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Dichlorvos Vapor for Insect Control in a Rice Mill[1]

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ABSTRACT

An average dose of 63.5 g/1000 m³ dispensed over 6 h once a week for 2 weeks in each of 7 rooms of a rice mill produced average concentrations of 4.52 to 6.26 μg of dichlorvos/liter of air. This concentration caused higher mortalities among caged test insects than a routine pyrethrins fog: 3–4.5 times higher among adult cigarette beetles, *Lasioderma serricorne* (F.); 48–92 times higher among adult red flour beetles, *Tribolium castaneum* (Herbst); 3–5.5 times higher among adult lesser grain borers, *Rhyzopertha dominica* (F.); and 5–7 times higher among larvae of the almond moth, *Cadra cautella* (Walker). The dichlorvos treatments caused a decrease in the insect population of the mill to ¼ the pretreatment level.

Residues on bagging materials exposed to as many as 13 successive daily treatments (by moving the materials from room to room) were relatively low on cotton (≤531.8 μg/dm²) and paper (≤669.5 μg/dm²), but high on burlap (as much as 3752.4 μg/dm²). Bulk products exposed similarly had residues as follows: 4.48 ppm on rough rice, 1.29 ppm on brown rice, 1.18 ppm on milled rice, and 8.26 ppm on bran. Milled rice and bran exposed in burlap bags had only ½ as much residue, milled rice exposed in cotton bags had about the same amount, and milled rice exposed in paper bags had about ⅓ as much residue. Spillage and sweepings exposed to single treatments had residues as follows: 0.67 ppm on rough rice, 0.56 ppm on brown rice, 0.72 ppm on hulls, 1.00 ppm on broken milled rice, and 7.12 ppm on bran.

Dichlorvos vapors evolved from aerosol or oil mist droplets effectively controlled the tobacco moth, *Ephestia elutella* (Hübner), in tobacco warehouses (Press and Childs 1966) and in food warehouses (Green et al. 1968), and the cigarette beetle, *Lasioderma serricorne* (F.), in tobacco warehouses (Childs 1967a,b, Childs et al. 1966; Tenhet et al. 1957, 1958). Gillenwater and Harein (1964) described a dispenser that would produce large quantities of dichlorvos vapors, and Harin et al. (1970) tested the dispenser and reported a method of estimating the concentration of dichlorvos in air. Subsequently, Gillenwater et al. (1971) exposed several packaged commodities to vapor evolved from the dispenser and found that concentrations of 6.4 μg/liter left only trace residues on rice. In addition, in later tests (Harein et al. 1971), the use of concentrations of 3–4 μg/liter (dispensed in 4–6 h) once a week protected against cross infestation of bagged flour for 5 months.

Pyrethrins are presently used to control insects in rice mills. However, at least 1 important species has developed resistance to this insecticide (Speirs and Zettler 1969). Since dichlorvos vapors are approved for use in food warehouses containing packaged commodities (Anonymous 1971), tests were made to evaluate the use of dichlorvos vapors in suppressing insect populations in a rice mill.

METHODS AND MATERIALS.—The rice mill used for the tests had 7 contiguous rooms ranging in size from 1351 to 5638 m³. The total space in the mill, including that occupied by equipment, was 18,961 m³. The dispenser described by Gillenwater and Harein (1964) was used to treat each room 1 night during each of the 2 wk of the test (May 11–24, 1971). A single batch (13.6 kg) of polyvinyl chloride (PVC) pellets containing 20% dichlorvos was used for all 14 treatments. Before each use the pellets were weighed and the average theoretical dose was determined to be 63.5 g/1000 m³ (average room size 2709 m³) dispensed over a 6-h period.

Since pretreatment preparation of the mill would not be practical in ordinary use, every effort was made to handle the treatments as they would be used during normal operation of the mill. Thus the mill was not sealed (fire doors and windows were closed but not sealed), and adjustments were not made in the operation of the dispenser to compensate for varying room size. For example, the connecting passages (as large as 1×3 m) from some rooms through which conveyors and drive mechanisms passed were not closed. Also, treatments were begun when milling stopped at 1700 h. The fire doors and windows then remained closed until 0600 h the next day.

On some occasions, the air concentration of dichlorvos was monitored by drawing air samples (113.28 liters) through 0.008 N NaOH as described by Harein et al. (1970) at 2-h intervals during treatment, at 6 h (just after treatment), and at 12 h (just before the room was opened). The NaOH was then analyzed for total phosphate.[3]

The biological effects of the treatments were measured by exposing adult red flour beetles, *Tribolium castaneum* (Herbst) (50/cage); adult lesser grain borers, *Rhyzopertha dominica* (F.) (50/cage); adult cigarette beetles (25/cage); and larvae of the almond moth, *Cadra cautella* (Walker) (10/cage), in 30-mesh screen cages. The caged insects were placed in the treatment area just before the dispenser was started and left there through the 6 h treatment and for an additional 6 h (until the rooms were opened). These cages were placed in both open locations (on the floor and on machinery in areas with unobstructed air circulation) and concealed locations (inside machinery, hoppers, conveyors, and spouts that were partially or completely enclosed). Mortality counts were made 6 h after the insects were removed and 7 days later. Surviving insects were held in a standard growth medium for reproduction.

The effects of the treatments on insects resident in the mill were monitored by exposing individual food traps for 7 days each from March 23 through June 22 (for 7 wk before the test, for the 2 wk of the test, and for 5 wk after the test). The traps were 12×12×2.3-cm

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[3] Savannah method Pr 2e-61, adapted from Chemical Method No. 7, U.S. Public Health Service, DHEW, Savannah, GA.

Table 1.—Concentrations (μg/liter) of dichlorvos vapor at intervals during and after 6-h treatment with an average dose of 172 g/room.[a]

Room	Treatment	Room size (m^3)	Concentration (μg/liter) at indicated sampling interval (h)				
			0	2	4	6	12
1	1, 8	1651					
2	2, 9	1351	0.04	1.77	2.18	1.67	0.09
3	3, 10	1351	.02	4.24	6.29	6.03	.24
4	4, 11	5638	.07	1.93	3.97	3.99	.85
5	5, 12	2487	.03	8.67	15.54	8.18	2.06
6	6, 13	1351		8.10	7.21	6.00	1.52
7	7, 14	5132	.13	2.40	2.38	1.72	.20
Average		2709	.06	4.52	6.26	4.60	.82

[a] The mill rooms were treated in sequence (1–7) and retreated in sequence (8–14). The concentrations reported are from the 1st treatment except in the case of Room 2; those concentrations are for the 2nd treatment. A malfunction in the sampling device rendered values for Treatment 1 invalid.

plastic weigh boats containing 200 cc of a flour and cornmeal mixture. Each week when they were replaced, the exposed traps were returned to the laboratory and the contents were examined for insects and then held and observed for 56 days for the emergence of progeny.

Residues of dichlorvos on the rice products were monitored by exposing open-top cylindrical cartons (10.5 cm diam and 9 cm high) filled with rough, brown, or milled rice or with rice bran. Sufficient cartons were prepared to provide replicates of all 4 commodities that could be exposed to single or multiple (7 or 13) treatments. The multiple exposures were arranged by moving the cartons to the room where the treatment was applied each night. (The contents of each carton were blended after exposure to form a homogenous sample.) Also, burlap bags of milled rice and rice bran, and cotton and multiwall paper bags of milled rice were similarly exposed to single and multiple treatments and sampled as were squares (2.32 dm^2) of paper, burlap, and cotton bagging. Finally, samples of rice products were drawn from conveyors, hoppers, bags, and piles of sweepings before and after each treatment to determine the extent of contamination of naturally exposed products. All these samples were taken when the mill rooms were opened and were frozen within 6 h except that samples exposed to multiple treatments were held in the mill between exposures. GLC analysis was used with all samples.[4]

The mill used for the test was normally treated with a pyrethrins fog twice a week. These treatments were suspended during the test. Therefore, when fogging was resumed, caged insects similar to those used in the test with dichlorvos vapor were placed in locations with unobstructed air circulation and exposed to a fog that contained 0.375% (wt/wt) pyrethrins + 1.875% piperonyl butoxide + 97.75% deodorized kerosene. A pneumatic fogger was used to dispense 22.7 liters throughout the 18,961 m^3 of building space.

RESULTS.—Table 1 presents the concentrations of dichlorvos measured in each room of the mill during 1 of the treatments in that room. However, a malfunction occurred in 1 sampling device that was not detected until the end of the test. Therefore, valid measurements were obtained only for 6 rooms. The considerable variation noted between concentrations in rooms at comparable intervals may be the result of variation in room size and tightness. However, the average con-

[4] Dichlorvos was extracted from the product samples with a 9:1 chloroform-methanol solution and subjected to GLC analysis by using a flame photometric detector. The limit of detectability was 0.02 ppm.

Table 2.—Results of exposing 4 species of insects in 30-mesh cages to dichlorvos vapors or to pyrethrins fog[a] in open (O)[b] or concealed (C)[c] sites.

Insect	Initial % knockdown after exposure to			% mortality at 7 days after exposure to			% reduction in progeny after exposure to Dichlorvos vapors in	
	Dichlorvos vapors in		Pyrethrins fog in	Dichlorvos vapors in		Pyrethrins fog in		
	O	C	O	O	C	O	O	C
Cigarette beetle adults	92	56	20	95	74	33	53	54
Red flour beetle adults	92	48	1	90	48	1	83	40
Lesser grain borer adults	72	41	13	67	40	6	60	30
Almond moth larvae	56	40	8	50	27	4		

[a] Dichlorvos was applied at an average rate of 172 g/room (Table 1); pyrethrins fog was applied at a rate of 22.7 liters of 0.375% (wt/wt) pyrethrins+1.875% piperonyl butoxide+97.75% deodorized kerosene/18,961 m^3 of building space.

[b] Four cages of each insect were placed on the floor or on machinery in areas with unobstructed air circulation for each of the 14 applications of dichlorvos vapors (Table 1). Values are averages of the 56 cages; 29 cages of each insect were placed in similar locations throughout the 7 mill rooms prior to treatment of the entire mill with pyrethrins fog. Values are averages of the 29 cages.

[c] Cages of each insect were placed inside closed and partially closed hoppers, conveyors, spouts, and other machinery for 10 of the 14 applications of dichlorvos vapors (Table 1). Values are averages of a total of 40 cages exposed.

Table 3.—Total insects collected from food traps exposed for 7 days before, during, and after treatment of a rice mill with 2 applications of dichlorvos vapor (7 days apart).[a]

Trap week	No. collected			No. progeny[b]		
	CB	RFB	AM	CB	RFB	AM
March 23	4	9	0	0	7	0
March 30	0	8	1	0	47	27
April 6	0	10	0	0	22	2
April 13	1	15	0	0	35	28
April 20	0	14	0	57	182	2
April 27	1	58	0	1	493	4
May 4	1	46	0	33	1062	19
May 11	0	22	0	0	140	2
May 18	0	11	0	6	315	0
May 25	0	16	0	20	327	4
June 1	0	17	0	0	545	3
June 8	4	35	0	10	866	22
June 15	0	29	0	2	441	48
June 22	2	22	0	53	826	19

[a] One of the 7 mill rooms was treated each day of the week beginning May 11 and again the week beginning May 18. CB, cigarette beetle; RFB, red flour beetle; AM, almond moth.
Adult emergence from the food traps after 56 days.

centration for all rooms was above the effective range of 3–4 μg/liter of air for 4–6 h suggested by Harein et al. (1971) even though operation of the dispenser was not adjusted to compensate for these differences.

Table 2 reports the effects of the experimental dichlorvos vapors and the routine pyrethrins fog on the caged test insects. The much greater effectiveness of the vapors may have resulted partly because the dichlorvos vapors penetrated the 30-mesh cages more readily than did the pyrethrins fog.

Table 3 indicates the effects of the dichlorvos treatments on the resident insect population in the mill. The insect populations were increasing until the treatment with dichlorvos. Then they dropped. Even 5 wk after the treatment they had not climbed to the pretreatment level though a gradual increase had occurred. Possibly, continued treatments with dichlorvos would have lowered the population enough to prevent cross infestation of rice products during processing such as Harein et al. (1971) observed with bagged flour in storage.

Table 4 reports the residues of dichlorvos in rice products in open-top cartons. Since the size of the rooms and therefore the concentrations of dichlorvos varied, the rooms are identified in the table (see Table 1 for data). These differences were significant. For example, in Room 4, which was 4 times as large as Room 3, the resulting concentration was ca. ½ as high and the residues were much lower: 34% those in Room 3 on milled rice, 88% on brown rice, 51% on rough rice, and 70% on bran.

Exposure to 7 or 13 successive treatments produced considerably higher residues than exposure to single treatments. However, with 2 exceptions, even the single exposures resulted in residues in excess of 0.5 ppm. The treatment would therefore have to be applied with hoppers and bins closed or the equipment would have to be altered so as to expose only small quantities of commodities and not cause excessive residues in the total product. With normal operations, little but waste or spilled bulk products overlooked in cleaning

Table 4.—Residues on rice products held in open cartons (10.5 cm diam and 9 cm high) exposed to dichlorvos vapors in a rice mill.[a]

Exposed to treatment no.[b]	Average residue (ppm)
Rough rice	
3	1.17
4	0.60
1–7	2.94
1–13	4.48
Brown rice	
3	.52
4	.46
1–7	1.10
1–13	1.29
Milled rice	
3	.68
4	.23
1–7	.76
1–13	1.18
Rice bran	
3	2.59
4	1.82
1–7	8.26
1–13	7.26

[a] Average dose was 172 g/room dispensed over 6-h periods. Commodities were moved from room to room for exposure to multiple treatments.
[b] Single samples for all single exposures; 2 samples for all multiple exposures. Sequence, size of room, and concentrations of dichlorvos are shown in Table 1.

would be apt to remain in the mill long enough to receive more than 1 treatment, and such multiple exposure of overlooked waste or spillage might prove beneficial. (Deliberate toleration of dust and debris, whatever the possible benefits, is not advocated.) This debris was not assayed for insect toxicity, but residues could build up to levels that would be toxic to insects that breed in mill dust and debris.

Table 5.—Residues on bagged rice products exposed to dichlorvos vapor in a rice mill.[a]

Exposed to treatment no.[b]	Residues (ppm) on			
	Rice bran in 45.4-kg burlap bag	Milled rice in ...		
		45.4-kg burlap bag	11.3-kg cotton bag	11.3-kg paper bag
1	0.14			
3			0.46	0.13
4		0.12	.32	.16
1–7	2.51	.34[c]	.58	.34
4–13		.44		
1–13	4.27	.50	1.11	.36

[a] Average dose was 172 g/room dispensed over 6-h periods. Multiple exposures were arranged by moving the commodities from room to room. Values are averages for 2 samples except as indicated. Composite samples were taken from each bag.
[b] Sequence, size of room, and concentrations of dichlorvos are shown in Table 1.
[c] Two samples were exposed to treatments 1–7 and 2 to treatments 4–10; therefore, this value is an average for 4 samples.

Table 6.—Residues on bagging materials exposed to dichlorvos vapor in a rice mill.[a]

Exposed to treatments[b]	Average residue ($\mu g/dm^2$) on ...		
	Paper	Cotton	Burlap
1	136.7	3.2	317.5
3	669.5	531.8	1616.8
4	88.3	50.6	245.4
1–7	398.3	58.1	2564.0
1–13	622.2	101.2	3752.4

[a] Average dose was 172 g/room dispensed over 6 h. Multiple exposures were arranged by moving the materials from room to room.
[b] Sequence, size of room, and concentrations of dichlorvos are shown in Table 1. 2 samples were analyzed for all except the single exposures to Treatment 1.

Table 5 reports the residues of dichlorvos in milled rice and rice bran contained in bags exposed to the single and multiple treatments, again with reference to the room treated. Residues in milled rice were low though they were slightly higher in the 11.3-kg cotton bags than in the 11.3-kg paper bags (lowest) or the 45.4-kg burlap bags. The highest residue was 1.11 ppm in cotton bags exposed to 13 successive treatments. All other residues were ½ or less than this amount. Therefore, the residues on milled rice in paper and burlap bags, even with 13 exposures, were less than the established tolerance of 0.5 ppm. However, similar exposure of rice bran in burlap bags and of milled rice in cotton bags did result in high levels. Care would therefore need to be exercised to avoid daily exposure of burlap bags of bran and cotton bags of milled rice. As with products exposed in open-top cartons (Table 4), room size and concentration had a direct bearing on residues resulting from single exposures except that residues in paper bags were low ($\leq$0.16 ppm) under all conditions.

Table 6 reports the residues of dichlorvos on bagging materials. Deposits were high and appeared to be related to concentration. On paper, the deposit resulting from a single exposure in the largest room was 88.3 $\mu g/dm^2$ compared with 669.5 $\mu g/dm^2$ resulting from a similar exposure in 1 of the smallest rooms, but deposits resulting from 7 or 13 exposures fell within this same range. A similar anomaly occurred with cotton. (Deposits on burlap were as anticipated with a wide range for single exposures in rooms of different sizes, but progressively higher deposits with more exposures.) Possibly cotton and paper did not retain the deposits from previous exposures long enough to permit accumulation. If so, those reported on these materials after multiple exposures are primarily the result of the final exposure. Then the relatively low concentrations in Room 7 (Table 1) may account for the low residues on cotton and paper that received a final exposure in that room. The high residues on burlap in contrast to those on cotton indicates that the burlap absorbs dichlorvos and thus prevents its penetration into the commodity. Also, residues on milled rice in burlap bags were lower than in cotton bags (Table 5).

Table 7 summarizes the net residues of dichlorvos (difference before and after individual treatments) in commodities present in the mill in normal operation as a result of the experimental treatment with dichlorvos. Except for milled rice, all commodities not enclosed in bags or held in closed hoppers had residues

Table 7.—Summary of residues on rice products exposed to dichlorvos vapors in a rice mill.[a]

Commodity[b]	No. samples	Residue (ppm)	
		Average	Range
Rough rice from closed bin	2	0.18	<0.02–.37
Rough rice spillage	1	.67	
Brown rice from open hoppers	4	.56	.16–1.34
Milled rice from closed bins	1	<.02	
Milled rice from open belts	3	.10	<.02–.38
Rice hulls from floor	1	.72	
Broken milled rice from burlap bags	1	.22	
Broken milled rice from loosely tarped (6-mil polyethylene) burlap bags	1	<.02	
Broken milled rice from open hoppers	6	1.00	.02–3.50
Rice bran from burlap bags	5	.44	<.02–1.16
Rice bran from open hoppers and spillage	6	7.12	3.25–12.09

[a] Average dose was 172 g/room (2709 m^3) dispensed over 6 h periods at daily intervals.
[b] Samples from bags were taken with a bag trier. All other samples were taken to a 2.5-cm depth in the commodity with a hand scoop.

in excess of 0.5 ppm. Levels in rice bran were particularly high. Check samples taken in each room before the 1st treatment had residues of <0.02 ppm. However, 3 of the check samples taken before the 2nd treatment had residues of >0.02 ppm. One of these, a sample of spilled rice bran taken before treatment 12, the 2nd treatment in Room 5, contained 0.32 ppm. (This particular spillage had remained undisturbed during the 7 days following the 1st treatment, though some additional spillage had taken place.) Another of these, a sample of spilled rice bran taken before Treatment 9 (2nd treatment in Room 2) contained 0.048 ppm, and the last, a sample of rough rice from an open hopper taken before Treatment 13 (2nd treatment in Room 6), contained 0.073 ppm. These 2 latter samples were not taken from commodities that had remained in the same location since the 1st treatment. Thus a slight amount of residue may have accumulated in the mill stream and in spillage. However, the levels observed do not suggest that weekly treatments would produce residues in excess of the established tolerance of 0.5 ppm.

DISCUSSION.—The results of the test indicate that dichlorvos vapors are highly effective in reducing insect populations in rice mills. The reduction in infestation observed in this test indicates that continued use of dichlorvos would reduce mill insect populations to low levels. The possibility of infestation of milling products would thereby be greatly reduced.

The residue data indicate that rice bran should not be exposed to dichlorvos vapors in the manner of this test unless it is bagged. Moreover, bagged bran should not be exposed to successive daily treatments. Minor equipment modifications to protect products such as broken milled rice, rough rice, or brown rice would reduce the amounts of the residues resulting in these commodities.

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Insects Research and Development Laboratory, USDA, ARS, Savannah, Georgia.

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Angoumois Grain Moth[1] Control in Rough Rice with a Gardona-Dichlorvos Mixture[2]

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Surface applications of malathion or synergized pyrethrins are routinely made on rough rice to control the Angoumois grain moth, *Sitotroga cerealella* (Olivier), but these insecticides give only limited control. In earlier tests, emergence of the Angoumois grain moth in rough rice in jar tests was completely prevented by bulk treatment with 5, 10, and 20 ppm dichlorvos, although the treatment had only short residual effectiveness vs. other insects (McGaughey 1970). When a 2:1 mixture of Gardona® (2-chloro-1-[2,4,5-trichlorophenyl] vinyl dimethyl phosphate) and dichlorvos was evaluated as a bulk-treatment protectant for rough rice, the biological effectiveness persisted longer than when either chemical was used alone (McGaughey 1972). Therefore, tests were made to investigate the effectiveness of surface applications of the 2:1 Gardona-dichlorvos mixture for controlling and preventing infestations of the Angoumois grain moth in rough rice.

METHODS AND MATERIALS.—Corrugated paper boxes 52×52×20 cm deep were filled 8 cm deep with 'Bluebelle' rough rice and treated with a mixture of 1.0 lb Gardona EC and 0.5 lb dichlorvos/gal, which was diluted with water for spray application at the rate of 20 ml of solution/bin to achieve doses of 538, 1076, and 2152 mg/m². Malathion, used as a comparison in 1 test, was prepared by diluting a 57% EC with water to achieve a dose of 1076 mg/m² when it was applied at the rate of 20 ml of solution/bin. The surface of the rice was not disturbed posttreatment, but individual bins were covered with cheesecloth to prevent moth entry and to confine any emerging moths until they could be counted. Bins were held at 25°C and 60% RH.

Test 1.—Heavily infested rice with a moisture content of 13% was placed in bins and treated with the 2:1 Gardona-dichlorvos mixture at rates of 1076 and 2152 mg/m² and with malathion at a rate of 1076 mg/m², to determine the disinfestation potential of the chemicals. Check bins were sprayed with an equal amount of water. Each treatment and the check were replicated 3 times.

Test 2.—Rice with a moisture content of 13.44% was placed in bins and treated as before. Five bins were treated with each dose. The persistence of residues was determined by taking samples from 2 bins/treatment at 1 and 30 days posttreatment, for GLC residue analysis. The duration of protection was tested by introducing moths (30/bin) from the laboratory colony into each of the remaining 3 bins from each dose, about once a month. Fresh check bins were used each time moths were introduced, to prevent establishing an infestation that would inflate the expected emergence. Emergence in the bins was then counted 3 times a week except for a period of ca. 10 days immediately following the introduction of the moths each month.

RESULTS.—Emerging moths from the heavily infested rice in Test 1 were counted at 3-, or 4-day intervals from 7 to 49 days posttreatment. Totals from the 3 bins/treatment and the check were: check–3387; malathion 1076 mg/m²–2953; and 2:1 Gardona-dichlorvos 1076 mg/m²–234 and 2152 mg/m²–115. The 2 doses of Gardona-dichlorvos reduced emergence by 93%, and 97%, respectively, while malathion reduced emergence by only 13%.

In Test 2, total progeny resulting from the monthly introduction of moths into the bins was counted. Total progeny in the 3 untreated bins averaged 400 moths/monthly introduction. The 538-mg/m² 2:1 Gardona-dichlorvos treatment caused an 87% reduction in progeny from moths introduced 30 days posttreatment; at subsequent intervals, reduction was <18%. This treatment level was considered insufficient for moth control. The 1076-mg/m² treatment caused >93% reduction in progeny at each interval through 7 months. Ten months posttreatment, effectiveness had declined to 74%, and to 45% after 13 months. The 2152-mg/m² treatment caused >94% reduction in progeny at each interval throughout the test (terminated after 15 months due to heavy infestation by the lesser grain borer, *Rhyzopertha dominica* [F.]).

Residues of Gardona declined ca. ¼ during the first 30 days posttreatment, and residues of dichlorvos ca. ⅔. Average Gardona and dichlorvos residues (GLC analysis) on samples taken to a depth of 8 cm at 1 and 30 days posttreatment with 2:1 Gardona-dichlorvos were: 538 mg/m²–Gardona 6.15 and 4.16 ppm, dichlorvos 5.42 and 2.02 ppm; 1076 mg/m²–Gardona 12.85 and 10.55 ppm, dichlorvos 11.75 and 3.82 ppm; and 2152 mg/m²–Gardona 24.60 and 19.25 ppm, dichlorvos 20.70 and 7.30 ppm. The data provided no explanation for the lack of a 2:1 ratio between Gardona and dichlorvos residues at the 1-day sampling interval.

The results showed that treatment of the surface of rough rice with 1076 or 2152 mg/m² of the 2:1 Gardona-dichlorvos mixture gave a high degree of control and prevented reinfestation by the Angoumois grain moth for several months. Residues decreased appreciably during the first 30 days. Large-scale tests should be made to determine whether actual storage conditions would alter the effectiveness of the treatments. Also, such tests would permit determination of average residues resulting from surface treatments of larger masses of rice.

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[1] Lepidoptera: Gelechiidae.

[2] Received for publication Jun. 7, 1973. This paper reports the results of research only. Mention of a pesticide or a proprietary product does not constitute a recommendation or an endorsement by the USDA.

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