Stored Grain Management in Oklahoma

OSU EXTENSION FACTS

Oklahoma Cooperative Extension Service • Division of Agricultural Sciences and Natural Resources

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Improper grain storage can result in grain damage due to severe insect and mold problems. Damage from insects and molds in stored grain can go unnoticed until removing the grain from storage. Managers may not be aware of the negative impacts that can result from improper grain storage, including market discount, cost of pest control, and grade loss. Implementation of an Integrated Pest Management (IPM) system will help keep pests below economically damaging levels and minimize storage costs.

What Regulates Storability?

The most important factors affecting stored grain insect and mold population dynamics are:

- stored grain moisture content
- grain temperature
- the length of time grain is in a susceptible condition
- storage accessibility to pests

Moisture Content

Insect and mold species have requirements for grain moisture level. The rice weevil is limited by its requirements for high grain moisture (>12 percent), whereas the lesser grain borer can tolerate dry grain (8-9 percent). Mold growth normally requires grain moisture greater than 14 percent. Higher moisture content results in higher populations of pests.

Temperature

Grain temperature is the most important factor to regulate in grain storage. Temperatures below 65°F are unfavorable for the development of insects and molds. If grain is not cooled in the fall by aeration, grain temperatures remain suitable for insect development all year.

Time

Insect populations are predictable because of their rapid rate of increase following the placement of grain in storage. Small insect populations will increase rapidly with favorable conditions. Grain held for a short period of time or grain held when conditions are unfavorable to insects will not allow populations to increase significantly. Managers can delay this increase and reduce it significantly through sanitation and fall aeration (Figure 1).

Access

Most stored product insects fly and move easily between storage structures. Sanitation and residual sprays are keys to minimizing populations entering storage facilities through aeration fans, augers, eaves, and other openings; also keys for controlling insects that remain from the last storage season. Sealing base openings, doors, conveyors, side openings, eaves, and other openings with expanding foam will enhance monitoring of insects at the surface, which will be the only place they can enter.

Insects in Storage

Insect identification and an estimate of population numbers are needed to make economically sound grain manage-

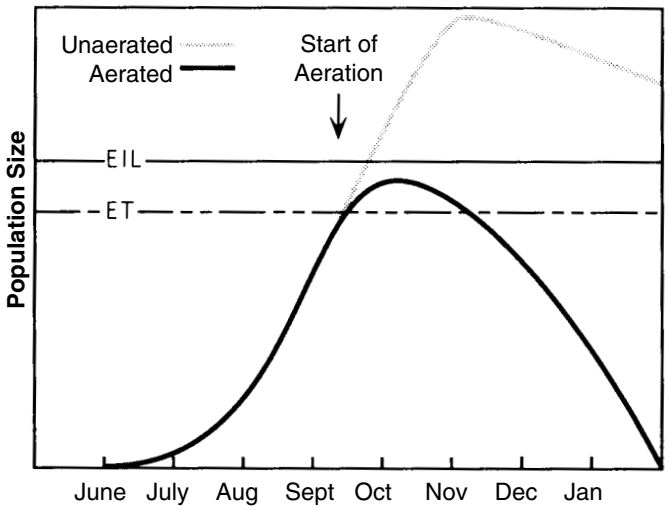

Figure 1. Population dynamics of stored grain insects in hypothetical bins with and without aeration cooling. ET is the economic threshold at which action should be taken, and EIL is the economic injury level, at which economic loss (price discounts) occur.

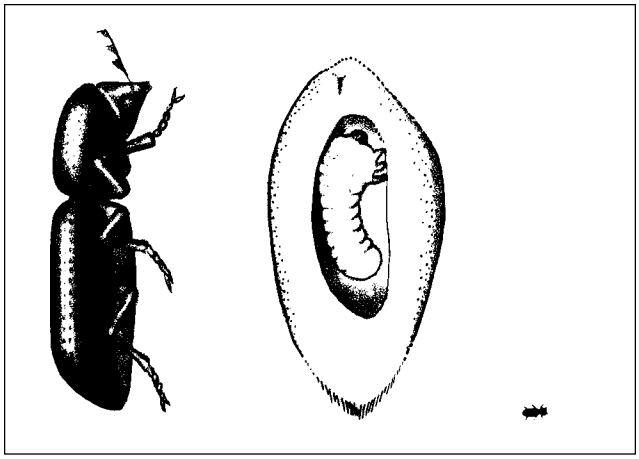

Figure 2. Lesser Grain Borer

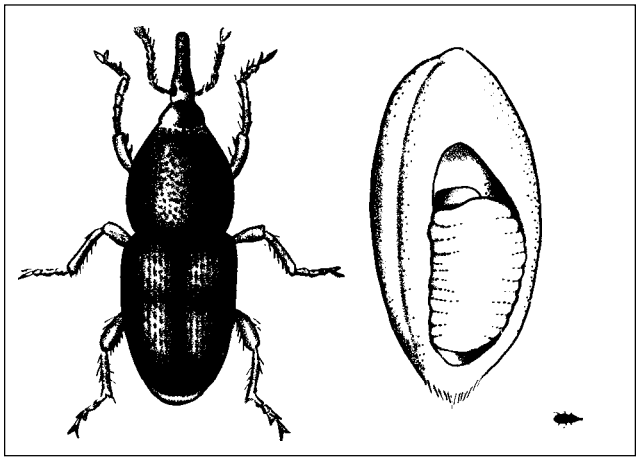

Figure 3. Rice Weevil*
***Actual size of insect is shown at lower right-hand corner of illustration.**

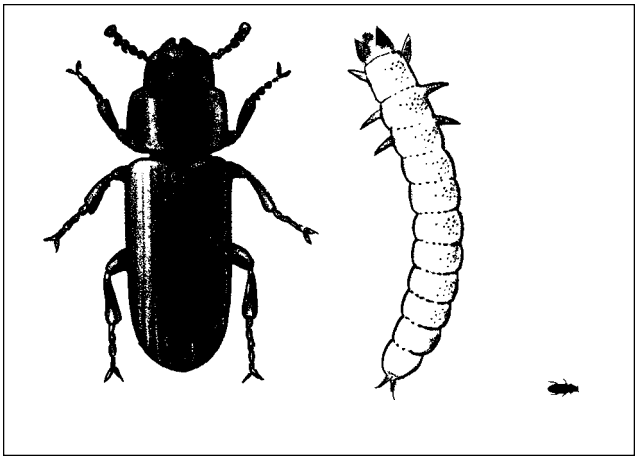

Figure 4. Red Flour Beetle

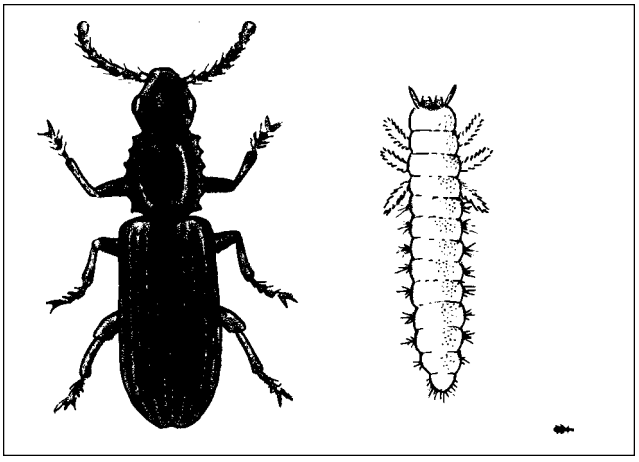

Figure 5. Sawtoothed Grain Beetle

ment decisions. Insect species vary *significantly* in damage potential. Some insects cause *no damage* to stored grain, but their presence can trigger discounts.

Primary Grain Insects

Primary grain insects describe insects that are capable of destroying whole, sound grain. Primary grain insects in Oklahoma include the rice weevil and lesser grain borer. Feeding by these insects results in Insect Damaged Kernels (IDK) that cause grain to be classified as "sample grade," which leds to discounts or load rejection at mills.

The lesser grain borer is the most abundant primary stored grain insect in Oklahoma and causes the most damage to stored grain (Figure 2). This insect is a strong flier and deposits its eggs on the grain surface. After hatching, the larvae tunnel into the seed and chew out its contents. Adult borers have strong jaws that enable them to chew into sound kernels. Extremely high populations of lesser grain borers cause grain to have a "sour," pungent odor.

The rice weevil (Figure 3) is seldom found due to low grain moisture but is important when it occurs. Other primary insects, including the granary weevil, are rarely found in Oklahoma because they require grain moisture over 12 percent. They have been incorrectly cited as important Oklahoma grain pests in the past.

Secondary Grain Insects

Secondary grain insects include several species of beetles referred to as "bran bugs," the Indianmeal moth, and miscellaneous pests such as mites, psocids (book lice), and spiders. Bran bugs feed on bits and fragments of grain, cereals, milled products, and molds. These include the flour beetles, the sawtoothed, rusty, and flat grain beetles.

Flour beetles are important pests in grain and milled products (Figure 4). They are especially important to the milling industry because they may transmit an odor to flour or other finished products.

The *sawtoothed grain beetle* gets its name from saw-like projections on the middle body segment (Figure 5). This insect is very common in stored grain, cereals, and milled products.

Rusty grain beetles (Figure 6) are the most abundant of the secondary insects found in Oklahoma. They are commonly the first insect found, do limited damage, and can survive low moisture conditions.

The Indianmeal moth (IMM) is one of the most troublesome pests attacking stored grain and cereal products (Fig-

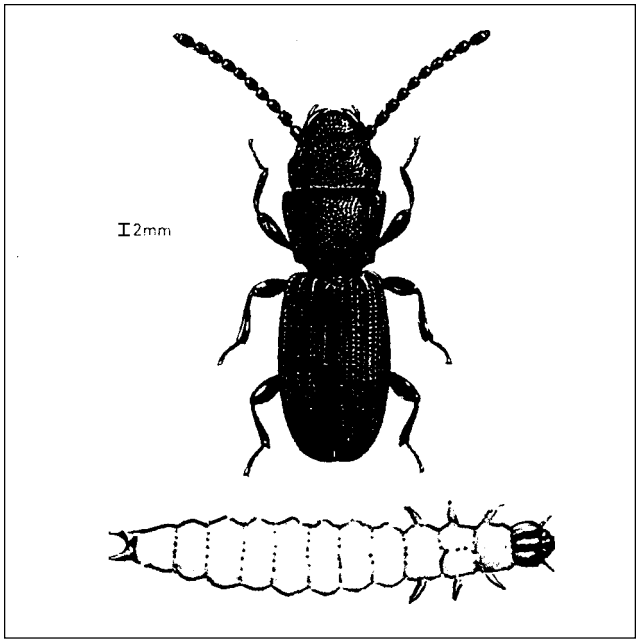

Figure 6. Rusty Grain Beetle

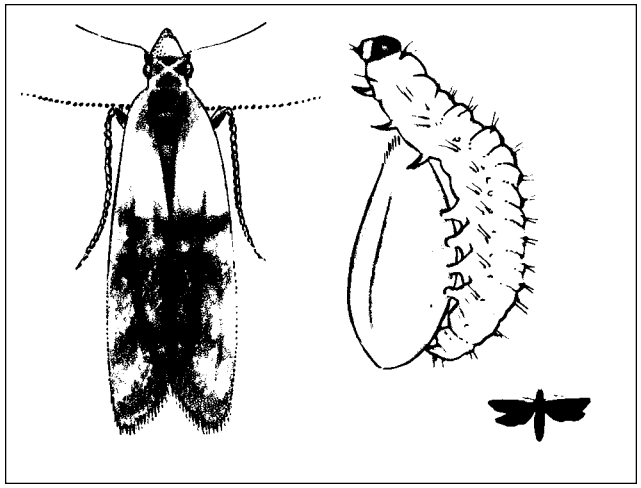

Figure 7. Indianmeal Moth (IMM)

ure 7). It will infest almost any kind of grain or milled product. The moth may be easily distinguished from other moth-like grain insects because the outer two-thirds of its front wings are copper-colored. The female lays eggs on the surface of the grain. The larvae are whitish in color and are about a half-inch long when mature. Although the IMM rarely causes IDK or grain discounts at time of sale, the larvae may completely web over the grain surface, thus preventing proper air movement for aeration and fumigation, causing surface grain moisture accumulation and *"top crusting."*

Treatment Guidelines for Wheat

The Federal Grain Inspection Service (FGIS), now part of Grain Inspection, Packers and Stockyards Administration (GIPSA), has revised the guidelines for grain grade requirements. The guidelines include a definition of and tolerances for insect damage requirements. Wheat becomes sample grade when 32 or more kernels/100 gram sample (approximately 3.5 ounces) have insect damage (IDK). GIPSA standards indicate "wheat is considered *infested* if a representative sample (1,000 grams) contains two live insects injurious to stored grain." This guideline of two or more live grain insects per sample can be used as an approximate *economic or action threshold* level to base treatment decisions on before IDK occurs.

Insect Ecology and Management

There is no scientific evidence that stored grain insects come from the field with harvested grain. Therefore, sanitation to reduce infestation already present in and around storage facilities is crucial.

Sanitation

Sweep up and remove all debris from the bin. Remove and destroy any grain from beneath aeration ducts, and around or near the bin area that may harbor or provide a food supply for stored grain pests. A shop vacuum, broom, and scoop are the tools for bin cleanup. All collected material should be discarded properly – well away from the storage area and preferably taken off site or destroyed.

Chloropicrin is labeled for use as a "clean-out" fumigant for empty bins and can be applied to the boots of elevators, beneath false floors, etc. to kill insects. This fumigant, significantly heavier than air, is ideal for fumigating subfloor aeration ducts or the space under aeration floors. Only sidewall and base openings on the bin need to be sealed. Application rate is 1 quart for small bins (5,000-25,000 bushel); 2 quarts for 30,000-100,000 bushel bins; and 3 quarts for bins over 100,000 bushel capacity.

Residual Bin Sprays

Residual insecticides should be used to spray inside and outside surfaces of storage facilities to help eliminate insects within them. Residual sprays also create a barrier for insects that may migrate into a storage area and insects that were not removed during the cleanup operation. The following are available residual pesticides for empty bin treatments.

Tempo 20WP
Tempo 2EC
Methoxychlor 25% EC
Reldan 4E
Diatomaceous earth

Malathion is registered as an empty bin spray, but it is not recommended because most grain insects are resistant to it.

Reldan may lose its registration soon.

These insecticides should be applied liberally to all seams, cracks, crevices, floors, ceilings, and walls of the bin to the point of runoff. Be sure to apply to "sheltered" areas, such as under false floors, aeration floor ducts, and unload conveyors. Residual sprays should be applied two to three weeks before new grain is binned.

To kill insects that migrate into bins, a residual spray barrier can be applied in and around the fan, aeration ducts, auger, door openings, and hatch covers. Keep the bin sealed to reduce entry migration. The outside walls and floor foundations should be sprayed as well as a perimeter spray around the outside of the bin.

Grain Protectant Treatment at Harvest

During binning, one option is to apply an insecticide as a grain protectant directly on the grain. Protectants are designed to kill migrating insects and reduce population development. Protectants may be advisable if the grain will be stored in flat structures, in emergency storage, or be stored for extended periods. Because of heat degradation, insect resistance, and buyer concerns, malathion is not recommended for use in Oklahoma as a protectant. The following are insecticides that are cleared as "protectants":

Liquids

Reldan 4E — Reldan is not registered for use in corn. Reldan is not labeled for lesser grain borer and has limited impact on existing populations. Reldan can only be applied from the top of the bin with the applicator outside the bin and spraying downward. The registration for Reldan may be cancelled or changed in the near future. Please check with the Cooperative Extension Service if uncertain about Reldan's registration.

Actellic 5E – Actellic 5E is labeled for use on stored corn and grain sorghum only. Actellic is effective against the Indianmeal moth and at the highest rate "suppresses lesser grain borer."

Pyrethrins — Pyrethrins degrade rapidly and have a short residual time, but can be effective for active life stages if properly applied.

Liquid grain protectants are applied to grain going into the bin using an applicator. Chemical spray applicators often under-apply liquid grain protectants, so they must be accurately calibrated before using.

Insecticide Dusts

Insecticide dusts are also available for use on stored grain.

Diatomaceous Earth (DE) – Recommended application of DE products include treating the first few loads of grain in the bottom 2 to 3 feet of the bin and the last few loads – the 1 to 2 feet of grain surface. This is designed to reduce migration of insects. There are several trade names available including: Protect-It and Insecto. DE is most effective when applied to the entire grain mass, but this will reduce test weight and grade, and is recommended only in special cases.

Reldan Liquid and Diatomaceous Earth Dust may also be applied as a "top-out" application against surface feeding insects. Reldan, Actellic, or *Bacillus thuringiensis* (B.t.) applied as a top-dress treatment will reduce infestation of the Indianmeal moth.

Most populations of IMM are resistant to malathion. However, Reldan, Actellic, and Diatomaceous Earth will control this pest when applied to the grain as a surface treatment. A biological insecticide, *Bacillus thuringiensis* (B.t.) sold as Dipel or Top-Side, gives good to fair protection against the Indianmeal moth when surface applied.

Dichlorvos Strips. Dichlorvos (vapona) is currently cleared for use in headspaces of grain storages. Dichlorvos strips eliminate Indianmeal moth adults as they attempt to reproduce, breaking their life cycle. If IMM has been a problem, strips should be used in the summer and the next spring.

Grain Protectant Degradation

Grain protectant degradation occurs from high grain moisture, high grain temperatures, or under applying the protectant dosage. The combination of high temperatures and high grain moistures will shorten residual life for the grain protectants used in Oklahoma. Grain cooled from 90-100°F to 75-85°F by aeration right after harvest will help stabilize protectants. However, this is difficult to accomplish because of costs, electricity, and shrink, and may move insects into a more ideal temperature. In addition, it may only be practical for Reldan. The operation of an aeration system will not remove the protectant from the grain. Protectants have no influence on stored grain molds. The OSU recommendation is to reduce grain temperature as soon as practical after binning to grain temperatures below the comfort zone (70°F or lower) of most stored grain insects.

Resistance to Certain Insecticides

Resistance is the genetically-based ability of insects to tolerate a pesticide dose that is lethal to normal insect populations. The red flour beetle and lesser grain borer have shown high resistance to Malathion - it is not recommended for use. The lesser grain borer has shown resistance to Reldan**. Do not use Reldan to control lesser grain borer**.

When red flour beetles and lesser grain borers from Oklahoma were tested for resistance to the fumigant phosphine, light to moderate resistance was found.

People who plan to apply fumigants must be specially certified in fumigation by the Department of Agriculture. Fumigators are encouraged to attend fumigation training workshops and request a fumigation applicator training manual from the local Cooperative Extension office

Pesticide Safety

All insecticides are poisonous and should be used with extreme caution. **Be sure to follow the label instructions**. All pesticide labels contain important safety information. In the event of an accident, take the exact information relative to ingredients to the physician. If possible, take the pesticide label too.

Managing Insect Populations

Insect populations and their growth are predictable based on temperature, grain moisture content, and time. Populations grow rapidly through summer and into fall. They usually peak during October and November. In September and October, when evening temperatures fall below 65-70°F, aeration should be used to cool grain and reduce insect development. If grain will be held through the next summer, a second partial recooling cycle in mid-winter to stabilize grain temperatures uniformly in the 40-50°F range is recommended. Figure 8 shows the dramatic impact aeration has on insect populations.

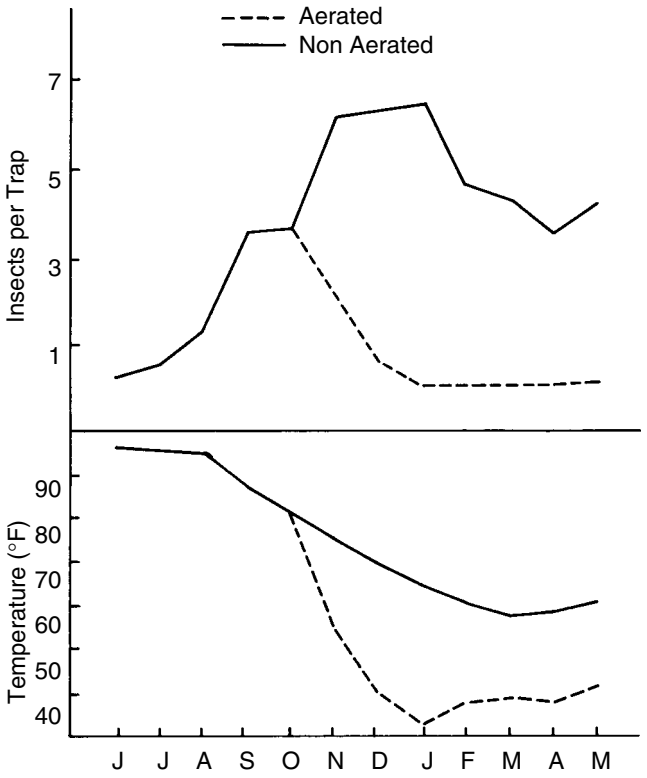

Figure 8. Influence of aeration on adult lesser grain borer density (top) and grain temperature (bottom).

Monitoring and Sampling

Managers should inspect their grain at regular intervals, especially during the summer and fall, monitoring grain temperatures, looking for insects, hot spots, mold growth, and/or any "off odor." Key areas to sample for insects are points of access such as fans, augers, entry doors, and the grain surface. Grain moisture should be checked and grain temperatures should be taken during each sampling. Temperature and moisture levels help managers determine risk and determine management strategies. Thermocouples spaced throughout the grain mass provide the most reliable estimate of grain temperatures, but portable thermocouples or digital temperature probes or protected grain thermometers can provide useful information.

A standard grain probe and pans are often used for insect sampling (Figure 9). Recommended sampling of 4 to 5 probes per bin can give a reliable estimate of insect populations.

Grain probe insect traps (Figure 9) are marketed for sampling insects and are very sensitive at detecting and estimating population trends. Traps provide a reliable, early warning of insect infestation.

Sampling Using Probe Traps

How Many Traps are Needed?

Key sampling information is needed to provide useful information for insect management. The greater the number of trap samples, the greater the probability of a correct

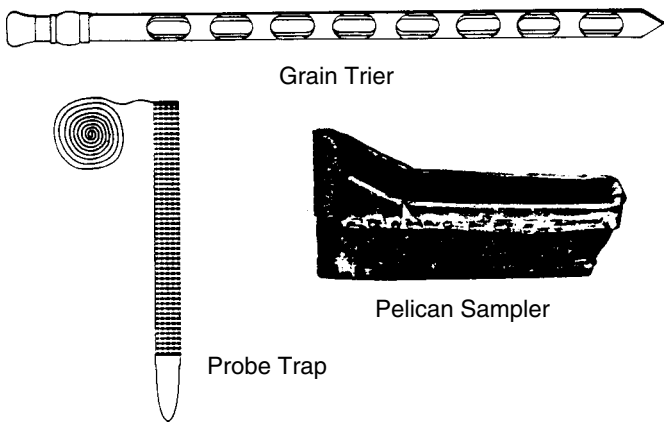

Figure 9. Standard Sampling Equipment and WBII Probe Traps.

answer. For grain, the standard is a minimum of 4 to 5 probe traps per round steel bin.

Thresholds for a one-week sampling period vary with the species sampled and the grain temperature (Table 1). If grain temperature is below 60°F, numbers in the following table indicate a very high pest population size.

Distribution of Insects:

Most stored grain insects are good fliers and migrate to bins. Typical insect population dynamics are shown in Figure 1. Any part of a bin that has an opening is a possible starting place for insects.

OSU research has shown that high numbers of flying insects are caught at roof-eave openings and doors. Openings are the point of access, and stored grain insect populations often vary with each type of facility:

- Steel – On the surface and unsealed points of access like roof eave, aeration fans, augers, fill hatch, downspouts, doors, and roof vents.
- Concrete – difficult places for sanitation like seams, cracks, doors, downspouts, basements. Insects tend to collect in basements that are moist and have thick layers of grain dust and fines.

Summary of How to Protect Stored Grain

A. Clean bin by sweeping and/or use of a shop vacuum.
B. Treat cleaned bin with a residual insecticide-methoxychlor, Tempo, Reldan, or diatomaceous earth.

Table 1. Insects per trap per week above which discounts occur.

Species	*Threshold levels number per week*
Rusty grain beetle	3,000-5,000
Lesser grain borer	5
Rice weevil	5
Red flour beetles	1,000

C. If Indianmeal moths are a problem, place a treatment of Reldan, Actellic, or *Bacillus thuringiensis* (Dipel, Top-Side, etc) on the surface of the grain or treat the last four inches of grain moving into the bin. An option for control of Indianmeal moth adults is to place Dichlorvos resin strips above the grain mass in the bin when moths are active.

D. Inspect grain bi-weekly or monthly, using either a grain trier or insect traps

E. Aerate to cool grain to 65°F or cooler as soon as practical in the fall as outside temperatures drop. Fall is a critical time when many insect populations can be detected and controlled by cooling grain.

F. If grain will be stored for several months or the structure is high risk, a protectant applied to the grain should be considered. **Caution - OSU does not recommend Malathion.**

G. Consider fumigating if two or more live injurious or primary insects are found per 2.2 pounds of grain (1.0-kg) sample or the number of borers or secondary species found in traps are shown in Table 1. Hire a commercial fumigator or obtain appropriate training and a fumigator's certification from the State Department of Agriculture prior to using these dangerous pesticides.

OSU Extension Facts are also available on the World Wide Web at: **http://agweb.okstate.edu/pearl/**

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