HEAT TREATMENT OF EMPTY STORAGE BINS FOR CONTROL OF INSECTS AND MOLDS

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The contamination of high-value identity-preserved food and specialty grains (as well as conventional commodity grains and oilseeds) due to residual insect populations below the perforated floor (plenum) of corrugated steel farm bins (as well as tanks, silos and flat storage buildings at grain elevators) is a major concern of growers, handlers and processors. Empty bin treatment with residual protectants such as inert diatomaceous earth dusts (ProtectIT®) and cyfluthrin (Tempo®) products have shown limited success because of the inherent inaccessibility of the plenum area. Similarly, the dousing of the perforated drying floor with cyfluthrin spray generally does not result in a uniform drip-through application of the hidden concrete floor and bin sidewalls. Disassembling the floor before filling a bin in order to clean and treat the plenum area is a labor intensive and dangerous alternative. Fumigating under the floor is possible but is costly. Chloropicrin (or tear gas; Chlor-O-Pic®) has been the product of choice for under-the-floor fumigation of farm and elevator bins, but it is no longer available to licensed fumigators because the manufacturer (Great Lakes Chemical Company) will no longer allow shipment of small bottled product quantities through normal commercial channels (John Mueller, Fumigation Services & Supply, Personal Communication). The use of phosphine as the only other legal fumigant product is generally limited to grain applications rather than empty bin treatment. Due to resistance concerns, it is primarily reserved to the control of primary stored product insect outbreaks above the economic threshold level in the grain mass. Therefore, a more effective method is needed to prevent contamination due to residual insect populations in empty bins.

One such alternative is using heat to control insects and molds. Heat treatment of processing facilities and other structures to kill stored product pests is a widely used pest control technique (Mueller, 1998; Burks et al., 2000). This project seeks to expand on our preliminary research and quantify the necessary engineering, entomological and economic parameters to make heat treatment of empty storage structures such as steel bins and tanks a successful control technique to prevent residual stored product pest populations from contaminating high-value identity-preserved food and specialty grains as well as conventional commodity grains and oilseeds.

Heat treatment trials were conducted at the Purdue Agronomy Farm in West Lafayette, Indiana and the Southeast Purdue Agricultural Center (SEPAC) located in Butlerville, Indiana. Two 30 ft diameter and 25 ft high bins were heat-treated using the burner of an in-bin drying system for SEPAC and the MHT 1500 heating unit TempAir (Burnsville, MN) in the Purdue farm. Before the start of the heat treatment, insect bioassays were prepared using PVC tubes. Species of adult maize weevils (MW), red flour beetles (RFB), and lesser grain borer (LGB) were used. Thirty insects were placed in each cage placed with either 300 grams of flour (for RFB), whole kernel corn (for MW), or wheat (for LGB). These cages were placed in the plenum and inside the augers near the door and away from the door. During the heat treatment using the in-bin dryer, the fan was covered halfway to restrict airflow through the bin and control of the burner was adjusted to provide inlet air close to 200°F. Temperature was monitored using twelve wireless sensors provided by TempAir and were placed in the three locations where the insect cages were placed and at four locations (North, East, South, and West) on the perforated floor and six feet above these points. The burner was turned off once the temperature inside the flour cage reached 130°F (55°C). Cages were collected and left for 24 hours before sieving and counting the dead and live insects. The sieved materials from each insect cage were kept in separate bottles and were observed weekly for two months for possible insect re-emergence. For the Purdue farm bins, monthly insect population were monitored using dome traps and cardboard rolls placed inside the plenum.

Based on temperature distribution for the in-bin drying system (as seen in Figure 1), inlet air varied from about 150°F to 220°F (66°C to 104°C). The temperature on the perforated floor at the north side which is the side directly opposite the burner, fluctuated with the shutting and turning on of the burner. Comparing the temperatures 6 ft above the floor, the south side reached the desired temperature of 130°F most slowly (i.e., almost 2 hours). While the north, east and west side (not all shown in the graph) temperature were higher and not far from each other. The auger on the south side took some time before the temperature inside reached the desired set-point. Examining the mortality of insects, 100% mortality was observed for the three trials with adult MW, RFB, and LGB for cages placed near the fan inlet by the plenum and in the center auger. However, none of the adult LGB was dead in cages placed in the auger in the south side. Similarly low insect mortality for the MW (7%) and RFB (27%) were observed in the same location. Though temperature in the auger reached the desired level, the heat penetrating the inside of the cages apparently needed more time. Moreover, the effect of forced convection inside the auger was minimal compared to inside the plenum and above the perforated floor. Further heat treatment trials with 3 hrs and 4 hrs of duration will be tested in the next set of experiments. Using the MHT 1500 heating unit by TempAir, based on data in Table 1, only mortality of maize weevil for cages in the plenum was significantly different between heat treatment at 55°C (131°F) versus 65°C (149°F). This indicates that heat treatment at 55°C (131°F) for three hours was more effective than heat treatment at 65°C ((149°F) for 5 min in controlling maize weevil in the plenum realizing the treatment temperature was not reached. In general, no significant difference was observed between these heat treatments for maize weevil mortality in the above-floor cages and red flour beetle mortality for both plenum and above the floor cages. The results of this study indicate that for heat treatment at any temperature, uniform distribution of the heated air has to be assured throughout the plenum. Additionally, the target temperature has to be reached and held sufficiently long to achieve 100% mortality.

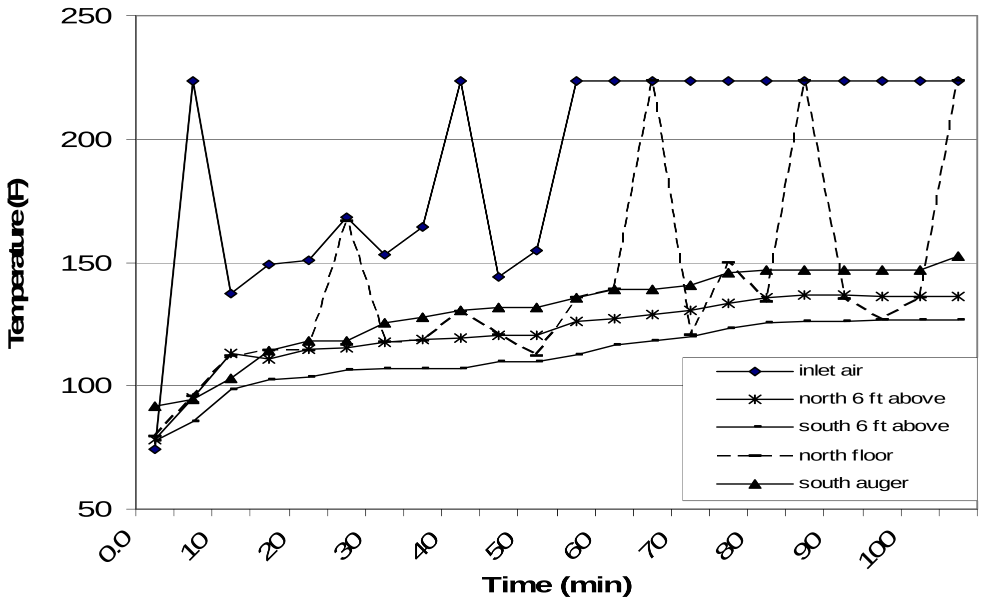

Figure 1. Temperature distribution at selected locations inside a heated bin using the in-bin drying system

Table 1. Summary of insect mortality for maize weevil and red flour beetle during heat treatment using the MHT 1500 at 55°C (131°F) and 65°C (149°F).

Temperature	% Mortality at 4 Locations				%Mortality (Mean)**
	North	South	East	West	
MAIZE WEEVIL (plenum)					
55°C (131°F)	100	100	62.4	100	90.6 a
65°C (149°F)	100	57.3	65	85	76.8 b
Control	0	0	0	7.7	1.9 c
RED FLOUR BEETLE (plenum)					
55°C (131°F)	87.9	100	70.7	87.5	86.5 a
65°C (149°F)	97.2	69.4	45	75	71.6 a
Control	0	0	5	0	1.2 b
MAIZE WEEVIL (above floor)					
55°C (131°F)	100	100	100	100	100 a
65°C (149°F)	95.2	87.5	100	100	95.7 a
Control	0	8.3	0	0	2.1 b
RED FLOUR BEETLE (above floor)					
55°C (131°F)	100	100	100	100	100 a
65°C (149°F)	100	100	100	100	100 a
Control	17.6	17.6	10	0	11.3 b

Note: ** for each insect species, means followed by the same letters are not significantly different from each other ($\alpha = 0.05$).