Protectants for Stored Rough Rice: Gardona, Dichlorvos, and a Gardona-Dichlorvos Mixture[1,2]

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ABSTRACT

Gardona® (2-chloro-1-(2,4,5-trichlorophenyl)vinyl dimethyl phosphate), dichlorvos, and a Gardona:dichlorvos (2:1) mixture were evaluated as bulk treatments in small-bin tests for controlling or preventing stored-product-insect infestations in stored rough rice. Gardona at 15 and 20 ppm, dichlorvos at 7.5 and 10 ppm, and the combination at 20:10 ppm eliminated pretreatment infestations, greatly reduced reinfestation for 3, 1, and 9 months, respectively, and did not affect germination of the rice. Gardona was highly toxic to rice weevils, *Sitophilus oryzae* (L.), for 6 months, and to lesser grain borers, *Rhyzopertha dominica* (F.), and confused flour beetles, *Tribolium confusum* Jacquelin duVal, for 1 month. The 20:10-ppm combination was highly toxic to rice weevils for 12 months, to lesser grain borers for 1 month, and to confused flour beetles for 3 months.

Gardona residues in rough rice persisted longer at the higher dosage and when applied in combination with dichlorvos. Gardona residues after 180 days with the 20:10-ppm combination were 5.5 ppm on rough rice, 7.6 ppm on rice bran, 13.8 ppm on rice hulls, and 0.18 ppm on milled rice. Dichlorvos residues dissipated rapidly on all milling fractions.

Dichlorvos applied as a bulk treatment is effective for disinfesting some stored grains (Green and Tyler 1966, Kirkpatrick et al. 1968, LaHue 1970) including rough rice (McGaughey 1970). Although some residual effectiveness has been noted on rice, persistence is greatly reduced by a high moisture content in the rice, and dichlorvos does not appear effective against major stored-rice insects beyond about 30 days (McGaughey 1970). In stored-product-insect control, Gardona® (2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate) is effective for certain mothproofing applications and as a protectant for cush-

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[2] Mention of a proprietary product does not imply endorsement by the USDA.

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ioning material (Bry et al. 1969, 1971); it is effective also as a contact insecticide against flour beetles, *Tribolium* spp. and larvae of several species of *Trogoderma* (Strong 1970a, b).

These indications of residual activity of Gardona have prompted its evaluation as a rough rice protectant. Results of small-bin tests with Gardona, dichlorvos, and a combination of the 2 materials (2 parts Gardona:1 part dichlorvos) are reported here.

METHODS AND MATERIALS.—Infested 'Bluebelle' rough rice with a moisture content of 12.9% was treated in 40.8-kg batches in a cement mixer by using a modification of the sprayer described by Hills and Taylor (1950). Emulsifiable concentrates containing 240 g/liter dichlorvos or Gardona, and 120:60 g/liter Gardona:dichlorvos were diluted in water and applied at the rate of 40 ml/40.8 kg of rice. Dosages of 15 and 20 ppm Gardona, 7.5 and 10 ppm dichlorvos, and 15:7.5 and 20:10 ppm of the Gardona:dichlorvos combination were used. Owing to an error in application, however, the 15:7.5 ppm treatment did not produce the intended deposit, and all biological data from that treatment are omitted. The treated lots (40.8 kg) of rice were held in foil-lined cardboard bins in an infested warehouse at 25°C and 60% RH.

Effectiveness of the treatments was periodically determined by sampling the bins of rice. At each sampling 1000 g of rice from each bin were sifted to determine live infestation; individual 150-g samples from each treatment were deliberately infested with 50 confused flour beetles, *Tribolium confusum* Jacquelin duVal; 50 rice weevils, *Sitophilus oryzae* (L.); and 50 lesser grain borers, *Rhyzopertha dominica* (F.), to determine the toxicity of the insecticide deposits; 500 g from each treatment were incubated for 49 days to determine the extent of internal infestation; and samples were processed for determination of residues on rough rice and the milling fractions. The milling fractions were prepared by shelling and milling treated rough rice. Residue analyses by GLC were performed by Shell Development Co., Modesto, Calif. Minimal detectable amounts were 0.03 ppm for Gardona and dichlorvos. In addition, the effect of the treatments on germination of the rice was evaluated 90 days after treatment by using the official method for testing rice seed (Anonymous 1952).

Table 1.—Mortality of adult insects exposed for 21 days in separate 150-g subsamples of treated rice.[a]

Interval after treatment	Dichlorvos		Gardona		Gardona: dichlorvos
	7.5 ppm	10 ppm	15 ppm	20 ppm	20:10 ppm
	Rice weevil				
1 day	100	100	100	100	100
1 month	0	0	100	100	100
3 months	0	0	100	100	100
6 months	2	0	100	100	100
9 months	4	6	97	98	100
12 months	0	0	87	96	100
	Lesser grain borer				
1 day	100	100	100	100	100
1 month	0	0	96	100	100
3 months	0	0	77	80	91
6 months	1	5	80	90	85
9 months	0	0	64	91	85
12 months	53	15	40	70	90
	Confused flour beetle				
1 day	3	14	100	100	100
1 month	0	2	99	100	100
3 months	0	0	88	90	97
6 months	5	10	46	68	80
9 months	0	3	35	61	80
12 months	2	1	22	21	52

[a] Mortality percentages are corrected for mortality occurring in subsamples from untreated bins and are averages of 3 replications.

Table 2.—Percent control of bin infestation (rice weevils, lesser grain borers, confused flour beetles, and flat grain beetles).[a]

Interval after treatment	Dichlorvos		Gardona		Gardona: dichlorvos
	7.5 ppm	10 ppm	15 ppm	20 ppm	20:10 ppm
	Bin infestation				
1 day	100	100	100	48	100
1 month	98	98	85	80	100
3 months	69	58	96	98	88
6 months	0	0	93	93	100
9 months	29	7	67	79	100
12 months	0	0	0	7	87
	Bin progeny				
1 day	100	100	100	100	100
1 month	86	100	100	100	100
3 months	83	63	90	97	100
6 months	66	59	91	98	100
9 months	33	25	35	71	100
12 months	0	0	0	28	96

[a] Samples of 1000 g were sifted to determine bin infestation, and samples of 500 g were incubated 49 days to determine progeny. Values are averages of 3 replications. Percent control is percent reduction from the numbers found in samples from untreated bins.

RESULTS AND DISCUSSION.—Table 1 presents the toxicity of the chemical deposits on rice samples removed from the bins at intervals after treatment. The 7.5- and 10-ppm dichlorvos treatments were effective only against rice weevils and lesser grain borers, and only at the 1-day sampling time. An earlier study indicated that dichlorvos deposits applied to rice of this moisture content (12.9%) would be ineffective against rice weevils at subsequent intervals (McGaughey 1970).

Gardona at 15 and 20 ppm produced 100% mortality of rice weevils for 6 months, and of lesser grain borers and confused flour beetles for 1 month at the higher dosage (Table 1). The combination of Gardona and dichlorvos at 20:10 ppm was 100% effective for 12, 1, and 1 months against rice weevils, lesser grain borers, and confused flour beetles, respectively. Progeny did not develop in any of the samples in which adult mortality was 100%.

When samples of 1000 g were sifted and examined at each sampling interval to determine bin infestation, and 500-g samples were incubated 49 days and then examined for emergence of progeny, the infestations consisted of rice weevils; lesser grain borers; confused flour beetles; and flat grain beetles, *Cryptolestes pusillus* (Schönherr). Values presented in Table 2 are percent reduction of all species as com-

Table 3.—Residues of dichlorvos and Gardona on rough rice (ppm).

Days after treatment	Dichlorvos		Gardona		15:7.5 ppm[a]		20:10 ppm	
	7.5 ppm	10 ppm	15 ppm	20 ppm	Gardona	Dichlorvos	Gardona	Dichlorvos
1			11.0	18.0	6.2		21.0	
7	0.75	0.90				0.37		1.1
30	.43	.58	6.3	9.3	3.8	.28	11.0	0.63
90	.07	.16	3.6	4.2	2.2	.03	8.8	.11
180	< .03	.03	1.8	3.4	1.0	< .03	5.5	.04

[a] Values for the 15:7.5-ppm treatment are low owing to an error in application.

pared with numbers in samples from highly infested bins.

With the exception of the 20-ppm Gardona dosage, all treatments eliminated infestation present at the time of treatment. Elimination of internal infestation is reflected by the progeny data from samples held 49 days after sampling. Adult infestation was observed, and progeny developed in dichlorvos-treated rice at 1 and 3 months, in Gardona-treated rice at about 3 months, and in rice with the combination treatment at 12 months. Although some variation was noted between the times of adult infestation and progeny development, progeny usually appeared within the next sampling interval after the appearance of adult infestation. The presence of live adults in the 20-ppm Gardona treatment at the 1-day and 1-month intervals and the fact that progeny did not develop in that treatment for about 3 months indicate that Gardona may be slow acting. However, reproduction was prevented by this Gardona treatment for 1 month.

Tables 3 and 4 present the residues on rough rice from the dichlorvos and Gardona treatments and residues on each milling fraction from the combination treatments. Although the error in application of the 15:7.5-ppm combination treatment caused the residues to be lower than had been expected, the residue data are presented here to show the degradation trend.

On the basis of the 20:10-ppm combination treatment, the presence of dichlorvos seems to slightly retard the degradation of Gardona. This sort of degradation was reported (Rowlands 1970) for malathion when it was combined with dichlorvos. Between 1 and 180 days residues in rough rice treated only with Gardona had dissipated by about 82%. With the combination at 20:10 ppm, Gardona residues decreased only about 74% between 1 and 180 days. The data indicate also that with higher dosages of Gardona alone the rate of residue degradation is slowed, suggesting that the rate may depend upon total dosage rather than on interaction between the 2 chemicals. Gardona residues in rice hulls from the 20:10 ppm application had dissipated by about 75% between 1 and 180 days, although levels were generally quite high. Levels in bran remained about the same, and in milled rice had increased slightly after 180 days. Dichlorvos residues dissipated rapidly in rough rice and all milling fractions.

Germination 90 days after treatment was unaffected by the dosages used. Replicated tests from all treatments and the controls revealed that germination varied only between 84.3% and 86.0%.

In general, all treatments disinfested rough rice and did not affect germination. Toxicity tests indicated that Gardona alone had less residual effectiveness than the combination of Gardona and dichlorvos. Although the combination did not cause 100% mortality of lesser grain borers and confused flour beetles for more than 1 month (Table 1), it did protect against bin infestation by all species for 9 months (Table 2). Gardona residues were generally high on the hull and bran milling fractions after 180 days. Residues of Gardona on rough rice persisted longer at higher dosages and when Gardona was combined with dichlorvos.

These chemicals have not yet been approved for use on rice in the manner tested.

Table 4.—Residues of dichlorvos and Gardona on milling fractions of rough rice treated with the combination spray (ppm).

Days after treatment	15:7.5 ppm[a]		20:10 ppm	
	Gardona	Dichlorvos	Gardona	Dichlorvos
	Rice bran			
1	4.2		8.6	
7		0.09		0.20
30	1.9	.12	6.4	.31
90	4.1	<.03	12.0	.05
180	2.2	<.03	7.6	<.03
	Rice hulls			
1	17.0		54.0	
7		2.80		29.00
30	18.0	2.20	65.0	7.00
90	5.5	.13	39.0	.36
180	3.8	.04	13.8	.09
	Milled rice			
1	0.03		0.08	
7		<.03		<.03
30	.05	<.03	.09	<.03
90	.05	<.03	.13	<.03
180	.05	<.03	.18	<.03

[a] Values for the 15:7.5-ppm treatment are low owing to an error in application.

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