Table 29. Frozen storage stability of carbofuran and its metabolites added to various commodities.

Sample	Analyte	Fort.[1] mg/kg	Recovery, %	
			9-11 months	24-26 months
Alfalfa, green	carbofuran	1.0	103	90
	3-keto-carbofuran	1.0	105	100
	3-hydroxy-carbofuran	8.0	60	99
Alfalfa, dry	Carbofuran	2.5	86	94
	3-keto-carbofuran	2.5	85	93
	3-hydroxy-carbofuran	20.	80	100
Maize grain	Carbofuran	0.5	94	113
	3-keto-carbofuran	0.5	104	110
	3-hydroxy-carbofuran	0.5	116	115
Maize forage	Carbofuran	1.0	106	105
	3-keto-carbofuran	1.0	113	112
	3-hydroxy-carbofuran	3.0	131	101
Orange (whole)	Carbofuran	0.5	108	107
	3-keto-carbofuran	0.5	104	98
	3-hydroxy-carbofuran	0.5	86	92
Peanut kernels	Carbofuran	0.5	94	83
	3-keto-carbofuran	0.5	90	79
	3-hydroxy-carbofuran	0.5	86	102
Peanut hulls	Carbofuran	2.0	105	116
	3-keto-carbofuran	2.0	105	89
	3-hydroxy-carbofuran	2.0	105	104
Potato, tuber	Carbofuran	0.5	96	86
	3-keto-carbofuran	0.5	104	75
	3-hydroxy-carbofuran	0.5	96	79
Sorghum, stalk	carbofuran	1.0	84	93
	3-keto-carbofuran	1.0	111	87
	3-hydroxy-carbofuran	1.0	78	79
Sugar beet tops	carbofuran	1.0	88	86
	3-keto-carbofuran	1.0	47	46
	3-hydroxy-carbofuran	1.0	85	79
Sugar beet root	carbofuran	0.5	110	99
	3-keto-carbofuran	0.5	94	72
	3-hydroxy-carbofuran	0.5	96	97
Cow milk	carbofuran	0.5	96	97
	3-keto-carbofuran	0.5	106	89
	3-hydroxy-carbofuran	0.5	98	95
Cow muscle	carbofuran	0.5	96	74
	3-keto-carbofuran	0.5	102	72
	3-hydroxy-carbofuran	0.5	90	69

[1]The three analytes were combined in fortified samples

Storage stability studies were also conducted with the processed fractions of maize (Schreier, 1990a) and sugar cane. No loss of carbofuran or 3-hydroxy-carbofuran occurred during more than 2 years of frozen storage.

Definition of the residue

MRLs currently refer to the sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran; 3-keto-carbofuran, the 7-phenol, the 3-keto-7-phenol and 3-hydroxy-7-phenol are excluded. Studies of plant and animal metabolism displayed similar metabolic pathways. In ruminants and poultry the parent carbofuran constitutes less than <1% of the residue. The major carbamate metabolite is 3-

hydroxy-carbofuran, but it is only found in certain animal commodities, e.g. 12% of the TRR in egg yolk and 11% in ruminant kidneys. Carbofuran is found in some plant commodities, e.g. 14% of the TRR in maize forage, but 3-hydroxy-carbofuran is generally the predominant carbamate compound. The metabolite 3-keto-carbofuran is not usually detected and contributes little to the total carbamate residue.

Studies of plant metabolism have shown that conjugate(s) of 3-hydroxy-carbofuran can constitute an appreciable proportion of the total residue. For example in soya bean forage 11% of the TRR was free and 28% of the TRR was conjugated (acid-released) 3-hydroxy-carbofuran. In soya beans, 1.5% was free and 3.2% was conjugated 3-hydroxy-carbofuran (Table 3). As the conjugated form might be released after human ingestion, it must be considered as part of the defined residue.

The residue should be defined both for estimates of dietary intake and compliance with MRLs as carbofuran plus 3-hydroxy-carbofuran, free and conjugated, expressed as carbofuran.

USE PATTERN

Carbofuran is a systemic acaricide, nematicide and insecticide, applied to foliage at 0.25-1.0 kg ai/ha, to the furrow at planting at 0.5-4.0 kg/ha to control soil-dwelling and foliar-feeding insects, or broadcast at 6-10 kg/ha to control nematodes. Information on the use patterns on crops (labels and/or summary tables) provided by the sponsors and the governments of Australia and the UK are summarized in Table 30.

RESIDUES RESULTING FROM SUPERVISED TRIALS ARE SUMMARIZED IN TABLE

Data were supplied on at planting, foliar and directed applications of carbofuran to numerous crops, mainly in Australia, Europe, and North, Central and South America.

Residues judged to be from treatments according to GAP and used to estimate maximum residue levels are underlined. Those resulting from the maximum applications consistent with GAP and used to estimate STMRs are double underlined. All residues have been corrected for the average analytical recovery of the compound determined unless otherwise indicated.

Table 30. Summary of information on supervised trials (not necessarily according to GAP) provided by the sponsors.

Label uses: Crop	Country	Form, type	Application type	Application, kg ai/ha or /kg seed (all metric are g or kg ai)	Volume	Application no.	PHI, days	Remarks
Alfalfa	USA	4 F	foliar	2 pts/A; 1.12	2 GPA - aircraft	1-2/cutting 1.1.2 total	28	
Apple	India	3 G		5 g/tree				
Banana	Brazil	350 SC	immersion of the horn type seedling	1.4 g/100 l		1		
Banana	Brazil	350 ST	Seed treatment	0.14 kg/100 L		1		
Banana	Brazil	5 G		3-80 g/hole		2		4 mo. retreatment

Label uses: Crop	Country	Form, type	Application type	Application, kg ai/ha or /kg seed (all metric are g or kg ai)	Volume	Application no.	PHI, days	Remarks
Banana	Cyprus	10 G		1.5-3 g ai/mat			30	
Banana	Cyprus	10 G		1.5-3 g ai/mat			30	
Banana	Cyprus	5 G		1.5-3 g ai/mat			30	
Banana	Cyprus	75 WP		1.5-3 g ai/mat				
Banana	India	3 G		1.5 g/sucker				
Banana	Kenya	10 G		3 g ai/mat		2		
Banana	Philippines	10 G	at planting + 4 mo	1.25-1.5 g/hole; 5g		2		4 mo interval
Banana	Philippines	10 G	base of the plant	2.5- 3 g/mat		4		established plantations
Banana	Philippines	5 G	at planting	1.25-1.5 g/hole; 5 g/hole				at planting + 4months later
Banana	Philippines	5 G		3.0 g/mat		4	0	once every 4 months for established plantations
Banana	Spain	20 F		5.6 kg ai/ha			60	
Banana	Spain	5 G		0.6-0.75kgai/ha			60	
Banana	Iv. Coast	10 G		3 g ai/mat				
Banana	Iv. Coast	4 F		1 g ai/mat			21	
Banana	Iv. Coast	5 G		3 g ai/mat				
Banana	Kenya	3 G		100gai/stool				
Banana	Kenya	5 G		3 g ai/mat		2		
Banana	Malaysia	3 G		0.6 g/tree				apply at base of tree at a distance of 1 foot
Barley	India	3 G	broadcast at plant	1.25 kg/ha				
Bean	Brazil	350 SC	at seeding	0.7-1.05 kg/ha	100-300l/ha	1		
Bean	Brazil	5 G	At planting, incorporated	1-2 kg/ha				
Bean	Cz. Republic	5 G		750 g ai/ha				
Beans	Argentina	10 G	at seedling	0.5 kg/ha				
Beets	Cz. Republic	10 G		1-2 kg ai/ha			>28	
Beets	Cz. Republic	350 F		1.05 kg ai/ha				
Beets	Cz. Republic	5 G		.75-1.5 kgai/ha				
Beets	Poland	5 G		.75 kg ai/ha				
Beets/fodder	Cz. Republic	350 ST		1.4/2.6kgai/100				
Beets/sugar	Cz. Republic	350 ST		1.4/2.6kgai/100				

Label uses: Crop	Country	Form, type	Application type	Application, kg ai/ha or /kg seed (all metric are g or kg ai)	Volume	Application no.	PHI, days	Remarks
Cabbage	Brazil	5 G	in furrow or filed hole	2 kg/ha		1		
Cabbage	Cz. Republic	10 G		2 kg ai/ha				
Cabbage	Cz. Republic	350 F		0.7 kg ai/ha				
Cabbage	Cz. Republic	350 F		0.0525 %				
Cabbage	India	3 G	at planting	1.5 kg/ha				
Canola	USA	10 CR		2.5lbs/A; 0.28				
Carrot	Cyprus	10 G		5-8 kg ai/ha			30	
Carrot	Cyprus	5 G		5-8 kg ai/ha			30	
Carrot	Cyprus	75 WP		5-8 kg ai/ha			30	
Coffee	Brazil	350 SC	gound application	0.35 g/hole				
Coffee	Brazil	5 G	at rains start and end of rains	0.5 - 3* g/hole		2		mechanically or manual application
Coffee	Brazil	5 G	incorporation in soil					* rate depends upon the the transplant age and pest infestation
Coffee	Kenya	10 G		2gai/tree x2				
Coffee	Kenya	5 G		4 g ai/tree				
Coffee	Malaysia	3 G		0.9 g /tree				apply around base of tree at one foot
Coffee	USA	10 G	incorporation in soil	1.5 g/tree		2		PR only. 1st application early winter (Jan/Feb); 2nd late June/July.
Corn (see maize also)	Argentina	10 G	in furrow, soil application	1-3.5 kg/ha				
Corn	Argentina	10 G						
Corn	Brazil	310 TS	seed treatment	697.5 g/100 kg seeds		1		
Corn	Brazil	350 SC	in furrow at seeding	1.05 -1.4 kg/ha	100-300l/ha	1		
Corn	Brazil	350 ST	Seed treatment	0.7-1.05 kg/100 kg seeds		1		
Corn	Brazil	5 G	At planting, incorporated	1.5-1.75 kg/ha		1		
Corn	Korea	3 G		3 TO 5		1	45	
Corn	USA	10 G	Post planting, band over row, incorporated	10 lbs/A; 1.1		1		row spacing = 40 inch
Corn	USA	10G	Foliar	10 lbs/A; 1.1		2		aerial application
Corn	USA	4 F	at planting	1 qt/A; 1.1		1	30 (forage)	row spacing=40 inch
Corn	USA	4 F	postplant	1 qt/A; 1.1			30 (forage)	no foliar application if soil application with granule formulation 10lbs/A-10 G; 6.7 lbs/A-15 G

Label uses: Crop	Country	Form, type	Application type	Application, kg ai/ha or /kg seed (all metric are g or kg ai)	Volume	Application no.	PHI, days	Remarks
Corn	USA	4 F	foliar	1/2-2 pints/A; 0.28-1.1		2	30 (forage)	1 only if soil application was made.
Cotton	Brazil	350 SC	furrow application at seeding	0.700-1.05 kg/ha	100-300l/ha	1		
Cotton	Brazil	350 ST	Seed treatment	0.7 kg/100 kg seeds		1		
Cotton	Brazil	5 G	in furrow at planting	1.5-3 kg/ha		1		rate depends upon pest type and infestation
Cotton	Bulgaria	10 G		5 kg ai/ha				
Cotton	Bulgaria	350 F		3 kg/100 kg				
Cotton	Bulgaria	350 ST		1.5 kg ai/100kg				
Cotton	China	3 G	in furrow, incorporated	0.675-0.9 kg/ha			60	
Cotton	India	3 G	at planting	1.0 kg/ha				
Cotton	Malaysia	3G	in hole at planting	0.03 g/hole				
Cotton	Spain	5 G		0.6-0.75kgai/ha			60	
Cotton	USA	10 G	in furrow at planting	10 lbs/A; 1.1		1		row spacing = 40 inch
Cotton	USA	4 F	in seed furrow,at planting	1 qt/A; 1.1		1		row spacing = 40 inch
Cranberries	USA (WA)	15 G	soil with rotary spreader	20 lbs/A; 3.4		1	60	incorporate with water sprinkler; do not use with flooding
Cranberries	USA (WA)	10 G	soil with rotary spreader	20 lbs/A; 2.2		2	60	incorporate with water sprinkler; do not use with flooding
Cucurbits	USA	10 G	soil incorporate	20 lbs/A; 2.2				row spacing = 60 inch
Cucurbit	USA	15 G	band application, incorporated	2.245 lbs /1000 linear feet				cucurbit=cucumber, melon, squash and pumpkins; Federal label
Cucurbit	USA	4 F	in furrow	2.4-3.8 oz/1000 linear feet row				
Cucurbit	Cyprus	10 G		1-1.5 kg ai/ha			30	
Cucurbit	Cyprus	5 G		1-1.5 kg ai/ha			30	
Cucurbit	Cyprus	75 WP		1-1.5 kg ai/ha			30	
Grape	USA	4F	broadcast to soil, incoporate	2.5gal/A, 11.2.; or 1.5gal/A chemigation, 6.72		1	##	
Grape	USA	4F	drip irrigation	075gal/A; 3.4		1	60	prohibited after May 1. Limited to 2.2 if a postharvest application was made in previous yr

Label uses: Crop	Country	Form, type	Application type	Application, kg ai/ha or /kg seed (all metric are g or kg ai)	Volume	Application no.	PHI, days	Remarks
Grape	USA	10 G	over soil between vines, incorporate	100 lbs/A; 11.2		1	##	
Maize	Bulgaria	350 ST		875 g ai/100 kg				
Maize	Cyrpus	10 G		5-8 kg ai/ha			30	
Maize	Cyrpus	10 G		5-8 kg ai/ha			30	
Maize	Cyrpus	10 G		5-8 kg ai/ha			30	
Maize	Cyrpus	5 G		5-8 kg ai/ha			30	
Maize	Cyrpus	5 G		5-8 kg ai/ha			30	
Maize	Cyrpus	75 WP		5-8 kg ai/ha			30	
Maize	India	3 G	at plant	1.0 kg/ha				
Maize	Makedonia	5 G		1-1.5 kg ai/ha			-	
Maize	Pakistan	3 G	at sowing, in furrow; at whorl	0.24 kg/A		2		irrigate immediately after application
Maize	Poland	5 G		.75 kg ai/ha				
Maize	Poland	5 G		.75 kg ai/ha				
Maize	Former Youg.	350 F		1.4-2.1kgaih			-	
Oats/barley	Germany	300 SK	at sowing	4.5			##	
Oats/barley	Argentina	35 TS	seed treatment	0.3 kg/100 kg seeds	134.4/l			diluted
Pea	India	3 G	at planting	1.0 kg/ha				
Peanut	Korea	3 G		5		1	55	
Peanuts	Brazil	350 SC	furrow application at planting	1.4-1.75 kg/ha	100-300l/ha			
Peanuts	Brazil	5 G	at planting, incorporation in soil	2 kg/ha		1		
Peanuts	China	3 G	furrow application	1.35-2.35 kg/ha			60	
Peppers	India	3 G	at planting	0.5 kg/ha				
Peppers	USA	4 F		3 qt/A; 3.4		2	21	first application at-plant. Arizona only.
Peppers	USA	10 G	side dressing	20 lbs/A, 30; 2.2, 3.4		2	21	
Potato	Argentina	10 G	in furrow	1.5-2.5 kg/ha				appl. at seeding or after planting
Potato	Brazil	350 SC	in furrow	3.5 kg/ha	200l/ha			
Potato	Brazil	5 G	At planting, incorporated	1.5-4 kg/ha		1		
Potato	Cyprus	10 G		4-8 kg ai/ha			30	
Potato	Cyprus	5 G		4-8 kg ai/ha			30	

Label uses: Crop	Country	Form, type	Application type	Application, kg ai/ha or /kg seed (all metric are g or kg ai)	Volume	Application no.	PHI, days	Remarks
Potato	Cyprus	75 WP		4-8 kg ai/ha			30	
Potato	Cyprus	75 WP		4-8 kg ai/ha			30	
Potato	Cz. Republic	350 F		240-350 g ai/ha			30	
Potato	Egypt	10 G		3.25 kg ai/ha			14	
Potato	India	3 G	at planting	2.6 kg/ha				
Potato	Korea	3 G		5 kg/10 A		1	45	
Potato	Makedonia	5 G		1-1.5 kg ai/ha			-	
Potato	Poland	5 G		2 kg ai/ha				
Potato	USA	4 F	Foliar	2 pts/A; 1.1	10 gal/A ground; 3 gal/A aerial	8	14	3 lbs ai/A/season if at plant application made
Potato	USA	4F	at-planting, in furrow	3 qt/A; 3.4		1		0.225lb/1000 feet of row
Potato	USA	4 F		1-2 pints/A	3 GPA aircraft	8/season		
Rice	USA	3 G	air/ground equipment	20 lb/A; 0.67		1/season	60	1 d before or up to 21 d after permanent flooding. State label Expires 9/97
Rice	USA	5 G	air/ground equipment	10 lbs/A; 0.56		1/season		1 d before or 2 or 21 days after flooding. Expires 9/97.
Rice	USA	5G or 2G	preplant, soil incorported. ground equip	0.56		1		CA only. Expires 8/97
Rice	USA	5G	postplant to soil. ground or aerial	0.56		1	60	CA only
Rice	Argentina	10 G	broadcast	0.75-1 kg/ha				
Rice	Australia	10 G		1 kg/ha		2/season		application at mid=tillerinf and 30-50 d after panicule initiation
Rice	Brazil	310 TS	seed treatment	527 g/100 kg seeds				
Rice	Brazil	350 SC	furrow application	0.700-1.05 kg/ha	400 ml/ha	1		vs irrigation system
Rice	Brazil	350 ST	Seed treatment	0.525 kg/100 kg seeds		1		
Rice	Brazil	350 ST						
Rice	Brazil	5 G		0.75-1 kg/ha		1		irrigated
Rice	China	3 G	broadcast, at seeding, incroporated	0.9-1.35 kg/ha			60	
Rice	India	3 G	at plant	2.0 kg/ha				
Rice	Japan	3G	broadcast	0.9		3	50	
Rice	Korea	3 G		0.09 - 0.12/10a (?)		2	7	2 applications (control 1st and 2nd generation)
Rice	Pakistan	3 G	nursery	0.3 g/m2				2nd application : 5 d before tansplanting
Rice	Pakistan	3 G		240 g/A		2		1st application 25 - 30 days after transplant. 2nd application 50 - 65 days after transplant
Rice	Philippines	3 G	seedbed	90 g/ha			28	
Rice	Thailand	3 G	seedbed	1.9 kg/ha				10 days after seeding
Rye grass	Argentina	35 TS	seed treatment	1.995 kg/100 kg seeds				undiluted

Label uses: Crop	Country	Form, type	Application type	Application, kg ai/ha or /kg seed (all metric are g or kg ai)	Volume	Application no.	PHI, days	Remarks
Rye/wheat	Argentina	35 TS	seed treatment	497 kg/100 kg seeds	39 g/l			diluted
Small grains	USA	4 F	foliar, before head emerges	1/2 pt/A; 0.28		2/season		do not feed forage
Sorghum	India	3 G	at planting	1.5 kg/ha				
Sorghum	Thailand	3 G	at-planting	1.5 kg/ha				
Sorghum	USA	15 G						
Sorghum	USA	10 G	at-planting	10 lbs/A; 1.1		1		row spacing = 40 inch
Sorghum	USA	4 F		1 pint	20 to 30 GBA	2		State label
Soya bean	Argentina	10 G	in furrow at seedong	1.5 kg/ha				
Soya bean	India	3 G	at planting	2.0 kg/ha				
Soya bean	Philippines	3 G		16.7-33.4 kg product/ha				
Soya bean	USA	10 G	at planting, incorporated	20 lbs/A; 2.2		1		row spacing = 40 inch
Soya beans	USA	4 F	at planting	3-4 pints/A; 1.7-2.2				row spacing=40 inch
Soya beans	USA	4 F	foliar appl.	0.5pint; 0.28	1 1/2 gal/A aerial; 20 gal /A ground	2/season	21	no foliar appl if treatment at planting
Strawberry	USA	4F	postharvest soil band. Ground equipment	2.2		1		limited to OR, MI, MN, MO, TN, WA, CT, NH, OH, VA, VT. May not be used after Sept. 1 or Oct. 1,
Sugar cane	Australia	10 G	band application, incorporated	3 kg/ha				application 3-5 leaf stage
Sugar cane	Brazil	350 SC	in furow along planting stick or in bands or streaks in the cane furoow	1.4-1.75 kg/ha	100-300l/ha			
Sugar cane	Brazil	350 SC						
Sugar cane	Brazil	5 G	application around the plant/ in bands or streaks	1.5-3 kg/ha		1		apllication at cane second harvest
Sugar cane	China	3 G	at planting, band application	1.35-2.25 kg/ha			60	
Sugar cane	Pakistan	3 G	at planting/ 30 d. after planting	0.3-0.45 kg/A				
Sugar cane	Philippines	3G	at planting/30 d aftr planting	0.3-0.45 kg/A				2 nd application at earthing
Sugar cane	Philippines	5 G	at planting, in furrow and furrow ridge	1-2 kg/ha				
Sugar cane	Thailand	3 G	at planting, in the rows	1.9 kg.ha				

Label uses: Crop	Country	Form, type	Application type	Application, kg ai/ha or /kg seed (all metric are g or kg ai)	Volume	Application no.	PHI, days	Remarks
Sugar cane	USA	4 F	after joint formation, foliar	1.5 pts/A; 0.84		2	17	do not use in Hawaii
Sugar cane	USA	10 G	over stubble cane, incorporated	40 lbs/A; 4.5		1		row spacing = 60 inch. Do NOT use in Hawaii
Sugar beet	Bulgaria	350 ST		875 g ai/100 kg				
Sugar beet	Hungary	10 G		1.5-2 kgaiha				
Sugar beet	Poland	350 ST		44.8g/100,000 s				
Sugar beet	Poland	480 FS		58 LITRE/TON				
Sugar beet	Russia	350 ST		8-10 kg ai/ton			-	
Sugar beet	Former Youg.	350 F		1.4-2.1kgaih			-	
Sugar beet	USA	10 G	at planting, incorporated	20 lbs/A; 2.2				row spacing = 22 inch
Sugar beets	USA	4 F		1 to 2 quarts/A				State label
Sunflower	Bulgaria	300 COMBI		1 kg ai/100 kg				
Sunflower	Bulgaria	350 ST		1.5 kg ai/100kg				
Sunflower	Hungary	10 G		1.5-2 kgaiha				
Sunflower	USA	4F	soil band or in-furrow at planting. ground equipment	1.4 qt/acre; 1.6		1		row spacing = 30 inch. 0.16 pt/1000 feet of row
Sunflower	USA	4F	foliar, ground or aerial	1 pint/A; 0.56	2 gal/A aerial; 10 gal/A ground	4	28	
Sweet corn	USA	4F	at planting, 7 inch band over the row or inject on each side of row with water	2 pt/A; 1.12			30	Forage may not be fed within 30 days of application. Use 2.5 fl oz/1000 linear feet of row.
Sweet corn	USA	4F	foliar	1 pt/A; 0.56	10 gallons/A ground; 2 gallons/A aerial	4	7	Limited to machine-harvested corn. 1st application just prior to silking, with 7 day repeat interval.
Tea	India	3 G	at planting	300 mg/plant				
Tobacco	Argentina	10 G	broadcast/in furrow application	3.5-6 kg/ha				
Tobacco	Australia	10 G	in furrow, incorporated	3.5 kg/ha				
Tobacco	Australia	10 G						
Tobacco	Brazil	350 SC	at planting	1.4-1.75 kg/ha	100-300l/ha	1		
Tobacco	Brazil	5 G	At planting/transplanting, incorporated	0.75-4 kg/ha		1		for granule manual or mechanical application
Tobacco	India	3 G	at planting	4 kg/ha				
Tobacco	Korea	3 G	planting	50 kg/10 a		1		

Label uses: Crop	Country	Form, type	Application type	Application, kg ai/ha or /kg seed (all metric are g or kg ai)	Volume	Application no.	PHI, days	Remarks
Tobacco	Pakistan	3 G	nursery, broadcast	0.3 kg/A				15 d before transplanting
Tobacco	Thailand	3 G	at-planting	0.06 g/hill				
Tobacco	USA	4F	pre-transplant, soil incorporated	1.5 gal/A;6.7		1		
Tobacco	USA	10 G	pre-transplant, incorporate	60 lbs/A; 6.7				
Tomato	Argentina	10 G	at transplanting, +1 mo transplanting	1.5 kg/ha		2		
Tomato	Argentina	10 G	in seedbed	3 kg/ha		2		at planting and 15 d before transplanting
Tomato	Brazil	350 SC	in furrow	1.75 kg/ha	200 l/ha	1		
Tomato	Brazil	5 G	at planting/transplanting	0.75-4 kg/ha		1		
Tomato	Brazil	5 G		0.15-0.25 g/ha				
Tomato	India	3 G	at planting	2.5 kg/ha				
Tomato	Malaysia	3 G	at planting, in hole, incorporated	0.09 g /hole		1		
Vege-tables	Cyprus	10 G		4-8 kg ai/ha			30	
Vege-tables	Cyprus	5 G		4-8 kg ai/ha			30	
Vege-tables	Cyprus	75 WP		4-8 kg ai/ha			30	
Vege-tables	Former Youg.	350 F		0.7 kg ai/ha				
Vege-tables	Former Youg.	350 F		0.0525 %				
Wheat	Brazil	350 SC	in furrow at seedling	1.05 -1.4 kg/ha	100-300l/ha			
Wheat	Brazil	5 G	At planting, incorporation in soil	0.75 - 1 kg/ha		1		
Wheat	India	3 G	at planting	3.0 kg/ha				
Wheat	USA	4 F	see small grain					
Wheat/ barley	Australia	360 F	in furrow, at seeding	1.1l/ha	10l/ha			

In the Tables of field trials that follow, a uniform procedure was used to treat residues of the two analytes 3-hydroxy-carbofuran and carbofuran limits at the determination and detection, which may be summarized as follows.

V_1	V_2	Total
<LOd	<LOd	LOd

LOd<V1<LOQ	LOd<V_2<LOQ	V_1 V_2
<LOd	>LOD	V_2
<LOd	LOd<V_2<LOD	V_2

V_1, V_2: carbofuran or 3-hydroxy-carbofuran
LOd: limit of detection
LOD: limit of determination

Residues below the limit of determination and above the limit of detection are in parentheses.

Furadan 4F was applied as a foliar spray to alfalfa in 28 supervised field trials in the USA (Singer, 1990a). Three applications were made at 1.12 kg ai/ha and at 0.004-0.006 kg/l. Each application was followed by cutting after 28 days. Both green and field-dried samples of alfalfa were analysed for carbofuran and carbamate and phenol metabolites by the method of Schreier. A limit of determination of 0.5 mg/kg was demonstrated for carbofuran, 3-hydroxy-carbofuran, 3-ket°Carbofuran, 7-phenol, 3-hydroxy-7-phenol and 3-keto-7-phenol. The limit of detection was estimated to be 0.1 mg/kg. The results are shown in Table 31. The water contents of the dried alfalfa samples were not determined.

The US GAP conditions are 2 applications, total 1.1 kg ai/ha, with the second application not exceeding 0.56 kg ai/ha. The PHIs are 28 days after a 1.1 kg ai/ha application , 14 days after 0.56 kg ai/ha, and 7 days after 0.28 kg ai/ha.

Table 31. Residues of carbofuran and its metabolites in or on green and dried alfalfa cut 28 days after foliar applications of carbofuran at 1.12 kg ai/ha in the USA.

Location, Year	No. appl[1]	Sample	Carbofuran	Residues, mg/kg						
				3-OH-CF	3-K-CF	Total carb-amates	7-Phenol	3-K-7-P	3-OH-7-P	Total phenols
California, 1986	1	green forage	(0.35)	1.3	<0.1	1.7	(0.17)	0.54	(0.25)	0.96
				Residues, mg/kg						
	1	dried fodder	1.4	6.2	(0.15)	7.6	0.60	1.3	0.90	2.8
	2	green	(0.17)	1.4	<0.1	1.6	(0.15)	0.50	(0.20)	0.85
	2	dried	(0.38)	4.3	<0.1	4.7	0.45	1.2	0.76	2.4
	3	green	(0.10)	1.2	<0.1	1.3	(0.19)	0.68	0.46	1.3
	3	dried	(0.24)	2.8	<0.1	3.0	(0.30)	0.65	0.58	1.5
Pennsylvania, 1987	1	green	<0.1	<0.1	<0.1	<0.1	<0.1	(0.13)	<0.1	(0.13)
	1	dried	<0.1	1.2	<0.1	1.2	<0.1	(0.25)	(0.19)	(0.44)
	2	green	<0.1	0.52	<0.1	0.52	<0.1	<0.1	<0.1	<0.1
	2	dried	<0.1	0.90	<0.1	0.90	<0.1	(0.42)	(0.24)	0.66
	3	green	<0.1	1.2	<0.1	1.2	<0.1	(0.34)	(0.25)	0.59
	3	dried	<0.1	1.4	(0.12)	1.4	<0.1	0.99	0.58	1.6
Ohio, 1987	1	green	<0.1	1.6	<0.1	1.6	(0.14)	0.52	(0.32)	0.98
	1	dried	<0.1	4.5	<0.1	4.5	(0.41)	1.1	1.2	2.7
	2	green	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	2	dried	<0.1	(0.32)	<0.1	(0.32)	<0.1	(0.22)	<0.1	(0.22)
	3	green	<0.5	(0.13)	<0.5	(0.13)	<0.1	<0.1	<0.1	(0.13)
	3	dried	<0.1	(0.28)	<0.1	(0.28)	<0.1	<0.1	<0.1	<0.5
California, 1988	1	green	<0.1	1.8	<0.1	1.8				
	1	dried	(0.41)	2.4	(0.34)	2.8	0.65	1.9	1.2	3.8
	2	green	<0.1	0.92	<0.1	0.92	<0.1	0.55	0.32	0.87
	2	dried	(0.37)	3.0	(0.23)	3.4	0.55	2.0	1.8	4.4
	3	green	(0.34)	1.9	<0.1	2.2	(0.28)	0.62	0.52	1.4
	3	dried	(0.40)	2.2	<0.1	2.6	0.64	1.2	1.3	3.1
Pennsylvania, 1987	1	green	<0.1	1.4	<0.1	1.4	(0.12)	0.50	0.62	1.2

Location, Year	No. appl[1]	Sample	Carbofuran	Residues, mg/kg						
				3-OH-CF	3-K-CF	Total carb-amates	7-Phenol	3-K-7-P	3-OH-7-P	Total phenols
California, 1986	1	green forage	(0.35)	1.3	<0.1	1.7	(0.17)	0.54	(0.25)	0.96
	1	dried	<0.1	5.2	<0.1	5.2	0.55	1.4	0.56	2.5
	2	green	<0.1	1.2	<0.1	1.2	<0.1	(0.46)	<0.1	(0.46)
	2	dried	<0.1	3.8	<0.1	3.8	0.36	1.0	0.72	2.1
	3	green	<0.1	4.3	0.90	4.3	<0.1	1.4	(0.30)	1.7
	3	dried	<0.1	4.2	<0.1	4.2				
Wisconsin,1986	1	green	<0.1	(0.29)	<0.1	(0.29)	<0.1	<0.1	<0.29	<0.5
	1	dried	<0.1	0.90	<0.1	0.90	(0.17)	(0.30)	(0.26)	0.73
	2	green	<0.1	1.2	<0.1	1.2	<0.1	0.13	(0.32)	.(0.45)
	2	dried	<0.1	4.6	(0.28)	4.6	(0.45)	0.96	1.6	3.0
	3	green					<0.1	<0.1	<0.1	<0.1
	3	dried					<0.1	0.59	(0.27)	0.86
Minnesota, 1985	1	green	<0.1	(0.34)	<0.1	(0.34)	<0.1	<0.1	<0.1	<0.1
	1	dried	<0.1	0.64	<0.1	0.64	<0.1	(0.22)	(0.16)	(0.38)
	2	green	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	2	dried	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	3	green					<0.1	<0.1	<0.1	<0.1
	3	dried					<0.1	(0.21)	<0.1	(0.21)
Iowa, 1984	1	green	<0.1	(0.38)	<0.1	(0.38)	<0.1	<0.1	<0.1	<0.1
	1	dried	<0.1	0.74	<0.1	0.74	<0.1	(0.23)	<0.1	(0.23)
	2	green	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	2	dried	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	3	green	<0.1	<0.1	<0.1	<0.1				
	3	dried	(0.30)	0.57	<0.1	0.87	<0.1	(0.18)	<0.1	0.18
Nebraska,1986	1	green	<0.1	0.94	<0.1	0.94	<0.1	(0.36)	(0.37)	0.74
	1	dried	<0.1	1.6	<0.1	1.6	(0.38)	0.90	(0.41)	1.7
	2	green	<0.1	(0.30)	<0.1	(0.30)	<0.1	<0.1	<0.1	<0.1

Location, Year	No. appl[1]	Sample	Carbofuran	Residues, mg/kg						
				3-OH-CF	3-K-CF	Total carb-amates	7-Phenol	3-K-7-P	3-OH-7-P	Total phenols
California, 1986	1	green forage	(0.35)	1.3	<0.1	1.7	(0.17)	0.54	(0.25)	0.96
	2	dried	<0.1	1.2	(0.28)	1.2	(0.28)	(0.48)	(0.32)	1.1

Abbreviated compound names: see Figure 1
Limits of detection, determination 0.1 , 0.5 mg/kg for each analyte
[1]The alfalfa was cut 28 days after each application and before the subsequent application

In a separate trial in the USA (Leppert, 1986a), alfalfa in California was treated twice at rates of 0.56 and 0.28 kg ai/acre with Furadan 4F applied as an aerial foliar spray. The PHI was 4 days. Samples of green hay, field-dried hay, meal and finished meal pellets were prepared and analysed by the method of Schreier. Limits of determination were established by determination of recoveries from fortified control samples. The recoveries listed in Table 32 were reported and some supporting chromatograms were included. The trial did not comply with GAP because of the 4-day PHI.

Table 32. Recovery of carbofuran and metabolites from alfalfa by the Schreier Method.

Sample	Spike, mg/kg	Recovery, %					
		Carbofuran	3-OH-CF	3-K-CF	7-Phenol	3-OH-7-P	3-K-7-P
Green hay	0.05			104			
	0.5			69	98	94	102
	2.5	87	105				
Cured hay	0.5			104			
	1.0				71	72	88
	2.5	78	93	109			
Meal	0.2	95	110	90			
	1.0				64	79	83
Pellet	0.2			85			
	1.0				82	87	110
	5.0	85	94	77			

Abbreviated compound names: see Figure 1

Table 33. Residues of carbofuran and metabolites in or on alfalfa harvested 4 days after two applications of Furadan 4F (0.56 and 0.28 kg ai/ha).

Sample	Residue, mg/kg					
	Carbofuran	3-OH-CF	3-K-CF	7-Phenol	3-OH-7-P	3-K-7-P
Green hay	3.6	2.7	0.26	0.31	0.22	0.77
	4.3	4.9	0.63	0.46	0.36	1.4
	3.1	2.4	0.40	0.52	0.45	1.6
Cured hay[1]	19	9.0	0.54	2.2	1.3	1.3
	15	8.9	0.29	1.8	1.2	1.6
	19	8.5	0.62	2.4	2.0	2.2
Meal	18	5.2	0.12	2.9	1.7	1.7
	16	4.5	<0.20	3.8	2.0	1.7
Pellets	14	4.8	0.21	2.8	1.3	1.4
	16	4.8	0.20	2.6	1.3	1.3

Abbreviated compound names: see Figure 1 [1]Moisture content not reported.

Maize. Field trial results were reported from Brazil (Sao Paulo University, 1994), France (Mollhoff, 1974), Germany (Mollhoff, 1974) and the USA (Brooks, 1995; Singer, 1990b). The trials represent various combinations of at planting plus foliar treatments and the findings are shown in Table 34. The reports from Brazil, France and Germany consisted of brief summaries and provided inadequate details. They were not suitable for use in estimating maximum residue levels.

The US trials were of two types: an in-furrow application of a 15G formulation at 1.5 kg ai/ha followed by a foliar whorl application of 15G at 1.1 kg ai/ha, and one or two foliar applications of a 4F formulation at 1.1 kg ai/ha. The GAP label conditions specify a soil band, in-furrow, or injection at planting of the F (not G) formulation at 1.12 kg ai/ha (0.090 kg ai/2.54 m row) with a PHI of 30 days for feeding forage, which may be followed by a soil band, side-dress, or basal spray of the F formulation at 1.12 kg ai/ha (2.24 kg ai/ha in South Carolina) with a 30-day restriction on feeding forage, but no other PHI and no limit to the number of treatments. Additionally, two foliar applications may be made at 1.12 kg ai/ha each, with a 30-day PHI, using ground or aerial equipment. The US trials exceed the initial GAP at planting rate by 34% and use an F formulation, which place the trials on the fringe of acceptability. The use of an F or G formulation appears to have no effect on the residue concentrations (see the trials on sweet corn). Only two trials (in Missouri) are within the GAP window.

The other (5) US trials consisted of foliar spray applications of an F formulation at 1.1 kg ai/ha, with PHIs of 102-145 days, far in excess of the 30-day GAP interval. The data could not be evaluated.

Table 34. Total residues of carbamates and phenols in or on maize treated with carbofuran.

Country, Year	Form.	Application		PHI, days	Residue, mg/kg		Method of analysis
		Method/ timing	kg ai/ha		Carbamates[1]	Phenols[2]	
Brazil 1994	Furadan 350 SC	foliar spray	1.4	30	<0.05 (grain)		Leppert
			2.8	30	<0.05		
Brazil 1993	Furadan 350 TS	seed treatment	1.05 kg ai/100 kg	159	<0.1 (grain)		Leppert
			2.1 kg ai/100 kg	159	<0.1 (grain)		
Brazil 1993	Furadan 50G	in-furrow at-plant	1.75	30[3]	<0.1		Leppert
			3.5	30[3]	<0.1		Leppert
France 1973	Curraterr 5G	in-furrow at sowing	0.60	122	<0.1 (cob with grain)		Mollhoff
				163	<0.1 (grain)		
			1.0	115	<0.1 (grain)		
Germany 1973	Curraterr 5G	in-furrow at sowing	1.0	115	<0.1 (grain)		Mollhoff
Germany 1976	Curraterr 5G	in-furrow at sowing	0.94	125 153	0.7, 0.6, 0.8 (silage) <0.1, <0.1, <0.1 (grain) 0.4, 0.3, 0.9 (fodder)		Mollhoff
Germany 1975	Curraterr 5G	in-furrow at sowing	0.50	123 143	0.1, 0.3, 0.2 (silage) <0.1, <0.1, <0.1 (grain)		Mollhoff
Germany 1985	Curraterr 5G	in-furrow at sowing	0.62	105	<0.1 (cob at milk to dough		Mollhoff

Country, Year	Form.	Application		PHI, days	Residue, mg/kg		Method of analysis
		Method/ timing	kg ai/ha		Carbamates[1]	Phenols[2]	
					stage)		
Germany 1974	Curraterr 5G	in-furrow at sowing	1.0	138	<0.1 (cob) <0.1 (grain)		Mollhoff
USA (OH) 1988	Furadan 15G	in-furrow at planting	1.5				
	Furadan 15G	foliar whorl	1.1				
	Furadan 4F	foliar spray	1.1	69	1.5, <0.1[4] (fodder)	0.62, <0.5[4] (fodder)	Schreier
USA (NC) 1988	Furadan 15G	in-furrow at planting	1.5				
	Furadan 15G	foliar whorl	1.1				
	Furadan 4F	foliar spray	2 x 1.1	65	<0.1 (fodder)	0.70, 0.67 (fodder)	
USA (MO) 1988	Furadan 15G	in-furrow at planting	1.5				
	Furadan 15G	foliar whorl	1.1				
	Furadan 4F	foliar spray	1.1	32	1.1, 1.0 (silage)		
	Furadan 4F	foliar spray	1.1	21	<1.0, 1.2 (silage)		
USA (MN) 1988	Furadan 15G	in-furrow at planting	1.5				
	Furadan 15G	foliar whorl	1.1				
	Furadan 4F	foliar spray	1.1	80	1.5 (silage)	<1.0 (silage)	
	Furadan 4F	foliar spray	1.1	55	1.3 (silage)	<1.0 (silage)	
USA (CA) 1988	Furadan 15G	in-furrow at planting	1.5				
	Furadan 15G	foliar whorl	1.1				
	Furadan 4F	foliar spray	1.1	63	2.0 , 2.2 (fodder)	0.80, 0.66 (fodder)	
	Furadan 4F	foliar spray	1.1	63	2.4, 3.1 (fodder)	0.80, 1.4 (fodder)	
USA (IA) 1994	Furadan 4F	foliar spray	1.1	120	<0.03 (grain) <0.1 (fodder)	<0.03 (grain) <0.50 (fodder)	Schreier
USA (IL) 1994	Furadan 4F	foliar spray	1.1	111	<0.03 (grain) <0.10 (fodder)	<0.03 (grain) <0.50 (fodder)	
USA (NE)	Furadan 4F	foliar spray	1.1	102	<0.03 (grain) <0.10 (fodder)	<0.03 (grain) <0.50 (fodder)	
USA (MN) 1994	Furadan 4F	foliar spray	1.1	143	<0.03 (grain) <0.10 (fodder)	<0.03 (grain) <0.10 (fodder)	
USA (IN)	Furadan 4F	foliar spray	1.1	125	<0.03 (grain) <0.10 (fodder)	<0.03 (grain) <0.50 (fodder)	
USA (OH) 1994	Furadan 4F	foliar spray	1.1	124	<0.03 (grain) <0.10 (fodder)	<0.03 (grain) <0.50 (fodder)	

[1]Carbofuran + 3-keto-carbofuran + 3-hydroxy-carbofuran
[2]7-phenol + 3-hydroxy-7-phenol
[3]30-day period from seed planting to mature crop
[4]Duplicate samples from same plot

Sweet corn (corn-on-the-cob). Field trials in the USA were reported by Martin (1986b, 1987). Thailand reported the GAP conditions used in field trials, but not the results (Thai Industrial Standards Institute, 1997). In 16 side-by-side trials in eight states of the USA, sweet corn was treated at planting with either Furadan granular (15G, 10 G in California) or Furadan flowable, at 3.4 kg ai/ha. Whorl applications were made with 15G (10 G in California) at 1.1 kg ai/ha 3-6 weeks after planting. Four additional foliar applications of the flowable formulation were made at 0.56 kg ai/ha

over a period of 2 to 7 weeks. The total seasonal application was 6.7 kg ai/ha. Ears and husks were harvested 0 and 7 days, and stalk (forage) samples 21 days, after the final treatment. The samples were analysed by the method of Schreier. Carbamates were measured by GC/NPD and phenols were measured by GC-MSD. Limits of determination of 0.5 and 0.03 mg/kg were demonstrated for each analyte in forage and corn ears respectively, with corresponding limits of detection of 0.01 mg/kg. The recoveries reported from stalks at a 0.5 mg/kg fortification (n = 13) were carbofuran 84 ± 13%, 3-keto-carbofuran 100 ± 18%, 3-hydroxy-carbofuran 87 ± 20%, 7-phenol 78 ± 14%, the 3-keto-7-phenol 80 ± 17%, 3-hydroxy-7-phenol 82 ± 19%. The recoveries from corn-on-the-cob at 0.03 mg/kg (n = 4 for carbamates, 5 for phenols) were carbofuran 79 ± 10%, 3-keto-carbofuran 84 ± 22%, 3-hydroxy-carbofuran 85 ± 13%, 7-phenol 77 ± 16%, the 3-keto-7-phenol 94 ± 7%, and 3-hydroxy-7-phenol 86 ± 14%. The limit of determination demonstrated by the analysis of fortified control husk samples was 0.5 mg/kg (n = 7 for carbamates, 6 for phenols). Recoveries were carbofuran 82 ± 20%, 3-keto-carbofuran 91 ± 12%, 3-hydroxy-carbofuran 86 ± 16%, 7-phenol 74 ± 5%, 3-keto-7-phenol 102 ± 17%, and 3-hydroxy-7-phenol 84 ± 13%.

The total carbamate residues in corn-on-the-cob 0 and 7 days after the final application were <0.03 (6), 0.03 (4), 0.04 (4), 0.05 and 0.08 mg/kg. The total phenol residues were ≤0.10 mg/kg. No single carbamate or phenol predominated and there were no differences between the residues from the two treatment programmes.

The residues found in the stalks (forage) and husks are shown in Table 35. Again there were no differences between the residues from the flowable and granular formulations. Sweet corn forage is not an animal feed item, although maize forage is.

US GAP for sweet corn permits application at planting of 1.12 kg ai/ha (90 g/2.54 m of row). Forage may not be fed within 30 days of treatment. Additionally, the F formulation may be applied at 0.56 kg/ai ha, maximum 4 applications per season, with a 7-day PHI. These treatments may not be made if the at planting application exceeded 1.12 kg ai/ha. There is a 21-day restriction on harvesting or feeding stalks.

All trials exceeded the maximum at planting application rate by 240%. The data were not acceptable for the estimation of maximum residue levels.

Thailand reported trials according to GAP, but without data on residues (Thai Industrial Standards Institute, 1977).

Table 35. Residues in or on sweet corn stalks and husks from the application of carbofuran, at planting and foliar, 6.7 kg ai/ha total rate, USA, 1985.

Location	PHI, days	Residue, mg/kg					
		Carbofuran	3-K-CF	3-OH-CF	7-Phenol	3-K-7-P	3-OH-7-P
Harvest stalks (forage)							
3.4 kg ai/ha 15G at planting, 1.2 kg ai/ha 15G at whorl, 4 x 0.56 kg ai/ha 4F foliar							
Arkansas	0	8.7	<0.1	(0.3)	0.64	(0.26)	(0.24)
	7	(0.20)	<0.1	(0.39)	(0.20)	(0.24)	(0.29)
	14	<0.1	<0.1	(0.20)	(0.29)	(0.32)	(0.38)
	21	<0.1	<0.1	(0.28)	0.50	<0.1 (0.44)	0.94
California	21	<0.1	<0.1	<0.1	0.70	<0.1	<0.1
Florida	21	<0.1	<0.1	(0.028)	<0.1	<0.1	<0.1
Iowa	21	1.2	<0.1	1.3	1.6	1.3	1.2
Illinois	0	13	<0.1	1.2	1.5	0.74	0.90
	7	<0.1	<0.1	1.5	0.46	1.0	1.2
	14	<0.1	<0.1	1.2	(0.17)	(0.22)	0.50

Location	PHI, days	Residue, mg/kg					
		Carbofuran	3-K-CF	3-OH-CF	7-Phenol	3-K-7-P	3-OH-7-P
	21	<0.1	<0.1	1.2	<0.1	<0.1	<0.1
New York	0	4.7	<0.1	0.90	0.62	(0.26)	(0.40)
	7	3.4	<0.1	1.3	0.60	(0.30)	0.52
	14	(0.38)	<0.1	0.52	(0.20)	(0.150	(0.25)
	21	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Oregon	21	<0.1	<0.1	0.88	(0.30)	0.50	0.56
Wisconsin	0	25 (5.2; 45)	<0.1	1.8	1.8	<0.1	<0.1
	7	0.56	<0.1	0.50	(0.20)	(0.20)	(0.21)
	14	<0.1	<0.1	0.98	(0.24)	(0.28)	(0.31)
	21	<0.1	<0.1	0.45	<0.1	(0.16)	(0.18)
4 kg ai/ha 4F at-3.plant, 1.2 kg ai/ha 15G at whorl, 4 x 0.56 kg ai/ha 4F foliar							
Arkansas	0	8.3	<0.1	0.62	0.82	0.62	0.63
	7	(0.25)	<0.1	0.60	0.54	0.88	0.76
	14	(0.16)	<0.1	0.86	0.52	0.68	1.0
	21	<0.1	<0.1	0.64	(0.38)	0.71	0.91
California	21	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Florida	21	<0.1	<0.1	0.54	<0.1	<0.1	(0.20)
Iowa	21	(0.48)	<0.1	1.7	1.9	0.93	1.2
Illinois	0	15	<0.1	1.6	1.1	(0.34)	0.52
	7	(0.15)	<0.5	1.4	(0.26)	(0.40)	0.63
	14	<0.1	<0.1	1.2	(0.29)	0.69	0.56
	21	<0.1	<0.1	1.2	<0.1 (0.32)	0.62	0.75
New York	0	4.1 (2.6; 5.7)	<0.1	0.92	0.68	<0.1	(0.32)
	7	1.5	<0.1	0.95	(0.28)	(0.20)	(0.30)
	14	(0.28)	<0.1	(0.32)	<0.1	<0.1	<0.1
	21	(0.15)	<0.1	(0.29)	<0.1	<0.1	<0.1
Oregon	21	<0.1	<0.1	0.67	(0.16)	(0.38)	0.63
Wisconsin	0	17	<0.1	(0.28)	0.90	<0.1	<0.1
	7	0.92	<0.1	0.64	(0.26)	(0.32)	0.59
	14	<0.1	<0.1	1.4	<0.1	<0.1	<0.1
	21	<0.1	<0.1	0.64	<0.1	(0.23)	<0.1
Sweet corn husks							
3.4 kg ai/ha 15G at planting, 1.2 kg ai/ha 15G at whorl, 4 x 0.56 kg ai/ha 4F foliar							
Arkansas	0	3.7	<0.5	<0.5	(0.27)		
	7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
California	7	0.94 (0.181; 1.71)	<0.1	<0.1	<0.1	<0.1	<0.1
Iowa	7	2.1	<0.1	<0.1	0.78	<0.1	<0.1
Illinois	0	0.83	<0.1	<0.1	(0.14)	<0.1	<0.1
	7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
New York	0	0.76	<0.1	<0.1	<0.1	<0.1	<0.1
	7	0.85	<0.1	(0.28)	<0.1	<0.1	<0.1
Oregon	7	(0.16)	<0.	(0.30)	<0.1	<0.1	(0.16)
Wisconsin	0	2.4	<0.1	(0.14)	(0.22)	<0.1	<0.1
	7	(0.18)	<0.1	<0.1	<0.1	<0.1	<0.1
3.4 kg ai/ha 4F at planting, 1.2 kg ai/ha 15G at whorl, 4 x 0.56 kg ai/ha 4F foliar							
Arkansas	0	1.4	<0.1	(0.0.20)	(0.19)	<0.1	<0.1
	7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
California	7	0.68	<0.1	<0.1	(0.24)	<0.1	<0.1
Iowa	7	4.9	<0.1	(0.46)	<0.1	<0.1	<0.1
Illinois	0	1.4	<0.1	<0.1	(0.18)	<0.1	<0.1
	7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
New York	0	0.96	<0.1	<0.1	<0.1	<0.1	<0.1

Location	PHI, days	Residue, mg/kg					
		Carbofuran	3-K-CF	3-OH-CF	7-Phenol	3-K-7-P	3-OH-7-P
	7	(0.37)	<0.1	(0.26)	(0.18)	<0.1	<0.1
Oregon	7	<0.1	<0.1	(0.18)	<0.1	<0.1	<0.1
Wisconsin	0	2.1	<0.1	(0.18)	(0.22)	<0.1	<0.1

Abbreviated compound names: see Figure 1

Oats. Carbofuran (Curraterr 300 SK) was applied at sowing to oats seeds at the rate of 4.5 kg/ha in 1975 in Germany. No residues were found in the grain at the claimed limit of detection (0.10 mg/kg) when the grain was harvested 112 days after treatment. The straw contained 1.4, 0.7 and 1.0 mg/kg total carbamates. Three varieties (Flamingskron, Luxor, Tiger) were planted in single plots. The method of Mollhoff was utilized to analyse the grain for carbofuran and 3-hydroxy-carbofuran. Only a summary of the studies was submitted, without adequate detail to validate the reported results. The results could not be used to estimate maximum residue levels, and three trials are insufficient, unless supported by data on other small grains.

Rice. Field trial reports on the use of carbofuran on rice were submitted from Australia, Brazil, Japan, the Philippines and the USA. Thailand submitted information on GAP field trials, but no report of the residues found (Thai Industrial Standards Institute, 1997). The results are shown in Table 36. The results from Brazil were reported as summaries with no detail and were not suitable for use in estimating maximum residue levels.

According to information supplied by the sponsors, GAP treatment in the Philippines is with 90 g/ha of a 3 G formulation, with a 28-day PHI. GAP in Brazil allows seed treatment with 350 ST at 0.525 kg/100 kg seed and at planting furrow application of 0.70-1.05 kg ai/ha by irrigation. Australian GAP specifies 2 x 1 kg ai/ha of a 10 G formulation, with the final application 30-50 days after panicule initiation. There is no PHI. US GAP specifies a pre-plant soil incorporation (before flooding) of a 2G or 5G formulation, at 0.56 kg ai/ha (California only). An additional 0.56 kg ai/ha may be applied after planting, with a 60-day PHI. Outside California a 3% G formulation may be applied after flooding to the water at 0.67 kg ai/ha, or the 5% G formulation may be applied at 0.56 kg ai/ha. A PHI is not specified. Most US uses are temporary. Japanese GAP was not available, but that for China specifies 1.35 kg ai/ha of a 3 G formulation broadcast at seeding, with a 60-day PHI.

The US trials were at twice the GAP application rate. The Japanese trials did not compare well with Chinese GAP: the single application rate was 67% of that specified and/or the PHI was 20-40 days (67%) longer. The Philippine trials were at 33 times the GAP application rate and the PHI was excessive, 49-62 days compared with the specified 28 days.

In one of the three Australian trials, the 2 x 1 kg ai/ha GAP treatment is approximated by a single application of 2 kg ai/ha, with a 58-day PHI.

One trial is insufficient for the estimation of a maximum residue level.

Table 36. Total residues of carbamates and phenolic metabolites from the application of carbofuran to rice.

f	Form./ Appln. method	Rate		PHI, days	Residue, mg/kg		Analytical method & LOD, mg/kg	Ref.
		kg ai/ha	kg ai/hl		Carbamates	Phenol		

f	Form./ Appln. method	Rate		PHI, days	Residue, mg/kg		Analytical method & LOD, mg/kg	Ref.
		kg ai/ha	kg ai/hl		Carbamates	Phenol		
Australia (Queens-land), 1982/ Starbonnet	Furadan 10G/Broad-cast	2.0	-	58	<0.05 (grain) 0.58 (hulls)		Mollhoff 0.05	Stearns,1982
Australia (Queensland), 1982/ Starbonnet	Furadan 10G/Broad-cast	2 x 0.5	-	57	<0.02 (grain) <0.02 (hulls)		Mollhoff 0.05	Stearns,1982
Australia (Queensland), 1982/ Starbonnet	Furadan 10G/Broad-cast	1.0	-	95	<0.02 (grain) <0.02 (hulls)		Mollhoff 0.05	Stearns,1982
Brazil, 1994/ BR-IRGA 409	Furadan 50G/Broad-cast	1	-	30	<0.02 (grain)		Leppert 0.05[1]	Sao Paolo U., 1994
Brazil, 1994/ BR-IRGA 409	Furadan 50G/Broad-cast	2	-	30	<0.02 (grain)		Leppert 0.05[1]	
Brazil, 1993/ Araguaia	Furadan 350 SC/ pulveri-zation in furrow at planting[2]	1.05	Not spec.	156	<0.05 (grain)		Leppert 0.1[1]	
Brazil, 1993/ Araguaia	Furadan 350 SC/ pulveri-zation in furrow at planting[2]	2.1	Not spec.	156	<0.05 (grain)		Leppert 0.1[1]	
Japan, 1974/ Honenwase	Curraterr 3G/ Broadcast	0.9	-	101	<0.01[3] (grain)		GLC (EC) (no detail) 0.01	Mollhoff,1974
		2 x 0.9	-	82	<0.01[3] (grain) <0.02[3] (straw)		GLC (EC) 0.01 0.02	Mollhoff,1974
		3 x 0.9	-	52	<0.01[3] (grain) <0.02[3] (straw)		GLC (EC) 0.01 0.02	Mollhoff. 1974
Japan, 1974/ Harebarc	Curraterr 3G/ Broadcast	0.9	-	110	<0.01[1] (grain) <0.02[4] (straw)		GLC (EC) 0.01 0.02	Mollhof, 1974
		2 x 0.9	-	95	<0.01 (grain) <0.02[4] (straw)		GLC (EC) 0.01 0.02	Mollhoff, 1974
		3 x 0.9	-	43	(0.01)[4] (grain) (0.04)[4] (straw)		GLC (EC) 0.01 0.02	Mollhoff, 1974
Philippines, 1971/ Miracle IR-8	Curraterr 3G/ Broadcast	0.99	-	62	<0.1 (grain)		Mollhoff 0.1[1]	Mollhoff, 1972
		2 x 1.5	-	60	<0.1 (grain)		Mollhoff 0.1[1]	Mollhoff, 1972
		2 x 1.5	-	49	<0.1 (grain)		Mollhoff 0.1[1]	Mollhoff, 1972
		2 x 1.5	-	62	<0.1 (grain)		Mollhoff 0.1[1]	Mollhoff, 1972
USA (Arkansas),	Furadan 4F/	1.1	0.012	117	<0.02	<0.02	Barros	Shevchuk,

f	Form./ Appln. method	Rate		PHI, days	Residue, mg/kg		Analytical method & LOD, mg/kg	Ref.
		kg ai/ha	kg ai/hl		Carbamates	Phenol		
1992/Katy	Broadcast spray, pre-flood				(grain) <0.02 (straw)	(grain) <0.02 (straw)	0.05	1993a
USA (California), 1992/M-201	Furadan 4F/ Broadcast spray, 5 days preplant	1.1	0.012	151	<0.02 (grain) <0.02 (straw	<0.02 (grain) 0.20 (straw)	Barros 0.05	Shevchuk, 1993a
USA/ (California)/M-201	Furadan 4F/ Broadcast spray, 1 day preplant	1.1	0.006	128	<0.02 (grain) 0.07 (straw)	<0.02 (grain) 0.98[5] (straw)	Barros 0.05	Shevchuk, 1993a
USA (Louisiana), 1992/ Lemont	Furadan 4F Broadcast spray, pre-flood	1.1	0.012	96	<0.02 (grain) 0.02 (straw)	0.13 (grain) 0.32	Barros 0.05	Shevchuk, 1993a
USA (Texas), 1992/ Gulfmont	Furadan 4F Broadcast spray, pre-flood.	1.1	0.008	72	<0.02 (grain) 0.06 (straw)	0.08 (grain) 0.30[6] (straw)	Barros 0.05	Shevchuk, 1993a

[1]No data were provided to validate the claimed limit of determination
[2]The method of application is not consistent with the formulation
[3]Limits of determination of 0.01 and 0.02 mg/kg for grain and straw respectively are claimed, but recovery is not reported below 0.2 mg/kg
[4]Limits of determination of 0.01 and 0.02 mg/kg for grain and straw respectively are claimed, but recovery is not reported below 0.05 mg/kg
[5]74% 7-phenol
[6]About 50% 7-phenol and 50% 3-hydroxy-7-phenol

Sorghum. Six trials were in the USA, where one application at planting was followed by two foliar applications (Shevchuk, 1994a). Adequate recoveries were demonstrated at 0.03 mg/kg from grain and at 0.1 mg/kg from all substrates. At a single location in India two varieties of sorghum seed were treated with carbofuran and in a separate trial the soil was treated after planting (Rallies, 1981). The results of the trials are shown in Table 37.

Information on GAP was not available for India or a neighbouring nation, so the data from India could not be evaluated. In the USA, GAP conditions include soil-band, in-furrow, or injection application at planting of the F formulation at 1.12 kg ai/ha (1.12 kg ai/3960 m row) in Arizona, Louisiana, Mississippi and Texas. An in-furrow application at 2.8 kg ai/ha may be made in Kansa, Missouri and Nebraska, when grazing or cutting for silage or forage within 75 days of planting is prohibited. Additionally, 2 applications of 0.56 kg ai/ha may be made as a post-emergence foliar directed spray before the head emerges from the boot. Grazing treated fields is prohibited (Louisiana), or there is a 30- or 75-day restriction (Kansa, Nebraska, Mississippi and Texas).

Table 37. Total residues of carbofuran and 3-hydroxy-carbofuran in or on sorghum.

Country, Year	Form.	Application		PHI, days	Residue, mg/kg[1]	Analytical method
		Method, timing	kg ai/ha			
India 1981	Furadan 40F	to seed, 4 days before planting	2.5% 5.0% 10% (w/w)	45	0.14 0.18 0.27 (forage)	Cook (colorime-tric)[3]
			2.5 5.0	62	0.076 0.12	

Country, Year	Form.	Application		PHI, days	Residue, mg/kg[1]	Analytical method
		Method, timing	kg ai/ha			
			10% (w/w)		0.18 (forage)	
			2.5 5.0 10% (w/w)	76	0.048 0.068 0.072 (forage)	
	Furadan 3G	soil incorporation 2 days after planting	1.0	45	0.14 (forage)	
				62	0.086 (forage)	
				76	0.046 (forage)	
USA 1993	Furadan 4F	in-furrow at planting	1.1	44 Texas 40 Kansas 39 Nebraska 37 Missouri 37 Oklahoma 60 S Dakota	1.2 <0.05 <0.05 0.11 0.13 <0.05 (forage)	Barros
	Furadan 4F	foliar	2 x 0.6[3]	29 Texas 57 Kansas 53 Nebraska 58 Missouri 21 Oklahoma 39 S Dakota	0.06 <0.05 <0.05 <0.05 0.26 0.11 (forage)	Barros
				63 Texas 79 Kansas 69 Nebraska 80 Missouri 59 Oklahoma 91 S. Dakota	(0.06) (fodder) <0.01 (grain) <0.10 (fodder) <0.01 (grain) (0.07) (forage) <0.01 (grain) <0.10 (fodder) <0.01 (grain) 0.20 (fodder) <0.01 (grain) 0.19 (forage)	Barros

[1]Carbofuran + 3-keto-carbofuran + 3-hydroxy-carbofuran
[2]No validation or limit of determination data were presented
[3]The two foliar applications are in addition to the one at-plant application at 1.1 kg ai/ha

Wheat. Supervised field trial results were reported from South Africa and the USA.

In the South African trials (Anon., 1985a) Curraterr 10G or Curraterr 9G (Curraterr 7% + Volaton 2%) were applied to the soil at the time of planting. The application rates were given as 0.03-0.06 g ai/linear metre. Grain samples (180 days PHI) were analysed for carbofuran and 3-hydroxy-carbofuran by an HPLC method. Neither was found at the stated limit of determination, 0.05 mg/kg. The limit of detection was not stated nor were any sample chromatograms supplied. Was not reported for South Africa or neighbouring countries, so the data could not be evaluated. The South African submission was rudimentary and did not contain necessary details.

The US trials (Stearns, 1986a) were conducted at six locations (South Dakota, Colorado, Oregon, Illinois, Washington and Arizona). Two foliar applications were made, one pre-boot and the second 21 days before harvest. Both were with Furadan 4F at 0.28 kg ai/ha. The volume of spray applied per ha was not stated. The mature grain samples were analysed for carbamates and phenolic metabolites by GC-MS (Schreier, 1989a). A limit of determination of 0.05 mg/kg was demonstrated for carbofuran and each of the metabolites. The limit of detection was estimated as 0.02 mg/kg. The 3-hydroxy-7-phenol was found in two trials (Colorado 0.05 mg/kg; Arizona 0.11 mg/kg) but was undetectable in the other four. All the other analytes (carbofuran, 3-keto-carbofuran, 3-hydroxy-carbofuran, 7-phenol) were below the limit of determination in all six locations. Thus, the residues from the six independent trials were (0.04), (0.04), (0.04), (0.04),<0.02 and <0.02 mg/kg.

US trials (Martin, 1985) were also conducted in Illinois with carbofuran as a seed treatment or at planting treatment. Immature spring wheat seedlings were collected 10, 20, 30, 45 and 60 days after emergence and analysed for carbofuran and 3-hydroxy-carbofuran by the method of Schreier. The demonstrated limit of determination was 0.1 mg/kg. The limit of detection was estimated to be 0.02 mg/kg for each analyte. The results are shown in Table 38.

US GAP specifies 2 post-emergence ground or aerial applications of an F formulation at 0.28 kg ai/ha, made before the heads emerge from the boot. Treated forage may not be fed. GAP limited to Nebraska, South Dakota and Wyoming allows the application of the 4F formulation in-furrow at planting to small grains (including barley, oats and wheat) at 1.5 g ai/cm row, with a 15-cm minimum row spacing. The feeding of treated forage is prohibited.

Table 38. Residues of carbofuran and 3-hydroxy-carbofuran in or on immature wheat plants[1] following seed treatment or at planting treatment with carbofuran at 1.0 kg/ha.

-Treatment/Procedure	Days after emergence	Residue, mg/kg	
		Carbofuran	3-OH-CF
Furadan 25 ST, applied as 1% ai to seed	10 (22-day PHI)	3.3	5.6
	20	1.1	5.0
	30	<0.02	0.62
	45	(0.07)	0.68
	60	<0.02	0.46
Furadan 4F, microtube to soil in furrow	10 (22-day PHI)	1.5	1.2
	20	0.60	2.4
	30	<0.02	0.52
	45	<0.02	(0.15)
	60	<0.02	(0.22)
Furadan 5G, in-furrow at planting	10 (22-day PHI)	2.1	2.8
	20	0.58	2.4

-Treatment/Procedure	Days after emergence	Residue, mg/kg	
		Carbofuran	3-OH-CF
	30	<0.1	0.38
	45	<0.1 (0.05)	0.30
	60	<0.1 (0.03)	0.78

[1]Not a food or feed item.

Legume Vegetables

Soya beans. Trials were carried out in Brazil, France and the USA. Residues of carbofuran plus 3-hydroxy-carbofuran were below the limits of determination of the methods. Thailand submitted information on GAP for soya beans, but no data from the field trials (Thai Industrial Standard Institute, 1997). The results are given in Table 39.

GAP in Argentina, which can be used to evaluate the Brazilian trials, calls for application of the 10 G formulation in-furrow at planting at 1.5 kg ai/ha. In US GAP the 4F formulation is applied at planting at 1.7-2.0 kg ai/ha with a 100 cm row spacing or, if not used at planting, twice as a foliar spray at 0.28-0.56 kg ai/ha. No PHI is specified. GAP for France is 0.4 kg/ha of a 5% G formulation, but the data presented lacked detail.

Table 39. Total residues of carbofuran and 3-hydroxy-carbofuran in or on soya bean seeds.[1]

Country, year, variety	Form.	Application		PHI, days	Residue, mg/kg	Method of analysis, LOD	Ref.
		Method, timing	kg ai/ha)				
Brazil, 1994/ Engopa 201- Gold	5% G	in-furrow at planting	2	75	<0.05	Leppert, 0.1	Anon., 1997 FMC
			4	75	<0.05	Leppert, 0.1	Anon., 1997 FMC
France, 1988/ King	5% G	Soil at planting	0.60	150	<0.04	Blass, 0.04	Anon., 1988
USA (NE) , 1979	Furadan 4F	foliar spray at pod set	0.28	63	<0.05	Mollhoff, 0.1	Cook, 1978
		foliar spray at pod set and at pod maturity	2 x 0.28	36	0.10	Mollhoff, 0.1	Cook, 1978

[1]No data were submitted for forage or fodder

Yard-long beans. Thailand submitted information on GAP, but no data on residues (Thai Industrial Standards Institute, 1997).

Root and tuber vegetables

Carrots. The Netherlands submitted summary reports of field trials with Curraterr 200 SC applied to soil in 1980 before sowing carrot seeds (The Netherlands, 1997). The soluble concentrate was applied at 3.6-3.7 kg ai/ha and 3.6-7.5 g ai/l. Samples were analysed by the HPLC method of The Netherlands. No recovery data or storage periods from harvest to analysis were reported. The findings are shown in Table 40. Multiple results are from field replicates.

No GAP was available for The Netherlands or Europe. The data could not be evaluated for the estimation of a maximum residue level.

Table 40. Residues of carbofuran and 3-hydroxy-carbofuran in or on carrot roots from the application of Curraterr 200 SC to the soil at the time of sowing in The Netherlands.

Location/ Year	Rate		PHI, days	Residues, mg/kg		Method of analysis
	kg ai/ha	g ai/l		Carbofuran + 3-OH-CF	3-OH-CF conjugates	
Alkmaar, 1977	3.6	3.6	95	0.05; 0.08; 0.14; 0.26 (mean 0.14)	<0.01; <0.01; <0.01	Netherlands GLC (Mollhoff, 1979a)
Nooruyk-erhouk, 1977	3.6	6.0	118			
Metevik/ 1978	3.7	6.2	102	<0.01 <0.01 < 0.01 (mean <0.01)	<0.01 <0.01 <0.01	
Wageningen, 1980	3.7	7.5	111	<0.02 <0.02 <0.02 <0.02	0.05 0.05 0.06 0.05 (mean 0.05)	Netherlands HPLC
Zaltbommel	3.7	7.5	145	<0.02 <0.02 <0.02 <0.02	<0.01 <0.01 <0.01 <0.01	Netherlands HPLC

Abbreviated compound names: see Figure 1

Celeriac. The Netherlands submitted a summary report of one field trial with Curraterr 200 SC applied to the soil before planting celeriac in 1978. The application rate was 3 kg ai/ha and 5 g ai/l. Mature roots were harvested 158 days after the application and samples were analysed by the method of Molhoff (The Netherlands GLC method). The combined residue of carbofuran and 3-hydroxy-carbofuran was 0.05 mg/kg and the residue of 3-hydroxy-carbofuran conjugates <0.1 mg/kg. The stated limits of determination were 0.05 mg/kg for carbofuran plus 3-hydroxy-carbofuran and 0.1 mg/kg for 3-hydroxy-carbofuran conjugates. No GAP was available for The Netherlands or Europe.

Potatoes. Field trials were reported from Colombia, France, the UK and the USA. The tubers were treated at planting or post-emergence. Results are shown in Table 41.

GAP for Poland (2 kg ai/ha of 5 G) may be used for the evaluation of trials in France and the UK. GAP for Colombia or a neighbour was not available and the data from Colombia could not be considered for the estimation of a maximum residue level. US GAP requires an in-furrow application at planting of a 4F formulation at 3.4 kg ai/ha (Delaware, Pennsylvania, Virginia only). The same formulation may also be used post-emergence at 3.4 kg ai/ha in a shank or band application up to a four-inch rosette potato size. Up to 8 applications of the 4F formulation may be made at 1.1 kg ai/ha with a PHI of 14 days. The maximum foliar application is 3.4 kg ai/ha after an at-plant application, but no foliar applications may be made after a shank or band application.

Table 41. Residues of carbamates and phenolic metabolites in or on white potato tubers from the application of carbofuran.

Country, year, variety	Form./ Applin.	Rate		PHI, days	Residue, mg/kg		Method of analysis, LOD	Ref.
		kg ai/ha	kg ai/l		Carbamates	Phenols		

Country, year, variety	Form./ Applin.	Rate		PHI, days	Residue, mg/kg		Method of analysis, LOD	Ref.
		kg ai/ha	kg ai/l		Carbamates	Phenols		
France, 1973/ Bintje	Curraterr 5 G in-furrow at planting	1.5	-	154	<0.05[1]	-	Mollhoff, 0.1	Bayer 1975 Bayer 7155-75
UK, 1977/ Maris Piper	Yaltox 5G in-furrow at planting	5.0	-	101	0.03[2]	-	Mollhoff, 0.01	Bayer 1977 Bayer TCR 155/20-77
Columbia 1984/	Furadan 3G at planting and band. Furadan 3F foliar	3 x 1.0 2 x 1.3 (5.6 total)	not stated	18	<0.02,[3] 0.07, 0.06	-	Schreier, 0.05	Martin 1985 FMC P-1316
Columbia, 1984	Furadan 3G at planting and band. Furadan 3F foliar	2 x 1.0 1 x 1.3 (3.3 total)	not stated	69	0.05, 0.06, <0.02	-	Schreier, 0.05	Martin 1985 FMC P-1316
Columbia, 1984	Furadan 3G	3 x 1.0	-	134	0.06, <0.02, <0.02	-	Schreier, 0.05	Martin 1985 FMC P-1316
Columbia, 1984	Furadan 3F	0.8	not stated	171	<0.02, <0.02, <0.02	-	Schreier, 0.05	Martin 1985 FMC P-1316
Columbia, 1984	Furadan 3G at planting Furadan 3G band post-emergence Furadan 3F band	0.42 2 x 0.18 1.0 (1.78 total)	- - not stated	28	0.10, 0.06, 0.06	-	Schreier, 0.05	Martin 1985 FMC P-1316
Columbia, 1985	Furadan 3G at planting Furadan 3F foliar	1.0 2 x 1.0 (3.0 total)	not stated	132	<0.02, <0.02, <0.02, <0.02	-	Schreier, 0.05	Martin 1985 FMC P-1316
Columbia, 1985	Furadan 3G at planting Furadan 3F foliar	1.0 2 x 1.0	not stated	92	<0.02, <0.02, <0.02: <0.02	-	Schreier, 0.05	Martin 1985 FMC P-1316
Columbia, 1985	Furadan 3F foliar	3 x 1.0	not stated	92	<0.02, <0.02, <0.02, <0.02	-	Schreier, 0.05	Martin 1985 FMC P-1316

Country, year, variety	Form./ Applin.	Rate		PHI, days	Residue, mg/kg		Method of analysis, LOD	Ref.
		kg ai/ha	kg ai/l		Carbamates	Phenols		
Columbia/ 1985	Furadan 3F foliar	3 x 1.0	not stated	66	0.07, <0.02, <0.02, <0.02	-	Schreier, 0.05	Martin 1985 FMC P-1316
Columbia/ 1985	Furadan 3F foliar	4 x 1.0	not stated	35	<0.02, <0.02, 0.06, <0.02	-	Schreier, 0.05	Martin 1985 FMC P-1316
USA (ID)/ 1991/ Russet Burbank	Furadan 4F banded at hill-up	3.4	0.036	105	0.04, 0.04 (3-OH-CF)	0.23, 0.21	Barros, 0.03	Singer, 1992a
USA (ID)/ 1991/ Russet Burbank	Furadan 4F banded at hill-up	3.4	0.020	105	<0.01, <0.01	0.09, 0.09	Barros, 0.03	Singer, 1992a
USA (ND)/ 1991/ Norchip	Furadan 4F banded at hill-up	3.4	0.036	74	<0.01, <0.01	0.07, 0.07	Barros, 0.03	Singer, 1992a FMC P-2682
USA (OR)/ 1991/ Manona	Furadan 4F banded at hill-up	3.4	0.036	88	<0.01, <0.01	0.11, 0.15	Barros, 0.03	Singer, 1992a FMC P-2682
USA (PA)/ 1991/ Katahdin	Furadan 4F banded at hill-up	3.9	0.042	119	<0.03, <0.03	0.26, 0.31	Barros, 0.03	Singer, 1992a
USA (WA), 1991/ Russet Burbank	Furadan 4F Banded at hill-up	3.4	0.037	126	0.03, 0.03 (3-OH-CF)	0.48, 0.47 (7-P, 3-K-7-P)	Barros, 0.03	Singer, 1992a

[1]Carbofuran + 3-hydroxy-carbofuran + conjugates
[2]Carbofuran + 3-hydroxy-carbofuran
[3]Carbofuran + 3-hydroxy-carbofuran + 3-keto-carbofuran

No data were submitted on trials with multiple foliar post emergence applications.

Sugar beet. Field trials were conducted in France, Italy, Germany, the UK and the USA. Applications were at planting and/or foliar and only carbamate residues were determined except in the US trials where the phenol metabolites were also determined.

The European trials were evaluated against the GAP for Hungary (1.5-2 kg ai/ha of 10 G) and Bulgaria (875 g ai/100 kg ST). US GAP is a soil band treatment with the 4F formulation at 2.2 kg ai/ha with a 90-day PHI in Idaho, Oregon, Texas only and a soil band at planting through the six-leaf

stage of the 4F formulation at 0.01 g ai/cm of row with a 90-day PHI in Nebraska only. The results are shown in Table 42.

Table 42. Total residues of carbamates and phenolic metabolites from the application of carbofuran to sugar beet.

Country, Year, Variety	Form./appln.	Rate		PHI, days	Residue, mg/kg		Method of analysis, LOD	Ref.
		kg ai/ha	kg ai/l		Carbamates	Phenols		
France, 1973/?	Curraterr 5G Unknown (?at-plant)	0.66		175	<0.05 (root) <0.05 (foliage)		Mollhoff 0.1	Mollhoff, 1974
France, 1973/?	Curraterr 5G Unknown (?at-plant)	0.68		186	<0.05 (root) <0.05 (foliage)		Mollhoff 0.1	Mollhoff 1974
Germany, 1973/ Poly-Beta	Curraterr 5G In-furrow at-plant	0.50		191	<0.05 (root) <0.05 (foliage)		Mollhoff 0.1	Mollhoff 1974
		1.0		191	<0.05 (root) 0.15 (foliage)			
Germany/ 1984/ Geem 65	500 SC Pelleting (with seed)	0.033 (30 g ai/100,000 pills)		174	<0.05 (root) 0.07 (foliage)		Mollhoff 0.05	Mollhoff 1985
				177	<0.05 (root) <0.05 (foliage)			
Germany/ 1984/ Novadima	500 SC Pelleting (with seed)	0.033 (30 g ai/100,000 pills)		208	<0.05 (root) <0.05 (foliage)			
UK, 1974/ Amono	Curraterr 5G Spreading at planting	0.75		136	<0.05 (root) <0.1 (foliage)		Mollhoff 0.1	Mollhoff 1975
Italy, 1974/Dickman Dima	Curraterr 5G Spreading at planting	0.60		155	<0.05 (root)		Moll-hoof 0.1	Mollhoff 1974
USA (Idaho), 1992/ WS-88	Furadan 4F Banded, postemergence (2-6 leaf)	2.24	0.019	86	0.05[1] (foliage)	0.18[2] (foliage) <0.01 (root)	Barros 0.03	Singer, 1992b
USA (Oregon), 1991/ Great North-western 2905	Furadan 4F Banded, post-emergence	2.24	0.017	92	<0.01 (foliage) <0.01 (roots)	0.03 (foliage) <0.03 (roots)	Barros 0.03	Singer, 1992b
USA (Idaho), 1991/ WS-88	Furadan 4F Banded, post-emergence	2.24	0.028	173	<0.01 (foliage) <0.01 (roots)	<0.03 (foliage) <0.03 (roots)	Barros 0.03	Singer, 1992b

Country, Year, Variety	Form./appln.	Rate		PHI, days	Residue, mg/kg		Method of analysis, LOD	Ref.
		kg ai/ha	kg ai/l		Carbamates	Phenols		
USA (Wyoming), 1991/ Monohikari	Banded, at planting	2.24	0.034	181	<0.01 (foliage) <0.01 (roots)	<0.03 (foliage) <0.03 (roots)	Barros 0.03	Singer, 1992b

[1]3-OH-CF, 0.03 mg/kg and 0.07 mg/kg total carbofurans
[2]About 50% 3-keto-7-phenol, 0.26 mg/kg and 0.10 mg/kg total phenols

Swedes or turnips. Supervised field trials were conducted in France and Norway. The results are shown in Table 43.

No information on GAP was available so the data could not be evaluated for the estimation of a maximum residue level.

Only carbamate residues were determined. The applications were made at planting or early bulb formation. No measurable residues were found in any of the samples.

Table 43. Residues of carbamates in or on swedes from the application of carbofuran.

Country, Year, Variety	Form./ Application	Rate, kg ai/ha	PHI, days	Residue, mg/kg	Method of analysis, LOD[1]	Ref.
France, 1978/ Croissy	Curraterr 5G at planting	1.0	59	<0.05 (tops) <0.05 (roots)	Mollhoff 0.1	Mollhoff 1979
UK, 1977/ Acme (rutabaga)	Yaltox 5G spread at early to mid bulb formation	1.25	40	<0.01 (root)	Mollhoff 0.01	Anon. 1977
Norway, 1982/ (rutabaga)	Curraterr 5G	1.25	133	<0.05 (root, carbofuran) (0.05) (root, 3-hydroxy-carbofuran)	Mollhoff 0.1	Mollhoff 1983
Norway, 1982/ (rutabaga)	Curraterr 5G post-emergence after thinning	1.25	98	<0.05 (root, carbofuran) (0.05) (root, 3-hydroxy-carbofuran)	Mollhoff 0.1	Mollhoff 1983
`Norway, 1982/ (rutabaga)	Curraterr 5G at planting	2.5	133	<0.05 (root, carbofuran) (0.05) (root, 3-hydroxy-carbofuran)	Mollhoff 0.1	Mollhoff 1983

[1]No data were submitted to support the claimed limits of determination

Cotton seed (SO 691). Field trials were carried out in Brazil and the USA. The Meeting was informed that trials were in progress (1996-1997) in Southern Europe.

The trials in Brazil were with a single post-emergence foliar treatment of cotton plants with Furadan 350 SC at 1.0 or 2.1 kg/ha, both at about 600 l/ha, or a single post-emergence application along the plant rows with Furadan 50G at 2.5 or 5 kg/ha. In all cases the PHI was 45 days. Delinted

cotton seeds were analysed by the method of Leppert. It was claimed that the method was validated at 0.1 mg/kg with 81% recovery, but no data were provided. The residues of carbofuran and 3-hydroxy-carbofuran were below the limit of determination, 0.1 mg/kg, in all four trials. The method does not include a hydrolysis step to release conjugated carbamates.

GAP for Brazil specifies an in-furrow treatment at planting with the 5 G formulation at 1.5-3 kg ai/ha or the 350 SC formulation at 0.7-1.05 kg ai/ha. There is also a seed treatment at 0.7 kg ai/100 kg seed with 350 ST formulation. The above trials therefore did not comply with GAP.

In two other trials in Brazil (San Paulo University, 1994) cotton seed (IAC 20) was treated with Furadan 350 TS at rates of 0.70 and 1.4 kg ai/100 kg seed. The seeds were planted in 1994 at an unstated rate of seeding and mature cotton seeds were harvested 154 days after treatment. The delinted seeds were analysed by the method of Leppert. Carbofuran and 3-hydroxy-carbofuran were below the limit of determination, 0.1 mg/kg. These trials complied with GAP.

The US trials (Shevchuk, 1993) were in California, Arizona, Texas, Mississippi and Louisiana with two broadcast foliar applications of Furadan 4F. Carbofuran and its carbamate and phenol metabolites were determined in delinted cotton seed by the method of Barros. A mass-selective detector was used for the phenols. Limits of determination were established for carbofuran at 0.1 mg/kg (76 ± 4% recovery), 3-hydroxy-carbofuran at 0.1 mg/kg (71 ± 1% recovery), 3-keto-carbofuran (77 ± 4% recovery), the 7-phenol at 0.2 mg/kg (85 ± 10% recovery), 3-keto-7-phenol at 0.2 mg/kg (107 ± 13% recovery) and 3-hydroxy-carbofuran at 0.2 mg/kg (73 ± 17% recovery). Recoveries of the carbamates at 0.05 mg/kg showed poor precision. Limits of detection of 0.01 mg/kg for the carbamates and 0.05 mg/kg for the phenols were claimed. The results of the trials are shown in Table 44. No results were reported for cotton fodder.

US GAP requires in-furrow treatment at planting with the 4F formulation at 0.14 or 1.12 kg ai/ha. The feeding of cotton forage is prohibited. The reported trials are not according to GAP as they are post-emergence treatments with PHIs of about 30 days.

Table 44. Residues of carbofuran and its carbamate and phenol metabolites in or on delinted cotton seed from the foliar application of Furadan 4F to cotton plants.

Location, Year, Variety	Rate		PHI, days	Residue, mg/kg							
	kg ai/ha	g ai/l		carbo-furan	3-K-CF	3-OH-CF	total carb-amates	7-phenol	3-K-7-P	3-OH-7-P	total phenols
Louisiana, 1992, Deltapine 5415	2 x 0.28	3	27	<0.05	<0.05	<0.05		<0.1	<0.1	<0.1	<0.1
Mississippi, 1992/ DES 119	2 x 0.28	3	27	<0.05	<0.05	<0.05		<0.1	<0.1	<0.1	<0.1
Texas, 1992/ GSC 71+	2 x 0.28	4	27	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1
Texas/ 1992/ Paymaster HS 200	0.28 2.8 (3.1 total)	4	27	(0.05)	<0.05	(0.02)	(0.07)	<0.1	<0.1	<0.1	<0.1
Arizona, 1992/ DPL 5461	2 x 0.28	3	27	(0.06)	<0.05	<0.05	(0.06)	<0.1	<0.1	<0.1	<0.1

Location, Year, Variety	Rate		PHI, days	Residue, mg/kg							
	kg ai/ha	g ai/l		carbo-furan	3-K-CF	3-OH-CF	total carb-amates	7-phenol	3-K-7-P	3-OH-7-P	total phenols
California, 1992/ Germains GC-510	2 x 0.28	3	27	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1

Abbreviated compound names: see Figure 1

Peanuts. Field trials were reported from Brazil and the USA. In Brazil, peanut plants were sprayed 80 days after planting with Furadan 350 SC at 1.75 or 3.0 kg/ha, 2.4 and 4.2 g/l respectively (Sao Paolo University, 1994b]. Peanuts with hulls were harvested 14 days after the treatment. The peanuts were shelled and the carbofuran residues in the kernels determined by the method of Leppert. Recoveries of 78 ± 6% at 0.1 mg/kg were reported, without data. No carbofuran (<0.1 mg/kg) was found in the two samples. The data could not be used for the estimation of a maximum residue level because adequate details were not provided. Brazilian GAP is an application at planting of the 350 SC formulation at 1.4-1.8 kg ai/ha (100-300 l/ha) or the 5 G formulation at 2 kg ai/ha.

Thailand submitted information on GAP, but none on residues (Thai Industrial Standards Institute, 1997).

Fourteen supervised field trials were reported from the USA (Helt, 1980, Nelson, 1981), in which peanut fields were treated at pegging, and in the 1981 trials at planting. Residues of carbofuran and 3-hydroxy-carbofuran were determined in or on kernels and hulls by the method of Schreier, with an NPD only. Limits of determination of 0.05 mg/kg or 0.1 mg/kg for carbofuran and 3-hydroxy-carbofuran on peanut kernels and 0.10 mg/kg or 0.20 mg/kg for carbofuran and 3-hydroxy-carbofuran on hulls were demonstrated by the analysis of fortified controls, with the following recoveries: carbofuran on kernels 88% at 0.05 mg/kg, 78 ± 6% (n = 4) at 0.10 mg/kg; carbofuran on hulls 76% at 0.10 mg/kg, 74% at 0.20 mg/kg; 3-hydroxy-carbofuran on peanuts 72% at 0.05 mg/kg, 83 ± 15% (n = 4) 94% at 0.10 mg/kg, 75% at 0.20 mg/kg. The results of the analyses are shown in Table 45. There are no registered US uses.

Table 45. Residues in or on peanut kernels and hulls from the application of carbofuran at planting and/or postemergence.

Location, Year, Variety	Form.	Application		PHI, days	Sample	Residue, mg/kg	
		kg ai/ha	Timing, method			Carbofuran	3-OH-CF
Alabama, 1979/	Furadan 10 G	2.2	Pegging 30-36 cm band	83	kernels	<0.02	<0.02
					hulls	(0.06)	0.30
Georgia, 1979/	Furadan 10 G	2.2	Pegging 30-36 cm band	92	kernels	<0.02	<0.02
					hulls	(0.03)	(0.08)
North Carolina/ 1979/ Florigiant	Furadan 10 G	2.2	Pegging 30-36 cm band	80	kernels	(0.02)	0.09
					hulls	0.12	0.62
Oklahoma / 1979/ Runner	Furadan 10 G	2.2	Pegging 30-36 cm band	121	kernels	<0.02	<0.02

Location, Year, Variety	Form.	Application		PHI, days	Sample	Residue, mg/kg	
		kg ai/ha	Timing, method			Carbofuran	3-OH-CF
					hulls	(0.04)	<0.05
Oklahoma, 1979/ Runner	Furadan 10 G	2.2	Pegging 30-36 cm band	120	kernels hulls	(0.01) (0.03)	<0.02 0.14
Virginia, 1979/Virginia 61R	Furadan 10 G	2.2	Pegging 30 -36 cm band	64	kernels hulls	<0.02 (0.06)	<0.02 0.10
Virginia, 1979 Florigiant	Furadan 10 G	2.2	Pegging 30-36 cm band	82	kernels hulls	(0.01) (0.03)	<0.02 <0.05
Georgia, 1980/ Florunner	Furadan 10 G	1.1 2.2 2.2 (5.5 total)	In-furrow at plant Band at plant Pegging 30 -36 cm band	60	kernels hulls	<0.02 1.2	0.22 1.8
Georgia, 1980/Florunner	Furadan 10 G	1.1 2.2 2.2 (5.5 total)	In-furrow at plant Band at plant Pegging 30 -36 cm band	50	kernels hulls	<0.02 0.48	(0.06) 0.60
Georgia, 1980/ Florunner	Furadan 10 G	1.1 2.2 2.2 (5.5 total)	In-furrow at plant Band at plant Pegging 30 -36 cm band	60	kernels hulls	(0.08) 0.74	(0.06) 0.35
Georgia, 1980/Runner	Furadan 10 G	1.1 2.2 2.2 (5.5 total)	In-furrow at plant Band at plant Pegging 30 -36 cm band	60	kernels hulls	(0.02) 0.22	(0.08) 0.22
Georgia, 1980/ Runner	Furadan 10 G	1.1 2.2 2.2 (5.5 total)	In-furrow at plant Band at plant Pegging 30 -36 cm band	60	kernels hulls	0.11 2.6	0.42 1.5
North Carolina/ 1980/ Florigiant	Furadan 10 G	1.1 2.2 2.2 (5.5 total)	In-furrow at plant Band at plant Pegging 30 -36 cm band	60	kernels hulls	(0.04) 0.36	0.10 0.40
North Carolina/ 1980/ Florigiant	Furadan 10 G	1.1 2.2 2.2 (5.5 total)	In-furrow at plant Band at plant Pegging 30 -36 cm band	60	kernels hulls	(0.04) 0.32	<0.02 (0.08)
North Carolina/ 1980/ NC 6	Furadan 10 G	1.1 2.2 2.2 (5.5 total)	In-furrow at plant Band at plant Pegging 30 -36	60	kernels hulls	(0.04) (0.12)	<0.05 (0.12)

Location, Year, Variety	Form.	Application		PHI, days	Sample	Residue, mg/kg	
		kg ai/ha	Timing, method			Carbofuran	3-OH-CF
			cm band				

Abbreviated compound names: see Figure 1

Rape (canola). Field trials were carried out in Canada and France. The trials in Canada included seed, at-plant and post-emergence foliar treatments. The treatments in France were at planting.

No GAP was reported for France, other European countries or Canada, but temporary GAP was reported for the USA where the 10% G formulation may be applied at 0.28 kg ai/ha by soil incorporation at planting. The use is limited to Minnesota, Montana, North Dakota and Washington, states bordering on or near Canada.

In Canada, rape seed was treated with Furadan 5G at planting in Manitoba and Alberta at 0.28 kg/ha (Leppert, 1980a). One or two additional applications of Furadan 4.8F were made at various growth stages (2 leaf, 3-4 inch, post-podding, post-flowering) at rates of 0.28 kg/ha for all stages except post-flowering at 0.14 kg/ha. The PHIs ranged from 23 days (post-flowering) to 108 days (at planting only). Rape seed was collected at normal harvest and analysed by the method of Leppert. Limits of determination of 0.09 mg/kg were demonstrated for carbofuran and 3-hydroxy-carbofuran, which were detectable (>0.01 mg/kg) but not measurable in one of eleven trials. The trial was in Manitoba and involved an at-plant application, a foliar application at the 3-4 inch growth stage, and a foliar application after podding, all at 0.28 kg ai/kg, with a 39-day PHI. Carbofuran was detected at an estimated 0.02 mg/kg and 3-hydroxy-carbofuran at an estimated 0.01 mg/kg, the total residue estimated as 0.03 mg/kg.

In Saskatchewan and Manitoba, Canada, rape seeds were treated with carbofuran (Furadan 350 ST) at 12 and 24 g ai/kg seed (Leppert, 1984). In 6 of the 7 trials, the treatment mixture also contained carbendazim and thiram. The seeds were grown to mature plants and the seeds from these were harvested (PHI 79-127 days) and analysed for carbofuran and 3-hydroxy-carbofuran by the Leppert method. A limit of determination of 0.1 mg/kg was demonstrated for each analyte. Carbofuran was detected at 0.01 mg/kg in one trial (127-day PHI). Neither carbofuran nor 3-hydroxy-carbofuran were detected in the remaining 6 trials.

As the Canadian trials did not comply with the temporary US GAP they could not be evaluated for the estimation of a maximum residue level.

In the French trials in 1976 (Ministry of Agriculture, 1977) carbofuran (5% granular) was incorporated into the soil when the seed was sown at rates of 0.68, 0.75 and 1 kg/ha, with PHIs of 275, 300 and 280 days. Seeds were analysed by an undefined semi-quantitative technique. It was claimed that carbofuran and 3-hydroxy-carbofuran were absent at limits of 0.005 mg/kg and 0.010 mg/kg respectively. GAP for France specifies 0.45 kg ai/ha of a 5% G formulation.

In four trials in 1979 in France (Anon., 1997) Curraterr 5G was applied in the furrow at rates of 0.9, 0.95 and 0.95 kg ai/ha. The PHIs were 345-364 days. Rape seed samples and straw were analysed by the method of Mollhoff and limits of determination of 0.2 mg/kg were demonstrated for carbofuran and 3-hydroxy-carbofuran on both seed and straw. The residues were undetectable in the seed and 0.20-0.24 mg/kg in the straw. The moisture content of the straw was not determined.

Sunflower. Field trials were reported from Canada, France and the USA. The Meeting was informed that trials were in progress (1996-1997) in northern and southern Europe.

No GAP was reported for France or Canada, but GAP in the USA, which may be applicable to Canada, specifies an in-furrow application of the 4F formulation at 3.1 kg ai/ha at planting and four foliar applications at 0.56 kg ai/ha with a 28-day PHI.

In six trials in Manitoba and Saskatchewan, Canada (Leppert, 1980b) sunflower plants 30-60 cm in 1-2 ft height were treated with one or two foliar applications of Furadan 4.8F at 0.28 or one at 0.56 kg/ha. The PHIs ranged from 91 to 111 days. Sunflower seeds were harvested at maturity and analysed by the method of Leppert. Limits of determination of 0.05 mg/kg were demonstrated for carbofuran (76% and 86% recovery) and 3-hydroxy-carbofuran (92 and 92%). No carbofuran or 3-hydroxy-carbofuran was found at or above 0.05 mg/kg. Carbofuran was detected in all samples at estimated concentrations of 0.01-0.03 mg/kg and 3-hydroxy-carbofuran was detected at 0.01 mg/kg in a single sample from the application of 0.56 kg/ha to 60 cm high plants after a 101-day PHI.

In France (Anon., 1977) carbofuran (5G) was applied to the seedbed line at the planting of sunflowers. The application rate was 0.40 kg ai/ha and the PHI 135 days. Residues of 0.02 mg/kg carbofuran and <0.05 mg/kg 3-hydroxy-carbofuran were reported, but the method of analysis was described as semi-quantitative and no details of it were provided.

In the USA (Brutschy, 1984) Furadan 4F or 15G applied as a band at cultivation at 1.1 kg ai/ha was followed by four foliar applications of Furadan 4F, each at 0.56 kg ai/ha. Seeds were collected at maturity and analysed by the method of Schreier. The phenol metabolites were determined by GC-MSD. Limits of determination of 0.05 mg/kg were demonstrated for each analyte by the analysis of triplicate fortified control samples, with the following recoveries: carbofuran 66, 50, 64%, 3-hydroxy-carbofuran 68, 62, 68%, the 7-phenol 68, 72, 56%, the 3-keto-7-phenol 98, 86, 80% and the 3-hydroxy-7-phenol 84, 84, 66%. The recoveries of the carbamates were low, about 60%, over the entire tested range of 0.05-0.20 mg/kg. The trial results are shown in Table 46. The maximum total residue was 0.65 mg/kg. Although the trials were according GAP, none were at the maximum at-plant application rate. The later season foliar applications, which were at the maximum rate, are more likely to have contributed most to the carbamate residues.

Table 46. Residues of carbofuran, 3-hydroxy-carbofuran and phenolic metabolites in or on sunflower seeds from the treatment of sunflowers with carbofuran.

Location, Year, Variety	Application		PHI, days	Residue, mg/kg						
	Form.	kg ai/ha		CF	3-OH-CF	Total carb.	7-P	3-K-7-P	3-OH-7-P	Total phenols
Kansas, 1983/ Oil	15G 4F	1 x 1.1 4 x 0.56	61	0.06	0.05	0.11	(0.02)	(0.02)	(0.04)	(0.08)
	4F	1 x 1.1 4 x 0.56	61	0.06	(0.04)	0.10	(0.02)	(0.02)	(0.04)	(0.08)
Arkansas, 1983/ Sunbred 265	15G 4F	1 x 1.1 4 x 0.56	52	(0.04)	(0.02)	(0.06)	(0.02)	(0.02)	(0.04)	(0.08)
	4F	1 x 1.1 4 x 0.56	52	(0.03)	<0.02	(0.03)	<0.02	<0.02	<0.02	<0.02
Minnesota, 1983/ Sigco Dwarf-Oil	15G 4F	1 x 1.1 4 x 0.56	42	0.05	(0.02)	0.07	(0.02)	(0.02)	(0.02)	(0.06)

Location, Year, Variety	Application		PHI, days	Residue, mg/kg						
	Form.	kg ai/ha		CF	3-OH-CF	Total carb.	7-P	3-K-7-P	3-OH-7-P	Total phenols
	4F	1 x 1.1 4 x 0.56	42	(0.04)	(0.02)	(0.06)	<0.02	<0.02	(0.02)	(0.02)
Illinois, 1983/ Oil	15G 4F	1 x 1.1 4 x 0.56	53	0.30	0.12	0.42	0.06	0.06	0.11	0.23
	4F	1 x 1.1 4 x 0.56	53	0.28	0.11	0.39	(0.04)	0.05	0.08	0.17
North Dakota, 1983/ Cargill 205-Oil	15G 4F	1 x 1.1 4 x 0.56	50	0.10	(0.02)	0.12	(0.02)	(0.02)	(0.02)	(0.06)
	4F	1 x 1.1 4 x 0.56	50	0.06	(0.02)	0.08	<0.02	(0.02)	(0.01)	(0.03)
Illinois, 1983/ Confectionery	15G 4F	1 x 1.1 4 x 0.56	53	0.21	0.08	0.29	0.06	0.06	0.08	0.20
	4F	1 x 1.1 4 x 0.56	53	0.18	0.08	0.26	0.05	0.05	0.06	0.16

Abbreviated compound names: see Figure 1

Leeks. The Netherlands provided the results of two field trials, one each in Waandenburg and Huissen, in 1977 (Ministry of Health, Welfare and Sport, 1997). Curraterr 200 SC was applied to the soil before planting at 4.4 kg ai/ha, 7.4 g/l. The mature crop was harvested 118 or 125 days after application. Leek bulbs were analysed by the method of Mollhoff. No limits of determination were stated. Results were reported as the sum of carbofuran, 3-hydroxy-carbofuran and conjugates of 3-hydroxy-carbofuran. In the Huissen trial the residues were <0.1 mg/kg (0.07, 0.07 mg/kg) and in the Waandenburg trial 0.13 mg/kg (0.15, 0.12, 0.12 mg/kg). No GAP was reported for The Netherlands or a neighbouring nation.

Onions. The Netherlands reported the results of three field trials in 1977 and 1978. Mature samples were analysed by the method of Mollhoff and limits of determination of 0.1 mg/kg were claimed for carbofuran plus 3-hydroxy-carbofuran and for conjugates of 3-hydroxy-carbofuran. The results are shown in Table 47. No GAP was reported.

Table 47. Residues of carbamate in onions after application of carbofuran.

Location, Year	Form.	Application			PHI, days	Carbofuran 3-OH-CF, mg/kg	Conjugate of 3-OH-CF, mg/kg) <0.1
		Timing	Rate, kg ai/ha	Rate, kg ai/l			
Nieuu Vossemeir, 1978	Curraterr 5G	after sowing	1.5	-	176	<0.1	<0.1
Willemstad, 1978	Curraterr 5G	after sowing	1.5	-	158	<0.1	<0.1
Zwingelspoon, 1977	Curraterr 200 SC	before sowing	5	8.4	90	<0.1	

Abbreviated compound names: see Figure 1

Celery. The Netherlands provided the results of two trials in 1978 in Berghen (trial 1) and Schayk (trial 2). Curraterr 200 SC was applied at 3.12 kg ai/ha, 5.2 g/l, to the soil one day before planting celery (goudgele relfblekende). Celery was harvested 84 days (trial 1) or 90 days (trial 2) after the treatment and samples were analysed by the method of Mollhoff. No limits of determination were stated. The combined residue of carbofuran and 3-hydroxy-carbofuran averaged 0.21 mg/kg (0.21, 0.18, 0.24 mg/kg) in trial 1 and 0.15 mg/kg (0.21, 0.12, 0.13 mg/kg) in trial 2. In both trials the conjugate of 3-hydroxy-carbofuran was <0.1 mg/kg (not detected). No GAP was reported for celery.

Tomatoes. Field trials were conducted in Brazil (Anon., 1994), Canada (Hawk, 1975), France (Anon., 1986b), Mexico (Shuttleworth, 1975) and the USA (Hawk, 1974). Thailand reported field trials according to GAP but without data or results (Thai Industrial Standards Institute, 1997). The findings are shown in Table 48.

GAP for Brazil specifies the use of the 350 SC formulation in-furrow at planting at 1.75 kg ai/ha or the 5 G at planting or transplanting at 4 kg ai/ha. There is no US GAP. GAP was not reported for Mexico, Canada or France.

Table 48. Residues of carbofuran and 3-hydroxy-carbofuran in or on tomatoes from the application of carbofuran to tomato plants.

Location, Year, Variety	Form.	Application		PHI, days	Residue, mg/kg		Method of analysis	Recovery, mg/kg/%	
		Method	kg/ha		CF	3-OH-CF		CF	3-OH-CF
Brazil, 1993/ Santa Clara	Furadan 350 SC	spray to soil around plant (200 l/ha)	3.5	60	≤0.05		Leppert	0.1/89	
			7.0	60	<0.05				
Brazil, 1993/ Santa Clara	Furadan 50G	broadcast and soil incorporation	2.6	60	<0.05		Leppert	0.1/89	
			5.2	60	<0.05				
Brazil, 1993/ Roma VF	Furadan 50G	broadcast and soil incorporation	4	60	≤0.05		Leppert	0.1/89	
			8	60	<0.05		Leppert	0.1/89	

Location, Year, Variety	Form.	Application		PHI, days	Residue, mg/kg		Method of analysis	Recovery, mg/kg/%	
		Method	kg/ha		CF	3-OH-CF		CF	3-OH-CF
Canada (Ontario), 1974/	Furadan 4.8F	foliar spray	0.56	83	<0.05	<0.05	Schreier	0.1/70, 85	0.1/93
		foliar spray	2 x 0.27	1	0.25	<0.05			
				3	<0.05	<0.05			
				6	<0.05	<0.05			
				10	<0.05	<0.05			
				27	<0.05	<0.05			
France, 1986/ Cam-Root	Curraterr MG (5%)	spread on seed beds	1.5	116	<0.05	<0.25 (conjugate)	Mollhoff		
France, 1986/ Lerica, F1 hybrid	Curraterr MG (5%)	spread on ground with 2-4 leaves on plants	0.75	98	<0.05	<0.25	Mollhoff		
France, 1986/ Variety ACE SS	Curraterr MG (5%)	Spread on ground before fruit formation	1	47	<0.05	<0.25	Mollhoff		
France, 1986/ Arimex	Curraterr MG (5%)	Spreading on 20 cm strips, at 2nd cluster, L 25 stage	1	29	<0.05	<0.25 (conjugate)	Mollhoff		
Mexico (Valle de Culia-can)/ 1975/	Furadan 3G Furadan 75WP	Spread, sidedress incorporated Foliar	2 3 x 1 (total 5)	7	<0.05 (9 plots) 0.056 (1 plot)	<0.05	Schreier	0.05/90	0.1/96, 80
				14	<0.05 (1 detect, 9 no detects)	<0.05 (10 no detects)			
USA/ (Florida), 1971/	Furadan 4F	Foliar spray	5 x 1.2	7	<0.05	<0.05	Schreier	0.1/100, 94, 80	0.1/109, 94, 64
USA / (Virginia, Maryland, Ohio), 1971	Furadan 10G	Banded at transplant	1 x 1.1	57 (VA) 77 (OH) 133 (MD)	<0.105	<0.05	Schreier	0.1/100, 94, 80	0.1/109, 94, 64

Abbreviated compound names: see Figure 1

Peppers, Chilli. Two trials were conducted, one each in California and New Mexico (Kim, 1995a). Furadan 4F was applied to the soil immediately before planting peppers at 1.2 kg ai/ha (5.9 g ai/l) in California (variety Jalapeno M) and at 1.1 kg ai/ha (3.5 g ai/ha) in New Mexico (variety NM 64). After approximately 2 months in California and 4 months in New Mexico, Furadan 4F was applied as a side-dressing (directed spray). The application rates were 1.7 kg/ha (9.0 g ai/l) in California and 1.7 kg/ha (14 g ai/l) in New Mexico. Mature peppers were harvested after a PHI of 28 days in both states.

The trials reflect the maximum US GAP.

The samples were analysed by the method of Barros. Limits of determination of 0.05 mg/kg were demonstrated for all the analytes, with the following recoveries from fortified control samples: carbofuran 94%, 3-keto-carbofuran 82%, 3-hydroxy-carbofuran 94%, 7-phenol 69%, 3-keto-7-phenol 91% and 3-hydroxy-7-phenol 96%. No carbamates were detected in any sample. The 7-phenol was detected below the limit of determination in both the California and New Mexico samples, at estimated levels of 0.02 and 0.04 mg/kg respectively. The 3-keto-7-phenol and the 3-hydroxy-7-phenol were also detected below the limits of determination in the New Mexico samples, both at 0.02 mg/kg.

Peppers, Sweet. Pepper plants were treated in 1974 with Furadan 4F 5 x 0.56 kg ai/ha in Ontario, Canada (Bednar and Stanovick, 1974). The PHI varied from 1 to 3 days. The samples were analysed by the method of Schreier, with limits of determination of 0.1 mg/kg for both carbofuran (78% recovery) and 3-hydroxy-carbofuran (97% recovery). At PHIs of 1, 2 and 3 days the carbofuran concentration was 0.26 mg/kg maximum (0.18 mg/kg average), 0.20 mg/kg maximum (0.18 mg/kg average) and 0.17 mg/kg maximum (0.15 mg/kg average) respectively. Residues of 3-hydroxy-carbofuran were <0.10 mg/kg at all PHIs.

Pepper plants in the USA (Kim, 1995b) were treated in 1994 either with Furadan 4F at 1.1 kg ai/ha at transplanting in-furrow or 4 weeks after transplanting as a side-dress. A second application was made after an interval of 1-3 months with side-dressing at 1.7 kg ai/ha (2.0 kg ai/ha in Florida). Bell peppers were collected at maturity 28 days after the final treatment from four plots in Florida, California, Texas and New Jersey and analysed by the method of Barros. The limit of determination was 0.05 mg/kg for all analytes as shown by the following recoveries from fortified control samples: carbofuran 84 ± 9%, 3-ket°Carbofuran 77 ± 3%, 3-hydroxy-carbofuran 78 ± 7%, 7-phenol 90%, 3-keto-7-phenol 111% and 3-hydroxy-7-phenol 94%.

Canadian GAP was not reported and US GAP does not reflect the conditions of either the Canadian or US trials. US GAP specifies two applications at 3.4 kg ai/ha, 1 at planting and a second 3-4 weeks later as a side-dress. The PHI is 21 days and the use is restricted to Arizona. The trials did not comply with GAP and two trials are inadequate to estimate a maximum residue level.

The LOD for all analytes was 0.05 mg/kg, with an estimated limit of detection of 0.01 mg/kg. The carbamate metabolites 3-keto-carbofuran and 3-hydroxy-carbofuran were not detected in any sample, and carbofuran was detected only in the California sample, at an estimated 0.01 mg/kg. The phenols were detected in all samples, but only the 7-phenol was quantifiable, in one Florida sample at 0.10 mg/kg. The maximum total residue was 0.21 mg/kg (Florida, in-furrow + side-dress). All others were ≤0.05 mg/kg.

Cucumbers. Twenty eight supervised field trials were conducted in the USA in Florida, Illinois, Virginia, Michigan, New York, Arkansas and California (Grigor and Tegris, 1987a). Furadan 15G was applied as an in-furrow treatment at planting (1.1 kg ai/ha or 3.4 kg ai/ha), or Furadan 4F was applied to the soil as a band at planting. Cucumbers were collected at maturity, at PHIs ranging from 44 to 67 days, and analysed by the method of Schreier, with the method extended to the determination of the phenol metabolites by GC-MSD. Limits of quantification of 0.05 mg/kg for each analyte were established by the analysis of replicate fortified controls. The recoveries (mean of 8) were as follows: carbofuran 93 ± 15%, 3-keto-carbofuran, 104 ± 16%, 3-hydroxy-carbofuran, 74 ± 1%, 7-phenol, 86 ± 19, 3-keto-7-phenol, 101 ± 16%, and 3-hydroxy-7-phenol, 84 ± 15%. The limits of detection were estimated as 0.02 mg/kg for the carbamates and 0.01 mg/kg for the phenols. Total

residues as high as 0.6 mg/kg were found in one of two duplicate samples from Illinois. The results are shown in Table 49.

US GAP for cucumbers specifies application of the 10 or 15G formulation at planting, soil band incorporated at 2.2 kg ai/ha, or of the 4F formulation at 1.7 kg ai/ha. No PHI is specified. Although the trials were not conducted at the maximum GAP rates, they were at rates above and below the maximum with similar results. It can be concluded that residues from treatments according to GAP would be similar.

Thailand submitted information on trials according to GAP, but without data (Thai Industrial Standards Institute, 1997).

Table 49. Residues of carbofuran and carbamate and phenol metabolites in or on cucumbers following at planting treatment with Furadan 15G or Furadan 4F.

Location, Year, Variety	Form.	Rate, kg ai/ha	PHI, days	Residue, mg/kg					
				Carbo-furan	3-K-CF	3-OH-CF	7-phenol	3-K-7-P	3-OH-7-P
Florida, 1984/ Poinsetta 76	4F	1.1	67	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	4F	3.4	67	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	15G	1.1	67	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	15G	3.4	67	(0.023)	<0.02	<0.02	<0.02	<0.02	<0.02
Illinois, 1984/ SMR 58	4F	1.1	53	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	4F	3.4	53	<0.02	<0.02	<0.02	<0.02	0.02	<0.02
	15G	1.1	53	<0.02	<0.02	<0.02	<0.02	0.027)	<0.02
	15G	3.4	53	0.17 (0.27, 0.071)	<0.02	<0.02	(0.024)	(0.24, 0.11)	(0.018)
Virginia, 1984/	4F	1.1	65	0.13	<0.02	<0.02	<0.02	0.07	<0.02
	4F	3.4	65	0.21	<0.02	0.02	<0.02	0.092	<0.02
	15G	1.1	65	(0.030)	<0.02	<0.02	<0.02	<0.02	<0.02
	15G	3.4	65	0.12	<0.02	<0.02	<0.02	0.054	<0.02
Michigan, 1984/ Chicago Pickling	4F	1.1	52	0.15	<0.02	<0.02	<0.02	O.17 (0.22, 0.12)	<0.02
	4F	3.4	52	0.12 (0.091, 0.16)	<0.02	<0.02	<0.02	0.13 (0.088, 0.18)	<0.02
	15G	1.1	52	0.1	<0.02	<0.02	<0.02	(0.044)	<0.02
	15G	3.4	52	0.12 (0.086, 0.15)	<0.02	<0.02	<0.02	0.14	<0.02

Location, Year, Variety	Form.	Rate, kg ai/ha	PHI, days	Residue, mg/kg					
				Carbo-furan	3-K-CF	3-OH-CF	7-phenol	3-K-7-P	3-OH-7-P
New York, 1984/ Victory	4F	1.1	66	(0.028)	<0.02	<0.02	<0.02	<0.02	<0.02
	4F	3.4	66	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	15G	1.1	66	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	15G	3.4	66	0.060	<0.02	<0.02	<0.02	<0.02	<0.02
Arkansas, 1984/ Green Star	4F	1.1	44	0.05	<0.02	<0.02	<0.02	0.022)	<0.02
	4F	3.4	44	0.12	<0.02	<0.02	<0.02	0.076	<0.02
	15G	1.1	44	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	15G	3.4	44	0.098	(0.026)	<0.02	<0.02	0.081 (0.062, 0.10)	<0.02
California, 1984/ Poinsetta 76	4F	1	52	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	4F	3.4	52	<0.02	0.002	<0.02	<0.02	<0.02	<0.02
	15G	1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	15G	3.4	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

[1]Furadan 4F was applied as an 18 cm band to the soil at planting. Concentration (kg ai/hl) not stated. Furadan 15G was applied to the furrow at planting

Cantaloupes. In supervised field trials reported from the USA in Florida, Illinois, Virginia, Michigan, New York, Arkansas and California, ± trials per state, Furadan 15G was applied in-furrow at planting (1.1 kg ai/ha or 3.4 kg ai/ha), or Furadan 4F was applied to the soil as ± band at planting (Grigor and Tegris, 1987b). Samples were collected at maturity, with PHIs of 60 to 92 days, and analysed by the method of Schreier, the phenols by GC-MSD. Limits of determination of 0.05 mg/kg for each analyte were established by the analysis of fortified controls, with recoveries from ± replicates of carbofuran 85 ± 15%, 3-keto-carbofuran 94 ± 15%, 3-hydroxy-carbofuran 68 ± 7%, 7-phenol71 ± 12%, 3-keto-7-phenol 102 ± 12%, and 3-hydroxy-7-phenol 80 ± 13%. Limits of detection were estimated as 0.02 mg/kg for the carbamates and 0.01 mg/kg for the phenols. The maximum total residue encountered was 0.12 mg/kg. No residues were detectable in or on the Florida samples (88-day PHI) and the residues were not quantifiable in or on any of the Arkansas (60-day PHI) or Virginia samples; one Arkansas sample (4F, 3.4 kg ai/ha) showed an estimated residue of 0.04 mg/kg carbofuran, estimated as ≤0.04 mg/kg, and all Virginia samples contained traces of carbofuran, estimated at 0.02 mg/kg. One of the duplicated samples from the 3.4 kg/ha treatments with 15G and 4F in Illinois contained quantifiable residues, 0.11 mg/kg and 0.081 mg/kg respectively. The major component was 3-hydroxy-carbofuran. In Michigan, treatment at 1.1 kg/ha yielded no quantifiable residues (<0.05 mg/kg) and treatment at 3.4 kg/ha yielded total residues of 0.10 mg/kg from the 4F formulation and 0.50 mg/kg in one of the duplicate from the 15G. The major components were 3-hydroxy-carbofuran and the 3-hydroxy-7-phenol. All New York samples contained carbofuran, ranging from 0.05 to 0.095 mg/kg. California samples from the 1.1 kg ai/ha applications (92 days PHI) also contained carbofuran, 0.05-0.11 mg/kg.

US GAP for cantaloupes is the same as for cucumbers: application of the 10 or 15G formulation at planting, soil band incorporated at 2.2 kg ai/ha, or of the 4F formulation at 1.7 kg ai/ha, no PHI specified. Although the trials were not at the maximum GAP rates, they included rates above and below the maximum, with similar results. It can be concluded that the residues from GAP treatments would also be similar.

Thailand submitted information on GAP trials, but without data on residues (Thai Industrial Standards Institute, 1997).

Summer squash. In trials in Florida, Illinois, Indiana, Michigan, New York, Arkansas and California (Grigor and Tegris, 1987c) Furadan 15G was applied in-furrow, or Furadan 4F to the soil as ± band, at planting at 1.1 or 3.4 kg ai/ha. Samples were collected at maturity, at PHIs ranging from 49 to 69 days, and analysed by the method of Schreier, with the same limits of determination (0.05 mg/kg) and detection (0.02 and 0.1 mg/kg) as for cantaloupes. Recoveries from fortified samples (n ± 8) were as follows: carbofuran 86 ± 16%, 3-keto-carbofuran 98 ± 13%, 3-hydroxy-carbofuran 68 ± 9%, 7-phenol 74 ± 6, 3-keto-7-phenol 112 ± 12%, and 3-hydroxy-7-phenol 85 ± 11%.

One Florida sample contained unquantifiable residues (15G, 3.4 kg ai/ha, estimated 0.04 mg/kg carbofuran and 3-keto-7-phenol) and residues were undetectable in the others (52-day PHI). One New York sample (15G, 3.4 kg ai/ha) contained an estimated 0.02 mg/kg of the 3-keto-7-phenol, and the remaining samples had no detectable residues (69-day PHI). Residues were undetectable in all the California samples (49-day PHI). All except one of the samples from Michigan (PHI 61 days, Yellow Crookedneck variety) contained residues of carbofuran only, 0.05-0.09 mg/kg. The exception contained unquantifiable carbofuran and 3-keto-carbofuran. All samples from Indiana (PHI 53 days, President Elite variety) contained detectable residues of carbofuran (estimated as 0.02-0.05 mg/kg) and the samples from the 15G applications contained total residues from 0.10 to 0.20 mg/kg, with each of the three phenols contributing 0.02-0.03 mg/kg and 3-hydroxy-carbofuran 0.07 mg/kg from the 3.4 kg ai/ha treatment and 0.05 mg/kg from 1.1 kg ai/ha. All Illinois samples contained detectable and quantifiable residues, except from the 1.1 kg ai/ha 15G treatment. Residues of the carbamates were 0.06, 0.08 and 0.10 mg/kg. All samples from Arkansas (PHI 37 days, Golden Girl variety) contained residues in the range 0.094-0.26 mg/kg, consisting of carbofuran only, except from the 15G formulation applied at 3.4 kg ai/ha where about 25% of the residue (0.26 mg/kg total) was 3-hydroxy-carbofuran.

US GAP for summer squash is the same as for cucumbers and cantaloupes. Again the squash trials were at rates above and below the maximum GAP rate with similar results, and residues from GAP applications would also be similar.

Thailand again submitted GAP information but no residue data (Thai Industrial Standards Institute, 1997).

Coffee beans. Supervised field trials were reported from Brazil and the USA.

In two trials in 1994-5 (Brooks, 1996c) in major coffee-growing regions of Brazil (Sao Paulo and Minas Gerais, Catuai variety) Furadan 5G was applied twice at 1.5 g ai/bush. The first application was 30-60 days after flowering and the second approximately 6 months later, with a 29-day PHI. The granules were applied as a band round the bases of the coffee bushes. The coffee cherries were harvested at maturity and sun-dried. The green beans were depulped by a commercial process and analysed by the method of Barros. Limits of determination of 0.05 mg/kg were established for carbofuran and the carbamate and phenol metabolites by the determination of recoveries from fortified controls. The average recoveries (means of duplicates) were carbofuran 76%, 3-keto-

carbofuran 63%, 3-hydroxy-carbofuran 81%, 7-phenol 79%, 3-keto-7-phenol 99%, 3-hydroxy-7-phenol 73%. The recovery of 3-keto-carbofuran improved at a 0.5 mg/kg to 72%.

Duplicate samples were analysed from each of the two locations. At Sao Paulo the 3-hydroxy-7-phenol was found at 0.08 mg/kg in both samples, the 7-phenol and 3-keto-7-phenol were detected but <0.05 mg/kg, and carbofuran and 3-hydroxy-carbofuran were undetectable (<0.02 mg/kg). In the Minas Gerais samples, the 3-hydroxy-7-phenol was found at 0.16 and 0.13 mg/kg, 3-hydroxy-carbofuran and the 7-phenol were detected at estimated concentrations of 0.03 mg/kg each, and carbofuran was undetectable.

In Brazil, samples of beans from coffee bushes treated with a foliar spray of Furadan 350 SC at 2.1 or 4.2 g ai/bush, 200 l/ha, in 1994 (Sao Paolo University, 1994) were analysed for carbofuran by the method of Leppert. The PHI was 90 days. A recovery of 79 ± 6% was reported at 0.1 mg/kg fortification, but no details were provided. Carbofuran was below the limit of determination (<0.1 mg/kg).

GAP in Brazil specifies application of 0.35 g ai/tree of the 350 SC formulation or application of 0.5-3 g ai/tree of the 5G; the timing is not specified. GAP for foliar treatment was not reported.

Four supervised field trials were conducted on the islands of Kauai, Hawaii and Oahu in the USA (Brooks, 1996a). Two applications of Furadan 5G were made in each trial at 1.5 g ai/tree, the first after flowering and the second after an interval of 5-6 months. For each treatment, approximately 30 g of the granular formulation was applied to the soil near the base of each tree and “minially incorporated (less than 1 cm)”. The PHIs were 28-29 days. The treated cherries were harvested at maturity, dried and shelled by the commercial wet method. The beans were analysed by the method of Barros. A limit of determination of 0.05 mg/kg for each analyte was established by the analysis of fortified controls but precision was generally poor. Recoveries were carbofuran (n = 9) 88 ± 16%), 3-keto-carbofuran (n = 8) 105 ± 13%, 3-hydroxy-carbofuran (n = 10) 88 ± 17%, 7-phenol (n = 6) 64 ± 12%, 3-keto-7-phenol (n = 6) 92 ± 14% and 3-hydroxy-7-phenol (n = 6) 72 ± 13%. The results are shown in Table 50.

GAP in the USA specifies the application of a 10% G formulation at 1.7 g ai/tree twice each year to the base of coffee trees in Puerto Rico only. The application rate in the trials was within 10% of the GAP rate and the results could be used to estimate a maximum residue level.

Table 50. Residues of carbamates and phenols in or on green coffee beans from the application of Furadan 5G (2 x 1.5 g ai/tree) to the base of coffee plants, 28-29-day PHI.

Location/Year/ Variety	Residue, mg/kg					
	Carbofuran	3-K-CF	3-OH-CF	7-Phenol	3-K-7-P	3-OH-7-P
Kauai, 1995/ Yellow catuai	<0.02	(0.02)	(0.02)	0.16	(0.03)	0.33
Kauai, 1995/ Yellow catuai	<0.02	<0.02	0.25	0.24	0.10	0.64
Kauai, 1995/ Yellow catuai	<0.02	<0.02	0.79	0.32	0.20	1.08
Hawaii, 1995/ Guatamalan	<0.02	<0.02	0.08	(0.04)	(0.02)	0.22
Hawaii, 1995/ Guatamalan	<0.02	<0.02	0.12	(0.04)	(0.02)	0.28

Location/Year/ Variety	Residue, mg/kg					
	Carbofuran	3-K-CF	3-OH-CF	7-Phenol	3-K-7-P	3-OH-7-P
Oahu, 1995/ Guatamalan	≤0.02	<0.02	≤0.02	(0.01)	<0.052	(0.02)

Abbreviated compound names: see Figure 1

Head cabbage. The Netherlands reported two supervised field trials in which Curraterr 200 SC was applied to head cabbage in 1977 at rates of 0.04 and 0.25 g ai/plant, 0.40 g ai/l water. The mode of application was not described. The PHI was 69 days for the lower application rate and 155 days for the higher. Mature heads were analysed by the method of Mollhoff. All residues were <0.1 mg/kg, the stated limit of determination. GAP was not reported for The Netherlands or a neighbouring country.

Brussels sprouts. The Netherlands reported two supervised field trials with the application of Curraterr 200 EC to Brussels sprouts in 1977 at a rate of 0.025 g ai/plant, 0.25 g ai/l water. Mature sprouts were harvested 126-127 days after the treatment and analysed by the method of Mollhoff. All residues were <0.1 mg/kg, the stated limit of determination. GAP was not reported.

Cauliflower. The Netherlands reported five trials. Curraterr 200 SC was applied to cauliflower plants at rates of 0.025 or 0.038 g ai/plant, and 0.25 or 0.38 g ai/l water. The mode of treatment was not described. Mature crops were harvested 61, 69 or 71 days after the application and analysed by the method of Molhoff. The residues of conjugates of 3-hydroxy-carbofuran were <0.1 mg/kg, the stated limit of determination. The combined residues of carbofuran and 3-hydroxy-carbofuran were 0.2, <0.1, 0.18, 0.22 and <0.1 mg/kg. GAP was not reported.

Kohlrabi. Germany submitted the results of two field trials with single applications of Curraterr-Granulat GR (50 g ai/kg) at a rate of 0.645 g/m. The rate per area and the type of application were not reported. It is implied that residues were determined as carbofuran plus 3-hydroxy-carbofuran and as 3-hydroxy-carbofuran conjugates. Limits of determination and sample chromatograms were not supplied. In the Oldenberburg trial, the application was made 38 days after planting and the carbamate and conjugate residues were <0.1 mg/kg at a 27-day PHI and <0.05 mg/kg after 40 and 54 days. In the Braunschweig trial, the treatment was 52 days after planting and residues of carbofuran plus 3-hydroxy-carbofuran were 2.99 mg/kg at a PHI of 25 days, 0.28 mg/kg at 36 days and 0.17 mg/kg at 52 days. The residues of the conjugates at the same PHIs were 0.7, <0.05 and 0.11 mg/kg. GAP was not reported.

Grapes. Field trials were reported from Germany (Federal Biological Research Centre for Agriculture and Forestry, 1996), Mexico (Fullmer, 1977) and the USA (Pejovich, 1984).

In Germany Curraterr-Granulat GR (50 g ai/kg) was applied to mature grape vines in 1986 at four locations and grapes were harvested at intervals of 0-79 days. The growth stages at treatment were described as stages 27-33 and the treatment was 2 x 0.5 g ai/vine; the rate per area was not reported. The PHIs of the analytical samples are significantly shorter than the crop harvest interval, suggesting that immature crops may have been sampled. Samples were analysed by an undisclosed method and it was not stated whether carbofuran only or carbofuran plus certain metabolites were determined. The results are shown in Table 51. GAP was not reported for Germany or the European Union.

Table 51. Residues in or on grapes resulting from the treatment of vines with a granular formulation of carbofuran in Germany in 1986 at 2 x 0.5 g ai/vine.

Location	PHI, days	Residue[1], mg/kg
Weinsberg	0	0.04
	21	0.08
	42	0.12
Bernkastel-Kues	0	0.09
	22	<0.04
	79	<0.04
Neustadt-W	0	<0.04
	21	>0.04
	35	<0.04
	56	<0.04
	70	0.11
Marienthal	0	<0.04
	21	0.26
	35	0.09
	56	0.12
	70	0.1

[1]The constituents of the residue were not reported

In Mexico, Furadan 5G was applied once to vineyard soil at 10 or 20 kg ai/ha in three trials. Samples of mature grapes were collected 123 days or 43 days after the treatment and analysed by the method of Schreier with limits of determination of 0.1 mg/kg for both carbofuran and 3-hydroxy-carbofuran. The recoveries from single spiked samples were 109% and 70% for carbofuran. The results are shown in Table 52.

GAP for Mexico was not reported, but GAP in the neighbouring USA (California only) requires 11.2 kg ai/ha of the 4F formulation, soil-incorporated after harvest with a PHI of 200 days. Pre-harvest drip irrigation of the same formulation may be made at 3.4 kg ai/ha with a 60-day PHI. The PHI of 123 days in one of the trials was within 40% of the US PHI and the 10 kg ai/ha rate was about 90% of the US rate.

Table 52. Residues of carbofuran in or on grapes from single applications of Furadan 5g to vineyard soil in Torreon, Mexico.

kg ai/ha	PHI, days	carbofuran, mg/kg	3-hydroxy-carbofuran, mg/kg
10	123	<u><0.1</u>	<u><0.1</u>
10	43	0.24	0.66

		(0.22; 0.27)	(0.52; 0.80)
20	43	1.1 (1.3; 0.93)	1.5 (1.5; 1.5)

In the USA, vineyards were treated 3 or 5 times by drip irrigation with Furadan 4F at 1.1 or 2.2 kg ai/ha/application at four locations in California in 1983-1984. Grapes taken at normal harvest were analysed by the method of Schreier. An MSD was used for the quantification of the carbamate residues and an NPD for the phenols. Limits of determination were demonstrated at 0.1 mg/kg by the analysis of fortified controls, with recoveries from triplicate analyses of carbofuran 78% ± 4.9%, 3-hydroxy-carbofuran 81% ± 6.2%, 7-phenol 89% ± 4.0%, 3-keto-7-phenol 101% ± 2.1%, and 3-hydroxy-7-phenol 63% ± 4.4%. Recoveries at 0.05 mg/kg were not acceptable and results at such concentrations would be semi-quantitative. The results are shown in Table 53. The maximum total carbamates residue was 0.15 mg/kg and the maximum combined residue of carbamates and phenols was 0.32 mg/kg.

Some trials corresponded to US GAP for post-harvest treatment of vineyards. The maximum total trial rate was 110% of the GAP rate and the PHIs were about 200 days. Some trials also complied with US GAP for pre-harvest treatments (3.4 kg ai/ha, 60-day PHI).

Table 53. Residues in or on grapes from the application of Furadan 4F by drip irrigation to vineyards in California, 1983-4.

Trial No., Location	Variety	Application			PHI, days	Residue, mg/kg				
		kg ai/ha	No.	Total kg ai/ha season		CF	3-OH-CF	7-phenol	3-K-7-P	3-OH-7-P
RRA-038 Thermal	Perlette	4.5 2.2	1 3	11	218	<0.05	<0.05	<0.05	<0.05	<0.05
RRA-041 Thermal	Cardinal	4.5 2.2	1 3	11	209	<0.05	<0.05	<0.05	<0.05	<0.05
RRA-057 Thermal	Thompson Seedless	2.2	3	6.7	238	<0.5	<0.05	<0.05	<0.05	<0.05
RRA-100 Lost Hills	Perlette	2.2	3	6.7	266	<0.05	<0.05	<0.05	<0.05	<0.05
RRA-113 Madera	Thompson Seedless	2.2	3	6.7	256	<0.05	(0.03)	<0.05	<0.05	<0.05
RRA-241 Soledad	Merlot	2.2	6	13	294	<0.05	<0.05	(0.02)	(0.02)	<0.2
RRA-039 Thermal	Perlette	3.4	1	3.4	54	<0.05	0.1	(0.04)	(0.04)	(.07)
RRA-042 Thermal	Cardinal	1.1	3	3.4	54	<0.05	(0.06)	(0.03)	(.03)	(0.03)
RRA-046 Thermal	Perlette	1.1	3	3.4	60	<0.05	(0.06)	(0.04)	(0.04)	<0.1 (0.04)
RRA-048 Thermal	Cardinal	1.1	3	3.4	60	<0.05	<0.05 (0.03)	<0.05 (0.02)	<0.05 (0.02)	<0.1 (0.02)

Trial No., Location	Variety	Application			PHI, days	Residue, mg/kg				
		kg ai/ha	No.	Total kg ai/ha season		CF	3-OH-CF	7-phenol	3-K-7-P	3-OH-7-P
RRA-059 Thermal	Thompson Seedless	1.1	3	3.4	59	<0.05	0.1	(0.06)	(0.05)	0.11
RRA-102 Lost Hills	Perlette	1.1	3	3.4	60	<0.05	0.12	(0.06)	<0.05 (0.04)	<0.1 (0.08)
RRA-111 Madera	Thompson Seedless	1.1	3	3.4	63	(0.02)	(0.08)	(0.04)	<0.05 (0.02)	<0.1 (0.02)
RRA-243 Soledad	Merlot	1.1	3	3.4	139	<0.05	(0.03)	(0.02)	(0.02)	<0.1 (0.02)
RRA-063 Thermal	Thompson Seedless	2.2 1.1	3 2	9	59	<0.05	(0.09)	(0.05)	(0.04)	(0.09)
RRA-105 Lost Hills	Perlette	2.2 1.1	3 2	9	60	<0.05	(0.08)	(0.04)	<0.05 (0.04)	<0.05 (0.05)
RRA-115 Madera	Thompson Seedless	2.2 1.1	3 2	9	63	(0.03)	0.10 (0.12; 0.07)	(0.04)	(0.02)	(0.02)
RRA-248 Soledad	Merlot	2.2 1.1	32	9	153	<0.05	(0.06)	(0.04)	(0.03)	<0.1 (0.05)

Abbreviated compound names: see Figure 1

Strawberries. Supervised field trials were conducted in France, The Netherlands, the UK and the USA.

In France (Anon., 1997) Curraterr 5 MG (microgranulate) was applied once or twice in 1982 to strawberry plants as a band. Ripe fruits were harvested and analysed by the method of Molhoff. Recoveries from fortified control samples were reported without details (3-hydroxy-carbofuran at 0.1 mg/kg, 90% and 99%, carbofuran at 0.05 mg/kg 36%, 41% and 47%; at 0.5 mg/kg 49%, 46% and 46%). A limit of determination was not adequately established for carbofuran and any results for this analyte are semi-quantitative. The results are shown in Table 54.

Table 54. Residues of carbofuran and 3-hydroxy-carbofuran in or on strawberries from the application of Curraterr 5 MG in France, 1982.

Variety	Application			PHI, days	Residue, mg/kg	
	Stage	Method	Kg ai/ha		Carbofuran[1]	3-OH-CF
Red Gauntlet	Before bloom	Band (0.90 m)	1.0	48	(<0.05)	<0.1
Tago	Before bloom Fruit-bearing plants	Band (0.90 m) Band over 2 rows	1.3 0.89	13	(0.4)	0.50 (0.46, 0.54)
Tago	Fruit-bearing plants	Band (0.90 m)	0.89	13	(0.06)	0.20
Tago	Before bloom Fruit-bearing plants	Band (0.90 m) Band over 2 rows	0.89	13	(0.20)	0.26

			0.89			
Tago	Before bloom. Fruit-bearing plants	Band (0.90 m). Band over 2 rows	0.44 0.89	13	(0.08)	0.37 (0.30; 0.43)
Red Gauntlet	Before bloom.	Band (0.90 m).	2.0	48	(0.06)	0.10

Abbreviated compound names: see Figure 1
[1]Limit of determination was not established. Results are estimates only

In three field trials with post-harvest application of carbofuran to strawberry plants in the UK (Bagnall, 1986) Yaltox 5G was applied to three-year-old plants arranged in matted-bed rows with a Horstine Microband Applicator at 1.5 or 2.0 kg ai/ha. Mature strawberries were harvested the following season. The PHIs ranged from 309 to 316 days. The method of Mollhoff was utilized, but the analytes were derivatized to 2,4-dinitrophenyl ethers (Cook *et al.*, 1977). Limits of detection of 0.05 mg/kg for carbofuran and 0.1 mg/kg for 3-hydroxy-carbofuran were claimed, but no recovery data or chromatograms were supplied. The manufacturer's submission listed recovery information (85% for carbofuran, 74% for 3-hydroxy-carbofuran, fortification level not reported), but not in the field trial report. None of the strawberry samples contained detectable residues of carbofuran or 3-hydroxy-carbofuran.

The Netherlands provided a summary report of a field trial conducted in 1977. Curraterr 5G was applied to strawberry plants 2 weeks after transplanting at rates of 5 or 10 kg ai/ha. Mature fruit were harvested 272 days after treatment and analysed by the method of Molhoff. The results are shown in Table 55.

Table 55. Residues of carbofuran and 3-hydroxy-carbofuran in or on strawberries from the application of Curraterr 5G at 5 or 10 kg ai/ha, 272-day PHI. The Netherlands, 1978.

Application, kg ai/ha	carbofuran + 3-OH-CF, mg/kg	Conjugates of 3-OH-CF, mg/kg
5	0.08; 0.13; 0.11 (0.14 mean)	0.13; 0.15; 0.17 (mean 0.15)
10	0.37; 0.18; <0.1 (0.22 mean)	0.34; 0.19; 0.20 (mean 0.24)

Abbreviated compound names: see Figure 1

Three field trials with the post-harvest application of Furadan 4F to strawberry plants as a foliar spray were reported from the USA (Shevchuk, 1995a). The trials were in New York, Michigan and Virginia at 2.2 kg ai/ha, 12 g/l in New York and Virginia and 19 g/l in Michigan. Strawberries were harvested at maturity the following season and analysed by the method of Barros. The PHIs ranged from 225 days to 270 days. The limits of determination were established by the analysis of fortified controls in triplicate. The following recoveries were reported at 0.05 mg/kg: carbofuran 79 ± 3.0%, 3-keto-carbofuran 87 ± 10%, 3-hydroxy-carbofuran 79 ± 6.0%, 7-phenol 109 ± 5.0%, 3-keto-7-phenol 85 ± 1.0%, and 3-hydroxy-7-phenol 57 ± 3%. No analyte was detected (<0.02 mg/kg) in any sample.

GAP was reported only for the USA, where the soil may be treated post-harvest at 2.2 kg ai/ha with the 4F formulation after 1 October. The use is limited to Oregon, Michigan, Minnesota, Missouri, Tennessee and Washington. The US trials reported complied with this GAP.

Bananas. Supervised field trials were reported from Central America, South America and Spain.

Eight supervised field trials were conducted in the 1985-1986 growing season in Costa Rica, Honduras, Mexico, Ecuador and Guatemala (Leppert, 1986b). Furadan 10G (5G in Mexico) was applied twice at rates of 8.1-11 kg ai/ha, except in Costa Rica where the two applications were at 3.8 kg ai/ha, at intervals of about 6 months. Samples of bananas taken at 10, 30, 60, 90 and 120 days after the second application were analysed by the method of Schreier with an NPD for carbamates and an MSD for phenols. The pulp and peel were analysed separately for carbamates but whole fruit were analysed for phenols. The following recoveries were reported, without supporting data, from replicated samples spiked at 0.05 mg/kg, carbofuran (n = 6) 74 ± 10%, 3-keto-carbofuran (n = 6) 86 ± 21%, 3-hydroxy-carbofuran (n = 6) 86 ± 21%, 7-phenol (n = 5) 79 ± 10%, 3-keto-7-phenol (n = 5) 96 ± 17%, 3-hydroxy-7-phenol (n = 5) 78 ± 12%. The precision was unacceptable at 0.05 mg/kg for 3-keto- and 3-hydroxy-carbofuran, but acceptable accuracy and precision were demonstrated at 0.1 mg/kg: 79 ± 10% (n = 10) and 76 ± 8% (n = 11) respectively.

In all eight trials at all PHIs, the carbofuran and metabolite residues were below the limits of determination (<0.05 mg/kg for carbofuran, and the phenols, <0.1 mg/kg for 3-keto-carbofuran and 3-hydroxy-carbofuran). In the Mexico trial, 3-keto-carbofuran and 3-hydroxy-7-phenol were detected at estimated levels of 0.02 and 0.04 mg/kg respectively. In the Costa Rica trial, each of the phenols was detected at one or more PHIs; the estimated maximum total concentration was 0.04 mg/kg.

Summary results (Sao Paolo University, 1994e) were reported from a 1993 field trial in Brazil that involved single applications of Furadan 350SC to the soil round banana plants at rates of 4.2 and 8.4 g ai/plant. Samples were harvested 90 days after treatment and analysed for carbofuran by the method of Leppert. A limit of determination of 0.1 mg/kg was claimed. No residues were found. No details were provided in the very short summary.

Summary results were provided from a field trial in Spain in 1986 (Anon., 1986a). Curraterr 350SC was applied by irrigation to banana plants at 16 kg ai/ha in 50,000 l water/ha. Mature fruits were harvested 61 days after treatment and analysed for carbofuran and 3-hydroxy-carbofuran by the method of Molhoff. A limit of determination of 0.05 mg/kg was claimed. No residues were detected in either pulp or peel.

GAP was reported only for Spain, where 5G is applied at 0.6-0.75 kg ai/ha and 20F at 5.6 kg ai/ha, both with 60-day PHIs. The trial in Spain was at a much higher application rate, but the data could be used because no residues were detected (<0.02 mg/kg).

Thailand submitted GLP field trial information, but no report on residues (Thai Industrial Standards Institute, 1997).

Sugar cane. Four supervised field trials were conducted in Brazil (Sao Paolo University, 1994c) and in the USA (Shevchuk, 1992).

In Brazil separate plots were treated with 3 or 6 kg ai/ha of Furadan 50G (50 g ai/kg) or 1.75 or 3.5 kg ai/ha of Furadan 350SC (350 g ai/l), applied to the soil on the plant row about 5 months after planting. The cane was harvested 90 days after treatment. Samples were analysed by the method of Leppert. A limit of determination of 0.1 mg/kg was claimed, with a recovery of 86 ± 3% at unspecified fortification concentration(s). All samples contained <0.1 mg/kg.

In the USA, Furadan 4F was applied to sugar cane in six trials in three States. The first application was made in-furrow at planting at 1.1 kg ai/ha, 3.9-5.9 g ai/l. Two additional applications were made as aerial foliar sprays after joint formation at 0.84 kg ai/ha (9.0 g ai/l), a total of 2.8 kg ai/ha. The final application was 30 days before harvest. Samples were analysed by the method of Barros. A limit of determination of 0.03 mg/kg was demonstrated for each analyte by the analysis of 10 fortified controls with the following recoveries: carbofuran 91 ± 7%, 3-hydroxy-carbofuran 85 ± 10%, 3-keto-carbofuran 86 ± 10%, 7-phenol 101 ± 15%, 3-hydroxy-7-phenol 104 ± 16%, and 3-keto-7-phenol 102 ± 14%. The results are shown in Table 56.

Table 56 . Residues of carbofuran and metabolites in or on sugar cane from the application of Furadan 4F at planting (1.1 kg ai/ha) and foliar (2 x 0.84 kg ai/ha), 30-day PHI. USA, 1990-91.

State	Residue, µg/kg					
	Carbofuran	3-K-CF	3-OH-CF	7-Phenol	3-K-7-P	3-OH-7-P
Florida[1]	0.05, 0.05	<0.01, <0.01	<0.01, <0.01	(0.01), (0.01)	<0.01, <0.01	<0.01, <0.01
Florida[1]	0.06, 0.06	<0.01 <0.01	<0.01, <0.01	(0.01), <0.01	<0.01 <0.01	<0.01, <0.01
Florida[1]	0.05, 0.05	<0.01, <0.01	<0.01, <0.01	(0.01), (0.02)	<0.01, <0.01	<0.01, <0.01
Florida[1]	0.04, 0.04	<0.01, <0.01	(0.02), <0.01	(0.02), (0.02)	<0.01, <0.01	<0.01, <0.01
Louisiana[2]	(0.02), (0.02)	<0.01, <0.01	<0.01, <0.01	(0.02), (0.02)	<0.01, <0.01	<0.01, <0.01
Louisiana[2]	0.04, 0.06	<0.01, <0.01	<0.01, <0.01	(0.02), (0.02)	<0.01, <0.01	(0.01), (0.01)
Louisiana[3]	(0.02), (0.02)	<0.01, <0.01	<0.01, <0.01	(0.02), (0.02)	<0.01, <0.01	<0.01 <0.01
Louisiana[3]	(0.01), (0.02)	<0.01, <0.01	<0.01, <0.01	<0.01, <0.01	<0.01, <0.01	(0.01), (0.01)
Texas[4]	<0.01, <0.01	<0.01, <0.01	<0.01 ,<0.01	<0.01, <0.01	<0.01, <0.01	<0.01, <0.01
Texas[4]	<0.01, <0.01	<0.01, <0.01	<0.01, <0.01	<0.01, <0.01	<0.01, <0.01	(0.01), <0.01

Abbreviated compound names: see Figure 1
[1]Four trials at same location [2]Two trials at same location [3]Two trials at same location [4]Two trials at separate locations

GAP for sugar cane in Brazil specifies 1.4-1.75 kg ai/ha (100-300 l/ha) of the 350 SC formulation applied in furrow with a planting stick or in bands or 1.5-3 kg/ha of the G formulation at 1.5-3 kg ai/ha applied in bands about the plants at second harvest. In US GAP for the 4F formulation no more than 2 foliar applications of 0.84 kg ai/ha each are made, with the use limited to the mainland, with a 17-day PHI. The 10G formulation may also be applied early in the season at 4.5 kg ai/ha with soil incorporation. None of the US trials complied with GAP, as an additional at-plant application was made at 1.1 kg ai/ha, but the residues were generally at or below the LOD.

Animal transfer studies

In a poultry feeding study in the USA in 1968 (Cook, 1968) three groups of 30 laying pullets were subdivided into three groups of 10 hens each for dosing or feeding at levels equivalent to 0.05, 0.5 or 5.0 ppm in the diet. The first group was fed carbofuran, the second group 3-hydroxy-carbofuran and the third alfalfa that had been treated with carbofuran. The dosing period was 10 consecutive weeks, during which eggs were collected periodically for analysis. At the end of the period, the pullets were killed and tissues taken for analysis. The period of frozen storage before extraction and analysis was not disclosed.

Eggs without shell, muscle, gizzard and liver were extracted with acetone. The extract was concentrated, hydrolysed with 0.25 N HCl and extracted with methylene chloride. The solvent was evaporated and the residue dissolved in acetonitrile and partitioned with hexane. The acetonitrile was evaporated and the residue dissolved in methylene chloride and cleaned up with Nuchar-Attaclay and silica gel. The final extract was analysed by GLC on a packed column with a microcoulometric nitrogen detector.

Fortified control samples were analysed to demonstrate the limits of determination, but the results are not acceptable because extensive corrections were made for column efficiency, typically 60%. The results of dosing with carbofuran and 3-hydroxy-carbofuran at 5 ppm are shown in Table 57. Residues were detected only in the gizzards of hens dosed with carbofuran and were below the LOD.

Table 57. Residues in poultry tissues and eggs from the oral dosing of hens with carbofuran or 3-hydroxy-carbofuran at the equivalent 5 ppm in the diet for 70 consecutive days and the recovery of analytes from control samples fortified at 0.05 mg/kg.

Sample	Compound	Analytical recovery, %[1]	carbofuran, mg/kg	3-hydroxy-carbofuran, mg/kg
Egg	carbofuran	51 58 58	<0.05 (14 and 56 days)	<0.05
	3-hydroxy-carbofuran	38 35 33	<0.05 (14 and 56 days)	<0.05
Muscle	carbofuran	63	<0.05	<0.05
	3-hydroxy-carbofuran	52	<0.05	<0.05
Liver	carbofuran	46	<0.05	<0.05
	3-hydroxy-carbofuran	55	<0.05	<0.05

Sample	Compound	Analytical recovery, %[1]	carbofuran, mg/kg	3-hydroxy-carbofuran, mg/kg
Gizzard	carbofuran	64	<0.05 (0.01)	<0.05 (0.01)
	3-hydroxy-carbofuran	60	<0.05	<0.05

[1]Column efficiency corrections (81% for carbofuran, 59% for 3-hydroxy-carbofuran in eggs) were removed

In a feeding study in the USA with cows in 1994 (Chen, 1995a) carbosulfan (not carbofuran) was fed to lactating dairy cattle for 28 consecutive days at rates equivalent to 1, 3, 10 and 50 mg/kg in the diet. The study is fully described in the monograph on carbosulfan. In summary, carbofuran was not found in any milk, skim milk, cream or tissue samples at any of the 4 feeding concentrations, where the limit of detection was estimated as 0.005 mg/kg for milk and 0.010 mg/kg for tissues and cream. The metabolite 3-keto-carbofuran was detected only in one liver sample at 0.023 mg/kg from the 50 ppm group, and 3-hydroxy-carbofuran was detected in most milk samples from the 50 ppm group, at 0.007-0.030 mg/kg, and in one from the 10 ppm group (day 4, 0.007 mg/kg). Total carbamate residues reached a plateau at about 0.03 mg/kg from days 1 to 21. At the 50 ppm feeding level 3-hydroxy-carbofuran was detected in the kidneys (0.090, 0.13 mg/kg), liver (0.047, 0.060 mg/kg) and muscle (0.020, 0.030 mg/kg), but not in fat. In the 10 ppm group the 7-phenol (0.057 mg/kg) and 3-hydroxy-7-phenol (0.012 mg/kg) were found in the kidneys.

FATE OF RESIDUES IN STORAGE AND PROCESSING

In storage

No data were submitted.

In processing

Sorghum. A processing study on sorghum was reported from the USA (Shevchuk and Singer, 1994). In Texas and Kansas, Furadan 4F was applied in-furrow at planting at 3.6 kg ai/ha and as two broadcast foliar sprays at 2.8 kg ai/ha. The total seasonal application of 9.2 kg ai/ha was four times the GAP limit. The PHI was 63 days in Texas and 87 days in Kansas. Grain samples from both locations were analysed by the method of Barros. The Texas grain sample contained no detectable residue of carbofuran (<0.01 mg/kg). Both 3-hydroxy-carbofuran and the 3-hydroxy-7-phenol were detected at about 0.01 mg/kg. No residues were detected in two of three Kansas grain samples; the 3-hydroxy-7-phenol was detected at about 0.01 mg/kg in one sample. Only the Texas grain was processed.

The grain was dried and cleaned by aspiration and screening, then abrasively milled thereby removing the bran and generating decorticated seeds and grits. Eighteen kg of raw grain yielded 17.1 kg dried grain and 16.8 kg cleaned seed, of which 6.8 kg was dry-milled to 4.2 kg decorticated grain, 1.1 kg bran and 1.3 kg grits. Limits of determination of 0.03 mg/kg were established for carbofuran and each metabolite by the analysis of fortified control samples of grain, decorticated seed, grits and bran. The minimum recovery was 65% of 0.03 mg/kg 7-phenol from grain and the maximum 109% of 0.03 mg/kg 3-hydroxy-carbofuran from bran. No residues were detected (<0.01 mg/kg) in decorticated seed or grits. The 7-phenol and 3-hydroxy-7-phenol were found in bran at estimated concentrations of 0.02 mg/kg each. CLICK HERE to continue