Hot Technology for Killing Insects [part II]

Catalytic infrared heaters effective on insects developing in stored wheat

In part one of this article, which appeared in the first quarter 2004 *Milling Journal* (pp. 48-50), I described a new method for disinfesting grains using flameless catalytic infrared heaters. In this column, I present new data—not only for killing external stored-product insects but also for internal stored-product insects in stored wheat.

Pest Management

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In the present tests, we used both a benchtop infrared source and a commercial infrared source.

Benchtop Model Tests

The benchtop model of the flameless catalytic heater has a circular heating surface of 613.4 cm^2 (27.94 cm diameter) that produces infrared energy in the 3 to 6 micrometer range using propane gas. Temperature across the heater surface, measured at 13 points using an infrared thermometer (Raytek® Ranger® MX4TM, Santa Cruz, CA), ranged from 356.3 to 474 degrees C. The propane gas pressure was 27.94 cm of water column (0.4 psi), and the total heat energy output of the unit was 1.47 kilowatt hours (kwh) (5,000 BTU/hour).

Hard red winter wheat of 12% moisture was infested with 25 unsexed, 2-week-old adults of the red flour beetle taken from laboratory cultures reared at 28 degrees C and 65% relative humidity (RH). The three factors examined were: quantity of grain (113.5, 227, 340.5, and 454 grams), distance from the heater (12.7 and 25.4 cm), and exposure time (30, 45, and 60 seconds).

Each quantity of grain, distance from the heater, and exposure time combination was replicated three times. Grain temperature during exposure was measured continuously using the infrared thermometer connected to a laptop computer via a RS232 cable. The thermometer works in the 8-to-14-micrometer range and has a response time of 250 msec with an accuracy of ± 1 degree C. An emissivity of 0.95, typical for organic materials, was used.

Calibration of the infrared thermometer with mercury thermometer indicated that the infrared thermometer readings were as accurate as those obtained with a mercury thermometer. Temperatures were averaged every second over the exposure to obtain a single value for each replication.

Table 1. Commercial Tests with Adults of Four Stored-Product Insects

Species	Temp Range (°C)	Total No. Adults	% Mortality
Red Flour Beetle	64-82	200	100
	57-71	1554	99.6
Rice Weevil	41-77	200	100
Merchant Grain Beetle	40-82	2002	100
Lesser Grain Borer	57-71	2034	98.9
	63-76	2707	100

Grain was exposed in a 27.94-cm-diameter stainless steel pan in a single layer. After exposure to infrared energy, the grain sample with insects was placed in 0.94-liter glass jar with mesh lid. After 24 hours, the grain was sieved to count the number of live and dead insects. Percentage of mortality was calculated from the number of dead insects out of the total exposed.

The grain temperature increased with an increase in exposure time, as expected, and was highest at the lowest quantity of grain. Also, low grain quantities heated faster, as expected, compared to higher grain quantities. Grain at 12.7 cm from the heater heated faster than grain 25.4 cm from the heater.

Insect mortality was a function of temperature, which was affected by the distance from the heater, grain quantity, and exposure time. A temperature of 80 degrees C was required to kill all red flour beetle adults. USDA scientists R.L. Kirkpatrick and E.W. Tilton in their 1972 paper observed 99.6% mortality of red flour beetle adults when soft red winter wheat was exposed for 20 to 40 seconds, resulting in a grain temperature of 65.5 degrees C. The output of the heater they used was 48,000 BTU/hour as opposed to 5,000 BTU/hour in our study.

Although grain quantity at 12.7 cm or 25.4 cm from the heater source had little effect on grain temperatures attained, it influenced mortality of red flour beetle adults, because in small grain samples, the insects perhaps were heated to a higher temperature than the grain.

Commercial Tests

Tests were conducted with a commercial heater, which was 6.1 m (20 feet) long and 61 cm (2 feet) wide. Eight infrared heaters were used in the study. The distance between the slanted heater surfaces and a vibrating steel conveyor surface was 4.4 cm (1.7 inches) at the lowest point and 8.9 cm (3.9 inches) at the highest point. All eight heaters produced 216,000 BTU/hour.

The grain flow rate was 1,308 kg/hour (2,800 lb./hour). Natural gas was used to produce the infrared radiation, and the natural gas pressure was 0.13 psi. The grain was treated in a single layer and exposed for a total duration of 43 seconds. The amount of heat was regulated by increasing the gas pressure.

One end of the heater had a gate to dump grain, and the other had a barrel to collect grain exposed to the heaters. We exposed adults of the red flour beetle, rice weevil, merchant grain beetles, and lesser grain borers from laboratory cultures using wheat.

All beetles were examined 24 hours after exposure, and their mortality was assessed. The mortality of all the exposed species ranged from 98.9% to 100% (see Table 1). In another test, we infested wheat with lesser grain borers for three days, and the adults were removed, so that we could obtain immature stages of different ages developing internally.

This wheat was exposed to the infrared radiation and, after exposure, was brought to the laboratory and incubated in a growth chamber at 28 degrees C (82.4 degrees F) and 65% RH until the emergence of adults. Wheat infested similarly but unexposed to infrared radiation served as the control treatment.

Emergence of lesser grain borer adults in infrared-treated grain relative to unexposed grain was used to determine the degree of control (see Table 2). Reduction in adult lesser grain borer emergence was 98.8% to 100% in infrared treatments.

These results document that short exposures to infrared radiation (60 seconds or less) can be used to control stored-product insects developing internally or externally in stored wheat.

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Table 2. Emergence of Lesser Grain Borer Adults

Days Since Adult Infestation*	Emergence of Adults in Untreated Wheat (50 g)	Emergence of Adults in Infrared Exposed Wheat (50 g)	% Reduction Adult Emergence
18-22	17.2	0	100.0
13-17	84.1	1	98.8
7-11	60.3	0	100.0
2-6	42.1	0.1	99.8

*Wheat infested at different dates were pooled to obtain a range of infestation dates.