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Integrating Temperature and Pest Management for Successful Grain Storage

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GRAIN QUALITY
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Integrating Temperature and Pest Management for Successful Grain Storage

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The time to start thinking about this year's harvest is upon us, and the management practices that we utilize after harvest are just as important as those used before. These practices can protect the grain from insects, molds, and losses in quality.

A proper storage management program integrates a range of tools and practices to assure maximum stored-grain quality. These include sanitation, application of residual insecticides to the structural surfaces and grain, temperature control through aeration, moisture control through drying, frequent grain and pest sampling, grain cleaning and low-impact handling, biological agents, and fumigants. The emphasis is on using a combination of these tools and practices to prevent quality deterioration, rather than using a singular “big gun” approach to treat a quality problem once it occurs.

Farmers and elevator managers are in a unique position to apply integrated stored-grain management programs successfully, if they take advantage of the ability to control the critical system parameters such as grain temperature and moisture content, storage time, market destination, and pest movement into their facilities. Because grain is generally binned with some initial population of molds and/or insects, the control of the environmental conditions throughout the storage period is critical to prevent quality deterioration.

To maintain quality grain in storage, the storage environment must prevent the growth of microorganisms and insects. The most important management factors include temperature, moisture, length of storage, and the condition of the grain when placed in storage.

Temperature Management Practices

One of the primary management practices to maintain quality is aeration. Aeration involves moving relatively low volumes of air through grain (1) to control and maintain uniform grain temperatures throughout the pile and (2) to reduce the risk of spoilage and damage due to molding and insect infestation. Aeration generally utilizes ambient air. However, an alternative gaining popularity is chilled aeration, which allows for cooling independent of the ambient conditions at any time of the year. Grain chilling is especially beneficial during summer storage because grain temperatures can be maintained below 55-60^{o}F.

For aeration to be successful, the grain has to be level and at moisture contents safe for storage because normal airflow in storage bins, silos, and flats is not enough to dry the grain.

Table 1. Maximum Moisture Content (% wet bins) for Aerated Grain Storage in Indiana.

Grain Type	Storage Time: Up to 6 months	6-12 months	Longer than 12 months
Shelled Corn	15	14	13
Soybeans	14	12	11
Wheat	14	13	12

Tables 1 and 2 summarize recommended maximum moisture contents for aerated grain storage in Indiana and the recommended airflow rates in upright and flat storages. Non-uniform temperatures in the grain bulk generate air currents that can lead to moisture migration when the stored grain is cooling off due to decreasing (i.e., fall) outdoor temperatures.

Table 2. Recommended Airflow Rates (cubic feet of air/per bushel of dry grain) in Upright and Flat Storages in Indiana.

Flat	1/20 - 1/10
Upright	1/40 - 1/20

Most storage problems result from improperly cooling the grain in the storage bin. The most common mistake is to stop running the aeration fan before the cooling front has moved through the entire grain pile. This can lead to condensation and crusted layers of spoiled grain in the bulk.

Four separate storage management periods can be distinguished (1) fall cool down, (2) winter holding, (3) spring rewarming, and (4) summer holding. In the fall it may take up to two aeration cycles to cool the grain to below 45^{o}F by mid November. At 0.1 cfm/bu it would require 150 hours per cycle regardless of grain depth. For winter storage in Indiana, the grain should be cooled below 35^{o}F before the end of December.

The fan operation time depends solely on the airflow rate in the storage bin. An aeration fan is usually sized for about 1/10 cfm/bu, while an inbin drying fan is usually sized for 1 cfm/bu. It is very important to recognize the difference in order to operate the fans long enough to move the cooling front completely through the bulk, and yet not so long as to waste electricity. Table 3 summarizes the approximate times for the last cooling cycle before the winter holding period for a range of common airflow rates.

Pest Management Practices

Correct drying, aerating, and managing stored grain minimizes the risks of quality deterioration due to pests. There are several species of insects that may infest stored grain, including internal grain feeders such as rice weevil, lesser grain borer and Angoumois grain moth, and external grain feeders (or bran bugs) such as Indianmeal moth, saw-toothed grain beetle, red and confused flour beetles, and flat grain beetles. Grain stored at excess moisture levels will likely be infested by mold (or fungi) feeders such as the foreign grain beetle and hairy fungus beetle (see E-66 for further information).

Sanitation in and around stored grain facilities is the most effective and economical management practice to prevent insect infestations in stored grain. Prior to storing grain, all surfaces that may come in contact with the newly harvested grain should be cleaned. In addition, storage bins with false floors and aeration ducts may need to be fumigated or treated with DE powder (diatomacious earth). The grain and dust that accumulate in these areas are an excellent source of insect infestations. If fumigation is selected as the optimal procedure, seek a licensed applicator to do the job. Fumigants are highly toxic to humans and must be applied with proper protective equipment.

After the storage is cleaned, an approved

Table 3. Time to Cool Grain for Final Winter Storage.

Airflow rate, cfm/bu	Winter cooling time, hours
1/20	400
1/10	200
1/4	80
1/2	40
3/4	27
1	20
1.5	13

residual insecticide should be applied on both the outside and inside bin walls and floors. Table 4 lists the approved residual insecticides (protectants) for bin and grain treatment. Pesticide applications without adequate cleaning generally is a waste of time and money.

As the grain is binned, preventative measures include applying a protectant if the grain will be in storage for more than a year. Grain protectants kill insects as they crawl about

Table 4. Approved Residual Insecticides for Bin and Grain Treatment.

Insecticide	Commodity	Comments
Bacillus thuringiensis Sold as: ACME BIOLOGICAL CATERPILLAR CONTROL, DIPEL, DIPEL 2X WORM KILLER	Corn (field and popcorn) Wheat (small grains) Sorghum Soybeans	Best if used as a top-dress treatment to prevent or control lepidopterous pests such as Indianmeal moth larva.
pirimiphos-methyl Sold as: ACTELLIC 5E, NU-GRO S.P.	Corn (field and popcorn) Sorghum	Can be used as either a grain protectant or top-dress treatment, not both. Is effective on all stored grain insect pests.
malathion There are over 30 products registered for use. Formulations vary from a 6% dust to a 80% liquid, the most common being a 57%EC.	Corn (popcorn, see comments) Wheat (small grains) Sorghum	Can be used for bin wall treatments, top-dress, or a grain protectant. Read and follow label directions so that legal tolerances are not exceeded. Do not use for Indianmeal moth control. 6% dust formulation only labeled for use on popcorn.
chlorpyrifos Sold as: RELDAN 4E, RELDAN 3% DUST	Wheat (small grains) Sorghum	Can be used for bin wall treatments, top-dress, or a grain protectant for only the crops listed.
pyrethrins and piperonyl butoxide Sold as: BESTICIDE, CROWN FOOD, GOLD CREST, PYRETHRIN, SYNEROL	Corn Wheat (small grains) Sorghum	These products are registered primarily to control exposed Indianmeal moth adults and larvae. There is no residual activity.
diatomaceous earth Sold as: Insecto	Corn Wheat (small grains) Sorghum Soybeans	Diatomaceaous earth (DE) kills insects by scratching the body surface and causing dehydration. Grainbuyers may be reluctant to purchase grain treated with DE because possible lower of a grade, reduced flowability, reduced test weight and increased wear on grain moving equipment. Its use as an empty bin treatment, especially beneath the slotted floor, shows promise.

or feed on the treated grain. However, grain protectants should not be applied to high moisture grain or above 90^{o}F because they can lose their effectiveness.

After binning, some grain protectants can be applied as a surface treatment ("top-dress") to protect the grain from surface feeders such as Indianmeal moth and invading beetles. Legal tolerances can be exceeded if a product is applied both as a grain protectant and top-dress, so the label MUST be read and followed.

Storages should not be overfilled. Furthermore, insecticide treatments, aeration, and fumigation cannot be done effectively when the grain surface is not leveled.

Above 55-60^{o}F, the grain should be inspected at least every two weeks for insect activity. Plastic grain probe traps are excellent sampling devices that can help determine insect activity below the grain surface.

Increasing the frequency of inspections may be necessary if numerous insects are trapped. Keeping record of where and how often a trap captures insects is part of a well-conducted integrated stored grain management program.

Insects collected in the traps should be identified before a treatment routine is selected. Depending upon the type of insects found, treatment may not be necessary, but other management practices may be indicated. Infested grain is not automatically "weevily." If grain is found to be weevil infested, but needs to remain in storage, fumigation may be the only solution. However, one needs to keep in mind, that although a fumigation treatment may dramatically reduce the insect population, there is no residual effect. The grain is susceptible to reinfestation as soon as the gas is vented unless additional preventive measures are taken.

To prevent stored grain insects, effective measures can be as simple as maintaining grain temperatures below 60^{o}F or above 100^{o}F. Grain temperatures above 100^{o}F have proven effective against insect development in dry wheat (below 10-11% moisture) binned and stored during the summer time in the south-central states. Research conducted by Oklahoma State University has reduced fumigation needs to less than one a year using this strategy. For other crops, such as corn and popcorn, or wheat above 10-11% moisture, grain temperatures can be reduced below 60^{o}F any time of the year using chilled aeration to prevent insect development.

Mold and Mycotoxin Management

Grain spoilage is the result of microorganisms using the nutrients within the grain for their own growth and development. During this process they produce heat and increase the temperature of the surrounding grain, which may result in hot spots. Heat damage significantly reduces grain quality. If environmental conditions in the grain are right, the major storage mold species *Aspergillus, Fusarium* and *Pencillium* may produce mycotoxins such as aflatoxin, fumonisin, DON, and zearalenone. These may cause serious illness and even death when consumed by livestock or humans.

The presence of mold does not mean mycotoxins will be present, but rather that the potential for their development exists given the right combination of temperature, moisture content, and storage time. Even more frustrating is the fact that the absence of mold does not guarantee a mycotoxin-free commodity. This is because the growth of the mold may not be extensive enough to cause visable damage, but nevertheless it can still produce toxins.

Generally, broken, ground, and dead grain is more vulnerable to fungal attack than whole

grain; stored grain dried at high temperatures is more vulnerable to molding than is grained dried at low temperature; and grain stored for long periods of time is more vulnerable than freshly harvested grain. Although molds are diverse in their requirements, all mold growth can be prevented by low moisture, low temperature, and low oxygen environmental conditions.

Summary

Maintaining stored grain quality requires an integrated approach by the stored grain manager that incorporates a number of tools and pesticides to prevent quality deterioration. Relying on a single tool to take care of a problem is an approach of the past that is doomed to fail in the future. Single solutions, especially if they are chemical in nature, are under intense public and regulatory scrutiny and will continue to be a limited option. Prevention is the only acceptable way to maintain grain quality.

For more information, obtain copies of AED-20, "Managing Dry Grain in Storage," E-66, "Stored Grain Insect Pest Management," and PIH-129, "Mycotoxins and Swine Performance" from your local CES office.