Pirimiphos Methyl as a Short Term Protectant of Grain Against Stored-Product Insects[1,2]

DELMON W. LAHUE[3]
Grain Marketing Research Center, Agric. Res. Serv., USDA, 1515 College Avenue, Manhattan, KS 66502

ABSTRACT

Pirimiphos methyl (*O*-[2-(diethylamino)-6-methyl-4-pyrimidinyl] *O,O*-dimethyl phosphorothioate), applied as a water emulsion (5, 10, and 20 ppm) to hard winter wheat and shelled yellow corn killed all exposed adult rice weevils, *Sitophilus oryzae* (L.), red flour beetles, *Tribolium castaneum* (Herbst), confused flour beetles, *T. confusum* Jacquelin duVal, and lesser grain borers, *Rhyzopertha dominica* (F.) at 24 h and 1 month after treatment; no F_1 progeny developed. After 3 months, a few red and confused flour beetles survived exposure to grain treated with 5 ppm, but no progeny developed. Also, some lesser grain borers survived, and F_1 progeny and damage were recorded in wheat treated with 5 ppm and in corn treated with 5 and 10 ppm. Malathion, applied at a calculated dosage of 10 ppm as the chemical standard, gave complete protection to both grains for 3 months.

The residues of pirimiphos methyl degraded gradually as the storage period lengthened except for the 20 ppm applied to shelled corn. The residues of malathion degraded gradually on both grains.

An urgent need for new materials that will protect stored grain from insect pests is arising because of the development of resistance by certain species of stored-product insects and the natural tolerance of others to materials now in use. New compounds should be low in mammalian toxicity, possess effective residual activity, and produce vapors that are toxic to a variety of insects that attack stored-grain and grain products. Malathion and synergized pyrethrins presently are applied to stored grain as protectants against insect pests, but certain species have developed a resistance to malathion (LaHue 1969a, Speirs et al. 1967). Malathion is used more generally because pyrethrin treatments are more expensive.

Zettler (1974) reported that 5 malathion-resistant strains of the Indian meal moth, *Plodia interpunctella* (Hübner) showed no cross resistance to pirimiphos methyl and concluded that it is a potential replacement for malathion as an insecticidal treatment to protect certain commodities against infestation by this species. In our preliminary residual studies with spray applications of 1076 mg/m² AI on wood panels, pirimiphos methyl was very effective against maize weevils, *Sitophilus zeamaize* Motschulsky, red flour beetles, *Tribolium castaneum* (Herbst), confused flour beetles, *T. confusum* Jacquelin duVal, saw-toothed grain beetles, *Oryzaephilus surinamensis* (L.), and newly hatched larvae of 2 resistant strains of the Indian meal moth. This organophosphorus compound with its relatively low mammalian toxicity (LD_{50} to rats of ca. 2050 mg/kg) was therefore selected as a candidate grain protectant material for further study.

The effectiveness of 3 doses of pirimiphos methyl was determined against the adult rice weevil, *Sitophilus oryzae* (L.), confused flour beetle, red flour beetle, and lesser grain borer, *Rhyzopertha dominica* (F.), when applied as a water emulsion to wheat and shelled corn. Also, residues remaining on the grain at 24 h and 1 and 3 months posttreatment were recorded.

MATERIALS AND METHODS.—Cleaned, uninfested lots of hard winter wheat and shelled corn were tempered to 12.5±0.05% moisture. The source lots were held in covered fiberboard drums at 26.7±1.1°C and 60±5% RH for 21 days for the moisture to come to equilibrium. Test insects were reared in a room maintained at 26.7±1.1°C and 60±5% RH. The 14-day-old rice weevil and 7-day-old lesser grain borer adults used in the test were reared on hard winter wheat containing ca. 12.5% moisture. The 14-day-old red and confused flour beetles were reared on a standard laboratory culture medium containing 10 parts flour, 10 parts yellow cornmeal, and 1.5 parts brewer's yeast.

Lots of 1000 g of tempered grain were placed in 3.785-liter widemouth glass jars. An emulsifiable concentrate containing 50% wt/vol pirimiphos methyl (499.7 g/liter) was diluted to produce emulsions for 1-ml applications to the grain of 5, 10, and 20 ppm of actual pirimiphos methyl. The emulsions, which were prepared immediately before use, were kept in constant agitation at 26.7±0.6°C.

Malathion was used as a standard for comparison. An emulsifiable concentrate containing 57.0% premium-grade malathion was diluted to make an emulsion for 1-ml applications of 10 ppm of actual malathion on the grain.

Applications were made with a 1-ml volumetric pipette to the inside wall of the 3.785-liter glass jars above the grain level while the jars were turning on a 33-rpm turnable. Immediately after application, the jars were shaken by hand for 30 s and then rotated for 15 min on a mechanical tumbler to mix the insecticides with the grain. Each application was replicated 5 times. After the required aging period in uncovered jars, 250-g samples were removed and placed in 473-ml glass mason jars for the toxicity exposures. The test jars were fitted with rings, 40-mesh screens, and filter-paper lids. About 50 adult insects were placed in individual samples.

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[2] This paper reports the results of research only. Mention of an insecticide or a proprietary product does not constitute a recommendation or an endorsement by the USDA.
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Insects were exposed for 21 days after the deposits had aged for 24 h and for 1 and 3 months. Mortality was determined when the exposure was terminated. After F_1 progeny was counted, the grain with the progeny was retained for at least 120 days for an assessment of progeny damage as described by LaHue (1969b).

RESULTS AND DISCUSSION.—All test insects in treated grain were killed by exposures begun at 24 h and at 1 month posttreatment, and no F_1 progeny developed, hence these data are not shown in tabular form. Grain treated with pirimiphos methyl was protected from noticeable damage by the rice weevil for 3 months, despite a few F_1 progeny that developed in corn treated with 5 ppm and in wheat treated with 5 and 10 ppm. As these rice weevil progeny emerged, they were killed by the residues remaining on the grain. A few red and confused flour beetles survived the killing action of the residues remaining after 3 months in grain with the 5 ppm treatment but no F_1 progeny developed.

Lesser grain borers were less susceptible to the killing action of residues of pirimiphos methyl than to malathion, but none survived exposure to the 20 ppm application to wheat or corn 3-months posttreatment (Table 1).

Table 1.—Mortality of adult lesser grain borers and F_1 progeny and damage to wheat and shelled corn 3 months after treatment.

Calculated dosage (ppm)	% mortality of adults	Progeny		
		Total no.	% dead	Visible damage[a]
Wheat				
PP-511				
5	56.9	8.0	37.5	1.2
10	98.3	0		0
Malathion				
10	100.0	0		0
Untreated	2.0	834.0	.5	5.0
Corn				
PP-511				
5	47.4	11.0	27.3	1.8
10	88.5	7.0	57.1	1.0
Malathion				
10	100.0	0		0
Untreated	0	219.0	0	4.0

[a] Damage 120 days after infestation ranged from 0 (no visible infestation or damage to 5 (heavy infestation, damage, and grain spoilage).

Table 2.—Residues of pirimiphos methyl and malathion on wheat and shelled corn at given intervals during storage.

Calculated dosage (ppm)	Residues (ppm) after—		
	24 h	1 month	3 months
Wheat			
PP-511			
20	15.4	12.4	11.2
10	8.4	6.3	4.7
5	4.7	2.2	1.7
Malathion			
10	9.0	6.5	4.0
Corn			
PP-511			
20	10.8	10.6	10.0
10	8.0	6.2	4.7
5	6.9	3.9	2.1
Malathion			
10	7.8	7.2	4.2

Different levels of residue resulted from the 3 scalar doses of pirimiphos methyl (Table 2), but acceptable patterns of degradation were shown, except in samples of corn treated with 20 ppm. Pirimiphos methyl appears promising as a protectant for bulk grain and other bulk-stored commodities. Therefore, it has been included as a candidate protectant material in small bin, intermediate-type storage studies with shelled corn, hard winter wheat, and high-moisture sorghum grain.

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