Controlling Red Flour Beetle

KSU, Purdue, USDA-ARS study examines three treatment methods.

Researchers at Kansas State University (KSU), Purdue University, and the U.S. Department of Agriculture's (USDA) Grain Marketing and Production Research Center in Manhattan received an integrated grant from the USDA last year to determine the cost effectiveness of three basic treatments: methyl bromide (MB), sulfuryl fluoride (SF), and heat treatment for managing insects associated with grain and food processing facilities.

Pest Management

Dr. Bhadriraju Subramanyam

The researchers involved included:Bhadriraju Subramanyam, Dirk Maier, Wat Chayaprasert, and Michael Langemeier from KSU; Linda Mason from Purdue University, West Lafayette; and James Campbell and Paul Flinn from the USDA-ARS Grain Marketing and Production Research Center, Manhattan, KS.

The initial research involved evaluating the three treatments in KSU's state-of- the-art Hal Ross flour mill.

This unique facility offers the ability to do a side-by-side comparison of all three pest intervention methods within a given month.

In the real world, such side-by-side comparisons are difficult, because whole facility treatments usually occur on major holidays, and only one of the three methods is used at any given time.

Therefore, comparing one method to the other in such circumstances can lead to misleading conclusions.

In May 2009, all three methods were tested in the Hal Ross flour mill for their ability to control all life stages of the red flour beetle.

Insect Bioassay Boxes

The Hal Ross flour mill opened in October 2006 and is a clean facility with little or no infestations.

In order to gauge the effectiveness of MB, SF, and heat, we designed a bioassay box with 12 compartments (see photo).

Eggs, young larvae, old larvae, pupae, adults of the red flour beetle (a major pest in the food industry), and a temperature sensor were used. In these boxes, two levels of sanitation were simulated— one compartment with a dusting of flour, and the other with flour at 2 cm deep.

Boxes with life stages were placed in 25 locations in the mill and across all five floors. In each compartment, there were 50 individuals of a life stage.

Pest Intervention Methods

The mill was treated with MB during May 6-7, 2009, with heat from gas heaters during May 13-15, and with SF during May 27-28.

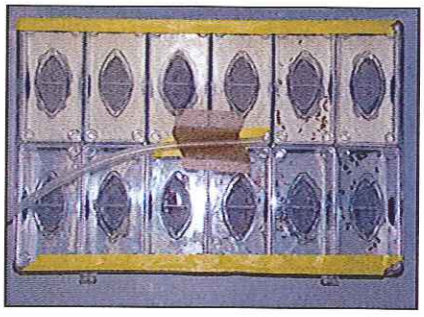
Each of these treatments lasted 24 hours. The MB and SF gas monitoring lines were placed near the bioassay boxes where gas concentrations could be measured continuously over time.

Temperatures were monitored in at least more than 40 locations during the heat treatment.

Pest Mortality Assessment Methods

After the treatments, the boxes were brought back to the laboratory. Boxes containing, eggs, young larvae, old larvae, and pupae were transferred to 150 ml round plastic containers with flour.

The containers were closed with lids, and these containers were labeled and placed in growth chambers at 28 degrees C and 65% relative humidity until adult emergence.



Insect bioassay box showing the 12 compartments with dusting and 2 cm deep flour.

Mortality was based on the number of adults that emerged out of the total that had been exposed to the treatments.

The adults were not transferred to boxes but were examined after 24 hours to determine mortality.

Research Results of May Treatments

The initial, ambient temperatures during all three treatments inside the mill ranged from 22 to 26 degrees C, and the humidity ranged from 34% to 50%.

The Hal Ross mill is a tight building, and the half-loss time during the MB fumigation ranged from 10 to 111 hours, and during the SF fumigation it was approximately 20 hours.

A total of 181.4 kg of MB and 567 kg of SF were used.

The CT product—or concentration multiplied by time—at the locations monitored for MB ranged from 283 to 327 gram-hours per cubic meter.

For the SF treatment, it ranged from 923 to 1,191 gram-hours per cubic meter.

During the heat treatment in boxes with a dusting of flour, it took from 9 to 22 hours for temperatures to reach 50 degrees C.

In a majority of the locations, the time it took to reach 50 degrees C was from 12 to 22 hours, which indicated a slow heating rate. The temperature was above 50 degrees C for about two to 15 hours. The maximum temperatures attained ranged from 42 to 67 degrees C.

The time required to reach 50 degrees C took from one to five hours longer than in boxes with a dusting of flour, and therefore the time above 50 degrees C was reduced correspondingly. The maximum temperatures attained ranged from 43 to 63 degrees C.

The mortality of all life stages in similar containers placed in the laboratory at 28 degrees C and 65% humidity was less than 10%.

The MB treatment killed 100% of all stages in the boxes placed at the 25 locations, irrespective of flour depth in compartments.

The heat treatment killed 100% of the eggs, young larvae, old larvae, and adults in all of the locations, except in one to seven locations where the temperatures took too long (more than 10 hours) to reach 50 degrees C, or where temperatures never reached 50 degrees C.

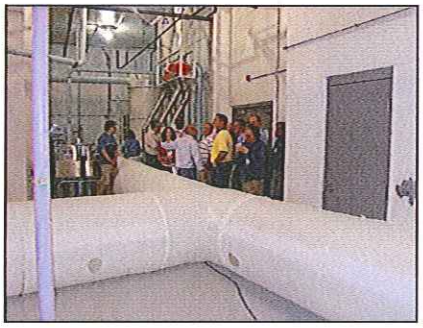
The mortality in these locations ranged from 0% to 98%, and higher mortalities were common, while lower mortalities in test boxes were rare.

The pupal mortality was 100% in 23 of the 25 locations, and in two locations it was slightly less than or equal to 98%.

In some locations, the life-stage survival rate of the red flour beetle is purely a result of not attaining lethal temperatures (>50 degrees C) in 10 hours or less.

On August 25-26, 2009, another heat treatment was conducted at the Hal Ross mill, and in all 25 locations temperatures of 50 degrees C were reached within 15 hours. The lessons learned from the first treatment helped insure a better second treatment.

SF killed100% of all stages, except the eggs because of underdosing. In compartments with flour dusting, egg mortality in 23 locations (one location had a missing value) was 60% to 98%, and in one location on the third floor, egg mortality was 100%.



Heat treatment workshop at Hal Ross mill provided hands-on information to participants.

In compartments with 2 cm deep flour (in 24 of 25 locations), egg mortality was 42% to 96%, with one location on the fourth floor showing 100% mortality.

More Results to Come

Another set of treatments was conducted this August, and a third treatment is planned for next year.

These preliminary results are not conclusive; they constitute data from just one out of the three replications that we plan to complete and summarize.

> The lessons learned from the first treatment helped insure a better second treatment.

During the May testing period, a heat treatment workshop was held, and during the August treatment a SF workshop was held to provide practical hands-on information to participants.

Pictures and information from these workshops are available at: *www.oznet.ksu.edu/grsc_subi/*. Click on Conferences/Workshops.

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The results of the three treatments in the study are shown on pages 24/25. ▶

Heat treatment: % mortality of red flour beetle life stages (n = 1) (May13-15, 2009)

Box no. (Floor)	Eggs (Dust)	Eggs (2 cm)	Young larvae (Dust)	Young larvae (2 cm)	Old larvae (Dust)	Old larvae (2 cm)	Pupae (Dust)	Pupae (2 cm)	Adults (Dust)	Adults (2 cm)
1(1F)	100	100	100	100	98	100	100	100	100	100
2 (1F)	100	100	100	100	100	71	100	98	100	4
3 (1F)	94	80	90	24	0	0	0	17	0	2
4 (1F)	100	100	100	100	100	98	98	100	100	98
5 (1F)	100	100	100	100	100	100	100	100	100	100
6 (2F)	100	100	100	100	100	100	100	100	100	100
7 (2F)	100	100	100	100	100	100	100	100	100	100
8 (2F)	100	100	100	100	100	100	100	100	100	100
9 (2F)	100	100	100	100	100	100	100	100	100	100
10 (2F)	100	100	100	100	100	100	100	100	100	100
11 (3F)	100	100	100	100	100	100	100	100	100	100
12 (3F)	100	100	100	100	100	100	100	100	100	100
13 (3F)	100	100	100	100	100	100	100	100	100	100
14 (3F)	100	100	100	98	100	96	100	100	100	100
15 (3F)	100	100	100	100	100	100	100	100	100	100

Heat treatment: %mortality of red flour beetle life stages (n = 1) (May13-15, 2009)

Box no. (Floor)	Eggs (Dust)	Eggs (2 cm)	Young larvae (Dust)	Young larvae (2 cm)	Old larvae (Dust)	Old larvae (2 cm)	Pupae (Dust)	Pupae (2 cm)	Adults (Dust)	Adults (2 cm)
16 (4F)	100	100	100	100	100	100	100	100	100	100
17 (4F)	100	100	100	100	100	98	100	100	100	100
18(4F)	100	100	100	100	100	100	100	100	100	100
19 (4F)	100	100	100	100	100	100	100	100	100	100
20 (4F)	100	100	100	100	100	100	100	100	100	100
21 (5F)	100	100	100	94	100	95	100	100	100	100
22 (5F)	100	100	100	100	98	100	100	100	100	100
23 (5F)	100	100	100	100	96	100	100	100	100	100
24 (5F)	100	100	100	100	100	100	100	100	100	100
25 (5F)	100	100	100	100	100	100	100	100	100	100

Methyl bromide fumigation: % mortality of red flour beetle life stages (n = 1)

Box no. (Floor)	Eggs (Dust)	Eggs (2 cm)	Young larvae (Dust)	Young larvae (2 cm)	Old larvae (Dust)	Old larvae (2 cm)	Pupae (Dust)	Pupae (2 cm)	Adults (Dust)	Adults (2 cm)	Gas Conc. (gh/m³)
1(1F)	100	100	100	100	100	100	100	100	100	100	300
2 (1F)	100	100	100	100	100	100	100	100	100	100	309
3 (1F)	100	100	100	100	100	100	100	100	100	100	327
4 (1F)	100	100	100	100	100	100	100	100	100	100	335
5 (1F)	100	100	100	100	100	98	100	100	100	100	321
6 (2F)	100	100	100	100	100	96	100	100	100	100	326
7 (2F)	100	100	100	100	100	98	100	100	100	100	315
8 (2F)	100	100	100	100	100	100	100	100	100	100	317
9 (2F)	100	100	100	100	100	100	100	100	100	100	314
10 (2F)	100	100	100	100	100	100	100	100	100	100	315
11 (3F)	100	100	100	100	100	96	100	100	100	100	324
12 (3F)	100	100	100	100	100	100	100	100	100	100	338
13 (3F)	100	100	100	100	98	100	100	100	100	100	327
14 (3F)	100	100	100	100	100	100	100	100	100	100	344
15 (3F)	100	100	100	100	100	100	100	100	100	100	331

Methyl bromide fumigation: % mortality of red flour beetle life stages (n = 1)

Box no. (Floor)	Eggs (Dust)	Eggs (2 cm)	Young larvae (Dust)	Young larvae (2 cm)	Old larvae (Dust)	Old larvae (2 cm)	Pupae (Dust)	Pupae (2 cm)	Adults (Dust)	Adults (2 cm)	Gas Conc. (gh/m³)
16 (4F)	100	100	100	100	100	100	100	100	100	100	334
17 (4F)	100	100	100	100	100	100	100	100	100	100	330
18(4F)	100	100	100	100	100	100	100	100	100	100	330
19 (4F)	100	100	100	100	100	100	100	100	100	100	344
20 (4F)	100	100	100	100	100	96	100	100	100	100	338
21 (5F)	100	100	100	100	100	100	100	100	100	100	330
22 (5F)	100	100	100	100	100	100	100	100	100	100	320
23 (5F)	100	100	100	100	100	100	100	100	100	100	330
24 (5F)	100	100	100	100	100	100	100	100	100	100	317
25 (5F)	100	100	100	100	100	100	100	100	100	100	320

Sulfuryl fluoride fumigation: % mortality of red flour beetle life stages (n = 1)

Box no. (Floor)	Eggs (Dust)	Eggs (2 cm)	Young larvae (Dust)	Young larvae (2 cm)	Old larvae (Dust)	Old larvae (2 cm)	Pupae (Dust)	Pupae (2 cm)	Adults (Dust)	Adults (2 cm)	Gas Conc. (gh/m³)
1(1F)	MV	70	100	100	100	100	100	100	100	100	1163
2 (1F)	60	62	100	100	100	100	100	100	100	100	1152
3 (1F)	70	74	100	100	100	100	100	100	100	100	1050
4 (1F)	80	70	100	100	100	100	100	100	100	100	1151
5 (1F)	68	42	100	100	100	100	100	100	100	100	1129
6 (2F)	74	60	100	100	100	100	100	100	100	100	1089
7 (2F)	84	72	100	100	100	100	100	100	100	100	1082
8 (2F)	98	82	100	100	100	100	100	100	100	100	1084
9 (2F)	98	82	100	100	100	100	100	100	100	100	1081
10 (2F)	70	80	100	100	100	100	100	100	100	100	1090
11 (3F)	86	96	100	100	100	100	100	100	100	100	1059
12 (3F)	92	84	100	100	100	100	100	100	100	100	1050
13 (3F)	92	90	100	100	100	100	100	100	100	100	1070
14 (3F)	100	96	100	100	100	100	100	100	100	100	1273
15 (3F)	94	88	100	100	100	100	100	100	100	100	1057

Sulfuryl Fluoride Fumigation: % mortality of red flour beetle life stages (n = 1)

Box no. (Floor)	Eggs (Dust)	Eggs (2 cm)	Young larvae (Dust)	Young larvae (2 cm)	Old larvae (Dust)	Old larvae (2 cm)	Pupae (Dust)	Pupae (2 cm)	Adults (Dust)	Adults (2 cm)	Gas Conc. (gh/m³)
16 (4F)	88	82	100	100	100	100	100	100	100	100	1182
17 (4F)	94	88	100	100	100	100	100	100	100	100	1176
18(4F)	94	100	100	100	100	100	100	100	100	100	1128
19 (4F)	92	92	100	100	100	100	100	100	100	100	1208
20 (4F)	86	86	100	100	100	100	100	100	100	100	1197
21 (5F)	84	90	100	100	100	100	100	100	100	100	1176
22 (5F)	82	82	100	100	100	100	100	100	100	100	1133
23 (5F)	96	94	100	100	100	100	100	100	100	100	1210
24 (5F)	78	90	100	100	100	100	100	100	100	100	1183
25 (5F)	92	94	100	100	100	100	100	100	100	100	1189