

MALATHION (049)

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Malathion was evaluated in 1965 (T), 1966 (T,R), 1967 (R), 1968 (R), 1969 (R), 1970 (R), 1973 (R), 1975 (R), 1977 (R), 1984 (R), 1997 (T), 1999 (R) and 2000 (R). The 1999 JMPR recommended the withdrawal of a number of existing CXLs as most of the trials reported were not based on the highest GAP. The manufacturer reported to the CCPR that a commitment was made with US EPA to support only realistic application rates and asked that the withdrawal of the existing Codex MRLs for apples, broccoli, head cabbages, citrus fruits, grapes, peaches, raspberries and potatoes should be reconsidered. The MRLs for peaches and raspberries were reinstated. No MRL was recommended for potatoes as no trial had been conducted according to maximum GAP. The manufacturer reported the results of trials on mandarins, oranges, apples, peaches, grapes, strawberries, tomatoes, alfalfa to the present Meeting.

Analytical methods

Analytical methods are included in the reports on the individual residue trials. The methods involved extraction with acetone, acetone plus 2-3 drops of dodecane, or acetonitrile, followed by liquid-liquid partition with dichloromethane or acetone/hexane (1:1). In some methods, the extract is further purified by gel permeation chromatography. Malathion and malaoxon are quantified by GC-FID. The LOQ was 0.01 mg/kg and recoveries were within the 70-110% range.

USE PATTERNS

Information on GAP is shown in Table 1. Labels were submitted for all the registered uses shown.

Table 1. Registered uses of malathion (all 440 g/l EW formulation).

Crop	Country	Method	Application		No. or frequency	PHI days
			Rate, kg ai/ha	Spray conc. kg ai/hl		
Alfalfa	Australia	Foliar spray	0.0704-0.55	-	-	1
		Foliar spray + bait	0.1254-0.2508	1.41-2.82		
	Spain	Foliar spray	-	0.11-0.15	-	7
					10-15 days interval	
Apple	Australia	Foliar spray	-	0.062	-	3
	Denmark	Foliar spray	1.32-1.76	-	3	7
	Greece	Foliar spray	-	0.044-0.088	-	7
		Foliar spray + bait	0.079-0.132	0.26-0.44	-	10-15 days interval
	Italy	Foliar spray	-	0.053-0.16	-	20
	Portugal	Foliar spray	-	0.05 - 0.30	-	7
		Foliar spray + bait	-	0.10 - 0.30	-	
	Romania	Foliar spray	4.62	0.31	-	-
Spain	Foliar spray	-	0.11-0.15	-	7	
Apricot	USA		4.21	-	4	6
Grapes	Australia	Foliar spray	-	0.062-0.10	-	3
	Greece	Foliar spray	-	0.044-0.088	-	7
					10-15 days interval	
	Italy	Foliar spray	-	0.053-0.16	-	20
	Portugal	Foliar spray	-	0.051-0.12	-	7
	Spain	Foliar spray	-	0.11-0.154	-	7
					10-15 days interval	
Citrus	Australia	Foliar spray	-	0.062-0.10	-	3

Crop	Country	Method	Application		No. or frequency	PHI days
			Rate, kg ai/ha	Spray conc. kg ai/hl		
	Dominican Republic	Foliar spray	0.66-1.32	-	- 10-14 days interval	-
	Greece	Foliar spray	-	0.044-0.088	- 10-15 days interval	7
		Foliar spray + bait	0.079-0.13	0.26-0.44		
	Italy	Foliar spray	-	0.053-0.16	-	20
	Portugal	Foliar spray	0.506-3.036	0.05-0.30	-	7
		Foliar spray + bait	-	0.10-0.30		
	Spain	Foliar spray	-	0.11-0.15	-	7
		Foliar spray + Bait	0.0003 kg a.i. / tree	0.31	10-15 days interval	
Aerial, using bait		0.1496	0.75			
Peach	Australia	Foliar spray	-	0.062	-	3
	Greece	Foliar spray	-	0.044-0.088	-	7
		Foliar spray + bait	-	0.26-0.44	10-15 days interval	
	Italy	Foliar spray	-	0.05-0.16	-	20
	Portugal	Foliar spray	-	0.051-0.30	-	7
		Foliar spray + bait	-	0.10-0.30		
	Spain	Foliar spray	-	0.11-0.154	-	7
		Foliar spray + Bait	-	0.31-0.75		
USA		4.21		-	7	
Strawberry	Denmark	Foliar spray	1.1	-	3	7
	Italy	Foliar spray	-	0.053-0.158	-	20
	Portugal	Foliar spray	-	0.10	-	1
	Spain	Foliar spray	-	0.11-0.15	- 10-15 days interval	7
Tomato	Australia	Foliar spray	-	0.06-0.10	-	3
	Denmark	Foliar spray	-	0.088	3	7
	Dominican Republic	Foliar spray	0.66-1.32	-	- 10-14 days interval	-
	Greece	Foliar spray	-	0.044-0.088	- 10-15 days interval	7
	Portugal	Foliar spray	-	0.051-0.101	-	1
Italy	Foliar spray	-	0.053-0.158	-	20	

RESIDUES RESULTING FROM SUPERVISED TRIALS ON CROPS

Information on residues in crops is shown in Tables 2 to 9.

Citrus fruits	Table 2	Mandarins
	Table 3	Oranges
Pome fruits	Table 4	Apples
Stone fruits	Table 5	Peaches
Berries and other small fruits	Table 6	Grapes
	Table 7	Strawberries
Fruiting vegetables, other than Cucurbits	Table 8	Tomatoes
Legume animal feeds	Table 9	Alfalfa hay and forage (green)

Undetected residues are shown as below the LOQ (e.g. <0.01 mg/kg). Control plots were included in all trials and residues in control samples are shown in parentheses when they exceeded the LOQ. Values within maximum GAP ($\pm 30\%$) are double-underlined and were used for the estimation of maximum residue levels, STMRs and HRs.

Mandarins and oranges. Malathion EW (440 g/l) was applied 4 or 6 times by a mistblower sprayer. Residues in the whole fruit were calculated from the residues found in the peel and pulp. Samples

were stored at -18° C for 9-29 months and there was a maximum interval of one month between extraction and analysis. The results are shown in Tables 2 and 3.

Table 2. Residues of malathion in mandarins (Gillis, 2003, AF/5223).

Country, year (variety)	Application					Sample	PHI days	Residues mg/kg		Reference
	Form	kg ai/ha	kg ai/hl	Water, l/ha	No.			Malathion	Malaoxon	
Greece, 2001 (Clementine)	EW	1.8-2.0	0.18	990- 1090	6	Fruit	11	0.75	<0.01	CN/11
							14	<u>0.76</u>	<0.01	
						Peel	11	2.4	0.02	
							14	2.4	0.02	
						Pulp	11	<u>0.02</u>	<0.01	
							14	<u>0.02</u>	<0.01	
Italy, 2002 (Tardivo di Ciaculli)	EW	4.0	0.18	2200	6	Fruit	10	1.8	0.03	CN/12
							14	<u>2.4</u>	0.03	
						Peel	10	6.8	0.10	
							14	<u>9.0</u>	0.13	
						Pulp	10	<u><0.01</u>	<0.01	
							14	<u><0.01</u>	<0.01	
Spain, 2000 (Clemenvilla)	EW	5.0-5.5	0.27- 0.31	1750- 1970	4	Fruit	0	2.6	0.04	CN/2
							3	2.3	<0.01	
							7	1.8	<0.01	
							10	1.5	<0.01	
							14	<u>2.4</u>	0.09	
							21	0.88	<0.01	
						Peel	3	8.2 (c0.02)	0.02	
							7	6.4	0.02	
							10	6.0	0.01	
						Pulp	3	0.07	<0.01	
							7	0.14	<0.01	
							10	<u>0.15</u>	<0.01	
Spain, 2001 (Marisol)	EW	2.9-4.4	0.18	1640- 2430	6	Fruit	10	<u>1.8</u>	<0.01	CN/9
							14	3.0	<0.01	
						Peel	10	7.0	0.03	
							14	13	0.05	
						Pulp	10	<u>0.12</u>	<0.01	
							14	<u>0.01</u>	<0.01	
Spain, 2001 (Fortuna)	EW	5.0-5.3	0.32- 0.39	1290- 1670	4	Fruit	0	7.5	0.06	CN/17
							3	4.4	<0.01	
							7	<u>4.7</u>	<0.01	
							10	2.7	<0.01	
							14	3.0	0.04	
							21	3.8	0.01	
						Peel	3	18 (c0.01)	0.03	
							7	18	0.02	
							10	12	0.02	
						Pulp	3	0.30	<0.01	
							7	<u>0.21</u>	<0.01	
							10	<u>0.01</u>	<0.01	
Spain, 2001 (Fortune)	EW	5.0-5.3	0.26- 0.29	1780- 1890	4	Fruit	0	9.4	0.09	CN/18
							3	3.7	<0.01	
							7	2.8	<0.01	
							10	2.1	<0.01	
							14	<u>2.9</u>	0.06	
							21	1.1	<0.01	
						Peel	3	12	0.01	
							7	9.5	0.01	
							10	7.5	0.01	
						Pulp	3	0.14	<0.01	
							7	<u>0.22</u>	<0.01	
							10	<u>0.02</u>	<0.01	
Spain, 2001 (Fortune)	EW	3.9-4.4	0.18	2170- 2460	6	Fruit	0	6.9	0.06	CN/21
							3	3.2	0.01	

Country, year (variety)	Application					Sample	PHI days	Residues mg/kg		Reference							
	Form	kg ai/ha	kg ai/hl	Water, l/ha	No.			Malathion	Malaoxon								
						Fruit	7	<u>2.4</u>	<0.01								
							10	1.3	<0.01								
							14	2.2	0.06								
							21	1.9	<0.01								
						Peel	3	11	0.03								
							7	9.1	0.03								
							10	5.2	0.02								
						Pulp	3	0.10	<0.01								
							7	<u>0.03</u>	<0.01								
							10	0.01	<0.01								
						Spain, 2002 (Mermandina)	EW	1.7-2.2	0.18		930- 1220	6	Fruit	10	<u>3.1</u>	0.02	CN/10
														14	3.1	0.02	
Peel	10	10 (c0.02)	0.06														
	14	10 (c0.02)	0.06														
Pulp	10	<u>0.01</u>	<0.01														
	14	<0.01	<0.01														

Table 3. Residues of malathion in oranges (Gillis, 2003, AF/5223).

Country, year (variety)	Application					Sample	PHI days	Residues, mg/kg		Referen ce	
	Form	kg ai/ha	kg ai/hl	Water, l/ha	No.			Malathion	Malaoxon		
Greece, 2001 (Merlin)	EW	1.8	0.18	990- 1040	6	Fruit	11	<u>0.58</u>	<0.01	CN/15	
							14	0.30	<0.01		
						Peel	11	1.8	<0.01		
							14	1.2	<0.01		
						Pulp	11	<u><0.01</u>	<0.01		
							14	<0.01	<0.01		
Italy, 2002 (Sanguinello)	EW	3.9-4.0	0.18	2170- 2210	6	Fruit	10	<u>1.6</u>	<0.01	CN/16	
							14	1.1	<0.01		
						Peel	10	4.2	0.01		
							14	2.8	0.01		
						Pulp	10	<u><0.01</u>	<0.01		
							14	<0.01	<0.01		
Spain, 2000 (Navelina)	EW	5.1-5.3	0.40-0.49	1080- 1270	4	Fruit	0	8.0	0.05	CN/8	
							3	1.7	<0.01		
							7	2.1	<0.01		
							10	1.7	<0.01		
							14	1.4	0.03		
							21	(c0.02) 0.95	<0.01		
						Peel	3	5.3	<0.01		
							7	6.3	<0.01		
							10	4.9	<0.01		
						Pulp	3	0.02	<0.01		
							7	0.03	<0.01		
							10	0.06	<0.01		
Spain, 2001 (Navelina)	EW	2.6-2.9	0.18	1430-1620	6	Fruit	10	<u>1.1</u>	<0.01	CN/13	
							14	1.2	<0.01		
						Peel	10	4.3	0.02		
							14	4.9	0.02		
						Pulp	10	<0.01	<0.01		
							14	0.01	<0.01		
Spain, 2001 (Lane Late)	EW	4.9-5.3	0.27-0.29	1660-1980	4	Fruit	0	6.7	0.04	CN/19	
							3	2.0	0.01		
							7	<u>1.4</u>	<0.01		
							10	1.4	<0.01		
							14	1.2	0.03		
							21	0.32	<0.01		
						Peel	3	7.1	0.04		

Country, year (variety)	Application					Sample	PHI days	Residues, mg/kg		Referen ce
	Form	kg ai/ha	kg ai/hl	Water, l/ha	No.			Malathion	Malaoxon	
							7 10	5.4 4.8	0.02 0.02	
						Pulp	3 7 10	0.05 <u>0.07</u> 0.04	<0.01 <0.01 <0.01	
Spain, 2001 (Lane Late)	EW	5.1	0.27-0.30	1680 1930	4	Fruit	0 3 7 10 14 21	2.9 1.3 <u>0.89</u> 0.66 0.49 0.47	0.02 <0.01 <0.01 <0.01 0.02 <0.01	CN/20
						Peel	3 7 10	5.5 3.5 (c0.01) 2.6	0.02 0.02 0.02	
						Pulp	3 7 10	0.08 <u>0.01</u> 0.01	<0.01 <0.01 <0.01	
Spain, 2001 (Valencia Late)	EW	2.0-2.7	0.18	1120- 1500	6	Fruit	0 3 7 10 14 21	3.3 1.2 <u>0.75</u> 0.45 0.48 0.26	0.04 <0.01 <0.01 <0.01 0.02 <0.01	CN/22
						Peel	3 7 10	3.5 2.6 1.5	0.01 0.01 0.01	
						Pulp	3 7 10	0.01 <u>0.01</u> <0.01	<0.01 <0.01 <0.01	
Spain, 2002 (Lane Late)	EW	1.8-2.2	0.18	1020-1240	6	Fruit	10 14	<u>1.7</u> 1.4	<0.01 <0.01	CN/14
						Peel	10 14	6.9 5.5	0.02 0.02	
						Pulp	10 14	<u>0.07</u> 0.02	<0.01 <0.01	

Apples. Malathion EW (440 g/l) was applied to the trees as a directed spray three times at approximately 14 day-intervals at growth stages 74-78, 77-81 and 81-85 respectively. Samples were stored frozen for a maximum of 6 months and kept for up to 2 weeks before analysis. The results are shown in Table 4.

Table 4. Residues of malathion in apples after 3 applications of an EW formulation in trials in France.

Year (variety)	Application			PHI days	Residues mg/kg		Reference
	kg ai/ha	kg ai/hl	Water, l/ha		Malathion	Malaoxon	
2000 (Melrose)	1.7-1.8	0.18	980- 1040	0 3 7 10 14 21	0.68 0.13 <u>0.09</u> 0.08 0.03 0.02	<0.01 <0.01 <0.01 <0.01 <0.01 <0.01	Goodband, 2002a AF/5230/CN/1
2000 (Braeburn)	1.7-1.9	0.18	990- 1070	0 3 7 10 14 21	1.2 0.42 <u>0.19</u> 0.02 0.01 <0.01	<0.01 <0.01 <0.01 <0.01 <0.01 <0.01	Goodband, 2002a AF/5230/CN/2
2000 (Kid's Orange)	1.7-1.9	0.18	970- 1090	0 3	1.3 0.37	0.01 <0.01	Goodband, 2002a

Year (variety)	Application			PHI days	Residues mg/kg		Reference
	kg ai/ha	kg ai/hl	Water, l/ha		Malathion	Malaoxon	
Red)				7	<u>0.24</u>	<0.01	AF/5230/CN/3
				10	0.16	0.01	
				14	0.11	<0.01	
				21	0.08	0.01	
2000 (Ozark Gold)	1.7-1.8	0.18	990- 1050	0	1.1	<0.01	Goodband, 2002a AF/5230/CN/4
				3	0.05	<0.01	
				7	<u>0.02</u>	<0.01	
				10	0.01	<0.01	
				14	0.02	<0.01	
				21	<0.0	<0.01	
2001 (Golden)	1.7-1.8	0.18	980- 1030	3	0.07	<0.01	Goodband, 2002a AF/5230/CN/5
				7	<u>0.05</u>	<0.01	
2001 (Golden)	1.7-1.9	0.18	980- 1060	3	0.46	0.02 (c0.06)	Goodband, 2002a AF/5230/CN/6
				7	<u>0.25</u>	0.01 (c0.03)	
2001 (Golden)	1.6-1.8	0.18	910- 1010	3	0.30	<0.01	Goodband, 2002a AF/5230/CN/7
				7	<u>0.13</u>	<0.01	
2001 (Melrose)	1.7-2.0	0.18	960- 1120	3	0.15	<0.01	Goodband, 2002a AF/5230/CN/8
				7	<u>0.05</u>	<0.01	
2001 (Granny Smith)	1.8	0.18	1000	0	1.1	0.01	Goodband, 2002b AF/6079/CN/1
				3	0.18	<0.01	
				7	<u>0.07</u>	<0.01	
				10	0.05	<0.01	
				14	0.02	<0.01	
				21	0.01	<0.01	
2001 (Granny Smith)	1.7-1.8	0.18	990- 1020	3	0.13	<0.01	Goodband, 2002b AF/6079/CN/3
				7	<u>0.08</u>	<0.01 (c0.01)	
2001 (Granny Smith)	1.7-1.8	0.18	970- 1010	3	0.23	<0.01 (c0.03)	Goodband, 2002b (392 FYF) AF/6079/CN/4
				7	<u>0.14</u>	<0.01 (c0.02)	
				10	0.05	0.01 (c0.02)	
				14	0.01	0.01	
				21	0.02	0.01 (c0.01)	
2001 (Lady)	1.8	0.18	1000	3	0.70	<0.01	Goodband, 2002b AF/6079/CN/5
				7	<u>0.37</u>	<0.01	

Peaches. Malathion EC (516 g/l) or EW (440 g/l) was applied three times to peaches using a directed mistblower sprayer, the first 48 days before commercial harvest, followed by two at 13-15 day-intervals. Whole peaches without stones were analysed and residues for whole fruit are shown in Table 5. Samples were stored at a minimum -18°C for up to 3 months.

Table 5. Residues of malathion in peaches in trials in Italy in 1977 (Cowley, 1998b, AF/3832).

Variety	Application					PHI days	Residues mg/kg		Reference
	Form	kg ai/ha	kg ai/hl	Water, l/ha	No.		Malathion	Malaoxon	
Padana	EW	2.4	0.16	1500	3	0	0.92	<0.01	CN/3
						3	0.28	-	
						7	0.10	<0.01	
						14	<0.01	<0.01	
						20	<u><0.01</u>	-	
Padana	EC	2.4	0.16	1500	3	0	0.68	<0.01	
						3	0.12	-	
						7	0.03	<0.01	
						14	<0.01	<0.01	
						20	<u><0.01</u>	-	

Variety	Application					PHI days	Residues mg/kg		Reference
	Form	kg ai/ha	kg ai/hl	Water, l/ha	No.		Malathion	Malaoxon	
Vega	EW	2.4	0.16	1500	3	0	1.0	<0.01	CN/2
						3	0.59	-	
						7	0.18	<0.01	
						14	0.07	<0.01	
						20	<u>0.01</u>	-	
Vega	EC	2.4	0.16	1500	3	0	1.2	0.01	
						3	0.44	-	
						7	0.12	<0.01	
						14	0.07	<0.01	
						20	<u>≤0.01</u>	-	

Grapes. Malathion EW (440 g/l) or EC (516 g/l) was applied as a directed spray three times with approximately 14 days intervals (Table 6). Samples were stored frozen for up to one year before extraction with an interval of up to 6 months before analysis. Recoveries were 84 and 91% for malathion and malaoxon respectively.

Table 6. Residues of malathion in grapes.

Country, year (variety)	Application					PHI days	Residues mg/kg		Reference
	Form	kg ai/ha	kg ai/hl	Water, l/ha	No.		Malathion	Malaoxon	
France, 2000 (Tanat)	EW	1.8-1.9	0.27	670-680	3	0	3.56	0.02	Goodband, 2002c AF/5224/CN/1
						3	1.25	0.04	
						7	0.42	0.02	
						10	0.37	<0.01	
						14	0.18	<0.01	
21	0.23	<0.01							
France, 2001 (Gamay)	EW	1.9-2.0	0.27	690-720	3	7	0.26	0.01	Goodband, 2002c, AF/5224/CN/8
						10	0.27	0.01	
France, 2001 (Chardonnay)	EW	1.8-1.9	0.27	670-700	3	0	2.58	0.03	Goodband, 2002d AF/6133/CN/1
						3	0.51	0.02	
						7	1.30	0.02	
						10	0.64	0.01	
						14	0.32	<0.01	
21	0.40	<0.01							
France, 2001 (Sauvignon)	EW	1.8-1.9	0.27	660-710	3	0	1.17	0.02	Goodband, 2002d AF/6133/CN/2
						3	0.78	0.02	
						7	0.26	<0.01	
						10	0.14	<0.01	
						14	0.12	<0.01	
21	0.10	<0.01*							
France, 2001 (Cabernet)	EW	1.7-2.0	0.27	640-720	3	7	0.59	0.01	Goodband, 2002d AF/6133/CN/3
11	0.34	0.01							
France, 2001 (Aligote)	EW	1.9-2.0	0.27	680-740	3	7	0.27	0.01	Goodband, 2002d AF/6133/CN/4
10	0.11	<0.01							
Italy, 1997 (Trebiano)	EW	1.9	0.16	1200	3	0	0.98	0.01	Cowley, 1998b AF/3831/CN/1
						3	0.31	0.01	
						7	<u>0.03</u>	0.01	
						14	0.01	-	
						20	<0.01	-	
Italy, 1997 (Trebiano)	EC	1.93	0.16	1200	3	0	0.85	0.01	Cowley, 1998b AF/3831/CN/1
						3	0.19	0.01	
						7	<u>0.01</u>	0.01	
						14	0.03	-	
						20	<0.01	-	
Italy, 1997 (Barbera)	EW	1.9	0.16	1200	3	0	1.9 (c0.06)	0.02	Cowley, 1998b AF/3831/CN/2
						3	0.41	0.02	
						7	<u>0.21</u>	0.01	
						14	0.05	-	
						20	0.08	-	
Italy, 1997	EC	1.9	0.16	1200	3	0	1.2 (c0.02)	0.02	Cowley, 1998b

Country, year (variety)	Application					PHI days	Residues mg/kg		Reference
	Form	kg ai/ha	kg ai/hl	Water, l/ha	No.		Malathion	Malaoxon	
(Barbera)						3	0.25	0.01	AF/3831/CN/2
						7	<u>0.21</u>	0.01	
						14	0.08	-	
						20	0.08	-	
Spain, 2000 (Tempranillo)	EW	2.0-2.2	0.16	1220- 1370	3	0	7.5	0.05	Goodband, 2002c AF/5224/CN/3
						7	<u>1.5</u>	0.05	
Spain, 2000 (Garnacha)	EW	1.9-2.0	0.16	1190- 1240	3	0	6.1	0.05	Goodband, 2002c AF/5224/CN/7
						3	3.3	0.13	
						7	<u>1.5</u>	0.11	
						10	1.5	0.06	
						14	0.62	0.04	
21	0.72	0.02							
Spain, 2001 (Garnacha)	EW	1.9- 2.0	0.16	1170 1270	3	7	<u>1.1</u> (c0.12)	0.05 (c0.01)	Goodband, 2002c AF/5224/CN/5
						10	1.4 (c0.18)	0.08	
Spain, 2001 (Garnacha)	EW	1.8-1.9	0.16	1180- 1200	3	7	<u>2.6</u>	0.06	Goodband, 2002c AF/5224/CN/6
						10	1.8	0.07	

Strawberries. Malathion EW (440 g/l) was applied as a directed spray and/or overall spray (Table 7). Samples were stored at minimum -18° C for up to 10 months. Recoveries of malathion and malaoxon were 76 and 96% respectively.

Table 7. Residues of malathion in strawberries (Oxspring, 2002, AF/5226).

Country, year (variety)	Application					PHI days	Residues mg/kg		Reference
	Form	kg ai/ha	kg ai/hl	Water, l/ha	No.		Malathion	Malaoxon	
France 2000 (Mara Des Bois)	EW	1.2-1.5	0.15	930- 1030	4	0	0.90 [±]	0.01 [±]	CN/1
						3	0.08	<0.01	
						7	<u>0.03</u>	<0.01	
						10	0.02	<0.01	
						14	0.01	<0.01	
						21	<0.01	<0.01	
France, 2000 (Seascape)	EW	1.5-1.6	0.15	990- 1060	4	0	0.40	0.01	CN/2
						3	0.01	<0.01	
						7	<u>0.01</u>	<0.01	
						10	<0.01	<0.01	
						14	<0.01	<0.01	
						21	<0.01	<0.01	
France, 2001 (El Santa)	EW	0.7-1.5	0.18	400- 860	6	0	0.39	0.02	CN/5
						3	0.09	<0.01	
						7	<u>0.06</u>	<0.01	
Italy, 2000 (Selva)	EW	1.5	0.15	1000	4	0	3.2 [±]	0.04 [±]	CN/3
						3	0.07	<0.01	
						7	<0.01	<0.01	
						10	0.03	<0.01	
						14	<0.01	<0.01	
						21	<0.01	<0.01*	
Italy, 2000 (Don)	EW	1.4-1.7	0.15	950- 1000	4	0	2.7	0.02 [±]	CN/4
						3	0.02	<0.01	
						7	<u><0.01</u>	<0.01	
						10	<0.01	<0.01	
						14	<0.01	<0.01	
						21	<0.01	<0.01	
Spain, 2001 (Camarrosa)	EW	1.2-1.8	0.18	700- 1000	6	0	0.60	0.02	CN/6
						3	0.07	<0.01	
						7	<u>0.10</u>	<0.01	
Spain, 2001 (Camarrosa)	EW	1.0-1.8	0.18	620- 1000	6	0	1.87	0.06	CN/7
						3	0.20	0.03	

Country, year (variety)	Application					PHI days	Residues mg/kg		Reference
	Form	kg ai/ha	kg ai/hl	Water, l/ha	No.		Malathion	Malaoxon	
Spain, 2001	EW	1.1-1.2	0.18	590- 660	6	7	<u>0.12</u>	0.02	CN/8
						0	2.40	0.03	
						3	0.24	0.01	
						7	<u>0.14</u>	0.01	

Tomatoes. A formulation of malathion EC (516 g/l) or EW (440 g/l) was applied as an overall spray to plants four or six times (Table 8). Samples were stored at -18 ° C for up to six and a half months. Recoveries were 73 and 100% for malathion and malaoxon respectively.

Table 8. Residues of malathion in tomatoes.

Country, year (variety)	Application					PHI days	Residues mg/kg		Reference
	Form	kg ai/ha	kg ai/hl	Water, l/ha	No.		Malathion	Malaoxon	
Italy, 1997 (PS1296)	EW	0.64	0.11	600	4	0	0.33	<0.01	Cowley, 1998c AF/3830/CN/1
						3	0.04	0.01	
						7	<u>0.02</u>	<0.01	
						14	<0.01	-	
						20	<0.01	-	
Italy, 1997 (PS1296)	EC	0.64	0.11	600	4	0	0.32	<0.01	Cowley, 1998c AF/3830/CN/1
						3	0.03	0.01	
						7	<u>0.01</u>	<0.01	
						14	<0.01	-	
						20	<0.01	-	
Italy, 1997 (PS1296)	EW	0.64	0.11	600	4	0	0.21	<0.01	Cowley, 1998c AF/3830/CN/2
						3	0.02	<0.01	
						7	<u><0.01</u>	<0.01	
						14	<0.01	-	
						20	<0.01	-	
Italy, 1997 (PS1296)	EC	0.64	0.11	600	4	0	0.20	<0.01	Cowley, 1998c AF/3830/CN/2
						3	0.04	<0.01	
						7	<u><0.01</u>	<0.01	
						14	<0.01	-	
						20	<0.01	-	
Italy, 2000 (VC 82)	EW	0.94	0.12	750	4	0	0.26	<0.01	Harrison, 2002 AF/5225/CN/2
						3	0.02	0.01	
						7	<u><0.01</u>	<0.01	
						10	<0.01	<0.01	
						14	<0.01	<0.01	
						21	<0.01	<0.01	
Italy, 2001 (1296)	EW	1.1 - 1.2	0.18	636 - 673	6	0	0.56	<0.01	Harrison, 2002 AF/5225/CN/6
						3	0.02	<0.01	
						7	<0.01	<0.01	
Spain, 2000 (Perfectil)	EW	0.9 - 0.9	0.12	745- 757	4	0	0.03 (c0.02)	<0.01	Harrison, 2002 AF/5225/CN/1
						3	0.04	<0.01	
						7	<u>0.01</u>	<0.01	
						10	<0.01	<0.01	
						14	<0.01	<0.01	
						21	<0.01	<0.01	
Spain, 2000 (H9491)	EW	0.9	0.12	720- 760	4	0	0.45	<0.01	Harrison, 2002 AF/5225/CN/3
						3	0.12	<0.01	
Spain, 2001 (H9036)	EW	1.8-	0.18	1000	6	0	0.64	<0.01	Harrison, 2002 AF/5225/CN/4
						3	0.22	<0.01	
						7	0.04	<0.01	
Spain, 2002 (H3044)	EW	1.8	0.18	1000	6	0	0.46	<0.01	Harrison, 2003 AF/6022/CN/1
						3	0.06	<0.01	
						7	0.06	<0.01	

Alfalfa. Malathion EW (440 g/l) was applied once as an overall spray to alfalfa (Table 9) and forage samples were handpicked approximately 5 cm above the ground immediately after the spray had dried up to 7 days later. Seven days after treatment the crop was cut, left on the ground to dry and sampled after 10-21 days. The forage samples were stored at -18°C for 4-10 months. Recoveries from forage were 84% and 75% and from hay 89% and 82% for malathion and malaaxon respectively.

Table 9. Residues of malathion, dry weight basis, in alfalfa after a single application of EW formulation.

Country, year (location)	Application			Sample	PHI days	Residues mg/kg		Reference	
	kg ai/ha	kg ai/hl	Water, l/ha			Malathion	Malaaxon		
Italy, 2000 (Romagnola)	1.5	0.15	1000	Forage	0	93	0.60	Anthony, 2002 AF/5228	
					3	2.0	0.04		
					7	<u>0.67</u>	0.01		
				Hay	10	<u>0.12</u>	<0.01		CN/2
					14	0.02	0.03		
					21	0.06	<0.01		
Italy, 2001 (Garisenda)	1.5	0.15	1000	Forage	0	11	1.89	CN/4	
					7	<u>0.41</u>	0.02		
Spain, 2000 (Aragon)	1.5	0.15	1000	Forage	0	110 (c0.20)	1.14	CN/1	
					3	11 (c0.16)	0.09		
					7	<u>3.5</u> (c0.18)	0.04		
				Hay	10	<u>3.3</u> (c0.10)	0.04		
					14	1.8 (c0.11)	0.02		
					21	0.61 (c0.03)	0.01		
Spain, 2001 (Aragon)	1.5	0.15	1000	Forage	0	137	1.50	CN/3	
					7	<u>1.2</u>	0.05		

RESIDUES IN FOOD IN COMMERCE OR AT CONSUMPTION

In a market basket study in 2001 samples were collected from 500 different randomly-selected grocery stores throughout the continental USA over a one-year period. Samples were prepared as consumers would typically prepare their food (i.e. washing, peeling, rubbing, coring, de-hulling, pitting and de-stemming). A multi-residue screen method was used with a limit of quantification (LOQ) of 0.001 mg/kg. The average limit of detection (LOD) of malathion and malaaxon was 0.00001 and 0.0007 mg/kg respectively (Polakoff and Daniels, 2003).

Table 10. Residues of malathion found in a market basket study in the USA.

Crop	No. of samples	Non-quantifiable		Average residue (mg/kg)		Maximum residue	
		Malathion	Malaaxon.	Malathion	Malaaxon.	Malathion	Malaaxon.
Apple	500	100%	100%	0.00001	<0.000005	NQ	NQ
Broccoli	493	99%	100%	0.00003	0.00001	0.00253	NQ
Cherry	144	84%	100%	0.00064	0.00001	0.00865	NQ
Cucumber	498	100%	100%	0.00001	<0.000005	NQ	NQ
Grape	491	100%	100%	0.00001	0.00002	NQ	0.00168
Green beans	465	100%	100%	0.00001	<0.000005	NQ	NQ
Head lettuce	496	100%	100%	0.00001	0.00001	NQ	NQ
Orange	499	99%	100%	0.00005	<0.000005	0.00167	NQ
Peach	352	100%	100%	0.00009	0.00002	0.01408	NQ
Potato	500	99%	100%	0.00001	<0.000005	0.00386	NQ
Strawberry	451	79%	90%	0.00676	0.00027	1.48832	0.00534
Sweet corn	452	100%	100%	0	0	NQ	NQ
Tomato	498	100%	100%	<0.000005	0	0.00107	NQ

NQ: non-quantifiable

NATIONAL MAXIMUM RESIDUE LIMITS

The current MRLs in Australia, the European Union and the USA for the commodities considered in this evaluation are shown below. The MRLs for Australia are downloaded from <http://www.apvma.gov.au>, February 02, 2004, and for the European Union from Directive 88/298/ECC downloaded from http://europa.eu.int/comm/food/plant/protection/resources/publications_en.htm, February 02, 2004. The website was updated Jan. 20, 2003. The US MRLs are downloaded from <http://npirs.ceris.purdue.edu/htbin/tolchem.com>, February 02, 2004.

MRLs for Australia, the EU and the USA.

Country	Commodity	MRL (mg/kg)
Australia	Citrus, fruit	4.0
	Fruit, dried	8.0
	Grape	8.0
	Pear	0.5
	Strawberry	1.0
	Tomato	3.0
EU	Almond	0.5
	Apple	0.5
	Citrus fruit (others)	2.0
	Grapefruit	2.0
	Lemon	2.0
	Lime	8.0
	Mandarin	2.0
	Peach	0.5
	Orange	2.0
	Pear	0.5
	Plum	0.5
	Pome fruit (others)	0.5
	Small fruit and berry (others)	0.5
	Stone fruit (others)	0.5
	Strawberry	0.5
	Table grape	0.5
	Tomato	3.0
	Wine grape	0.5
USA	Alfalfa	135
	Apple	8.0
	Apricot	8.0
	Citrus, pulp, dehydrated (cattle feed)	50.0
	Grape	8.0
	Grapefruit	8.0
	Lemon	8.0
	Lime	8.0
	Nectarine	8.0
	Orange	8.0
	Peach	8.0
	Pear	8.0
	Plum (pre- and post- harvest application)	8.0
	Plum, prune	8.0
Strawberry	8.0	

Country	Commodity	MRL (mg/kg)
	Tangerine	8.0
	Tomato	8.0

APPRAISAL

Malathion has been evaluated many times since 1965. The company asked the CCPR at its Thirty-third Session in 2001 to reconsider withdrawal of the existing Codex MRLs recommended during the periodic review of the compound by the 1999 JMPR. The CCPR at its Thirty-sixth Session decided to retain the current CXL for apple, broccoli, cabbage (head), cereal grains, citrus fruit and grape, awaiting the review of the new residue data by the 2004 JMPR. The company submitted data on mandarin, orange, apple, peach, grape, strawberry, tomato, alfalfa fodder and forage (green) to the present Meeting.

Results of supervised trials on crops

Citrus fruit

Sixteen trials were conducted with mandarin and orange in Greece (GAP for citrus, 0.044–0.088 kg ai/hl, 7-day PHI), Italy (GAP, 0.053 kg ai/hl, 20-day PHI) and Spain (GAP for foliar application, 0.11–0.15 kg ai/hl, 7-day PHI) between 2000 and 2002. Malaoxon was analysed in all trials and the maximum residue level found in fruit was 0.09 mg/kg on the day of the last application.

Ten trials conducted at 0.18 kg ai/hl and five trials performed at 0.30 kg ai/hl were evaluated against Spanish and Portuguese GAP for citrus (0.05–0.30 kg ai/hl, 7-day PHI), respectively. Decline studies conducted in both crops indicated that residue levels decreased slowly within 3 days of the last application and samples harvested from 7 up to 10–11 days could be considered at GAP.

The residue levels in *mandarin* fruit were, in ranked order: 0.75, 1.8 (three), 2.4 (two), 2.9, 3.1 and 4.7 mg/kg. In mandarin pulp, the levels were: < 0.01, 0.01, 0.02, 0.03, 0.12, 0.15, 0.21 and 0.22 mg/kg.

The residue levels in *orange* fruit were, in ranked order: 0.58, 0.75, 0.89, 1.1, 1.4, 1.6, 1.7 and 2.1 mg/kg. The levels in orange pulp were: < 0.01 (three), 0.01 (two), 0.03 and 0.07 (two) mg/kg. One trial conducted at 0.4 kg ai/hl gave residue levels within the same range.

The Meeting agreed that the levels of residues of malathion in mandarin and orange from trials conducted at GAP could be combined to represent a residue population for citrus. In fruit, the levels were, in ranked order: 0.58, 0.75 (two), 0.89, 1.1, 1.4, 1.6, 1.7, 1.8 (three), 2.1, 2.4 (two), 2.9, 3.1 and 4.7 mg/kg. In citrus pulp, the levels were: < 0.01 (four), 0.01 (three), 0.02, 0.03, 0.07 (two), 0.12, 0.15, 0.21 and 0.22 mg/kg.

The Meeting recommended a maximum residue level of 7 mg/kg, a STMR of 0.02 mg/kg and a highest residue level of 0.22 mg/kg for malathion in citrus.

Apple

Twelve trials were conducted on apples in northern France in 2000 and 2001, with three applications at 0.18 kg ai/hl. There is no GAP for malathion in France; however, the results can be evaluated against Spanish or Italian GAP (up to 0.16 kg ai/hl). The PHI is 7 days in Spain and 20 days in Italy. The residue levels in apple fruit at the most critical PHI (7 days) were, in ranked order: 0.02, 0.05 (two), 0.07, 0.08, 0.09, 0.13, 0.14, 0.19, 0.24, 0.25 and 0.37 mg/kg. The levels of malaoxon were < 0.01–0.02 mg/kg.

The Meeting recommended a maximum residue level of 0.5 mg/kg, an STMR of 0.11 mg/kg and an HR of 0.37 mg/kg for malathion in apple.

Peach

Four trials were conducted in Italy in 1997 on peaches, with three applications of 0.16 kg ai/hl, corresponding to GAP. The residue levels of malathion in the fruit at 20 days' PHI were < 0.01 (three) and 0.01 mg/kg. No malaoxon was found in the fruit after the last application (0–20 days).

The Meeting agreed that four trials is not enough to recommend a maximum residue level for malathion in peaches. The Meeting confirmed the previous recommendation of 1999 JMPR to withdraw the CXs for malathion in peaches

Grape

Six trials were conducted in grapes in southern and northern France (no GAP) in 2000–01, with three applications at 0.27 kg ai/hl. The residue levels of malathion 7 days after the last application were 0.26–1.3 mg/kg.

In four trials conducted in northern Spain in 2000–01 within maximum GAP (0.11–0.15 kg ai/hl, 7-day PHI), the residue levels of malathion at 7 days' PHI were: 1.1, 1.5 (two) and 2.6 mg/kg. The levels of malaoxon were 0.02–0.13 mg/kg. Four trials conducted in Italy at GAP (0.05–0.16 kg ai/hl, 20-day PHI), evaluated against Spanish GAP, showed levels of 0.01, 0.03 and 0.21 (two) mg/kg.

The residue levels in trials conducted in Italy and Spain according to GAP were 0.01, 0.03, 0.21 (two), 1.1, 1.5 (two) and 2.6 mg/kg.

The Meeting recommended a maximum residue level of 5 mg/kg, a STMR of 0.16 mg/kg and a highest residue level of 2.6 mg/kg for malathion grapes.

Strawberry

GAPs for malathion on strawberry in Europe are: Denmark, three times 1.1 kg ai/ha, 7-day PHI; Italy, up to 0.16 kg ai/hl, 20-day PHI; Portugal, 0.10 kg ai/hl, 1-day PHI; and Spain, up to 0.15 kg ai/hl, 7-day PHI. In three trials conducted in France, two in Italy and three in Spain with four or six applications at 0.15–0.18 kg ai/hl, the residue levels at 7 days' PHI were < 0.01–0.14 mg/kg.

The Meeting confirmed the currently recommended maximum residue level of 1 mg/kg of malathion in strawberry, which was set by the 1999 JMPR on the basis of trials conducted in the USA according to GAP with a 1-day PHI.

Tomato

GAP for malathion in tomato is up to 0.088 kg ai/hl with a 7-day PHI in Greece, up to 0.16 kg ai/hl with a 20-day PHI in Italy and up to 0.10 kg ai/hl with a 1-day PHI in Portugal. In five trials conducted in Italy and one in Spain in 1997–2001 according to Greek GAP, the residue levels were < 0.01 (three), 0.01 and 0.02 (two) mg/kg. Four other trials were conducted in these countries at higher or lower rates than GAP.

The Meeting confirmed the currently recommended maximum residue level of 0.5 mg/kg for malathion in tomato, which was set by the 1999 JMPR on the basis of trials conducted in the USA according to GAP with a 1-day PHI.

Alfalfa

Two trials were conducted in Italy in 2000–01 (no GAP) and two in Spain (GAP, 0.12–0.25 kg ai/hl or 1.5–2.8 kg ai/ha) with one application at 0.15 kg ai/hl (1.5 kg ai/ha). The Italian trials, evaluated against Spanish GAP, gave residue levels of malathion of 0.67 and 0.41 mg/kg on a dry weight basis in alfalfa forage (green) at 7 days' PHI and 0.12 mg/kg in hay harvested at 7 days' PHI and allowed to dry on the field for 3 days. In the Spanish trials, the residue levels were 1.2 and 3.5 mg/kg in forage and 3.3 mg/kg in hay.

The Meeting confirmed the currently recommended maximum residue levels for malathion on alfalfa forage (green) and alfalfa hay of 500 and 200 mg/kg, respectively, which were set by the 1999 JMPR on the basis of trials conducted in USA according to GAP at 1 day PHI.

RECOMMENDATIONS

On the basis of the data derived from supervised trials, the Meeting concluded that the residue levels listed below are suitable for establishing maximum residue limits and for dietary intake assessment.

Summary of recommendations for MRLs, STMRs and HRs.

Commodity		MRL, mg/kg		STMR or STMR-P	HR or HR-P,
CCN	Name	New	Previous	mg/kg	mg/kg
FP 00226	Apple	0.5	W	0.11	0.37
FC 0001	Citrus fruits	7	W	0.02	0.22
FB 0269	Grape	5	W	0.16	2.6
FS 0247	Peach	W	W		

DIETARY RISK ASSESSMENT

Long-term intake

The current ADI for malathion is 0.3 mg/kg bw. IEDIs were calculated for commodities for human consumption for which STMRs were estimated by the 1999 JMPR and by the present Meeting (Annex 3 of the Report). The IEDI for the five GEMS/Food regional diets was 0% of the maximum ADI. The Meeting concluded that long-term intake of residues of malathion resulting from uses considered by the JMPR is unlikely to present a public health concern.

Short-term intake

An ARfD for malathion of 2 mg/kg bw was established by the 2003 JMPR. The IESTIs of malathion by the general population and by children were calculated for commodities for which STMR and highest residue values were estimated by the current Meeting (Annex 4 of the Report). The IESTI was 0–4% of the ARfD for the general population and 0–10% of the ARfD for children. The Meeting concluded that short-term intake of residues of malathion from its use in citrus, apples and grapes is unlikely to present a public health concern.

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Polakoff, B.M., Daniels, C.L. (2003). Organophosphates Market Basket Survey: Malathion. Exponent. Project/Study No.: Malathion '03-01 WD00602.000-A0T0-0203-0001. Unpublished Report, CHA Doc No.: 441 FYF

CROSS REFERENCES

Study no.	Reference
AF/3830	Cowley, 1998c
AF/3831	Cowley, 1998b
AF/3832	Cowley, 1998a
AF/5223	Gillis, 2003
AF/5224	Goodband, 2002c
AF/5224	Goodband, 2002c
AF/5225	Harrison, 2002
AF/5226	Oxspring, 2002
AF/5228	Anthony, 2002
AF/5230	Goodband, 2002a
AF/6022	Harrison, 2003
AF/6079	Goodband, 2002b
AF/6133	Goodband, 2002d
Malathion 03-01	Polakoff and Daniels, 2003

METALAXYL-M (212)

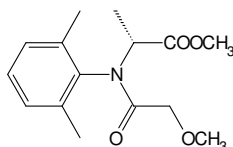
First draft prepared by Denis Hamilton, Department of Primary Industries and Fisheries, Brisbane, Australia

EXPLANATION

The toxicology of metalaxyl-M was evaluated by the 2002 JMPR, which established a group ADI of 0–0.08 mg/kg bw for metalaxyl and metalaxyl-M. Residue and analytical aspects were considered for the first time by the present Meeting. Metalaxyl-M is the biologically active enantiomer (R-enantiomer) of the racemic compound metalaxyl. Metalaxyl was first evaluated by the JMPR in 1982, and Codex MRLs for metalaxyl have been established.

IDENTITY

ISO common name	metalaxyl-M
Synonyms	Mefenoxam® CGA 329351
Chemical name	
IUPAC name	methyl <i>N</i> -(methoxyacetyl)- <i>N</i> -(2,6-xylyl)-D-alaninate
CAS	methyl <i>N</i> -(2,6-dimethylphenyl)- <i>N</i> -(methoxyacetyl)-D-alaninate
CAS Number	70630-17-0
CIPAC Number	580
Molecular formula	C ₁₅ H ₂₁ NO ₄
Molecular mass	279.3
Structural formula	



PHYSICAL AND CHEMICAL PROPERTIES

Pure active ingredient. Purity 99.4% (including S-enantiomer), 97.2% R-enantiomer.

		<u>Ref</u>
Appearance	Pale yellow, clear viscous liquid	26171
Odour	Weak	26171
Boiling point	Thermal decomp ~ 270°C (below bp)	26165
Relative density	1.125 at 20°C	26166
Vapour pressure:	3.3 × 10 ⁻³ Pa at 25°C (extrapolated from measurements between 41.4 and 91.4°C)	PP-94/45P.VPC
Henry's law constant	3.5 × 10 ⁻⁵ Pa.m ³ /mol (calc from vp and water sol)	
Solubility in water	26 g/l at 25°C	26169
Solubility in organic solvents at 25°C:	See technical material	26833

Dissociation constant in water	No dissociation	PP-94/45P.DCW
Octanol/water partition coefficient:	$\log P_{ow} = 1.71 \pm 0.04$ at 25°C	26168
Hydrolysis (sterile soln)	Stable to hydrolysis up to pH 7 even at 50°C. At pH 9 Half-life 116 days at 25°C 7.7 days at 50°C 2.7 days at 60°C	95EH05
Photolysis in water	Not degraded by light (2.2 ppm solution in pH 7 buffer, irradiated for 240 h). Degradation of metalaxyl-M by direct photolysis in surface waters is not expected because metalaxyl-M does not absorb sunlight wavelengths (above 290 nm).	95EH04

Technical material (97.1% ai)

Appearance:	Light brown, clear viscous liquid.	26831
Odour	Weak	26831
Minimum purity	Metalaxyl-M: no FAO specification . Metalaxyl, technical: FAO specification: 950 g/kg minimum, impurity 2,6-dimethylaniline maximum 1 g/kg.	FAO, 1992
Solubility in organic solvents at 25°C:	Completely miscible at 25°C in toluene, dichloromethane, ethanol, ethyl acetate, acetone, n-octanol. Hexane at 25°C: 59 g/l.	26833

FORMULATIONS

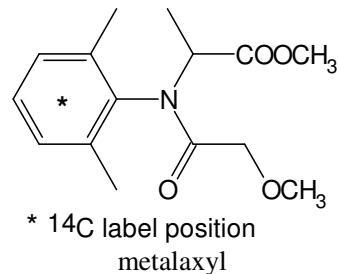
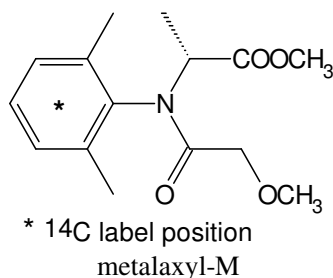
Metalaxyl-M is available in the following formulations:

EC	metalaxyl-M only and in combination with fluazinam
FS	combination with fludioxonil
GR	metalaxyl-M only
KL	combination with chlorothalonil
LS	metalaxyl-M only
SC	metalaxyl-M in combination with chlorothalonil
WG	combination with folpet, mancozeb
WP	combination with chlorothalonil, copper, folpet, mancozeb, zineb

Metalaxyl-M is the biologically active R-enantiomer in the racemic compound metalaxyl. Metalaxyl was first evaluated by the JMPR in 1982 and Codex MRLs were recommended. In recent years it has become possible to manufacture metalaxyl-M industrially and to register products based on the active R-enantiomer only. However as metalaxyl-M constitutes 50% of metalaxyl-M investigations into the metabolism and fate of metalaxyl can legitimately be accepted as representative of the metabolism and fate of metalaxyl-M.

METABOLISM

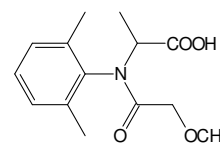
Animal and plant metabolism and environmental fate studies were with metalaxyl or metalaxyl-M uniformly ^{14}C -labelled in the aromatic ring.



Structures, names and codes for metabolites are summarised below. The designations Metabolite 1 to Metabolite 14 were used in the toxicological evaluation of metalaxyl and metalaxyl-M (WHO, 2003) and are also used here. Metabolites are further identified by CAS numbers where available. Chemical names do not necessarily follow IUPAC or CAS practice.

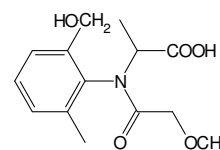
Metabolite 1 (CGA 62826. Enantiomer from metalaxyl-M is NOA 409045)

N-(2,6-dimethylphenyl)-*N*-(methoxyacetyl)alanine
CAS 75596-99-5



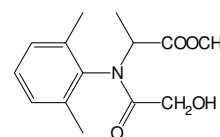
Metabolite 2 (Metab M9 or metab P0)

N-(2-hydroxymethyl-6-methylphenyl)-*N*-(methoxyacetyl)alanine



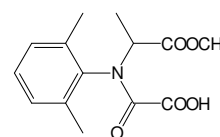
Metabolite 3 (CGA 67869)

N-(2,6-dimethylphenyl)-*N*-(hydroxyacetyl)alanine methyl ester
CAS 66637-79-4



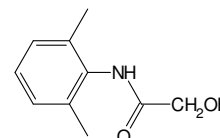
Metabolite 4 (CGA 79353)

N-(carboxycarbonyl)-*N*-(2,6-dimethylphenyl)alanine methyl ester



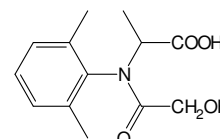
Metabolite 5 (CGA 37734)

N-hydroxyacetyl-2,6-dimethyl-aniline
CAS 29183-14-0



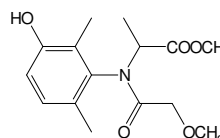
Metabolite 6 (CGA 107955)

N-(2,6-dimethylphenyl)-*N*-(hydroxyacetyl)alanine
CAS 104390-55-8



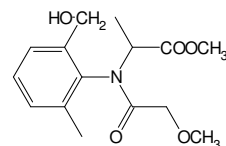
Metabolite 7 (CGA 100255)

N-(2,6-dimethyl-5-hydroxyphenyl)-*N*-(methoxyacetyl)alanine methyl ester
CAS 96258-85-4



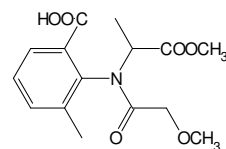
Metabolite 8 (CGA 94689)

N-(2-hydroxymethyl-6-methylphenyl)-*N*-(methoxyacetyl)alanine methyl ester (occurs as 2 isomers)
CAS 85933-49-9



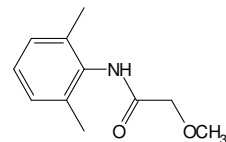
Metabolite 9 (CGA 108905)

N-(2-carboxy-6-methylphenyl)-*N*-(methoxyacetyl)alanine methyl ester



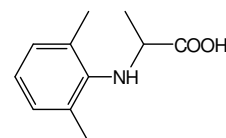
Metabolite 10 (CGA 67868)

N-methoxyacetyl-2,6-dimethyl-aniline
CAS 53823-88-4



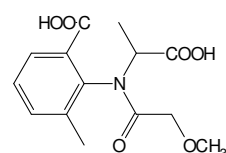
Metabolite 11 (CGA 67867)

N-(2,6-dimethylphenyl) alanine



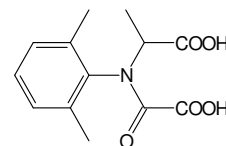
Metabolite 12 (CGA 108906)

N-(2-carboxy-6-methylphenyl)-*N*-(methoxyacetyl)alanine
CAS 104390-56-9



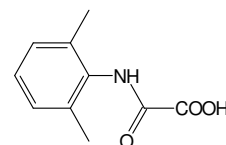
Metabolite 13 (CGA 78532)

N-(carboxycarbonyl)-*N*-(2,6-dimethylphenyl)alanine



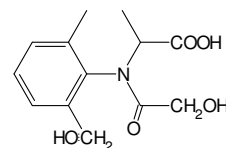
Metabolite 14 (CGA 68124)

2,6-dimethylanilinoxoacetic acid
[(2,6-dimethylphenyl)-amino]oxoacetic acid
CAS 2903-48-2



Metab P2

N-(2-hydroxymethyl)-6-methylphenyl]-*N*-(hydroxyacetyl)alanine



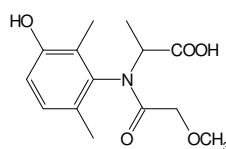
Metab P1

N-(2-hydroxymethyl)-6-methylphenyl]-*N*-(hydroxyacetyl)alanine
(Stereoisomer of P2)

(St

CGA 119857

N-(3-hydroxy-2,6-dimethylphenyl)-*N*-(methoxyacetyl)alanine



Animal metabolism

Studies on the use of metalaxyl on rats, lactating goats and laying hens were reported to the Meeting. (The metabolism of metalaxyl and metalaxyl-M in rats, goats and hens had already been evaluated for toxicology by the 2002 JMPR (WHO, 2003).)

When animals were dosed orally with radiolabelled metalaxyl, in a short time most of the radioactivity was excreted in the urine and a small amount in the faeces. In a goat study, metalaxyl was not detected in the residues in the tissues or milk. In a laying hen study, low levels were present in liver and eggs.

Numerous metabolites formed by hydrolysis, oxidation and demethylation of metalaxyl and subsequent conjugation were identified.

Rats

Rats dosed orally with a single treatment (27.9 mg/kg bw) of ring-labelled [¹⁴C]metalaxyl excreted 63% and 33% of the administered ¹⁴C within 48 h in the urine and faeces respectively (Hamböck, 1978, study 26/78). Metabolite 1, Metabolite 10, Metabolite 5 and Metabolite 8 were identified in the urine as free metabolites or glucuronic acid conjugates.

Four groups of rats were dosed with [¹⁴C]metalaxyl at 1.1 mg/kg bw (intravenous), 1.1 mg/kg bw (oral), 1.1 mg/kg bw (oral, after 14 daily doses of unlabelled metalaxyl) and 203 mg/kg bw (oral) (Itterly and Eberle, 1990, report ABR-90079). Nine metabolites (2, 5, 1, 11, 4, 8, 7, 6 and 9) were identified in the excreta as free compounds, or as glucuronide or sulfate conjugates.

Muller (1997, report 19/97) showed that the absorption, distribution, metabolism and excretion of radiolabel from metalaxyl and metalaxyl-M dosing were similar in rats.

Goats

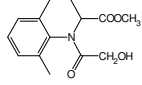
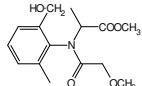
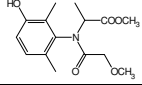
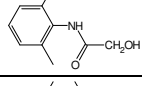
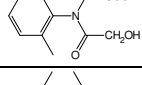
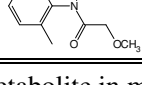
Fisher *et al.* (1978, report ABR-78046) orally dosed a lactating goat by capsule with [¹⁴C]metalaxyl at the equivalent of 7 ppm in the feed for 10 consecutive days. Most of the radiolabel was excreted in the urine (93%) and faeces (11.6%), with total recovery of radiolabel of 107%. Very little ¹⁴C was found in the milk (0.003 mg/kg) or tissues (0.019 and 0.057 mg/kg in kidney and liver respectively). TLC showed similar patterns of metabolites in rat and goat urine.

In another trial two lactating dairy goats weighing 37.4 and 38.5 kg were dosed orally once daily for 4 consecutive days by gelatin capsule with 150 mg/day of [¹⁴C]metalaxyl, equivalent to 77 ppm metalaxyl in the diet (Emrani and Meadows, 1990, report ABR-90078). Milk was collected twice a day and the animals slaughtered 6 and 7 h respectively after the last dose. Recovery of administered ¹⁴C was 80%.

Within 24 h of administration 67%, 9% and 0.1% of the daily dose was found in the urine, faeces and milk respectively. Six metabolites (5, 1, 3, 8, 7 and 6), mostly present as glucuronic acid conjugates, were identified in the urine. Tissues and milk were treated with glucuronidase to hydrolyse conjugates before analysis and identification (Table 1). Metalaxyl was not detected as a component of the residue. The metabolic pathways for metalaxyl in goats were similar to those in hens and rats.

Emrani and Meadows (1991, report ABR-91075) identified the main metabolites (66% of the radioactivity) in the milk as C₁₀ and C₈ fatty acid conjugates through the hydroxyacetyl group of Metabolite 3.

Table 1. Metabolites in the tissues and milk of goats dosed orally by gelatin capsule for 4 consecutive days with 150 mg/day of [¹⁴C]metalaxyl, equivalent to 77 ppm metalaxyl in the diet (Emrani and Meadows, 1990, 1991, reports ABR-90078, ABR-91075).

Metabolites	¹⁴ C, mg/kg as metalaxyl					
	Milk, goat 2, day 2	Liver, goat 2	Kidney, goat 2	Leg muscle, goat 2	Tenderloin, goat 2	Perirenal fat, mean of 2 goats
¹⁴ C as % of dose	0.10%	0.17%	0.02%	0.19%	0.16%	<0.01%
¹⁴ C conc	0.089	1.37	1.06	0.074	0.065	0.25
Metabolite 3 	0.004	0.025	0.036	0.006	0.004	0.029
Metabolite 3 fatty acid conj	0.058 ¹					
Metabolite 8 	0.005	0.11	0.36	0.009	0.007	0.034
Metabolite 7 	0.008	0.070	0.029	0.004	0.011	0.007
Metabolite 5 	<0.001	²	0.007	0.006	²	0.014
Metabolite 6 	0.004	0.19	0.335	0.014	0.011	0.065
Metabolite 1 	<0.001	0.022	0.007	0.008	0.006	0.006

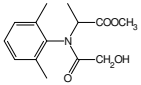
¹ Major metabolite in milk C₈ and C₁₀ fatty acid conjugates of Metabolite 3.

² Metabolite 5 included in Metabolite 7 value.

Hens

Five laying hens weighing 1.3 to 1.7 kg were dosed orally once daily for 4 consecutive days by gelatin capsule with 10 mg/day of [¹⁴C]metalaxyl, equivalent to approximately 100 ppm metalaxyl in the diet (Kennedy *et al.*, 1990, report ABR-90077). Eggs were collected once a day and the hens killed 6 h after the last dose. Recovery of administered ¹⁴C was 92%, with 0.97% in edible tissues and eggs and the remainder in the excreta. Metabolites in eggs, liver, thigh muscle and peritoneal fat are shown in Table 2. Recoveries from other tissues were breast muscle 0.25%, skin + fat 0.05%, gizzard 0.08% and kidney 0.04%.

Table 2. Metabolites in the tissues and eggs of hens dosed orally for 4 consecutive days by gelatin capsule with 10 mg/day of [¹⁴C]metalaxyl, equivalent to approximately 100 ppm metalaxyl in the diet (Kennedy *et al.*, 1990, report ABR-90077; 1991, report ABR-91077).

Metalaxyl, metabolites	¹⁴ C, mg/kg as metalaxyl (includes conjugates except where separately listed)				
	Egg white	Egg yolk	Liver	Thigh muscle	Fat
¹⁴ C as % of dose	0.01%	0.01%	0.14%	0.31%	0.02%
¹⁴ C conc	0.18	0.21	1.4	0.67	0.25
Metalaxyl	0.013	0.010	0.018	<0.001	<0.001
Metabolite 3 	<0.001		0.009	<0.001	
P3a (glucuronide of Metabolite 3)	<0.001	0.006		<0.001	0.002

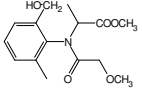
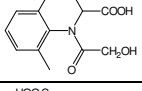
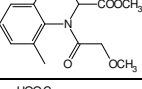
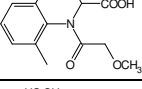
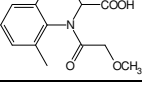
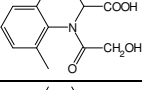
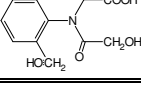
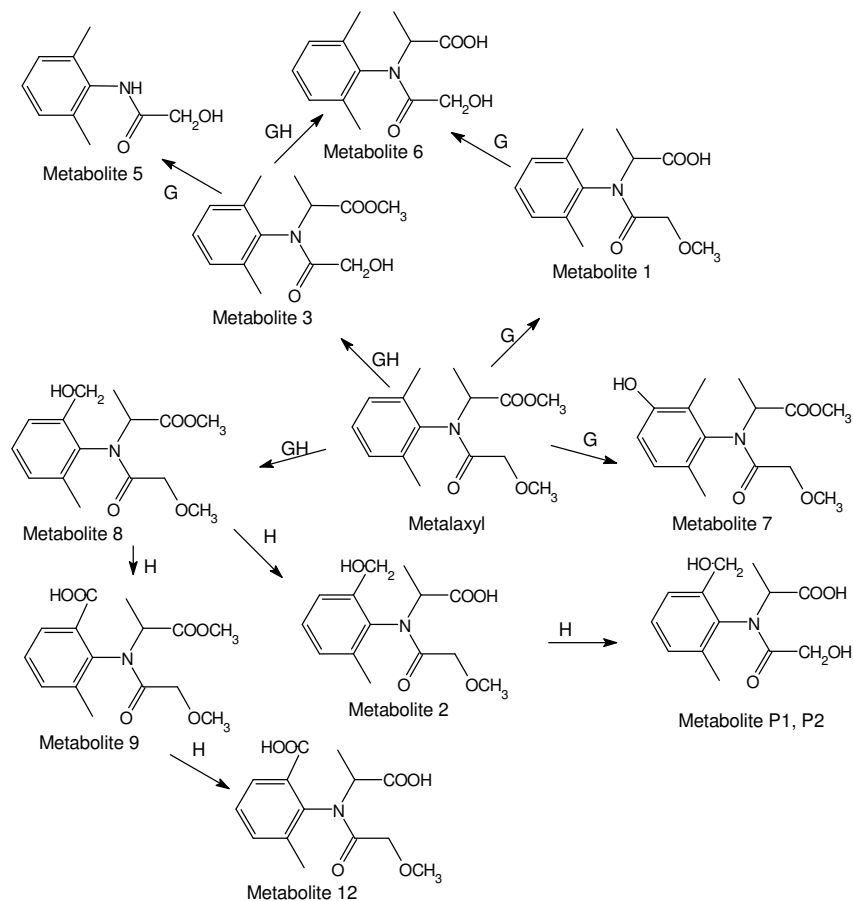
Metalaxyl, metabolites	¹⁴ C, mg/kg as metalaxyl (includes conjugates except where separately listed)				
	Egg white	Egg yolk	Liver	Thigh muscle	Fat
P4 (sulfate of Metabolite 3)	0.014	0.015		0.20	0.021
Metabolite 13 + Metabolite 14 + Metabolite 4			0.049		
Metabolite 8 	0.017	0.016	0.013	<0.001	<0.001
Metabolite 6 	<0.001	0.052	0.24	<0.001	0.10
Metabolite 9 	<0.001	0.007		<0.001	<0.001
Metabolite 12 			0.17		
Metabolite 2 	0.011	0.005		<0.001	<0.001
P1 	0.032	0.038		0.25	0.013
P2 	0.024	0.034		0.062	0.005

Figure 1. Metabolic pathways of metalaxyl in goats and hens. Metabolites may occur as conjugates in tissues, milk and eggs.



Plant metabolism

Studies on the metabolism of metalaxyl in grapes, lettuce and potatoes and of metalaxyl-M in lettuce were reported to the Meeting. The plant metabolites had previously been identified as animal metabolites.

The parent compound was the main component of the residue in grapes and grape juice when metalaxyl was applied to vines. In treated lettuce, metalaxyl and metabolite 8 were each present at approximately 20% of the total residue. Metabolite 8 was the main residue in both cases when metalaxyl and metalaxyl-M were applied to lettuce.

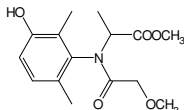
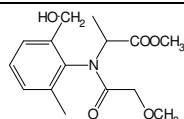
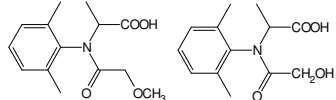
When metalaxyl was applied to potato plants, the main residue in the tubers was the parent compound.

Grapes

In a field trial in Switzerland Riesling and Sylvaner grapevines were sprayed to run-off seven times at 14-day intervals at a [^{14}C]metalaxyl concentration of 0.050 kg ai/hl. Although a severe hailstorm occurred sufficient ripe grapes and leaves were harvested 52 days after the seventh and last application for analysis (Gross, 1978, 11/78). Levels of ^{14}C (as metalaxyl) were 3.1 mg/kg in grapes, 1.04 mg/kg in juice, 7.3 mg/kg in presscake and 30 mg/kg in leaves. Metalaxyl constituted 64% and 22% of the total residues in grapes and leaves respectively.

In a further field trial in Switzerland two vines were sprayed to run-off 6 times at approximately 14-day intervals with a [^{14}C]metalaxyl spray concentration of 0.030 kg ai/hl. Ripe grapes and leaves were harvested 68 days after the last application (Gross, 1979, 06/79). The grapes were separated into juice and presscake. The results are shown in Table 3.

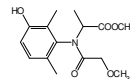
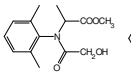
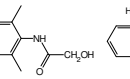
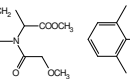
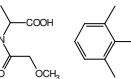
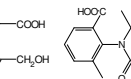
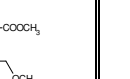

Table 3. Metalaxyl and its metabolites in grapes and leaves 68 days after spraying the vines with [^{14}C]metalaxyl (Gross, 1979, 06/79).

Component	Concentration, mg/kg, as metalaxyl			
	Grapes	Juice	Presscake	Leaves
^{14}C , % of total applied	0.18	0.06	0.12	2.4
^{14}C concentration, mg/kg as metalaxyl	1.4	0.9	1.7	19.8
Metalaxyl concentration, mg/kg	0.83	0.56	0.96	2.9
Compound including conjugates	% of ^{14}C in grapes			% of ^{14}C in leaves
Metalaxyl	64.1	7.8	56.3	22.4
Metabolite 7 	4.3	1.7	2.6	13
Metabolite 8 	20.4	7.0	13.4	55.4
Metabolite 1 + Metabolite 6 	1.8	1.0	0.8	5.0

Lettuce

Lettuce seedlings (variety Suzanne) in a greenhouse were sprayed twice with a 2-week interval with [^{14}C]metalaxyl at a rate equivalent to 0.25 kg ai/ha and harvested 2 weeks after the second application (Gross, 1979, 38/79). The total ^{14}C residue in the lettuce constituted 17.6% of the applied dose. Table 4 shows the identified components of the residues (Gross, 1980, 38/80).

Table 4. Percentages of residues identified in lettuce harvested 2 weeks after the second application of [^{14}C]metalaxyl at a rate equivalent to 0.25 kg ai/ha (Gross 1980, 38/80). Glucose conjugates are included in the metabolite concentrations.

Metalaxyl	Metabolite 7	Metabolite 3	Metabolite 5	Metabolite 8	Metabolite 1	Metabolite 6	Metabolite 9
							
18.6	6.2	8.9	2.9	22.1	6.0	10.1	1.2

Stingelin (2000, 98JS30) compared the metabolism of metalaxyl and metalaxyl-M in Sunny lettuce plants, in a field trial in Switzerland. The plants were treated 3 times (at 10-day intervals) with the labelled compound and samples taken 1 h and 14 and 21 days after the third treatment (Table 5).

Levels of total residue and proportions of parent compounds in the residue were generally comparable. Metabolite 8, free + conjugated, was the main identified component of the residue in the 14- and 21-days samples, accounting for approximately 60% and 35% of the total residue for the

metalaxyl-M and metalaxyl treatments respectively. Enantiomeric ratio measurements suggested similar degradation rates for both isomers and very little interconversion.

Table 5. Comparison of identified components of the residue in lettuce after treatments with [^{14}C]metalaxyl-M and [^{14}C]metalaxyl (Stingelin 2000, 98JS30).

Component	^{14}C , mg/kg, as parent compound					
	Metalaxyl-M			Metalaxyl		
	1 h	14 days	21 days	1 h	14 days	21 days
Total ^{14}C	8.7	2.4	0.62	7.2	1.8	1.1
Parent	6.8	0.30	0.037	6.2	0.36	0.13
II ₃ O-malonyl glycoside of Metabolite 8	0.83	1.0	0.20	0.35	0.27	0.16
II ₈ O-glucoside of Metabolite 8	0.20	0.31	0.090	0.097	0.26	0.17
Metabolite 8	0.15	0.083	0.085	0.074	0.10	0.088
Metabolite 1	0.015	0.035	0.015	0.013	0.025	0.023
	Enantiomeric ratio (S/R)					
Parent compound, enantiomeric ratios	0.5/99.5	1.0/99.0	2.3/97.7	51.4/48.6	61.0/39.0	53.8/46.2

Potatoes

In a field trial in Switzerland Bintje plants were treated 5 times with [^{14}C]metalaxyl at a rate of 0.2 kg ai/ha at 10-day intervals and harvested at maturity 5 weeks after the last treatment (Gross 1977, 30/77).

Of the radiolabel applied to the plants 1.5% was present in the plants at harvest (90% in the leaves and 7.4% in the tubers, ^{14}C as metalaxyl 0.02 mg/kg) demonstrating that little of the residue was translocated to the tubers. The ^{14}C in the tubers was polar material; no ^{14}C was detected in the organic extract so no parent was detectable in tubers.

In a second experiment the level of ^{14}C as metalaxyl in tubers was below 0.0001 mg/kg after [^{14}C]metalaxyl was applied to the soil at 4.1 kg ai/ha (residues in soil approximately 0.5 mg/kg), demonstrating that metalaxyl is not taken up by the tubers directly from the soil.

Gross (1979, 39/79) identified the components of the residue in potato leaves, showing percentages of ^{14}C found in the plants, metalaxyl 2.7; Metabolite 9, 43; Metabolite 1, 13.5; Metabolite 8, 5.7; and Metabolite 12, 4.5.

In an experiment in New York, USA, field-growing potato plants were treated 3 times with [^{14}C]metalaxyl at a rate of 1.2 kg ai/ha at 28-day intervals (Marco 1978, ABR-78001). Plant and soil samples were taken just before the second and third treatments and at maturity 4 weeks after the last treatment. Tubers were cut into pieces and immersed in a bucket of water that removed most of the soil but left a fine coating of soil particles on exposed surfaces. The level of ^{14}C in the mature tubers was 0.14 mg/kg as metalaxyl. The level of ^{14}C in the 0-7.5 cm soil layer at the same time was 2.6 mg/kg, most of which was identified as parent metalaxyl with a small amount of Metabolite 1. The composition of the residue in stalks and foliage was similar to that in the trial in Switzerland.

In a further trial two plots of field growing potato plants, variety Green Mountain, in New York, USA were treated 6 times, at about 2-week intervals, with [^{14}C]metalaxyl at rates of 0.43 (1 \times) and 1.3 (3 \times) kg ai/ha (Marco 1981, ABR-81037). Samples of tubers, foliage and soil were taken 24 h after the first treatment and at maturity 1 week after the last treatment. Total residues in the tubers were 0.14 mg/kg (peel 0.22 and flesh 0.11 mg/kg) and 0.5 mg/kg (peel 0.9 and flesh 0.4 mg/kg) for the 1 \times and 3 \times treatments respectively. The composition of the residue in tubers and foliage from the

3× treatment is summarised in Table 6. Metalaxyl was the major component of the residue in the tubers.

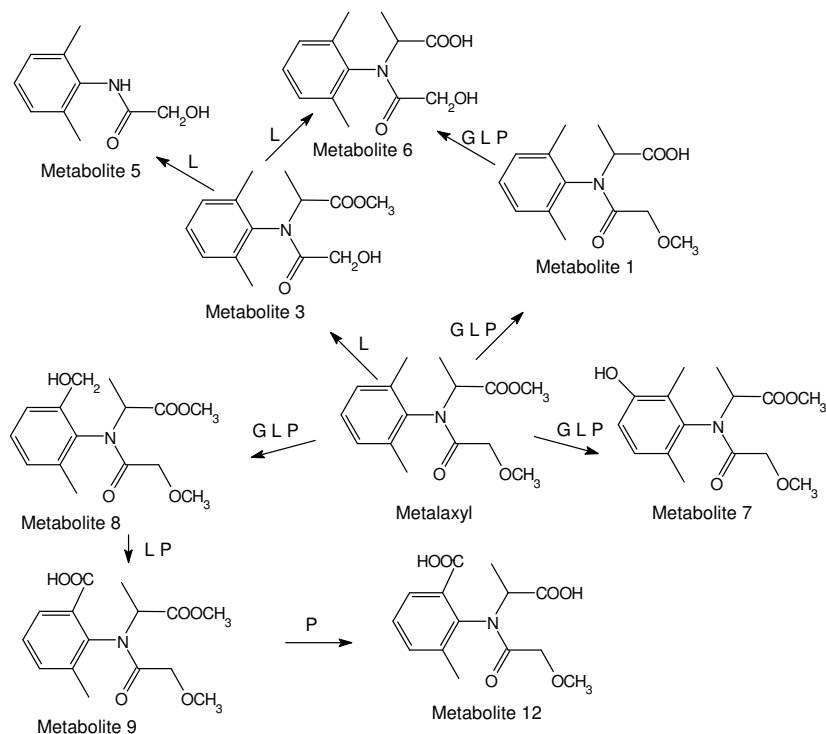
Table 6. Composition of the residue in tubers and foliage of potato plants treated three times with [^{14}C]metalaxyl at 1.3 kg ai/ha (Marco 1981, ABR-81037).

Component		^{14}C in compound as % of total ^{14}C			
		Tubers, ext A ¹	Tubers, ext B ¹	Foliage, early	Foliage, maturity
Total ^{14}C , mg/kg		0.5 mg/kg	0.5 mg/kg	3.7 mg/kg	32 mg/kg
Metalaxyl		51	57	20	2.2
Metabolite 8		5.6	1.6	8.5	20
Metabolite 7			4.0		
Metabolite 1			2.8		
Metabolite 6		1.0	1.4	1.8	1.0
Metabolite 9			0.6		<0.2
Metabolite 12			0.6		
Glucose conjugate of Metabolite 8		5.6	2.5	19	30
Glucose conjugate of Metabolite 7		1.4	0.4	8.9	2.7
Glucose conjugate of Metabolite 6		1.0	0.6	0.8	0.9

¹ A and B are different extraction procedures.

Metabolic pathways in grapes, lettuce and potatoes are shown in Figure 2.

Figure 2. Metabolism of metalaxyl in grapes, lettuce and potatoes. Some metabolites occur as glucose conjugates.



Environmental fate in soil

The Meeting received information on the aerobic degradation of [^{14}C]metalaxyl and [^{14}C]metalaxyl-M in a number of soils.

The rate of degradation is strongly influenced by the properties of the soil, including biological activity, its temperature and % moisture, and concentration of the residue. In direct comparisons of metalaxyl and metalaxyl-M, the latter was more persistent in one case and less persistent in two others. The main degradation product was Metabolite 1 or, in the case of metalaxyl-M, the specific enantiomer of Metabolite 1 (NOA 409045).

The details of one anaerobic and the aerobic studies (including one study with Metabolite 1 in chronological order) are summarized below. The maximum concentration of each metabolite as the percentage of the dose plus the day it occurred are given.

Aerobic

Ref: Ellgehausen, 08/78, 1978

Test material: [^{14}C -phenyl]metalaxyl

Duration: 360 days

Clay loam

Half-life of metalaxyl: approx 40 days

metalaxyl remaining, day 360 <2%

Products

Temp: 25°C

pH: 6.5

Dose rate: 10 mg/kg dry soil

Moisture: 75% water-holding capacity

Organic carbon: 2.2%

mineralization, day 360 = 25%

	Max (% of dose)	Day
Metabolite 1	54	66
Unextractable ^{14}C	38	360

Anaerobic (30 days aerobic, then flooded)

Ref: Ellgehausen, 08/78, 1978

Test material: [¹⁴C-phenyl]metalaxyl

Dose rate: 10 mg/kg dry soil

Duration: 89 days

Temp: 25°C

Clay loam

pH: 6.5

Organic carbon: 2.2%

Half-life of metalaxyl: approx 40 days

metalaxyl remaining, day 89 = 33%

Products

	Max (% of dose)	Day
Metabolite 1	52	89
Unextractable ¹⁴ C	9	66

Aerobic

Ref: Guth, 19/85, 1985

Test material: [¹⁴C-phenyl]metalaxyl

Dose rate: 10 mg/kg dry soil

Duration: 252 days

Temp: 15°C

Soil: silt loam

pH: 8.1

Moisture: 70% water-holding capacity

Organic carbon: 1.4%

Half-life of metalaxyl: approx 100 days. Initial (0-56 days) half-life approx 42 days

metalaxyl remaining, day 252 = 12%

mineralization, day 252 = 16%

Products

	Max (% of dose)	Day
Metabolite 1	34	84
Unextractable ¹⁴ C	37	252

Aerobic

Ref: Guth, 19/85, 1985

Test material: [¹⁴C-phenyl]metalaxyl

Dose rate: 10 mg/kg dry soil

Duration: 252 days

Temp: 15°C

Soil: sand

pH: 7.7

Moisture: 70% water-holding capacity

Organic carbon: 0.6%

Half-life of metalaxyl: approx 50 days

metalaxyl remaining, day 252 = 1.9%

mineralization, day 252 = 20%

Products

	Max (% of dose)	Day
Metabolite 1	34	84
Unextractable ¹⁴ C	44	252

Aerobic

Ref: Schanné, 262315, 1991

Test material: [¹⁴C-phenyl]metalaxyl

Duration 167-246 days

Soil: silt loam

pH: 6.1

Organic carbon: 1.4%

(1) Dose rate: 1.3 mg/kg dry soil

Temp: 20°C

Moisture: 60% water-holding capacity

Metalaxyl half-life (0-70 d): approx 14 days. Day 167, 2.3% metalaxyl remaining. 35% mineralization.

Metabolite 1 reached 22% (max) of dose on day 14.

(2) Dose rate: 1.3 mg/kg dry soil

Temp: 20°C

Moisture: 30% water-holding capacity

Metalaxyl half-life (0-113 d): approx 26 days. Day 246, 1.1% metalaxyl remaining: 32% mineralization.

Metabolite 1 reached 34% (max) of dose on day 28.

(3) Dose rate: 1.3 mg/kg dry soil

Temp: 10°C

Moisture: 60% water-holding capacity

Metalaxyl half-life (0-113 d): approx 45 days. Day 422, 1.9% metalaxyl remaining: 23% mineralization.

Metabolite 1 reached 34% (max) of dose on day 49.

(4) Dose rate: 0.13 mg/kg dry soil

Temp: 20°C

Moisture: 60% water-holding capacity

Metalaxyl half-life (0-70 d): approx 7-15 days. Day 167, 3.9% metalaxyl remaining: 33% mineralization.

Metabolite 1 reached 26% (max) of dose on day 7

Aerobic

Ref: Ellgehausen, 35/94, 1994

Test material: [¹⁴C-phenyl]metalaxyl and metalaxyl-M

Dose rate: 0.5 mg/kg dry soil

Duration: 21 days

Temp: 20°C

Soil: silt loam

pH: 7.3

Moisture: 40% water-holding capacity

Organic carbon: 2.1%

Half-life: metalaxyl approx 13 days; metalaxyl-M approx 6 days

% remaining, day 21: metalaxyl 32%; metalaxyl-M 8%

Aerobic

Ref: Ellgehausen, 95EH03 1995

Test material: [¹⁴C-phenyl]metalaxyl and metalaxyl-M
 Duration: 29 days Temp: 20°C
 Soil: sand pH: 7.4
 Half-life: metalaxyl approx 15 days; metalaxyl-M approx 8 days
 % remaining, day 29 metalaxyl 29%; metalaxyl-M 8.7%

Dose rate: 0.5 mg/kg dry soil
 Moisture: 40% water-holding capacity
 Organic carbon: 1.6%

Aerobic

Ref: Ellgehausen, 95EH06 1996

Test material: [¹⁴C-phenyl]metalaxyl-M
 Duration: 120 days Temp: 20°C
 Soil: sandy loam pH: 7.3
 Half-life metalaxyl-M (0-28d): approx 5 days
 % remaining, day 28; 1.9%

Dose rate: 0.2 mg/kg dry soil
 Moisture: 40% water-holding capacity
 Organic carbon: 2.2%

Products	mineralization, day 120 = 34%	
	Max (% of dose)	Day
Metabolite 1	26	7
Metabolite 10	6.2	7

Aerobic

Ref: Ellgehausen, 95EH06 1996

Test material: [¹⁴C-phenyl]metalaxyl-M
 Duration: 120 days Temp: 20°C
 Soil: sandy loam pH: 7.3
 Half-life metalaxyl-M (0-28d): approx 8 days
 % remaining, day 56; 0.95%

Dose rate: 2 mg/kg dry soil
 Moisture: 40% water-holding capacity
 Organic carbon: 2.2%

Products	mineralization, day 120 = 24%	
	Max (% of dose)	Day
Metabolite 1	40	14
Metabolite 10	3.7	14

Aerobic

Ref: Ellgehausen, 95EH06 1996

Test material: [¹⁴C-phenyl]metalaxyl-M
 Duration: 120 days Temp: 20°C
 Soil: sandy loam pH: 7.3
 Half-life metalaxyl-M: approx 80-180 days
 % remaining, day 120; 56%

Dose rate: 0.2 mg/kg dry soil
 Moisture: 40% water-holding capacity
 Organic carbon: 0.8%

Products	mineralization, day 120 = 2.6%	
	Max (% of dose)	Day
Metabolite 1	23	120
Metabolite 10	1.3	120

Aerobic

Ref: Ellgehausen, 95EH06 1996

Test material: [¹⁴C-phenyl]metalaxyl
 Duration: 120 days Temp: 20°C
 Soil: sandy loam pH: 7.3
 Half-life metalaxyl: approx 70-140 days
 % remaining, day 120; 50%

Dose rate: 0.2 mg/kg dry soil
 Moisture: 40% water-holding capacity
 Organic carbon: 0.8%

Products	mineralization, day 120 = 1.6%	
	Max (% of dose)	Day
Metabolite 1	30	120
Metabolite 10	2.4	120

Aerobic

Ref: Fathulla HWI 6117-280, 1996

Test material: [¹⁴C-phenyl]metalaxyl-M and [¹⁴C]-metalaxyl

Dose rate: 1.5 mg/kg dry soil

Duration: 160 days

Temp: 25°C

Moisture: 75% water-holding capacity

Soil: sandy loam

pH: 7.0

Organic matter: 0.8%

Half-life: metalaxyl-M: approx 50-80 days; metalaxyl 35-40 days

% remaining day 160: metalaxyl-M 4%. metalaxyl 3%

mineralization, day 160:

metalaxyl-M 2.5% metalaxyl 2.8%

Metabolites from metalaxyl-M		Max (% of dose)	Day
Metabolite 1		67	160
Unextractable ¹⁴ C		7	130-160
Metabolites from metalaxyl		Max (% of dose)	Day
Metabolite 1		61	130-160
Unextractable ¹⁴ C		8	160

Aerobic

Ref: Dorn, NOV11, 2001

Test material: [¹⁴C-phenyl]metalaxyl

Dose rate: 0.3 mg/kg dry soil

Duration: 118 days

Temp: 20°C

Moisture: 40% water-holding capacity

Soil: sandy loam

pH: 5.6

Organic matter: 1.4%

Half-life of metalaxyl: approx 12 days (days 2 to 21), approx 35 days (days 42 to 118)

metalaxyl remaining, day 118 = 3.4%

mineralization, day 118 = 16%

Products

		Max (% of dose)	Day
Metabolite 1		53	28
Metabolite 10		3.8	21
Metabolite 12		3.0	118
Unextractable ¹⁴ C		37	118

Aerobic

Ref: Dorn and Hein, NOV07, 2003

Test material: [¹⁴C-phenyl]metalaxyl-M

Dose rate: 0.3 mg/kg dry soil

Duration: 119 days

Temp: 20°C

Moisture: 40% water-holding capacity

Soil: sandy loam

pH: 5.6

Organic matter: 1.4%

Half-life of metalaxyl-M: approx 27 days

metalaxyl-M remaining, day 119 = 5.1%

mineralization, day 119 = 16%

Products

		Max (% of dose)	Day
NOA 409045		38	63
Metabolite 10		4.1	28
Metabolite 12		4.1	119
Unextractable ¹⁴ C		32	119

Aerobic

Ref: Dorn and Hein, NOV06, 2003

Test material: [¹⁴C-phenyl]-Metabolite 1

Dose rate: 0.18 mg/kg dry soil

Duration: 118 days

Temp: 20°C

Moisture: 40% water-holding capacity

Soil: sandy loam

pH: 5.6

Organic matter: 1.4%

Half-life of Metabolite 1 : approx 50-60 days

% Metabolite 1 remaining, day 118 = 25%

mineralization, day 118 = 22%

Products

		Max (% of dose)	Day
Metabolite 12		2.8	84
Unextractable ¹⁴ C		43	118

Field dissipation

Field dissipation studies on metalaxyl-M were reported from Switzerland, France, Italy and Spain. Also, soils from the previously described metabolism studies on lettuce and potatoes were examined for their content of parent compound and metabolites.

Metalaxyl-M residues disappeared from the soil with half-lives ranging from 5 to 35 days. The residues occurred mostly in the top 10 cm of soil. Metabolite NOA 409045 (enantiomer of Metabolite 1) was produced in all cases and on some occasions its level exceeded that of the parent.

A comparison of enantiomeric ratios in metalaxyl residues in soil suggested that the R-enantiomer (i.e. the metalaxyl-M enantiomer) was degraded more quickly than the S-enantiomer as there was a preponderance of S-enantiomer in the metalaxyl residue and of R-enantiomer in Metabolite 1.

The soil degradation studies suggested that when metalaxyl-M is used as a seed treatment or at the time of sowing, very little or none should remain as a residue in the soil at harvest.

In trials in Switzerland, France and Italy, metalaxyl-M was applied at a rate of approximately 1 kg ai/ha to plots of bare soil and soil cores (0-30 cm) were taken at intervals for 6-7 months for analysis by method REM 7/77, which is not enantio-selective, for residues of metalaxyl-M and NOA 409045 (the corresponding enantiomer of Metabolite 1). The results are shown in Table 7.

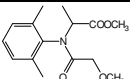
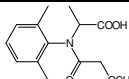
In one trial in Switzerland (Kühne, 2028/99, 2003), residues were detected in the 20-30 cm soil horizon on day 0 suggesting rapid movement (Table 7). Metalaxyl-M in the soil had a half-life of approximately 4-5 days. Residues of NOA 409045 reached a maximum 7 days after treatment and then also decreased rapidly. In the second trial in Switzerland (Kühne (2029/99, 2003), residues were again detected in the 20-30 cm soil horizon on day 0 suggesting rapid movement of a small part of the residue. Metalaxyl-M had a half-life of approximately 10 days, and residues of NOA 409045 reached a maximum 21 days after treatment and then decreased to a low level by day 56.

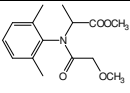
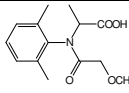
In a trial in France (Kühne, 2036/98, 2000), residues mostly remained in the top 10 cm of the soil (Table 7). Metalaxyl-M had a half-life of approximately 14 days. Residues of the metabolite NOA 409045 reached a maximum 21 days after treatment and then declined to a low level by day 56. In a second trial in France (Kühne, 2030/99, 2003), residues also mostly remained in the top 10 cm. Metalaxyl-M had a half-life of approximately 20-35 days. Residues of the metabolite NOA 409045 reached a maximum 28 days after treatment and always remained below those of metalaxyl-M.

In a trial in Italy (Kühne, 2383/97, 1998), residues were again mostly in the top 10 cm, with more product than parent appearing in the 10-20 cm horizon (Table 7). Metalaxyl-M had a half-life of approximately 10-12 days. Residues of NOA 409045 reached a maximum 14 days after treatment and exceeded those of the parent compound on days 28 and 57. In a second trial in Italy (Kühne, 2027/99, 2003), most of the residue remained in the top 10 cm. Metalaxyl-M had a half-life of about 10-20 days and residues of NOA 409045 reached a maximum 28 days after treatment and exceeded those of the parent on days 28 and 56.

In a trial in Spain with a loamy sand (Kühne, 2057/99, 2003), residues were mainly in the top 10 cm, with little product or parent in the 10-20 cm layer (Table 7). Metalaxyl-M had a half-life of about 10-16 days. Residues of NOA 409045 reached a maximum 21 days after treatment and never exceeded those of the parent compound.

Table 7. Residues of metalaxyl-M and NOA 409045 in soils after direct treatment with metalaxyl-M at 1 kg ai/ha.

Period after treatment	Metalaxyl-M, mg/kg			NOA 409045, mg/kg		
						
Kühne (2028/99, 2003)						
Switzerland, plot area 180 sq m. Loam soil - core 0-30 cm: pH 7.4, organic carbon 1.6%, sand 52%, silt 38%, clay 9%						
Days	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm
0	0.65	0.02	0.037	0.056	<0.01	<0.01
2	0.54	0.027	0.040	0.054	<0.01	0.016
4	0.48	0.011	0.012	0.17	0.013	0.015
7	0.22	<0.01	<0.01	0.33	<0.01	<0.01
14	0.038	<0.01	<0.01	0.087	0.10	0.010
21	0.013	<0.01	<0.01	0.011	0.052	0.013
28	<0.01	<0.01	<0.01	<0.01	0.052	<0.01
56	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
128	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
203	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Kühne (2029/99, 2003)						
Switzerland, plot area 240 sq m. Silty clay soil - core 0-30 cm: pH 7.2, organic carbon 5.4%, sand 0.4%, silt 56%, clay 43%						
Days	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm
0	0.68	0.017	0.039	0.015	<0.01	<0.01
2	0.75	0.017	0.043	0.028	<0.01	0.017
4	0.80	0.01	0.012	0.026	<0.01	0.016
7	0.60	<0.01	<0.01	0.12	<0.01	<0.01
14	0.33	0.011	<0.01	0.18	0.01	0.014
21	0.21	<0.01	<0.01	0.22	0.01	0.014
28	0.097	<0.01	<0.01	0.036	0.01	<0.01
56	0.023	<0.01	<0.01	0.020	<0.01	<0.01
128	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
203	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Kühne (2036/98, 2000)						
France, plot area 200 sq m. Silty clay loam - core 0-30 cm: pH 7.4, organic carbon 0.99%, sand 9.6%, silt 59%, clay 32%						
Days	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm
0	0.79	<0.01	<0.01	0.033	<0.01	<0.01
2	0.89	0.037	<0.01	0.026	<0.01	<0.01
4	0.36	<0.01	<0.01	0.056	<0.01	<0.01
7	0.81	<0.01	<0.01	0.11	<0.01	<0.01
14	0.34	<0.01	<0.01	0.098	<0.01	<0.01
21	0.32	<0.01	<0.01	0.17	<0.01	<0.01
28	0.20	<0.01	<0.01	0.15	<0.01	<0.01
56	0.041	<0.01	<0.01	0.050	0.032	0.012
127	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
198	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Kühne (2030/99, 2003)						
France, plot area 200 sq m. Loam soil - core 0-30 cm: pH 7.6, organic carbon 0.75%, sand 30%, silt 51%, clay 19%						
Days	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm
0	0.51	0.015	0.020	0.010	<0.01	<0.01
2	0.41	<0.01	0.011	<0.01	<0.01	<0.01
4	0.39	0.010	0.028	0.013	<0.01	<0.01
7	0.36	<0.01	0.013	0.015	<0.01	<0.01
14	0.29	<0.01	0.027	0.025	<0.01	<0.01
21	0.36	<0.01	0.012	0.032	<0.01	<0.01
28	0.45	<0.01	<0.01	0.054	<0.01	<0.01

Period after treatment	Metalaxyl-M, mg/kg			NOA 409045, mg/kg		
						
55	0.091	0.030	<0.01	0.022	0.010	<0.01
125	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
200	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Kühne (2383/97, 1998)						
Italy, plot area 114 sq m. Sandy loam - core 0-10 cm: pH 7.5, organic carbon 0.57%, sand 58%, silt 28%, clay 14%						
Days	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm
0	0.76	0.017	0.01	0.020	<0.01	<0.01
2	0.85	<0.01	<0.01	0.026	<0.01	<0.01
7	0.47	<0.01	<0.01	0.074	<0.01	<0.01
14	0.54	0.024	<0.01	0.20	0.038	<0.01
21	0.17	0.01	<0.01	0.13	0.067	<0.01
28	0.11	<0.01	<0.01	0.18	0.033	<0.01
57	<0.01	<0.01	<0.01	0.014	0.040	0.01
128	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
203	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Kühne (2027/99, 2003)						
Italy, plot area 500 sq m. Silty clay loam - core 0-30 cm: pH 7.3, organic carbon 1.0%, sand 19%, silt 50%, clay 31%						
Days	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm
0	0.61	0.02	0.02	0.039	<0.01	<0.01
2	0.62	<0.01	0.024	0.028	<0.01	<0.01
4	0.58	0.01	0.017	0.042	<0.01	<0.01
7	0.62	<0.01	0.018	0.038	<0.01	<0.01
14	0.65	<0.01	<0.01	0.091	<0.01	<0.01
21	0.28	0.01	0.01	0.25	0.029	0.013
28	0.21	<0.01	<0.01	0.26	0.01	<0.01
56	0.012	<0.01	<0.01	0.025	<0.01	<0.01
128	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
200	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Kühne (2057/99, 2003)						
Spain, plot area 200 sq m. Loamy sand - core 0-30 cm: pH 7.8, organic carbon 0.68%, sand 82%, silt 5.2%, clay 13%						
Days	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm	soil 0-10 cm	soil 10-20 cm	soil 20-30 cm
0	0.522	0.023	0.025	<0.01	<0.01	<0.01
2	0.487	<0.01	0.014	0.01	<0.01	<0.01
4	0.43	<0.01	0.01	0.01	<0.01	<0.01
7	0.409	<0.01	<0.01	0.029	<0.01	<0.01
14	0.279	<0.01	0.01	0.029	<0.01	<0.01
21	0.254	<0.01	<0.01	0.046	<0.01	<0.01
28	0.056	0.017	0.01	0.016	0.026	0.017
56	0.012	<0.01	<0.01	<0.01	<0.01	<0.01
128	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
200	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Soil (44.7% sand, 31.5% silt, 23.8% clay, 3.1% organic carbon, pH 7.6) from the previously described lettuce metabolism study (Stingelin 2000, 98JS30) was examined for residue composition, including enantiomeric ratios of parent and the major product Metabolite 1 (Table 8). Little of the residue moved below the 10 cm layer. The R-isomer of metalaxyl disappeared more quickly than the S-isomer, leading to a preponderance of R-isomer in Metabolite 1.

Table 8. Comparison of identified components of the residue in soil after treatment of lettuce with [^{14}C]metalaxyl-M and [^{14}C]metalaxyl (Stingelin 2000, 98JS30). Soil samples were taken 1 h and 21 days after the last of 3 treatments at 0.02 kg ai/ha.

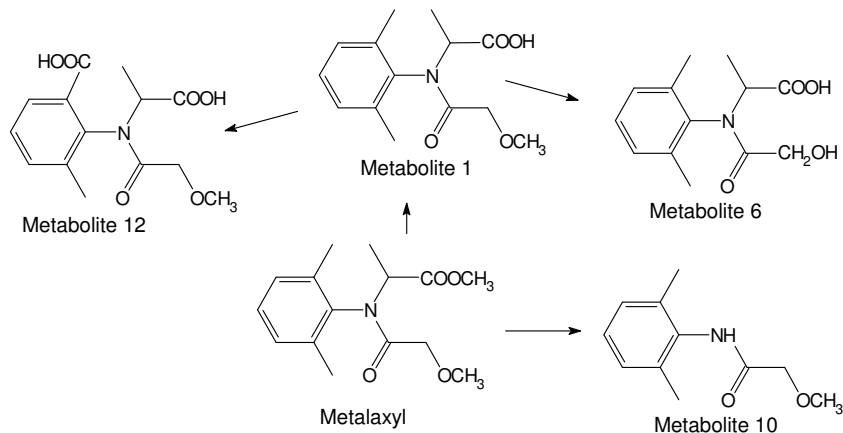
Component	Residues in 0-10 cm soil layer, mg/kg. Enantiomeric ratio (S/R).			
	Metalaxyl-M		Metalaxyl	
	1 h	21 d	1 h	21 d
Total ^{14}C , mg/kg	0.34	0.16	0.41	0.14
Parent	0.062 mg/kg (5.5/94.5)	0.058 mg/kg (7.0/93.0)	0.18 mg/kg (83.6/16.4)	0.081 mg/kg (86.0/14.0)
Metabolite 1	0.16 mg/kg (3.2/96.8)	0.073 mg/kg (3.3/96.7)	0.13 mg/kg (28.4/71.6)	0.044 mg/kg (36.0/64.0)

Soil (31.2% sand, 46.4% silt, 22.4% clay, 2.7% organic matter, pH 6.5) from the previously described potato metabolism study in the USA (Marco 1981, ABR-81037) was similarly examined. Some residue, including parent metalaxyl, moved below the 0-7.5 cm layer.

Table 9. Comparison of identified components of the residue in soil after treatment of potatoes with [^{14}C]metalaxyl (Marco 1981, ABR-81037). Soil samples were taken after the first application and at harvest.

Component	Residues in soil		
	After 1st application	Harvest	
	0-7.5 cm	0-7.5 cm	7.5-15 cm
Total ^{14}C , mg/kg as metalaxyl	0.33	1.7	0.58
Unextractable, % of total ^{14}C	13	37	40
Metalaxyl, % as metalaxyl	87	48	31
Metabolite 6, % as metalaxyl	-	1.6	2.5
Metabolite 1, % as metalaxyl	-	3.3	4.5

Figure 3. Degradation of metalaxyl in soil.



Crop rotation studies

Information on the fate of radiolabelled metalaxyl in confined rotational crops and unlabelled metalaxyl-M in field rotational crops was reported to the Meeting.

The radiolabel studies showed that parent metalaxyl was usually a very minor part of the residue that reached the rotational crop. Identifiable metabolites were also usually very low, but Metabolite 8 was detected as glucose conjugates in spring wheat stalks at 2.3 mg/kg. Metalaxyl-M residues were not detected in the unconfined rotational crops in Switzerland or the UK, but residues of 0.11 mg/kg were present in broccoli and 0.03 mg/kg in lettuce leaves from crops sown 29 days after treatment of the first crop. The short interval was designed to simulate the ploughing in of a failed crop and the sowing of a new one.

The Meeting was provided with residue data from confined crop rotation trials using [¹⁴C]metalaxyl (Table 10). In the earlier trials (1977) only the level of radiolabel was measured in the rotational crops. In the later trials (1989) the residue components were identified (Table 11) as well.

The highest levels of ¹⁴C in the tissue of a rotational crop occurred in the stalks and hulls of spring wheat (ABR-91084). Parent metalaxyl constituted only 0.1% of the ¹⁴C in the stalks, with the glucose conjugates of Metabolite 8 being the major identified component at 32% of the ¹⁴C. Metalaxyl constituted 3.35 and 15% of the radiolabel in sugar beet roots and lettuce foliage respectively.

Table 10. Confined rotational crop studies in the USA.

First crop (state), year, ref.	Application		PHI, days ¹	Crop	TSI ² days	THI ³ days	Sample	¹⁴ C, mg/kg as metalaxyl	Residues, metalaxyl, mg/kg
	Compound	kg ai/ha							
Potatoes (NC), 1977, ABR-78013	[¹⁴ C]metalaxyl	0.55 n=6	1 14 14				tuber tuber soil ⁵	0.090 0.094 <0.003	na na
ABR-78013, ABR-78077				winter wheat	15	50 257 286 313 313	plant plant plant grain straw	4.0 0.36 0.35 0.11 0.56	na na na na na
ABR-78013, ABR-79005				sugar beet	246	292 333 372 372 413 413	plant plant tops roots tops roots	0.16 0.07 0.06 0.03 0.02 0.02	na na na na na na
ABR-78013, ABR-79004				maize	257	295 326 363 413 413 413	plant plant plant stalks cobs grain	0.05 0.06 0.05 0.06 0.02 0.03	na na na na na na
ABR-78013, ABR-79003				soya beans	270	314 341 363 413 413	plant plant plant leaves/ stems beans	0.40 0.81 0.74 0.59 0.17	na na na na na

First crop (state), year, ref.	Application		PHI, days ¹	Crop	TSI ² days	THI ³ days	Sample	¹⁴ C, mg/kg as metalaxyl	Residues, metalaxyl, mg/kg
	Compound	kg ai/ha							
ABR-78013, ABR-79002				spring oats	246	277 294 323 343 343	plant plant plant grain straw	0.33 0.17 0.21 0.09 0.19	na na na na na
ABR-78013, ABR-78078				lettuce	246	292 313 326	leaves leaves leaves	0.11 0.06 0.05	na na na
Tobacco, USA (NC), 1989, BIOL-90017 <i>greenhouse</i>	[¹⁴ C- phenyl]metalaxyl	3.4 on soil	226				soil ⁶ soil ⁷	1.1 0.59	0.18 0.089
BIOL-90017, ABR-91084				lettuce	232	261 292	foliage foliage	0.88 0.56	0.13 na
BIOL-90017, ABR-91084				spring wheat	232	254 279 323 323 323	stalks stalks stalks grain hulls	5.1 2.6 7.2 0.59 7.8	na na 0.007 na na
BIOL-90017, ABR-91084				soya beans	232	261 292 432 432 432	stalks stalks stalks pods beans	2.4 2.7 3.6 1.1 0.40	na na na na na
BIOL-90017, ABR-91084				sugar beet	232	271 307 307 411 411	foliage foliage roots foliage roots	1.1 0.86 0.29 1.1 0.28	na na na na 0.009

na: not analysed.

¹ Pre-harvest interval of first crop.

² Interval between last treatment on first crop and sowing of rotation crop.

³ Interval between last treatment on target crop and sampling or harvest of rotation crop.

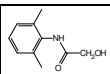
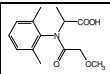
⁴ Concentrations appear to be expressed on fresh weight.

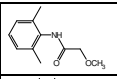
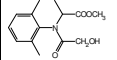
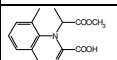
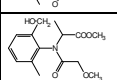
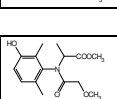
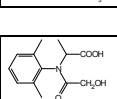
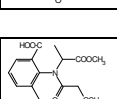
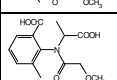
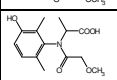
⁵ ¹⁴C in soil, expressed as metalaxyl 14 days after last treatment: 1.8, 0.31 and 0.05 mg/kg for 0-7.5 cm, 7.5-15 cm and 15-22.5 cm respectively.

⁶ 0-7.5 cm.

⁷ 15-20 cm.

Table 11. Compounds identified in tissues of rotation crops sown 232 days after soil treatment with [¹⁴C-phenyl]metalaxyl at 3.4 kg ai/ha for a first crop of tobacco (McFarland 1992, BIOL-9016, BIOL-90017, ABR-91084).

Compound	Sugar beet roots		Lettuce foliage		Spring wheat stalks	
	metalaxyl, mg/kg	% of ¹⁴ C residue	metalaxyl, mg/kg	% of ¹⁴ C residue	metalaxyl, mg/kg	% of ¹⁴ C residue
Metalaxyl	0.009	3.3	0.13	15	0.007	0.1
Metabolite 5					0.086	1.2
Metabolite 5, gluc conj			0.015	1.7	0.31	4.3
Metabolite 1		0.017	6.2		0.086	1.2
Metabolite 1, complex conj		0.053	19			

Compound	Sugar beet roots		Lettuce foliage		Spring wheat stalks			
	metalaxyl, mg/kg	% of ¹⁴ C residue	metalaxyl, mg/kg	% of ¹⁴ C residue	metalaxyl, mg/kg	% of ¹⁴ C residue		
Metabolite 1, gluc conj			0.013	1.5	0.14	2.0		
Metabolite 10		Included with Met 1		0.008	0.9	0.014	0.2	
Metabolite 3					0.007	0.1		
Metabolite 4		0.022	7.9					
Metabolite 8		0.003	1.1	0.004	0.5	0.40	5.6	
Metabolite 8, gluc conj			0.019	2.1	2.3	32		
Metabolite 7				Included with Met 10		0.036	0.5	
Metabolite 7, gluc conj			0.097	11	0.093	1.3		
Metabolite 6		Included with Met 8		0.011	1.3	0.079	1.1	
Metabolite 6, gluc conj			0.003	1.0	0.016	1.8	0.11	1.5
Metabolite 9		0.008	3.0	0.008	0.9	0.14	2.0	
Metabolite 12		0.006	2.1					
CGA-119857						0.029	0.4	
Total			0.28 mg/kg equiv to 100%		0.88 mg/kg equiv to 100%		7.2 mg/kg equiv to 100%	

Simoneaux (1994, ABR-91084 A1) showed that extracts of tissue samples from the 1989 crop rotation study (McFarland 1992, BIOL-9016, BIOL-90017, ABR-91084) were stable stored at approximately -20°C. HPLC profiles of extracts after 3-4 years were similar to those of extracts analysed within 8 months. The stability of parent and metabolites in homogenates of lettuce foliage, wheat stalks and sugar beet roots stored at approximately -20°C for 4.5 to 11.5 months was also indicated, since the HPLC profiles of their extracts were shown to be comparable with profiles from earlier samplings.

Table 12. Residues in unlabelled metalaxyl-M rotational crop studies.

First crop, country, year, ref.	Application				PHI ¹ days	Rotational crop	TSI ² days	THI ³ days	Sample	Residue, metalaxyl-M mg/kg
	Compound	Form	No	kg ai/ha						
Potato (Désirée), Switzerland, 1998 208/98	metalaxyl-M	EC	1	0.70	12 ⁴	barley	29	63	plant	<0.02
								79	plant	<0.02
								93	plant	<0.02
						carrots	29	71	leaves	<0.02
								82	roots	<0.02
								93	roots	<0.02
lettuce	30	51	lettuce	<0.02						
		58	leaves	<0.02						
		65	leaves	<0.02						

First crop, country, year, ref.	Application				PHI ¹ days	Rotational crop	TSI ² days	THI ³ days	Sample	Residue, metalaxyl-M mg/kg
	Compound	Form	No	kg ai/ha						
						cauliflower	27	51 75 82	plant flower head flower head	<0.02 <0.02 <0.02
Potato (Saxon), UK, 1998 209/98	metalaxyl-M	EC	1	0.70	12 ⁴	carrots	29	86 99	plant roots	<0.02 <0.02
						lettuce	29	99	plant	<0.02
						cauliflower	29	59 99	plant leaves	<0.02 <0.02
						wheat	29	86 99	plant plant	<0.02 <0.02
Potato (Primura), Italy, 1998 210/98	metalaxyl-M	EC	1	1.0	8 ⁴	lettuce	29	50 56 71	plant leaves leaves	0.04 0.03 <0.02
						broccoli	29	53 89 98	plant flower head flower head	0.11 <0.02 <0.02
						barley	29	89 124 141	plant plant plant	<0.02 <0.02 <0.02
						carrots	29	89 98 124	plant roots roots	<0.02 <0.02 <0.02

¹ Pre-harvest interval of first crop.

² Interval between treatment on first crop and sowing of rotation crop.

³ Interval between treatment on first crop and sampling or harvest of rotation crop.

⁴ In trials 208/98 and 209/98 potatoes were ploughed in 12 days after application simulating crop loss before replanting, and in trial 210/98 8 days after application.

RESIDUE ANALYSIS

Analytical methods

The Meeting received validation data and details of analytical methods used for the determination of residues of metalaxyl in plant material, animal tissues, milk and eggs.

Common moiety methods rely on determination of the 2,6-dimethylaniline moiety of metalaxyl and many of its metabolites, and in particular have been used for animal commodities. Typical LOQs are 0.05 and 0.01 mg/kg for tissues and milk respectively. Metabolite 8, containing the 2-hydroxymethyl-6-methylaniline moiety, is apparently partially converted to 2,6-dimethylaniline and produces low and variable recoveries.

GLC-NPD and HPLC-MSD procedures for metalaxyl or metalaxyl-M after a simple extraction and limited clean-up achieve LOQs of 0.02-0.04 mg/kg for many crop substrates. A modification with the introduction of an HPLC chiral separation before the determination allows analysis for specific enantiomers.

The methods used in the studies are summarized below in chronological order, and recoveries are shown in Table 13.

Method DFG S19 is a multi-residue regulatory method suitable for metalaxyl, and Method REM 181.06 although not multi-residue is enantioselective and suitable as a regulatory method for metalaxyl-M.

Animal tissues, milk and eggs (Balasubramanian 1980, AG-349).

Analyte:	2,6-dimethylaniline	GLC-AFID or GLC-MS	AG-349
LOQ:	milk 0.01 mg/kg; muscle, fat tissues, eggs 0.05 mg/kg; liver and kidney 0.1 mg/kg		
Description	Samples are extracted with acetonitrile or acetonitrile/water, except fat samples, which are extracted with hexane. The extract is cleaned up by solvent partitioning and, after solvent evaporation, is refluxed with phosphoric acid in the presence of cobalt chloride. The solution is made alkaline and the resulting 2,6-dimethylaniline is steam distilled and derivatised with trichloroacetyl chloride for GLC determination		

Poultry tissues (Eudy 1991, AG-576)

Analyte:	2,6-dimethylaniline	capillary GLC-NPD	AG-576
LOQ:	0.05 mg/kg as metalaxyl equivalents		
Description	Samples are extracted with acetonitrile or acetonitrile/water, except fat samples, which are extracted with hexane. The extract is cleaned up by solvent partitioning and, after solvent evaporation, is refluxed with aqueous methanesulfonic acid. The solution is made alkaline and the resulting 2,6-dimethylaniline is steam distilled and cleaned up with a silica clean-up cartridge for capillary GLC-NPD determination		

Plant material (Kühne 1995, REM 181.01)

Analyte:	metalaxyl-M or metalaxyl	GLC-NPD	REM 181.01
LOQ:	0.02 mg/kg		
Description	Homogenized samples are extracted with methanol, the extract is diluted with water and the residue is partitioned into dichloromethane. Clean-up is by normal-phase preparative HPLC. GLC with NPD is used for the final determination. GC-MS is needed for confirmation. Method REM 181.01 is not enantioselective.		

Grapes, grape juice, wine (Adams, 1998, 261B.00)

Analyte:	metalaxyl	GLC-NPD	261B.00
LOQ:	0.02 mg/kg		
Description	Homogenized samples of grapes are extracted with methanol. The extract is diluted with saturated sodium chloride + water and the residue is partitioned into dichloromethane. Juice or wine is diluted with water and extracted with ethyl acetate. Clean-up is on a small chromatography column. The eluate is evaporated and the residue taken up in ethyl acetate for GLC with NP detection. Method 261B.00 is not enantioselective.		

Onions (Kühne 1998, 2338/97)

Analyte:	metalaxyl-M	GLC-MSD	DFG S19
LOQ:	0.02 mg/kg		
Description	Samples are extracted with acetone. Water is added before extraction to maintain a water:acetone ratio of 2:1. The residue is partitioned into ethyl acetate + cyclohexane and cleaned up by gel permeation chromatography on a polystyrene gel. The relevant fraction is collected and analysed by capillary GLC with MSD. Selected ions: m/z 249 for quantification and m/z 206 and 192 for verification. Method DFG S19 is not enantioselective.		

Plant material (Kühne 1999, 517/99)

Analyte:	metalaxyl-M	LC-MS/MS	REM 181.01
LOQ:	0.02 mg/kg		
Description	Samples are thoroughly extracted with methanol. No clean-up is required. A 1 ml aliquot of filtered crude extract is diluted with HPLC water containing 0.2% formic acid ready for LC-MS/MS analysis. The HPLC is a 2-column switching system. For detection the diagnostic masses are the parent ion (M+H) at m/z 280 and a product ion at m/z 220. Method REM 181.01 is not enantioselective.		

Lettuce (Weber and Pelz 2000, NOV-0015)

Analyte:	metalaxyl-M	GLC-MSD	L 00.00-34
LOQ:	0.02 mg/kg		
Description	Method L 00.00-34 is almost the same as DFG S19, the only difference being that the selected ions are m/z 206 for quantification and m/z 192 and 249 for verification. The method is not enantioselective.		

Plant material, orange, potato, rape seed, tomato, wheat (Kühne 2001, REM 181.06)

Analyte: metalaxyl-M
 LOQ: 0.02 mg/kg
 Description: Homogenized samples are extracted with methanol. An aliquot of the extract is evaporated to dryness and the residue taken up in water-methanol. Clean-up is by a C-18 cartridge and preparative HPLC. Chiral separation is on a preparative HPLC system before GLC-MSD determination (m/z 206, 220, 234, 249, 279) of the metalaxyl enantiomers from the relevant HPLC fractions.

REM 181.06

Yokley (1991, ABR-91008) tested the precision of method AG-576 by analysing quadruplicate samples of eight different goat or poultry commodities. The mean relative standard deviation was 0.18. Tissue, egg and milk samples from the metabolism studies were analysed for comparison with the ¹⁴C measurements, but interpretation was difficult because the common moiety method would not have included metabolites where parts of the 2,6-dimethylaniline had been oxidised or hydroxylated. The results of these and other recovery experiments are shown in Table 13.

Table 13. Analytical recoveries of metalaxyl or metalaxyl-M in from various spiked substrates. Metalaxyl was used in testing the common moiety method in ABR-81014 and ABR-91008.

Commodity	Analyte	Spike conc, mg/kg	no.	Mean recov., %	Recov., % range	Method	Ref.
Fat	common moiety	0.05-0.5	4	69	50-87	AG-349	ABR-81014
Kidney	common moiety	0.1-0.5	4	56	44-61	AG-349	ABR-81014
Liver	common moiety	0.1-0.2	9	68	44-103	AG-349	ABR-81014
Milk	common moiety	0.01	4	64	52-71	AG-349	ABR-81014
Milk	common moiety	0.02	4	70	56-76	AG-349	ABR-81014
Milk	common moiety	0.105	2	63	60, 65	AG-349	ABR-81014
Muscle	common moiety	0.05-0.1	4	80	64-100	AG-349	ABR-81014
Eggs	common moiety	0.05, 0.3	3	90	87-93	AG-576	ABR-91008
Goat leg muscle	common moiety	0.05, 0.2	3	94	88-104	AG-576	ABR-91008
Goat liver	common moiety	0.05, 2.0	3	73	52-101	AG-576	ABR-91008
Goat milk	common moiety	0.01, 0.05	3	112	88-159	AG-576	ABR-91008
Goat omental fat	common moiety	0.05, 0.07	3	101	83-127	AG-576	ABR-91008
Poultry breast	common moiety	0.05, 0.5	3	93	75-115	AG-576	ABR-91008
Poultry liver	common moiety	0.05, 1.5	3	135	103-194	AG-576	ABR-91008
Poultry skin+fat	common moiety	0.05, 0.5	3	88	82-96	AG-576	ABR-91008
Beef liver	metabolite 1, common moiety	0.05-0.5	5	72	23-97	AG-576	ABR-96108
Eggs	metabolite 1, common moiety	0.05-0.5	5	56	52-59	AG-576	ABR-96108
Poultry muscle	metabolite 1, common moiety	0.05-0.5	5	97	80-116	AG-576	ABR-96108
Poultry skin + fat	metabolite 1, common moiety	0.05-0.5	5	0.2	0-1	AG-576 ¹	ABR-96108
Beef liver	metabolite 8, common moiety	0.05-0.5	5	40	11-84	AG-576	ABR-96108
Eggs	metabolite 8, common moiety	0.05-0.5	5	54	21-109	AG-576	ABR-96108
Poultry muscle	metabolite 8, common moiety	0.05-0.5	5	56	45-66	AG-576	ABR-96108
Poultry skin + fat	metabolite 8, common moiety	0.05-0.5	5	8.4	7-11	AG-576 ¹	ABR-96108
Grape juice, wine	metalaxyl	0.02-0.1	14	95	78-128	261B.00	261B.00
Grapes	metalaxyl	0.02-5	21	95	72-118	261B.00	261B.00
Lemon fruits, peel, pulp	metalaxyl	0.04-0.8	10	100	79-117	REM 16/76 ²	517/99
Orange fruits, peel, pulp	metalaxyl	0.04-0.8	26	105	81-132	REM 16/76 ²	517/99
Sunflower seeds	metalaxyl	0.04-0.4	2	96	92, 100	REM 16/76 ²	519/99
Oranges	metalaxyl ³	0.02-0.2	10	85	70-101	REM 181.06	212/00
Potatoes	metalaxyl ³	0.02-0.2	10	94	76-104	REM 181.06	212/00

Commodity	Analyte	Spike conc, mg/kg	no.	Mean recov., %	Recov., % range	Method	Ref.
Rapeseed	metalaxyl ³	0.02-0.2	10	90	81-94	REM 181.06	212/00
Tomatoes	metalaxyl ³	0.02-0.2	10	89	65-105	REM 181.06	212/00
Wheat	metalaxyl ³	0.02-0.2	10	100	90-109	REM 181.06	212/00
Lettuce	metalaxyl-M	0.02-4	10	98	84-114	L00.00-34	
Orange fruits, peel, pulp	metalaxyl-M	0.02-4	29	93	81-108	REM 181.01	517/99
Cotton seeds, hulls	metalaxyl-M	0.02-0.4	4	92	85-99	REM 181.01	518/99
Grapes	metalaxyl-M	0.02, 0.2	6	104	96-107	REM 181.01	REM 181.01
Potato tubers	metalaxyl-M	0.02, 0.2	6	101	84-112	REM 181.01	REM 181.01
Tomatoes	metalaxyl-M	0.02, 0.2	19	99	90-114	REM 181.01	REM 181.01
Mandarin fruits, peel, pulp	metalaxyl-M	0.02-0.4	24	98	85-111	REM 181.01 ⁴	517/99
Orange fruits, peel, pulp	metalaxyl-M	0.02-0.4	12	94	83-106	REM 181.01 ⁴	517/99
Cotton seeds, hulls	metalaxyl-M	0.02-0.4	8	99	89-107	REM 181.01 ⁴	518/99
Sunflower seeds	metalaxyl-M	0.02-0.2	4	91	83-103	REM 181.01 ⁴	519/99
Tomatoes	metalaxyl-M	0.02-0.2	6	93	90-98	REM 181.06	212/00
Oranges	metalaxyl-M ⁵	0.02-0.2	10	81	64-107	REM 181.06	NOV/MET/00111
Rapeseed	metalaxyl-M ⁵	0.02-0.2	10	82	70-91	REM 181.06	NOV/MET/00111
Tomatoes	metalaxyl-M ⁵	0.02-0.2	10	103	86-114	REM 181.06	NOV/MET/00111

¹ The extraction solvent, hexane, does not extract the compound from fat.

² REM 16/76 is the same procedure as REM 181.01, but used for metalaxyl.

³ Samples spiked with metalaxyl, analytical results for the R-isomer (metalaxyl-M). Analytical recoveries for the S-isomer were similar, but are not recorded here.

⁴ REM 181.01 with LC-MS-MS finish.

⁵ Parallel recoveries with the S-isomer gave similar results, but are not recorded here.

Stability of residues in stored analytical samples

The Meeting received information on the stability of metalaxyl-M residues in crop and animal commodities during storage of analytical samples (Tables 14 and 15).

Metalaxyl-M residues were stable in the substrates and under the conditions and period of storage. There was no evidence of epimerization during freezer storage. A common moiety method was used for the animal commodity samples, so the storage stability refers to the total residue rather than parent metalaxyl-M. The common moiety method is not suitable for Metabolite 8 (low and variable recoveries) so the stability of this metabolite during storage was not demonstrated.

Kühne (201/01, 2003) tested the storage stability of metalaxyl-M residues in wheat, tomatoes, rape seed, oranges and potatoes to represent respectively cereals and other dry crops, commodities with high water content, commodities with high fat content, fruits with high acid content and starch-containing commodities. The homogenised and fortified samples were stored in polyethylene containers or plastic bags at or below -18°C. Periodically, analytical subsamples were analysed by the enantioselective method REM 181.06 (

Table 14). Metalaxyl-M was stable in samples throughout the two years; it was neither degraded nor converted to the S-isomer.

Table 14. Freezer storage stability of metalaxyl-M in spiked oranges, potatoes, rape seed, tomatoes and wheat (Kühne, 201/01, 2003).

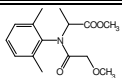
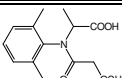
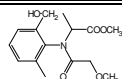
Months stored	Metalaxyl-M		S isomer		Metalaxyl-M		S isomer	
	Procedural recov %	Conc., mg/kg ¹	Procedural recov %	Conc., mg/kg ¹	Procedural recov %	Conc., mg/kg ¹	Procedural recov %	Conc., mg/kg ¹
	Oranges				Potatoes			
0	96 101	0.44	93 87	0.018	105 100	0.43	93 93	0.019
1	95 94	0.45	93 93	0.017	98 95	0.45	107 107	0.020
3	97 99	0.42	93 100	0.017	102 102	0.42	100 100	0.019
6	88 87	0.42	87 93	0.016	90 91	0.39	93 93	0.017
12	90 93	0.49	100 100	0.019	100 98	0.41	113 113	0.019
18	86 93	0.41	67 60	0.016	92 90	0.41	73 67	0.018
24	93 92	0.41	133 133	0.018	94 91	0.40	140 127	0.020
	Rape seed				Tomatoes			
0	105 93	0.43	93 87	0.020	108 103	0.47	93 93	0.019
1	88 93	0.43	93 83	0.018	102 101	0.56	100 100	0.023
3	102 103	0.46	100 100	0.020	100 102	0.43	93 100	0.017
6	87 85	0.41	87 87	0.017	87 96	0.52	93 93	0.021
12	92 93	0.47	93 93	0.018	105 97	0.51	113 113	0.023
18	96 91	0.43	67 67	0.018	91 92	0.46	73 73	0.022
24	86 83	0.38	93 93	0.014	101 95	0.48	133 120	0.019
	Wheat							
0	99 98	0.44	87 87	0.019				
1	96 94	0.45	93 100	0.019				
3	101 99	0.45	93 100	0.019				
6	92 91	0.40	93 93	0.017				
12	98 92	0.36	100 100	0.015				
18	92 88	0.39	73 73	0.018				
24	93 93	0.50	120 120	0.019				

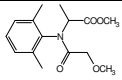
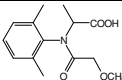
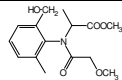
¹ Residue concentrations unadjusted for recoveries are means of triplicate analyses for storage periods of 1-24 months and of quintuplicate analyses at time zero.

Gruenwald (ABR-98053, 1998) tested the freezer storage stability of metalaxyl-M, Metabolite 1 and Metabolite 8 in beef muscle, beef liver, milk and eggs under frozen conditions at approximately -20°C for 2 years (Table 15). Samples were analysed by method AG-576, a common moiety method that determines the total residue of metalaxyl-M and metabolites containing the 2,6-dimethylaniline moiety.

Total residues of metalaxyl-M were stable in the animal commodities in freezer storage for 22 months. Residues of Metabolite 1 were also generally stable, but the results for eggs are questionable because of poor recoveries. The method mostly produced poor recoveries for Metabolite 8, so it is difficult to conclude whether the residues are stable or unstable.

Table 15. Freezer storage stability of metalaxyl-M and metabolites in animal commodities (Gruenwald, ABR-98053, 1998). Samples were analysed by common moiety method AG-576 (concentrations unadjusted for procedural recoveries).

Metalaxyl-M			Metabolite 1			Metabolite 8 ²		
								
Storage, days	Procedural recov %	Conc., mg/kg ¹	Storage, days	Procedural recov %	Conc., mg/kg ¹	Storage, days	Procedural recov %	Conc., mg/kg ¹
BEEF MUSCLE								
0	89 92 76	1.71	0	80 78 77	1.46	0	56 58 54	2.56
97	85 84	1.55	86	79 75	1.44	86	60 38	2.63

Metalaxyl-M			Metabolite 1			Metabolite 8 ²		
								
Storage, days	Procedural recov %	Conc., mg/kg ¹	Storage, days	Procedural recov %	Conc., mg/kg ¹	Storage, days	Procedural recov %	Conc., mg/kg ¹
180	80 85	1.68	183	77 80	1.32	183	56 58	2.77
382	90 86	1.67	360	84 85	1.66	360	52 51	2.50
543	87 77	1.74	546	86 79	1.57	567	33 41	2.80
657	81 76	1.44	701	88 83	1.58	701	30 35	1.53
BEEF LIVER								
0	81 92 86	1.84	0	56 57 77	1.43	0	21 20 29	1.36
96	84 85	1.80	89	75 71	1.44	89	28 23	1.18
181	85 86	1.66	187	74 76	1.47	187	20 28	1.27
382	96 96	1.87	365	79 80	1.64	365	24 26	1.23
545	99 85	1.77	550	86	1.72	550	22 22	1.03
656	80	1.44	705	89 86	1.64	705	19 23	0.72
MILK								
0	61 66 72	1.43	0	81 77 70	1.49	0	72 64 64	3.24
98	80 80	1.60	98	118 70	1.84	98	57 61	3.17
181	71 69	1.45	196	56 58	1.18	196	53 52	2.33
377	90 98	1.84	368	66 64	1.28	368	44 44	2.37
541	81 86	1.82	578	87 80	1.59	588	35 26	1.58
653	79 81	1.80	711	81 65	1.48	711	43 36	0.86
EGGS								
0	76 79 85	1.56	0	48 51 50	1.02	0	50 56 53	2.73
94	85 93	1.62	86	50 51	1.05	86	49 44	2.31
185	81 87	1.73	183	50 51	1.06	183	27 23	0.90
386	98 87	1.93	359	52 47	1.01	359	48 50	2.07
548	82 90	1.73	546	48	0.98	546	27 24	0.90
671	77 75	1.56	703	55 55	1.08	703	27 19	0.93

¹ Residues, unadjusted for recoveries, are means of triplicate analyses at time 0 and of duplicate analyses at other intervals.

² Yokley (ABR-91008, 1991) reported that Metabolite 8 is converted to 2,6-dimethylaniline during the refluxing step with aqueous methanesulfonic acid in Method AG-576.

USE PATTERN

Metalaxyl-M is registered for use on fruit, nut and vegetable crops for control of various fungal diseases such as *Phytophthora* and *Pythium* spp applied to foliage, soil or seed and as a post-harvest fruit treatment. The details are shown in Table 16.

Table 16. Registered uses of metalaxyl-M. Labels were provided for all listed uses.

Crop	Country	Formulation	Method	Timing	Rate kg ai/ha	Spray conc ka ai/hl	No.	PHI, days
Citrus	Israel	EC 480	post-harvest			0.10	1	
Citrus	Italy	EC 480	drench		0.48-0.96 g ai/sq m at plant base		1	30
Cocoa	Côte d'Ivoire	WP 60 (+copper 600)	foliar		0.012	0.02-0.03	4	28
Grapes	Australia	WP 50 (+copper 390)	foliar		0.11	0.011	4	7
Grapes	Greece	WP 25 (+copper 400)	foliar		0.05-0.10		4	15

Crop	Country	Formulation	Method	Timing	Rate kg ai/ha	Spray conc ka ai/hl	No.	PHI, days
Grapes	Greece	WP 40 (+mancozeb 640)	foliar		0.05-0.10		4	15
Grapes	Uruguay	WP 40 (+mancozeb 640)	foliar		0.10	0.05	4	14
Lettuce	Israel	WG 40 (+mancozeb 640)	foliar		0.12		3	14
Lettuce	Germany	WG 50 (+folpet 400)	foliar		0.097		2	21
Lettuce	Spain	WP 40 (+mancozeb 640)	foliar		0.10		3	14
Onion	Ecuador	WP 40 (+mancozeb 640)	foliar		0.10-0.12		3	7
Onion	Germany	WG 50 (+folpet 400)	foliar		0.097		3	21
Onion	Israel	WG 40 (+mancozeb 640)	foliar		0.12		3	7
Onion	Uruguay	WP 40 (+mancozeb 640)	foliar		0.10	0.05	3	7
Peppers	Spain	GR 25	soil		0.75		3	15
Peppers, sweet	Australia	GR 25	soil	pre-transplant	1.0		1	7
Peppers, sweet	Italy	EC 480	soil		0.96		3	15
Peppers, sweet	Italy	GR 25	soil		1.00		3	15
Pome fruit	Italy	EC 480	drench		0.48-0.96 g ai/sq m at plant base		2	28
Pome fruit	Italy	GR 25	soil		approx 2-4 g ai/tree		1	30
Pome fruit	Spain	GR 25	soil		0.5 - 1 g ai/tree		2	15
Potato	Algeria	WP 40 (+mancozeb 640)	foliar		0.10		3	7
Potato	Australia	GR 25	soil	at sowing	0.50		1	
Potato	Australia	WP 40 (+mancozeb 640)	foliar		0.10		3	7
Potato	Austria	WG 40 (+mancozeb 640)	foliar		0.10		4	14
Potato	Chile	WP 40 (+mancozeb 640)	foliar		0.10		3	7
Potato	Ecuador	WP 40 (+mancozeb 640)	foliar		0.10-0.12		3	7
Potato	Greece	WP 25 (+copper 400)	foliar		0.10		3	28
Potato	Greece	WP 40 (+mancozeb 640)	foliar		0.10		3	28
Potato	Israel	WG 40 (+mancozeb 640)	foliar		0.12		3	7
Potato	Morocco	WG 40 (+mancozeb 640)	foliar		0.10		4	15
Potato	Uruguay	WP 40 (+mancozeb 640)	foliar			0.01	3	14
Spinach	Chile	WP 40 (+mancozeb 640)	foliar		0.10		3	10
Spinach	Italy	WP25 (+copper 400)	foliar		0.10		3	20
Spinach	Switzerland	WG 40 (+mancozeb 640)	foliar		0.10		6	14
Sunflower	China	ES 350	seed treatment		0.035-0.105 kg ai/100 kg seed			
Sunflower	Serbia and Montenegro	ES 350	seed treatment		0.105 kg ai/100 kg seed			
Tomato	Algeria	WP 40 (+mancozeb 640)	foliar		0.14		3	3
Tomato	Australia	GR 25	soil	pre-transplant	0.50-1.0		2	
Tomato	Chile	WP 40 (+mancozeb 640)	foliar		0.10		4	3
Tomato	Ecuador	WP 40 (+mancozeb 640)	foliar		0.10-0.12		3	3
Tomato	Greece	WP 25 (+copper 400)	foliar		0.05-0.14		3	3
Tomato	Greece	WP 40 (+mancozeb 640)	foliar		0.06-0.14		3	3
Tomato	Israel	WP 40 (+mancozeb 640)	foliar		0.12		3	5
Tomato	Morocco	WG 40 (+mancozeb 640)	foliar		0.14		4	3
Tomato	Uruguay	WP 40 (+mancozeb 640)	foliar			0.014	4	3

RESIDUES RESULTING FROM SUPERVISED TRIALS

The Meeting received information on supervised field trials with metalaxyl-M on the following crops.

Citrus fruits in Israel.	Table 18
Apples in France, Italy and Spain.	Table 19
Grapes in Australia, Germany, Italy, Portugal and Switzerland.	Table 20
Onions in Brazil, Italy, Spain and Switzerland.	Table 21
Tomatoes in France, Spain and Switzerland.	Table 22
Peppers in Italy and Spain.	Table 23
Lettuce in France, Germany, Italy, The Netherlands, Spain and Switzerland.	Table 24
Spinach in France, Germany and Switzerland.	Table 25
Potatoes in Brazil, Germany, Switzerland and the UK.	Table 26
Sunflowers in France and Spain.	Table 27
Cocoa in Côte d'Ivoire.	Table 28

Trials were well documented with laboratory and field reports. Laboratory reports included method validation, including procedural recoveries with spiking at residue levels similar to those occurring in samples from the supervised trials. Dates of analyses or duration of residue sample storage were also provided. Although trials included control plots, control data are only recorded in the Tables where residues exceeded the LOQ. Residues are unadjusted for recoveries.

When residues were undetected they are shown as below the LOQ (e.g. <0.02 mg/kg). Residues, application rates and spray concentrations have generally been rounded to two significant figures or, for residues near the LOQ, to one significant figure. Residues from the trials conducted according to maximum GAP have been used for the estimation of maximum levels. Residue trials at exaggerated application rates have also been included when residues did not exceed the LOQ. Those results included in the evaluation are double underlined.

Conditions of the supervised residue trials are shown in Table 17. In most trials unreplicated plots were used, and details of sprayers used, plot size, sample size and sampling dates are given when reported.

Periods of frozen storage between sampling and analysis were recorded for all trials and were covered by the conditions of the freezer storage stability studies.

In some trials, residues were measured on samples taken just before the last application as well as just after (the "zero day" samples). The samples taken just before the last application are listed in the Tables as having one fewer application and with a PHI equivalent to the interval between the penultimate and last applications. They provide information on carry-over from previous applications.

Table 17. Sprayers, plot and field sample sizes in the supervised trials. Almost all trials were with unreplicated single plots.

Crop	Country	Year	Application method	Plot	Sample
Apple	France	1997	manual application on soil	16-20 m ²	2 kg
Apple	Italy	2000	soil drench in root zone	50-140 m ²	12 fruits
Apple	Spain	1997	manual application on soil	20-50 m ²	2.1-3.4 kg
Cocoa	Côte d'Ivoire	2000, 2001	motorised knapsack	1000 m ²	12-68 kg pods
Grapes	Australia	1998	backpack CO ₂ , orchard pump sprayer	2-8 panels	0.5-1 kg

Crop	Country	Year	Application method	Plot	Sample
Grapes	Germany	1994, 1997	high-volume plot sprayer	250-300 m ²	1.3-2.8 kg
Grapes	Italy	1994, 1997	knapsack, motor sprayer	36-250 m ²	2.2-2.9 kg
Grapes	Portugal	1997	knapsack	250 m ²	12 bunches
Grapes	Switzerland	1997	knapsack with lance	151 m ²	0.9-1.2 kg
Lettuce	France	1997-2000	knapsack with boom	30-50 m ²	2.1-11 kg
Lettuce	Germany	1997-2000	mobile plot sprayer, boom sprayer	30-80 m ²	0.5-4.5 kg
Lettuce	Italy	1997-1999	knapsack with boom, knapsack sprayer	20-40 m ²	1-2.8 kg
Lettuce	Netherlands	1999	compressed air sprayer	45 m ²	0.34-5.8 kg
Lettuce	Spain	1999	motorised knapsack sprayer	50 m ²	1.5 kg
Lettuce	Switzerland	1999	knapsack with boom, knapsack sprayer	18 m ²	0.9-2.4 kg
Onion	Brazil	1997	CO ₂ sprayer	20 m ²	2 kg
Onion	Italy	1997, 1998	knapsack sprayer	20-50 m ²	12 bulbs
Onion	Spain	1997	knapsack sprayer	20-50 m ²	1-3.9 kg
Onion	Switzerland	1997	knapsack with boom	24-31.5 m ²	0.4-2.5 kg
Orange	Spain	1999	motorised knapsack	12 trees	500 kg
Peppers, sweet	Italy	1997	manual on soil	20-86 m ²	1.6-3.5 kg
Peppers, sweet	Spain	1998-2000	manual on soil	25-45 m ²	1.3-3.5 kg
Potatoes	Brazil	1997	CO ₂ sprayer	40 m ²	2 kg
Potatoes	Germany	1995, 1996	plot sprayer	30 m ²	2-3 kg
Potatoes	Switzerland	1998	knapsack with boom	22.5-60 m ²	3-4 kg
Potatoes	UK	1994, 1995	precision plot sprayer	40-60 m ²	6-24 tubers
Spinach	France	1997, 1999	knapsack with boom, hand-carried boom with flat fan	75-80 m ²	0.9-1.2 kg
Spinach	Germany	1998	boom sprayer	75 m ²	0.5-0.8 kg
Spinach	Switzerland	1999	knapsack with boom	24-30 m ²	0.6-2.5 kg
Sunflowers	France	1998, 1999	seed treatment	45-90 m ²	1-1.7 kg
Sunflowers	Spain	1998, 1999	seed treatment	53-54 m ²	1.1 kg
Tomatoes	France	1997-2001	knapsack with boom	20-30 m ²	1.9-4.4 kg
Tomatoes	Spain	1997, 1998	motorised knapsack	12-99 m ²	2-3 kg
Tomatoes	Switzerland	1997-2001	knapsack with lance	8-18 m ²	12 fruits

Table 18. Metalaxyl-M residues from oranges in supervised trials in Israel in 1997 with post-harvest uses of metalaxyl-M.

ORANGES ¹ (variety)	Application			Commodity ²	Metalaxyl-M, mg/kg			Ref.
	Form	kg ai/hl	spray l/100 kg fruit		Pulp	Peel	Whole fruit calc from pulp and peel	
(Valencia)	EC 480	0.096	0.22	large fruit (275 g)	<0.02	3.4	1.7	2325/97
				small fruit (125 g)	<0.02	3.2	1.7	
				large fruit (250 g)	<0.02	2.3	1.1	
				small fruit (125 g)	<0.02	3.9	1.9	
				large fruit (240 g)	<0.02	3.7	1.8	
				small fruit (160 g)	<0.02	3.1	1.6	
							mean <u>1.6</u>	
(Valencia)	EC 480	0.096	0.22	fruit (310 g)	<0.02	2.2	1.0	2326/97
				fruit (150 g)	<0.02	2.4	1.2	
				fruit (300 g)	<0.02	2.0	0.94	
				fruit (275 g)	<0.02	2.2	1.1	
				fruit (160 g)	<0.02	2.8	1.4	
				fruit (160 g)	<0.02	2.5	1.3	
							mean <u>1.2</u>	

ORANGES ¹ (variety)	Application			Commodity ²	Metalaxyl-M, mg/kg			Ref.
	Form	kg ai/hl	spray l/100 kg fruit		Pulp	Peel	Whole fruit calc from pulp and peel	
	EC 480	0.096	0.22	fruit (275 g) fruit (160 g) fruit (260 g) fruit (160 g) fruit (250 g) fruit (170 g)	<0.02 <0.02 <0.02 <0.02 <0.02 <0.02	2.6 2.6 2.4 2.7 2.0 2.6	1.3 1.4 1.2 1.3 1.0 1.3 mean <u>1.3</u>	2327/97

¹ 400 ml formulation was mixed with a commercial wax to produce 200 l of spray solution, sufficient for approximately 90 tonnes of fruit (theoretical concentration of residue 2.1 g/tonne). The solution was sprayed onto the fruit in a single layer on a conveyor belt with rotating brushes to distribute the wax evenly on the fruit surface. Six sequential samples were taken during the 30-min treatment, each consisting of 4, 8 or 12 fruits. The mean weight of a fruit is recorded.

² Mean weight of an orange in parentheses.

Table 19. Metalaxyl-M residues in apples from supervised trials in France, Italy and Spain.

APPLES country, year (variety)	Application			PHI days	Residues, mg/kg metalaxyl-M	Ref.
	Form	kg ai/ha	No.			
France, 1997 (Golden)	GR	10.0 soil treatment	1 2	31	<0.02	124/97 2139/97
				0	<0.02	
				7	<0.02	
				14	< <u>0.02</u>	
				21	<0.02	
France, 1997 (Golden)	GR	10.0 soil treatment	1 2	30	<0.02	124/97 2140/97
				0	<0.02	
				7	<0.02	
				14	< <u>0.02</u>	
				21	<0.02	
Italy, 2000 (Imperatore, Morgenduft)	EC	10 soil treatment	2	31	< <u>0.02</u>	2081/00
Italy, 2000 (Stark Spur Red)	EC	10 soil treatment	2	30	< <u>0.02</u>	2082/00
Spain, 1997 (Golden Delicious)	GR	0.78 soil treatment	1 2	124	<0.02	2015/97
				3	<0.02	
				7	<0.02	
				14	<0.02	
				21	< <u>0.02</u>	
Spain, 1997 (Golden)	GR	1.9 soil treatment	1 2	113	<0.02	2016/97
				0	<0.02	
				3	<0.02	
				7	<0.02	
				14	< <u>0.02</u>	
21	<0.02					

Table 20. Metalaxyl-M residues in grapes and grape commodities from supervised trials in Australia, Germany, Italy, Portugal and Switzerland.

GRAPES country, year (variety)	Application					PHI, days	Commodity	Residues, mg/kg metalaxyl-M ¹	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.				
Australia (NSW), 1998 (Cabernet Sauvignon)	WP includes copper hydroxide	0.11		900 -1100	5 6	8 0 1 3 7	grapes	0.04 0.44 0.16 0.15 <u>0.06</u>	98/7/1615
Australia (NSW), 1998 (Cabernet Sauvignon)	WP includes copper hydroxide	0.22		900 -1100	5 6	8 0 1 3 7	grapes	0.12 0.98 0.76 0.36 0.20	98/7/1615
Australia (SA), 1998 (Cabernet Sauvignon)	WP includes copper hydroxide	0.11	0.013	853	5 6	7 0 1 3 7 7 7	grapes grape juice wine	0.03 0.14 0.05 0.04 <u><0.02</u> <u><0.02</u> 0.02	98/7/1615
Australia (SA), 1998 (Cabernet Sauvignon)	WP includes copper hydroxide	0.22	0.026	853	5 6	7 0 1 3 7 7 7	grapes grape juice wine	0.04 0.14 0.12 0.08 0.08 0.02 0.04	98/7/1615
Australia (SA), 1998 (Cabernet Sauvignon)	WP includes copper hydroxide	0.11	0.041	274	5 6	7 0 1 3 7 7 7	grapes grape juice wine	0.06 0.10 0.10 0.06 <u>0.03</u> <u><0.02</u> 0.03	98/7/1615
Australia (SA), 1998 (Cabernet Sauvignon)	WP includes copper hydroxide	0.22	0.082	274	5 6	7 0 1 3 7 7 7	grapes grape juice wine	0.05 0.14 0.08 0.10 0.10 0.03 0.05	98/7/1615
Australia (Vic), 1998 (Chardonnay)	WP includes copper hydroxide	0.11	0.012	947	5 6	7 0 1 3 7	grapes	0.11 0.30 0.18 0.16 <u>0.14</u>	98/7/1615
Australia (Vic), 1998 (Chardonnay)	WP includes copper hydroxide	0.22	0.024	947	5 6	7 0 1 3 7	grapes	0.18 0.41 0.41 0.34 0.28	98/7/1615

GRAPES country, year (variety)	Application					PHI, days	Commodity	Residues, mg/kg metalaxyl-M ¹	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.				
Australia (Vic), 1998 (Riesling)	WP includes copper hydroxide	0.22	0.022	1050	5 6	7 0 1 3 7 7 7	grapes grape juice wine	3.5 5.7 1.5 1.4 1.1 0.51 0.72	98/7/1615
Australia (Vic), 1998 (Riesling)	WP includes copper hydroxide	0.11	0.044	253	5 6	7 0 1 3 7 7 7	grapes grape juice wine	0.68 2.0 1.2 1.0 <u>0.52</u> 0.19 0.20	98/7/1615
Australia (Vic), 1998 (Riesling)	WP includes copper hydroxide	0.22	0.088	253	5 6	7 0 1 3 7 7 7	grapes grape juice wine	1.4 8.5 1.9 3.7 3.6 0.61 0.57 ²	98/7/1615
Australia (Vic), 1998 (Riesling) ³	WP includes copper hydroxide	0.11	0.011	1050	5 6	7 0 1 3 7 7 7	grapes grape juice wine	0.34 1.4 0.71 0.62 <u>0.48</u> 0.28 0.32	98/7/1615
Germany, 1994 (Dornfelder)	WP includes folpet	0.10		400 +600 +800 +800	3 4	18 0 14 29 34 43 34 34	grapes grapes grapes grapes grapes grapes young wine wine	0.27 0.43 0.19 0.14 0.12 0.11 0.08 0.08	gr 5194 gr 52994
Germany, 1994 (Kerner)	WP includes folpet	0.10		400 +600 +800 +800	3 4	18 0 14 29 34 43 34 34	grapes grapes grapes grapes grapes grapes young wine wine	0.30 0.45 0.33 0.24 0.18 0.23 0.11 0.12	gr 5194 gr 52894
Germany, 1997 (Riesling)	WP includes folpet	0.10 +0.10 +0.10 +0.12		400 +600 +800 +800	3 4	35 0 14 28 35 42 35	grapes grapes grapes grapes grapes grapes young wine	0.13 0.32 0.19 0.11 0.08 0.04 0.06	gr 50597

GRAPES country, year (variety)	Application					PHI, days	Commodity	Residues, mg/kg metalaxyl-M ¹	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.				
Germany, 1997 (Riesling)	metalaxyl WP includes folpet	0.20		400	3	35	grapes	0.41 metalaxyl	gr 50597
		+0.20		+600	4	28	grapes	0.31 metalaxyl	
		+0.20		+800		42	grapes	0.13 metalaxyl	
		+0.24		+800		35	young wine	0.13 metalaxyl	
Italy, 1994 (Moscato)	WP includes copper	0.10	0.02	500	4	0	grapes	0.29 c 0.07	2124/94
						7	grapes	0.17	
						14	grapes	0.15	
						21	grapes	<u>0.19</u> c 0.31	
						28	grapes	0.13	
						44	grapes	0.08	
						85	grapes	0.04 c 0.10	
						85	new wine wine	0.03 c 0.05 0.04 c 0.03	
Italy, 1994 (Schiava)	WP includes folpet	0.10	0.0094	1060	3	0	grapes	0.10	2123/94
						7	grapes	0.07	
						14	grapes	<u>0.04</u>	
						21	grapes	0.03	
						28	grapes	0.02	
						45	grapes	0.02	
						78	grapes	<0.02	
						78	new wine wine	<0.02 <0.02	
Italy, 1994 (Tocai)	WP includes copper	0.10	0.09	1100	4	0	grapes	0.71 c 0.16	2125/94
						7	grapes	0.26	
						14	grapes	<u>0.21</u>	
						21	grapes	0.19	
						28	grapes	0.17 c 0.10	
						46	grapes	0.07	
						74	grapes	0.04 c 0.02	
						74	new wine wine	<0.02 <0.02	
Italy, 1994 (Trebiano Romagnolo)	WP includes folpet	0.10	0.01	1000	3	0	grapes	1.2 c 0.06	2122/94
						7	grapes	0.60	
						14	grapes	<u>0.55</u>	
						21	grapes	0.40	
						28	grapes	0.44 c 0.03	
						45	grapes	0.26	
						88	grapes	0.17 c 0.03	
						88	new wine wine	0.05 0.03	
Italy, 1997 (Merlot)	WP includes mancozeb	0.10	0.01	1000	3 4	12	grapes	0.04	2035/97
						0	grapes	0.10	
						14	grapes	<u>0.06</u>	
						21	grapes	0.03	
						28	grapes	0.03	
						42	grapes	0.02	
						42	young wine	<0.02	
						42	wine	<0.02	

GRAPES country, year (variety)	Application					PHI, days	Commodity	Residues, mg/kg metalaxyl-M ¹	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.				
Portugal, 1997 (Periquita)	WP includes mancozeb	0.10	0.01	1000	3	14	grapes	0.09	2030/97
					4	0	grapes	0.16	
						14	grapes	<u>0.18</u>	
						21	grapes	0.10	
						28	grapes	0.10	
						42	grapes	0.07	
						42	young wine	0.18	
	42	wine	0.08						
Switzerland, 1997 (Pinot Noir)	WP includes folpet	0.10	0.083	1200	3	14	grapes	0.41	2332/97
					4	0	grapes	0.96	
						14	grapes	0.43	
						21	grapes	0.49	
						28	grapes	0.52	
						42	grapes	0.24	
						42	young wine	0.24	
	42	wine	0.27						

¹ c: control sample from untreated plot

² Fermented only until 25 g/l residual sugar.

³ Suffered drought damage: berries small and matured 1 month earlier than expected, vines defoliated with bird damage to the berries, which were left on the vines too long. The trial was described as atypical and should be disregarded.

Table 21. Metalaxyl-M residues in onion bulbs from supervised trials in Brazil, Italy, Spain and Switzerland.

Country, year (variety)	Application					PHI, days	Residues, mg/kg metalaxyl-M	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.			
Brazil (SP), 1997 (Cerrana)	WP includes mancozeb	0.10			4	0	<0.02	FR 033/96
						3	<0.02	
						7	<u><0.02</u>	
						10	<0.02	
						14	<0.02	
Brazil (SP), 1997 (Cerrana)	WP includes mancozeb	0.20			4	0	<0.02	FR 034/96
						3	<0.02	
						7	<0.02	
						10	<0.02	
						14	<0.02	
Brazil (SP), 1997 (Granex 33)	WP includes chlorothalonil	0.10			4	7	<u>0.02</u>	RFFA 09/97
						14	<0.02	
Brazil (SP), 1997 (Granex 33)	WP includes chlorothalonil	0.20			4	7	0.03	RFFA 09/97
						14	0.03	
Brazil (SP), 1997 (Serrana)	WP includes chlorothalonil	0.10			4	0	<0.02	RFZO 09/97
						3	<0.02	
						7	<u><0.02</u>	
						10	<0.02	
						14	<0.02	
Brazil (SP), 1997 (Serrana)	WP includes chlorothalonil	0.20			4	0	<0.02	RFZO 09/97

Country, year (variety)	Application					PHI, days	Residues, mg/kg metalaxyl-M	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.			
Italy, 1997 (Density)	WP includes copper oxychloride	0.15	0.025	600	2 3	11 0 7 14 21	<0.02 0.02 <0.02 <0.02 <0.02	2032/97
Italy, 1997 (Density)	SC includes chlorothalonil	0.10	0.017	600	2 3	11 0 7 14 21	<0.02 <0.02 <0.02 <0.02 <0.02	2033/97
Italy, 1998 (Musona)	WP includes copper oxychloride	0.15	0.021	700	3	0 3 7 21	0.05 <0.02 <0.02 <0.02	2025/98
Italy, 1998 (Musona)	SC includes chlorothalonil	0.10	0.014	700	3	0 3 7 21	0.03 <0.02 <0.02 <0.02	2025/98
Spain, 1997 (Liria)	WP includes mancozeb	0.15	0.030	500	2 3	7 0 4 7 14 21	<0.02 0.06 0.02 <0.02 <0.02 <0.02	2013/97
Spain, 1997 (Llopi)	WP includes mancozeb	0.15	0.038	400	2 3	8 0 3 7 14 21	<0.02 0.07 <0.02 0.02 <0.02 <0.02	2014/97
Switzerland, 1997 (Burgos F1)	WP includes mancozeb	0.15	0.019	800	2 3	9 0 7 14 21	<0.02 0.04 <0.02 <0.02 <0.02	2338/97
Switzerland, 1997 (Burgos F1)	SC includes chlorothalonil	0.10	0.013	800	2 3	9 0 7 14 21	<0.02 0.03 <0.02 <0.02 <0.02	2339/97
Switzerland, 1997 (Cupra F1)	WP includes mancozeb	0.15	0.019	800	2 3	8 0 7 14 21	<0.02 <0.02 <0.02 <0.02 <0.02	2340/97
Switzerland, 1997 (Cupra F1)	SC includes chlorothalonil	0.10	0.013	800	2 3	8 0 7 14 21	<0.02 <0.02 <0.02 <0.02 <0.02	2341/97

Table 22. Metalaxyl-M residues in tomatoes from supervised trials in France, Spain and Switzerland.

Country, year (variety)	Application					PHI days	Residues, mg/kg ¹	Ref.
	Form	kg ai/ha	kg ai/ha	water, l/ha	No.			
France, 1997 (4369) <i>greenhouse</i>	WP includes mancozeb	0.15	0.038	400	4	3	<u>0.08</u>	2349/97
France, 1997 (Kalimba) <i>greenhouse</i>	WP includes mancozeb	0.15	0.038	400	4	3	< <u>0.02</u>	2350/97
France, 1997 (Le Trepier) <i>greenhouse</i>	WP includes mancozeb	0.15	0.037	400	3 4	7 0 3 7 14 22	<0.02 <0.02 < <u>0.02</u> <0.02 <0.02 <0.02 c 0.02 ¹	2347/97
France, 1997 (Roncoula) <i>greenhouse</i>	WP includes mancozeb	0.15	0.038	400	3 4	7 0 3 7 14 21	<0.02 <0.02 <u>0.02</u> <0.02 <0.02 <0.02	2348/97
France, 2001 (Brenda) <i>greenhouse</i>	WG includes mancozeb	0.15	0.015	1000	4	3	<u>0.03</u>	0111301
France, 2001 (Granitio) <i>greenhouse</i>	WG includes mancozeb	0.15	0.015	1000	4	0 1 3 7 10	0.05 0.02 <u>0.04</u> <0.02 <0.02	0111401
Spain, 1997 (Genaro)	WP includes mancozeb	0.15	0.0088	1700	3 4	11 0 7 14 21 28	<0.02 0.06 <0.02 <0.02 <0.02 <0.02	2011/97
Spain, 1997 (Royestra)	WP includes mancozeb	0.15	0.015	1000	3 4	12 0 7 14 21 28	<0.02 0.02 <0.02 <0.02 <0.02 <0.02	2012/97
Spain, 1998 (Daniella) <i>greenhouse</i>	WP includes mancozeb	0.15	0.015	1000	4	0 3 7 14 20	0.23 <u>0.18</u> 0.07 0.06 0.03	2048/98

Country, year (variety)	Application					PHI days	Residues, mg/kg ¹	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.			
Spain, 1998 (Genaro) <i>greenhouse</i>	WP includes mancozeb	0.15	0.012	1300	4	0 3 7 14 21	0.17 <u>0.05</u> <0.02 <0.02 <0.02	2049/98
Switzerland, 1997 (Cristal)	WP includes mancozeb	0.15	0.0075	2000	4	3	0.02	2334/97
Switzerland, 1997 (Cristal)	WP includes copper	0.15	0.0075	2000	4	3	<0.02	2335/97
Switzerland, 1997 (Selhardy)	WP includes copper	0.15	0.0075	2000	3 4	7 0 3 7 14	<0.02 0.04 <0.02 <0.02 <0.02	2337/97
Switzerland, 1997 (Selhardy)	WP includes mancozeb	0.15	0.0075	2000	3 4	7 0 3 7 14	<0.02 0.03 <0.02 <0.02 <0.02	2336/97
Switzerland, 1998 (Paola) <i>greenhouse</i>	WG includes mancozeb	0.15	0.0075	2000	4	0 3 7 14 21	0.18 <u>0.09</u> 0.06 0.03 <0.02	2071/98
Switzerland, 1998 (Paola) <i>greenhouse</i>	WG includes mancozeb	0.15	0.0075	2000	4	0 3 7 14 21	0.07 <u>0.04</u> 0.02 <0.02 <0.02	2072/98
Switzerland, 2001 (Paola) <i>greenhouse</i>	WG includes mancozeb	0.15	0.0083	1800	4	3	<u>0.12</u>	2011/01
Switzerland, 2001 (Paola) <i>greenhouse</i>	WG includes mancozeb	0.15	0.015	1000	4	0 1 3	0.12 0.08 <u>0.05</u>	2012/01

¹ c: sample from control plot.

Table 23. Metalaxyl-M residues in sweet peppers from supervised trials in Italy and Spain with a granular formulation used in soil treatments.

Country, year (variety)	Application			PHI days	Residues, mg/kg	Ref.
	Form	kg ai/ha	No.			
Italy, 1997 (Benrico) <i>greenhouse</i>	GR	1.0 soil treatment	3	10	< <u>0.02</u>	121/97 2130/97

Country, year (variety)	Application			PHI days	Residues, mg/kg	Ref.
	Form	kg ai/ha	No.			
Italy, 1997 (Campor) <i>greenhouse</i>	GR	1.0 soil treatment	2 3	20	<0.02	121/97 2129/97
				0	0.02	
				5	<0.02	
				10	<u><0.02</u>	
				20	<0.02	
Italy, 1997 (Friariello)	GR	1.0 soil treatment	3	30	<0.02	2045/97
Italy, 1997 (Magister)	GR	1.0 soil treatment	2 3	20	<0.02	121/97 2127/97
				0	<0.02	
				5	<0.02	
				9	<u>0.02</u>	
				20	0.02	
Italy, 1997 (Osir)	GR	1.0 soil treatment	3	9	<u><0.02</u>	121/97 2128/97
Italy, 1997 (Peto)	GR	1.0 soil treatment	2 3	39	<0.02	2044/97
				0	<0.02	
				5	<0.02	
				10	<u><0.02</u>	
				20	<0.02	
Spain, 1997 (Diamante) <i>greenhouse</i>	GR	1.0 soil treatment	2 3	40	0.04	2008/97
				0	0.03	
				5	0.02	
				10	0.02	
				15	<u>0.02</u>	
				20	0.02	
Spain, 1997 (Italico) <i>greenhouse</i>	GR	1.0 soil treatment	2 3	46	0.08	2007/97
				0	0.07	
				5	0.25	
				10	0.40	
				15	0.35	
				20	<u>0.36</u>	
				Spain, 1998 (Estar) <i>greenhouse</i>	GR	
5	0.08					
10	0.09					
15	<u>0.08</u>					
20	0.03					
Spain, 1998 (Italico) <i>greenhouse</i>	GR	1.0 soil treatment	3			10
Spain, 2000 (Cadia) <i>greenhouse</i>	GR	1.0 soil treatment	3	0	0.06	2024/00
				3	0.05	
				7	0.07	
				15	<u>0.10</u>	
				21	0.07	
Spain, 2000 (Roxi) <i>greenhouse</i>	GR	1.0 soil treatment	3	0	0.04	2023/00
				3	0.05	
				7	0.06	
				15	<u>0.03</u>	
				21	0.02	

Table 24. Metalaxyl-M residues in lettuce from supervised trials in France, Germany, Italy, The Netherlands, Spain and Switzerland.

Country, year (variety)	Application					PHI, days	Sample	Residues, mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.				
France, 1997 (head lettuce, Christine)	WP includes mancozeb	0.10	0.025	400	3	14	heads	0.03	2262/97
France, 1997 (head lettuce, Flandria)	WP includes mancozeb	0.10 ¹	0.030	330	3	14	heads	<0.02	2263/97
France, 1997 (head lettuce, Floreal)	WP includes mancozeb	0.10	0.025	400	3	14	heads	<0.02	2260/97
France, 1997 (head lettuce, Newton)	WP includes mancozeb	0.10	0.025	400	3	10 0 7 15 21	heads heads heads heads heads	0.03 1.5 0.06 0.02 0.03	2261/97
France, 1999 (head lettuce, Angie) <i>greenhouse</i>	WG includes acibenzolar-S-methyl	0.14	0.035	400	3	0 3 7 10 14	heads heads heads heads heads	3.0 1.6 1.0 0.64 0.43	2169/99
France, 1999 (head lettuce, Angie) <i>greenhouse</i>	WG includes acibenzolar-S-methyl	0.14	0.035	400	3	0 3 7 10 14	heads heads heads heads heads	4.5 2.6 1.5 1.1 0.43	2170/99
France, 1999 (head lettuce, Augié) <i>greenhouse</i>	WG includes acibenzolar-S-methyl	0.14 +0.14 +0.13	0.035	400 +410 +370	3	11	heads	0.86	2000/00
France, 1999 (head lettuce, Nalis) <i>greenhouse</i>	WG includes acibenzolar-S-methyl	0.14	0.035	400	4	0 3 7 10 14	heads heads heads heads heads	8.1 4.0 1.8 1.0 0.50	2171/99
France, 1999 (head lettuce, Norma) <i>greenhouse</i>	WG includes acibenzolar-S-methyl	0.14	0.035	400	3	0 3 7 10 14	heads heads heads heads heads	7.3 3.0 1.8 1.7 1.1	2172/99
France, 2000 (head lettuce, Manita) <i>greenhouse</i>	WG includes acibenzolar-S-methyl	0.14 +0.15 +0.16	0.035	410 +430 +440	3	10	heads	0.17	2001/00
France, 2000 (head lettuce, Perlane) <i>greenhouse</i>	WG includes acibenzolar-S-methyl	0.14	0.028	500	3	10	heads	0.15	2002/00

Country, year (variety)	Application					PHI, days	Sample	Residues, mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.				
Germany, 1997 (head lettuce, Rapsodi)	WP includes folpet	0.10	0.017	600	2 3	8 0 6 14 21	heads heads heads heads heads	0.07 3.6 0.56 0.04 <u>0.02</u>	2255/97
Germany, 1997 (head lettuce, Rapsodi) <i>greenhouse</i>	WP includes folpet	0.10	0.017	600	2 3	7 0 7 14 21	heads heads heads heads heads	0.40 10 0.72 0.07 <u><0.02</u>	2254/97
Germany, 1997 (head lettuce, Rosali)	WP includes folpet	0.10	0.017	600	2 3	12 0 7 14 21	heads heads heads heads heads	<0.02 3.5 0.04 0.03 <u><0.02</u>	2252/97
Germany, 1997 (head lettuce, Rosali)	WP includes folpet	0.10	0.017	600	2 3	9 0 7 14 21	heads heads heads heads heads	<0.02 2.6 0.04 0.03 <u>0.03</u>	2253/97
Germany, 1998 (head lettuce, Macarena)	WP includes folpet	0.10		610	2	0 7 10 14 21	plants plants heads heads heads	1.6 0.06 <0.02 <0.02 <u><0.02</u>	gr 22998
Germany, 1998 (head lettuce, Troubadur) <i>greenhouse</i>	WP includes folpet	0.10		630	2	0 7 10 14 21	whole plant whole plant heads heads heads	3.4 1.7 0.94 0.59 <u>0.41</u>	gr 23998
Germany, 2000 (head lettuce, Fiorella)	WP includes folpet	0.10		610	3	0 14	plants heads	1.1 0.02	gr 52700
Germany, 2000 (head lettuce, Nadine)	WP includes folpet	0.10		610	3	0 14	plants heads	2.1 0.02	gr 51900
Germany, 2000 (head lettuce, Nadine)	WP includes folpet	0.10		630	3	0 7 10 13 20	plants plants heads heads heads	1.2 0.09 0.02 <0.02 <u><0.02</u>	gr 50800
Germany, 2000 (lettuce, Pullmann)	WP includes folpet	0.10		600	3	0 7 10 14 20	plants plants plants heads heads	2.6 0.03 0.02 <0.02 <u><0.02</u>	gr 49500

Country, year (variety)	Application					PHI, days	Sample	Residues, mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.				
Italy, 1997 (head lettuce, Justine)	WP includes copper oxychloride	0.10	0.016	600	2	10 0 3 7 14 21	heads heads heads heads heads heads	<0.02 2.1 0.02 <u><0.02</u> <0.02	2062/97
Italy, 1998 (head lettuce, Martina)	WG includes acibenzolar-S-methyl	0.14	0.023	600	3	0 3 7 10 14	heads heads heads heads heads	2.4 0.31 0.04 0.02 0.02	2028/98
Italy, 1999 (head lettuce, Martina)	WG includes acibenzolar-S-methyl	0.14	0.014	1000	3	0 3 7 10 14	heads heads heads heads heads	1.8 <0.02 0.02 0.02 <0.02	2035/99
Italy, 1999 (head lettuce, Musette ez)	WG includes acibenzolar-S-methyl	0.14	0.014	1000	3	0 3 7 10 14	heads heads heads heads heads	2.3 1.7 0.26 0.07 0.02	2036/99
Netherlands, 1999 (head lettuce, Ardeola)	WP includes mancozeb	0.11 + 0.12	0.012	900 + 1040	2	0 7 14 21	heads heads heads heads	0.84 <0.02 <0.02 <u><0.02</u>	2131/99
Netherlands, 1999 (head lettuce, Einstein)	WP includes mancozeb	0.12 + 0.13	0.012	970 + 1060	2	0 7 14 21	heads heads heads heads	1.2 <0.02 <0.02 <u><0.02</u>	2132/99
Spain, 1999 (head lettuce, Iceberg)	WG includes acibenzolar-S-methyl	0.14	0.020	700	3	0 3 7 10 14	heads heads heads heads heads	0.11 0.07 0.02 <0.02 <0.02	2009/99 ²
Spain, 1999 (head lettuce, Iceberg)	WG includes acibenzolar-S-methyl	0.14	0.020	700	3	0 3 7 10 14	heads heads heads heads heads	0.10 0.07 0.02 <0.02 <0.02	2010/99 ²
Switzerland, 1999 (head lettuce, Levis) <i>greenhouse</i>	WG includes acibenzolar-S-methyl	0.14	0.018	800	3	0 3 7 11 14	heads heads heads heads heads	5.2 3.7 1.8 0.96 0.68	2052/99
Switzerland, 1999 (head lettuce, Reskia NL)	WG includes acibenzolar-S-methyl	0.14	0.018	800	3	0 3 7 10 14	heads heads heads heads heads	1.0 0.13 0.04 0.02 <0.02	2050/99

Country, year (variety)	Application					PHI, days	Sample	Residues, mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.				
Switzerland, 1999 (head lettuce, Reskia NL)	WG includes acibenzolar-S- methyl	0.14	0.018	800	3	0 3 7 10 14	heads heads heads heads heads	1.6 0.07 <0.02 <0.02 <0.02	2051/99

¹ Outdoor foliar under protective covering.

² Trials 2009/99 and 2010/99 appear to be replicate plots with same treatment rather than separate trials.

Table 25. Metalaxyl-M residues in spinach resulting from supervised trials in France, Germany and Switzerland.

Country, year (variety)	Application					PHI, days	Sample	Residues, mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.				
France (Beaucaire), 1997 (Kerdion)	WP includes copper	0.10	0.029	360	1 2	10 0 5 10 21	leaf leaf leaf leaf leaf	0.03 3.5 0.09 <u>0.02</u> <0.02	125/97 2142/97
France (Beaucaire), 1997 (Kerdion)	ES				ST	105	leaf	<0.02	125/97 2141/97
France (Beaucaire), 1997 (Kerdion)	ES + WP includes copper	0.10	0.029	360	ST 1 2	10 0 5 10 21	leaf leaf leaf leaf leaf	0.05 2.8 0.07 <u>0.02</u> <0.02	125/97 2143/97
France (Senas), 1997 (Kerdion)	WP includes copper	0.10	0.029	360	1 2	10 0 5 10 20	leaf leaf leaf leaf leaf	0.02 2.7 0.18 <u>0.05</u> 0.03	125/97 2148/97
France (Senas), 1997 (Kerdion)	ES				ST	108	leaf	<0.02	125/97 2147/97
France (Senas), 1997 (Kerdion)	ES + WP includes copper	0.10	0.029	360	ST 1 2	10 0 5 10 20	leaf leaf leaf leaf leaf	0.03 3.3 0.19 <u>0.04</u> 0.03	125/97 2149/97
France (Tarascon), 1997 (Kerdion)	WP includes copper	0.10	0.029	360	1 2	10 0 5 10 21	leaf leaf leaf leaf leaf	0.03 2.1 0.07 <u>0.02</u> <0.02	125/97 2145/97

Country, year (variety)	Application					PHI, days	Sample	Residues, mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.				
France (Tarascon), 1997 (Kerdion)	WP includes copper	0.10	0.029	360	1 2	10 0 5 10 20	leaf leaf leaf leaf leaf	0.03 3.3 0.10 <u>0.04</u> 0.02	125/97 2151/97
France (Tarascon), 1997 (Kerdion)	ES				ST	105	leaf	<0.02	125/97 2144/97
France (Tarascon), 1997 (Kerdion)	ES				ST	103	leaf	<0.02	125/97 2150/97
France (Tarascon), 1997 (Kerdion)	ES + WP includes copper	0.10	0.029	360	ST 1 2	10 0 5 10 21	leaf leaf leaf leaf leaf	0.03 2.2 0.05 <u>0.02</u> <0.02	125/97 2146/97
France (Tarascon), 1997 (Kerdion)	ES + WP includes copper	0.10	0.029	360	ST 1 2	10 0 5 10 20	leaf leaf leaf leaf leaf	0.03 2.9 0.07 <u>0.03</u> <0.02	125/97 2152/97
France, 1999 (Santana)	WG includes acibenzolar-S- methyl	0.10 ¹	0.025	380	3	10	leaf	< <u>0.02</u>	2062/99
France, 1999 (Santana)	WG includes acibenzolar-S- methyl	0.14 ¹	0.035	390	3	10	leaf	< <u>0.02</u>	2062/99
Germany, 1998 (Bolero)	WP includes folpet	0.10		580	2	0 7 10 14 21	leaf leaf leaf leaf leaf	5.1 <0.02 <0.02 <u><0.02</u> <0.02	gr 24998
Germany, 1998 (Laska)	WP includes folpet	0.10		600	2	0 7 10 14 21	leaf leaf leaf leaf leaf	4.3 0.13 0.02 <u><0.02</u> <0.02	gr 25998
Switzerland, 1999 (Chica F1)	WG includes acibenzolar-S- methyl	0.10	0.013	800	3	0 3 7 10 14	leaves leaves leaves leaves leaves	2.6 <0.02 <0.02 <0.02 <u><0.02</u>	2045/99
Switzerland, 1999 (Chica F1)	WG includes acibenzolar-S- methyl	0.14	0.018	800	3	0 3 7 10 14	leaves leaves leaves leaves leaves	5.2 0.02 <0.02 <0.02 <u><0.02</u>	2045/99

Country, year (variety)	Application					PHI, days	Sample	Residues, mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.				
Switzerland, 1999 (Monnopa)	WG includes acibenzolar-S- methyl	0.10	0.013	800	3	10	whole plant	<0.02	2046/99
Switzerland, 1999 (Monnopa)	WG includes acibenzolar-S- methyl	0.14	0.018	800	3	10	whole plant	<0.02	2046/99
Switzerland, 1999 (Monnopa)	WG includes acibenzolar-S- methyl	0.10	0.013	800	3	0 3 7 10 14	whole plant whole plant whole plant whole plant whole plant	2.0 <0.02 <0.02 <0.02 <0.02	2044/99
Switzerland, 1999 (Monnopa)	WG includes acibenzolar-S- methyl	0.14	0.018	800	3	0 3 7 10 14	whole plant whole plant whole plant whole plant whole plant	3.0 0.02 <0.02 <0.02 <0.02	2044/99

ST: seed treatment 0.088 kg ai/100 kg seed.

¹ seeds treated by the seller with metalaxyl before sowing.

Table 26. Metalaxyl-M residues in potato tubers from supervised trials in Brazil, Germany, Switzerland and the UK.

Country, year (variety)	Application					PHI, days	Residues, mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.			
Brazil (SP), 1997 (Achat)	WP includes mancozeb	0.10			4	7 14	<0.02 <0.02	FR 017/96
Brazil (SP), 1997 (Achat)	WP includes mancozeb	0.20			4	7 14	<0.02 <0.02	FR 018/96
Brazil (SP), 1997 (Achat)	WP includes chlorothalonil	0.10			4	0 7	<0.02 <0.02	RFFA 06/97
Brazil (SP), 1997 (Achat)	WP includes chlorothalonil	0.20			4	7	<0.02	RFFA 06/97
Brazil (SP), 1997 (Monalisa)	WP includes chlorothalonil	0.20			4	7	<0.02	RFLU 06/97
Brazil (SP), 1997 (Monalisa)	WP includes chlorothalonil	0.10			4	0 3 7 14 21	<0.02 <0.02 <0.02 <0.02 <0.02	RFLU 06/97
Germany, 1995 (Agria)	WP includes mancozeb	0.10		400	4	0 14	<0.02 <0.02	gr 4795 gr 41395
Germany, 1995 (Agria)	EC includes fluazinam	0.10		400	5	0 7	<0.02 <0.02	gr 4895 gr 41495

Country, year (variety)	Application					PHI, days	Residues, mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.			
Germany, 1995 (Linda)	WP includes mancozeb	0.10		400	4	0 15	<0.02 <u><0.02</u>	gr 4795 gr 31395
Germany, 1995 (Linda)	EC includes fluazinam	0.10		400	5	0 7	<0.02 <u><0.02</u>	gr 4895 gr 31495
Germany, 1996 (Hansa)	EC includes fluazinam	0.10		400	5	0 7	<0.02 <u><0.02</u>	gr 46696
Germany, 1996 (Panda)	EC includes fluazinam	0.10		400	5	0 7	<0.02 <u><0.02</u>	gr 45396
Switzerland, 1998 (Agria)	WP includes mancozeb	0.075	0.015	500	5	0 1 3 7 14	<0.02 <0.02 <0.02 <0.02 <u><0.02</u>	2068/98
Switzerland, 1998 (Désirée)	WP includes mancozeb	0.075	0.015	500	5	7	<u><0.02</u>	2070/98
Switzerland, 1998 (Sirtema)	WP includes mancozeb	0.075	0.015	500	5	0 1 3 7 14	<0.02 <0.02 <0.02 <0.02 <u><0.02</u>	2069/98
UK, 1994 (Estima)	WP includes mancozeb	0.1		250	5	0 28	<0.02 <u><0.02</u>	02/95
UK, 1994 (Pentland Squire)	WP includes mancozeb	0.1		250	5	0 28 29	<0.02 <u><0.02</u> <0.02	01/95
UK, 1995 (Anna)	EC includes fluazinam	0.10	0.05	200	5	1 7	<0.02 <u><0.02</u>	FR0595BR
UK, 1995 (Kerrs Pink)	EC includes fluazinam	0.10	0.05	200	5	1 7	<0.02 <u><0.02</u>	FR0595AR

Table 27. Metalaxyl-M residues in sunflower seed resulting from supervised trials in France and Spain.

Country, year (variety)	Application			Days after sowing	Residues, mg/kg	Ref.
	Form	g ai/100 kg seed	No.			
France, 1998 (Albena)	ES	83 (nominal 105)	1	125	<u><0.02</u>	2118/98
France, 1998 (Albena)	ES	80 (nominal 105)	1	139	<u><0.02</u>	2120/98
France, 1998 (Autan)	ES	75 (nominal 105)	1	126	<u><0.02</u>	2121/98

Country, year (variety)	Application			Days after sowing	Residues, mg/kg	Ref.
	Form	g ai/100 kg seed	No.			
France, 1998 (Clisol)	ES	70 (nominal 105)	1	151	< <u>0.02</u>	2119/98
France, 1999 (Clisol)	ES	61 (nominal 105)	1	144	< <u>0.01</u>	4013/99
France, 1999 (Clisol)	ES	61 (nominal 105)	1	134	< <u>0.01</u>	4014/99
Spain, 1998 (Tornasol)	ES	67 (nominal 105)	1	138	< <u>0.02</u>	2116/98
Spain, 1999 (Coban)	ES	71 (nominal 105)	1	146	< <u>0.02</u>	4012/99

Table 28. Metalaxyl-M residues in cacao beans resulting from supervised trials in Côte d'Ivoire.^{1,2}

Year (variety)	Application					PHI days	Residues, mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.			
2000 (Selectioné)	WP includes copper	0.09	0.09	100	4	29	< <u>0.02</u>	2148/00
2000 (Tout Venant)	WP includes copper	0.09	0.09	100	4	30	<u>0.02</u>	2149/00
2000 (Selectioné)	WP includes copper	0.09	0.09	100	4	30	< <u>0.02</u>	2150/00
2000 (Tout Venant)	WP includes copper	0.09	0.09	100	4	29	<u>0.02</u>	2151/00
2001 (Various local varieties)	WP includes copper	0.09	0.020	450	4	30	<u>0.02</u>	2102/01
2001 (Various local varieties)	WP includes copper	0.09	0.020	450	4	30	<u>0.02</u>	2103/01
2001 (Various local varieties)	WP includes copper	0.09	0.020	450	4	30	< <u>0.02</u>	2104/01
2001 (Selectioné)	WP includes copper	0.09	0.020	450	4	30	< <u>0.02</u>	2105/01

¹ Pods harvested, and fermented and dried beans analysed.

² Kühne (2148/00, 2002) described the fermentation and drying of cacao beans after harvest and before analysis in supervised trials on cocoa. The pods were cut open and beans and pulp were removed from the shell, placed inside black plastic and sealed. Every 48 h the plastic was opened and the contents stirred. Fermentation lasted 6 days. The fermented beans were then placed in a thin layer on black plastic under the open sky and stirred 2-3 times per day for 5 days, and overnight were protected with a layer of plastic. Samples of fermented and dried beans were deep-frozen for despatch to the analytical laboratory.

FATE OF RESIDUES IN STORAGE AND PROCESSING

In processing

The Meeting received information on the fate of metalaxyl-M residues during the production of fruit juices and wine, and on its fate under hydrolysis conditions simulating commercial food processing.

Adam (00.DAOS, 2000) hydrolysed [¹⁴C]metalaxyl-M as in food processing. The HPLC analytical method was not enantiomer-selective, so epimerisation, if it occurred, would not have been observed. Metalaxyl-M was stable under these conditions (Table 29).

Table 29. Effect of food processing conditions on the hydrolysis of metalaxyl-M (Adam, 00DA05, 2000).

pH	Temperature, °C	Incubation, min	% of applied metalaxyl-M remaining	Process represented
4	90	20	96, 101	pasteurisation
5	100°C	60	96, 106	baking, brewing, boiling
6	120°C	20	97, 102	sterilisation

In a study on orange processing (Kühne, 2186/99, 2000), 163 kg of fruit were used for juice production, while 44 kg were used for marmalade. Subsamples of peel (1 kg) and pulp (6 kg) were used to produce 10 kg of marmalade.

Table 30. Fate of metalaxyl-M residues in oranges during orange processing.

Country, year (variety)	Application					PHI, days	Sample	Residues, mg/kg	Ref.
	Form	kg ai/ha	kg ai/hl	water, l/ha	No.				
Spain, 2000 (Valencia)	WP includes mancozeb	0.20 +0.60	0.02 +0.06	1000 +980	2	0	fruit	1.0	2186/99
						14	fruit fruit washed peel pulp	0.11 0.11 0.23 0.24 <0.01 <0.01	
						14	fruit fruit washed juice, raw juice, pasteurised oil pomace, wet pomace, dry	0.13 0.15 <0.01 <0.01 <0.01 0.01 0.01 1.3 0.98 1.2 1.2 0.13 0.11 0.15 0.17 0.51 0.51 0.61 0.48	
						14	fruit fruit, washed peel pulp marmalade	0.11 0.086 0.34 0.01 0.043 0.042 0.040 0.048	

Table 31. Calculated processing factors for metalaxyl-M residues in orange products (2186/99).

Residue in RAC, mg/kg	Sample	Residues, mg/kg	Processing factors (PF)	Mean PF
0.13	Fruit, washed	0.15	1.2	

Residue in RAC, mg/kg	Sample	Residues, mg/kg	Processing factors (PF)	Mean PF
0.11	Fruit, washed	0.086	0.78	0.97
0.13	Juice, raw	<0.01	<0.08	<0.08
0.13	Juice, pasteurised	0.007 0.006 0.009 0.009	0.054 0.046 0.069 0.069	0.060
0.13	Oil	1.3 0.98 1.2 1.2	10.0 7.5 9.2 9.2	9.0
0.13	Pomace, wet	0.13 0.11 0.15 0.17	1.0 0.8 1.2 1.3	1.1
0.13	Pomace, dry	0.51 0.51 0.61 0.48	3.9 3.9 4.7 3.7	4.1
0.11	Peel	0.34 0.23 0.24	3.09 2.09 2.18	2.5
0.11	Pulp	0.01	0.09	0.09
0.11	Marmalade	0.043 0.042 0.040 0.048	0.39 0.38 0.36 0.44	0.39

Table 32. Processing factors calculated from the metalaxyl-M residues in grapes and their processed commodities shown in Table 20.

Residues, mg/kg				Processing factors			Ref.
Grapes	Grape juice	Young wine	Wine	Juice	Young wine	Wine	
<0.02	<0.02		0.02				98/7/1615
0.08	0.02		0.04	0.25		0.50	98/7/1615
0.03	<0.02		0.03			1.00	98/7/1615
0.1	0.03		0.05	0.30		0.50	98/7/1615
1.1	0.51		0.72	0.46		0.65	98/7/1615
0.52	0.19		0.2	0.37		0.38	98/7/1615
3.6	0.61		0.57	0.17		0.16	98/7/1615
0.48	0.28		0.32	0.58		0.67	98/7/1615
0.12		0.08	0.08		0.67	0.67	gr 5194
0.18		0.11	0.12		0.61	0.67	gr 5194
0.08		0.06			0.75		gr 50597
0.41		0.13			0.32		gr 50597
0.04		0.03	0.04		0.75	1.00	2124/94
<0.02		<0.02	<0.02				2123/94
0.04		<0.02	<0.02				2125/94
0.17		0.05	0.03		0.29	0.18	2122/94
0.02		<0.02	<0.02				2035/97
0.07		0.18	0.08		2.57	1.14	2030/97
0.24		0.24	0.27		1.00	1.13	2332/97
			Mean	0.36	0.87	0.66	

RESIDUES IN ANIMAL COMMODITIES

Farm animal feeding studies

A lactating dairy cow feeding study and a laying hen study with metalaxyl, which provided information on likely residues in tissues, milk and eggs from residues in animal feeds, were reported to the Meeting.

In the first study 3 lactating Holstein cows weighing 445-698 kg each were dosed daily at a rate of 1.5 g metalaxyl per cow per day, equivalent to 75 ppm in the diet (Kahrs, ABR-82052, 1982). The dose was mixed with 1 kg of untreated commercial dairy ration. Milk was collected twice daily and a cow was slaughtered on days 14, 21 and 28. Animals consumed approximately 20 kg of dairy ration and hay each per day. Samples of liver, kidney, fat and muscle were analysed by the dimethylaniline common moiety method AG-349.

Residues did not accumulate and were transitory, with the interval between the last dose and slaughter influencing the levels more than the duration of dosing (Table 33). Residues 4 h after dosing in the cow slaughtered on day 14 were higher than in the cows that were dosed for the last time 23.5 h before slaughter. Residues in the blood were higher 1.5-2 h after dosing (0.32 mg/kg on day 13) than after 19-20 h (<0.05 mg/kg on days 21 and 28).

Table 33. Residues in the tissues and milk of dairy cows dosed with metalaxyl at 1.5 g metalaxyl per cow per day, equivalent to 75 ppm in the diet (Kahrs, ABR-82052, 1982).

Tissue	Total residues, mg/kg. Method AG-349			
	Day 14 (4 h post-dosing)	Day 21 (23.5 h post-dosing)	Day 28 (23.5 h post-dosing)	
Tenderloin muscle	0.09	<0.05	0.06	
Round muscle	0.15	0.07	0.08	
Round muscle (control)	0.06		0.07	
Omental fat	<0.05	<0.05	<0.05	
Perirenal fat	<0.05	<0.05	<0.05	
Liver	0.96	0.14	0.12	
Kidney	5.4	0.12	0.11	
Milk	Day 1	Day 14	Day 20	Day 27
Cow A	0.02	0.02		
Cow B	0.02	0.02	0.02	
Cow C	0.02	0.02	0.02	0.02

In the second study three groups of 15 laying White Leghorn hens, were dosed daily for 28 days with metalaxyl mixed with untreated poultry feed at levels equivalent to 10 ppm, 30 ppm and 100 ppm in the feed, fed *ad libitum* (Eudy, ABR-91047, 1991). Average consumption was 0.133-0.153 kg/bird/day. Eggs were collected for analysis. Birds were slaughtered on days 7, 14, 21 and 28 days after the first dose, and samples analysed by the dimethylaniline common moiety method AG-576.

There were no detectable residues in the eggs (<0.05 mg/kg) at any dose level (Table 34). In the tissues, residues were higher at higher doses. In the 10 ppm group, residues in the tissues were generally below the LOQ (<0.05 mg/kg) or, in a few cases, slightly above. Highest residues occurred in the skin + attached fat. In the 100 ppm feeding group, residues at 14, 21 and 28 days were generally similar, suggesting no continued accumulation in the tissues.

Table 34. Residues in tissues and eggs of laying hens dosed daily for 28 days with metalaxyl at levels equivalent to 10 ppm, 30 ppm and 100 ppm in the feed (Eudy, ABR-91047, 1991).

Sample	Total residues, mg/kg. Method AG-576					
	Days of dosing					
	7	14	21	28		
10 ppm group						
Muscle, breast plus thigh	<0.05	0.06	<0.05	<0.05		
Skin + attached fat	<0.05	<0.05	<0.05	<0.05		
Fat, peritoneal	<0.05	<0.05	<0.05	<0.05		
Liver	<0.05	<0.05	0.10 c	0.08	0.05	
30 ppm group						
Muscle, breast plus thigh	0.06	0.10	<0.05	<0.05		
Skin + attached fat	<0.05	0.07	0.10	0.08		
Fat, peritoneal	<0.05	0.07	0.08	0.07		
Liver	0.07	0.07	0.09 c	0.08	0.10	
100 ppm group						
Muscle, breast plus thigh	0.13	0.13	<0.05	0.12		
Skin + attached fat	0.12	0.32	0.40	0.34		
Fat, peritoneal	0.09	0.27	0.34	0.17		
Liver	0.16	0.10	0.09 c	0.08	0.11	
Eggs	Day 1	Day 3	Day 7	Day 14	Day 21	Day 28
10 ppm group	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
30 ppm group	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
100 ppm group	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

c: control group sample

RESIDUES IN FOOD IN COMMERCE OR AT CONSUMPTION

No information was reported for metalaxyl-M.

NATIONAL MAXIMUM RESIDUE LIMITS

The Meeting was aware of the following national MRLs. Only MRLs that have been set solely for metalaxyl-M uses on crops that have residue data provided for this residue evaluation are included. (MRLs or tolerances based on metalaxyl data covering the use of metalaxyl-M and metalaxyl are not included.)

Country	Crop	MRL, mg/kg
Brazil	Grape	1
	Onion	0.5
	Potato	0.05
	Tomato	0.05
EU	Citrus fruit	0.5
	Grape	1
	Lettuce	2
	Onion	0.02
	Pepper	0.5
	Pome fruit	0.02
	Potato	0.02
	Spinach	0.05
	Sunflower seeds	0.05
	Tomato	0.2