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A PRELIMINARY STUDY WITH MALATHION AEROSOLS APPLIED WITH A CORN DRYING SYSTEM FOR THE CONTROL OF INSECTS[1, 2]

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ABSTRACT

One 96.5 metric ton lot (3800 bu.) of shelled corn 3.8 m deep stored in a circular metal drying bin was treated with a thermally-generated malathion aerosol.

Ninety-eight percent of the insects placed in test cages through the grain mass were killed, and all the insects that occurred naturally in the corn were killed. Red flour beetles, *Tribolium castaneum* Herbst, exposed to samples of the treated corn had an average of 81% mortality and all rice weevils, *Sitophilus oryzae* L. similarly exposed were killed. The ability of each species to reproduce was reduced ca. 99%.

Malathion residues were recovered at all points within the grain mass, but more was found in the surface areas and near the floor than in the center.

Key Words: Aerosol, malathion, red flour beetle, rice weevil, corn, drying system

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

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Malathion (*O,O*-dimethyl phosphorodithioate of diethyl mercaptosuccinate), which is widely used to control insects attacking stored grains, may be applied as a spray to bin walls and floors, to the grain surface, or directly as a protectant to the entire grain mass as it is being moved into storage. Currently an experimental method of applying protectants has been studied with thermally-generated insecticides aerosols that are pulled and/or pushed into the grain mass with air movement created by grain aeration fans or with a drying system. The advantage to this type of treatment is that the grain need not be moved and it may be treated at any time. I (Quinlan 1972) demonstrated in an exploratory study in a flat storage structure that this aerosol treatment distributed lethal amounts of malathion through aerated shelled corn to depths of 3.05 m. I (Quinlan 1979) also showed that surface areas of corn could be treated with malathion aerosol if it was used in conjunction with a vertical aeration system. The following exploratory study was undertaken using a drying system that distributed the insecticide to greater depths (3.8 m) by using a higher and more even airflow rate than was used in the previous studies. This study was not conducted for recommendation purposes but was exploratory to determine if more studies are justified.

PROCEDURE

The corn drying system consisted of a 142.2 metric ton (5600 bu.) capacity, steel circular bin (6.4 m in diameter and 5.8 m high) equipped with a perforated false floor and a drying fan (0.61 m diam) powered with a 7.5-hp electric motor. Static pressure readings were taken at 0.61 m intervals within the grain mass and converted to airflow rates by utilizing charts published by Shedd (1953).

The bin contained ca. 96.5 metric ton (3800 bu) of corn. The corn moisture content ranged from 15.1 to 16.2% and averaged 15.6% ± 5%. The corn had been cleaned before being placed in storage and contained foreign material (0.3 - 1.2% by wt) evenly dispersed through the grain mass. The grain temperature ranged from 26.6 C to 34.4 C and averaged 30.8 C ± 4 C.

The thermal aerosol generator was a Dyna Fog® Model 150-B that delivers 15 gallon of formulation per hour at the number 10 setting. It employed the resonant pulse principle to cause hot gases to flow at high velocity. The aerosol generator was operated at setting number three during the grain treatment and which produced particles of a mass median diam. of ca. 0.5 micron. The particle size determinations were made by a method I described (Quinlan 1975). The formulation used contained the following: malathion 96.0% (730 ml) and carbon tetrachloride (6,840 ml). This was sufficient to give a total applied dosage of 8.0 ppm malathion.

One-half of the aerosol formulation (3785 ml) was applied directly into the aeration system at the fan which forced the aerosol (Fig. 1) particles upward into the grain. Thirty minutes after this operation, the drying fan was reversed electrically, and the other half of the malathion was introduced into the overspace by putting the machine into the roof opening. Thus, the aerosol particles were pulled down into the grain mass. It required ca. 20 min to apply each treatment.

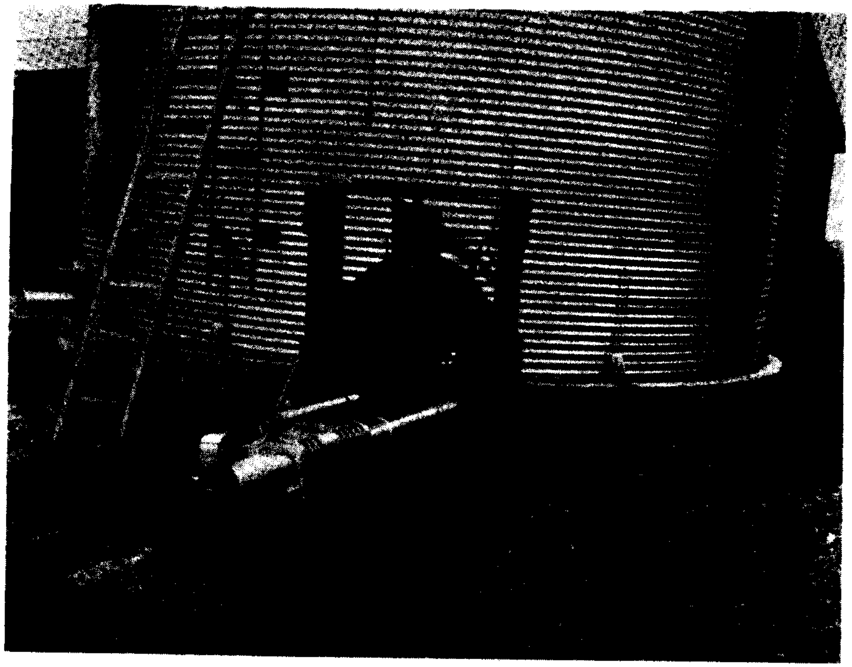

Fig. 1. – Thermal aerosol being introduced into the drying system.

Before treatment, screened insect test cages containing 50 adult red flour beetles, *Tribolium castaneums,* (Herbst) and 50 adult rice weevils, *Sitophilus oryzae* (L.) were placed at 0.61 m intervals between the surface of the corn and the floor, at the center; half way between the center and the bin wall and 0.6 m from the bin wall. The cages were placed in a perforated pipe which was threaded to a 0.32 cm hollow standard pipe which also served as a static pressure probe.

Samples of the shelled corn were drawn before the 1st treatment to determine natural insect populations present, moisture content, and foreign material and use in bioassay. Samples were also taken for bioassay and for determination of residues immediately after each treatment. The residue samples were held at room termperature for 2 weeks before analyses. The sampling procedure was as follows: a 1.22 m grain trier equipped with extension and handle was used to take samples from the top 1.22 m of grain, the middle 1.22 m, and the bottom 1.22 m at the points where the cages of insects were located. The 450-gram samples were placed in plastic-lined envelopes and taken to the laboratory for evaluation. There the species and number of living and dead insects were noted and recorded. The moisture content was determined by Motomco®Model 919 moisture meter, and the amount of foreign material present was determined by weighing.

Insects used in the bioassays were adult rice weevil 14-21 days old that had been reared in the laboratory on hard red winter wheat (12.5% moisture) or red flour beetles 14-21 days old that had been reared in a medium of flour, cracked wheat and brewer's yeast, 10:50:1.5 parts by volume, respectively. Fifty such insects were placed on 250 g of the test corn in a 473-ml jar having a lid fitted with a 40-mesh screen and filter paper. After 3 weeks, the adult insects were removed, mortality counts were made, and the jars of corn were retained for an additional 42 days to determine numbers of F_1 progeny. During exposure and incubation, the jars of corn were stored in the insect rearing room held at 60% RH and 26 ± 1 C.

Samples of corn were analyzed for residues of malathion by chemists at the Stored Products Insects Research and Development Laboratory, Savannah, GA.

RESULTS AND DISCUSSION

The air flow rate was found to be 1.8 cfm/bu when the fan was pulling and 2.4 cfm/bu when it was pushing.

Live sawtoothed grain beetles, *Oryzaephilus surinamensis* (L) were found in the samples of corn before it was treated (0.5 insects/1000 g or corn), and no live insects were found after treatment.

Most of the insects in the test cages were killed by the two treatments (pushing and pulling). In two test cages located 0.61 m from the bin wall, the mortality of red flour beetles was 68 and 88% in the cages at the surface and at 0.6 m depth, respectively. All rice weevils were dead.

Insect mortality, progeny, and residue information from the samples exposed in the laboratory are shown in Table 1. After the 1st treatment, the mortality of insects confined in the corn samples and the residues of malathion indicated that most of the malathion was in the bottom areas of the grain mass where it was applied. In the upper areas there was not enough malathion to inhibit reproduction or to produce a high mortality of the rice weevil and flour beetle. The highest residue (0.8 - 1.0 ppm) was found in the lower 1.22 m of corn close to the point where the aerosol was introduced into the grain.

The 2nd treatment produced an average of 81% mortality among the red flour beetles, but the rice weevils were killed. Reproduction of both species after the 2nd treatment was low as only two flour beetles and 17 rice weevils were found in the samples. However, the malathion residues were low within the grain mass; an average of only ca. 10% of the amount applied was recovered. The reasons for this low recovery is not known. However, the aerosol was applied at a high airflow rate (ca. 2.0 cfm/bu). Some of the aerosol was observed coming out the fan when it was pulling, and some came out of the roof top when the fan was pushing. Also, there probably was decomposition of the malathion because of the high temperatures (ca. 610 C) of the thermal aerosol generator. In addition, the corn moisture and temperature was also high and under these conditions decomposition of malathion is rapid (Strong 1960). Also the corn samples were kept at ca. 80 F for 2 weeks before analyses. These three factors together probably explain, at least in part, the low malathion residues.

This preliminary study provides interesting points for the consideration of

Table 1. – Mortality (M) and F_1 progeny (P) of red flour beetle (RFB) and rice weevil (RW) and residues collected before and after treatment of shelled corn with a malathion aerosol. Insects were exposed to samples of corn held in the laboratory.

Location in bin	Before treatment RFB M(%)	P(no)	RW M(%)	P(no)	After 1st treatment RFB M(%)	P(no)	RW M(%)	P(no)	Malathion residues[1] (ppm)	After 2nd treatment RFB M(%)	P(no)	RW M(%)	P(no)	Malathion residues[1] (ppm)
Center														
Top[2]	0	43	0	396	22	1	100	27	0.4	100	0	100	0	1.8
Mid.	0	34	0	420	88	0	100	2	0.6	100	0	100	0	0.7
Bott.	0	29	0	349	100	0	100	1	0.8	100	0	100	0	1.2
½ way between center and bin wall														
Top	0	67	0	547	0	33	2	427	0.3	100	0	100	0	0.8
Mid.	0	40	0	520	2	1	90	69	0.4	36	0	100	8	0.4
Bott.	0	44	0	306	78	0	100	1	1.0	92	0	100	0	1.0
.61 m from bin wall														
Top	0	70	0	579	2	57	2	431	0.4	48	2	100	7	0.4
Mid.	0	71	0	513	2	5	62	149	<0.2	74	0	100	2	0.2
Bott.	0	72	2	464	72	1	100	2	0.8	82	0	100	0	0.8

[1] Corn samples taken before treatment indicated no malathion was present.
[2] 1.22m (4 ft).

future detailed research studies. One application of an aerosol protectant that would reduce an existing infestation in grain would be decidedly helpful in maintaining grain quality. Also, the application of a protectant could be made at any time after the grain is binned which would give the grain handler considerable flexibility in choosing a time of treatment. However, subsequent aerosol application might be more practical if they were made with pressurized disposable aerosol cans, which would be more convenient and less expensive than the aerosol generator and also would not expose the malathion to the high temperature of the thermal generator.

There is a great deal to learn about aerosol applications to stored grain. Aerosol particle size, airflow rate, foreign material, type of commodity, moisture content of commodity, uniformity of airflow, temperature of commodity, depth of commodity, the degree that the commodity is packed, tightness of storage structure, insecticide and type of formulation all may influence aerosol effectiveness. Some of these factors are now being studied under controlled laboratory conditions. However, the majority of the insecticide was deposited on the areas closest to the points where the aerosol entered the grain. This may be an advantage because the grain surface and the aeration duct are usually important points of entry for stored-grain insects, and these areas are usually where the heaviest infestations are located.

ACKNOWLEDGMENT

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