# Angoumois Grain Moth:[1] Chemical Control of Infestation in Shelled Corn[2]

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ABSTRACT

Four candidate protectants for grain were evaluated monthly for 8 mo as controls for indigenous infestations of *Sitotroga cerealella* (Olivier) in shelled corn by counting the number of adult moths that emerged from the bins during a 48-h period. At the doses applied, pirimiphos methyl, chlorpyrifos-methyl, and fenitrothion protectant sprays and a malathion-diatomaceous earth dust gave control and protection equal or superior to that of the recommended treatment of 1.0 pt of 57% malathion EC/1000 bu.

The Angoumois grain moth, *Sitotroga cerealella* (Olivier), is an important pest of corn, rice, and wheat, especially in the southern part of the United States. However, relatively little toxicological information is available regarding the control of this insect except for that compiled from tests with malathion and synergized pyrethrum that were not designed to evaluate the effectiveness of these materials on grain already infested with the moth. Therefore, a test was conducted to investigate the effectiveness of bulk-lot protective treatments of grain to eliminate an indigenous infestation of the Angoumois grain moth and prevent reinfestation.

MATERIALS AND METHODS.—Yellow shelled corn that had been stored in an elevator bin from harvest until early December was used. Two generations of the Angoumois grain moth had developed in the grain during this period. The corn was then cleaned with a Clipper® cleaner, and at that time, the moisture content averaged 13.4%.

Malathion was used as the standard treatment for comparison and was applied as a water emulsion spray prepared from premium grade 57% malathion EC (5 lb AI/gal) for a dose of 1 pt EC/1000 bu. All emulsions were applied with a ULV atomizing spray assembly (LaHue 1969) modified with high volume fluid and air nozzles that delivered 5 gal finished spray/1000 bu. Pirimiphos methyl (5 lb AI/gal) was applied at the rate of 0.75 pint/1000 bu; chlorpyrifos-methyl (2 lb AI/gal) at 1.5 pint/1000 bu, and fenitrothion (8 lb AI/gal) at 0.5 pint/1000 bu. Also, a dust, hereafter referred to as M + K dust, was formulated for an application of 1 pt malathion EC in 60 lb of a diatomaceous earth (Kenite® 2-I)/1000 bu corn.

All materials were applied to 2-bu lots of corn in 55 gal steel barrels as they were rolled at 16 rpm for 10 min on a barrel roller. Immediately after 2 such lots were treated, and 4 bu of treated corn were placed in 5-ft³ uncovered fiber drums (bins) for storage. After all bins were filled to within 2 in. below the top, the surface of the grain was leveled so that each bin had an equal area available for insect entry. The 4 replications of each treatment, and the 4 check bins (untreated corn) were stored in a 17×22-ft room maintained at 26.4±1°C and 60±5% RH.

Immediately after the corn was cleaned and before it was treated, samples were taken to determine the uniformity and extent of the initial infestation and for a separate study of the life history of this (native) strain of the moth. These studies of the life cycle, fecundity, and egg viability were conducted in the storage room so we could establish whether the conditions in the room were favorable for Angoumois grain moth development.

The grain was held in storage for 8 mo. Each month, counts were made of adult moths that were on the surface of the corn in each bin and on the bin walls. Then the bin (drum) lids were put on for 48 h and counts were made again when lids were removed. Corn samples for determination of residue were taken each month by probings made directly after the counts of the adults. After 8 mo storage, samples taken by probing and also from the surface 2 in. of corn were used to determine the extent of the infestations and the amount of damage that the larvae had done to the kernels.

RESULTS.—Adults were seen emerging from the untreated check bins 4 days after the test was begun, but none were observed emerging from any of the treated bins during the 1st 3 mo of storage. Dissection of kernels collected immediately after cleaning the source corn showed that 1.17% were infested with live Angoumois grain moth larvae. Also, the average initial emergence of 140 adults/4000 g of infested untreated corn indicated that ca. 95.9% of the larvae were developing to adults. During the storage period, counts of all resting and flying adults showed that sufficient numbers were always present to infest the corn (Fig. 1).

Life studies in the storage room revealed that the moths were continually emerging from infested, untreated corn and that a continuous overlap of generations occurred for nearly the entire 8 mo. From 26–37 days were required to complete the life cycle of the moths, with an average of 30.2 days. However,

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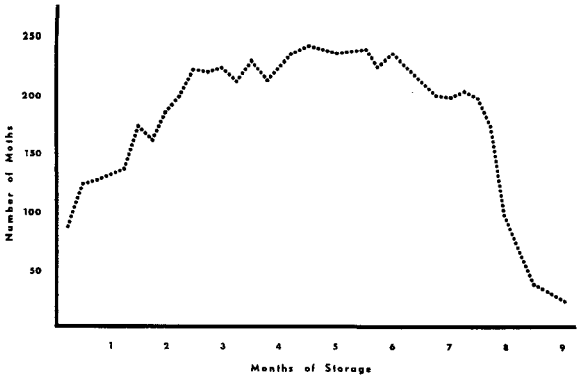


FIG. 1.—Average number of resting and flying Angoumois grain moth adults in storage room; counts made every 7 days.

by the end of the 8-mo storage period, moth populations were beginning to decline very rapidly, apparently because the corn in the check bins, which had been the main source of the emerging populations, was now heavily infested with the red flour beetle *Tribolium castaneum* (Herbst), confused flour beetle *T. confusum* Jacquelin duVal, and foreign grain beetle *Ahasverus advena* (Waltl). There were lesser populations of *Cryptolestes* spp., rice weevil, *Sitophilus oryzae* (L.), and granary weevil, *S. granarius* (L.). Parasitic insects and predaceous mites were not a problem.

Table 1 reports the number of live Angoumois grain moths in the bins of corn from 4–8 mo after treatment. No live moths were found in any treated bin during the 1st 3 mo of storage. All 5 materials were effective in controlling the indigenous infestation and preventing reinfestation by the Angoumois grain moth for 8 mo. After 8 mo, the percentages of damaged kernels of corn (with moth exit holes) from the different treatments were as follows:

| Insecticide | Avg % damaged kernels from: Surface sample | Probled sample |
|---|---|---|
| Malathion | 1.97 | 1.51 |
| Pirimiphos methyl | 1.55 | 1.23 |
| Fenitrothion | 1.92 | 1.56 |
| Chlorpyrifos-methyl | 1.65 | 1.31 |
| M + K dust | 1.34 | 1.22 |
| Check | 32.75 | 14.14 |

The loss in kernel weight due to feeding by Angoumois grain moth larvae varies with the ratio between the size of the kernel and the amount eaten by the larvae infesting it. In the present test, I recorded losses ranging from 11.9–25.2% and averaging 17.2%, caused by 1 larvae/kernel in corn containing 12.5% moisture. These data agree with those of Back (1929) who also determined that 56.2% of a wheat kernel could be destroyed by 1 larva.

Since the average weight for an undamaged corn kernel was found to be 0.32 g, the calculated weight loss for composited samples from each treatment and percentage increase in kernel infestation during 8 mo of storage were as follows:

| Insecticide | Avg % weight loss | % increase in kernel infestation |
|---|---|---|
| Malathion | 0.42 | 0.40 |
| Pirimiphos methyl | 0.25 | 0.12 |
| Fenitrothion | 0.43 | 0.41 |
| Chlorpyrifos-methyl | 0.30 | 0.16 |
| M + K dust | 0.14 | 0.07 |
| Check | 6.44 | 18.01 |

**Table 1.—Infestation of adult Angoumois grain moths in bins from 4 to 8 mo after treatment of corn with protectants.[a]**

| Insecticide and intended dose—p/m | No. of live moths in bins at indicated month after treatment: 4 Open[b] | 4 Closed[c] | 5 Open[b] | 5 Closed[c] | 6 Open[b] | 6 Closed[c] | 7 Open[b] | 7 Closed[c] | 8 Open[b] | 8 Closed[c] |
|---|---|---|---|---|---|---|---|---|---|---|
| Malathion 11.2 | 0.8 | 0 | 0.8 | 0 | 0.5 | 0.3 | 1.5 | 1.0 | 1.5 | 1.3 |
| Pirimiphos methyl 8.4 | 1.0 | 0 | 0.8 | 0 | 1.8 | 0.3 | 2.5 | 0.8 | 1.3 | 0.3 |
| Fenitrothion 8.9 | 1.3 | 0.8 | 2.5 | 0.8 | 1.8 | 3.0 | 1.8 | 3.0 | 3.0 | 1.5 |
| Chlorpyrifos-methyl 6.7 | 1.5 | 0 | 0.8 | 0 | 2.5 | 0 | 3.0 | 0.3 | 2.5 | 0.3 |
| M + K dust 11.2 | 1.3 | 0 | 1.3 | 0 | 1.5 | 0 | 1.8 | 0 | 2.0 | 0.3 |
| Check 0.0 | 26.8 | 357.8 | 23.8 | 441.5 | 18.5 | 291.0 | 18.0 | 212.3 | 12.3 | 62.5 |

[a] Avg per bin (4 replications).
[b] Moths on surface of grain and resting on inside exposed bin walls.
[c] After bin was covered for 48 h to confine emerging adults.

Table 2.—Residues in p/m on shelled corn during 8 mo of storage.[a]

| Insecticide and intended dose—p/m | Residues at indicated times | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 24 h | 1 mo | 2 mo | 3 mo | 4 mo | 5 mo | 6 mo | 8 mo |
| Malathion 11.2 | 7.3 | 4.5 | 4.3 | 4.1 | 3.0 | 3.2 | 3.0 | 2.3 |
| M + K dust 11.2[b] | 7.7 | 6.8 | 6.0 | 5.8 | 4.6 | 5.0 | 5.3 | 4.0 |
| Pirimiphos-methyl 8.4 | 7.9 | 6.3 | 6.7 | 4.5 | 4.3 | 4.0 | 4.1 | 4.0 |
| Fenitrothion 8.9 | 6.2 | 4.8 | 4.2 | 3.4 | 2.2 | 2.1 | 1.7 | 1.5 |
| Chlorpyrifos-methyl 6.7 | 6.1 | 5.0 | 4.8 | 4.0 | 3.2 | 2.5 | 2.3 | 1.9 |

[a] Avg of 4 replications.
[b] Malathion residue.

Damage to the untreated kernels of corn was considerable, with a range of 4.48–10.62% loss in weight and increases of 16.16–23.14% in kernel infestation. However, all treatments gave excellent protection, and differences between the treatments were not significant.

Table 2 gives residues found when samples of corn from each bin were analyzed by GLC with a Tracor® Model MT-220. Malathion residues on corn treated with the dust formulation degraded more slowly than those on corn treated with the emulsion since ca. 36 and 21%, respectively, remained on the corn after 8 mo storage. Pirimiphos methyl degraded more slowly than any of the other materials as 47.8% remained on the corn when the test was terminated.

Discussion.—Indigenous infestations of the Angoumois grain moth were controlled by 5 protectants, and the residues that persisted on the grain prevented reinfestation for at least 8 mo. The 4 candidate protectants gave control and protection equal or superior to the presently recommended dose of malathion. They are therefore promising replacements should a number of stored-grain insect species become resistant to malathion residues.

## REFERENCES CITED

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