Grain Protectants for Seed Corn: Field Test[1,2]

DELMON W. LAHUE[3]
U.S. Grain Marketing Research Center, Agric. Res. Serv., USDA, Manhattan, KS 66502

ABSTRACT

Water emulsions of pirimiphos-methyl, chlorpyrifos-methyl, fenitrothion, malathion, and a diatomaceous earth dust impregnated with malathion were tested as protectants of seed corn in commercial marketing channels. Indigenous infestations of foreign grain beetles, *Ahasverus advena* (Waltl), Indian meal moths, *Plodia interpunctella* (Hübner), Angoumois grain moths, *Sitotroga cerealella* (Olivier), *Oryzaephilus* spp., *Cryptolestes* spp., *Trogoderma* spp., and *Tribolium* spp. were present in all exposure areas.

At the doses used, the general order of effectiveness of the emulsion sprays was pirimiphos methyl > chlorpyrifos-methyl > fenitrothion > malathion > untreated check. The malathion-diatomaceous earth (M + K) dust was very effective, but its abrasive quality (largely from SiO_2 content) damages all types of machinery used in commercial seed handling and farm planters.

Chemical controls are needed to protect seed corn stocks during the spring sales season when the corn is usually subjected to indigenous infestations of insects in the warehouses and storerooms. Seed that is not sold is usually returned for blending and reprocessing and storage until it can be sold the following season. Insecticides that are readily available, economical, and relatively safe (low mammalian toxicity) are needed as protectants. In addition, they should have a stable shelf life and a long-lasting residual quality.

Previously, it was found that several chemicals gave good protection to seed corn for 21 mo (2 sales seasons) under controlled temperatures and relative humidity (LaHue 1976). Reported here is the effectiveness of these chemicals as protectants of seed corn against insect attack in commercial outlet seed storage and sales rooms. All steps in handling and storage of the seed (except for blending after the 1st sales seasons) corresponded to the procedures practiced by a commercial seed producer.

MATERIALS AND METHODS.—White combine-harvested shelled hybrid seed corn was dried from 16.7 to 12.2% moisture by using forced air heated to ca. 40°C. Then the corn was cleaned, sized, and hand picked, and stored (ca. 22°C) in a bulk storage bin for ca. 1 mo.

Sufficient corn for treatment was placed in 1-kg lots in 3.8-liter large-mouth glass jars, and the jars were capped with solid lids. The chemicals tested were water emulsion sprays of: pirimiphos-methyl EC (599.2 g AI/liter) applied at a rate of 354.8 ml EC 25.5 metric tons (8.4 ppm); chlorpyrifos-methyl EC (239.7 g AI/liter) applied at a rate of 709.7 ml EC 25.5 metric tons (6.7 ppm); fenitrothion EC (958.7 g AI/liter) applied at a rate of 236.6 ml EC 25.5 metric tons (8.9 ppm); and a dust formulation of 473 ml of 57% malathion EC in 27.2 kg of a diatomaceous earth (Kenite® 2-I) /25.5 metric tons (11.2 ppm malathion). Premium-grade 57% malathion EC (599.2 g AI/liter) used as the standard protectant emulsion spray was applied at a rate of 473 ml EC/25.5 metric tons (11.2 ppm).

All emulsions were formulated with tap water so that the intended amounts of AI were deposited by applying 1 ml/kg corn. The materials were applied with a 1-ml volumetric pipette to that portion of the inside wall of the 3.8-liter glass jars that was above the grain while the jars were turning on a turntable at 33 rpm. Immediately after application the jars were rolled on a ball mill roller for 1 min and then rotated on an end-over-end mechanical tumbler for 15 min to mix the insecticide with the corn. In the case of the dust treatments, a weighed amount of dust was added to 1000-g lots of corn before mixing. All treatments were replicated 5 times.

After treatment, 1-kg lots were combined, 2/jar, and the jars fitted with solid lids. The jars were held at ca. 22°C for 10 days posttreatment before they were placed in a cold room for storage at ca. 8°C. After ca. 4 mo, the corn was removed from cold storage, and 1-kg lots of each treatment were placed in 8×8-hexagonal mesh nylon net produce bags (2 liter capacity) so that insects would have easy access to the grain. Untreated corn was similarly bagged. The bags (1 replicate of each treatment and a check) were placed in rectangular containers 60×90×30 cm high made of 4×4-mesh hardware cloth (to prevent damage by rodents).

Bags were placed at 5 locations in 3 warehouses located at 3 separate geographical areas in Kansas (farm feed and seed retail stores) at ambient conditions for ca. 4 mo, which represented the 1st year's sales period. After ca. 4 mo exposure in the store rooms, the contents of each bag were examined for insects, and the insects discarded. Then the corn was returned to its original bags and again stored at 8°C for 8 additional mo, until the following sales season. After 8 mo, the nylon net bags of corn were again exposed for the 4 mo of the 2nd sales season. Then the corn was examined for insects and insect

[1] Received for publication May 18, 1977.
[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.
[3] The author acknowledges the assistance of Leslie Stanwix and Dennis Vanderpool, student laboratory aids, in preparing the bags and conducting the tests.

Table 1.—Avg and range in numbers of live immature Indian meal moths recovered from 1-kg of corn in net bags.[a]

Insecticide	Store 1	Store 2	Store 3
	At 8 mo posttreatment		
M + K dust	0.4 (0–1)	0.4 (0–1)	0.0
Pirimiphos-methyl	1.0 (0–2)	1.8 (1–3)	0.8 (0–2)
Chlorpyrifos-methyl	3.0 (2–4)	4.0 (3–5)	2.0 (0–3)
Fenitrothion	5.0 (3–7)	7.6 (6–10)	3.6 (2–5)
Malathion	5.6 (3–8)	8.6 (7–12)	4.4 (3–6)
Untreated	12.2 (8–17)	13.6 (10–19)	9.4 (7–13)
	At 21 mo posttreatment		
M + K dust	3.4 (2–5)	3.8 (2–5)	3.0 (2–4)
Pirimiphos-methyl	3.2 (2–4)	2.6 (1–4)	2.8 (2–4)
Chlorpyrifos-methyl	5.4 (3–7)	4.4 (3–6)	5.2 (3–7)
Fenitrothion	8.8 (7–11)	12.2 (9–16)	12.0 (8–17)
Malathion	10.8 (8–14)	13.6 (10–17)	13.8 (11–18)
Untreated	24.8 (19–28)	20.2 (17–25)	21.4 (18–25)

[a] Avg of 5 replications.

damage. Also, the 1-kg lots were held for emergence of any hidden infestations.

Germination tests and moisture determinations were conducted with samples of corn taken before treatment and at 5, 8, 17, and 21 mo posttreatment.

RESULTS.—The moisture content of the corn averaged 12.2% before treatment, and 13.3, 12.0, 13.4, and 11.9% at 5, 8, 17, and 21 mo posttreatment, respectively. None of the treatments affected the germination of the corn, but there was a gradual decline from 99.4 to 91.2% germination during the 21 mo. In contrast, only 79.3% of the untreated (insect-damaged) check corn germinated after 21 mo.

As there was only one dose of each formulation, the rates (not shown on the tables) were: pirimiphos-methyl 8.4 ppm, chlorpyrifos-methyl 6.7 ppm, fenitrothion 8.9 ppm, malathion (emulsion) 11.2 ppm, and malathion plus dust (M + K dust) 11.2 ppm.

In the examinations made at 8 mo posttreatment, i.e., at the end of 1st sales season, larvae of the Indian meal moth, *Plodia interpunctella* (Hübner), were found infesting the corn in practically all bags (Table 1). The number of larvae recovered varied somewhat at the different locations of the bags within a particular storage area, but the relative effectiveness of the treatments was consistent at all 3 locations. The total numbers of Indian meal moth larvae recovered from treated and untreated corn from the 3 stores were 136, 180, and 100 with 44.9, 37.8, and 47.0%, of the numbers being in the untreated corn, respectively. All Indian meal moths recovered from the treated corn were large 4th and 5th instars; no adults or pupae were recovered. However, pupae were found in the untreated check lots, and adults were seen in the storage rooms.

The M + K dust was effective since the 4 larvae collected from grain treated by this method died before pupation when they were confined to a sample of this corn. Pirimiphos-methyl also was effective since only 22.2% of the larvae emerged as adults compared with 55.6, 60.4, and 72.0% that emerged from larvae collected from bagged corn treated with chlorpyrifos-methyl, fenitrothion, or malathion, respectively. About 96% of the 176 larvae and pupae from the untreated corn emerged as adults.

No live Coleoptera were recovered from the treated corn 8 mo posttreatment, i.e., at the end of the 1st sales season. However, the untreated (check) corn in the stores became infested with the following numbers of insects during this 1st exposure:

Insect	Store 1	Store 2	Store 3
Sitophilus spp.	55	83	101
Oryzaephilus spp.	16	4	0
Cryptolestes spp.	19	0	0
Tribolium spp.	51	54	43
P. interpunctella	61	68	47
Others	4	9	7
Total	206	218	198

At the end of the 2nd season's exposure, i.e., at 21 mo posttreatment, the M + K dust was still effective against Indian meal moths though a few live, mature larvae were found (Table 1). Also, a few adult *Sitophilus* spp. and *Tribolium* spp. were recovered in the lots with this dust treatment (Table 2), and the *Sitophilus* spp. had established an indigenous infestation in the corn at the termination of the storage period (Table 3). Malathion and fenitrothion were less effective but still gave considerable protection compared to untreated corn.

A few *Tribolium* developed in corn treated with pirimiphos-methyl and chlorpyrifos-methyl, but little feeding damage to the kernels was found. Moreover, in corn treated with pirimiphos-methyl, insects did not develop an indigenous infestation when held 90 days; and only small numbers of live *Sitophilus* and *Tribolium* developed in 12 of the 15 samples treated with chlorpyrifos-methyl. Populations were large and damage was heavy in all samples of corn treated with malathion and fenitrothion at the end of the 90-day emergence period. Untreated corn became heavily infested with *Sitophilus* spp. and *Tribolium* spp.

Table 2.—Mean number of Coleoptera recovered from corn at 21 mo posttreatment.[a]

Insecticide	*Tribolium* spp.	*Sitophilus* spp.	Others
M + K dust	6.0 a[b]	28.2 b	6.4 a
Pirimiphos-methyl	19.8 b	14.0 a	11.0 b
Chlorpyrifos-methyl	19.4 b	16.2 a	18.4 c
Fenitrothion	39.8 c	36.2 c	32.6 d
Malathion	44.8 c	41.6 c	39.0 d
Untreated	178.8 d	246.2 d	62.0 e

[a] Avg for the 5 replications in each of the 3 stores.
[b] Means within a column followed by the same letter not significantly different at the 5% level of probability, Duncan's multiple range test.

Table 3.—Avg and range in numbers of insects found in 1-kg lots of corn at 21 mo posttreatment.[a,b]

Insecticide	*Sitophilus* spp.	*Tribolium* spp.	*Cryptolestes* spp.	*Oryzaephilus* spp.	*Plodia interpunctella*	Others
M + K dust	43.2 (31–54)	5.0 (2–9)	0	0	0	0
Pirimiphosmethyl	21.2 (16–25)	16.8 (11–20)	2.2 (0–5)	4.0 (0–6)	10.4 (6–13)	1.6 (0–3)
Chlorpyrifosmethyl	26.4 (18–29)	28.0 (22–30)	2.8 (0–4)	3.2 (0–6)	30.6 (21–37)	9.8 (3–12)
Fenitrothion	166.4 (140–187)	56.2 (41–69)	19.8 (12–29)	12.6 (7–17)	69.4 (50–81)	13.0 (9–19)
Malathion	173.6 (156–201)	46.4 (40–52)	29.2 (21–43)	8.4 (4–11)	107.8 (81–136)	19.2 (11–30)
Untreated	918.0 (798–981)	216.2 (141–267)	56.0 (41–67)	18.4 (9–23)	79.4 (51–88)	110.8 (80–133)

[a] Held an additional 90 days for development of indigenous infestations.
[b] Avg of 5 replications from each of 3 stores.

during the 2nd exposure. The avg ratings of visible damage by all insects at that time were:

Insecticide	Damage rating
Malathion	3.0
Pirimiphos-methyl	0.0
Chlorpyrifos-methyl	.8
Fenitrothion	2.4
M + K dust	.6
Untreated	4.6

where 0 = no visible live insects or damage; 1 = a few insects and little frass; 2, 3, and 4 = ascending numbers of insects and amounts of frass; 5 = heavy infestation with destruction of grain.

DISCUSSION.—Sufficient insects were present in all 3 stores throughout the 2 test periods to ensure satisfactory exposures; also, the nylon net bags allowed insects easy access to the corn. For the emulsion sprays and at the doses used, pirimiphos-methyl gave the best protection to the corn at all 3 locations. The M + K dust, which gave excellent overall protection, would not be satisfactory for commercial use because its abrasiveness would damage machinery used in handling the seed (White et al. 1966). Pirimiphos-methyl, chlorpyrifos-methyl, and fenitrothion were as effective or more effective than malathion, the standard used for comparison. These potential replacements for malathion are relatively low in mammalian toxicity, have broad spectrum activity, and are available in stable formulations.

REFERENCES CITED

LaHue, D. W. 1976. Grain protectants for seed corn. J. Econ. Entomol. 69: 652–4.

White, G. D., W. L. Berndt, J. H. Schesser, and C. C. Fifield. 1966. Evaluation of four inert dusts for the protection of stored wheat in Kansas from insect attack. ARS 51-8, Agr. Res. Serv., USDA. 21 pp.