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Insecticidal Dusts: Grain Protectants During High Temperature-Low Humidity Storage[1,2]

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ABSTRACT

Diatomaceous earth dusts impregnated with 4.5, 6.0, and 7.5 ppm AI pirimiphos-methyl and with 5.0, 7.5, and 10 ppm AI malathion were tested as protectants against insect attack on hard winter wheat (11.2% moisture) stored at ca. 33.4°C and 40% RH. The dusts were applied at a rate of 0.5 kg dust/metric ton of wheat. Sprays prepared from emulsifiable concentrates and the dust base alone were used for treatment checks.

Dust formulations were more effective than sprays that contained equivalent doses and were much more effective than diatomaceous earth alone. Pirimiphos-methyl was more effective than malathion.

In certain food deficient areas of the world, such as Ethiopia, grain available as the staple food for one family for a year may amount to less than a metric ton (M. Kamahd, pers. comm.). It is important that grain harvested at the end of a growing season be protected from insects during storage as little or no food can be produced during the following dry season. Temperatures usually are very high and the humidity low during the storage period. As a result, infestations of stored-grain insects develop rapidly, e.g., as much as 40% of the food supply is lost to developing populations of insects in the Sahel (T. Bourla, pers. comm.).

Studies were made to find simple methods for controlling insects in small lots of low moisture wheat stored at relatively high temperatures. Malathion was one of the materials used because it is among the most commonly used and approved grain protectants. Pirimiphos-methyl was tested because it is one of the more promising chemicals presently being tested as a candidate protectant (McDonald and Gillenwater 1976, LaHue 1975a, b).

MATERIALS AND METHODS.—Newly harvested 'Scout' variety wheat, 12.4% moisture, was exposed to infestations of rice weevils, *Sitophilus oryzae* (L.), and maize weevils, *S. zeamais* Motschulsky, for one wk while air drying to ca. 11.2% moisture (determined with a Steinlite® RCT-B moisture tester); adult weevils were then removed by sieving the grain. Red flour beetles, *Tribolium castaneum* (Herbst), were added to the wheat at a rate of ca. 135 adults/kg wheat, then the wheat was maintained at 32°±1°C for one wk. Finally, after the wheat was gradually warmed during a 24-h period until the temperature of the mass reached 41.3°C, ca. the maximum temperature in some African food deficient areas, the protective treatments were applied.

The insecticidal dusts were formulated by mixing either pirimiphos-methyl (to produce AI residues of 4.5, 6.0, or 7.5 ppm) or malathion (to produce 5.0, 7.5, or 10 ppm) with a diatomaceous earth Kenite® 2-I in a ball machine for 3 h. Dusts were then added at 0.5 g/kg wheat in 3.8-liter large-mouth glass jars. Immediately after addition of the dusts, the jars were shaken by hand for 30 sec and then rotated for 15 min on a mechanical tumbler to mix the insecticide with the grain. The jars of dust-treated grain were then held in storage at ca. 33°C and 40% RH. Tell Tale® silica gel indicating drier was kept in the incubator and renewed lots were substituted as needed to determine that the RH was being maintained at ca. 40% by a dehumidifier.

Pirimiphos-methyl and malathion emulsion sprays were used as standards for comparison. The EC's were diluted with distilled water to make emulsions for one ml applications/kg wheat in 3.8-liter glass jars to deposit 5.0, 7.5, and 10.0 ppm malathion and 4.5, 6.0, and 7.5 ppm pirimiphos-methyl, respectively. Treated grain was stored in 2.5-kg lots in the 3.8-liter glass jars, which were covered with 40-mesh screen and filter paper lids held in place by metal rings. Sufficient wheat was treated for 6 replications of each dose. Lots of uninfested wheat and infested wheat treated with Kenite 2-I alone (0.5 g/kg wheat) were included for comparison with the wheat treated with the insecticidal formulations.

Other samples of dust treated wheat were retained in uncovered jars and were subjected to continuous infestation by rice weevils, maize weevils, and red flour beetles. These samples were covered with screened lids one wk before counts were made. The treated wheat was stored for 8 mo. Six representative kg lots from each replication were examined for adult insect population counts by sifting at monthly intervals.

RESULTS.—Table 1 shows avg numbers of *Sitophilus* spp. recovered from the dust-treated wheat each month. The 7.5-ppm dose of pirimiphos-methyl controlled the 2 species, although a few adults emerged from the kernels during the 1st and 2nd mo. Very little emergence occurred in the wheat treated with 6.0-ppm pirimiphos-methyl, and this dose eliminated the infestation by the 5th mo. No live insects were found after 7 mo in samples treated with 4.5 ppm. The 5.0-, and 7.5-ppm doses of malathion on dust did not eliminate the indigenous infestations of

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[2] This paper reports the results of research only. Mention of a pesticide does not constitute a recommendation for use by the USDA nor does it imply registration under FIFRA as amended. Also, mention of a proprietary product does not constitute an endorsement by the USDA.

Table 1.—Average number of live rice weevil and maize weevil adults found in 1000-g samples of wheat that contained an indigenous infestation before treatment with insecticidal dusts.[a,b]

Insecticide and dose (ppm)	Avg no. of adult weevils found at indicated months after treatment							
	1	2	3	4	5	6	7	8
Covered samples								
Pirimiphos-methyl								
4.5	5.3	11.3	3.0	5.0	0.3	0.3	0	0
6.0	2.0	1.3	.5	.3	0	0	0	0
7.5	0	0	0	0	0	0	0	0
Malathion								
5.0	49.3	46.8	22.3	19.0	28.0	26.3	78.8	90.3
7.5	9.5	17.3	11.8	7.5	3.5	11.0	8.0	15.8
10.0	1.8	7.3	4.3	0	0	0	0	0
Kenite	167.3	149.5	162.0	202.0	216.0	246.8	316.5	303.5
Untreated[c]	243.0	496.5	696.3	789.0	1041.0	989.3	516.3	213.5
Uncovered samples								
Pirimiphos-methyl								
4.5	6.3	8.5	4.3	4.8	0.8	0.5	0	0.3
6.0	3.0	2.3	0	.3	0	0	0	0
7.5	0	0	0	0	0	0	0	0
Malathion								
5.0	56.0	43.3	34.8	22.3	44.3	43.0	87.8	159.8
7.5	11.3	10.3	6.0	.3	0	6.5	11.3	20.5
10.0	2.0	5.3	2.0	0	0	0	0	0
Kenite	142.3	127.0	103.3	115.3	101.3	52.5	79.0	86.0
Untreated	278.5	342.8	416.8	527.5	416.0	401.3	296.5	149.3

[a] Dusts formulated in Kenite 2-I, a diatomaceous earth.
[b] Avg of 6 replicates.
[c] Uncovered after 3rd mo.

Sitophilus, but damage to the wheat was relatively light compared to untreated check lots. The 10-ppm application of malathion eliminated infestations in 4 mo. Adults that developed in all dust-treated lots usually were much smaller than those that emerged from untreated checks. Kenite 2-I alone applied to the wheat did not control the indigenous infestation but reduced the numbers developing in the samples.

There were no marked differences in the numbers of live weevils in comparable covered and uncovered jars containing wheat treated with malathion and pirimiphos-methyl, but greater numbers were found in covered jars with Kenite alone than in comparable uncovered jars. Weevils that developed in uncovered jars of untreated wheat left the wheat as the populations increased.

Table 2 shows avg numbers of *Sitophilus* spp. recovered from covered samples of spray-treated wheat. The dust applications (Table 1) generally were more effective than the sprays although the trends were

Table 2.—Average number of live rice weevil and maize weevil adults found in 1000-g samples of wheat that contained an indigenous infestation before treatment with insecticidal spray.[a,b]

Insecticide and dose (ppm)	Avg no. of adult weevils found at indicated months after treatment							
	1	2	3	4	5	6	7	8
Pirimiphos-methyl								
4.5	14.8	16.3	11.5	7.8	5.9	3.5	0	0
6.0	4.3	2.5	1.8	1.8	0	.3	0	0
7.5	0	0	0	0	0	0	0	0
Malathion								
5.0	61.8	56.5	46.3	53.0	74.3	114.8	147.8	166.5
7.5	7.3	11.3	9.0	7.3	11.0	22.5	33.8	49.5
10.0	0	7.5	3.5	1.5	0.3	0	.3	.3
Untreated-check[c]	271.5	529.5	733.3	770.5	939.0	787.3	571.5	319.8

[a] Avg of 6 replicates.
[b] Jars uncovered after 3rd mo.
[c] Covered jars.

essentially the same. Pirimiphos-methyl was more effective than malathion at all comparable doses. Adults that developed in the grain treated with sprays were larger than those from the dusted wheat.

The emergence of *Sitophilus* adults and the development of red flour beetle infestations in the different replicates of covered check lots were similar which indicated that the grain was uniformly infested. The *Sitophilus* populations peaked (Table 1, 2) in the untreated wheat during the 5th mo, and after that, the flour beetles replaced the weevils as the dominant species. Development of red flour beetle populations in the untreated check lots was gradual, and only 1.3 and 2.8% mortality was found in counts made at 4 and 8 mo.

All red flour beetle adults were killed by applications of impregnated insecticidal dusts and sprays, and no progeny developed in the covered jars. An avg of 123.5 dead adults/kg sample was recovered, which accounted for ca. 92.4% of the numbers originally introduced to infest the wheat. The avg numbers of live red flour beetle adults in one kg samples of untreated wheat were:

Month	Covered jars	Open jars
1	116.3	86.4
2	119.8	93.5
3	127.0	116.5
4	122.5	122.5
5	146.3	147.3
6	191.3	203.0
7	211.5	267.3
8	242.8	281.8

In uncovered samples of wheat treated with 5 ppm malathion, averages of 4.5, 18.0, and 31.3 adult red flour beetles were found in siftings made after 6, 7, and 8 mo storage, respectively.

The avg moisture content of wheat samples with the 7.5 ppm pirimiphos-methyl and 10 ppm malathion treatments was 10.8% (dust-treated, 10.6%; spray treated, 11.0%) after 8 mo storage; in untreated infested wheat, the moisture content averaged 11.9%.

DISCUSSION.—Rowlands (1967) stated that higher storage temperatures generally result in a more rapid degradation of certain grain protectants, particularly the organophosphates, because of stimulation of enzymatic activity. Enzymatic activity in grain of low moisture content (below 11%) is not stimulated as much as that of grain at 11.5% moisture, which is ca. the critical moisture level for enzymatic activity. Enzymatic action in wheat is characteristic of high moisture content, early stages of germination, or a combination of both. Wheat of low moisture content is not subjected to the same oxidative and hydrolytic processes, which are the main factors (moisture, temperature, aeration) that determine respiration intensity. Protein digestibility does not change rapidly in low moisture wheat, consequently, the food value of wheat in dry, food deficient areas is maintained until consumed. Furthermore, insect free grain maintained at a sufficiently low moisture level (below the critical level) can be stored for years with little deterioration in total food value provided that the temperatures are not greatly elevated.

The dust formulations of malathion and pirimiphos-methyl look exceedingly promising for use on small farms in underdeveloped agricultural areas that experience high temperatures and low humidities following harvest season. Insecticidal protectant dusts could be prepackaged for distribution according to the capacity of the normal storage structures in a geographical area and then used for application to the relatively small lots of grain placed in farm storages. No special equipment would be needed as for spray applications and the grain can easily be washed free of the dusts before use.

REFERENCES CITED

LaHue, D. W. 1975a. Pirimiphos methyl as a short term protectant of grain against stored-product insects. J. Econ. Entomol. 68: 235–6.

1975b. Angoumois grain moth: chemical control of infestation in shelled corn. Ibid. 68: 769–71.

McDonald, L. L., and H. B. Gillenwater. 1976. Toxicity of pirimiphos methyl and Bay SRA 7660 to six species of stored-product insects. J. Ga. Entomol. Soc. 11: 110–14.

Rowlands, D. G. 1967. The metabolism of contact insecticides in stored grains. Pestic. Rev. 17: 105.