ALDICARB (117)

EXPLANATION

Aldicarb was last evaluated for residues in 1994 within the CCPR periodic review programme. The Meeting estimated maximum residue levels for a wide range of commodities including a temporary maximum residue level of 0.5 mg/kg for potato pending the submission of data on supervised trials corresponding with current use patterns. The previous recommendation for an MRL for banana was withdrawn because the use pattern had changed.

The manufacturer submitted extensive residue data obtained from recent supervised trials on potatoes and bananas reflecting the currently recommended uses. The new results are summarized and evaluated in this monograph together with other information provided by member countries.

The Meeting was informed that additional trials are being conducted in the USA on potatoes, and that a residue programme has been initiated in the French West Indies and West Africa on bananas to generate additional data to support the new use pattern and to determine whether the PHI can be further refined. The residue data will be submitted to the JMPR when the studies are completed.

USE PATTERN

The use patterns on potatoes reported by the 1994 Meeting are still in effect, except in the USA where requirements such as the use of positive-displacement application (PDA) equipment, the exclusion of in-furrow irrigation and new PHIs of 100 and 150 days in Florida and the Pacific Northwest States, respectively, have been included on the labels. The approved rate for PDA application is 3.36 kg ai/ha.

The countries in which aldicarb is still used on bananas are Argentina, Cameroon, Egypt, France, Ivory Coast, South Africa and Zimbabwe. The recommended use has been changed to a maximum of two applications per year, a maximum rate of 2 g ai per plant, and a PHI of 180 days.

RESIDUES RESULTING FROM SUPERVISED TRIALS

Supervised field trials were carried out with granular formulations of aldicarb. The samples were mainly analysed by HPLC methods which determine aldicarb, its sulfoxide and sulfone individually. The limits of determination were typically around 0.01-0.02 mg/kg for each residue component. In some of the trials the residues were oxidized to the sulfone and determined by GLC with an FPD. The residues, expressed as aldicarb sulfone, are shown in the following Tables.

Bananas. Trials were conducted in Cameroon, Egypt, France (Martinique), and the Ivory Coast. Aldicarb was applied to the soil at the recommended maximum rate of 2 g ai/plant, corresponding to 3.6-4 kg ai/ha. Samples were taken from 3 to >360 days after the last application. The residues were determined in composite samples consisting of 7-12 fingers, or in individual fingers. In some experiments the peel and pulp were analysed separately. The results are summarized in Table 1.

Potatoes. The reported supervised trials represented a wide geographical distribution and covered a period of 15 years. The samples were analysed either by GLC or HPLC methods based on the principles described in the 1994 evaluation. The major residue component was aldicarb sulfoxide.

Supervised trials were carried out in Argentina, Belgium, Canada, Czechoslovakia, Ecuador, Germany, Greece, Hungary, Italy, Netherlands, Spain, and the UK between 1978 and 1992. The trial conditions reported and the residues detected in composite samples are summarized in Table 2. In addition, a number of "commercial trials" were reported from South Africa in a summarized form without details of the trial conditions, the actual dosage rates or the analytical methods. The data from the trials are also given in Table 2, but are distinguished from the fully reported trials by shading.

Table 1. Aldicarb residues[1] in bananas from supervised trials.

Country, Location, Year	Variety	Application		PHI, days	Portion of commodity analyzed	Residues mg/kg			Ref.
		No., Form.	Rate, ai, kg/ha &/or g/plant			Mean	Min.	Max.	
Cameroon Nyombe, 1992	Grand Naine		3.6 2 g/plant	33 63 92 124	Whole fruit[2]	0.11 0.23 0.11 0.04	0.05 0.09 0.04 0.02	0.20 0.41 0.19 0.08	JM27
Cameroon Penja, 1993	Grand Naine		3.6 2 g/plant	114	Whole fruit[2]	0.02	0.02	0.03	JM28
Egypt, Menoufia 1992	Balika		2 g/plant	87	Whole fruit[2]	0.02	0.02	0.03	JM29
			2.55 g/plant	154	Whole fruit[2]	0.02	0.02	0.02	
France (Martinique) Danoux, 1991	Poyo	3	2 g/plant	119	Pulp of mature yellow fruit	0.04			JM30
Barriere 1991	Grand Naine	3		175-205	Pulp of mature yellow fruit	<0.01			
Moulin a vent, 1991	Grand Naine	2		148-175	Pulp of mature yellow fruit	0.04			
Camille 1990	Grand Naine	2		>360	Pulp of mature yellow fruit	0.02			
Daroux 1991	Grand Naine	2		85-114	Pulp of mature yellow fruit	0.02			
Mangot 1991		3		175-205	Pulp of mature yellow fruit	0.025			
Cloture 1991	Grand Naine	2		175-205	Pulp of mature yellow fruit	0.02			
La Pointe 1991	Poyo	2		85-114	Pulp of mature yellow fruit	0.025			
Sapotille 1991	Grand Naine	3		146-173	Pulp of mature yellow fruit	0.01			
Ravine 1991	Poyo	1		85-114	Pulp of mature yellow fruit	0.06			
Terre Grasse 1991	Grand Naine	1		119	Pulp of mature yellow fruit[2]	0.13			
Etuve 1991	Grand Naine	1		85-114	Pulp of mature yellow fruit[2]	0.10			
Savane	Grand	1	2 g/plant	94	Pulp of mature	0.01			

Country, Location, Year	Variety	Application		PHI, days	Portion of commodity analyzed	Residues mg/kg			Ref.
		No., Form.	Rate, ai, kg/ha &/or g/plant			Mean	Min.	Max.	
1991	Naine				yellow fruit				
CAF9 1991	Grand Naine	1		55-85	Pulp of mature yellow fruit	0.05			
Papaye 1991	Poyo	1		113-143	Pulp of mature yellow fruit	0.04			
Fefe 1991	Grand Naine	1		122	Pulp of mature yellow fruit	0.01			
Dinde 1991	Grand Naine	1		151	Pulp of mature yellow fruit	0.03			
Beauvallon 1991	Grand Naine	3		88	Pulp of mature yellow fruit	0.29			
Neuf Chateau 1991	Grand Naine	4		86-89	Pulp of mature yellow fruit	0.12			
Lamberty 1991	Grand Naine	1		167	Pulp of mature yellow fruit	0.03			
La Rose 1991	Grand Naine	1		126	Pulp of mature yellow fruit[2]	0.09	0.05	0.18	
Mapoue 1991	Poyo	2		114-144	Pulp of mature yellow fruit[2]	0.07	0.02	0.18	
Carangaise 1991	Poyo/G. N	2		94	Pulp of mature yellow fruit[2]	0.15	0.03	0.25	
France/ Guadeloupe 1991	Grand Naine	1	2 g/plant	100	Pulp of mature green fruit[2]	0.172	0.04	0.75	JM31
Martinique 1993	Grand Naine	1	2 g/plant	89	Pulp of mature green fruit[2]	0.39	0.08	0.81	
Martinique 1987		1	2 g/plant	3	Whole fruit[3] Pulp	0.015 0.012	0.01	0.02	JM32
				7	Whole fruit[3] Pulp	0.067 0.056	0.02	0.09	
				14	Whole fruit[3] Pulp	0.21 0.20	0.09	0.41	
				30	Whole fruit[3] Pulp	0.20 0.16	0.04	0.29	
				45	Whole fruit[3] Pulp	0.35 0.28	0.02	0.53	
				60	Whole fruit[3] Pulp	0.50 0.45	0.23	0.70	
				75	Whole fruit[3] Pulp	0.23 0.18	0.05	0.38	
				90	Whole fruit[3] Pulp	0.31 0.26	0.12	0.38	
				120	Whole fruit[3] Pulp	0.077 0.071	0.01	0.11	
				150	Whole fruit[3] Pulp	0.037 0.035	0.01	0.11	
Grand Reduit 1988	Grand Naine	3	2 g/plant	19 19	Green fruit[4], whole Peel Pulp Yellow fruit, whole Peel	0.11 0.11 0.07 0.11 0.15			JM33

Country, Location, Year	Variety	Application		PHI, days	Portion of commodity analyzed	Residues mg/kg			Ref.
		No., Form.	Rate, ai, kg/ha &/or g/plant			Mean	Min.	Max.	
					Pulp	0.085			
Moulin l'Etang 1988	Grand Naine	3	2 g/plant	93 103	Green fruit[4], whole Peel Pulp Yellow fruit, whole Peel Pulp	0.04 0.06 0.04 0.13 0.20 0.08			
Union II 1989	Grand Naine	5G	2 g/plant	27 59 87	Pulp of mature fruit	< 0.11 < 0.06 < 0.04	0.02 < 0.02 < 0.02	0.23 0.09 0.08	JM34
		10G	2 g/plant	27 59 87	Pulp of mature fruit	< 0.09 0.05 < 0.03	< 0.03 < 0.03 < 0.02	0.13 0.06 <0.03	
		15G	2 g/plant	27 59 87	Pulp of mature fruit	0.06 < 0.05 < 0.03	0.04 0.02 < 0.02	0.09 0.07 0.05	
Gradis 1989	Poyo	1 5G	2 g/plant	27 60 88	Pulp of mature fruit	0.18 0.20 0.18	0.06 0.14 0.11	0.28 0.30 0.34	
		10G	2 g/plant	27 60 88	Pulp of mature fruit	0.17 0.39 0.19	0.12 0.14 0.08	0.26 0.65 0.32	
		15G	2 g/plant	27 60 88	Pulp of mature fruit	0.26 0.17 0.16	0.05 0.12 0.09	0.83 0.23 0.29	
Ressource 1989	Grand Naine	1 5G	2 g/plant	27 81 88	Pulp of mature fruit	0.11 0.13 0.23	0.04 0.07 0.16	0.20 0.27 0.3	
		10G	2 g/plant	27 81 88	Pulp of mature fruit	0.18 0.23 0.18	0.11 0.19 0.15	0.36 0.39 0.27	
		15G	2 g/plant	27 81 88	Pulp of mature fruit	0.43 ≤0.23 0.19	0.27 <0.02 0.07	0.98 0.55 0.29	
Ivory Coast Azaguie, 1992		1	4.0 ca. 2.0 g/plant	31 60 90 122	Whole fruit[2]	0.16 0.28 0.40 0.23	0.05 0.08 0.06 0.06	0.28 0.48 0.82 0.47	JM35
Thomasset 1993		1	4.0 ca. 2.0 g/mat	92 120	Whole fruit[2]	0.23 0.17	0.14 0.08	0.33 0.28	JM36
Bamacomoe 1993	Grand Naine		4.0 ca. 2.0 g/plant	94 123	Whole fruit[2]	0.20 0.07	0.05 0.05	0.31 0.10	
			3.6 ca. 2 g/plant	≥90	Whole fruit[2]	0.07	0.02	0.12	JM37
Damotte	Grand Naine		4.0 ca. 2 g/plant	≥90	Whole fruit	0.036			JM38
			4.0 ca. 2 g/plant	≥90	Whole fruit	0.032			

[1]Residues of aldicarb its sulfoxide and sulfone were either measured and reported individually or determined as sulfone after oxidation. In the Table the residues are expressed as aldicarb sulfone.

[2]Individual fingers were analyzed.

[3]Samples were taken from the upper and lower parts of the bunch. At each PHI the pulp and peel of 10 fruits were analyzed separately.

Whole fruit: residues in the peel and pulp of individual fingers were determined separately, but only the mean values of residues found in 10 fingers were reported.

Pulp: reported as the mean value and range of residues in the pulp of individual fingers.

[4]Results for mature green and yellow fruits are each based on 2 individual samples. Shipment of fruit lasted approximately 13 days; an additional 6 days was allowed for ripening to the yellow fruit stage.

Table 2. Aldicarb residues[1] in composite potato samples from supervised trials. All single applications except where otherwise shown.

Country Year	Application		Residues (mg/kg) at days after application							Ref.
	Rate, ai	Type[2]	38-56	57-63	64-84	85-99	100-110	111-140	141-206	
UK 1983	8.6 g/100m	F.							<0.05	JM16
	4.3 g/100m	S.					<0.05			
	8.6 g/100m	F.						<0.05		
	4.3 g/100m	S.					<0.09			
	8.6 g/100m	F.							<0.05	
	4.3 g/100m	S.				<0.05				
	8.6 g/100m	S.				<0.05				
UK 1982	12.8 g/100m	F.							0.09 0.10	JM17
	8.6 g/100m	F.							<0.05 0.07	
	8.6 g/100m	S.					<0.05			
	8.6 g/100m	F.							0.08 0.07	
	8.6 g/100m	F.						<0.05		
	8.6 g/100m	S.				<0.05				
	4.3 g/100m	F.						<0.05		
Argentina 1991	2 x 1.0 kg/ha	S.	0.0008							JM01
	2.0 kg/ha	F.						0.0006		
	2.0 kg/ha	S.		0.0006						
Belgium 1988	1.0 kg/ha	F.	0.35	0.18	0.19	0.09[3]	0.08	0.03		JM02
	3.0 kg/ha	F.	1.32	0.51	0.45	0.47	0.14	0.20		
	5.0 kg/ha	F.	1.95	1.35	0.69	0.47	0.53	0.29		
	10.0 kg/ha	F.	5.25	2.54	1.12	0.74	0.53	0.60		

Country Year	Application		Residues (mg/kg) at days after application							Ref.
	Rate, ai	Type[2]	38-56	57-63	64-84	85-99	100-110	111-140	141-206	
	25 kg/ha	F.	16.12	8.50	6.77	2.87	3.33	194		
Canada 1985	2.0 kg/ha		1.53	0.90	0.45 0.47 0.49	0.19 0.30	<0.02			JM03
	1.6 kg/ha		0.48		0.73 0.26 0.15	0.26 0.43	0.03			
	2.0 kg/ha		0.34	0.11	0.11	0.07				
Czechoslovakia 1987	2 x 5.0 kg/ha	B. B.						0.03 0.35		JM04
Germany 1984	6.0 g/100m	F.					0.114	0.067	0.038	JM06
	6.0 g/100m	F. i				0.072 0.044		0.03		
	6.0 g/100m	F.				0.022		0.016 0.012		
	6.0 g/100m	F.				0.104	0.101	0.046		
	6.0 g/100m	F.			0.343 0.322	0.217				
	6.0 g/100m	F.			0.056 0.038	0.009				
Greece 1986	3.5 kg/ha	B.						0.09		JM07
	7.0 kg/ha	B.						0.15		
	2.5 kg/ha	F.						<0.03		
	5.0 kg/ha	F.						0.12		
Hungary 1984	4.0 kg/ha	B.				<0.015				JM08
Italy 1992	1.425 kg/ha							0.035		JM09
	2.850 kg/ha							0.029		
Nethlnds 1982	1.0 kg/ha	F.							0.05	JM10
	1.0 kg/ha	F.							<0.03	
Nethlnds 1982	3.0 kg/ha	B.					0.09			JM11
	3.0 kg/ha	B.				0.12				

Country Year	Application		Residues (mg/kg) at days after application							Ref.
	Rate, ai	Type[2]	38-56	57-63	64-84	85-99	100-110	111-140	141-206	
	3.0 kg/ha	B.						<0.03		
	3.0 kg/ha	B.						<0.03		
	3.0 kg/ha	B.						<0.03		
	3.0 kg/ha	B.				0.06				
	3.0 kg/ha	B.							<0.03	
	3.0 kg/ha	B.							<0.03	
	3.0 kg/ha	B.						<0.03		
	3.0 kg/ha	B.							<0.03	
	3.0 kg/ha	B.						0.07		
	3.0 kg/ha	B.						<0.03		
	3.0 kg/ha	B.							0.05	
	3.0 kg/ha	B.					<0.03			
	3.0 kg/ha	B.							0.05	
	3.0 kg/ha	B.						0.25		
	3.0 kg/ha	B.						0.04		
	3.0 kg/ha	B.							<0.03	
	3.0 kg/ha	B.							0.03	
	3.0 kg/ha	B.							0.07	
	3.0 kg/ha	B.							<0.03	
	3.0 kg/ha	B.							<0.03	
	3.0 kg/ha	B.							0.18	
	3.0 kg/ha	B.							0.03	
	3.0 kg/ha	B.							<0.03	
	3.0 kg/ha	B.							0.09	
	3.0 kg/ha	B.						<0.03		
	3.0 kg/ha	B.						<0.03		
	3.0 kg/ha	B.							0.03	
	3.0 kg/ha	B.							0.05	
	3.0 kg/ha	B.							<0.03	
South	7.5 kg/ha at				0.04			<0.01		JM12

Country Year	Application		Residues (mg/kg) at days after application							Ref.
	Rate, ai	Type[2]	38-56	57-63	64-84	85-99	100-110	111-140	141-206	
Africa 1989	planting									
	2 x 3.75 kg/ha		0.14			0.04				
	3.75 kg/ha at emergence		0.10			0.04				
	7.5 kg/ha at planting				0.09			0.07		
	2 x 3.75 kg/ha		0.38		0.31					JM13
	3.75 kg/ha at emergence		0.36		0.22					
South Africa 1990	5.25 kg/ha					2.8		0.61		JM14
	5.25 kg/ha					2.1		1.14		
	5.25 kg/ha					0.3		0.12		
	4.2 kg/ha					0.28				
	7.5 kg/ha					0.64		0.55		
	7.5 kg/ha					0.94		0.75		
	7.5 kg/ha					1.02		0.40		
	7.5 kg/ha					0.40		0.46		
	7.5 kg/ha					0.49		0.6		
	7.5 kg/ha					0.77		0.54		
	3.3 kg/ha					0.43				
	5.25 kg/ha					1.06 0.74				
	5.25 kg/ha					1.86 0.66		0.64 0.43		
	5.25 kg/ha					0.11 0.64		0.01 0.12		
	5.25 kg/ha at planting					0.18				
	7.5 kg/ha at planting					0.66				
	3.75+3.75 kg/ha			0.02						
	3.75 kg/ha at emergence							0.24		

Country Year	Application		Residues (mg/kg) at days after application							Ref.
	Rate, ai	Type[2]	38-56	57-63	64-84	85-99	100-110	111-140	141-206	
1991	7.5 kg/ha at planting					0.009				
	5.25 kg/ha					0.007				
	3.75+3.75 kg/ha			0.027						
	3.75 kg/ha					0.39		0.58		
	7.5 kg/ha					0.56		0.78		
Spain 1980	1.5 kg/ha								0.02	JM15
	1.5 kg/ha								0.2	
	1.5 kg/ha							0.03		
	1.5 kg/ha								0.04	
	4.1 kg/ha							0.08		
	1.5 kg/ha							0.30		
	1.5 kg/ha							<0.02		
	1.5 kg/ha								0.07	
	1.5 kg/ha							0.7		
	1.5 kg/ha								0.2	
	1.5 kg/ha								0.02	
	1.5 kg/ha								0.03	
	3.0 kg/ha								0.07 0.06 0.20 0.08	
	2.0 kg/ha								0.06	
	1.5 kg/ha								0.04	
	1.5 kg/ha							0.20		
	1.5 kg/ha								<0.02	
	1.5 kg/ha								0.02	
	1.5 kg/ha								<0.02	
	1.5 kg/ha								0.04	
	1.5 kg/ha								0.03	
	1.5 kg/ha								0.08	
	1.5 kg/ha							0.02		

Country Year	Application		Residues (mg/kg) at days after application							Ref.
	Rate, ai	Type[2]	38-56	57-63	64-84	85-99	100-110	111-140	141-206	
	3.4 kg/ha							0.40		
1978	1.57 kg/ha								<0.005	
	1.71 kg/ha								<0.005	
	2.0 kg/ha								<0.005	
	2.28 kg/ha								<0.005	
	1.86 kg/ha								<0.05	
	1.28 kg/ha								<0.05	
	2.43 kg/ha								0.07	
	1.71 kg/ha								0.01	
	2.0 kg/ha								0.005	
	2.14 kg/ha								0.007	
	1.86 kg/ha								0.01	
	1.57 kg/ha								<0.005	
1979	1.57 kg/ha					0.23				
	1.57 kg/ha							0.05		
	1.86 kg/ha								0.03	
	1.57 kg/ha								0.03	
	1.86 kg/ha								0.03	
	1.57 kg/ha								<0.005	
	1.57 kg/ha							0.03		
	1.57 kg/ha							0.03		
	1.57 kg/ha							0.02		
	1.57 kg/ha								0.07	
	3.5 kg/ha							0.01		
1981	2.5 kg/ha 3.5 kg/ha							0.01	<0.005	
	3.5 kg/ha								0.03	
	3.5 kg/ha								0.04	
	3.5 kg/ha								0.20	
	3.5 kg/ha								0.03	

Country Year	Application		Residues (mg/kg) at days after application							Ref.
	Rate, ai	Type[2]	38-56	57-63	64-84	85-99	100-110	111-140	141-206	
	5.0 kg/ha								0.07	
	3.5 kg/ha								<0.005	
1982	2.0 kg/ha				0.08					
	2.0 kg/ha				0.25					
	2.0 kg/ha				0.10					
	2.0 kg/ha						<0.05			
	2.0 kg/ha					0.10				
	1.5 kg/ha							0.02		
	2.0 kg/ha							0.03		
	2.66 kg/ha							0.06		
	1.5 kg/ha							0.10		
	2.0 kg/ha							0.06		
	2.0 kg/ha							<0.02		
1983	1.7 kg/ha								<0.05	
	2.0 kg/ha								<0.05	
	2.1 kg/ha								<0.05	
	2.4 kg/ha								<0.05	

[1]Residues expressed as aldicarb sulfone
[2]B.: broadcast application. F.: in furrow application. S.: side band or side dress application.
[3]No GAP PHI, tubers were ready for marketing at new potato stage

Many studies have been conducted to determine the level of residues in potatoes in the USA. and the UK during 1990-1993. In these trials large number of individual potato tubers taken from single sites were analysed in order to obtain information on the within-field and the field-to-field variation of residues, depending on the mode of application, method of irrigation and climatic conditions. The trial conditions, numbers of tubers analysed and the sum of the carbamate residues expressed as aldicarb sulfone are given in Table 3. The residues deriving from trials according to the different use patterns established for the Northwest States and for Florida are underlined. In estimating maximum residue levels the growing and climatic conditions of the Northern States (Washington, Idaho, Oregon, Michigan, North Dakota, Pennsylvania and Maine) and the Southern States (Florida, Texas) of the USA were considered to be comparable.

The many residues measured in individual tubers provide an excellent basis for the precise estimation of acute dietary risk deriving from the use of the compound. However, since the range of residues in individual tubers is much wider than the range of average residues in composite samples consisting of 10-12 tubers, the results cannot be used directly for estimating maximum residue levels.

Therefore composite random samples consisting of 12 tubers, the recommended sample size according to FAO Guidelines (FAO, 1990), were drawn with replacement from some of the primary residue data sets obtained from individual tubers according to a computer programme described recently (Ambrus, 1996). The programme draws the composite samples and calculates their average residues from the residue content of the potatoes selected for each sample. Figures 1-6 show the relative frequency distribution of residues in individual potatoes and in composite samples. It can be seen that the distributions of the residues in the primary samples are far from normal, so distribution-free statistics have to be used for their analysis.In such cases a minimum of 90 samples are required to estimate the 95th percentile of the population with 99% confidence (FAO, 1993). Composite samples were therefore drawn from primary sample populations taken from uniformly treated areas (excluding the end sections of rows) and consisted of at least 100 samples with one exception where there were 79 samples.The means, medians, and minimum and maximum residues found in 100 replicate composite samples are also presented in Table 3 together with the corresponding primary residue data. Since the average residues in composite samples are used to determine whether the crop had been treated according to GAP, the maximum residues found in composite random samples drawn by the computer are underlined in the Table.

Six field trials were conducted in different locations of the UK at recommended and double rates. Fifty individual tubers were collected from each site and analysed for aldicarb residues (Maycey *et al.*, 1991; Brockelsby *et al.*, 1991). The average residues ranged from 0.14 to 0.46 mg/kg following applications according to GAP.

Table 3. Aldicarb residues[1] in individual potato tubers deriving from supervised trials. All single applications.

Location,[2] Trial no.	Application	PHI, days	No. of samples	Residues (mg/kg) at days	Ref.

	Rate, ai	Type[3]			Mean	Median	Min.	Max.	
UK trials, 1990									
Isle of Wright	3.36 kg/ha	B	90	49	0.46	0.455	0.07	0.9	JM18
Kilverstone	11.4 g/100m	F	84	50	0.14	0.099	0.02	0.44	JM18
Holbeach	3.36 kg/ha	B	91	50	0.21	0.175	0.05	0.84	JM18
Jersey	2.24 kg/ha	B	79	50	0.40	0.333	0.02	0.89	JM18
Scunthorpe	5.6 kg/ha	B	95	50	0.64	0.584	<0.02	1.98	JM18
Scunthorpe	5.6 kg/ha	B	95	50	0.66	0.613	<0.02	1.99	JM19
			121	10	0.32	0.274	0.06	0.62	
			145	10	0.57	0.327	0.06	1.23	
			171	10	0.23	0.204	0.05	0.54	
USA trials, 1990-1993									
WA. 90-131	3.27 kg/ha	B, f.i.	156	100	0.09		<0.02	0.48	JM21
WA. 90-132	3.35 kg/ha	B. f.i.	160	40	0.30	0.07	<0.02	2.82	JM21
WA. 90-133	3.36 kg/ha	B. f.i.	160	20	0.08	0.04	<0.02	0.57	JM21
WA. 90-134	3.27 kg/ha	B. f.i.	126	20	0.08	0.065	<0.02	0.37	JM21
WA. 90-135	3.35 kg/ha	B. f.i.	160	60	0.24	0.065	<0.02	5.30	JM21
WA. 90-136	3.36 kg/ha	B. f.i.	160	20	0.15	0.12	0.04	0.35	JM21
WA. 90-137	3.38 kg/ha	B. o.i.	159	100	0.07	0.05	<0.02	0.32	JM21
			Composite Samples		0.073	0.07	0.04	0.13	
WA. 90-138	3.38 kg/ha	B. o.i.	155	100	0.08	0.06	<0.02	0.49	JM21
			Composite samples		0.08	0.076	0.04	0.15	
WA. 90-139	3.35 kg/ha	B. o.i.	156	100	<0.02	<0.02	<0.02	0.02	JM21
WA 90-140	3.32 kg/ha	Be. o.i.	124	100	0.11	0.1	0.01	0.39	JM21
			Composite samples		0.11	0.108	0.072	0.174	
WA. 90-141	3.32 kg/ha	Be. o.i.	118	45	0.15	0.13	0.05	0.28	JM21
WA. 90-142	3.37 kg/ha	Be. o.i.	119	100	0.17	0.15	0.03	0.71	JM21
			Composite samples		0.163	0.160	0.09	0.26	
ID. 90-147	3.20 kg/ha	B. f.i.	139	20	0.02	0.015	<0.02	0.10	JM21
ID. 90-148	2.93 kg/ha	B. f.i.	108	20	<0.02	<0.02	<0.02	0.01	JM21
ID. 90-149	3.40 kg/ha	B. f.i.	135	20	0.21	0.115	0.03	0.91	JM21
ID. 90-150	3.82 kg/ha	B. f.i.	142	20	0.02	0.01	<0.02	0.17	JM21
ID. 90-151	3.42 kg/ha	B. o.i.	129	100	0.05	0.04	<0.02	0.21	JM21
			Composite samples		0.048	0.045	0.021	0.099	

Location,[2] Trial no.	Application		PHI, days	No. of samples	Residues (mg/kg) at days				Ref.
	Rate, ai	Type[3]			Mean	Median	Min.	Max.	
ID. 90-152	3.74 kg/ha	B. o.i.	146	100	0.03	0.01	<0.02	0.38	JM21
			Composite samples		0.031	0.027	0.011	0.063	
ID. 90-153	3.48 kg/ha	Be. o.i.	94	79	0.12	0.08	<0.02	0.74	JM21
			Composite samples		0.124	0.112	0.024	0.346	
CO. 92-112	3.34 kg/ha	F. o.i.	133	30[4]	0.05		<0.02	0.11	JM22
				24[5]	0.22		<0.02	1.11	JM22
CO. 92-113	3.34 kg/ha	F. o.i.	126	30[4]	0.06		0.04	0.15	JM22
				24[5]	0.10		<0.02	0.68	
NE. 92-114	3.18 kg/ha	F. o.i.	104	30[4]	0.03		<0.02	0.15	JM22
				24[5]	0.04		0.02	0.09	
FL. 92-115	3.21 kg/ha	F. o. i.	102	30[4]	0.21		0.04	0.57	JM22
				24[5]	0.25		0.02	1.04	
MN. 92-118	3.18 kg/ha	F. o.i.	109	30[4]	0.17		0.07	0.40	JM22
				24[5]	0.18		<0.02	0.98	
OR. 92-119	3.60 kg/ha	F. o.i.	167	30[4]	0.04		0.02	0.04	JM22
				24[5]	0.03		<0.02	0.06	
OR. 92-120	3.40 kg/ha	F. o.i.	167	30[4]	0.04		0.02	0.05	JM22
				24[5]	0.03		<0.02	0.06	
MT. 92-121	3.12 kg/ha	F. o.i.	107	30[4]	0.10		<0.02	0.26	JM22
				24[5]	0.23		<0.02	1.75	
MI. 92-122	6.63 kg/ha	F. o.i.	110	30[4]	0.16		0.04	0.56	JM22
				24[5]	0.24		<0.02	1.16	
MI. 92-123	6.63 kg/ha	F. o.i.	110	30[4]	0.40		0.05	0.91	JM22
				24[5]	0.53		<0.02	3.13	
WA. 92-124	3.20 kg/ha	F. o.i.	152	30[4]	<0.02		<0.02	0.02	JM22
				24[5]	<0.02		<0.02	0.02	
WA. 92-125	3.64 kg/ha	F. o.i.	140	30[4]	0.03		<0.02	0.06	JM22
				24[5]	0.03		<0.02	0.04	
ID. 92-126	3.74 kg/ha	F. o.i.	136	30[4]	0.05		0.02	0.13	JM22
				24[5]	0.07		<0.02	0.30	
ID. 92-127	3.74 kg/ha	F. o.i.	139	30[4]	0.02		<0.02	<0.02	JM22
				24[5]	<0.02		<0.02	0.02	
CA. 92-128	3.18 kg/ha	F. o.i.	145	30[4]	0.02		<0.02	0.04	JM22

Location,[2] Trial no.	Application		PHI, days	No. of samples	Residues (mg/kg) at days				Ref.
	Rate, ai	Type[3]			Mean	Median	Min.	Max.	
				24[5]	0.01		<0.02	0.06	
ND. 92-129	3.46 kg/ha	F. o.i.	118	30[4]	0.08		0.04	0.15	JM22
				24[5]	0.07		<0.02	0.20	
TX. 92-130[7]	3.42 kg/ha	F. o.i.	109	30[4]	0.12		0.04	0.35	JM22
				24[5]	0.12		0.02	0.57	
ME. 90-107	2.44 kg/ha	BR.	97	100	0.14	0.13	0.04	0.34	JM24
			Composite samples		0.14	0.135	0.09	0.19	
WA. 90-129	3.32 kg/ha	BR.	97	300	0.29	0.24	0.04	1.3	JM24
			Composite samples		0.296	0.277	0.183	0.458	
WA. 90-130	3.30 kg/ha	BR.	123	100	0.06	0.04	0.02	0.22	JM24
			Composite samples		0.055	0.053	0.04	0.081	
ID. 90-146	3.29 kg/ha	F.	146	100	0.019	0.02	<0.02	0.06	JM24
			Composite samples		0.022	0.022	<0.02	0.03	
PA. 90-191	2.93 kg/ha	F.	132	100	0.045	0.04	0.02	0.15	JM24
			Composite samples		0.045	0.043	0.037	0.059	
FL. 90-026	3.39 kg/ha	F.	106	100	0.085	0.07	0.02	0.54	JM24
			Composite samples		0.083	0.08	0.05	0.15	
MI. 90-095	3.36 kg/ha	BR.	100	100	0.09	0.075	0.02	0.37	JM24
			Composite samples		0.091	0.088	0.056	0.14	
MI. 90-096	3.52 kg/ha	F.	120	100	0.05	0.04	0.02	0.15	JM24
			Composite samples		0.056	0.051	0.034	0.099	
FL. 93-001	3.02 kg/ha	F. PDA	104	85	0.034[5]		<0.02	0.23	JM25
					0.075[4]		0.022	0.34	
	3.81 kg/ha	F. GFA	104	84	0.12[5]		0.04	0.59	
FL. 93-002	3.14 kg/ha	F. PDA	104	81	0.025[5]		<0.02	0.065	JM25
					0.061[4]		0.022	0.27	
	3.58 kg/ha	F. GFA	104	75	0.13[5]		0.04	1.3	
TX. 93-003	3.28 kg/ha	F. PDA	106	100	0.23[5]		0.02	1.2	JM25
	4.16 kg/ha	F. GFA	106	100	0.50[5]		0.05	7.7	
TX. 93-004	3.33 kg/ha	F. PDA	106	100	0.09[5]		<0.02	0.31	JM25

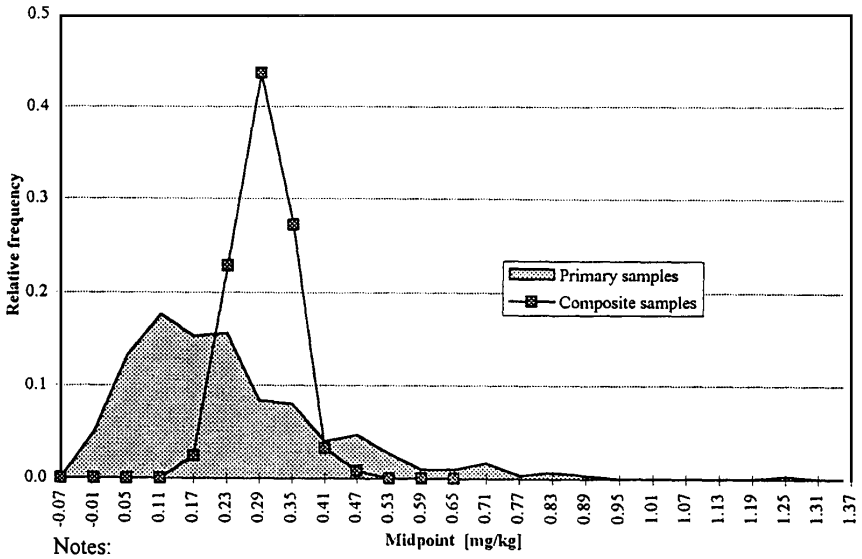
Location,[2] Trial no.	Application		PHI, days	No. of samples	Residues (mg/kg) at days				Ref.
	Rate, ai	Type[3]			Mean	Median	Min.	Max.	
	4.13 kg/ha	F. GFA	106	97	0.26[5]		<0.02	3.2	
OR. 93-005	3.33 kg/ha	F. PDA	152	94	0.01[5]		<0.02	0.21	JM25
			152	30	0.03[4]		<0.02	0.072	
	3.51 kg/ha	F. GFA	152	100	0.069[5]		<0.02	1.2	
OR. 93-006	3.30 kg/ha	F. PDA	152	87	<0.02[5]		<0.02	0.046	JM25
				30	≤0.02[4]		<0.02	0.023	
	3.62 kg/ha	F. GFA	152	90	0.03[5]		<0.02	0.165	
OR. 93-007	3.34 kg/ha	F. PDA	149	93	0.059[5]		<0.02	0.22	JM25
				30	0.053[4]		0.044	0.10	
	3.67 kg/ha	F. GFA	149	95	0.15[5]		0.022	0.98	
OR. 93-008	3.33 kg/ha	F. PDA	170	90	<0.02[5]		<0.02	0.063	JM25
				30	0.024[4]		<0.02	0.065	
	3.35 kg/ha	F. GFA	170	93	0.034[5]		<0.02	0.28	
WA. 93-009	3.33 kg/ha	F. PDA	152	100	0.06[5]		<0.02	0.29	JM25
				30	0.18[4]		0.049	0.61	
	3.6 kg/ha	F. GFA	152	96	0.46[5]		0.042	3.94	
WA. 93-010	3.33 kg/ha	F. PDA	142	98	0.06[5]		<0.02	0.20	JM25
				30	0.11[4]		0.042	0.32	
	3.64 kg/ha	F. GFA	152	100	0.79[5]		0.04	6.8	
WA. 93-011	3.08 kg/ha	F. PDA	152	100	0.030[5]		<0.02	0.112	JM25
				30	0.048[4]		0.042	0.094	
	4.55 kg/ha	F. GFA		100	0.072[5]		<0.02	0.342	
WA. 93-012	3.33 kg/ha	F. PDA	151	100	<0.02[5]		<0.02	0.048	JM25
				30	≤0.02[4]		<0.02	0.045	
	3.85 kg/ha	F. GFA	151	98	0.014[5]		<0.02	0.084	
ID. 93-013	3.36 kg/ha	F. PDA	131	101	<0.02[5]		<0.02	1.12	JM25
				30	0.14[4]		0.04	0.51	
	4.03 kg/ha	F. GFA	131	98	0.41[5]		0.042	7.2	
ID. 93-014	3.25 kg/ha	F. PDA	151	100	0.09[5]		<0.02	1.2	JM25
				30	0.09[4]		<0.02	0.26	
	3.81 kg/ha	F. GFA	151	100	0.69[5]		0.022	12.8	
ID. 93-015	3.36 kg/ha	F. PDA	146	100	<0.02[5]		<0.02	0.045	JM25
				30	≤0.02[4]		<0.02	0.17	
	3.58 kg/ha	F. GFA	146	100	<0.02[5]		<0.02	0.049	

Location,[2] Trial no.	Application		PHI, days	No. of samples	Residues (mg/kg) at days				Ref.
	Rate, ai	Type[3]			Mean	Median	Min.	Max.	
ID. 93-016	3.47 kg/ha	F. PDA	146	100	0.026[5]		<0.02	0.25	JM25
				30	0.034[4]		<0.02	0.17	
	4.03 kg/ha	F. GFA	146	100	0.043[5]		<0.02	0.39	

[1]Expressed as aldicarb sulfone (aldicarb residues mg/kg = aldicarb sulfone mg/kg x 0.856)
[2]States of the USA: WA Washington; ID Idaho; CO Colorado; NE Nebraska; FL Florida; MN Minesota; OR Oregon; MT Montana; MI Michigan; CA California; ND North Dakota; TX Texas; ME Maine; PA Pennsylvania.
[3]B broadcast application; Be broadcast at emergence; BR band over row application at emergence; F in furrow application; GFA gravity-flow application; PDA positive-displacement application; f.i. furrow irrigation; o.i. overhead irrigation
[4]Samples were taken from the centre of the row
[5]Samples were taken from the end of the row

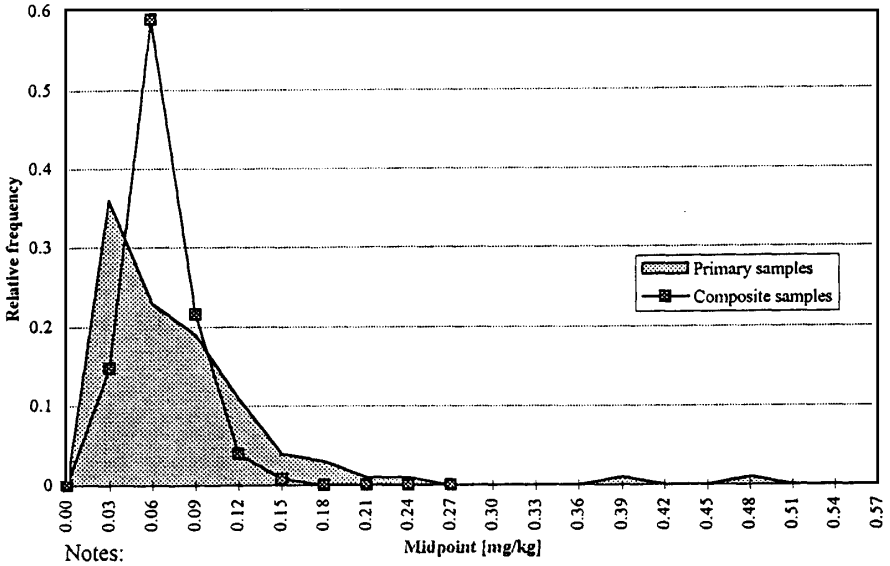
Nineteen field trials were conducted in the Pacific Northwest region of the USA to determine whether irrigation methods affected the magnitude of aldicarb residues in potatoes treated with a 15G formulation (Tew, 1992). Overhead and in-furrow irrigation methods were compared. All plots were treated with the nominal maximum label rate of 3.36 kg ai/ha with commercial ground equipment. Plots irrigated in-furrow were treated at planting, while overhead irrigation was either at planting or at emergence. A total of 340 tubers from plots irrigated in-furrow and 824 tubers from plots treated by overhead irrigation plots were analysed.

Figure 1. Relative frequency distribution of aldicarb sulfone residues in potato samples from trial 90-129.



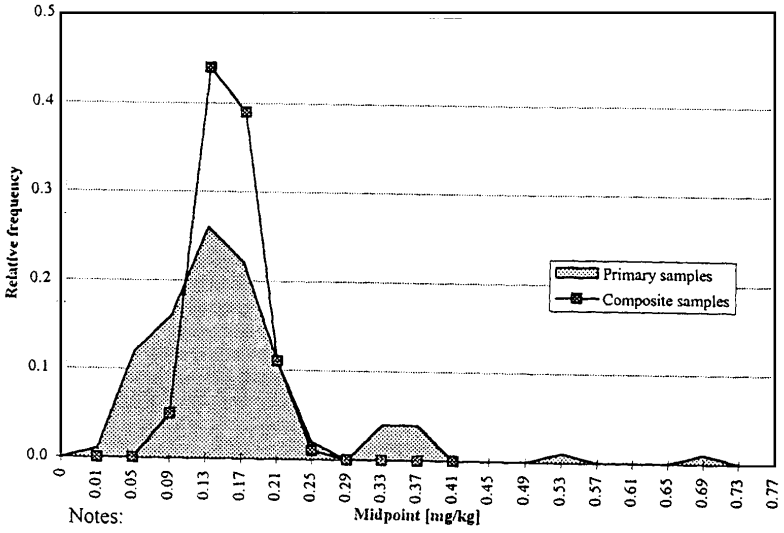
Notes:
Primary samples:
Mean = 0.295 Standard Deviation = 0.1820 Median = 0.255
Composite samples:
Mean = 0.294 Standard Deviation = 0.04989 Median = 0.2875

Figure 2. Relative frequency distribution of aldicarb sulfone residues in potato samples from trial 90-138.



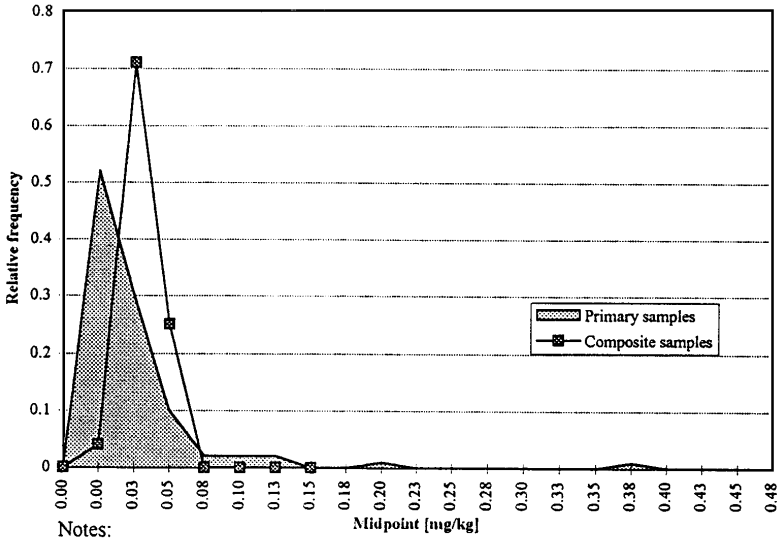
Notes:
Primary samples:
Mean = 0.0773 Standard Deviation = 0.0724723 Median = 0.06
Composite samples:
Mean = 0.077 Standard Deviation = 0.0200693 Median = 0.076

Figure 3. Relative frequency distribution of aldicarb sulfone residues in potato samples from trial 90-142.



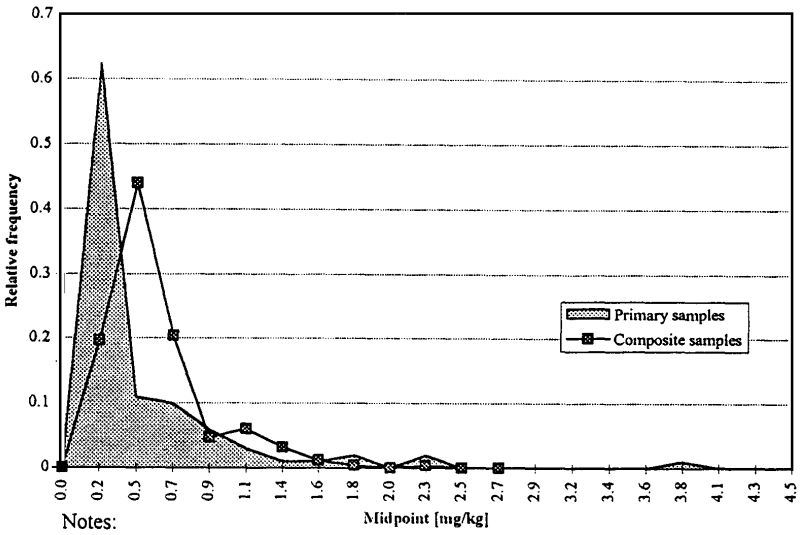
Notes:
Primary samples
Mean = 0.166 Standard Deviation = 0.10245 Median = 0.15
Composite samples
Mean = 0.163 Standard Deviation = 0.02897 Median = 0.160

Figure 4. Relative frequency distribution of aldicarb sulfone residues in potato samples from trial 90-152.



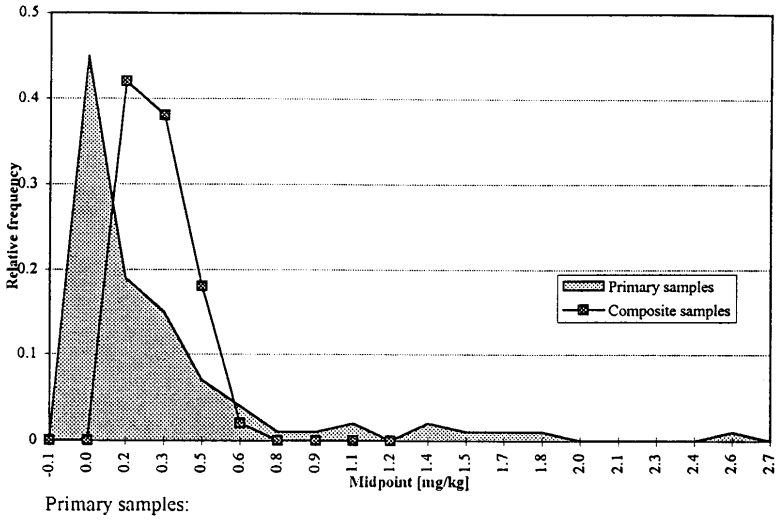
Notes:
Primary samples:
Mean = 0.0306 Standard Deviation = 0.04690 Median = 0.01
Composite samples:
Mean = 0.0311 Standard Deviation = 0.01242 Median = 0.0275

Figure 5. Relative frequency distribution of aldicarb sulfone residues in potato samples from several fields after harvest.



Notes:
Primary samples:
Mean = 0.454 Standard Deviation = 1.0590 Median = 0.12
Composite samples:
Mean = 0.4576 Standard Deviation = 0.31584 Median = 0.371
Residues between 9.1 and 10.2 mg/kg level at
1% relative frequency are not shown

Figure 6. Relative frequency distribution of aldicarb sulfone residues in potato samples after 6 months storage.



Primary samples:
Mean = 0.301 Standard Deviation = 0.4347 Median = 0.125
Composite samples:
Mean = 0.302 Standard Deviation = 0.1108 Median = 0.2788

In the in-furrow irrigation trials the maximum residue (aldicarb plus its metabolites) was 5.30 mg/kg, and eight tubers contained residues above 1 mg/kg.

Following treatments at planting and at plant emergence with overhead irrigation, the maximum residues found were 0.49 and 0.74 mg/kg respectively, and 95% of the tubers contained residues below 0.15 and 0.3 mg/kg respectively. The average residues ranged from 0.03 to 0.3 mg/kg in both primary and composite samples. At 155 and 159 days PHI the maximum residues found in composite samples deriving from two trials were 0.15 mg/kg and 0.13 mg/kg, respectively.

Seventeen field trials were conducted in twelve States of the USA in which aldicarb was applied in-furrow at planting at a target rate of 3.36 kg ai/ha (Tew, 1993a). Treated plots were subdivided into three sections at the time of sampling. The first and last 1.5 m sections of each row were marked and identified as row-end sections. The remaining centre parts of the plots were considered as the uniform application area (row centre). Samples were collected separately from the row centre and the row-end sections. In one trial (92-130) PDA equipment was used, while in the other trials the treatment was carried out by gravity-flow application (GFA). A total of 918 individual potato tubers were analysed. Of these, twelve contained total aldicarb residues above 1 mg/kg, and all of these samples were taken from row-end sections. The maximum residue found was 3.13 mg/kg. The maximum residue found in any row-centre sample was 0.91 mg/kg. The 95th percentile for all samples was 0.40 mg/kg, for row-end samples 0.52 mg/kg, and for row-centre samples 0.34 mg/kg. Since 24-30 potatoes were analysed from each sections, the residues in composite samples were not calculated.

Eight field trials in six States of the USA were designed to determine the variability of aldicarb residues within treated plots and within individual plants (Tew, 1993b). The pesticide was applied at the maximum nominal recommended rate in furrow at planting or with a granular spreader at emergence. One hundred individual potato tubers were analysed from each plot, except in trial 90-129 from which 300 tubers were analysed. Of the total of 1621 samples analysed, only two tubers contained residues above 1 mg/kg, the maximum residue found was 1.3 mg/kg. At PHIs corresponding to GAP the average residues ranged from 0.02 mg/kg to 0.09 mg/kg and the maximum residues in composite samples were between 0.03 and 0.15 mg/kg (Table 3).

Ten potato plants were randomly selected from each plot. All of the tubers found under the selected plants were analysed individually. The coefficient of variation of residues in the tubers from one plant ranged from 0% (three plants) to 350% (one plant), but some of these results are biased by the very low residue levels and few (4-6) tubers per plant . The average residues and their relative standard deviations (coefficients of variation) are shown in Table 4.

Sixteen trials were conducted in four States of the USA to compare the variability and magnitude of the residues in potato tubers grown in the 6 m end-sections of rows, where the tractor comes to a stop before the applicator is lifted, with the mid-row variability and residue levels (Tew, 1994a). Positive-displacement application (PDA) equipment and the conventional gravity-flow applicator (GFA) were used on the side-by-side test plots in each trial. The number of samples analysed from the end-row sections varied from 75 to 101. Thirty tubers were analysed from the mid-row section. A total of 3414 individual potato tubers from the treated plots were analysed. The results are summarized in Table 3.

From the PDA-treated plots a total of 1529 end-row tubers were analysed, of which three contained residues above 1 mg/kg (1.2, 1.2, and 1.12 mg/kg). The highest residues found in mid-row samples were 0.61, 0.51 and 0.32 mg/kg. The average residues in mid-row and end-row samples from treatments complying with GAP ranged from <0.02 to 0.18 mg/kg and from <0.02 to 0.23 mg/kg respectively.

A total of 1525 individual tubers were analysed from end-row sections following GFA treatment. Of these 67 tubers contained residues over 1 mg/kg with a maximum value of 12.8 mg/kg.

The average residues in end-row samples ranged from 0.03 to 0.79 mg/kg.

The Meeting examined the relationship between the average and maximum residues detected in individual potato tubers at sites treated according to the GAP rate and PHI, taking into consideration all middle and end-row ground applications, representing most of the world-wide conditions of use, where the number of potato tubers was above 80 (in most cases it was 100). The selected primary sample populations cover about 95% of residues with 98-99% confidence, which provides a valid data base for estimating the ratio of maximum to average residues. The data are shown graphically in Figure 7. The linear regression of the data resulted in a regression coefficient of 0.904 which indicates an acceptable correlation.

Figure 7. Relation between maximum and average residues from trials according to GAP, including end-row samples.

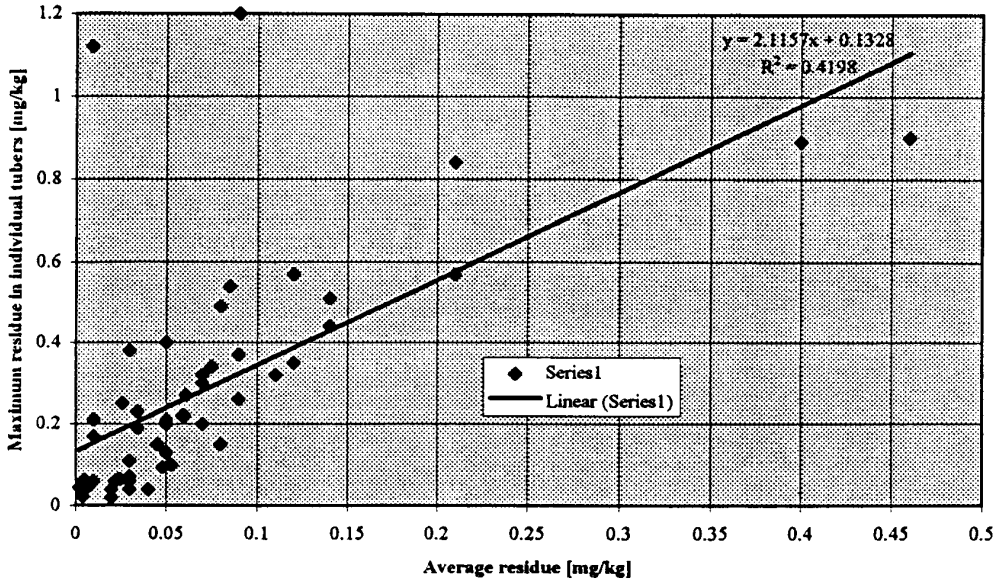


Table 4. Average numbers of tubers found under one plant, and the average residues and their coefficients of variation in single potato tubers under individual plants and within experimental plots.

Trial No.	Within-plant			Within-plot	
	Mean no. of tubers	Mean residue, mg/kg	CV%	Residue, mg/kg	CV%
90-026	6	0.12	24	0.085	88.8
90-095	8	0.1	46	0.089	67.2
90-096	8	0.06	27	0.05	81.9
90-107	7	0.09	37	0.14	51.7
90-129	11	0.24	55	0.295	65.7
90-130	14	0.06	51	0.057	57.4
90-146	8	0.06	109	0.019	31.7
90-191				0.046	40.9
Grand average		0.104	49.9	0.098	60.7
Between-plot CV					87.4

The within-field variation of composite potato samples taken between 118 and 155 days after treatment (Table 5) gave an average CV of 23% and an average variance (square of standard deviations) of 0.0002. The field-to-field variation of the average residues in different regions following GAP applications (Table 6) gave CVs ranging from 70% to 139% with an average of 102%. The average variance for centre-row samples from GAP treatments was 0.0105. The total variance of residues in the samples (V_s) is the sum of the within-field (V_{wf}) and between-field (V_{bf}) variances:

$$V_s = V_{bf} + V_{wf}$$

Since the average within-field variation is only 2-40% of the between-field variation, it effectively does not influence the total variance of the residues and the average residues obtained by the analyses of ≥12 individual potato samples can be used to estimate the maximum residue levels reflecting GAP.

Table 5. Variation of aldicarb residues in composite and primary samples arising soil treatment with aldicarb

Trial No.	Composite samples	Primary samples CV

	Residues expressed as sulfone, mg/kg				SD	Variance	CV	
	Mean	Median	Minimum	Maximum				
90-026	0.083	0.080	0.050	0.150	0.0184	0.00034	0.22	0.89
90-096	0.056	0.051	0.034	0.099	0.0137	0.00019	0.24	0.82
90-137	0.073	0.070	0.044	0.132	0.0166	0.00028	0.23	0.82
90-138	0.077	0.076	0.038	0.148	0.0202	0.00041	0.26	0.94
90-146	0.022	0.022	0.020	0.030	0.0023	0.00001	0.10	0.32
90-151	0.048	0.045	0.021	0.099	0.0151	0.00023	0.31	1.12
90-152	0.031	0.028	0.011	0.063	0.0125	0.00016	0.40	1.53
90-191	0.045	0.043	0.038	0.059	0.0050	0.00003	0.11	0.41
Average	0.054					0.00021	0.23	0.86
Between-field SD: 0.0221			Between-field variance: 0.000488					
Between-field CV: 0.405			Within-field average CV: 0.23					

Table 6. Distribution of average residues in potatoes expressed as aldicarb sulfone measured at experimental field sites.

Type of application	Residue as aldicarb sulfone, mg/kg				Variance	CV%
	Mean	Median	Minimum	Maximum		
Treatment according to US N.W. GAP	0.046	0.04	0.004	0.14	0.00114	73.1
Treatment according to US Florida GAP	0.11	0.075	0.061	0.21	0.003588	54.3
Treatment according to GAP other than USA & South Africa	0.071	0.03	0.005	0.7	0.0103	143.2
Treatment according to GAP other than USA	0.101	0.03	0.005	1.14	0.0299	170.9
All GAP samples	0.099	0.04			average: 0.0105	average: 99.4
Non-GAP applications						
US N.W., PHI 100-135 days	0.148	0.09	0.01	0.9	0.0369	130
US row-end samples, PHI around 150 days	0.10	0.038	0.005	0.69	0.0293	171
US row-end samples, PHI around 100 days	0.176	0.125	0.025	0.5	0.0247	89

FATE OF RESIDUES IN STORAGE AND PROCESSING

In storage

The rate of degradation of aldicarb residues in stored potatoes was determined by analysing 100 individual tubers after 0, 1 and 6 months of storage under simulated commercial storage conditions. No residues of parent aldicarb were detected (<0.02 mg/kg) in any of the samples. The residues were mainly the sulfoxide metabolite with smaller amounts of the sulfone. The mean total residues calculated as sulfone after 0, 1 and 6 months storage were 0.45, 0.44 and 0.30 mg/kg respectively (Hunt, 1991).

In processing

Potatoes were treated at 10 times the normal rate to obtain high residues for a study of the effects of processing. Three replicate potato samples (90 kg each) were processed to chips, flakes and French fries by the following procedures which closely resembled commercial practice.

Chips: washing in tub for 5-10 min; sorting; peeling with Hobart Abrasive Peeler; removing damaged potatoes; cutting to about 1.5 mm slices, frying at 163-177^{o}C for 90 seconds; draining and salting.

Flakes: washing in tub for 5-10 min; sorting; steam peeling for 45 seconds at about 0.55-1 MPa; scrubbing to remove peel;cutting into about 12.5 mm slabs; rinsing with tap water to remove starch; precooking 71-74^{o}C for 20 min.; cooling to 32^{o}C for 20 min; steam cooking at 95-100^{o}C for 45 min.; mashing and mixing with pre-weighed additives; drying into thin sheet; milling to obtain finished potato flakes.

Frozen French fries: washing in tub for 5-10 min; sorting; steam peeling for 45 seconds at about 0.55-1 MPa; scrubbing to remove peel; cutting into about 6 x 6 mm shoestrings with French Fry cutter; blanching at 71-74°C for 10 min.; further blanching at 88-92°C for 3 min.; dipping into 1% dextrose solution for 30 sec.; air drying at 71°C for 18 min.; frying dried strips at 175-190°C for 60 sec.; draining and freezing at about -18°C.

A portion of the fries were further fried at about 175°C for 1.5 min in the laboratory under conditions similar to those used in fast-food restaurants. Potato flakes, chips, fries and wet and dry peel samples were analyzed for aldicarb residues in triplicate. The results are summarized in Table 7.

Additional potatoes were harvested and shipped directly to the laboratory where they were used to determine the effects of baking and microwaving on aldicarb residues. The tubers were cut in half and half of each tuber was frozen. The other half of each potato was then either baked or microwaved and frozen after cooking. All raw tuber halves were individually analyzed. Altogether 200 raw halves, and the 30 pieces from the baked and cooked groups corresponding to the raw halves with the highest residues (60 processed halves altogether) were analyzed.

The mean residues, expressed as aldicarb sulfone, before and after cooking were 0.98 and 0.63 mg/kg for baking, and 1.05 and 0.88 mg/kg for microwaving (Tew 1993c).

Table 7. Effect of processing potatoes on the residue levels of aldicarb.

Sample	Aldicarb residues expressed as aldicarb sulfone, mg/kg			Average change, %
	1st. proc.	2nd proc.	3rd proc.	
Fresh potato	0.57	0.67	0.75	
Flakes	0.77	0.76	0.73	+15
Chips	0.40	0.48	0.55	- 27
Wet peel	0.42	0.33	0.40	- 41
Dry peel	1.36	0.51	1.36	+ 65.3
Frozen fries	0.25	0.29	0.34	- 55.5
Cooked fries	0.34	0.40	0.42	- 41.7

APPRAISAL

Residue aspects of aldicarb were last evaluated in 1994 within the CCPR periodic review programme. A temporary MRL of 0.5 mg/kg was recommended for potato pending the submission of data on supervised trials according to current use patterns. The previous estimate of a maximum residue level for banana was withdrawn owing to a change in the use pattern.

Extensive new information was provided on residues deriving from the currently recommended uses on bananas and potatoes, and on the revised GAP for potatoes in the USA. The Meeting was

informed about ongoing trial programmes for refining use patterns on bananas and expanding the use permit for potatoes within the USA, where the use of compound is authorised at present only in Florida and the Northwest States.

The new GAP for bananas allows a maximum of two applications at a rate of 2 g ai/plant each season with a 180-day PHI. The new US GAP for potatoes specifies positive-displacement application equipment, a single application at a maximum rate of 3.36 kg ai/ha, and the exclusion of in-furrow irrigation. PHIs are 100 days for Florida and 150 days for Northwest States.

The trials were with granular formulations of aldicarb. The samples were mainly analysed by HPLC methods which determined aldicarb, its sulfoxide and its sulfone individually. In some cases the residues were oxidized to, and determined as, the sulfone by GLC. The typical limit of determination was about 0.01-0.02 mg/kg for each residue component. The residues are reported in the monograph and appraisal as the total carbamate residue expressed as aldicarb sulfone, which can be converted to the parent aldicarb by multiplying by 0.856.

In trials with bananas, aldicarb was applied to the soil at the recommended maximum rate of 2 g ai/plant, corresponding to 3.6-4 kg ai/ha. Samples were taken from 3 to >360 days after the last application. Aldicarb residues were determined in composite samples consisting of 7-12 fingers or in individual fingers. The average residue ranges found in whole bananas were 0.23-0.5 mg/kg at 45 and 75 days, 0.02-0.4 mg/kg at 87 and 124 days, and 0.04 mg/kg at 150 days.

The residues were determined in the peel and pulp separately and calculated for the whole fruit in 14 trials. There was little difference between the residues in whole fruit and pulp, the average ratio of whole fruit to pulp residues being 1.19.

The residues were determined only in the pulp in most of the samples, at PHIs much shorter than the recommended 180 days. In 6 samples the residues in the pulp were between 0.02 and 0.04 mg/kg at PHIs of about 150 days and longer. Of these 6 trials, one or two applications (GAP) were made at five occasions resulting in maximum, median and mean residues of 0.04 mg/kg, 0.03 mg/kg and 0.029 mg/kg, respectively.

The main residue was aldicarb sulfoxide. Aldicarb was not detected in any of the samples and the sulfone in only a few. The sulfoxide/sulfone ratio ranged from 3 to 23 in those samples where both residues were present in detectable concentrations.

Taking into consideration the slow decline of residues, the factor for the conversion of aldicarb sulfone to the parent compound according to the residue definition, and the factor of 1.2 for the ratio of the residues in the whole fruit to those in the pulp, the Meeting concluded that a maximum residue level of 0.05 mg/kg expressed as aldicarb would be likely to cover residues from applications in accord with GAP. However, since residues were reported in the whole commodity in only a single trial which complied with GAP, the Meeting considered the data from GAP applications insufficient to recommend an MRL.

A number of trials on potatoes were reported from 14 countries. The residues were mainly aldicarb sulfoxide.

In supervised trials representing national GAP except in the USA and South Africa, the total residue expressed as aldicarb sulfone ranged from 0.005 mg/kg to 0.7 mg/kg with a median of 0.03 mg/kg. Of the total of 94 trials the highest residues measured in rank order were 0.21, 0.23, 0.25, 0.26, 0.3, 0.35, 0.4, 0.4, 0.46 and 0.7 mg/kg. The 95th and 98th percentiles were 0.25 and 0.4 mg/kg

respectively.

Twenty-nine trials were reported from South Africa in a summarized form without sufficient details of trial conditions or analytical methods. Aldicarb was applied once or twice at rates from 3.75 to 7.5 kg ai/ha, and PHIs were from 38 to 125 days. Eight of the 29 trials were in accordance with GAP for food and feed potatoes (1 application with 2.55-5.25 kg ai/ha and 120 days PHI). Residues in composite samples from these trials ranged from 0.01 to 1.12 mg/kg. Although the residue levels fit well into the distribution of residues in Spanish trials (0.02-0.7 mg/kg), taking into account the higher rate (5.25 kg ai/ha compared to 1.5 kg ai/ha in the Spanish trials), the Meeting was not able to evaluate the trials because essential details were not reported.

In most of the reported US trials the nominal application rate was the maximum recommended 3.36 kg ai/ha. Treatment was either with positive-displacement application (PDA) equipment according to the new GAP requirement or with the traditional gravity-flow applicator (GFA).

Residues were measured in a very large number of individual potato tubers to determine the effects of the mode of application, method of irrigation, and climatic conditions on the magnitude and distribution of the residues. The residues in individual potatoes extended over wide ranges and their relative frequency distributions were not normal, in accord with previous findings with other crop-pesticide combinations. In order to estimate maximum residue levels, 100 composite random samples of 12 tubers each were drawn from the selected primary sample populations with replacement, according to a computer programme.

The relative frequency distributions of composite samples taken from a single site were close to normal. The average residues found in composite samples and the average of the residues in the primary samples (field site residues) were very similar.

In the case of trials according to US GAP the between-field variance (square of the standard deviation) of the maximum residues in the composite samples (V_{bf} = 0.000488) was about 2.4 times the average within-field variance (V_{wf} = 0.00021). The between-field coefficient of variation of the residues was found to be 40%, while the combined between- and within-field CV was 48%. When all US trials complying with GAP were taken into consideration (either with field site residues or with maximum composite residues) the V_{bf}/V_{wf} ratio was >10. Consequently the within-field variation has little or no effect on the overall coefficient of variation of residues, and the calculated average residues obtained from the analysis of large numbers of primary samples (79-100 from an experimental site) or the average of smaller numbers of primary samples (>12 equal to one composite sample) can be used to estimate maximum residue levels.

Following single applications at planting or at emergence with commercial ground equipment and at PHIs above 139 days, in-furrow irrigation in 6 trials resulted in higher residues (average 0.18 mg/kg; range 0.025-0.316 mg/kg) than overhead irrigation (average 0.048 mg/kg; range 0.01-0.077 mg/kg) in four trials. The between-field coefficients of variation of the average residues were very similar: 66% and 69% respectively.

Eight field trials were conducted in 6 States of the USA to determine the variability of residues within fields and within plants. One hundred potato tubers and ten potato plants were selected from each field. The average within-plant and within-field coefficients of variation were 49.9% and 60.7% respectively. The between-field coefficient of variation was 87.4%. At trial sites where the PHIs complied with GAP, the field site residues ranged from 0.02 mg/kg to 0.09 mg/kg and the maximum residues in composite samples were from 0.03 to 0.15 mg/kg.

Seventeen field trials were conducted in twelve States of the USA to determine the distribution of residues in centre-row and end-row areas. The average residues in the centre and end parts of the rows were 0.094 and 0.12 mg/kg respectively. Twelve of a total of 918 tubers contained residues above 1 mg/kg with a maximum of 3.13 mg/kg. All of these tubers were taken from the end sections of the rows. The 95th percentiles for the centre and end parts of rows were 0.34 and 0.52 mg/kg respectively.

Positive-displacement application (PDA) equipment and the conventional gravity-flow applicator (GFA) were used in sixteen trials to compare the variability and magnitude of residues in potato tubers grown in the 6 m end-sections with rows to the residues in mid-row tubers. Following PDA treatment according to the field site residues in mid-row and end-row samples ranged from <0.02 to 0.18 and <0.02 to 0.23 mg/kg respectively. The averages of the field site residues found in mid-row and end-row sections of the experimental sites (0.065 and 0.052 mg/kg) did not differ significantly. The average residue in end-row samples from GFA treatments (0.234 mg/kg) was significantly higher than that found following PDA treatments, while the mid-row samples were not analyzed. The between-field variation (CV%) of the average residues from mid-row and end-row sections following PDA and GFA treatments did not differ significantly and were 78.2%, 115% and 109% respectively. The highest 10 residues found in individual potato tubers in trials according to US GAP including end-of-row sections were 1.2, 1.2, 1.12, 0.61, 0.51, 0.32, 0.31, 0.29, 0.26 and 0.25 mg/kg.

To estimate a maximum residue level the Meeting took into consideration all of the 87 residues measured in composite field samples and the averages of residues measured in individual potatoes from trials which complied with relevant national GAP, but excluded the summarized data from the South African trials and the results of the trials from The Netherlands (where GAP is limited to seed and starch potatoes).

To estimate the STMR level only those samples were considered which were taken within ±30% of the GAP PHI and which had been treated by applications at rates within the range GAP to GAP +30%. The residue values considered in reverse rank order were 0.7, 0.43, 0.4, 0.4, 0.35, 0.3, 0.3, 0.25, 0.25, 0.24, 0.23, 0.23, 0.1-0.18 (6), 0.09, 0.09, 0.053-0.08 (7), 0.03-0.048 (5) and <0.03 (5) mg/kg. The same residues were considered for the estimation of a maximum residue level: these gave a 98th percentile value between 0.4 and 0.43 mg/kg.

On the basis of the results the Meeting confirmed its previously estimated maximum residue level (no longer temporary), of 0.5 mg/kg for potato, and estimated an STMR level of 0.09 mg/kg expressed as aldicarb sulfone (0.077 mg/kg expressed as aldicarb).

The Meeting examined the relationship between the average and maximum residues found in individual potato tubers at sites treated according to the US GAP rate and PHI, including both PDA and GFA treatments to reflect the current world-wide uses. For acute risk assessment the residues found at the end-of- row sections were also included in the data base. Taking into consideration the populations consisting of >80 residues determined in individual potatoes which provided an estimate for 95% of the residues with 98-99% confidence, the linear regression of the data resulted in a regression equation of

$$R_{max} = 13.25R_{av} - 0.46 \qquad \text{(eq. 1)}$$

with a correlation coefficient of 0.904, which indicates an acceptable correlation. Consequently, the maximum residues in individual tubers in a treated field may be expected on average to be in the range of 13-14 times the average residue found at the site. It should be noted that higher values may occasionally occur.

When only the residues arising from PDA treatment according to current US GAP were taken into account the linear regression equation was

$$R_{max} = 5.5R_{av} + 0.06 \quad \text{(eq. 2)}$$

with a correlation coefficient of 0.79.

The Meeting noted that the data points available for estimating maximum residues arising from PDA treatments were limited and rather scattered, and the correlation between the average and maximum residues was poor. The results were of some interest however, and underline the importance of considering the effect of different use patterns individually first, and pooling only residues from similar populations. The results may otherwise be distorted and unrealistic. The Meeting therefore decided to present both estimates.

On the basis of equation 1 and the estimated maximum residue level (0.5 mg/kg) the estimated maximum residue in individual potatoes is 6.2 mg aldicarb/kg. When the 98th percentile residue value (between 0.4 and 0.43 mg/kg as aldicarb sulfone or 0.415 x 0.856 mg/kg as aldicarb) which was obtained from all field trials which were in accordance with GAP is used, the calculated maximum residue in individual potato tubers is 4.2 mg/kg.

However, if only the residues arising from PDA treatments according to new US GAP are taken into account, with a maximum field site residue of 0.2 mg/kg, the maximum residue in individual potatoes (see equation 2) would be 0.94 mg aldicarb/kg.

Under normal commercial storage conditions the mean total residues calculated as sulfone after 0, 1 and 6 months storage were 0.45, 0.44 and 0.30 mg/kg respectively.

Three replicate potato samples were processed by treatments closely resembling commercial procedures. A portion of deep-frozen French fries were further cooked in hot oil for 1.5 min under conditions similar to those used in fast-food restaurants. The average decrease of the total carbamate residue level was 3.2% in potato flakes, 27% in chips, 55.5% in processed fries, 41.7% in cooked fries and 41% in wet peel. After drying, the residue level in the peel increased to 65.3% of that in the fresh potato owing to the loss of moisture.

The effects of baking and microwave cooking were studied on additional potato samples. The residues decreased by 35.7% and 16.1% respectively.

RECOMMENDATIONS

On the basis of the data on residues resulting from supervised trials the Meeting estimated the maximum residue level shown below for potato, which is recommended for use as an MRL.

Definition of the residue for compliance with MRLs and for estimation of dietary intake:
sum of aldicarb, its sulfoxide and sulfone, expressed as aldicarb.

Commodity		Recommended limits, mg/kg			PHI on which based, days
		MRL		STMR or STMR-P	
CCN	Name	New	Previous		
VR 0589	Potato	0.5	0.5 T	0.077	56-150
	Potato chips			0.056	

	Potato fries			0.045	
	Potato (microwaved)			0.065	
	Potato (baked)			0.050	56-150

FURTHER WORK OR INFORMATION

Desirable

1. Results of supervised trials according to maximum Spanish and South African GAP on potatoes.

2. Residue data on whole bananas and banana pulp reflecting current GAP.

3. Data on the effect of boiling (cooking) on aldicarb residues in potatoes.

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