DEPARTMENTS OF
BIOLOGICAL AND AGRICULTURAL
ENGINEERING AND ENTOMOLOGY

Storing Wheat

Insects or fungi in grain during storage and transport affect grain quality and value. Even a few insects in stored grain can develop into damaging populations before the grain reaches its destination. Stored grain must be free of pests to ensure that domestic and foreign grain buyers will accept it.

In Kansas, more than 20 different species of insects are adapted to survive in grain or grain products. Insect life cycles are typically four to 12 months long and may pass from egg to adult in 30 days in optimal conditions. The high reproductive rate of 300 or more eggs per female means that only a few individuals are necessary for large numbers to develop in a short time. Overlooking infested grain when cleaning out the storage structure may make it more difficult to keep grain pest free in the future.

Insect Control

Optimal feeding and reproduction of storage insects occurs at grain temperatures of 70 to 90°F. As grain temperatures drop to 60°F, reproduction declines rapidly. Most visible insect activity, including feeding, stops when grain temperatures fall below 50°F. In addition, mold activity may double with each 10°F rise in temperature. Aeration fans can slow or stop pest damage with the onset of cooler weather. In addition, grain moisture of 12 percent or less makes it more difficult for insects to develop. Mold growth is slowed at less than 14 percent moisture.

Only clean, dry grain should be considered for storage. Combines and other harvesters, transportation equipment, conveying equipment and storage structures should be cleaned and insect infestations eliminated before new grain is stored.

Destroy or feed livestock the first few bushels of grain augered through each piece of equipment as harvest begins. The new grain "scours out" material that was inside since last season. Many operators forget this step and unintentionally, but routinely, reinfest cleaned storage structures every year. Adjusting combines to minimize dockage or non-grain foreign material is a good practice. Dockage, usually composed of plant fragments, helps insects survive less favorable conditions.

New wheat or insect-free grain should never be added to old grain that has been in storage because of the high risk of overlooking a low-level infestation. If the old grain was infested, the problem will spread into the new grain. Extensive damage may result before the infestation reaches the surface and is detected.

Unfortunately, the trend toward fewer and larger storage units often leaves a farmer or commercial manager without many storage options. A precautionary fumigation should be done if new grain must be placed on grain that has been in storage. Remember, putting new grain on old grain is not a good management practice and is not recommended.

Structures used for grain storage should:

1. Hold the grain without leaks or spills.
2. Prevent rain, snow or soil moisture from reaching the grain.
3. Protect grain from rodents, birds, poultry, objectionable odors and theft.
4. Provide safety from fire and wind damage.
5. Permit effective treatment to prevent or control insect infestation.
6. Provide headroom over the binned grain for sampling, inspecting and ventilating.

Grain should be stored in a weatherproof, rodent-proof, metal structure that is separated from hay and feed areas and animal housing. It should be easy to clean and inspect. Adding an aeration system keeps grain cool and limits insect development, minimizes moisture migration through the grain, and facilitates fumigant distribution.

Newly harvested grain is at optimum temperature and moisture for insect development. Breeding areas

in the immediate storage area are the most important sources of insects that invade newly stored grain. This crossover infestation results in several generations of insects developing in summer-harvested grain before winter temperatures restrict development. Small areas of extreme infestation could cause grain to heat and prolong damage into the winter.

Remove all leftover grain from bins and sweep down the walls, ceilings, sills, ledges and floors to avoid contaminating grain. Destroy the sweepings. Clear trash and litter from outside the bin area and remove spilled grain from under and around the bins. Make repairs while the bin is empty to make sure it is weatherproof, particularly where side walls join the floor and roof.

Bin Sprays: Special formulations of insecticides are registered as outside perimeter sprays and/or inner and outer bin-wall treatments. These treatments reduce the chance of insects being in the bin when grain is stored. In general, treatments should be applied three to four weeks before the grain is binned, but after all old grain and sweepings have been removed. A treatment should be applied to the plenum area or beneath the floors.

Protectants: Applying an insecticide to the grain as it is binned may reduce insect development. This treatment will protect the grain from insect damage for most of the storage season if it is properly applied.

Distribute the product evenly during application. Several methods are available, and each product label has specific application instructions. Most labels advise to apply as the grain is entering the auger for delivery to the final storage site. Gravity-flow drip applicators and pressurized sprayers of various types are frequently used for applying liquid products.

Dust formulations may be applied with mechanical applicators, if listed on the label, by spreading the proper amount of the product on the grain surface while in the truck or wagon. It is usually suggested to mix the product in with a shovel as much as possible. Final distribution is achieved as the grain and product leave the truck through the unloading gate and travel up the auger. The persistence and effectiveness of these products is severely reduced if they are applied before high-temperature drying. Refer to the product label for additional information

Top-dress or cap-out treatments: These treatments are used to protect the surface of the grain from Indian meal moth larvae and to reduce infestations by other pests, depending on the insecticide. The goal is to uniformly mix the product with the top 6 to 12 inches of grain. This is normally done by raking the material into the surface or by adding the product to the last truckload(s) of grain before it enters the bin. These treatments may need to be reapplied every time the surface is disturbed.

Slow-release insecticide strips are available for use against adult Indian meal moths. Hang strips in the overspace and replace them every few months when temperatures in the bin are high enough to allow insect development.

Fumigants: Fumigants are highly volatile insecticides that are sometimes needed to eliminate insect infestations. Fumigants rapidly form toxic gases when released from the container used to transport them. These gases penetrate infested kernels and eliminate all insect life stages if applied properly. Fumigants do not provide residual protection, so reinfestation can occur immediately after the grain has been aired out and gas concentrations fall below lethal levels.

Fumigation is relatively complicated, requires specialized training and well-maintained application, monitoring, and safety equipment. It can be fatal to the user if recommended procedures are not followed closely. Unless the grain storage manager is willing to invest the time and money to acquire the equipment and knowledge needed, this job should be left to professionals.

The probability of grain becoming infested with insects or spoiled because of moisture and mold increases when it is stored and undisturbed in the same location for several months. Establish and maintain a monthly inspection routine throughout grain storage to detect changing conditions (including early signs of insect infestation, dampness or grain heating). Inspections are particularly important during summer and early fall when grain temperatures are optimal for rapid insect development. During this part of the year, inspect grain twice a month.

For more information on insecticides labeled for managing stored grain insects, refer to K-State Research and Extension publication MF-917 *Management of Stored Grain Insects, Part III: Structural Sprays, Pest Strips, Grain Protectants, and Surface Dressings* or check for links to stored grain on *www.oznet.ksu.edu/entomology/extension/extension.htm*.

Bin information

To inspect grain properly, you need a grain probe; a section of eave trough or strip of canvas for handling the grain from the probe' screening pans for sifting insects from the grain samples; and a way of measuring temperatures in the grain. Temperature sensor cables

installed as a permanent part of the storage bin provide an excellent means of monitoring temperatures. You can also measure temperatures by fastening a thermometer to a stick and thrusting it into the grain.

An in-bin temperature monitoring system should be installed in large-diameter bins. These systems allow the manager to check the temperature at many locations in a bin in just a few minutes. Temperature monitors reduce labor and grain deterioration because temperatures can be measured where probing is impossible.

Disadvantages are the initial expense, installation labor requirements and the inconvenience of the temperature sensors inside the bin. However, the success of a stored-grain management program depends on being able to detect temperature changes in a mass of grain. Bin-monitoring temperature systems are an easy, quick and reliable method of determining the temperature of stored grain.

Grain temperature is a good indicator of grain condition. It identifies areas where conditions are favorable for insect development and are heating. Stored grain contains moisture that can be shifted from one location to another as a result of temperature differences in the grain bulk that develop when surface and perimeter areas of the grain cool or heat. Moisture from warm grain is transferred to cooler parts of the grain, resulting in damp areas that favor insects and mold, which cause rapid grain deterioration and heating.

During warm weather, infestations begin near the grain surface, particularly in areas below the point of entry where foreign material accumulates during loading. Sample several locations in the upper portion of the grain by inserting the probe vertically to its full length and horizontally by laying the probe on the grain and pushing it 1 to 2 inches beneath the surface.

During cold weather, use grain temperature as a location guide and sample areas where the temperature is above 65°F. Sift the samples over a 10- to 12-mesh screen and examine the screening for insects. The presence of many types of live stored-grain insects in the probed samples is significant, particularly if several weeks of warm weather remain before the onset of cold grain temperatures.

Temperature control

Insect development and reproduction are slowed when grain temperatures drop. Many insects die from starvation because they are unable to remain active and feed at low temperatures. Grain can be cooled by equipping grain storage with an air distribution system that forces air through the grain when the outside air temperature is lower than the grain temperature. This removes heat from the grain and exhausts it from the bin.

Because outside air is used to cool grain, operating aeration equipment depends on the weather. Air temperatures of 10°F or more below the grain temperature are usually selected to cool the grain.

Since most wheat is harvested dry or nearly dry, aeration is a key to keeping it in good condition. Aeration is a process in which the temperature of the grain is changed to minimize the potential problems of moisture migration and insect and mold reproduction and growth.

The ideal wheat aeration system has a bin with a total perforated floor and a fan capable of moving at least 1/10 cfm per bushel when the bin is full. If perforated tubes or air tunnels are used in the floor to aerate, distribution should be as uniform as possible. While not as good as the total perforated floor, air ducts within 6 feet of bin walls and not separated by more than 12 feet will give fair distribution.

Aeration may help manage wheat storage initially after harvest if the fans are operated intermittently at night using a thermostat or aeration controller. This controller operates a fan when the temperature drops below the set point, which is normally 10 to 15 degrees below the grain temperature. Wheat is warm as it is stored and the outside air is close to the temperature of the wheat kernels. Intermittent aeration should only be used in conjunction with an aeration controller.

If wheat is being stored for more than one year, research in Oklahoma suggests that wheat should not be warmed in the spring. The aeration system is used to cool the wheat during fall and winter, and then recool the grain as quickly as possible during the second fall of storage. Some of the most damaging insects go from egg to adult in 30 days, so the first three months of storage at warm temperatures can be sufficient to establish a damaging infestation.

The wheat should be clean and level on top to ensure uniform air movement throughout the grain. Peaking grain in the center of a grain mass creates storage problems. Aeration is ineffective at cooling grain located in the peaks and probing is difficult. These areas are breeding grounds for insects and molds. Peaked areas also cause problems if fumigation becomes necessary.

Generally, aeration equipment operating during prolonged periods of rain or fog do not significantly increase the moisture content of the wheat kernels.

Cloudy weather is often a good time to operate aeration fans because there is less variability between the nighttime low and daytime high temperature. When cool air is moved through the grain, the incoming air and the grain equalize in temperature. This creates a front that moves in the direction of the airflow. The cooling front moves through the grain about 10 times faster than the drying front.

Once a cooling front or zone is started through the grain, the aeration system should be operated long enough to move the zone completely through the grain. Otherwise, a moist layer of grain may be left that allows for mold and insect development. Airflow rates are usually ⅒ cfm per bushel or less for dry storable grain. Normally, it takes five to seven days to complete an aeration cycle. Intermittent aeration may take longer depending on the outdoor air temperatures and the set point of the controller.

Condensation occurs when warm, moist air comes in contact with a cold surface such as metal or grain. Condensation is often a result of natural air movement, known as moisture migration, or of improper fan use. Operate the fan when the outside air temperature is within 20°F of the grain temperature to eliminate these problems. Moisture migration occurs when there is a large temperature difference between the grain and outside air temperature. It is more of a problem in steel bins rather than wood or concrete structures.

Blowing air up through the grain is the best management practice. In on-farm storage facilities, moisture condensation can be audited by operating fans under proper conditions and openings in the roof to allow the warm air to escape. Plenty of roof opening is necessary to remove the heat and moisture. Provide 1 ft^2 of opening (ridge caps, vents, doors, crack between roof and wall) for every 1,000 cfm of air. After the grain has been cooled and the aeration fan turned off, cover the aeration fan. This prevents birds and rodents from entering the grain bin and reduces the risk of air currents moving through the grain and condensing moisture.

Even dry grain should be probed periodically and aerated when hot spots are detected. For long-term storage, keep the wheat temperature close to the average day-night temperatures. In the fall, the grain should be cooled in 10- to 15-degree increments until it reaches 40°F and held at this temperature during the winter.

If fumigants are applied, the grain may have to be warmed in the spring to a higher temperature. Otherwise, it may not be necessary to warm wheat if it is to be stored for more than one year. Wheat that is going to be marketed in the spring or summer should be warmed to 55 to 60°F.

Many fumigants are ineffective at grain temperatures below 60°F. Read and follow the instructions before applying a fumigant. It is not wise to aerate dry grain during long humid periods unless the wheat is heating. However, during an aeration cycle, do not cut the fan off just because clouds or a rain showers are moving through.

Summary

Although storage problems are more common if conditions at harvest were unfavorable, many problems result from poor dry-grain management practices. Proper use of aeration and insect management, along with an adequate observation program will minimize dry-grain problems.

If bins are not equipped with aeration, store grain at 10 to 11 percent moisture content and use a grain protectant. The grain may have to be turned every three to six months to break up hot spots. This requires either additional storage space or available trucks to load the grain into and treat if necessary. Grain should not be stored more than six months if the storage facility does not have aeration.

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