0.2	
		21	0.03, 0.02, 0.02, 0.02 (0.02)	0.3	
1976 Trials					
Whole tomatoes	0.96	0	0.38, 0.65, 0.29, 0.26 (0.52)	1	GHE-P 489
		7	0.49, 0.21, 0.22, 0.13 (0.26)	1	
		14	0.11, 0.08, 0.05, 0.09 (0.08)	1	
		21	0.14, 0.11, 0.19, 0.05 (0.12)	1	
Juice	0.96	0	0.03, 0.01, 0.01, 0.03 (0.02)	0.04	GHE-P 489
		7	<0.01, 0.01, 0.01, <0.01 (0.01)	0.04	
		14	<0.01 (0.01), <0.01, <0.01, <0.01 (0.01)	0.1	
		21	<0.01, <0.01, <0.01, <0.01 (0.01)	0.08	
Paste	0.96	0	0.03, 0.01, 0.01, 0.03 (0.02)	0.04	GHE-P 489
		7	<0.01, 0.02, <0.01, <0.01 (0.01)	0.04	
		14	<0.01, <0.01, <0.01, <0.01 (0.01)	0.1	
		21	<0.01, <0.01, <0.01, <0.01 (0.01)	0.08	

[1] LOQ 0.01 mg/kg. Results not corrected for recoveries
[2] Recoveries from all fractions averaged 98%

Soya beans. Lorsban 4E was applied 5 times at exaggerated rates in the USA and seeds harvested 14 days after the last application for processing by a commercial solvent extraction procedure (Miller, 1979a). The recovery of chlorpyrifos from fortified control samples was 88±15%% from soya beans (0.01 mg/kg, n = 5), 80% from hulls (0.05 mg/kg), 82% from extracted meal (0.05 mg/kg), 90% from crude oil (0.01 mg/kg), 80% from refined oil (0.01 mg/kg), 90% from refined bleached oil (0.01 mg/kg) and 100% from soapstock (0.02 mg/kg). The results are shown in Table 119. No details of the processing were provided.

Table 119. Residues of chlorpyrifos in soya beans and processed fractions (USA).

Sample	Application, kg ai/ha	PHI, days	Residues, mg/kg[1]	Processing factor	Reference
Soya beans (RAC)	4.4 + 1.1 x2 + 2.2 x2	14	0.04	1	GH-C 1224
Hulls	4.4 + 1.1 x2 + 2.2 x2	14	0.02	0.5	

Sample	Application, kg ai/ha	PHI, days	Residues, mg/kg[1]	Processing factor	Reference
Extracted meal	4.4 + 1.1 x2 + 2.2 x2	14	<0.05	1.2	
Crude oil	4.4 + 1.1 x2 + 2.2 x2	14	0.02	0.5	
Refined oil	4.4 + 1.1 x2 + 2.2 x2	14	0.02	0.5	
Refined bleached oil	4.4 + 1.1 x2 + 2.2 x2	14	0.02	0.5	
Soapstock	4.4 + 1.1 x2 + 2.2 x2	14	<0.02	0.5	

[1] LOQ 0.01-0.05 mg/kg. Results not corrected for recoveries

Sugar beet. Sugar beet were treated at planting and/or post-emergence with chlorpyrifos at 2.2 kg ai/ha in the USA. Samples were collected at normal harvest (133 days after the last treatment) and processed, simulating commercial practices. Untreated samples were also fortified with 1 mg/kg chlorpyrifos before processing. Residues of chlorpyrifos were determined in the roots, pulp, cake and juice (Wetters and Dishburger, 1974). The results are shown in Table 120.

Table 120. Residues of chlorpyrifos in sugar beet and processed fractions (USA).

Sample	Application, kg ai/ha	PHI, days	Residues, mg/kg [1,2]	Processing factor	Reference
Roots	2.2 x2	133	<0.01		GH-C 729
Wet pulp	2.2 x2	133	<0.01		
Wet pulp, fortified	+ 1 mg/kg		0.43	0.43	
Dry pulp	2.2 x2	133	0.01		
Dry pulp, fortified	+1 mg/kg		0.48	0.48	
Lime cake	2.2 x2	133	<0.01		
Lime cake, fortified	+1 mg/kg		0.01	0.01	
Diffusion juice	2.2 x2	13.	<0.01		
Diffusion juice, fortified	+1 mg/kg		0.12	0.12	
Thin juice	2.2 x2	133	<0.01		
Thin juice, fortified	+1 mg/kg		<0.01	0.01	GH-C 729
Thick juice	2.2 x2	133	<0.01		
Thick juice, fortified	+1 mg/kg		<0.01	0.01	
Sugar	2.2 x2	133	----		
Sugar, fortified	+ 1 mg/kg		----		
Molasses	2.2 x2	133	----		
Molasses, fortified	+ 1 mg/kg		----		

[1] LOQ 0.01 mg/kg. Results not corrected for recoveries
[2] Recoveries averaged 87% from roots, 99% from lime cake, 103% to 106% from juice, 90% from wet pulp and 100% from dry pulp.

Maize (corn). In two processing studies in 1990 in the USA, maize was treated with 5 applications of chlorpyrifos at 8.4 kg ai/ha total and samples harvested 35 days after the last treatment were processed in a processing plant. Residues of chlorpyrifos in the processed fractions from dry and wet milling were determined. The simulated commercial process is shown in Figures 6a and b (Robb and Schotts, 1993b). The results are shown in Table 121.

Figure 6a. Wet milling processing of maize (corn).

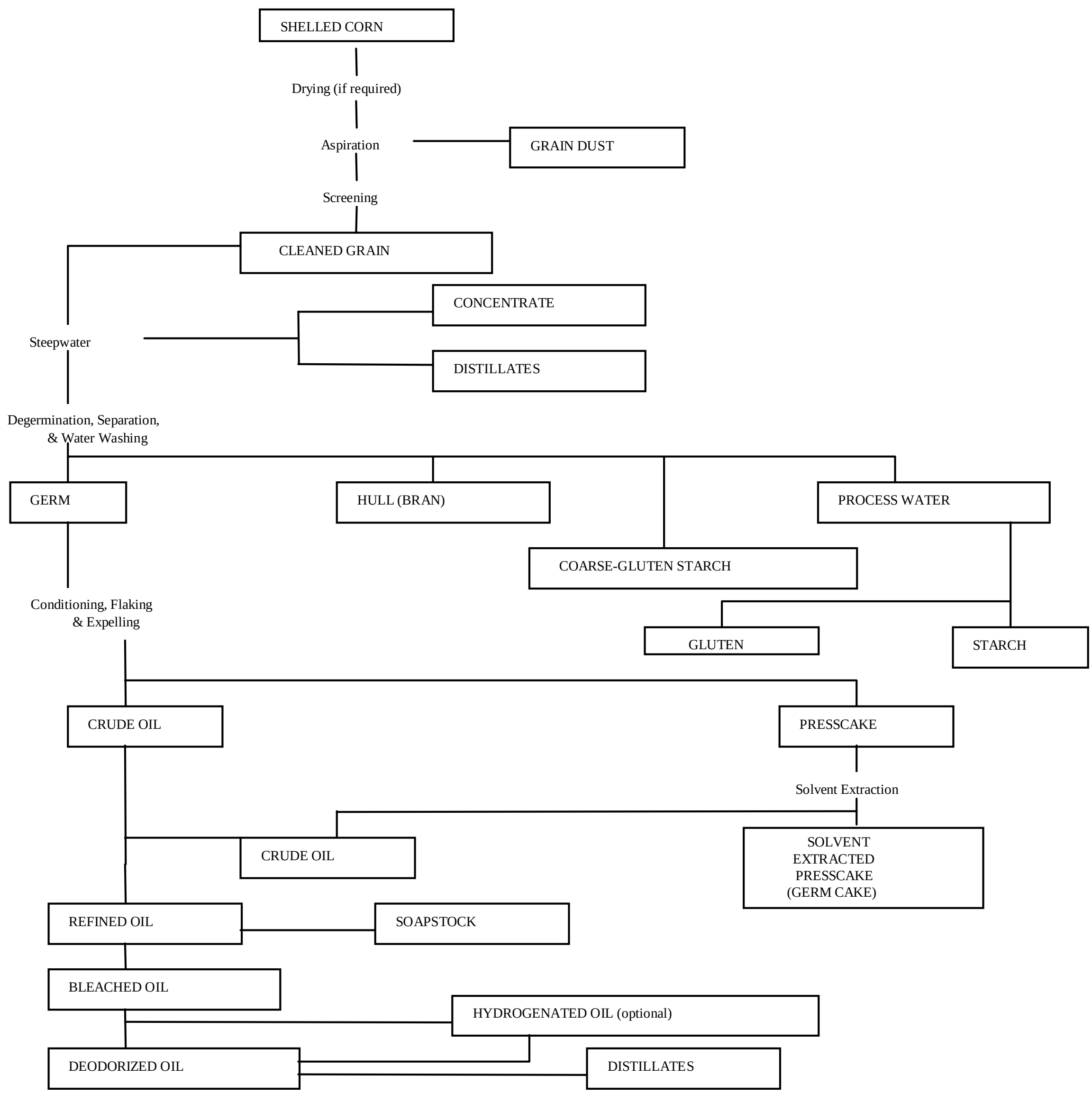


Figure 6b. Dry milling processing of maize.

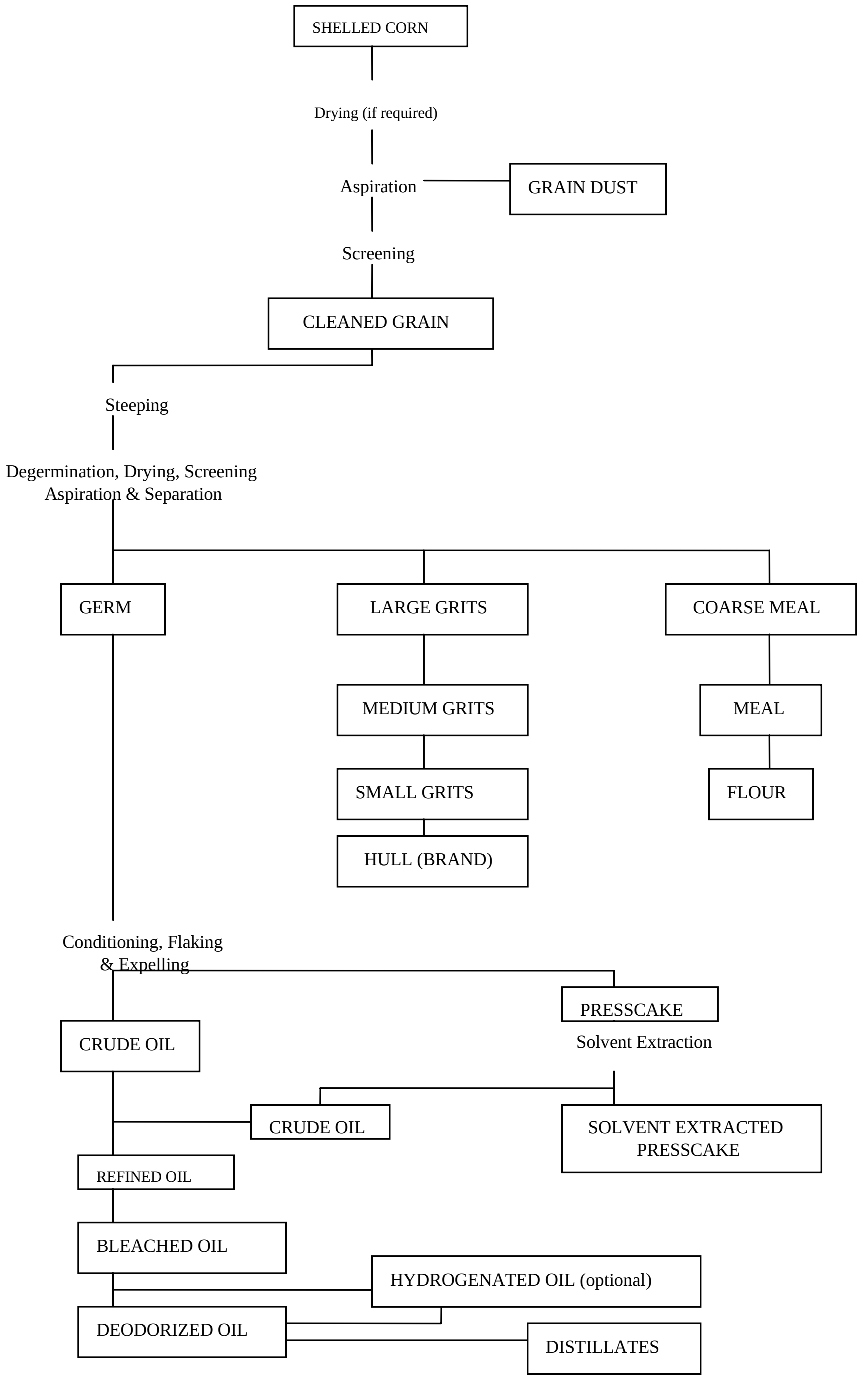


Table 121. Chlorpyrifos residues in maize and its processed fractions.

Sample	Application, kg ai/ha	PHI, days	Residues, mg/kg [1,2]	Processing factor	Reference
Illinois					
Bulk grain	8.4	35	0.01	1	GH-C 2878
Dry milling					
Large grits	8.4	35	<0.01	1	GH-C 2878
Medium grits	8.4	35	<0.01	1	
Small grits	8.4	35	<0.01	1	
Coarse meal	8.4	35	<0.01	1	
Meal	8.4	35	<0.01	1	
Flour	8.4	35	<0.01	1	
Crude oil	8.4	35	0.01	1	
Refined oil	8.4	35	0.01		
Wet milling					
Coarse gluten-starch	8.4	35	0.01	1	GH-C 2878
Starch	8.4	35	<0.01	1	
Crude oil	8.4	35	0.01	1	
Refined oil	8.4	35	0.01	1	
Michigan					
Bulk grain	8.4	35	0.04, 0.03 (0.04)		GH-C 2878
Dry milling					
Large grits	8.4	35	0.01	0.2	GH-C 2878
Medium grits	8.4	35	0.03	0.8	
Small grits	8.4	35	0.04	1	
Coarse meal	8.4	35	0.05	1.2	
Meal	8.4	35	0..5	1.2	
Flour	8.4	35	0.07	1.8	
Crude oil	8.4	35	0.06	1.5	
Refined oil	8.4	35	0.06	1.5	
Wet milling					
Coarse gluten-starch	8.4	35	0.07	1.8	GH-C 2878
Starch	8.4	35	<0.01	0.2	
Crude oil	8.4	35	0.12	3	
Refined oil	8.4	35	0.13	3.2	

[1] LOQ 0.01 mg/kg. Results not corrected for recoveries
[2] Recoveries averaged 88% from grain, 90% from dry and wet milling fractions, 71% from oil.

Rice. Rice plants in the Philippines were treated with single applications of EC formulation at 1.05 kg ai/ha, 10 days before harvest. Samples of the grain were taken at random, sundried and milled. Chlorpyrifos residues were determined in the processed fractions by GLC with flame photometric detection (Cowles *et al.*, 1999e). In a trial in Australia, a single broadcast application of 1 kg ai/ha chlorpyrifos 500 EC was applied to rice 10 days before harvest, and samples were taken, sun-dried and processed at a commercial facility. Chlorpyrifos was determined in each of the processed fractions (Cowles *et al.*, 1999f). The results are shown in Table 122.

Table 122. Residues of chlorpyrifos in rice grain and its processed fractions.

Sample	Application, kg ai/kg	PHI, days	Residues, mg/kg [1]	Processing factor	Reference
Australia, 1999	1	10			GHF-P 1795
Paddy rice			0.33	1	
Brown rice			0.06	0.2	
White rice			0.01	0.03	
Rice hulls			1.41	4.3	
Rice pollard			0.36	1.1	
Rice thrash			1.85	5.6	
Philippines, 1999	1.05	10			GHF-P 1794
Unhulled rice			1.55	1	
Hulled rice			0.10	0.06	
Rice bran			3.89	2.5	
Rice hulls			4.06	2.6	

[1]LOQ 0.01 mg/kg. Recoveries averaged 90% from all processed fractions

Sorghum. Plants were treated 3 times with chlorpyrifos at 0.28 kg ai/ha beginning when heads were about 30% in flower. Samples of grain were collected at normal harvest, 49 days after the last treatment in Mississippi (6 x 15 m row) and 62 days in Kansas (0.2 ha)) and submitted for milling. One grain sample was collected in Mississippi (45 kg) and six replicate samples in Kansas (60 kg total). The grain was tempered to 15.5% moisture before milling, and the grain and milling fractions analysed for chlorpyrifos (Wetters and Miller, 1978). The results are shown in Table 123.

Table 123. Residues of chlorpyrifos in grain and milling fractions of sorghum.

Sample	Application, kg ai/kg	PHI, days	Residues, mg/kg [1,2]	Processing factor	Reference
MS					
Grain	0.28 x3	42	0.04	1	GH-C 1109
Flour	0.28 x3	42	0.01	0.2	
Shorts[3]	0.28 x3	42	0.04	1	
Middlings[4]	0.28 x3	42	0.01	0.2	
Bran[5]	0.28 x3	42	0.06	1.5	
Screenings	0.28 x3	42	0.11	2.8	
Germ	0.28 x3	42	0.06	1.5	
KS					
Grain	0.28 x3	69	0.01	1	GH-C 1109
Flour	0.28 x3	69	0.01	1	
Shorts	0.28 x3	69	0.01	1	
Middlings	0.28 x3	69	0.01	1	
Bran	0.28 x3	69	0.01	1	
Screenings	0.28 x3	69	<0.01	1	
Germ	0.28 x3	69	<0.01	1	

[1] LOQ 0.01 mg/kg in grain, 0.05 mg/kg in milling and baking fractions
[2] Recoveries averaged 85% from grain, 79% from flour, 92% from shorts, 88% from middlings, 90% from bran, 82% from screenings and 77% from germ
[3] Shorts is finely ground particles of bran, endosperm, and some germ
[4] Middlings refers to a product between whole grain and flour
[5] Bran refers to pericap, seed coat and the aleurone layer

Wheat. Wheat plots in Illinois, USA, were treated with three aerial or ground applications of chlorpyrifos at 0.56 kg ai/ha, and samples of grain collected at normal harvest for determination of the residues before and after milling and baking (Norton, 1980b). The results are shown in Table 124.

Table 124. Residues of chlorpyrifos in wheat grain and milling and baking fractions.

Sample	Application, kg ai/kg	PHI, days	Residues, mg/kg [1]	Processing factor	Reference
Grain	0.56 x3	14	0.51	1	GH-C 1346
Bran	0.56 x3	14	1.3	2.5	
Straight grade flour	0.56 x3	14	0.08	0.2	
Break shorts	0.56 x3	14	0.88	1.7	
Reduction shorts	0.56 x3	14	1.2	2.4	
Red dog	0.56 x3	14	0.41	0.8	
Bread	0.56 x3	14	0.05	0.1	

[1] LOQ 0.01 mg/kg in grain and 0.05 mg/kg in milling and baking fractions. Recoveries averaged 92% from grain, 84% from baking and milling fractions.

Cotton. Chlorpyrifos was applied twice or four times at 0.28 and 12 or 13 times at 1.12 kg ai/ha at various times during May/October 1974 to cotton in Mississippi (ground) and Texas (aerial). Cotton was picked by hand and samples collected 18 days after aerial and 7 days after ground applications. The cotton samples were ginned and seeds and gin trash collected. The seed samples were processed into linters, hulls, solvent-extracted meal, crude oil and refined bleached oil (McKellar, 1975). The process is shown in Figure 7 and the results in Table 125.

Figure 7. Processing of cotton seed.

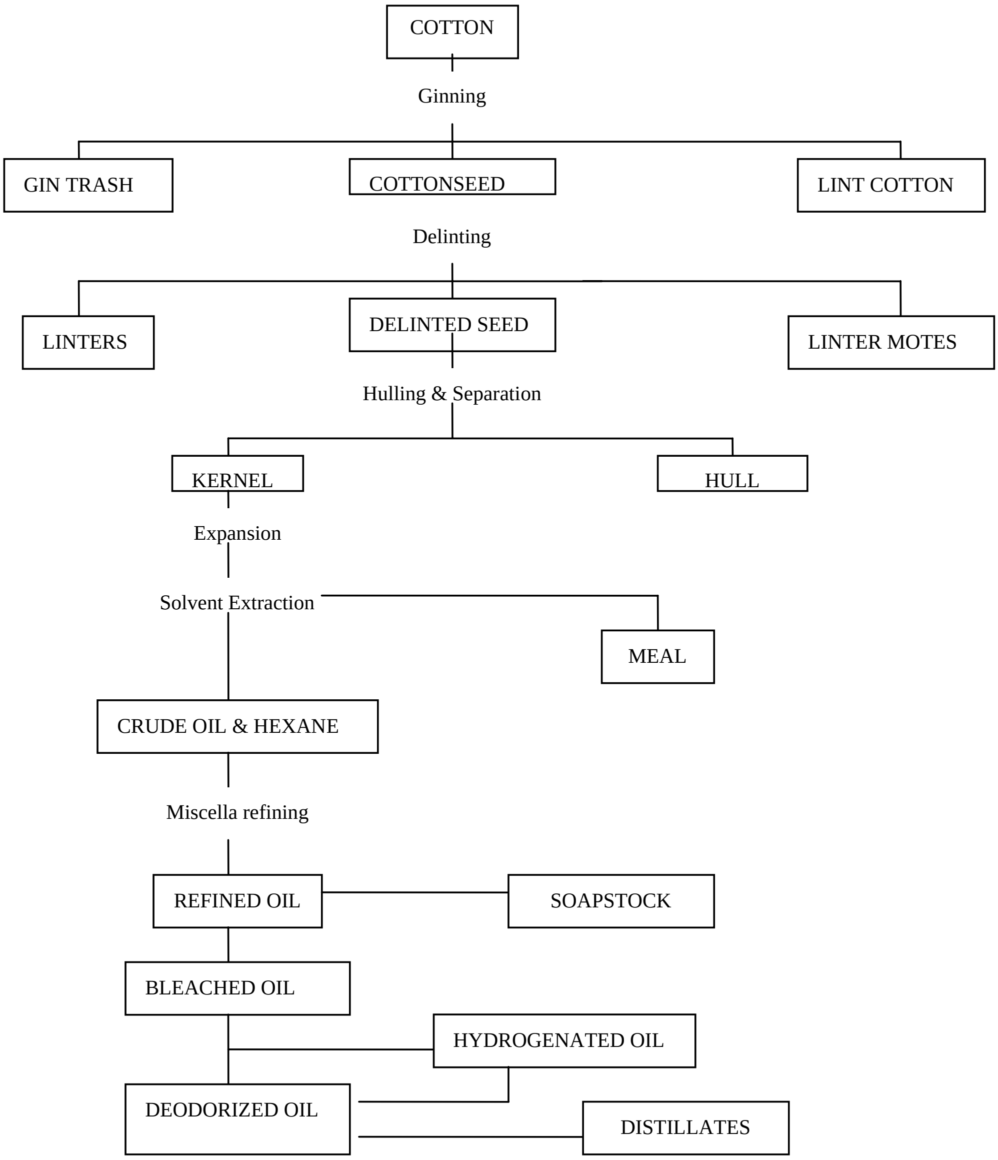


Table 125. Residues of chlorpyrifos in cotton seed and processed fractions.

Sample	Application, kg ai/ha	PHI, days	Residues, mg/kg [1]	Processing factor	Reference
Ground application (MS)					
Seed	0.28 x2 + 1.12 x12	15	0.043±0.016 (0.031-0.066) (control 0.009)	1	GH-C 840
Gin trash			75 (control 1.3)	1700	
Hulls			<0.01	0.2	
Linters			0.04	1	
Solvent extracted meal			<0.01	0.2	
Crude oil			0.01	0.2	
Refined oil			0.01	0.2	
Aerial application (TX)					
Seed	0.28 x4 + 1.12 x13	18	0.103 ±0.019 (0.078-0.123) (control 0.016)	1	GH-C 840
Gin trash			0.50 (control 0.36)	Invalid	
Hulls			0.07	0.5	
Linters			0.52	5.0	
Solvent extracted meal			0.01	0.1	
Crude oil			0.14	1.4	
Refined oil			<0.01	0.1	

[1] LOQ 0.01 mg/kg. Recoveries averaged 94% from seed, 90% from gin trash, 100% from crude oil.

Peanuts. In several processing trials on peanuts to determine the residues of chlorpyrifos in processed oil the 15G formulation of chlorpyrifos was applied twice at a rate equivalent to 1.12 kg ai/ha. Samples of peanuts were taken 49 days after the last treatment and processed to pressed cake and oil (Miller, 1979b). The results are shown in Table 126.

Table 126. Residues of chlorpyrifos in peanuts and processed fractions (USA).

Sample	Application, kg ai/kg	PHI, days	Residues, mg/kg[1]	Processing factor	Reference
Kernels	1.12 x2	49	0.03	1	GH-C 1199
Press cake	1.12 x2	49	0.04	1.3	
Pressed oil	1.12 x2	49	0.07	2.3	

[1] LOQ 0.02 mg/kg for kernels and 0.05 mg/kg for processed fractions. Recoveries averaged 90% from kernels, 88% from pressed cake and 86% from oil.

In another trial, chlorpyrifos was applied to the plants at 1.12 kg ai/ha at bloom and again 49 days before harvest. Samples were collected at normal harvest for processing into crude oil, with a Carver press, and then to refined oil and soapstock. The concentration of chlorpyrifos in the peanuts was not determined, but fortified crude oil from untreated peanuts was also processed to refined oil and soapstock (Miller, 1980e). The results are shown in Table 127.

Table 127. Residues of chlorpyrifos in peanut oil fractions from peanuts treated with two applications of 15 G formulation (USA).

Sample	Application, kg ai/kg	PHI, days	Residues, mg/kg [1]	Reference
Crude oil	1.12 x2	49	0.07	GH-C 1278
Refined oil	1.12 x2	49	0.05	
Soapstock	1.12 x2	49	0.02	
Crude oil fortified with 0.25 mg/kg chlorpyrifos				
Refined oil			0.18	GH-C 1278

Sample	Application, kg ai/kg	PHI, days	Residues, mg/kg [1]	Reference
Soapstock			0.07	

[1] LOQ 0.01 mg/kg.
[2] Recoveries averaged 92% from crude oil, 90% from refined oil and 91% from soapstock.

Sunflowers. In a processing study in 1993 sunflowers were treated with 3 applications of EC at 1.7 kg ai/ha/application. Samples of whole seeds were collected and cracked and residues determined in the whole seed (kernel + hull), seed (RAC) and hulls (Turner, 1994).

In another trial, application of the 15 G chlorpyrifos formulation at planting was followed by 5 aerial applications of the EC formulation. Samples were collected 45 days after the last treatment (0.6 kg ai/ha) and processed, following commercial practices. Residues of chlorpyrifos were determined in the processed fractions (Miller, 1981b). The results are shown in Table 128.

Table 128. Residues of chlorpyrifos in sunflower seed and processed fractions.

Sample	Application, kg ai/ha	PHI, days	Residues, mg/kg [1]	Processing factor	Reference
Hull + kernel	1.7 x3	42	0.08	-	GH-C 3239
Hull	1.7 x3	42	0.16	-	
Seed	1.7 x3	42	0.04	-	
Seed	0.6 x3 + 1.7 x2 + 0.012 kg ai/100 m row x1	45	0.03	1	GH-C 1468
Meal	0.6 x3 + 1.7 x2 + 0.012 kg ai/100 m row x1	45	0.01	0.3	GH-C 1468
Hulls	0.6 x3 + 1.7 x2 + 0.012 kg ai/100 m row x1	45	0.51	17	GH-C 1468
Crude oil	0.6 x3 + 1.7 x2 + 0.012 kg ai/100 m row x1	45	0.02	0.7	GH-C 1468
Refined oil	0.6 x3 + 1.7 x2 + 0.012 kg ai/100 m row x1	45	0.01	0.3	GH-C 1468
Soapstock	0.6 x3 + 1.7 x2 + 0.012 kg ai/100 m row x1	45	0.01	0.3	GH-C 1468

[1]LOQ 0.01 mg/kg. Recoveries averaged 91% from seeds, 77% from meal, 97% from hulls, 75% from oil and 81% from soapstock.

Coffee. In a trial in Brazil coffee plants were treated with 3 applications of 480 EC formulation at the maximum label rate of 0.72 kg ai/ha (1.5 l/ha) or at a double rate (Catta-Preta and Rampazzo, 1997). Twenty-one days after the last application, samples of unshelled beans were allowed to dry for 20 days at 17-48^o C in a greenhouse, shelled in a small-scale machine and some were then roasted in a country-style coffee roaster. A freeze-drying process further processed a sub-set of the latter into instant coffee. After each process samples were frozen and shipped for analysis.

In another field trial in Columbia a 480 EC chlorpyrifos formulation was applied 3 times to plants at 0.96 and 1.92 kg ai/ha. Samples were collected 0, 2, 7, 14, 21 and 28 days after the last application. Ripe beans gathered by hand were shelled wet in a small-scale machine, fermented in water for 48 hours and dried in sunshine for 4-6 days. The unshelled fraction (green beans) and the shelled and dried fraction (divided into 3 subfractions) were packed in polyethylene bags, frozen and sent for processing. Two of the subfractions were roasted in a home-style roaster and one of these was converted to instant coffee by grinding and extracting with boiling water. All fractions were analysed for chlorpyrifos (Catta-Preta and Rampazzo, 1999). The results are shown in Table 129.

Table 129. Residues of chlorpyrifos in coffee and processed fractions.

Location, year, sample	Application, kg ai/ha	PHI, days	Residues, mg/kg [1]	Processing factor	Reference
Brazil, 1997					
Shelled beans	0.72	21	0.02, 0.02, 0.03 (0.02)	1	GHB-P 310
	1.44	21	0.06, 0.05, 0.12 (0.08)	1	
Roasted beans	0.72	21	<0.01, <0.01, <0.01 (0.01)	0.5	
	1.44	21	<0.01, <0.01, <0.01 (0.01)	0.1	
Instant coffee	0.72	21	<0.01, <0.01, <0.01 (0.1)	0.5	
	1.44	21	<0.01, <0.01, <0.01 (0.01)	0.1	
Columbia, 1999					
Green beans with shell	0.96	0	1.14, 1.98, 0.84,, 2.28		GHB-P 413
		2	0.29, 0.77, 0.58, 0.58		
		7	0.1, 0.29, 0.26, 0.38		
		14	0.11, 0.17, 0.14, 0.23 (0.14)		
		21	0.05, 0.08, 0.15, 0.05		
		28	0.04, 0.04, 0.05, 0.07		
Green beans with shell	1.92	0	2.12, 2.90, 3.98, 3.45		
		2	0.85, 2.27, 0.60, 1.67		
		7	0.72, 1.4, 0.68, 0.79		
		14	0.31, 0.60, 0.44, 0.79 (0.54)		
		21	0.22, 0.44, 0.43, 0.38		
		28	0.08, 0.20, 0.28, 0.18		
Shelled dried beans	0.96	0	<0.01, 0.03, 0.05, 0.04 (0.03)		
		2	<0.01, 0.03, 0.03, 0.03 (0.02)		
		7	<0.01, 0.02, 0.02, 0.02 (0.02)		
		14	<0.01, 0.02, 0.02, 0.02 (0.02)	1	
		21	<0.01, 0.01, 0.02, 0.02 (0.02)		
		28	<0.01, 0.01, 0.02, 0.02 (0.02)		
	1.92	0	0.04.0.14, 0.10, 0.09 (0.09)		
		2	0.02, 0.07, 0.08, 0.09 (0.06)		
		7	0.02, 0.06, 0.06, 0.04 (0.04)		
		14	0.01, 0.05, 0.05, 0.03 (0.04)	1	
		21	0.03, 0.04, 0.05, 0.03 (0.04)		
		28	0.02, 0.02, 0.05, 0.02 (0.03)		
Roasted beans	0.96	14	<0.01, <0.01, <0.01, <0.01 (0.01)	0.05	
	1.92	14	<0.01, 0.01, 0.02, <0.01 (0.01)	0.25	
Instant coffee	0.96	14	<0.01, <0.01, <0.01, <0.01 (0.01)	0.07	
	1.92	14	<0.01, <0.01, <0.01, <0.01 (0.01)	0.02	

[1] LOQ 0.01 mg/kg. Recoveries in Brazil averaged 83%, 80% and 84% from dried beans, roasted beans and instant coffee. Recoveries in Columbia averaged 82%, 80%, 95%, and 95% from green beans, shelled dried beans, roasted beans and instant coffee respectively.

RESIDUES IN FOOD IN COMMERCE OR AT CONSUMPTION

The manufacturer reported monitoring data from the USA, where chlorpyrifos is determined in several pesticide monitoring programmes. Among them are the California Environmental Protection Agency Food Safety Program, the Food and Drug Administration Enforcement

Monitoring Program, the US Department of Agriculture Pesticide Data Program (PDP), and the Pesticide Residues Information System (PRIS).

The residue monitoring of the California Environmental Protection Agency (Cal-EPA) Food Safety Programs is designed to enforce laws and regulations involving pesticide registrations in California. Samples of the commodities are collected randomly at points of entry, packing sites, wholesale distribution centres and retail outlets and analysed for a wide range of pesticides.

The FDA Enforcement Monitoring Programs are designed to enforce tolerances established by the US EPA. Raw agricultural commodities sampled at the "farm gate" are analysed. Samples are classified as either surveillance or compliance. Most of them are surveillance samples. Compliance samples are collected as follow-up to findings of illegal residues or when there is evidence of a pesticide residue problem.

The USDA Pesticide Data Program (PDP) was developed to collect residue data on fresh fruits and vegetables. Sampling has been designed to be statistically representative of the US food supply. Samples of peeled and/or washed fruits and vegetables are analysed. The Program collects residue data for the US EPA dietary risk assessments and to aid decisions on re-registration and special reviews.

The Pesticide Residue Information System (PRIS) has developed the FOODCONTAM national database to compile and summarize existing data on the analyses of domestically-produced foods for residues of pesticides and industrial chemicals. The system is administered by The Mississippi State Chemical Laboratory under contract with the US FDA. Most of the data are from routine state surveillance programmes.

Table 130 summarizes the residue data for chlorpyrifos compiled by the manufacturer from the above US sources (Tomerlin *et al.*, 1995).

Table 130. Summary of chlorpyrifos residue data from national food survey and monitoring programmes in the USA.

Commodity	No. of samples	Mean, mg/kg	Min., mg/kg	Max., mg/kg	No. >LOD	% >LOD
Cal-EPA 1986-1991						
Alfalfa	8	0.005	0.005	0.005	0	0.00
Almonds	188	0.067	0.005	2.6	10	5.32
Apples	1733	0.007	0.005	1.0	34	2.0
Bananas	404	0.006	0.005	1.0	10	2.5
Beans	1096	0.005	0.005	0.09	2	0.18
Beets, roots	207	0.005	0.005	0.01	1	0.48
Beets, tops	228	0.005	0.005	0.005	0	0.00
Brussels	378	0.010	0.005	0.79	8	2.1
Broccoli	825	0.005	0.005	0.03	3	0.36
Cabbage	1071	0.005	0.005	0.48	1	0.09
Carrots	661	0.006	0.005	0.73	2	0.30
Cauliflower	572	0.005	0.005	0.005	0	0.00
Citrus	8	0.051	0.005	0.28	2	25
Corn	806	0.005	0.005	0.005	0	0.00
Egg plant	494	0.005	0.005	0.005	0	0.00
Grapefruit	733	0.007	0.005	0.19	17	2.3
Grapes	1930	0.005	0.005	0.40	2	0.10
Kale	136	0.005	0.005	0.005	0	0.00
Kiwifruit	180	0.01	0.005	0.23	19	10
Lemons	607	0.01	0.005	0.39	65	11

Commodity	No. of samples	Mean, mg/kg	Min., mg/kg	Max., mg/kg	No. >LOD	% >LOD
Lettuce-head	943	0.005	0.005	0.005	0	0.00
Lettuce-leaf	1670	0.005	0.005	0.26	3	0.18
Mushrooms	304	0.005	0.005	0.005	0	0.00
Onions	1607	0.005	0.005	0.06	1	0.06
Oranges	1262	0.04	0.005	0.84	235	19
Other nuts	221	0.005	0.005	0.005	0	0.00
Peaches	741	0.005	0.005	0.005	0	0.00
Peanuts	11	0.005	0.005	0.005	0	0.00
Pears	955	0.005	0.005	0.005	0	0.00
Peas	596	0.006	0.005	0.34	2	0.33
Peppers	3049	0.01	0.005	0.71	166	5.4
Plums	684	0.005	0.005	0.005	0	0.00
Potatoes	1704	0.007	0.005	2.0	3	0.18
Strawberries	781	0.005	0.005	0.005	0	0.00
Sugar beet	286	0.007	0.005	0.27	2	0.70
FDA Monitoring, 1992-1993						
Apples	919	0.01	0.002	0.32	139	15
Banana	342	0.009	0.005	0.23	72	21
Berries	1593	0.005	0.002	0.26	21	1.3
Br. sprouts	40	0.005	0.005	0.005	0	0.00
Broccoli	378	0.005	0.005	0.04	4	1.1
Cabbage	306	0.006	0.005	0.12	3	0.98
Carrots	303	0.005	0.005	0.009	1	0.33
Cauliflower	210	0.005	0.005	0.00	0	0.00
Citrus fruit	737	0.02	0.002	0.450	165	22
Corn grain	48	0.005	0.005	0.00	0.	0.00
Egg plant	119	0.005	0.005	0.04	1	0.84
Eggs	526	0.005	0.005	0.01	1	0.19
Kale	109	0.01	0.005	0.40	4	3.7
Kiwifruit	199	0.03	0.005	0.800	24	12
Lettuce, head	360	0.005	0.005	0.005	0	0.00
Lettuce, leaf	615	0.005	0.005	0.04	9	1.5
Milk	636	0.005	0.005	0.005	0	0.00
Mushrooms	383	0.007	0.005	0.13	24	0.06
Nuts	175	0.005	0.005	0.02	4	2.3
Onion, bulb	210	0.005	0.005	0.005	0	0.00
Peach	353	0.007	0.005	0.20	22	6.2
Pears	282	0.005	0.005	0.07	5	1.8
Peppers	1497	0.010	0.005	0.93	105	7.0
Plum	145	0.005	0.005	0.03	2	1.4
Potato	520	0.005	0.005	0.02	1	0.19
Rice grain	120	0.005	0.005	0.01	10	8.3
Soya beans	127	0.007	0.005	0.08	6	4.7
Tomatoes	627	0.007	0.005	0.33	28	4.5
Wheat grain	197	0.005	0.005	0.03	9	4.6
PDP Monitoring, 1992						
Apples	567	0.010	0.002	0.640	100	18
Bananas	564	0.003	0.002	0.006	0	0.00
Broccoli	153	0.005	0.002	0.140	8	5.2
Carrots	153	0.003	0.002	0.006	0	0.00
Grapefruit	567	0.003	0.002	0.01	1	0.18
Grapes	552	0.007	0.002	0.77	24	4.3
Beans	466	0.003	0.002	0.01	1	0.21
Lettuce	565	0.003	0.002	0.09	3	0.53
Oranges	569	0.004	0.002	0.01	18	3.2

Commodity	No. of samples	Mean, mg/kg	Min., mg/kg	Max., mg/kg	No. >LOD	% >LOD
Peaches	360	0.004	0.002	0.07	31	8.61
Potatoes	568	0.003	0.002	0.006	0	0.00
PRIS (FOODCONTAM) Monitoring, 1988-1991						
Apples	1638	0.03	0.003	24.0	137	8.4
Banana	283	0.02	0.005	0.30	81	29
Blueberries	105	0.005	0.005	0.005	0	0.00
Broccoli	814	0.005	0.005	0.03	1	0.12
Br. sprouts	227	0.009	0.005	0.50	4	1.76
Cabbage	1190	0.007	0.005	1.13	5	0.42
Carrots	713	0.005	0.005	0.005	0	0.00
Cauliflower	506	0.005	0.005	0.07	1	0.20
Ch. cabbage	310	0.005	0.005	0.005	0	0.00
Egg plant	280	0.005	0.005	0.005	0	0.00
Grapefruit	300	0.007	0.005	0.18	6	2.0
Grapes	1063	0.006	0.005	0.24	10	0.94
Kale	352	0.008	0.003	0.51	6	1.7
Lemon	394	0.02	0.005	0.39	56	14
Lettuce	3276	0.005	0.005	0.26	6	0.18
Milk/cream	7290	0.005	0.005	0.005	0	0.00
Mushrooms	261	0.005	0.005	0.005	0	0.00
Oranges	871	0.03	0.005	0.63	183	21
Peaches	597	0.005	0.005	0.03	6	1.0
Pears	616	0.005	0.005	0.02	4	0.65
Pepper, sweet	1031	0.007	0.005	0.20	22	2.1
Plums	458	0.005	0.005	0.04	1	0.22
Potatoes	871	0.006	0.005	0.26	7	0.80
Strawberry	691	0.005	0.002	0.06	5	0.72
Tomatoes	1171	0.006	0.005	0.45	17	1.4

The Government of The Netherlands reported monitoring data on food in commerce for 1994-1996, 1997 and 1998. The information is shown in Table 131.

Table 131. Residues of chlorpyrifos in food in commerce in The Netherlands, 1994-1998.

Commodity	No. of samples			% ≥ 0.05 mg/kg		
	1994-1996	1997	1998	1994- 1996	1997	1998
Citrus fruit						
Grapefruit	301	87	35	9.6	1.1	11
Lemon	243	335	24	8.6	15	8.3
Orange	902	112	124	11.	14	18
Pomelo			4			25
Tangerine	560	21	70	12	4.8	16
Other citrus fruit			12			8.4
Pome fruit						
Apple	1495	398		1.9	1.2	
Stone fruit						
Apricot	80			0		
Cherry	252			0.4		
Peach	252			1.2		
Nectarine	221			0		
Plum		85			1.2	
Berries and small fruit						
Grape	667	196	99	3.6	1.0	3.0
Strawberry	2378	779		0.2	0.2	

Commodity	No. of samples			% ≥ 0.05 mg/kg		
	1994-1996	1997	1998	1994- 1996	1997	1998
Currant	450			0		
Miscellaneous fruit						
Avocado	125			0.8		
Banana	57			0		
Date		8			12	
Kiwifruit	223	60		2.2	1.7	
Litchi	351			0		
Mango	191			0.5		
Other fruits and fruit products	385	152	51	1.3	1.3	2.0
Fruiting vegetables						
Tomato	1108			0.2		
Pepper	1525	607	213	0.3	0.5	0.5
Aubergine (egg plant)	148			0.7		
Melon	390			0		
Brassica vegetables						
Broccoli	154	62	42	0.6	3.2	4.8
Brussels sprouts			47			2.1
Chinese cabbage	297			0.3		
Leaf vegetables and fresh herbs						
Lamb's lettuce	268			0.7		
Iceberg lettuce	471			0		
Lettuce	3306			0.09		
Endive	1137			0		
Other herbs	148			0		
Stem vegetables						
Asparagus	244			0.4		
Celery	233		105	1.7		0.9
Other stem vegetables	341			0		
Pulses						
Beans, fresh with pods	617			0		
Root and tuber vegetables						
Potatoes	325			0.3		
Carrot		164			0.6	
Beetroot			20			5.0
Cereals						
Rice	96			0		
Other arable products	699			0.1		

The Government of Poland submitted monitoring data on chlorpyrifos for the years 1997 and 1998, as shown in Table 132.

Table 132. Residues of chlorpyrifos in food in commerce in Poland, 1997-1998.

Commodity	LOQ, mg/kg	No. of samples		% ≥LOQ	
		1997	1998	1997	1998
Apple	0.05	78	77	0	0
Carrot	0.02	180	167	0	0
Cabbage, head	0.03	141	119	7.8	7.6
Onion, bulb	0.04	46	90	0	1.1
Potato	0.02	277	258	0	0

NATIONAL MAXIMUM RESIDUE LIMITS

The National MRLs listed below were supplied by the manufacturer and the governments of The Netherlands, Poland and the USA. The USA supplied revised tolerances (MRLs) arising from the Reregistration Eligibility Decision for chlorpyrifos.

Country	Commodity	MRL, mg/kg
Argentina	Alfalfa	4
	Apple	0.2
	Apple	0.2
	Asparagus	0.5
	Barley	0.05
	Bell pepper	0.5
	Citrus fruits	0.3
	Corn	0.05
	Cotton seed	0.05
	Cotton seed oil	0.05
	Flax seed	1
	Garlic	0.5
	Oats	0.05
	Olive	0.5
	Onion bulb	0.05
	Pear	0.2
	Potato	0.05
	Rye	0.05
	Sorghum	0.05
	Soya bean	0.01
	Stone fruits	0.5
	Sunflower seed	0.05
	Sunflower seed oil	0.1
	Sweet corn (kernels)	0.05
	Tomato	0.5
	Wheat	0.05
Austria	Cereal	0.05
	Corn	0.05
	Carrot	0.1
	Hops (dry)	0.1
	Kiwifruit (pulp)	0.1
	Kiwifruit	2
	Fruit (others)	0.2
	Citrus fruits without peel	0.2
	Sugar beet	0.05
Australia	Asparagus	0.5
	Avocado	0.5
	Banana	0.5T
	Brassica (cole or cabbage) vegetables	0.5
	Cabbage, head	0.5
	Flowerhead brassicas	0.5
	Cassava	0.02*
	Cattle, edible offal	2
	Cattle meat (in the fat)	2
	Cereal grains (except sorghum)	0.1
	Citrus fruits	0.5
	Cotton seed	0.05
	Cotton seed oil, crude	0.2
	Dried fruits	2
	Grapes	1
	Eggs	0.01T
	Ginger, root	0.01*
	Kiwifruit	2
	Mango	0.05*
	Milks (in the fat)	0.2T
	Oilseed	0.01
	Passion fruit	0.05*
	Pig, edible offal	0.1

Country	Commodity	MRL, mg/kg
	Pig meat (in the fat)	0.1
	Pineapple	0.5
	Pome fruits	0.2
	Potato	0.05
	Poultry, edible offal	0.1T
	Poultry meat (in the fat)	0.1T
	Sheep, edible offal	0.1
	Sheep, meat (in the fat)	0.1
	Sorghum	3
	Stone fruits	1
	Strawberry	0.05
	Sugar cane	0.1
	Tomato	0.5
	Tree nuts	0.2
	Vegetables (except asparagus, brassica, cassava, celery, potato, tomato, sweet potato)	0.01*
	Cotton fodder, dry	30
	Cotton meal and hulls	0.05
Belgium	Beef (meat)	2
	Beet	0.2
	Bilberry (red or red whortleberry)	0.1
	Blackberry	0.1
	Carrot	0.1
	Citrus fruit	0.3
	Corn (sweet)	0.2
	Corn salad	0.2
	Currant	0.1
	Endive	0.2
	Eggs, egg products	0.01
	Food (except as otherwise listed)	0.05
	Gooseberry	0.1
	Grapes	0.5
	Herbs	0.2
	Kiwifruit	2
	Lettuce	0.2
	Milk and milk products	0.01
	Onion	0.2
	Parsnip	0.2
	Plum	0.2
	Pome fruits	0.5
	Sheep (meat	0.2
	Strawberries	0.2
	Tea (green, black)	0.1
	Turnip (garden)	0.2
	Turnip (Swedish turnip or Swede fodder)	0.2
	Vegetables (legume)	0.2
	Vegetables (stalk))	0.2
Brazil	Apple	1
	Bean (field)	0.1
	Bean (dry)	0.1
	Beef (fat)	2
	Cabbage	1
	Carrot	0.5
	Cereal grains	0.75
	Citrus fruit	0.3
	Coffee (bean)	0.02
	Corn	0.1
	Cotton (seed oil), cotton (seed, whole)	0.05
	Grasses	2
	Hay or fodder (dry) or grasses	6
	Kale	1
	Milk (fat basis)	0.01
	Peanut	0.01
	Miscellaneous fodder and forage	1.5
	Potato	0.01

Country	Commodity	MRL, mg/kg
	Poultry fats	0.2
	Sheep fat	0.2
	Sorghum	0.01
	Soya bean	0.01
	Tomato	0.5
	Wheat	0.01
Canada	Apples	1.5
	Citrus fruits	1
	Kiwifruit	2
	Peppers	1
	Rutabagas	0.5
	Meat and meat by-products of cattle, fat content basis	1
	Fat, liver and kidney of cattle	1
	Apples	1
	Beans (dry)	0.2
	Beef (carcasses, fat)	2
	Carrot	0.5
	Citrus fruit	0.3
Chile	Eggs	0.01*
	Grapes	1
	Lettuce	0e1
	Pear	0.5
	Potato	0.05
	Poultry (fat)	0.1
	Rice	0.1
	Sheep (carcasses, fat basis)	0.2
	Sugar beet	0.05
	Tomato	0.5
Denmark	Carrot	0.5
	Citrus fruit	0.5
	Fruit (other)	0.5
	Potato	0.05
	Vegetables (leafy)	0.5
	Artichoke	1
	Bananas	3
	Barley	0.2
	Blackberries	0.5
EU	Cherries	0.3
	Chinese cabbage	0.5
	Cranberries	0.05*
	Currants	1
	Flowerhead Brassica	0.05*
	Gooseberries	1
	Head cabbage	1
	Herbs	0.05*
	Lamb	0.05*
	Legume vegetables	0.05*
	Lemon	0.2
	Lettuce	0.05*
	Mandarin	2
	Onions	0.2
	Other cane fruits	0.05*
	Other head brassicas	0.05*
	Other leaf brassicas	0.05*
	Other stem vegetables	0.05*
	Peaches	0.2
	Radish	0.2
	Raspberries	0.5
	Scarole	0.05*
Finland	Vegetables	0.1
	Kiwifruit	2
France	Beans, French	0.2
	Carrot	0.1
	Cereals	0.05
	Citrus fruit	0.3

Country	Commodity	MRL, mg/kg
	Fruit (Other), vegetables (Other)	0.05*
	Grapes	0.5
	Kiwifruit	2
	Maize	0.05
	Oilseed	0.05
	Onion	0.2
	Pome fruits	0.5
	Soya beans (dry)	0.05
	Stone fruit	0.2
	Strawberries	0.2
	Tea (green, black)	0.1
	Sunflower seed	0.05
Germany	Carrot	0.1
	Citrus fruit	0.3
	Coffee (bean, raw)	0.2
	Corn	0.05
	Fruit	0.1
	Grapes	0.5
	Hops (dry)	0.1
	Kiwifruit	2
	Legumes (Stored or for direct consumption)	0.05
	Peppers (bell)	0.1
	Plum	0.2
	Pome fruit	0.5
	Strawberry	0.2
	Sugar beet	0.05
	Tomato	0.1
	Vegetables (bulb)	0.1
	Vegetables (root, tuber, stalk, sprouts)	0.05
Hungary	Cereals	0.1
	Corn	0.05
	Pome fruits	0.2
	Sunflower seed	0.1
India	Cabbage	0.01
	Cauliflower	0.01
	Cotton (seed)	0.05
	Cotton (seed, oil, crude)	0.025
	Food grains	0.05
	Food grains (milled)	0.01
	Fruit	0.5
	Onion	0.01
	Potato	0.01
	Vegetables (other)	0.2
Israel	Alfalfa forage (green)	0.1
	Artichoke (globe)	0.05
	Citrus fruit	0.3
	Corn (Sweet, kernels)	0.05
	Cotton (seed)	0.05
	Grapes	1
Italy	Cabbage	0.2
	Citrus (fruit)	0.2
	Corn	0.05
	Fruit	0.5
	Peach	0.2
	Pear (Japanese)	0.5
	Pome fruits	0.2
	Potato	0.2
	Sugar beet	0.2
	Tomato	0.5
Japan	Apple	1
	Beet root	0.05
	Citrus fruit	0.3
	Grapes	1

Country	Commodity	MRL, mg/kg
	Mandarin	0.3
	Oranges, sweet, sour	0.5
	Peach	1
	Pear, Japanese	0.5
	Plums (including prunes)	1
	Sweet potato	0.1
	Tea, green, black	3
Korea	Apple	1
	Cabbage	0.5
	Chinese cabbage	1
	Citron	0.5
	Citrus fruits	0.5
	Garlic	0.5
	Onion bulb	0.5
	Peach	0.5
	Pear	0.5
	Tea, green, black	1
Malaysia	Cocoa	0.01
Mexico	Alfalfa fodder	4
	Apple	1.5
	Bean (forage, green)	1
	Bean (string)	0.05
	Broccoli	1
	Cattle meat	2
	Citrus fruit	1
	Coffee beans	0.2
	Corn	0.1
	Cotton (seed)	0.5
	Cucumber	0.1
	Peach	0.05
	Pear	0.05
	Peppers	1
	Rice	0.1
	Sorghum (grain)	0.75
	Sorghum forage, green	1.5
	Soya beans	0.5
	Sugarcane	0.1
	Sweet potato	0.1
	Tomato	0.5
	Wheat	0.5
New Zealand	Banana	2
	Fruit (other)	0.2
	Fruit (stone)	1
	Grapes	1
	Kiwifruit	2
	Meat fat in any food	1.5
	Tomato	0.2
Netherlands	Beef (meat)	2
	Bananas	3
	Barley	0.2
	Blackberries	0.5
	Cabbage, head	1
	Carrots	0.1
	Cherries	0.3

Country	Commodity	MRL, mg/kg
	Chicken (meat)	0.05*
	Chinese cabbage	0.5
	Citrus fruit (except lemons and mandarins)	0.3
	Currants (red, black and white)	1
	Eggs	0.01*
	Globe artichokes	1
	Gooseberries	1
	Grapes (table and wine)	0.5
	Hops	0.1*
	Kiwifruit	2
	Lemons	0.2
	Mandarins	2
	Onions	0.2
	Peaches (including nectarines)	0.2
	Plums	0.2
	Radishes	0.2
	Raspberries	0.5
	Sheep (meat)	0.2
	Strawberries	0.2
	Milk	0.01*
	Pome fruit	0.5
	Raspberries (red, black)	0.2
	Solanacea	0.5
	Tea	0.1*
Poland	Cereal grains	0.05
	Citrus fruits	0.3
	Eggs	0.01
	Fruiting vegetables, cucurbits	0.5
	Fruiting vegetables, other than cucurbits	0.5
	Meat and meat products	0.2
	Milks and milk product	0.01
	Poultry meat	0.05
	Pome fruits	0.5
	Potato	0.05
	Stone fruits	0.2
	Sugar beet	0.05
	Tea	0.1
	Vegetables except as otherwise noted	0.1
Romania	Eggs (less shell)	0.01
	Poultry (meat)	0.2
	Meat (cattle, pigs and sheep)	2
South Africa	Apple	0.05
	Apricot	0.05
	Banana	0.5
	Carrot	0.05
	Citrus	0.3
	Grapes	0.5
	Lettuce	0.05
	Peach	0.3
	Pear	0.3
	Plum	0.3
	Potato	0.3
	Tomato	0.5
	Wheat	0.3
Spain	Alfalfa	0.05
	Aubergine	0.5
	Banana	0.2

Country	Commodity	MRL, mg/kg
	Brassica	0.05
	Cabbage	1
	Carrot	0.1
	Cereal grains	0.05
	Citrus fruit	0.3
	Cucurbits	0.05
	Grapes	0.5
	Hazelnuts	0.05
	Leafy vegetables	0.05
	Lettuce head	0.5
	Lettuce leaves	0.5
	Maize	0.05
	Olive	0.2
	Pepper	0.5
	Pome fruit	0.5
	Potato	0.05
	Sorghum	0.05
	Strawberry	0.2
	Sugar beet	0.05
	Tomato	0.5
	Tree nuts	0.05
Sweden	Milk	0.003
	Eggs	0.01
	Meat (raw material)	0.02
	Potato	0.05
	Butter	0.1
	Cheese	0.1
Switzerland	Milk	0.005
	Vegetables	0.05
	Citrus (fruit, in pulp)	0.1
	Kiwifruit)pulp)	0.1
	Citrus (whole fruit)	0.3
	Oil (wheat germ)	0.5
	Kiwifruit (whole)	2
Taiwan	Banana	1
	Bulb vegetable	0.5
	Citrus	2
	Coconut	1
	Large berry	1
	Leafy vegetable	1
	Litchi	1
	Maize	0.5
	Pineapple	1
	Pome fruit	1
	Rice	0.1
Ukraine	Apples	0.05
	Hops, dry	1
	Peach	0.05
	Potato	0.05
	Sugar beet	0.05
USA	Alfalfa forage	3
	Alfalfa hay	13
	Almonds	0.2
	Almond hulls	12

Country	Commodity	MRL, mg/kg
	Apple	0.01
	Apple pomace, wet	0.02
	Asparagus	5
	Banana, whole	0.1
	Banana, pulp	0.01
	Cattle fat	0.3
	Cattle meat	0.05
	Cattle, meat by-products	0.05
	Chinese Cabbage	1
	Citrus	1
	Citrus oil	20
	Citrus pulp, dried	5
	Corn, field, grain	0.05
	Corn, field, fodder	8
	Corn, field, forage	8
	Corn oil	0.25
	Cotton seed	0.2
	Cranberries	1
	Cucumber	0.05
	Eggs	0.01
	Figs	0.01
	Filbert	0.2
	Goats, fat	0.2
	Goat, meat	0.05
	Goat, meat by-products	0.05
	Grapes	0.01
	Hogs, fat	0.2
	Hogs, meat	0.05
	Hogs, meat by-products	0,05
	Horses, fat	0.25
	Horses, meat	0.25
	Horses, meat by-products	0.25
	Kiwifruit	2
	Legumes (except soya beans)	0.05
	Lettuce	1
	Macadamia nuts	0.2
	Milk fat	0.25
	Nectarines	0.05
	Onions, dry bulb	0.5
	Peach	0.05
	Peanuts	0.2
	Peanut oil	0.2
	Pears	0.01
	Pecans	0.2
	Peppermint, tops	0.8
	Peppermint oil	8
	Peppers	1
	Plums	0.05
	Poultry, fat (incl turkeys)	0.1
	Poultry, meat (incl turkeys)	0.1
	Pumpkin	0.05
	Radishes	2
	Rutabagas	0.5
	Sheep, fat	0.2

Country	Commodity	MRL, mg/kg
	Sheep, meat	0.05
	Sheep, meat by-products	0.05
	Soya bean, grain	0.3
	Sorghum, fodder	6
	Sorghum, forage	1.5
	Sorghum, Grain	0.75
	Spearmint, tops	0.8
	Spearmint oil	8
	Strawberries	0.2
	Sugar beet molasses	15
	Sugar beet, pulp, dried	5
	Sugar beet, roots	1
	Sugar beet, tops	8
	Sunflower seeds	0.1
	Sweet potato	0.05
	Turnip greens	0.3
	Turnips	1
	Vegetables, leafy brassica cole	1
	Walnuts	0.2
	Wheat forage	3.0
	Wheat grain	0.5
	Wheat straw	6.0
Venezuela	Banana	0.25
	Cabbage	0.05
	Coffee beans	0.01
	Corn	0.1
	Cotton seed	0.05
	Onion, bulb	0.01
	Peanut	0.01
	Plantain	0.1
	Potato	0.05
	Rice	0.1
	Sesame	0.01
	Sugarcane	0.1
	Sorghum	10
	Tomato	0.5
Zimbabwe	Carrots	0.05
	Citrus	0.3
	Cucurbits	0.05
	Fruiting vegetables, except cucurbits	0.05
	Leafy vegetables	0.05
	Maize	0.05
	Potato	0.05

* Residue at the LOQ.
T: temporary

APPRAISAL

Metabolism

Animals

Two female *goats* were fed [^{14}C]chlorpyrifos in gelatin capsules twice daily for 10 days for a total dose of 0.26 mCi/goat per day and dietary intakes of 15 and 19 ppm. Urine and faeces contained 79-89% of the administered dose, and about 2% was found in milk and tissues combined. The concentration of residue in milk attained a maximum on day 8 (0.047 mg/kg) and then fell slightly. The concentrations in the tissues of the two goats, respectively, expressed as equivalents of chlorpyrifos, were fat, 0.10 and 0.22; liver, 0.18 and 0.27; kidney, 0.26 and 0.35; muscle, 0.03 and 0.03; and skin, 0.11 and 0.18 mg/kg. When tissues were hydrolysed with 0.6 N potassium hydroxide, >94% of the radiolabelled residue in all tissues and 92-94% of that in milk was 3,5,6-trichloropyridinol. Chlorpyrifos and 3,5,6-trichloropyridinol represented 70 and 14% of the recovered activity in solvent extracts of milk, 76 and 21% in fat, 1.9 and 84% in liver, and 0.9 and 92% in kidney. The oxygen analogue of chlorpyrifos was not detected.

In a study in *poultry*, acclimatized white Leghorn laying hens received a daily oral dose of 2.26 mg of [^{14}C-2 and ^{14}C-6]chlorpyrifos for 10 days. Ring C-2 is adjacent to the thiophosphate. The concentrations of chlorpyrifos equivalents in treated tissues were kidney, 0.15 mg/kg; liver, 0.054 mg/kg; muscle, 0.10 mg/kg; fat, 0.20 mg/kg; skin, 0.13 mg/kg; gizzard, 0.024 mg/kg; and heart, 0.068 mg/kg. Eggs were separated into yolk and whites and combined by group and day. The concentration of radiolabel in the whites reached a plateau of 0.026 mg/kg on day 7, and that in the yolks appeared to reach a plateau of 0.15 mg/kg on day 9 or 10. Chlorpyrifos and 3,5,6-trichlorpyridinol accounted for 72% of the total radiolabel in kidney, 81% in egg yolk, <2% in liver, 65% in hydrolysed liver, 83% in skin, and 89% in fat.

The Meeting concluded that chlorpyrifos is metabolized in livestock to 3,5,6-trichloropyridinol and derivatives thereof, which are released by base hydrolysis. The Meeting also concluded that the residues are concentrated to a greater degree in fat than in muscle.

Plants

The metabolism of [^{14}C-2 and ^{14}C-6]chlorpyrifos was studied in leaves of *maize (corn), soya bean, and sugar beet.* A total of 24 maize plants were maintained in a chamber which permitted collection of volatile products, and radiolabelled chlorpyrifos was applied to the upper surfaces of the leaves as 1-µl drops up to a typical total dose of 200 µg of chlorpyrifos per plant. At intervals, the treated leaf areas were excised, rinsed with methanol, and analysed or homogenized in 75% acetone to extract metabolites. The untreated plant parts were also analysed to determine the extent of translocation as a function of time. The radiolabel that could be removed by rinsing with a solvent decreased from 99% on the day of application to 1% on day 4, while the volatile radiolabel increased from 0 to 84% of the applied dose. The amount of translocated radiolabel did not represent more than 0.8% of the applied dose. The combined surface rinses and leaf extracts did not contain more than 10% of the applied dose 8-16 days after application, and the amount of radiolabel that could not be extracted did not exceed 3% of the applied dose. The extracts contained chlorpyrifos (0.1-0.4% of the applied dose) and polar metabolites. Acid hydrolysis, base hydrolysis, or enzyme hydrolysis of the extracts released 25-58% of the radiolabel in the extracts as 3,5,6-trichlorpyridinol.

Maize (field corn) was treated twice with radiolabelled chlorpyrifos, once by ground application at planting (223 mg ai/m of row) and again by foliar application (1.7 kg ai/ha). Green forage was harvested 49 days after the foliar application, and grain and fodder were harvested after 153 days. The concentrations of chlorpyrifos equivalents were 1.6 mg/kg in green forage, 4.2 mg/kg in dry fodder, and 0.13 mg/kg in grain. About 3% of the total residue in forage was chlorpyrifos, and 1% was 3,5,6-trichloropyridinol. Base hydrolysis of the green forage solubilized 90% of the total radiolabelled residue, and 30% was identified as 3,5,6-trichloropyridinol. A similar result was obtained with dry fodder, except that trichloromethoxypyridine was tentatively identified as representing 3% of the residue. Corn forage was further characterized by sequential extraction as containing 17% polysaccharide, 10% hemicellulose, and 26% lignin. The residue in grain could not be released by mild base hydrolysis, but sequential extraction revealed 4% in protein, 14% in cellulose, 8% in gluten, and 34% in starch.

Soya beans were sprayed in mid-season with [^{14}C]chlorpyrifos at a rate of 1.12 kg ai/ha. Forage was sampled 14 days after treatment, and beans and field trash were sampled at the normal harvesting time 52 days after treatment. The forage was found to contain 46% of the total radiolabelled residue as chlorpyrifos and 24% as 3,5,6-trichloropyridinol, free and conjugated. The beans contained 2.6% of the residue as chlorpyrifos, 8.8% as free 3,5,6-trichloropyridinol, and 66% as incorporated (protein).

Sugar beets were given two applications of [^{14}C]chlorpyrifos in a manner analogous to the field corn. Green foliage was taken 38 days after the soil application and before the foliar application, and tops and mature beets were harvested 108 days after the foliar application. The green foliage contained primarily polar radiolabelled compounds, 90% of which were extractable. Alkaline hydrolysis of the extract released 3,5,6-trichloropyridinol, representing 57% of the total residue. When mature beet tops were hydrolysed with base, 65% of the total radiolabel was released. About 29% of the radiolabel was associated with 3,5,6-trichloropyridinol. Solvent extraction of the tops released a mixture of polar compounds, accounting for 45% of the total residue. Methanol extraction of the beet roots released 85% of the residue. About 40% of the total residue was shown to be sucrose. Also present were the methoxypyridine (7% of the total residue), 3,5,6-trichloropyridinol (36%), and chlorpyrifos (<0.5%).

An *apple* tree was sprayed nine times with a wettable powder formulation of chlorpyrifos, and in the last two applications [^{14}C]chlorpyrifos was admixed with unlabelled compound. The apples were harvested 14 days after the final treatment. Most of the radiolabel was found in the peel, with 0.8 mg/kg in peel and 0.005 mg/kg in flesh. In the peel, 36% of the residue was chlorpyrifos, 5.3% was free 3,5,6-trichloropyridinol, 1.2% was conjugated 3,5,6-trichloropyridinol, 5% was unknown compounds converted by refluxing base hydrolysis to 3,5,6-trichloropyridinol, and 15% was postulated to be natural products.

A study of confined rotational crops was conducted in which *carrots, lettuce,* and *wheat* were planted in soil treated with [^{14}C]chlorpyrifos 30 and 132 days after treatment. The concentrations of residue ranged from 0.19 mg/kg in carrot roots planted 30 days after treatment to 1.3 mg/kg in wheat straw planted after 132 days. In the carrot roots, chlorpyrifos represented 2.0% of the residue; trichloropyridinol, 10%; trichloromethoxy-pyridine, 26%; and glucose, 21%. In wheat straw planted 30 days after treatment, trichloropyridinol represented 4.3% of the residue; cellulose, 13%; lignin, 17%; and glucose, 21%, In wheat grain planted 30 days after treatment, the values were trichloropyridinol, 0.3%; cellulose, 8.5%; starch, 46%; and glucose, 49%. The identification of glucose was tentative.

The Meeting concluded that chlorpyrifos is metabolized to 3,5,6-trichloropyridinol, which is then conjugated or further degraded. Much of the chlorpyrifos is ultimately incorporated into natural components (such as protein, cellulose, and lignin) of the plants. The Meeting also concluded that chlorpyrifos has a low to moderate tendency to translocate from the site of application.

Environmental fate

Under aerobic conditions in loam soil, chlorpyrifos degraded to CO_2 over 360 days. The maximal concentration of 3,5,6-trichloropyridinol represented 4.3% of the applied dose at about day 60, and that of 3,5,6-trichloromethoxypyridine represented 1.6% at about day 30. The conversion was slower in clay soil. The degradation of 3,5,6-trichloropyridinol in soil involved extensive mineralization, with an average half-life of 73 days. Under anaerobic conditions in loam soil, 92% was converted to 3,5,6-trichloropyridinol over 360 days and none to 3,5,6-trichloromethoxypyridine.

Owing to its nonpolar nature, chlorpyrifos is sparsely soluble in water and tends to partition from aqueous into organic phases in the environment. It has a strong affinity for soil, as evidenced by an average soil and sediment sorption coefficient (K_{OC}) of 8500 ml/g (range, 970-31 000) in 28 laboratory studies in which the batch equilibrium method was used. 3,5,6-Trichloropyridinol shows only moderate sorption, with K_{OC} values of 18-390 ml/g (average, 160 ml/g).

Several studies have been conducted of leaching, in both the laboratory and the field. A typical study involved 30-cm glass columns packed with Commerce loam (0.68% organic carbon), Tracy sandy loam (1.1% organic carbon), or Catlin silty clay loam (2.0% organic carbon) which were treated with [^{14}C]chlorpyrifos at 0.5 kg/ha and eluted with 51 cm of water. Most of the chlorpyrifos (95-99%) remained in the top 2 cm of the column, and none moved beyond the upper 5 cm of soil. A maximum of 1.3% of the applied radiolabel appeared in the leachates. Field studies were conducted under natural conditions of rainfall and irrigation. Chlorpyrifos applied at 1.1-2.2 kg ai/ha remained in the top 20 cm of soil throughout the growing season. One of the studies indicated that 3,5,6-trichloropyridinol has at least a moderate tendency to leach. When chlorpyrifos was applied three times at 1.12 kg ai/ha during the growing season in a citrus grove, with a rainfall of 110 cm and irrigation with 48 cm, it was confined to the upper 15 cm of soil, but 3,5,6-trichloropyridinol was found at a depth of 46 cm.

The Meeting concluded that chlorpyrifos is converted in soil to 3,5,6-trichloropyridinol and ultimately to CO_2. The Meeting also concluded that chlorpyrifos has no tendency to leach from the soil, but that the metabolite 3,5,6-trichloropyridinol has a moderate tendency to do so.

Methods of analysis

Methods for both enforcement and data collection and monitoring have been developed for the determination of chlorpyrifos in plant and animal matrices, soil, and water. Various extraction and clean-up methods are followed by analysis by gas chromatography with a flame photometric detector or, infrequently, an electron capture detector. Gas chromatography with mass spectrometry may be used for confirmation. A variation involves base hydrolysis of the matrix, which converts chlorpyrifos and conjugated 3,5,6-trichloropyridinol to 3,5,6-trichloropyridinol. The limit of determination is 0.01 mg/kg for methods for the determination of chlorpyrifos and 0.05 mg/kg for those for 3,5,6-trichloropyridinol.

The Meeting concluded that adequate analytical methods are available for the enforcement of MRLs and for monitoring.

Stability of residues in stored analytical samples

Substantial data were made available on the stability of chlorpyrifos in frozen crop matrices. Generally, no loss occurred over 360 days of frozen storage, except from walnuts and almonds (20-23% loss within 258 days), oranges and orange juice (20% loss within 170 days), sorghum silage (23% loss within 65 days), and sugar beet roots (37% loss within 150 days).

Only summary information was provided on the stability of chlorpyrifos in animal commodities. The data for muscle, liver, and kidney were variable. In subcutaneous fat, 60-86% of the incurred residue remained after 41 months of frozen storage. About 74% of chlorpyrifos added at 0.1 or 1.0 mg/kg to whole milk remained after 49 months of frozen storage.

The Meeting concluded that chlorpyrifos is stable in crop matrices stored frozen for up to 1 year. Insufficient detail was provided on animal commodities.

Definition of the residue

The studies on animal and plant metabolism and on environmental fate indicate that use of chlorpyrifos could result in the presence of the parent compound and the major metabolite 3,5,6-trichloropyridinol (free and conjugated) in agricultural commodities. The 1999 Meeting considered the trichloropyridinol metabolite during its deliberations, but established an ADI and an acute RfD only for the parent compound. Analytical methods for enforcement purposes are available for the determination of chlorpyrifos residues in plant and livestock commodities, soil, and water.

The octanol/water partition coefficient for chlorpyrifos, log P_{OW} = 4.7, indicates that chlorpyrifos is fat-soluble. This conclusion is confirmed by the results of studies in goats and poultry, in which the concentration of radiolabelled material in fat was up to 10 times that in muscle.

The Meeting concluded that the residue definition both for compliance with MRLs and estimation of dietary intake should be chlorpyrifos and that chlorpyrifos should be designated as fat-soluble.

Results of supervised trials

The results of supervised trials were provided for citrus (mandarin, orange, grapefruit, lemon), apple, pear, peach, plum, blueberry, caneberry, strawberry, grape, banana, kiwifruit, broccoli, Brussels sprout, cabbage, Chinese cabbage, cauliflower, pepper, tomato, soya, pea, carrot, potato, onion, lettuce, common bean, sugar beet, maize (corn), sweet corn, grain sorghum, rice, wheat, alfalfa, almond, pecan, peanut, sunflower, and coffee.

Data on the relevant GAP were not available to evaluate the data on blueberry, egg plant, and leaf lettuce. The percentage moisture was not available for any of the animal feed commodities, such as alfalfa, and the default values for dry matter from the *FAO Manual* (FAO, 1997) were used to estimate MRLs on a dry-weight basis, where appropriate.

The results of five field trials on *mandarin orange* conducted according to GAP were presented from Spain (0.10 kg ai/hl, 3 kg ai/ha, 21-day PHI), in which the residue concentrations were 0.15, 0.33, 0.55, 0.99, and 1.2 mg/kg. Five trials on *oranges* were reported from South Africa at GAP (0.048 kg ai/hl, 60-day PHI), showing concentrations of 0.05, 0.12, 0.14, 0.19, and 0.21 mg/kg. In three trials from the USA (GAP, 0.7 kg ai/hl, 6.7 kg ai/ha foliar treatment, 35-day PHI; 0.5 kg ai/hl, 1.1 kg ai/ha, ground treatment, 28-day PHI), the concentrations were 0.26 (foliar), 0.41 (foliar), and 0.66 mg/kg (foliar and ground). One trial on *grapefruit* from Spain showed a concentration of 0.10 mg/kg. Trials on citrus fruit from Italy and the USA were not conducted according to GAP and were not evaluated further.

Thus, six trials at GAP rates were available for small citrus (mandarin, lemon) and eight for large citrus (orange, grapefruit). The ranked order of concentrations of chlorpyrifos residues (median in italics) was: 0.05, 0.10, 0.12, 0.14, 0.15, 0.19, ***0.21***, ***0.26***, 0.33, 0.41, 0.55, 0.66, 0.99, and 1.2 mg/kg. The concentrations in small citrus and on large citrus were similar. No data were presented from analyses of pulp, but a study of orange processing showed a threefold reduction in the concentration between a whole orange and its pulp. Using this factor, the Meeting estimated an STMR value of 0.08 mg/kg for citrus pulp from the STMR value for whole citrus fruit (0.24/3). The Meeting estimated a HR value of 0.4 mg/kg for citrus pulp from the HR value for whole citrus fruit (1.2/3), and a maximum residue limit of 2 mg/kg for whole citrus.

One field trial on *apple* from Chile (GAP, 0.06 kg hl/hl, 28-day PHI) showed a concentration of 0.09 mg/kg, two from Italy (GAP, 0.053 kg ai/hl, 30-day PHI) gave values of 0.17 and 0.19 mg/kg, two from New Zealand (GAP, 0.025-0.038 kg ai/hl, 1 kg ai/ha minimum, 14-day PHI) gave values of 0.16 and 0.19 mg/kg, six trials from Germany (at the GAP rate of the UK of 0.96 kg ai/ha, 14-day PHI) showed concentrations of 0.08, 0.13, 0.17, 0.43, 0.53, and 0.94 mg/kg, and two from the UK resulted in values of 0.17 and 0.18 mg/kg. Trials were reported from Brazil, Canada, and the USA but were not conducted according to GAP and were not evaluated further.

For *pear*, field trials were reported from Canada, the UK, and the USA, but no information on GAP was available or the trials were not conducted according to GAP. As GAP rates for apple and pear in the UK are similar, the Meeting agreed to extrapolate the results for apples to pears and to estimate an STMR value and MRL for pome fruit. The ranked order of concentrations in the 13 trials for apples conducted according to GAP was: 0.08, 0.09, 0.13, 0.16. ***0.17*** (3 trials), 0.18, 0.19 (2 trials), 0.43, 0.53, and 0.94 mg/kg. The Meeting estimated an STMR value of 0.17 mg/kg, a HR value of 0.94 mg/kg, and a maximum residue level of 1 mg/kg. The latter replaces the existing MRLs for apples and pears.

Supervised field trials on *peach* were conducted in Chile (14 trials at the GAP rate of 0.06 kg ai/hl, 45-day PHI), with concentrations of 0.017, 0.023, 0.03, 0.04 (4 trials), 0.045, 0.05, 0.07, 0.08, 0.09, 0.13, and 0.25 mg/kg), Greece (one trial at the GAP rate of 0.08 kg ai/hl, 20-day PHI) with a value of 0.33 mg/kg, Spain (one trial at the Greek GAP) showing a concentration of 0.04 mg/kg), Italy (two trials at the GAP rate of 0.054 kg ai/hl, 0.80 kg ai/ha, 30-day PHI) with values of 0.04 and 0.05 mg/kg, and the USA (four trials at the GAP rate of 0.36 kg ai/ha directed to trunk, 14-day PHI), which showed <0.01 mg/kg, reflecting the non-foliar use pattern.

The ranked order of the concentrations of residues after foliar application in 18 trials was 0.017, 0.023, 0.03, ***0.04*** (6 trials), ***0.045***, 0.05 (2 trials), 0.07, 0.08, 0.09, 0.13, 0.25, and 0.33 mg/kg. These values represent the whole fruit, including the pit. For the whole fruit, the Meeting estimated an STMR value of 0.042 mg/kg, a HR value of 0.33 mg/kg, and a maximum residue level of 0.5 mg/kg.

Supervised field trials on *plum* were submitted from Chile (three trials at the GAP rate of 0.06 kg ai/hl, 45-day PHI) with values of 0.002 (2 trials) and 0.005 mg/kg, Japan (two trials at the GAP rate of 0.025 kg ai/hl, 14-day PHI) with values of 0.03 and 0.05 mg/kg, and Germany (four trials at UK GAP rate of 0.38 kg ai/hl, 0.96 kg ai/ha, 14-day PHI) with concentrations of 0.04, 0.08, 0.14, and 0.20 mg/kg. The ranked order of concentrations in the nine trials was 0.002 (2 trials), 0.005, 0.03, ***0.04***, 0.05, 0.08, 0.14, and 0.20 mg/kg. These values represent the whole fruit, including the pit. For the whole fruit, the Meeting estimated an STMR value of 0.04 mg/kg, a HR value of 0.2 mg/kg, and a maximum residue level of 0.5 mg/kg.

Seven trials on *blueberry* were reported from the USA, but no GAP was reported. The Meeting could not estimate an STMR value or maximum residue level.

Eleven trials on *blackberry*, *boysenberry*, and *raspberry* were reported from the USA, but no GAP was reported. The results of two trials on raspberries were reported from the UK at the GAP rate of 0.14 kg ai/hl, 0.72 kg ai/ha,7-day PHI. The Meeting decided that the results of two trials (0.25 and 0.52 mg/kg) were insufficient for estimating a maximum residue level or an STMR value and recommended withdrawal of the existing MRL for red and black raspberries of 0.2 mg/kg.

Supervised field trials on *strawberry* were reported from the UK (eight trials at the GAP rate of 0.072 kg ai/hl, 0.72 kg ai/ha, 7-day PHI) showing concentrations of 0.04, 0.09 (2 trials), 0.10 (2 trials), 0.12, 0.14, and 0.15 mg/kg) and from the USA (three trials at the GAP rate of 0.30 kg ai/hl, 1.1 kg ai/ha, 21-day PHI) with values of 0.02, 0.04, and 0.07 mg/kg. The ranked order of the concentrations of residues in the 11 trials was 0.02, 0.04 (2 trials), 0.07, ***0.09*** (2 trials), 0.10 (2 trials), 0.12, 0.14, and 0.15 mg/kg. The Meeting estimated an STMR value of 0.09 mg/kg, a HR value of 0.15 mg/kg, and a maximum residue level of 0.3 mg/kg.

Supervised field trials on *grape* were available from France (10 trials at the GAP rate of 0.34 kg ai/ha, 21-day PHI) showing concentrations of 0.02, 0.04, 0.06, 0.07, 0.08 (2 trials), 0.10, 0.14, and 0.15 (2 trials) mg/kg, Italy (two trials at the GAP rate of 0.05 kg ai/hl, 30-day PHI) with concentrations of 0.02 and 0.04 mg/kg, Greece (two trials at the GAP rate of 0.065 kg ai/hl, 0.54 kg ai/ha, 28-day PHI) showing values of 0.09 and 0.32 mg/kg, and South Africa (two trials at the GAP rate of 0.036 kg ai/hl, 28-day PHI) with values of 0.13 and 0.17 mg/kg. The ranked order of concentrations in the 16 trials conducted at GAP was 0.02 (2 trials), 0.04 (2 trials), 0.06, 0.07, ***0.08*** (2 trials), 0.09, 0.1, 0.13, 0.14, 0.15 (2 trials), 0.17, and 0.32 mg/kg. The Meeting estimated an STMR value of 0.085 mg/kg, a HR value of 0.32 mg/kg, and a maximum residue level of 0.5 mg/kg. Although trials were reported from the USA, none was at GAP.

The results of supervised trials on *banana* treated by foliar application were reported from Australia (one trial at the GAP rate of 0.1 kg ai/hl, 1.0 kg ai/ha, 14-day PHI) with a value of 0.03 mg/kg whole fruit and <0.02 mg/kg pulp; South Africa (two trials at the GAP rate of 0.036 kg ai/hl, 28-day PHI) showing 0.07 mg/kg assuming 20% of banana is peel, 0.33 mg/kg of peel, and 0.01 mg/kg of pulp, <0.01 mg/kg of pulp, no data on peel; and Spain (seven trials including five in glasshouses, at the GAP rate of 0.1 kg ai/hl, 21-day PHI) giving values of 0.37 (<0.01 pulp), 0.48 (0.01 pulp), 0.75, 1.1 (2 trials), 1.6 (2 trials) mg/kg of whole fruit. Additional trials were reported on the use of plastic bags impregnated with chlorpyrifos, from Ecuador (one trial at the GAP rate of Colombia, 1%, 1 bag per season, PHI, about 12 weeks: 0.06 whole fruit, <0.01 mg/kg of pulp), Costa Rica (five trials at the GAP rate of Colombia: 0.01, 0.02, 0.04, 0.05, and 0.13 mg/kg of whole fruit; <0.01 (4 trials), 0.01 mg/kg of pulp), Honduras (two trials at the GAP rate of Colombia: 0.01 (2 trials) mg/kg of whole fruit; <0.01 (2 trials) mg/kg of pulp), and the Philippines (two trials at the GAP rate of 1%, 1 bag/season, PHI, about 12 weeks: 0.13 and 0.21 mg/kg of whole fruit; 0.04 and 0.05 mg/kg of pulp).

The ranked order of concentrations of residues on whole bananas after bag treatment was 0.01 (3 trials), 0.02, 0.04, 0.05, 0.06, 0.13 (2 trials), and 0.21 mg/kg. The ranked order of concentrations on whole bananas after foliar treatment was 0.03, 0.07, 0.37, 0.48, 0.75, 1.1 (2 trials), and 1.6 (2 trials) mg/kg. The Meeting estimated a maximum residue level of 2 mg/kg. The ranked order of the concentrations in pulp samples after bag treatment was: <0.01 (7 trials), 0.01, 0.04, and 0.05 mg/kg, whereas those in pulp samples after foliar treatment were

0.01 (4 trials) and 0.05 mg/kg. The Meeting estimated an STMR value of 0.01 mg/kg and a HR value of 0.05 mg/kg for banana pulp.

Four trials on *kiwifruit* were reported from New Zealand, conducted at the GAP rate of 0.025 kg ai/hl, 0.50 kg ai/ha, 14-day PHI, with concentrations of 0.26, 0.75, 1.0, and 1.9 mg/kg. The Meeting concluded that four trials were insufficient to estimate an STMR value, and recommended withdrawal of the existing MRL of 2 mg/kg.

Supervised trials on *onion* were reported from Greece (seven trials at the GAP rate of 0.3 kg ai/hl, 0.96 kg ai/hl when banded, 7- or 20-day PHI) with concentrations of <0.01 (2 trials), 0.02 (2 trials), 0.03, and 0.05 (2 trials) mg/kg; and the UK (four trials at the GAP rate of 0.16 kg ai/hl, 0.96 kg ai/ha, 21-day PHI) with values of 0.04, 0.06, 0.07, and 0.08 mg/kg. One trial of application to seeds at the time of planting was reported from Canada, resulting in a concentration of 0.14 mg/kg. This trial represented a substantially different use, and the results were not used, even though they represent the maximum residue; however, one trial was considered insufficient to estimate a maximum residue level. The ranked order of concentrations in the 11 trials of foliar application at GAP was: <0.01 (2 trials), 0.02 (2 trials), 0.03, ***0.04***, 0.05 (2 trials), 0.06, 0.07, and 0.08 mg/kg. The Meeting estimated an STMR value of 0.04 mg/kg, a HR value of 0.08 mg/kg, and a maximum residue level of 0.2 mg/kg. The latter replaces the existing MRL of 0.05* mg/kg.

Reports were submitted of eight trials on *broccoli* in the USA at the GAP rate of 1.1 kg ai/ha. The PHI is 21 days in California and Arizona and 30 days elsewhere; the Meeting agreed to consider the data from all states at the 21-day PHI. The ranked order of residue concentrations was: <0.01 (3 trials), 0.01, 0.03, 0.05, 0.07, and 1.4 mg/kg. The latter value, from a trial in New Jersey, seemed excessive, but there was no indication of error in the trial conduct. The Meeting estimated an STMR value of 0.02 mg/kg, a maximum residue level of 2 mg/kg, and a HR value of 1.4 mg/kg.

One trial on *Brussels sprouts* was submitted from the USA, but the application rate did not comply with GAP. The Meeting decided that there were insufficient data to estimate a maximum residue level or an STMR value.

Reports of supervised field trials on *cabbage* were available from South Africa (three trials at the GAP rate of 0.024 kg ai/hl, 7-day PHI) showing concentrations of 0.01, 0.21, and 0.22 mg/kg, the UK (five trials at the GAP rate of 0.72 kg ai/ha, 21-day PHI) with values of 0.01, 0.02, 0.10, 0.15, and 0.26 mg/kg, and the USA (15 trials at the GAP rate of 2.5 kg ai/ha at the time of planting, 1.12 kg ai/ha foliar treatment, 21-day PHI. The ranked order of concentrations of residues was: <0.01 (3 trials), 0.01 (3 trials), 0.02, 0.03 (3 trials), 0.10, ***0.15*** (2 trials), 0.21, 0.22 (3 trials), 0.26 (2 trials), 0.4, 0.5, 0.71, and 0.94 mg/kg. The Meeting estimated an STMR value of 0.15 mg/kg, a HR value of 0.94 mg/kg, and a maximum residue level of 1.0 mg/kg. The latter is recommended to replace the existing MRL of 0.05* mg/kg. Trials reported from Brazil did not correspond to GAP.

Six trials on *Chinese cabbage* were reported from the UK at the GAP rate of 0.16 kg ai/hl, 0.96 kg ai/ha, 21-day PHI. The ranked order of the concentrations of residues was 0.04 (2 trials), 0.17, 0.19, 0.34, and 0.60 mg/kg. The Meeting estimated an STMR value of 0.18 mg/kg, a HR value of 0.60 mg/kg, and a maximum residue level of 1.0 mg/kg. The latter confirms the existing MRL of 1 mg/kg.

Five trials on *cauliflower* were reported from the UK at the GAP rate of 0.96 kg ai/ha, 21-day PHI. The ranked order of concentrations was <0.01 (3 trials), 0.01, and 0.02 mg/kg. The Meeting considered that the results of five trials were sufficient, as the residue values were low and showed little variation. The Meeting estimated an STMR value of 0.01 mg/kg, a

HR value of 0.02 mg/kg, and a maximum residue level of 0.05 mg/kg. This replaces the existing MRL of 0.05* mg/kg.

Results for *peppers, sweet* were reported from Spain (three trials at the GAP rate of 0.1 kg ai/hl, 7-day PHI) with values of 0.37, 0.45, and 0.47 mg/kg and the USA (17 trials at the GAP rate of 1.12 kg ai/hl, 7-day PHI). The ranked order of concentrations was 0.01, 0.06, 0.10 (2 trials), 0.13, 0.14, 0.27 (2 trials), 0.30, ***0.37***, ***0.39***, 0.40, 0.45, 0.47, 0.48, 0.52, 0.60 (2 trials), 0.81, and 1.4 mg/kg. The Meeting estimated an STMR value of 0.38 mg/kg, a HR value of 1.4 mg/kg, and a maximum residue level of 2.0 mg/kg. The latter replaces the existing MRL of 0.5 mg/kg.

Reports of supervised field trials on *tomato* were provided from Australia (one trial at the GAP rate of 0.10 kg ai/hl, 3-day PHI) giving a value of 0.13 mg/kg, Brazil (one trial at the GAP rate of 0.72 kg ai/ha, 21-day PHI) showing a concentration of 0.03 mg/kg, Mexico (three trials at the GAP rate of 1 kg ai/ha, 1-day PHI) with concentrations of 0.06, 0.19, and 0.33 mg/kg, South Africa (two trials at the GAP rate of 0.1 kg ai/hl, 4-day PHI) with a value of 0.23 (2 trials) mg/kg, and Spain (two trials at the GAP rate of 0.1 kg ai/hl, 7-day PHI) with values of 0.06 and 0.08 mg/kg. The ranked order of concentrations was 0.03, 0.06 (2 trials), 0.08, ***0.13***, 0.19, 0.23 (2 trials), and 0.33 mg/kg. The Meeting estimated an STMR value of 0.13, mg/kg, a HR value of 0.33 mg/kg, and a maximum residue level of 0.5 mg/kg. This confirms the existing MRL. Although trials were conducted in the USA, none conformed with GAP.

A report on one supervised trial on *egg plant* was received from Turkey, but no GAP was reported. The Meeting regarded the database as inadequate.

Reports on field trials on *head lettuce* were provided from Spain and on *leaf lettuce* from the USA, but no information was provided on GAP. The Meeting could not estimate STMR values or maximum residue levels, given the lack of data.

The results of supervised field trials on *common bean (snap and kidney)* were reported from Italy (three trials at the GAP rate of 0.53 kg ai/ha, foliar treatment, 15-day PHI) and the USA (four trials at the GAP rate of 0.62 g ai/kg, seed treatment). The ranked order of concentrations of residues after foliar treatment was <0.01 (2 trials) and 0.05 mg/kg, and that after seed treatment was <0.01 (2 trials) and 0.01 (2 trials) mg/kg. The Meeting concluded that three or four trials were insufficient for estimating a maximum residue limit or STMR value. The results of seed treatment of peas (see below) were considered suitable for evaluating bean seed treatment. The ranked order of concentrations of residues of chlorpyrifos in common beans and peas with pods after seed treatment at 0.62 kg ai/kg of seed, was <0.01 (3 trials) and 0.01 (5 trials) mg/kg. The Meeting estimated a HR value of 0.01 mg/kg, a maximum residue level of 0.01 mg/kg, and an STMR value of 0.01 mg/kg for common beans. The MRL would replace the existing MRL of 0.2 mg/kg.

The results of four supervised trials on *pea* that conformed to GAP were reported from the USA (GAP, 0.62 kg ai/kg of seed, seed treatment), resulting in a concentration of 0.01 mg/kg in all four trials. The results for seed treatment of common beans (see above) may be used to support the results for pea seed treatment. The ranked order of concentrations of residues of chlorpyrifos in common beans and peas with pods after seed treatment at 0.62 kg ai/kg seed was <0.01 (3 trials) and 0.01 (4 trials) mg/kg. The Meeting estimated a HR value of 0.01 mg/kg, a maximum residue level of 0.01 mg/kg, and an STMR value of 0.01 mg/kg for peas with pods. Trials reported from the UK did not conform to GAP and were not considered.

Reports were received on supervised trials conducted on *soya* in Thailand (two trials at the GAP rate of 0.72 kg ai/ha, 7-day PHI) giving concentrations of 0.23 and 1.6 mg/kg and the USA (five trials at the GAP rate of 1.1 kg ai/ha, 28-day PHI) showing values of <0.01 (2 trials), 0.01 (2 trials), and 0.05 mg/kg). The Thai and USA data represent different populations of residues and cannot be grouped. The Meeting concluded that five data values were insufficient to permit estimation of a maximum residue level or an STMR value.

Supervised trials were conducted on *carrot* in The Netherlands (two trials at the GAP rate of the UK of 0.96 kg ai/ha, 14-day PHI) giving values of 0.01 and 0.03 mg/kg, South Africa (one trial at the GAP rate of 0.48 kg ai/ha, 21-day PHI) showing a value of 0.05 mg/kg, and the UK (three trials) resulting in concentrations of <0.01, 0.02, and 0.03 mg/kg. The ranked order of concentrations of residues found in the six trials was <0.01, 0.01, ***0.02***, ***0.03*** (2 trials), and 0.05 mg/kg. The Meeting estimated an STMR value of 0.025 mg/kg, a HR value of 0.05 mg/kg, and a maximum residue level of 0.1 mg/kg. The latter replaces the existing MRL of 0.5 mg/kg.

Reports were available for supervised trials of ground application to *potato* at the time of planting in Brazil (four trials at the GAP rate of Argentina of 3 kg ai/ha) with residue concentrations of 0.02, 0.13, 0.29, and 0.51 mg/kg. Data were also provided from trials of foliar and planting plus foliar treatment from Australia (two trials at the GAP rate of 3 kg ai/ha before planting, 0.5 kg ai/ha at hilling up) showing a value of <0.01 mg/kg in both trials, Brazil (one trial at the GAP rate of 0.72 kg ai/ha, 21-day PHI) with a value of 0.01 mg/kg, Canada (one trial at the GAP rate of 0.48 kg ai/ha for emulsifiable concentrate, 7-day PHI) with a value of 0.01 mg/kg, and Poland (one trial at the GAP rate of 0.42 kg ai/ha, 30-day PHI) showing <0.02 mg/kg. The ranked order of concentrations in the five trials of foliar residues was: <0.01 (2 trials), 0.01 (2 trials), and <0.02 mg/kg. The ranked order in the four trials of ground application at the time of planting was 0.02, 0.13, 0.29, and 0.51 mg/kg. The Meeting concluded that neither data set contained an adequate number of values for estimating a maximum residue level or an STMR value. The Meeting also recommended withdrawal of the existing MRL of 0.05* mg/kg. Trials reported from Colombia, South Africa, and the UK were not conducted according to GAP and not evaluated.

Supervised trials on *sugar beet* were conducted in Canada (one trial at the GAP rate of 1.2 kg ai/ha for foliar application, 90-day PHI) showing a residue concentration of <0.01 mg/kg, France (one trial at the GAP rate of 1.5 kg ai/ha before planting) with a value of <0.01 mg/kg, and the USA (eight trials at the GAP rate of 1.1 kg ai/ha for foliar application, 30-day PHI) with values of 0.01 (4 trials), 0.02 (3 trials), and 0.03 mg/kg). The ranked order of concentrations of residues in the nine trials in roots after foliar treatment was: <0.01, ***0.01*** (4 trials), ***0.02*** (3 trials), and 0.03 mg/kg. The Meeting estimated an STMR value of 0.015 mg/kg, a HR value of 0.03 mg/kg, and a maximum residue level of 0.05 mg/kg. The latter replaces the existing MRL of 0.05* mg/kg. Trials in Germany and the UK did not comply with GAP, and although trials were reported from Japan, no GAP was reported.

Supervised field trials on *maize* were reported for application at the time of planting in Brazil (two trials at the GAP rate of Argentina of 1.9 kg ai/ha, incorporated into soil) both showing <0.01 mg/kg). Trials from the USA were not according to GAP. Trials were also reported for foliar application or preplanting plus foliar application in Brazil (one trial at the GAP rate of 0.48 kg ai/ha, 2-day PHI) with a value of <0.01 mg/kg and the USA (seven trials at the GAP rate of 3.4 kg ai/ha before planting, 1.7 kg ai/ha for foliar treatment, 35-day PHI for grain and fodder, 14-day PHI for silage). The ranked order of the concentrations of residues in grain after foliar application was: <0.01, 0.01 (3 trials), 0.02, 0.03 (2 trials), and 0.04 mg/kg. The Meeting estimated an STMR value of 0.015 mg/kg and a maximum residue level of 0.05 mg/kg.

Supervised field trials were conducted on *sweet corn* in Canada (one trial at the GAP rate of 1.15 kg ai/ha, 70-day PHI) and the USA (six trials at the GAP for grain and 10 at the GAP for forage of 3.4 kg ai for emulsifiable concentrate before planting and 1.7 kg/ai for foliar emulsifiable concentrate, 2.3 kg ai for granular formulation before planting and 1.1 kg/ai for foliar treatment, 35-day PHI for grain and fodder, 14-day PHI for silage). The concentration of residues in grain was <0.01 mg/kg in all seven trials. Information was also supplied on seed treatment in the USA (seven trials at the GAP rate of 62 g ai/100 kg of seed, wettable powder). The concentration was <0.01 mg/kg in all five trials. In two trials, results were not reported for kernel with cob. On the basis of the values after foliar application, the Meeting estimated an STMR value of 0.01 mg/kg, a HR value of 0.01 mg/kg, and a maximum residue level of 0.01* mg/kg.

Trials of use of chlorpyrifos in *rice* were reported from Australia, Colombia, India, the Philippines, Thailand, and Vietnam, but none was at the relevant GAP. As no data were available on treatment of rice under GAP conditions, the Meeting decided that the database was inadequate for estimating either an STMR value or a maximum residue level. The Meeting further recommended withdrawal of the existing MRL of 0.1 mg/kg.

Supervised field trials on *sorghum* were reported from Brazil (one trial at the GAP rate of 0.36 kg ai/ha, 21-day PHI) showing a residue concentration of 0.07 mg/kg, and the USA (six trials at the GAP rate of 1.1 kg ai/ha, emulsifiable concentrate, 60-day PHI; 2 kg ai/ha of granular formulation at the time of planting). The ranked order of concentrations was: <0.01 (2 trials), 0.02, ***0.04***, 0.07, 0.20, and 0.27 mg/kg. The Meeting estimated an STMR value of 0.04 mg/kg and a maximum residue level of 0.5 mg/kg. Two trials from Australia did not comply with GAP and were discarded.

Supervised field trials on *wheat* were reported from Brazil (three trials at the GAP rate of 0.72 kg ai/ha, 21-day PHI) with values of 0.04, 0.06, and 0.30 mg/kg and the USA (17 trials at the GAP rate of 0.56 kg ai/ha, 28-day PHI for grain, 14-day PHI for forage or hay). The ranked order of the concentrations of residues after use on grain were <0.01 (3 trials), ***0.01*** (7 trials), ***0.02*** (3 trials), 0.03, 0.04, 0.05, 0.06, 0.19, 0.23, and 0.30 mg/kg. The Meeting estimated an STMR value of 0.015 mg/kg and an MRL of 0.5 mg/kg. Trials from Canada and the UK were not in accordance with GAP in those countries, and although trials were reported from Germany no GAP was provided.

Supervised trials on *almond* were conducted in the USA (three trials at the GAP rate of 2.2 kg ai/ha for foliar application, 4.5 kg ai/ha for ground application, 14-day PHI; four trials at the GAP rate of 2.2 kg ai/ha for dormant crop). The ranked order of the concentrations in almond nutmeat was: <0.01, 0.01 (2 trials), ***<0.05*** (3 trials), and 0.05 mg/kg. The highest concentration resulted from the use on dormant crop. The two uses are distinguished by the PHI, 14 days versus about 180 days for use on dormant crop (with no nuts). As metabolic studies showed that chlorpyrifos is not readily translocated, any residues on almond nutmeat probably result from contamination during removal of the shells. The Meeting estimated an STMR value of 0.05 mg/kg, a HR value of 0.05 mg/kg, and a maximum residue level of 0.05 mg/kg.

Supervised trials on *pecan* were conducted in the USA (eight trials at the GAP rate of 2.2 kg ai/ha for foliar application, 28-day PHI). The ranked order of the concentrations of residues on the nutmeat was: <0.01 (2 trials) and <0.05 (6 trials). The latter value resulted from use of a method to determine combined residues of chlorpyrifos and 3,5,6-trichloropyridinol. The Meeting estimated an STMR value of 0.05 mg/kg, a HR value of 0.05 mg/kg, and a maximum residue level of 0.05* mg/kg.

Six supervised trials were conducted on *walnut* in the USA (at the GAP rate of 2.24 kg ai/ha, 14-day PHI). The concentration of residues on the nutmeat was <0.05 mg/kg in all six trials. The Meeting estimated an STMR value of 0.05 mg/kg, a HR value of 0.05 mg/kg, and a maximum residue level of 0.05* mg/kg.

Supervised field trials were conducted on *cotton seed* in Brazil (two trials at the GAP rate of 0.96 kg ai/ha, 21-day PHI: 0.02 and 0.07 mg/kg) and the USA (three trials at the GAP rate of 1.1 kg ai/ha, 14-day PHI). The ranked order of concentrations of residues in cotton seed was 0.02, 0.07, 0.16, 0.17, and 2.0 mg/kg. The Meeting concluded that five values were insufficient for estimating an STMR value or a maximum residue level. The Meeting further recommended the withdrawal of the existing MRL of 0.05* mg/kg

The results of a supervised field trial on *peanut* conducted in the USA at the GAP rate of 2.2 kg ai/ha, 21-day PHI were available. The Meeting concluded that the data were insufficient to estimate an STMR value or a maximum residue level.

A supervised field trial was conducted on *sunflower* in the USA at the GAP rate of 2.2 kg ai/ha before planting, 1.7 kg ai/ha foliar, 42-day PHI. A trial in Canada did not comply with GAP. The Meeting concluded that the data were insufficient to estimate an STMR value or a maximum residue level.

The results of supervised field trials on *coffee* were reported from Brazil (five trials at the GAP rate of 0.72 kg ai/ha, 21-day PHI) and the United Republic of Tanzania (one trial at the GAP rate of 0.96 kg ai/ha, 7-day PHI) with a residue concentration of 0.04 mg/kg. Two trials conducted in Colombia did not comply with GAP. The ranked order of concentrations of residues was 0.01 (3 trials), ***0.03*** (2 trials), and 0.04 mg/kg. The Meeting estimated a maximum residue level of 0.05 mg/kg, an STMR value of 0.03 mg/kg, and a HR value of 0.04 mg/kg.

Supervised trials were conducted on *alfalfa* in the USA, where the GAP specifies tiered application rates and PHIs: 0.28 kg ai/ha, 7-day PHI; 0.56 kg ai/ha, 14-day PHI; and >0.56-1.12 kg ai/ha, 21-day PHI. Additionally, a specific GAP applies to California and Arizona: 0.56 kg ai/ha, 4-day PHI. In all cases, only one foliar application may be made per cutting cycle, and the maximum number of applications is four per season. Of the trials reported, 29 conformed to GAP. The ranked order of concentrations of residues in green alfalfa forage was: <0.01, 0.01, 0.06 (2 trials), 0.08, 0.12, 0.17, 0.20, 0.21, 0.22, 0.25, 0.27, 0.30, 0.38, ***0.42***, 0.43 (2 trials), 0.45, 0.57, 0.62, 0.65, 0.89, 0.90, 1.3, 1.4, 1.5, 2.2, 2.7, and 5.6 mg/kg (fresh weight). As the moisture contents were not determined, the Meeting used the value given in the *FAO Manual* (FAO, 1997) of 35% dry matter. The Meeting estimated an STMR value of 1.2 mg/kg (0.42/0.35) and a maximum residue level of 20 mg/kg (5.6/0.35 = 16).

The ranked order of the concentrations of residues in the 28 trials on alfalfa hay was: 0.02, 0.04 (2 trials), 0,28, 0.35, 0.36, 0.43 (2 trials), 0.45, 0.46, 0.59, 0.63, 0.64, ***0.66***, ***0.78***, 0.92, 0.93, 1.0, 1.1, 1.2 (2 trials), 1.3, 1.7, 1.8 (2 trials), 2.0, 2.3, and 2.6 mg/kg (fresh weight). One value of 12 mg/kg for hay was discarded. In numerous comparative trials of the emulsifiable concentrate and water-dispersible granule formulations, the concentrations of residue were comparable within a factor of 2. However, in the case in which the emulsifiable concentrate yielded 12 mg/kg, the water-dispersible granule formulation yielded 1.8 mg/kg. Using the value for moisture in the *FAO Manual* of 89% dry matter, the Meeting estimated an STMR value of 0.81 mg/kg (0.72/0.89) and a maximum residue level of 5 mg/kg (2.6/0.89 = 2.9).

Three supervised trials on *almond hull* were conducted in the USA at the GAP rate of 2.2 kg ai/ha for foliar application, 4.5 kg ai/ha for ground application, 14-day PHI. The ranked order of concentrations in almond hulls was 1.9, 2.3, and 3.2 mg/kg. The Meeting estimated an STMR value of 2.3 mg/kg and a HR value of 3.2 mg/kg.

Residues in *green pea vine* after seed treatment were reported from the USA (four trials at the GAP rate of 0.62 kg ai/kg of seed). The ranked order of concentrations of residues on pea vines was 0.01, 0.02, 0.05, and 0.17 mg/kg**.** These data are comparable to those for common bean vines: 13 trials, six at the GAP rate of 0.62 g ai/kg, water-dispersible granule; ranked order of concentrations of residues: <0.01 (2 trials), 0.01, 0.03, 0.05, and 0.06 mg/kg. The ranked order in the combined database was <0.01 (2 trials), 0.01 (2 trials), ***0.02***, ***0.03***, 0.05 (2 trials), 0.06, and 0.17 mg/kg. As no data were provided on the moisture content of the vines, the value in the *FAO Manual*, 25% dry matter, was used. The Meeting estimated an STMR value of 0.10 mg/kg (0.025/0.25) and a maximum residue limit of 1 mg/kg (0.17/0.25 = 0.68), both for dry weight.

Reports were available from supervised trials on *soya forage and hay* in Thailand (two trials at the GAP rate of 0.72 kg ai/ha, 7-day PHI) and the USA (six trials at the GAP rate of 1.1 kg ai/ha, 28-day PHI). One value was reported from the USA for green forage, 0.38 mg/kg. Additional data were supplied for straw, which is not a commodity listed by Codex. The Meeting could not estimate STMR values or maximum residue levels for forage and hay.

Supervised trials of residues in *sugar-beet tops and leaves* after foliar application or preplanting plus foliar application to sugar beets were conducted in Canada (one trial at the GAP rate of 1.2 kg ai/ha, 90-day PHI) with a residue concentration of <0.01 mg/kg and the USA (eight trials at the GAP rate of 2.3 kg/ai of granular formulation at the time of planting, 1.1 kg ai/ha for foliar application, 30-day PHI). Although trials were reported from Japan, no GAP was reported, and of trials carried out in the UK, none was according to GAP. The results of trials of application of chlorpyrifos to soil before or at the time of planting were reported from France (one trial at the GAP rate of 1.5 kg ai/ha before planting, with a concentration of <0.01 mg/kg. None of the trials from Germany was according to GAP. The ranked order of concentrations of residues in samples of tops after foliar application was: <0.01, 0.15, 0.42, 0.44, ***0.68***, 1.3, 1.4, 3.1, and 6.6 mg/kg. As no information was provided on the moisture content, the value in the *FAO Manual*, 23% of dry matter, was used. The Meeting estimated an STMR value of 3.0 mg/kg (0.68/0.23) and a maximum residue level of 40 mg/kg (6.6/.23 = 28.6), both on a dry weight basis.

Supervised field trials were reported of residues on *maize (field corn) fodder and forage* after application at the time of planting of maize in Brazil (two trials at the GAP rate of Argentina of 1.9 kg ai/ha, incorporated into soil), but with no data on fodder or forage. Of six trials in the USA, none was at the GAP). Additional trials were reported of early-to-late seasonal foliar application of chlorpyrifos to maize in Brazil (one trial at the GAP rate of 0.48 kg ai/ha, 21-day PHI; no data on forage or fodder) and the USA (seven trials at the GAP rate of 3.4 kg ai/ha before planting, 1.7 kg ai/ha for foliar application, 35-day PHI for grain and fodder, 14-day PHI for silage).

The ranked concentrations of residues in fodder were 1.6, 1.7, 2.0, *2.3*, 3.1, 5.9, and 7.2 mg/kg. As no data were provided on moisture content, the value in the *FAO Manual* (Appendix IX) for stover of 83% of dry matter was used. The ranked order on a dry weight basis was 1.9, 2.0, 2.4, ***2.8***, 3.7, 7.1, and 8.7 mg/kg. The Meeting estimated a maximum residue level of 10 mg/kg and an STMR value of 2.8 mg/kg for maize fodder, both on a dry weight basis**.**

The ranked concentrations of residues in maize forage were 2.1, 2.8, *3.0*, *3.6*, 5.5, and 7.2 mg/kg. As data on moisture content were not available, the value in the *FAO Manual* (Appendix IX) of 40% of dry matter was used. The ranked order of concentrations on a dry-weight basis was 5.2, 7.0, ***7.5***, ***9.0***, 14, and 18 mg/kg. The Meeting estimated an STMR value of 8.2 mg/kg and a maximum residue level of 20 mg/kg, both for dry-weight.

Supervised field trials on residues in *sweet corn fodder (stover) and forage* after treatment of sweet corn were conducted in Canada (one trial at the GAP rate of 1.15 kg ai/ha, 70-day PHI, no data on forage or fodder) and the USA (six trials at the GAP for grain, 10 at the GAP for forage, and seven at the GAP for fodder of 3.4 kg ai of emulsifiable concentrate before planting, 1.7 kg/ai for foliar application of emulsifiable concentrate, 2.3 kg ai of granular formulation before planting, and 1.1 kg/ai for foliar application, respectively; 35-day PHI for grain and fodder, 14-day PHI for silage). The ranked order of concentrations in forage was 0.11 (2 trials), 0.24, 0.38, 0.64, 0.81, 1.1, 1.2 (2 trials), and 3.4 mg/kg. As data on moisture content were not available, the value in the *FAO Manual* (Appendix IX), 48% of dry matter, was used to arrive at the following ranked order (dry-matter basis): 0.23 (2 trials), 0.50, 0.79, ***1.3***, 1.7, 2.3, 2.5 (2 trials), and 7.1 mg/kg. The Meeting agreed that sweet corn forage represented a different population from maize forage and considered that the STMR value and maximum residue limit for maize forage would suffice for sweet corn forage.

Seven values were available for concentrations of residues in sweet corn fodder (stover), ranked as follows: 0.06, 0.14, 0.16, 0.23, 0.77, 1.3, and 1.6 mg/kg. As data on moisture content were not available, the value in the *FAO Manual* (Appendix IX) for the moisture content of stover, 83% of dry matter, was used to arrive at the following ranked order of values (dry-matter basis): 0.07, 0.17, 0.19, ***0.28***, 0.93, 1.6, and 1.9 mg/kg. The Meeting agreed that sweet corn stover represents a different population from maize fodder and considered that the MRL and STMR value for maize fodder would suffice for sweet corn fodder (stover).

Supervised field trials of the residues in *sorghum forage and fodder* after treatment of sorghum were reported from Brazil (one trial at the GAP rate of 0.36 kg ai/ha, 21-day PHI; no data on fodder) and the USA (six trials at the GAP rate of 1.1 kg ai/ha, emulsifiable concentrate, 60-day PHI; 2 kg ai/ha of granular formulation at the time of planting). Two trials from Australia did not comply with the GAP. The ranked order of concentrations was 0.01, 0.08, ***0.17***, ***0.34***, 0.39, and 1.3 mg/kg. Using the value in the *FAO Manual* (Appendix IX) for water content, 88% of dry matter, the Meeting estimated an STMR value of 0.29 mg/kg (0.255/0.88), and a maximum residue limit of 2 mg/kg (1.3/0.88 = 1.5).

Only four values were available for residues in green forage, ranging from 0.01 to 0.14 mg/kg, and the Meeting concluded that this was an insufficient database for estimating an STMR or HR value.

The residues in *wheat fodder and straw* after treatment of wheat were reported from Brazil (three trials at the GAP rate of 0.72 kg ai/ha, 21-day PHI; no data on forage) and the USA (19 trials at the GAP rate of 0.56 kg ai/ha, 28-day PHI for grain, 14-day PHI for forage and hay). Trials from Canada and the UK were not according to GAP, and for one trial from Germany no GAP was reported. The ranked order of concentrations was 0.01, 0.03, 0.09, 0.11, 0.2, 0.39, 0.47, ***0.48*** (2 trials), ***0.60***, 0.63, 0.64, 0.96, 1.2 (2 trials), 2.1, 2.2, and 4.1 mg/kg. Using the value of 88% of dry matter from the *FAO Manual* (Appendix IX), the Meeting estimated an STMR value of 0.54 mg/kg (0.48/0.88) and a maximum residue limit of 5 mg/kg (4.1/0.88 = 4.6), both on a dry-weight basis.

No studies that were conducted in accordance with GAP were provided for green forage.

Fate of residues during processing

The Meeting received data on the fate of incurred residues of chlorpyrifos during the processing of apples, citrus, grapes, tomatoes, soya beans, maize (corn), rice, sorghum, wheat, cotton, peanuts, sunflower, and coffee. MRLs were not estimated for cotton, peanuts, soya beans, sunflower, or coffee, and these studies are not considered further. Moreover, a study in which fortified sugar beets as opposed to incurred residues were used was considered inappropriate.

Apples with an average residue concentration of 3.2 or 0.53 mg/kg were processed into juice, wet pomace, and dry pomace, with average concentration factors of 0.15, 2.0, and 6.6, respectively. The factors for juice and dry pomace applied by the Meeting to the STMR value for apple (0.18) yield STMR-P values of 0.027 mg/kg for juice and 1.2 mg/kg for dry pomace. The HR value for apple, 0.94 mg/kg, yields HR-P values of 6.2 mg/kg for dry apple pomace and 1.9 mg/kg for wet apple pomace.

Oranges bearing residues of chlorpyrifos were processed into orange juice in eight studies in which home processing was simulated. The processing factors ranged from 0.02 to 0.06. Single studies of commercial processing were conducted with oranges, *grapefruit*, *lemons*, and *tangelos*, in which the processing factors were 0.02-0.03. The average processing factor for the 12 studies was 0.03. By applying the factor to the median concentration for whole citrus (0.24) the Meeting estimated the STMR-P value to be 0.007 mg/kg for juice.

Oranges, grapefruit, lemons, and tangelos with incurred residues of chlorpyrifos were processed commercially into juice, dried pulp, and oil. The processing factors for pulp were 3.8 for grapefruit, 1.5 for lemons, 2.6 for oranges, and 4.0 for tangelos, with an average of 3.0. The respective processing factors for oil were 22, 3.2, 6.4, and 13, with an average of 11. With the average processing factor for citrus oil, the median residue for whole citrus (0.24 mg/kg) and the HR value for whole citrus (1.2 mg/kg), the STMR-P value for citrus oil is 2.6 mg/kg and the HR value is 13 mg/kg. With the average processing factor for citrus pulp, the HR value for whole citrus (1.2 mg/kg), and the median residue for whole citrus (0.24 mg/kg), the HR value for dried citrus pulp was estimated by the Meeting to be 3.6 mg/kg and the STMR-P value to be 0.72 mg/kg.

When *grapes* with concentrations of incurred residues of chlorpyrifos of 1.3 or 0.38 mg/kg were sun-dried, the processing factors for raisins were 0.22 and 0.20 (average, 0.21). The Meeting applied this average factor to the HR and STMR values for grapes (0.32 and 0.08 mg/kg) and estimated a HR value of 0.07 mg/kg and an STMR-P value of 0.017 mg/kg for raisins. The Meeting also estimated a maximum residue level of 0.1 mg/kg for raisins.

Grapes containing chlorpyrifos at 0.48 mg/kg were processed into juice, with a processing factor of 0.06. Using the STMR value for grapes (0.08 mg/kg), the Meeting estimated an STMR-P value of 0.005 mg/kg for juice.

In studies in France, Israel, and Italy in which grapes were processed into wine, the processing factor ranged from 0.006 to 0.3, with an average of 0.08. The wide range may be due to the absence of quantifiable residue in the wine (<0.01 mg/kg). The Meeting applied the average factor to the STMR value for grapes (0.08 mg/kg) to estimate an STMR-P value for wine of 0.007 mg/kg.

Tomatoes were processed into juice and tomato paste in a study in Israel and into juice and purée in a study in the USA. The processing factors for juice ranged from 0.03 to 0.4 (ν = 9; average, 0.18 or 0.2). The processing factor for purée was 0.1, and those for paste ranged from 0.08 to 0.3 (ν = 8; average, 0.16 or 0.2). Using the average processing factors and the STMR value for tomatoes (0.13 mg/kg), the Meeting estimated STMR-P values of 0.026 mg/kg for tomato paste and juice.

Corn (maize) with an incurred residue of 0.04 mg/kg was processed by both wet and dry milling in the USA. The processing factors for dry milling were 1.2 for meal, 1.8 for flour, and 1.5 for crude and refined oil. Those for wet milling were 3 for crude oil and 3.2 for refined oil. The Meeting decided to use the processing factor for wet milling for oil. Using the STMR value for corn grain (0.01 mg/kg), the Meeting estimated the following STMR-P values: meal, 0.01 mg/kg; crude oil, 0.03 mg/kg; refined oil, 0.03 mg/kg; and milled by-products, 0.02 mg/kg based on flour. The Meeting also estimated a maximum residue level of 0.2 mg/kg for refined oil and a HR-P value of 0.09 mg/kg for milled by-products, on the basis of the factor of 1.8 for flour.

Sorghum grain bearing chlorpyrifos residue at 0.04 mg/kg was milled into flour in the USA, with a processing factor of 0.2. Using the sorghum grain STMR value of 0.04 mg/kg, the Meeting estimated an STMR-P value of 0.008 mg/kg for sorghum flour.

Wheat grain with an incurred concentration of chlorpyrifos residue of 0.51 mg/kg was milled in the USA into bran, flour, shorts, and milled by-products, with processing factors of 2.5, 0.2, 2.4, and 2.5. Using the STMR value for wheat grain (0.01 mg/kg), the Meeting estimated the following STMR-P values: bran, 0.03 mg/kg; flour, 0.002 mg/kg; shorts, 0.03 mg/kg; and milled by-products, 0.03 mg/kg. The Meeting also estimated a maximum residue level of 0.1 mg/kg for wheat flour. Using the HR value of wheat, 0.30 mg/kg, the Meeting estimated a HR-P value for wheat milled by-products of 0.75 mg/kg.

Coffee beans (shelled and dried) with incurred residues of chlorpyrifos were roasted in trials in Brazil and Colombia. The processing factors were 0.5 and 0.1 in Brazil and 0.5 and 0.25 in Columbia (average factor, 0.34). Application of this factor to the STMR value for coffee (0.03 mg/kg) yields an STMR-P value of 0.01 mg/kg for roasted coffee beans.

Residues in animal and poultry commodities

The Meeting estimated the dietary burden of chlorpyrifos in farm animals and poultry on the basis of the diets listed in Appendix IX of the *FAO Manual*. Calculation from the MRLs yields maximum theoretical dietary intakes, or the concentrations of residues in feed suitable for estimating MRLs for animal commodities. Calculation from STMR values for feed allows estimation of STMR values for animal commodities. The diets are designed to maximize dietary intake of chlorpyrifos, and nutritional requirements are not taken into consideration.

Maximum theoretical dietary burden

Commodity	Maximum residue level	Group	% dry matter	% o diet				Concentration of residue, mg/kg			
				Beef cattle	Dairy cows	Poultry	Pigs	Beef cattle	Dairy cows	Poultry	Pigs
Alfalfa forage (green)	20	AL	100	70	60			14	12		
Alfalfa hay	5	AL									
Almond hulls	3.2	-	90								
Apple pomace, wet	6.2	AB	40								
Citrus pulp, dried	3.6	AB	91								
Maize	0.05	GC	88								
Maize forage	20	AF	100	10	30			2	6		
Maize fodder	10	AS	100								
Maize, milled	0.09	-	85								
by-products											
Pea vines (green)	1	AL	100								
Sorghum	0.5	GC	86			50	50			0.29	0.29
Sorghum stover	2	AS	100								
(fodder)											
Sugar beet, tops	40	AV	100	20	10			8	4		
Wheat	0.5	GC	89								
Wheat, milled	0.75	-	88			50	50			0.43	0.43

Commodity	Maximum residue level	Group	% dry matter	% o diet				Concentration of residue, mg/kg			
				Beef cattle	Dairy cows	Poultry	Pigs	Beef cattle	Dairy cows	Poultry	Pigs
by-products											
Wheat, straw	5	AS	100								
Total				100	100	100	100	24	22	0.77	0.77

Average dietary burden

Commodity	STMR/ STMR-P	Group	% dry matter	% of diet				Concentration of residue, mg/kg			
				Beef cattle	Dairy cows	Poultry	Pigs	Beef cattle	Dairy cows	Poultry	Pigs
Alfalfa forage (green)	1.2	AL	100								
Alfalfa hay	0.81	AL									
Almond hulls	2.3	AL	90	10	10			0.26	0.26		
Apple pomace, wet	0.34	AB	40	25	25			0.21	0.21		
Citrus pulp, dried	0.72	AB	91								
Maize	0.015	GC	88								
Maize forage	8.2	AF	100	40	50			3.3	4.1		
Maize fodder	2.8	AS	100	25	15			0.7	0.42		
Maize, milled	0.02	-	85								
by-products											
Pea vines (green)	0.10	AL	100								
Sorghum	0.04	GC	86			80	90			0.037	0.042
Sorghum stover	0.29	AS	100								
(fodder)											
Sugar beet, tops	3.0	AV	100								
Wheat	0.015	GC	89								
Wheat, milled	0.03	-	88			20	10			0.007	0.003
by-products											
Wheat, straw	0.54	AS	100								
Total				100	100	100	100	4.5	5.0	0.044	0.045

Acceptable feeding studies were provided for chickens, cows, and swine. Hens were fed chlorpyrifos in their daily rations at a rate of 0, 0.3, 3, or 10 ppm for 30 days. No residues (<0.01 mg/kg) of chlorpyrifos were found in muscle, liver, or kidney at any concentration. Chlorpyrifos was found in peritoneal fat at concentrations of <0.01-0.01 mg/kg in hens at 3 ppm and at 0.02-0.05 mg/kg at 10 ppm. Over a 45-day feeding period of chlorpyrifos at 10 ppm in the feed, the concentration in eggs was <0.01-0.01 mg/kg, reaching a plateau within 10 days. The calculated dietary burdens are 0.77 ppm on the basis of the MRL and 0.044 ppm on the basis of the STMR value. In hens at 2 ppm, residues were found at a concentration near the LOQ in fat only. The Meeting estimated the following maximum residue levels: poultry meat (fat), 0.01 mg/kg; eggs, 0.01* mg/kg; and offal, 0.01* mg/kg. The STMR values were estimated to be 0.001 mg/kg for meat (fat), 0.001 mg/kg for eggs, and 0.00 mg/kg for offal. The HR values were estimated to be 0.01 mg/kg for each of eggs, meat (fat), and offal.

Heifers were given capsules containing chlorpyrifos at a concentration of 0, 3, 10, 30, or 100 ppm for 30 days. In animals at 10 ppm, residues were found in muscle (0.02 mg/kg) and liver (0.02 mg/kg). At 100 ppm, the concentration in muscle increased to 0.29 mg/kg, but that in liver remained constant. Kidney was found to contain chlorpyrifos (0.02 mg/kg) only in animals at the highest dose (100 ppm). Fat showed concentrations of 0.01-0.03 mg/kg in animals at 3 ppm, which increased to 2.0-4.2 mg/kg at 100 ppm. At 30 ppm, which is comparable to the calculated dietary burden of 24 ppm based on MRLs, the concentrations were 0.02 mg/kg (<0.01-0.02 mg/kg) in muscle, 0.99 mg/kg (0.18-0.99 mg/kg) in fat, and

0.01 mg/kg in each of liver and kidney. In animals at 10 ppm, which is comparable to the 4.5 ppm dietary burden based on STMR values, the concentrations were <0.01-0.02 mg/kg in meat and liver, <0.01 mg/kg in liver, and 0.15 mg/kg (0.07-0.15 mg/kg) in fat. The Meeting estimated the maximum residue levels for cattle commodities to be: meat (fat), 1.0 mg/kg, liver, 0.01 mg/kg, and kidney, 0.01 mg/kg, and those for sheep commodities to be: meat (fat), 1.0 mg/kg; edible offal, 0.01 mg/kg. It estimated the STMR values for cattle commodities to be: meat, 0.02 mg/kg; liver, 0.01 mg/kg; and kidney, 0.01 mg/kg, and those for sheep commodities to be: meat, 0.02 mg/kg; edible offal, 0.01 mg/kg. The Meeting estimated the HR values for cattle commodities to be: meat, 0.02 mg/kg; kidney, 0.01 mg/kg; and liver, 0.01 mg/kg, and those for sheep commodities to be: meat, 1 mg/kg; edible offal, 0.01 mg/kg.

Cows were fed rations containing 0.3, 1, 3, 10, or 30 ppm of chlorpyrifos for 14 consecutive days. Residues were found in whole milk at a maximum of 0.02 mg/kg only in cows fed 30 ppm. Residues were found in cream at maximum concentrations of 0.01, 0.04, and 0.15 mg/kg at 3, 10, and 30 ppm, respectively. The concentration of chlorpyrifos residue reached a plateau within 6 days. No detectable residues were found in cows fed 30 ppm after a 1-day withdrawal period. The dietary burden, based on MRLs, was estimated to be 22 ppm for dairy cattle. The Meeting estimated the maximum residue level in whole milk to be 0.02 mg/kg on the basis of the maximum residue level of 0.02 mg/kg at 30 ppm. The dietary burden based on STMR values was estimated to be 5.0 ppm. The Meeting estimated the STMR value for whole milk to be 0.005 mg/kg, on the basis of the concentration of <0.01 mg/kg in milk of cows at 10 ppm.

Pigs were fed chlorpyrifos in their diets at a concentration of 0, 1, 3, or 10 ppm for 30 days. The concentrations of residues found in pigs at 30 ppm were 0.03 mg/kg in muscle, 0.01 mg/kg in liver, and 0.18 mg/kg in omental, renal, and subcutaneous fat. In pigs at 3 and 1 ppm, residues were found only in fat (0.02 mg/kg), muscle, liver, and kidney, each containing <0.01 mg/kg. The calculated dietary burdens are 0.77 and 0.045 ppm on the basis of MRLs and STMR values, respectively. At these levels, the estimated concentrations of chlorpyrifos in tissues are estimated to be <0.01 mg/kg, except for 0.02 mg/kg in fat, on the basis of MRLs, and 0.002 mg/kg in fat and 0.00 mg/kg in other tissues on the basis of STMR values. The MLR for pig meat (fat) was estimated to be 0.02 mg/kg, the STMR value was estimated to be 0.001 mg/kg, and the HR value was estimated to be 0.01 mg/kg. The STMR value and MRL for offal were estimated to be 0.00 mg/kg and 0.01* mg/kg, respectively. The HR value for pig offal was estimated to be 0.01 mg/kg.

Dermal application of chlorpyrifos is no longer a veterinary use.

RECOMMENDATIONS

The Meeting estimated the maximum residue and STMR levels shown below. The maximum residue levels are recommended for use as MRLs.

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

The residue is fat-soluble.

Commodity		MRL, mg/kg		STMR, mg/kg	HR, mg/kg
CCN	Name	New	Previous		
AL 1020	Alfalfa fodder	5	-	0.81	
AL 1021	Alfalfa forage (green)	20	-	1.2	
TN 0660	Almonds	0.05	-	0.05	0.05
	Almond hulls			2.3	3.2
FP 0226	Apple	W[1]	1		

Commodity		MRL, mg/kg		STMR, mg/kg	HR, mg/kg
CCN	Name	New	Previous		
JF 0226	Apple juice			0.027	
AB 0226	Apple pomace, dry		-	1.2	6.2
	Apple pomace, wet			0.34	1.9
FI 0327	Banana	2	-	0.01	0.05
VB 0400	Broccoli	2	-	0.02	1.4
VB 0041	Cabbages, Head	1	0.05*	0.15	0.94
VR 0577	Carrot	0.1	0.5	0.025	0.05
MO 1280	Cattle, kidney	0.01	-	0.01	0.01
MO 1281	Cattle, liver	0.01	-	0.01	0.01
MM 0812	Cattle meat	1 (fat)	2 (fat)V	0.02	0.02
VB 0404	Cauliflower	0.05	0.05*	0.01	0.02
VS 0624	Celery	W	0.05*		
VL 0467	Chinese cabbage (type Pe-tsai)	1	1	0.18	0.60
FC 0001	Citrus fruits	2	2	0.08	0.4
JF 0001	Citrus juice			0.007	
	Citrus oil			2.2	11
AB 0001	Citrus pulp, dry			0.72	3.6
SB 0716	Coffee	0.05		0.010	0.014
VP 0526	Common bean (pods and/or immature seeds)	0.01	0.2	0.01	0.01
SO 0691	Cotton seed	W	0.05*		
OC 0691	Cotton seed oil, crude	W	0.05*		
DF 0269	Dried grapes (= Currants, Raisins and Sultanas)	0.1	2	0.017	0.07
VO 0440	Egg plant	W	0.2		
PE 0112	Eggs	0.01*	0.05*	0.001	0.01
FB 0269	Grapes	0.5	1	0.085	0.32
JF 0269	Grape juice			0.005	
	Grapes, wine			0.007	
VL 0480	Kale	W	1		
FI 0341	Kiwifruit	W	2		
VL 0482	Lettuce, Head	W	0.1		
GC 0645	Maize	0.05	-	0.015	
AS 0645	Maize fodder	10	-	2.8	
AF 0645	Maize forage	20	-	8.2	
	Maize, milled by-products			0.02	0.09
OR 0645	Maize oil, edible	0.2	-	0.03	
CF 0645	Maize meal			0.01	
ML 0106	Milks	W	0.01*		
ML 0107	Milk of cattle, goats and sheep	0.02	-	0.005	
VO 0450	Mushrooms	W	0.05*		
VA 0385	Onion, Bulb	0.2	0.05*	0.04	0.08
VP 0063	Peas (pods and succulent = immature seeds)	0.01	-	0.01	0.01
AL 0528	Pea vines (green)	1	-	0.10	
FS 0247	Peach	0.5	-	0.042	0.33
FP 0230	Pear	W[1]	0.5		
TN 0672	Pecan	0.05*	-	0.05	0.05
VO 0051	Peppers	W	0.5		
VO 0445	Peppers, Sweet	2	-	0.38	1.4
FS 0014	Plums (including Prunes)	0.5	-	0.04	0.20
MO 0818	Pig, Edible offal of	0.01*	-	0.00	0.01
MM 0818	Pig meat	0.02 (fat)	-	0.001	0.01
FP 0009	Pome fruits	1	-	0.17	0.94
VR 0589	Potato	W	0.05*		
PM 0110	Poultry meat	0.01 (fat)	0.1 (fat)	0.001	0.01
PO 0111	Poultry, Edible offal of	0.01*	-	0.00	0.01
FB 0272	Raspberries, Red, Black	W	0.2		
GC 0649	Rice	W	0.1		
MO 0822	Sheep, Edible offal of	0.01	-	0.01	0.01
MM 0822	Sheep meat	1 (fat)	0.2 (fat)V	0.02	0.02
GC 0651	Sorghum	0.5	-	0.04	
AS 0651	Sorghum straw and fodder, dry	2	-	0.29	

Commodity		MRL, mg/kg		STMR, mg/kg	HR, mg/kg
CCN	Name	New	Previous		
	Sorghum flour			0.008	
FB 0275	Strawberry	0.3		0.09	0.15
VR 0596	Sugar beet	0.05	0.05*	0.015	0.03
AV 0596	Sugar beet leaves or tops	40	-	3.0	
VO 0447	Sweet corn	0.01*	-	0.01	0.01
VO 0448	Tomato	0.5	0.5	0.13	0.33
JF 0448	Tomato juice			0.026	
	Tomato paste			0.026	
PM 0848	Turkey meat	W	0.2 fat (V)		
TN 0678	Walnuts	0.05*	-	0.05	0.05
GC 0654	Wheat	0.5	-	0.015	
AS 0654	Wheat straw and fodder, dry	5	-	0.54	
	Wheat, milled by-products			0.03	0.75
CF 1211	Wheat flour	0.1	-	0.002	
CM 0654	Wheat bran, unprocessed			0.03	
	Wheat shorts			0.03	

[1] Now included in recommendation for Pome fruit

Further work or information

Desirable

Study of the stability of analytical samples of farm animal commodities in frozen storage

Dietary risk assessment

Chronic intake

STMR or STMR-P levels were estimated by the present Meeting for 61 commodities. When data on consumption were available, these values were used in the estimates of dietary intake.

The dietary intakes in the five GEMS/Food regional diets, on the basis of the new STMR values, represented 1-6% of the ADI (Annex 3). The Meeting concluded that the intake of residues of chlorpyrifos resulting from uses that have been considered by the JMPR is unlikely to present a public health concern.

Short-term intake

The IESTI for chlorpyrifos was calculated for the commodities for which MRLs, STMR values, and HR values were established and for which data on consumption (of large portions and unit weight) were available. The results are shown in Annex 4.

The acute RfD for chlorpyrifos is 0.1 mg/kg bw. The calculated short-term intakes of those commodities for which calculations were possible were less than 100% of the acute RfDs for children and for the general population. The Meeting concluded that the intake of residues of chlorpyrifos resulting from uses that have been considered by the JMPR is unlikely to present a public health concern for consumers.

REFERENCES

Balderrama, O.P. 1994. Residues of Chlorpyrifos in Wheat Following Multiple Applications of Lorsban* 480 BR-Brazil, 1992-94. GHB-P 197. DowElanco Latin America. Unpublished.

Balderrama, O.P. and De Vito, R. 1994. Residues of Chlorpyrifos in Sorghum Following Multiple Application of Lorsban* 480 BR-Brazil, 1992-93. GHB-P 188. DowElanco Latin America. Unpublished.

Balderrama, O.P. and Gagnotto, S.R. 1994. Residues of Chlorpyrifos in Tomatoes Following Multiple Applications of Lorsban* 480 BR-Brazil, 1992-94. GHB-P 159. DowElanco Latin America. Unpublished.

Balderrama, O.P. and Matos, J.C.G. 1994a. Residues of Chlorpyrifos in Cabbage Following Multiple Applications of Lorsban* 480 BR-Brazil, 1992-1994. GHB-P 192. DowElanco Latin America. Unpublished.

Balderrama, O.P. and Matos, J.C.G. 1994b. Residues of Chlorpyrifos in Savoy Cabbage Following Multiple Applications of Lorsban* 480 BR-Brazil, 1992-94. GHB-P 193. DowElanco Latin America. Unpublished.

Balderrama, O.P. and Matos, J.C.G. 1994c. Residues of Chlorpyrifos in Potatoes Following Treatments with Lorsban* 10G-Brazil, 1993-94. GHB-P 218. DowElanco Latin America. Unpublished.

Balderrama, O.P. and Matos, J.C.G. 1994d. Residues of Chlorpyrifos in Potato Following Multiple Applications of Lorsban* 480 BR-Brazil, 1992-94. GHB-P 194. DowElanco Latin America. Unpublished.

Balderrama, O.P. and Matos, J.C.G. 1994e. Residues of Chlorpyrifos in Potatoes After Multiple Treatments with Sabre*-Brazil, 1993-94. GHB-P 224. DowElanco Latin America. Unpublished.

Balderrama, O.P. and Matos, J.C.G. 1994f. Residues of Chlorpyrifos in Corn Grains Following Treatment with Lorsban* 10G-Brazil, 1993-94. GHB-P 217. DowElanco Latin America. Unpublished.

Balderrama, O.P. and Matos, J.C.G. 1994g. Residues of Chlorpyrifos in Corn Following Multiple Applications of Lorsban* 480 BR-Brazil, 1992-94. GHB-P 185. DowElanco Latin America. Unpublished.

Balderrama, O.P. and Matos, J.C.G. 1994h. Residues of Chlorpyrifos in Cotton Following Multiple Applications of Lorsban* 480 BR-Brazil, 1992-94. GHB-P 195. DowElanco Latin America. Unpublished.

Balderrama, O.P. and Matos, J.C.G. 1994i. Residues of Chlorpyrifos in Cotton Following Applications of Lorsban* 480 BR-Brazil, 1992-94. GHB-P 196. DowElanco Latin America. Unpublished.

Balderrama, O.P. and Matos, J.C.G. 1994j. Residues of Chlorpyrifos in Wheat Following Applications of Lorsban* 480 BR-Brazil, 1992-94. GHB-P 200. DowElanco Latin America. Unpublished.

Balderrama, O.P. and Matos, J.C.G. 1994k. Residues of Chlorpyrifos in Processed Coffee Grains Following Multiple Applications of Lorsban* 480 BR-Brazil, 1992-94. GHB-P 201. DowElanco Latin America. Unpublished.

Bauriedel, W.R. 1986a. Fate of ^{14}C-Chlorpyrifos Administered to Laying Hens. GH-C 1837. Dow Chemical USA. Unpublished.

Bauriedel, W.R. 1986b. The Early Fate of ^{14}C-Chlorpyrifos Applied to Leaf Surfaces of Corn, Soybean and Sugar Beet. GH-C 1808. Dow Chemical USA. Unpublished.

Bauriedel, W.R. and Miller, J.H. 1977. Uptake of ^{14}C-Chlorpyrifos by Corn Plants. GH-C 1036. Dow AgroSciences. Unpublished.

Bauriedel, W.R. and Miller, J.H. 1980. The Metabolic Fate of ^{14}C-Chlorpyrifos Applied to an Apple Tree. GH-C 1397. Dow Chemical USA. Unpublished.

Bauriedel, W.R. and Miller, J.H. 1981. The Metabolic Fate of ^{14}C-Chlorpyrifos Applied Topically to Soybeans. GH-C 1414. Dow AgroSciences. Unpublished.

Bauriedel, W.R. and Miller, J.H. 1986a. The Metabolic Fate of ^{14}C-Chlorpyrifos Applied to Field Corn at Planting (Soil Application) and in Mid-Season (Foliar Application). GH-C 1807. Dow Chemical USA Unpublished.

Bauriedel, W.R. and Miller, J.H. 1986b. The Metabolic Fate of 14C-Chlorpyrifos Applied to Sugar Beets at Planting (Soil Application) and in Mid-Season (Foliar Application). GH-C 1809. Dow Chemical USA. Unpublished.

Bauriedel, W.R., McCall, P.J. and Swann, R.I. 1985. Volatility Characteristics of Chlorpyrifos from Soil and Corn. GH-C 1782. Dow AgroSciences. Unpublished.

Bidlack, H.D. 1979. Degradation of Chlorpyrifos in Soil Under Aerobic, Aerobic/Anaerobic and Anaerobic Conditions. GH-C 1258. Dow Chemical USA. Unpublished.

Bjerke, E.L., Ervick, D.K. and Schotts, B.A. 1991. Determination of Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Peanuts Receiving at-Plant and Post-Plant applications of Lorsban 4E and 15G Insecticides. GH-C 2665. DowElanco. Unpublished.

Butcher, S. and Teasdale, R. 1990. Residues of Chlorpyrifos and 3,5,6-Trichloropyridin-2-ol in Lettuce Following Application of Dursban 4 (EF 747)-Spain, 1989. GHE-P 2194. DowElanco Europe. Unpublished.

Catta-Preta, R.F. and Balderrama, O.P. 1994. Residues of Chlorpyrifos in Plums after Treatment with Lorsban* 50W, Chile 1993-94. GHB-P 213. DowElanco Latin America. Unpublished.

Catta-Preta, R.F. and Rampazzo, P.E. 1994. Residues of Chlorpyrifos in Peaches After Treatment with Lorsban* 50W-Chile, 1993-94. GHB-P 212. DowElanco Latin America. Unpublished.

Catta-Preta, R.F. and Rampazzo, P.E. 1995. Simplified Decay Curve of Chlorpyrifos in Peaches After Treatment with Lorsban* 50W-Chile, 1993-94. GHB-P 254. DowElanco Latin America. Unpublished.

Catta-Preta, R.F. and Rampazzo, P.E. 1997. Residues of Chlorpyrifos in Coffee Beans after Multiple Applications of Lorsban 480BR Insecticide. Brazil, 1994-95. GHB-P 310. Dow AgroSciences. Unpublished.

Catta-Preta, R.F. and Rampazzo, P.E. 1999. Residues of Chlorpyrifos in Coffee Beans after Multiple Applications of Lorsban 4EC Insecticide. Colombia, 1995. GHB-P 413. Dow AgroSciences. Unpublished.

Chakrabarti, A. and Gennrich, S.M. 1987. Vapor Pressure of Chlorpyrifos. ML-AL 87-40045. The Dow Chemical Company. Unpublished.

Cowles, J., Williamson, W. and Quin R. 1999a. Magnitude of Chlorpyrifos Residues in Rice Treated with Lorsban 500EC Insecticide in Australia, 1998. GHF-P 1790. Dow AgroSciences. Unpublished.

Cowles, J., Penn, M. and Quin R. 1999b. Magnitude of Chlorpyrifos Residues in Rice Treated with Lorsban 3E Insecticide in the Philippines, 1998. GHF-P 1791. Dow AgroSciences. Unpublished.

Cowles, J., Penn, M. and Quin R. 1999c. Magnitude of Chlorpyrifos Residues in Rice Treated with Lorsban 30EC Insecticide in Vietnam, 1998. GHF-P 1792. Dow AgroSciences. Unpublished.

Cowles, J., Penn, M. and Quin R. 1999d. Magnitude of Chlorpyrifos Residues in Rice Treated with Lorsban 40EC Insecticide in Thailand, 1998. GHF-P 1793. Dow AgroSciences. Unpublished.

Cowles, J., Quin, R. and Taylor, J. 1999e. Magnitude of Chlorpyrifos Residues in Rice Processing Fractions After Treatment with Lorsban 3E in the Philippines, 1998. GHF-P 1794. Dow AgroSciences. Unpublished.

Cowles, J., Quin, R. and Taylor, J. 1999f. Magnitude of Chlorpyrifos Residues in Rice Processing Fractions After Treatment with Lorsban 500EC in Australia, 1998. GHF-P 1795. Dow AgroSciences. Unpublished.

Day, S.R. 1987a. Chlorpyrifos Residues in Sugarbeet Foliage and Roots Following Application of Dursban 300 SC-France 1986. GHE-P 1709. Dow Chemical Europe. Unpublished.

Day, S.R. 1987b. Chlorpyrifos Residues in Coffee Beans Following Application of Dursban 4-Tanzania 1986. GHE-P 1737. Dow Chemical Europe. Unpublished.

Dejonckheere, W. *et al.* 1993. Pesticide Residues in food commodities of vegetable origin and the total diet in Belgium 1991-1993. University of Gent, Belgium. Unpublished.

Dishburger, H.J. *et al.* 1972a. Determination of Residues of Chlorpyrifos, its Oxygen Analog and 3,5,6-Trichloro-2-pyridinol, in Tissues of Cattle Fed Chlorpyrifos. GH-C 566. Dow Chemical Company. Unpublished.

Dishburger, H.J., McKellar, R.L. and Rice, J.R. 1972b. Residues of Chlorpyrifos, its Oxygen Analog and 3,5,6-Trichloro-2-pyridinol in Milk and Cream from Cows Fed Chlorpyrifos. GH-C 533. Dow Chemical USA. Unpublished.

Dishburger, H.J., McKellar, R.L. and Wetters, J.H. and 1972c. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Tissues of Swine Fed Chlorpyrifos. GH-C 549. Dow Chemical USA. Unpublished.

Dishburger, H.J., McKellar, R.L. and Wetters, J.H. 1972d. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Tissues and Eggs from Chicken fed Chlorpyrifos. GH-C 555. Dow Chemical USA. Unpublished.

Dixon-White, H.E. 1991. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Apples and Pears Following Application of Lorsban 50W Insecticide to Apples and Pears in Canada. GH-C 2449. DowElanco USA. Unpublished.

Do Amaral, L.C. 1999. Residues of Chlorpyrifos in Potatoes After Treatment with Sabre at Planting-Brazil, 1994-95. GHB-P 349. DowElanco Latin America. Unpublished.

Do Amaral, L.C. and De Vito, R. 1999. Residues of Chlorpyrifos in Wheat After Treatment with Lorsban 480 BR-Brazil, 1997. GHB-P 411. DowElanco Latin America. Unpublished.

Do Amaral, L.C., Merino, C. and De Vito, R. 1999a. Residues of Chlorpyrifos in Peaches after Treatment with Lorsban 75WG– Chile, 1998-99. GHB-P 422. Dow AgroSciences. Unpublished.

Do Amaral, L.C., Merino, C. and De Vito, R. 1999b. Residues of Chlorpyrifos in Peaches after Treatment with Lorsban 50WP-Chile, 1998-99. GHB-P 423. Dow AgroSciences. Unpublished.

Doom, J.P. 1986. Determination of Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol on or in Onions Following at-Plant Application of Lorsban 15G or 4E. GH-C 1848. Dow Chemical

USA. Unpublished.

Doom, J.P. 1987. Determination of Residues of Chlorpyrifos and 3,5,6- Trichloro-2-pyridinol on or in Cottonseed Following Multiple Post Plant Applications of the Experimental Insecticide Formulation XRM-4656. GH-C 1879. Dow Chemical USA. Unpublished.

Dow Chemical USA. 1987. Technical Bulletin. Unpublished.

Duebelbeis, D.O. 1990. Determination of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol Residues in Alfalfa Green Forage and Cured Hay Following Preplant and Postplant Applications of Lorsban 4E Insecticide. GH-C 2288. DowElanco. Unpublished.

Fairbairn, R.D.D. and McKellar, R.L. 1980. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Potatoes Following Multiple Applications of Lorsban* 4C Insecticide. GHS-C 12. Dow Chemical of Canada, Limited. Unpublished.

Fairbairn, R.D.D. and Norton, E.J. 1980. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Sweet Corn Following Application of Lorsban* EC Insecticide. GHS-C 13. Dow Chemical of Canada, Limited. Unpublished.

Fairbairn, R.D.D., Miller, P.W. and Wetters, J.H. 1980. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Sunflower Seed Following Application of Lorsban 4C Insecticide. GHS-C 11. Dow Chemical of Canada, Limited. Unpublished.

Federal Biological Research Center for Agriculture and Forestry, Government of the Federal Republic of Germany, Summary of Good Agricultural Practices for Pesticide Uses and Other Information, 1999.

Freeman, J.M.H. 1976. Determination of Residues of Chlorpyrifos (DOWCO* 179) in Potato Tubers Following Multiple Foliar Treatment with Dursban* 4 Insecticide, South Africa 1976-Cooperator Fisons AgroChemicals. GHE-P 560. Dow Chemical Europe. Unpublished.

Freeman, J.M.H. 1978a. Determination of Residues of Chlorpyrifos (DOWCO* 179) in Soft Fruit, Strawberries, Raspberries and Gooseberries, Treated with Dursban* 4 Insecticide-Cooperator Murphy Chemical. GHE-P 575. Dow Chemical Europe. Unpublished.

Freeman, J. M. H. 1978b. Determination of Residues of Chlorpyrifos (DOWCO* 179) in Cabbage and Brussels Sprouts Treated with Dursban* 4 Insecticide-South Africa 1977. Cooperator Fisons. GHE-P 585. Dow Chemical Europe. Unpublished.

Freeman, J.M.H., Iosson, D.I. and Clipson, J.A. 1980. Determination of Chlorpyrifos Residues on Grapes Following Treatments with Dursban® 4 Insecticide-South Africa 1980. GHE-P 792. Dow Chemical Europe. Unpublished.

Gale, D.L. 1999. Residues of Chlorpyrifos in Wine Grapes at Intervals and in Process Fractions Following Multiple Applications of Dursban* WG (EF-1315)-Northern France, 1998. GHE-P 7467. Dow AgroSciences. Unpublished.

Glas, R.D. 1981a. The Metabolic Fate of ^{14}C-Chlorpyrifos Fed to Lactating Goats. GH-C 1408. Dow Chemical USA. Unpublished.

Glas, R.D. 1981b. Identification of ^{14}C-Labeled Residues in Milk from Goats Fed ^{14}C-Chlorpyrifos. GH-C 1470. Dow Chemical USA. Unpublished.

Hamburg, A.W. and Thalacker, F.W. 1994. ^{14}C-Chlorpyrifos: Accumulation in Confined Rotational Crops (Screenhouse Study)-HWI6397-114. GH-C 3284. Dow AgroSciences. Unpublished.

Herman, J.L. and Dishburger, H.J. 1972. Determination of Residues of Chlorpyrifos 3,5,6-Trichloro-2-pyridinol in or on Bananas Grown in Chlorpyrifos-Impregnated Polyethylene Bags (Shrouds). GH-C 603. Dow Chemical USA. Unpublished.

Hollick, C.B. 1983. Residues of Chlorpyrifos in Potatoes Following Multiple Treatment with Lorsban® 4E Insecticide-Colombia. GHB-P 013. Dow Quimica S.A. Brazil. Unpublished.

Hollick, C.B. and Collison, R.J. 1972. Determination of Residues of O,O-Diethyl O-(3,5,6-Trichloro-2-pyridyl) Phosphorothioate (DOWCO 179) in Eggplants, Tomatoes, Beans and Peppers Treated with Dursban 4 Insecticide in Turkey. GHE-P 101. Dow Chemical Europe. Unpublished.

Hollick, C.B. and Gilmour, M.M. 1974. Determination of Residues of Chlorpyrifos (DOWCO 179) in Apples and Pears Treated with Dursban Insecticide. GHE-P 195. Dow Chemical Europe S.A. Unpublished.

Hollick, C.B. and Iosson, D.I. 1977. Determination of Residues of Chlorpyrifos and 3,5,6- Trichloro-2-pyridinol in Fresh Tomatoes, Juice and Paste from Israel Following Multiple Treatment with Dursban* 4 Insecticide. GHE-P 489. Dow Chemical Limited. Unpublished.

Hollick, C.B. and Iosson, D.I., 1978. GHE-P 603. Unpublished.

Hollick, C.B. and Sandenskog, C. 1976. Determination of Residues of Chlorpyrifos (DOWCO 179) in Oranges from South Africa Treated with Dursban® Insecticide-Cooperator Fisons. GHE-P 413. Dow Chemical Europe. Unpublished.

Hollick, C.B. and Walker, S.M. 1976a. Determination of Residues of Chlorpyrifos (DOWCO* 179) in Soft Fruit, Blackcurrants, Strawberries, Raspberries and Gooseberries, Treated with Dursban* 4E Insecticide. Cooperator Murphy Chemical. GHE-P 435. Dow Chemical Europe. Unpublished.

Hollick, C.B. and Walker, S.M. 1976b. Determination of Residues of Chlorpyrifos (DOWCO® 179) in Cabbage and Cauliflower Treated with Dursban® 4 Insecticide, U.K. Cooperator Murphy Chemical. GHE-P 438. DowElanco Europe. Unpublished.

Hollick, C.B. and Walker, S.M. 1976c. Determination of Residues of Chlorpyrifos (DOWCO* 179) in Peas Following Treatment with Dursban* 4 Insecticide. UK 1975 Cooperator P.G.R.O. GHE-P 437. Dow Chemical Europe. Unpublished.

Hollick, C.B. and Walker, S.M. 1977. Determination of Residues of Chlorpyrifos (DOWCO® 179) in Carrots and Sugar Beet Treated with Dursban® 4 Insecticide Cooperators-Murphy Chemical. GHE-P 439. DowElanco Europe. Unpublished.

Hollick, C.B. and Walker, S.M. 1978a. Determination of Residues of Chlorpyrifos (DOWCO® 179) in Carrots Following Multiple Treatment with Dursban® 4 Insecticide-South Africa 1976-Cooperator Fisons. GHE-P 542. Dow Chemical Europe. Unpublished.

Hollick, C.B. and Walker, S.M. 1978b. Determination of Residues of Chlorpyrifos (DOWCO® 179) in Potatoes Treated with Dursban* 4 Insecticide-UK 1977. GHE-P 572. Dow Chemical Europe. Unpublished.

Hollick, C.B. and Walker, S.M. 1980. Determination of Residues of Chlorpyrifos on Banana Pulp and Skin Following Treatment with Dursban® 4 Insecticide-South Africa 1978/79. GHE-P 722. Dow Chemical Europe. Unpublished.

Institute of Plant Protection, Government of Poland, Summary of Good Agricultural Practice for Pesticide Uses and Other Information, 2000.

Iosson, D.I. 1979. Determination of Residues of Chlorpyrifos in Tomatoes Following Treatment with Dursban 4* Insecticide. GHE-P 664. South Africa 1978. Dow Chemical Europe. Unpublished.

Ishikura, H. 1993. Residues of Chlorpyrifos in Plum Following Application of DURSBAN* 25WP Insecticide in Japan. GHF-P 1328. DowElanco. Unpublished.

Ishikura, H. 1996. Residues of Chlorpyrifos in Sugar Beets Following Applications of Dursban* 40 EC Insecticide in Japan. GHF-P 1491. DowElanco. Unpublished.

Khoshab, A. 1995a. Residues of Chlorpyrifos and its Pyridinol Metabolite in Head Cabbage at Harvest Following Two Applications of Dursban 4 (EF 747), UK-1994. GHE-P 4513. DowElanco Europe. Unpublished.

Khoshab, A. 1995b. Residues of Chlorpyrifos and its Pyridinol Metabolite in Head Cabbage at Intervals following Two Applications of Dursban 4 (EF 747), UK-1994. GHE-P 4512. DowElanco Europe. Unpublished.

Khoshab, A. 1995c. Residues of Chlorpyrifos and its Pyridinol Metabolite in Cauliflower at Intervals Following Two Applications of Dursban 4 (EF 747), UK-1994. GHE-P 4511. DowElanco Europe. Unpublished.

Khoshab, A. 1995d. Residues of Chlorpyrifos and its Pyridinol Metabolite in Field Beans at Intervals Following a Single Application of Dursban 480 (EF 1042), Italy-1994. GHE-P 4515. DowElanco Europe. Unpublished.

Khoshab, A. 1996a. Residues of Chlorpyrifos and its Pyridinol Metabolite in Bulb Onions at Intervals Following a Single Application of Dursban 4 (EF 747), Greece-1994. GHE-P 4514. DowElanco Europe. Unpublished.

Khoshab, A. 1996b. Residues of Chlorpyrifos in Winter Wheat at Intervals Following Three Applications of Dursban 480 (EF 1042), UK-1994. GHE-P 5204. DowElanco Europe. Unpublished.

Khoshab, A. and Berryman, T. 1994a. Residues of Chlorpyrifos in Whole Mandarins at Harvest Following a Single Application of Dursban 4 (EF 747), Spain 1993. GHE-P 3733. DowElanco Europe. Unpublished.

Khoshab, A. and Berryman, T.,1994b. Residues of Chlorpyrifos and its Pyridinol Metabolite in Grapes at Harvest Following a Single Application of Dursban 2 (EF 121) or Dursban 480 (EF 1042), Northern France-1993. GHE-P 3636. DowElanco Europe. Unpublished.

Khoshab, A. and Berryman, T. 1994c. Residues of Chlorpyrifos and its Pyridinol Metabolite in Cauliflower at Harvest Following Two Applications of Dursban 4 (EF 747), UK-1993. GHE-P 3506. DowElanco Europe. Unpublished.

Khoshab, A. and Berryman, T. 1994d. Residues of Chlorpyrifos and its Pyridinol Metabolite in Cauliflower at Harvest Following Single Application of Dursban 4 (EF 747), UK-1993. GHE-P 3633. DowElanco Europe. Unpublished.

Khoshab, A. and Berryman, T. 1994e. Residues of Chlorpyrifos and its Pyridinol Metabolite in Vining Peas at Harvest Following a Single Application of Dursban 4 (EF 747), UK-1993. GHE-P 3487. DowElanco Europe. Unpublished.

Khoshab, A. and Berryman, T. 1994f. Residues of Chlorpyrifos in Winter Wheat, Grain and Straw at Harvest Following Three Applications of Dursban 4 (EF 747), UK-1992. GHE-P 3720. DowElanco Europe. Unpublished.

Khoshab, A. and Bolton, A. 1995. Frozen Storage Stability Study of Chlorpyrifos in Banana, Beans, Cauliflower, Peaches and Onions. GHE-P 4344. DowElanco Europe. Unpublished.

Khoshab, A. and Clements, B. 1995a. Residues of Chlorpyrifos and its Pyridinol Metabolite in Whole Banana at Harvest Following a Single Application of Dursban 4 (EF 747), Spain-1994. GHE-P 4518. DowElanco Europe. Unpublished.

Khoshab, A.and Clements, B. 1995b. Residues of Chlorpyrifos and its Pyridinol Metabolite in Whole Banana at Intervals Following a Single Application of Dursban 4 (EF 747), Spain-1994. GHE-P 4519. DowElanco Europe. Unpublished.

Khoshab, A. and Hastings, M. 1994a. Residues of Chlorpyrifos and its Pyridinol Metabolite in Cabbage at Intervals Following Two Applications of Dursban 4 (EF 747), UK-1993. GHE-P 3634. DowElanco Europe. Unpublished.

Khoshab, A. and Hastings, M. 1994b. Residues of Chlorpyrifos and its Pyridinol Metabolite in Cabbage at Harvest Following Two Applications of Dursban 4 (EF 747), UK-1993. GHE-P 3635. DowElanco Europe. Unpublished.

Khoshab, A. and Koliopanos, C. 1994. Residues of Chlorpyrifos and its Pyridinol Metabolite in Onions at Harvest Following Two Applications of Dursban 4 (EF 747), Greece-1993. GHE-P 3466. DowElanco Europe. Unpublished.

Khoshab, A. and Press, A. 1995. Residues of Chlorpyrifos and its Pyridinol Metabolite in Peaches at Harvest Following a Single Application of Dursban 2 (EF 121) or Dursban 480 (EF 1042), Southern France-1994. GHE-P 4079. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1991. Residues of Chlorpyrifos and 3,5,6-Trichloropyridin-2-oL in Sugar Beets Following Application of Dursban Fluessig* (EF 747)-Germany 1990. GHE-P 2467. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1993a. Residues of Chlorpyrifos and its Pyridinol Metabolite in Whole Mandarin Fruit at Intervals and in Peel and Pulp at Harvest Following a Single Application of Dursban 4 (EF 747), Spain 1992. GHE-P 3213. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1993b. Residues of Chlorpyrifos and its Pyridinol Metabolite in Whole Lemons at Harvest and in Peel and Pulp at Harvest Following a Single Application of Dursban 4 (EF 747), Spain 1992. GHE-P 3228. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1993c. Residues of Chlorpyrifos and its Pyridinol Metabolite in Peaches at Intervals Following a Single Application of Dursban 4 (EF 747)-Spain 1992. GHE-P 3138. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1993d. Residues of Chlorpyrifos and its Pyridinol Metabolite in Peaches at Intervals Following a Single Application of Dursban 4 (EF 747)-Greece 1992. GHE-P 3139. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1993e. Residues of Chlorpyrifos and its Pyridinol Metabolite in Peaches at Intervals Following a Single Application of Dursban 4 (EF 747)-Italy 1992. GHE-P 3142. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1993f. Residues of Chlorpyrifos and its Pyridinol Metabolite in Chinese Cabbage at Intervals Following a Single Application of Dursban 4 (EF 747) or Dursban 480 (EF 1042), UK-1993. GHE-P 3252. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1993g. Residues of Chlorpyrifos and its Pyridinol Metabolite in Cauliflower at Intervals Following a Single Application of Dursban 4 (EF 747), UK-1992. GHE-P 3212. DowElanco Europe. Unpublished.

Khoshab A. *et al.* 1993h. Residues of Chlorpyrifos and its Pyridinol Metabolite in Field Beans at Intervals Following a Single Application of Dursban 220E (EF 121)-Italy 1992. GHE-P 3231. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1993i. Residues of Chlorpyrifos and its Pyridinol Metabolite in Peas at Intervals Following a Single Application of Dursban 4 (EF 747), UK-1992. GHE-P 3232. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1994a. Residues of Chlorpyrifos and its Pyridinol Metabolite in Peaches at Intervals Following a Single Application of Dursban 2 (EF 121) or Dursban 480 (EF 1042), Southern France-1993. GHE-P 3734. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1994b. Residues of Chlorpyrifos and its Pyridinol Metabolite in Peaches at Harvest Following a Single Application of Dursban 2 (EF 121) or Dursban 480 (EF 1042) Southern France-1993. GHE-P 3721. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1994c. Residues of Chlorpyrifos and its 3,5,6-Trichloropyridin-2-ol Metabolite in Bananas at Intervals of Following a Single Application of Dursban 4 (EF 747), Spain-1991. GHE-P 3349. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1994d. Residues of Chlorpyrifos and its Pyridinol Metabolite in Bulb Onions at Harvest Following a Single Application of Dursban

4 (EF 747), UK-1993. GHE-P 3488. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1995a. Residues of Chlorpyrifos and its Pyridinol Metabolite in Peaches at Intervals Following a Single Application of Dursban 2 (EF 121) or Dursban 480 (EF 1042), Southern France-1994. GHE-P 4081. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1995b. Residues of Chlorpyrifos and its Pyridinol Metabolite in Wine Grapes at Intervals Following a Single Application of Dursban 2 (EF 121) or Dursban 480 (EF 1042), Northern France-1994. GHE-P 4080. DowElanco Europe. Unpublished.

Khoshab, A. *et al.* 1995c. Residues of Chlorpyrifos and its Pyridinol Metabolite in Wine Grapes at Harvest Following a Single Application of Dursban 2 (EF 121) or Dursban 480 (EF 1042), Southern France-1994. GHE-P 4082. DowElanco Europe. Unpublished.

Leung, E. 1978. Chlorpyrifos Residues in Indian Brown Rice Treated with Dursban 20EC Insecticide. GHF-P 084. Dow Chemical Pacific. Unpublished.

Lewer, P. 1990. Reinvestigation of the Nature of the Residues in Forage form ^{14}C-Chlorpyrifos Treated Field Corn. GH-C 2291. DowElanco. Unpublished.

Ling, I.N.C. 1986. Determination of Residues of Chlorpyrifos in Banana from Philippines Shrouded with Slow Release and Standard Lorsban IPE Bags. PM 86-010 (RTH). Dow Chemical Pacific. Unpublished.

MacDairmid, B.N. and Mercer, C.E. 1978. Chlorpyrifos-Residues and Insect Control in Kiwifruit (Chinese Gooseberries). GHF-P 086. Dow Chemical Pacific. Unpublished.

McCollister, D. D. 1973, Pesticide Petition No. 3F1306 (Chlorpyrifos), DowElanco, Unpublished.

McCormick, R.W. and Bormett, G.A. 1996a. Comparison of Lorsban 4E and WG Insecticide Formulations on the Magnitude of Residue of Chlorpyrifos in Sugarbeets. GH-C 4223. DowElanco. Unpublished.

McCormick, R.W. and Bormett, G.A. 1996b. Comparison of Lorsban 4E and WG Insecticide Formulations on the Magnitude of Residue of Chlorpyrifos in Alfalfa. GH-C 4198. DowElanco. Unpublished.

McCormick, R.W., Dixon-White, H.E. and Fisher, S.E. 1994. Magnitude of Chlorpyrifos Residues in Grapes After an Application of Lorsban 4E Insecticide Followed by Four Applications of Lorsban 50W Insecticide. GH-C 3272. DowElanco. Unpublished.

McDonald, I.A. *et al.* 1985. The Determination of Physico-Chemical Parameters of Chlorpyrifos. GHE-P 1393. DowElanco. Unpublished.

McKellar, R.L. 1975. Determination of Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Cottonseed, Gin Trash and Process Fractions Following Multiple Treatments of Cotton Plants with Lorsban Insecticide. GH-C 840. Dow Chemical USA. Unpublished.

McKellar, R.L. and Dishburger, H.J. 1973. Determination of Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Snapbeans and Green Snapbean Plants Grown from Seed Treated with Lorsban Insecticide. GH-C 660. Dow Chemical USA. Unpublished.

McKellar, R.L and Dishburger, H.J. 1974. Determination of Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Cottonseed and Gin Trash Following Multiple Treatments of Cotton Plants with Lorsban Insecticide. GH-C 739. Dow Chemical USA. Unpublished.

McKellar, R.L. and Ordiway, T.R. 1986a. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Broccoli, Brussels Sprouts, Cabbage and Cauliflower Following Two Applications of Lorsban 4E Insecticide. GH-C 1802. Dow Chemical USA. Unpublished.

McKellar, R.L. and Ordiway, T.R. 1986b. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in or on Canadian Wheat Following an Application of Lorsban 4E Insecticide. GH-C 1804. Dow Chemical USA. Unpublished.

McKellar, R.L. and Ordiway, T.R. 1986c. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol on or in Alfalfa Seed Following an Application of Lorsban 4E Insecticide. GH-C 1803. Dow Chemical USA. Unpublished.

McKellar, R.L. *et al.* 1971. Residues of Chlorpyrifos, its Oxygen Analog and 3,5,6-Trichloro-2-pyridinol in Peaches Following Trunk or Foliar Applications of Dursban* Insecticide. GH-C 479. Dow Chemical USA. Unpublished.

McKellar, R.L. *et al.* 1972. Determination of Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Green Forage, Grain and Stover of Corn Following Surface Band and Seed Furrow Applications of Dursban Insecticide. GH-C 530. Dow Chemical USA. Unpublished.

Miller, P.W. 1979a. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in or on Soybeans Receiving Multiple Applications of Lorsban Insecticide. GH-C 1224. Dow Chemical USA. Unpublished.

Miller, P.W. 1979b. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Peanut Fractions. GH-C 1199. Dow Chemical USA. Unpublished.

Miller, P.W. 1980a. Determination of Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Apples Following Multiple Foliar Applications of Lorsban 50W Insecticide. GH-C 1485. Dow Chemical USA. Unpublished.

Miller, P.W. 1980b. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Tomatoes from Multiple Ground Application of Lorsban 4E Insecticide. GH-C 1372. Dow Chemical USA. Unpublished.

Miller, P.W. 1980c. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Sunflower Seed and Forage from Multiple Applications of Lorsban Insecticides. GH-C 1371. Dow Chemical USA. Unpublished.

Miller, P.W. 1980d. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Tomatoes and Process Fractions from Multiple Ground or Aerial Applications of Lorsban 4E Insecticide. GH-C 1282. Dow Chemical USA. Unpublished.

Miller, P.W. 1980e. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Peanut Oil Fractions. GH-C 1278. Dow Chemical USA. Unpublished.

Miller, P.W. 1981a. Determination of Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Apples Process Fractions. GH-C 1488. Dow Chemical USA. Unpublished.

Miller, P.W. 1981b. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Sunflower Seed and Process Fractions from Sunflowers Treated with Lorsban Insecticides. GH-C 1468. Dow Chemical USA. Unpublished.

Miller, P.W. 1981c. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Sun Dried Coffee Beans from Brazil. GH-C 1462. Dow Chemical USA. Unpublished.

Miller, P.W. 1982. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Walnuts Treated with Multiple Foliar Applications of Lorsban Insecticides. GH-C 1579. Dow Chemical USA. Unpublished.

Miller, P.W. 1983a. Residues of Chlorpyrifos and TCP in Tomatoes Receiving Multiple Foliar Applications of Lorsban 4E Insecticide. GH-C 1641. Dow Chemical USA. Unpublished.

Miller, P.W. 1983b. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Alfalfa Green Forage and Cured Alfalfa Hay Following a Single Foliar Application of Lorsban 4E Insecticide. GH-C 1610. Dow Chemical USA. Unpublished.

Miller, P.W. 1983c. Residues of 3,5,6-Trichloro-2-Pyridinol in Pecans Receiving Multiple Foliar Applications of Lorsban 4E Insecticide. GH-C 1652. Dow Chemical USA. Unpublished.

Miller, P.W. 1983d. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-Pyridinol in Cottonseed from Cotton Treated Aerially with Multiple Applications of Lorsban 4E Plus Pydrin and XRM-4656 plus Pydrin Insecticide. GH-C 1658. Dow Chemical USA. Unpublished.

Miller, P.W. and Ervick, D.K. 1976. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in/on Tomatoes Grown in Mexico Following Multiple Foliar Applications of Lorsban* Insecticide. GH-C 952. Dow Chemical USA. Unpublished.

Miller, P.W. and Ervick, D.K. 1977. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in or on Sorghum Grain and Stover from Plots Treated with Multiple Aerial or Ground Applications of Lorsban 4E Insecticide. GH-C 998. Dow Chemical USA. Unpublished.

Miller, P.W. and Ervick, D.K. 1978. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in or on Peanuts Receiving Multiple Applications of Lorsban Insecticides. GH-C 1071. Dow Chemical USA. Unpublished.

Miller, P.W. and McKellar, R.L. 1986a. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Pears Treated with Multiple Applications of Lorsban 50W Insecticide. GH-C 1789. Dow Chemical USA. Unpublished.

Miller, P.W. and McKellar, R.L. 1986b. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Green Forage, Fodder and Grain Following at-Plant and Post Plant Applications of Lorsban 15G and Lorsban 4E Insecticides. GH-C 1813. Dow Chemical USA. Unpublished.

Miller, P.W. and McKellar, R.L. 1986c. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Wheat Following Aerial or Ground Applications of Lorsban 4E Insecticide. GH-C 1790. Dow Chemical USA. Unpublished.

Miller, P.W. *et al.* 1985. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Fruiting Vegetables Treated with Multiple Applications of Lorsban and Dursban Insecticides. GH-C 1757. Dow Chemical USA. Unpublished.

Miller, P.W. *et al.* 1986. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Broccoli, Cabbage and Mustard Greens Following Applications of Lorsban and/or Dursban Insecticides. GH-C 1788. Dow Chemical USA. Unpublished.

Netherlands, 1996. Ministery of Health, Welfare and Sport, The Hague. Multi-residue Methods, part I, Multi-residue Method 1, Pesticides amenable to gas chromatography; Analytical Methods for Pesticide Residues in Foodstuffs, 6th edition.

Nolan, R.J. *et al.* 1987. Chlorpyrifos: Tissue Distribution and Metabolism of Orally Administered ^{14}C-Labeled Chlorpyrifos in Fischer

344 Rats. HET-K-044793-(76). Dow Chemical USA. Unpublished.

Norton, E.J. 1978. Residues of Chlorpyrifos and 33,5,6-Trichloro-2-pyridinol in Kidney Beans and Pods, Kidney Bean Vines, Whole Kidney Bean Plants, Field Beans and Field Beans Vines Grown from Seed Treated with Lorsban Insecticide. GH-C 1157. Dow Chemical USA. Unpublished.

Norton, E.J. 1979. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Peas and Pods, Pea Vines and Whole Pea Plants Grown from Seed Treated with Lorsban Insecticide. GH-C 1158. Dow Chemical USA. Unpublished.

Norton, E.J. 1980a. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Field Corn Following Preplant and Postemergence Applications of Lorsban Insecticides. GH-C 1284. Dow Chemical USA. Unpublished.

Norton, E.J. 1980b. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Wheat Grain, Straw and Milling and Baking Fractions Receiving Multiple Applications of Lorsban 4E Insecticide. GH-C 1346. Dow Chemical USA. Unpublished.

Norton, E.J. and Wetters, J.H. 1983. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Wheat Grain, Straw and Green Forage Receiving Single or Multiple Applications of Lorsban 4E Insecticide. GH-C 1639. Dow Chemical USA. Unpublished.

Norton, E.J. *et al.* 1981. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Field Corn Following Multiple Applications of Lorsban Insecticides. GH-C 1440. Dow Chemical USA. Unpublished.

Nugent, P.A. and Schotts, B.A. 1991. Residues of Chlorpyrifos in Sweet Corn Ears and Forage Following Multiple Applications of Lorsban 4E. GH-C 2569. DowElanco. Unpublished.

Osborne, K. 1989a. Residues of Chlorpyrifos and 3,5,6-Trichloropyridin-2-ol in Plums Following Application of Dursban 25WP-Germany 1987. GHE-P 1911. Dow Chemical Europe. Unpublished.

Osborne, K. *et al.* 1989b. Residues of Chlorpyrifos and 3,5,6-Trichloropyridin-2-ol in Peppers Following a Double Application of Dursban 4E (EF 747)-Spain, 1988. GHE-P 1990. DowElanco Limited. Unpublished.

Olthof, P. D. A., Ministry of Health, Welfare and Sport, Government of the Netherlands, Information of the Netherlands to the 2000 JMPR, 2000.

Penttilä, P.L. and Siivinen, K. 1995. Control and Intake of Pesticide Residues During 1981-1993 in Finland. National Food Administration, Finland. Unpublished.

Pinheiro, A.C. and De Vito, R. 1998. Magnitude of Residues of Chlorpyrifos in Rice Treated with Lorsban 4E-Colombia, 1998. GHB-P 406. Dow AgroSciences. Unpublished.

Pinheiro, A.C., De Vito, R. and Neves, R. 1999. Residue of Chlorpyrifos in Apples Following Multiple Treatments of Lorsban 75WG Insecticide-Brazil, 1998-99. GHB-P 415. Dow Chemical-Brazil. Unpublished.

Plaumann, D.E. *et al.*,1982. The Determination of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Onions Following the Application of Lorsban* 15G Insecticide. GHS-C 43. Dow Chemical Canada Limited, Inc. Unpublished.

Pompeu-Braga, A.M. 1982. Residue of Chlorpyrifos in Apples Following the Application of Lorsban 50WP Insecticide-Chile. GHB-P 008. Dow Chemical-Brazil. Unpublished.

Portwood, D.E. 1996a. Residues of Chlorpyrifos in Strawberries at Different Harvest Intervals Following Multiple Applications of Dursban 480 (EF 1042) or Dursban WG (EF 1315), UK-1995. GHE-P 5492R. DowElanco Europe. Unpublished.

Portwood, D.E. 1996b. Residues of Chlorpyrifos in Strawberries at Harvest Following Multiple Applications of Dursban WG (EF-1315), UK-1995. GHE-P 5493R. DowElanco Europe. Unpublished.

Portwood, D.E. 1996c. Residues of Chlorpyrifos in Tomatoes at Intervals Following One Application of Dursban 480 (EF 1042) or Dursban WG (EF 1315), Spain-1995. GHE-P 5495. DowElanco Europe. Unpublished.

Portwood, D.E. 1996d. Residues of Chlorpyrifos in Carrots at Intervals Following Two Application of Dursban WG (EF 1315), Netherlands-1995. GHE-P 5491R. DowElanco Europe. Unpublished.

Portwood, D.E. 1996e. Residues of Chlorpyrifos in Cauliflower at Harvest Following Two Applications of Dursban WG (EF 1315), UK-1995. GHE-P 5451. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1995a. Residues of Chlorpyrifos in Mandarins at Intervals Following a Single Application of Dursban 480 (EF 1042) or Dursban WG (EF 1315), Spain 1994. GHE-P 4516. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1995b. Residues of Chlorpyrifos in Peaches at Intervals Following a Single Application of Dursban 480 (EF 1042) or Dursban WG (EF-1315), Italy-1994. GHE-P 4229. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1995c. Residues of Chlorpyrifos in Cabbage at Intervals Following Two Applications of Dursban 480 (EF 1042) or Dursban WG (EF 1315), UK-1994. GHE-P 4355. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1995d. Residues of Chlorpyrifos in Cauliflower at Intervals Following Two Applications of Dursban 480 (EF 1042) or Dursban WG (EF-1315, UK-1994. GHE-P 4354. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1996a. Residues of Chlorpyrifos in Mandarins at Intervals Following One Application of Dursban 480 (EF 1042) or Dursban WG (EF 1315), Spain 1995. GHE-P 4808. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1996b. Residues of Chlorpyrifos in Mandarins at Harvest Following One Application of Dursban 480 (EF 1042) or Dursban WG (EF 1315), Spain 1995. GHE-P 4809. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1996c. Residues of Chlorpyrifos in Oranges at Intervals Following One Application of Dursban 480 (EF 1042) or Dursban WG (EF 1315), Spain 1995. GHE-P 4816. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1996d. Residues of Chlorpyrifos in Oranges at Intervals Following Three Applications of Dursban 480 (EF 1042) or Dursban WG (EF 1315), Italy 1995. GHE-P 4969. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1996e. Residues of Chlorpyrifos in Clementines at Intervals Following Three Applications of Dursban 480 (EF 1042) or Dursban WG (EF 1315), Italy 1995. GHE-P 4970. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1996f. Residues of Chlorpyrifos in Oranges at Harvest Following Three Applications of Dursban 480 (EF 1042) or Dursban WG (EF 1315), Italy 1995. GHE-P 5426. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1996g. Residues of Chlorpyrifos in Peaches at Intervals Following a Single Application of Dursban 480 (EF 1042) or Various Dursban WG Formulations, Southern France-1995. GHE-P 4805. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1996h. Residues of Chlorpyrifos in Peaches at Intervals Following a Single Application of Dursban 480 (EF 1042) or Various Dursban WG Formulations, Greece-1995. GHE-P 4806. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1996i. Residues of Chlorpyrifos in Wine Grapes at Intervals Following One Application of Dursban 480 (EF 1042) or Dursban WG (EF 1315), Southern and Northern France-1995. GHE-P 4968R. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams M. 1996j. Residues of Chlorpyrifos in Wine Grapes at Harvest Following One Application of Dursban 480 (EF 1042) or Dursban WG (EF 1315), Greece-1995. GHE-P 4967R. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1996k. Residues of Chlorpyrifos in Onions at Intervals Following Two Applications of Dursban 480 (EF-1042) or Dursban WG (EF 1315), Greece 1995. GHE-P 4807. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams M. 1996l. Residues of Chlorpyrifos in Cauliflower at Intervals Following Two Applications of Dursban 480 (EF 1042) or Various Dursban WG Formulations, UK-1995. GHE-P 5450. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1996m. Residues of Chlorpyrifos in Carrots at Harvest Following Two Applications of Dursban WG (EF 1315), UK-1995. GHE-P 5473R. DowElanco Europe. Unpublished.

Portwood, D.E. and Williams, M. 1996n. Residues of Chlorpyrifos in Winter Wheat at Intervals Following Three Applications of Dursban WG (EF 1315), UK-1994. GHE-P 5471. DowElanco Europe. Unpublished.

Racke, K.D. 1993. In: Ware, G.W., Reviews of Environmental Contamination and Toxicology, Vol. 131, Springer-Verlag, New York. Unpublished.

Robb, C.K. 1991a. Determination of Chlorpyrifos Residues in Valencia Oranges. GH-C 2554. DowElanco. Unpublished.

Robb, C.K. 1991b. Determination of Chlorpyrifos Residues in Sorghum Grain and Fodder. GH-C 2555. DowElanco. Unpublished.

Robb, C.K. 1991c. Determination of Residues of Chlorpyrifos in Sunflowers. GH-C 2683. DowElanco. Unpublished.

Robb, C.K. 1994. Determination of Residues of Chlorpyrifos in Sorghum Grain, Green Forage and Fodder Following Applications of Lorsban 4E Insecticide to Provide Data for Reregistration. GH-C 3226. DowElanco. Unpublished.

Robb, C.K. and Schotts, B.A. 1993a. Determination of Residues of Chlorpyrifos in Alfalfa for the Reduction in Port-Harvest Interval Restrictions. GH-C 2752R. DowElanco. Unpublished.

Robb, C.K. and Schotts, B.A. 1993b. Determination of Residues of Chlorpyrifos in Processed Fractions of Corn. GH-C 2878. DowElanco. Unpublished.

Smith, G.N., Watson, B.S. and Fischer, F.S. 1967a. Investigations on Dursban Insecticide. Metabolism of O,O-Diethyl-O-3,5,6-Trichloro-2-pyridyl Phosphorothioate and O,O-Diethyl-O-3,5,6-Trichloro-2-pyridinol in Plants. *J. Agr. Food Chem.* 1967. 15,870-877.

Smith, G.N., Watson, B.S. and Fischer, F.S. 1967b. Investigations on Dursban Insecticide. Uptake and Translocation of [^{36}CL]O,O-Diethyl-O-3,5,6-Trichloro-2-pyridyl Phosphorothioate and [^{14}C]O,O-

Diethyl-O-3,5,6-Trichloro-2-pyridyl Phosphorothioate by Beans and Corn. *J. Agr. Food Chem*. 1967. 15, 127-131.

Stenhouse, F. 1992. The 1992 Australian Market Basket Survey. National Food Authority. Australian Government Publishing Service, Canberra, Australia. Unpublished.

Teasdale, R. 1997. Residues of Chlorpyrifos in Winter Wheat at Intervals Following Three Applications of Dursban 480 (EF 1042), Germany, 1995. GHE-P 4834. DowElanco Europe. Unpublished.

Teasdale, R. 1988a. Chlorpyrifos and 3,5,6-Trichloropyridin-2-ol Residues in Apples Following Application of Dursban 4-Italy, 1987. GHE-P 1872. Dow Chemical Company Limited, UK. Unpublished.

Teasdale R. 1988b. Chlorpyrifos and 3,5,6-Trichlorpyridin-2-ol Residues in Grapes, Must and Wine Following Applications of Lorsban 40-Italy 1986. GHE-P 1818R. Dow Chemical Company Limited, UK. Unpublished.

Thai Industrial Standards Institute. 2000. Government of Thailand, Information to the 2000 JMPR.

Tomerlin, J.R. *et al.* 1995. Chronic and Acute Dietary Exposure Analyses for Chlorpyrifos. GH-C 3695. DowElanco. Unpublished.

Tucker, K.E.B. 1974. Chlorpyrifos Residues in Sorghum Treated with Lorsban*. GHF-P 019. Dow Chemical (Australia) Limited. Unpublished.

Tucker, K.E.B. 1975. Chlorpyrifos Residues in Tomatoes Following Treatment with Lorsban* Insecticide. GHF-P 030. Dow Chemical (Australia) Limited Unpublished.

Turner, L.G. 1994. Magnitude of the Residue of Chlorpyrifos in Whole Seed and Hulls from the Processing of Sunflowers. GH-C 3239. DowElanco. Unpublished.

United States Environmental Protection Agency. 2000. Reregistration Eligibility Decision Document.

Upritchard, E.A. *et al.* 1980. Chlorpyrifos Residues in Kiwifruit. GHF-P 147. Dow Chemical Pacific. Unpublished.

Upritchard, E.A. *et al.* 1982. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Apples Following Multiple Applications of Lorsban 50W Insecticide. GHF-P 230. Dow Chemical Pacific. Unpublished.

Vella, D.P. 1981. Determination of Residues of Chlorpyrifos in Bananas After Application with Lorsban* 50 EC Insecticide. PAU 3183042. Dow Chemical (Australia) Limited. Unpublished.

Vella, D.P. 1983. Determination of Residues of Chlorpyrifos in Potatoes After Application with Lorsban* 50EC Insecticide. PAU 3183-068. Dow Chemical (Australia) Limited. Unpublished.

Ware, G.W. 1993. Reviews of Environmental Contamination and Toxicology, Volume 131, 1993.

Wetters, J.H. 1973. Determination of Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Green Plants, Kernels, Kernels and Cobs, Cobs and Husks and Husks of Sweet Corn Grown from Seed Treated with Lorsban Insecticide. GH-C 664. Dow Chemical USA. Unpublished.

Wetters, J.H. 1977. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Oranges, peel plus Pulp and Juice following a Foliar Application with a Lorsban Insecticide. GH-C 1041. Dow Chemical USA. Unpublished.

Wetters, J.H. 1978. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-Pyridinol in Whole Oranges, Peel, Pulp and Juice Following a Foliar Application with Lorsban Insecticide. GH-C 1141. Dow Chemical Company. Unpublished.

Wetters, J.H. 1979. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-Pyridinol in Sunflower Seed Following an Application of Lorsban 4E Insecticide. GH-C 1180. Dow Chemical USA. Unpublished.

Wetters, J.H. 1981. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Whole Citrus and Citrus Process Fractions Following Foliar Applications of Lorsban 4E Insecticide, GH-C 1441. Dow Chemical USA. Unpublished.

Wetters, J.H. 1983. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Grapes and Process Fractions Following Multiple Foliar Applications of Lorsban 4E Insecticide. GH-C 1611. Dow Chemical. Unpublished.

Wetters, J.H. 1984. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in or on Grapes, Raisins and Raisin Waste Following a Foliar Application of Lorsban 4E Insecticide. GH-C 1698. Dow Chemical USA. Unpublished.

Wetters, J.H. 1985. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol on or in Whole Oranges Following a Foliar Application of Lorsban 4E Insecticide with and Without Oil Using High Volume and Low Volume Spray Equipment. GH-C 1724. Dow Chemical USA. Unpublished.

Wetters, J.H. 1986. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol on or in Blueberries Receiving Three Foliar Applications of Lorsban* 50W Insecticide. GH-C 1832. Dow Chemical USA. Unpublished.

Wetters, J.H. 1987a. Residues of Chlorpyrifos and 3,5,6-TCP on or in Strawberries Treated at Preplant and/or Following Two Foliar Applications of

Lorsban* 4E Insecticide. GH-C 1871. Dow Chemical USA. Unpublished.

Wetters, J.H. 1987b. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in or on Cottonseed Following Five Foliar Applications of Lorsban 4E Insecticide. GH-C 1893. Dow Chemical USA. Unpublished.

Wetters, J.H. 1989. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in or on Pecans Following Multiple Aerial Applications of Lorsban 4E Insecticide. GH-C 2195. Dow Chemical USA. Unpublished.

Wetters, J.H. 1990a. Summary of Frozen Storage Stability Studies for Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Various Crops. GH-C 2308R. DowElanco USA. Unpublished.

Wetters, J.H. 1990b. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol on or in Alfalfa Green Forage and Hay Following Foliar Applications of Lorsban 4E Insecticide. GH-C 2334. DowElanco. Unpublished.

Wetters, J.H. and Dishburger, H.J. 1974. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Sugar Beets and Process Fractions Treated with Lorsban Insecticide. GH-C 729. Dow Chemical USA. Unpublished.

Wetters, J.H. and Dishburger, H.J. 1975. Determination of Residues in Fruits and Nuts Following Dormant Application of Lorsban Insecticide. GH-C 783. Dow Chemical USA, Unpublished.

Wetters, J.H. and Dishburger, H.J. 1976. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Sorghum Green Plant, Silage, Dry Plant and Grain Following Multiple Applications with Lorsban® Insecticide. GH-C 900. Dow Chemical USA. Unpublished.

Wetters, J.H. and Ervick, D.K. 1978. Determination of Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Apples and Process fractions Following Multiple Foliar Applications of Lorsban Insecticides. GH-C 1107. Dow Chemical USA. Unpublished.

Wetters, J.H. and Ervick, D.K. 1990a. Residues of Chlorpyrifos and 3,5,6-TCP in Apples Treated with Lorsban 50W Insecticide Following Reduced Spray Schedules. GH-C 2397. DowElanco USA. Unpublished.

Wetters, J.H. and Ervick, D.K. 1990b. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Alfalfa Resulting from Lorsban 4E Insecticide Applied to Four Consecutive Cuttings. GH-C 2294. DowElanco. Unpublished.

Wetters, J.H. and Fairbairn, R.D.D. 1980. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Sugar Beet Roots and Tops Following the Application of Lorsban® 4C Insecticide. GHS-C 10. Dow Chemical USA. Unpublished.

Wetters, J.H. and Markle, G.M. 1987. Chlorpyrifos-Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in or on Caneberries Receiving Multiple Foliar Applications of Lorsban* 50W Insecticide. GH-C 1903. Dow Chemical USA. Unpublished.

Wetters, J.H. and McKellar, R.L. 1989. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol on or in Almond Nutmeats and Hulls Following Multiple Foliar and Soil Applications of Lorsban 4E Insecticide. GH-C 2180. Dow Chemical USA. Unpublished.

Wetters, J.H. and Miller, P.W. 1978. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Grain and Milling Fractions Following Multiple Applications of Lorsban 4E Insecticide to Sorghum. GH-C 1109. Dow Chemical USA. Unpublished.

Wetters, J.H. *et al.* 1977. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Green Forage, Fodder and Grain from Field Corn Treated with Lorsban Insecticides. GH-C 1068. Dow Chemical USA. Unpublished.

Wetters, J.H. *et al.* 1986. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol on or in Sweet Corn Ears and Green Forage Following Multiple Foliar Applications of Lorsban 50W or Lorsban 4E Insecticides. GH-C 1797. Dow Chemical USA. Unpublished.

Wilson, B.I. 1986. Residues of Chlorpyrifos in Kiwifruit after Treatment with Lorsban 50W. New Zealand 1985/86. GHF-P 544. Dow Chemical Pacific. Unpublished.

Woods, J.S. *et al.* 1984. Residues of Chlorpyrifos and 3,5,6-Trichloro-2-pyridinol in Head and Leaf Lettuce Treated with Multiple Applications of Insecticides Containing Chlorpyrifos. GH-C 1696. Dow Chemical USA. Unpublished.