Hot Technology for Killing Insects

Infrared energy shows promise as a grain disinfestation tool

Occasionally, I get inquiries about new technologies and products for managing insects in grain storage and food processing facilities. Many advances have been made recently in the development or evaluation of new and effective products and technologies for management of stored grain insects.

These new developments include spinosad, Storicide, Diacon II, carbonyl sulphide, ozone, and ECO_2FUME.

Several companies and researchers are re-examining old technologies as alternatives to conventional pesticides. These old technologies never met commercial success, because they were not cost-competitive with conventional pesticides, which were quick acting and effective against a broad range of insects.

There is renewed interest in exploring, or at least modifying, some of the old technologies in light of the restrictions or phaseout of existing pesticides. The impetus for this interest can be attributed to strict federal regulations, consumers' concerns regarding pesticides in their diet, and perceived adverse effects of pesticides on the environment.

I am in favor of re-examining old technologies, especially if they are effective against insects and cost about the same as conventional pesticides. In this article, I will review and share some of my experiences about an old technology that may have great potential for managing insects in stored grain.

Pest Management

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The technology in question is the use of infrared energy for disinfesting grain. For readers who are unfamiliar with infrared energy, it is the electromagnetic energy that has a wavelength between 0.075 and 1,000 micrometers.

The wavelength of infrared energy is higher than that of visible light (380-750 nanometers) and less than that of microwaves (0.1-100 cm).

Past Tests With Infrared Energy

Like microwaves, grain and insects heat up by absorbing infrared energy or non-ionizing radiation.

Heat energy from infrared sources was tested by the U.S. Department of Agriculture (USDA) scientists to control grain insects in the early 1960s and '70s, although the first report in literature dates back to 1944.

Among the primary USDA scientists involved in evaluating infrared technology for grain disinfestation were R. L. Kirkpatrick, J. H. Brower, E. W. Tilton, and H. H. Vardell.

These scientists compared infrared with microwave radiation and found that infested grain exposed to infrared heated faster—and the insect control was better—than grain exposed to microwaves.

In their tests, the surface temperature of the infrared heaters was 1,699 degrees F, and these heaters produced a peak infrared emission at 2.5 micrometers.

Nearly 99.7% of rice weevils and 99.3% of lesser grain borers were killed by exposing soft red winter wheat to infrared heaters to obtain a grain temperature of 119.5 degrees F.

At this temperature, only 75% of immature rice weevils and 83% of immature lesser grain borers developing within kernels were killed, when grain was cooled soon after infrared exposure to 78.8 degrees F.

However, delaying cooling of grain exposed to infrared to 100 degrees F in 48 hours resulted in 99.8% and 93% mortality of immature rice weevils and lesser grain borers, respectively.

Generally, older life stages of the lesser grain borer and younger life stages of the rice weevil were highly susceptible to infrared radiation. Besides age, the susceptibility of insect species is also a function of how far the grain and insect samples are from the heaters, duration of exposure, heat intensity (pressure), and grain moisture.

For example, exposure for 5seconds of 200 grams of rough rice of 14% moisture at a distance of six inches from the infrared radiation source increased the rice

temperature to 107.8 degrees F. However, a 10- and 15-second expo- sure resulted in rice temperatures of 127.4 and 145.2 degrees F, respectively.

The ability of infrared radiation to kill immature lesser grain borers and rice weevils in rough rice was at commercial levels (greater than 95% dead), when the infested samples were 6 inches as opposed to 14 and 20 inches from the heater after 15 seconds of exposure.

Insect Mortality

Mortality of adults of three insect species exposed to flameless catalytic infrared heaters, January 12, 2004.

Insect species	Amount of food product (lb)	Exposure time (sec)	Product temperature (°F)	No. dead/ total	% dead
Sawtoothed grain beetle	0.25	10	113	21/100	21.0
	0.25	15	135	96/100	96.0
	0.25	15	140	100/100	100.0
	0.25	30	149	100/100	100.0
	0.25	30	156	95/100	95.0
Rice weevil	1.00	60	142	216/220	98.2
	0.50	30	140	254/254	100.0
Red flour beetle	0.50	30	142	268/268	100.0

Note: The material was placed in one square foot stainless steel holder, and during the exposure period was shaken to simulate what would happen on a vibrating conveyor. Three to four temperature measurements of the product were taken immediately after exposure to infrared heaters, and the highest reading is presented in the table. Rolled oats were used for the sawtoothed bettle test and paddy rice for the rice weevils and red flour beetle tests.

At short exposures (less than 30 seconds) to infrared radiation, the moisture content dropped by about 0.5% or less. Similar results were observed in tests with wheat.

The reduction in immature-to-adult emergence of both rice weevils and lesser grain borers was greater, when infested grain was subjected to infrared radiation under vacuum (25 mm Hg), as opposed to those subjected to infrared radiation at normal atmospheric pressure.

New Infrared Heaters

I recently came across an advertisement in a 2003 issue of *Milling Journal* on a new method of generating infrared energy using flameless catalytic technology (see www.catalyticdrying.com).

In this technology, infrared energy is generated when natural gas or propane is combined with oxygen in the presence of a heated catalyst (platinum). The resulting reaction releases infrared energy at wavelengths of 3 to 7 micrometers.

The surface temperatures of the infrared heaters are 700 to 800 degrees F, significantly lower than the ones tested by the USDA scientists.

Scientists at the University of Arkansas have been evaluating a benchtop model of the flameless catalytic infrared energy for killing immature stages of rice weevils

in small samples of rough rice.

The results are encouraging and show that exposures of 45 to 55 seconds to infrared energy, which resulted in grain temperatures of 140 or 158 degrees F, completely prevented emergence of adults from the infested kernels.

The main focus of the University of Arkansas scientists is to use this new technology for rice drying.

Catalytic Infrared Energy Exposure

I took cultures of three stored grain insects to the company that makes the flameless catalytic infrared dryers and exposed these insects in products for specific time periods to determine mortality.

A pilot scale infrared heater was used to expose infested products. Briefly, the test involved exposing unsexed adults of mixed ages of the sawtoothed grain beetle in one-fourth of a pound of rolled oats for 10, 15, or 30 seconds.

Rice weevil adults were exposed in one-half- and 1-pound lots of paddy rice for 30 and 60 seconds, respectively.

Red flour beetle adults were placed in a half-pound of paddy rice and exposed for 30 seconds. Infested samples were placed in a 1-ft.-x-1-ft. stainless steel holder with a handle.

Unlike tests conducted by USDA scientists, infested grain was shaken manually for specified time periods, to ensure exposure of all sides of the kernels to infrared energy. In addition, this shaking simulates exposure of kernels to infrared energy on a vibrating stainless steel conveyor.

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After the specified exposure time, temperature of the sample was taken using an infrared gun. The temperatures measured with the gun are approximate, and tend to provide a crude measure of temperatures attained by the infested samples.

A 10-second exposure of sawtoothed grain beetles resulted in a product temperature of 113 degrees F and produced only 21% mortality of adults (*see table, page 49*).

A 15- or 30-second exposure produced complete mortality of adults. All rice weevil adults were dead after 30 to 60 seconds of exposure, and all red flour beetle adults were killed after 30 seconds of exposure.

These preliminary findings are very encouraging, and additional replicated tests are planned to determine the effects of flameless catalytic infrared energy on various life stages of internal and external stored grain insects.

There were some conflicting reports in literature on the changes in the quality of flour from grains exposed to infrared energy, including effects on some rheological, and organoleptic properties.

Our ongoing tests, besides examining the adverse effects of infrared energy on insect pests, will also thoroughly evaluate the effects of this energy on the quality of exposed grain, primarily wheat, and quality of flour and flour products made from such grain.

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