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Grain Drying and Storage on Florida Farms [1]

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The drying and storage of agricultural products date back to the beginning of civilization. Drying of food and food products, the subject of this publication, is one of the oldest methods of preservation. Other preservation options are available, such as acid preservation, ensiling, and oxygen free storage for grain, if the product is to be used as livestock feed. For more information about these subjects refer to the extension publication entitled *High Moisture Grain Storage* .

In agricultural work, drying refers to the removal of moisture until the moisture content of the product is such that decrease in quality from molds, enzymic activity (respiration and heating), and insects will be negligible.

Drying farm products offers the farmer the following advantages:

- It permits an early harvest, which reduces the field loss of products due to weather, insects, rodents, birds, and natural shattering, in addition to permitting the farmer to prepare the ground for the following crop earlier in the year (or for double-cropping).
- It allows planning the harvest season to make better use of labor because harvesting will not be dependent on fluctuations of the moisture content of grain in the field.
- It allows long-term storage with little deterioration.
- It permits taking advantage of possible higher prices a few months after harvest.
- It provides maintenance of seed viability, since the possibility of the natural heating of grain with subsequent reduction or destruction of germination is decreased.
- It enables the production of a better-quality product.

Fundamentals of Grain Drying and Storage

The major objective in drying grains is to reduce the moisture content so that spoilage will not occur before the grain is used. The objective of proper grain storage is to maintain the characteristics that the grain possesses immediately following harvesting and drying. Thus, viability should be maintained for

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seed grain, milling and baking qualities should be preserved for industrially used grain, and nutritive properties should be sustained for grain fed to animals.

During storage, the quality of grain cannot be improved. Grain improperly produced, harvested, or dried will remain of low quality no matter how well it is stored. Many complaints about poor quality grain refer to improper storage, but too early harvesting (high moisture content), improper combine settings (high cylinder speeds), and too rapid drying (high drying temperature) are also possible culprits.

The principal causes of loss in quality and quantity in grain during storage are fungi, insects, rodents, mites, respiration, and moisture migration. Although storage problems are common during bad harvest years, many problems result from poor dry grain management practices as well. Proper aeration and insect control, along with adequate observation, minimize these dry grain difficulties. For more information on these subjects, refer to the extension publications entitled *Management of Stored Grain with Aeration* and *Pest Management Strategies for Storing Grain in Florida* .

Moisture Content

The moisture content of a grain is an indicator of maturity or quality. Two methods are used to represent moisture content: wet basis and dry basis. The moisture content on a wet basis is obtained by dividing the weight of water in grain by its total weight. The moisture content on a dry basis is obtained by dividing the weight of the water in the grain by its oven dry weight. Market pricing structure is based primarily on the wet basis moisture content. Additional information on methods of obtaining samples and of determining moisture content can be found in the extension publications entitled *Grain Sampling* and *Grain Moisture Determination* .

For proper drying and storage, the moisture content of the grain is controlled.The three most important grain moisture content levels are the harvest moisture content, the initial storage moisture content, and the equilibrium moisture content.

The harvest moisture content will depend on many factors, but this is the starting point for the drying process (or storage if the grain is field dried to an acceptable initial storage moisture content). The storage moisture content is the moisture content recommended for safe crop storage. The maximum moisture contents of several crops for satisfactory air-drying with heated air and for safe storage in tight structures are shown in Table 1 .

The third moisture content level mentioned above is the equilibrium moisture content. Grain contains moisture, and depending on the amount of moisture in the surrounding air, grain will gain or lose moisture. The amount of moisture in the surrounding air is determined by the air temperature and relative humidity. The grain is in equilibrium with the surrounding air when there is no moisture flow between it and the grain. The moisture content of the grain when it is in equilibrium with the surrounding air is the equilibrium moisture content. The equilibrium moisture content is important specifically in the drying and storage of grains. The equilibrium moisture content determines the minimum moisture content to which the grain can be dried under a given set of drying conditions (temperature and relative humidity). Since the humidity and temperature of surrounding air change throughout storage, the storage moisture content will also change. The equilibrium moisture content of several grains is shown in Table 2 . Note that Table 2 is for a constant temperature of 77°F. The equilibrium moisture content also varies with temperature, but not by a great amount. Table 3 gives the approximate moisture content for shelled corn in equilibrium with air at various humidity and temperature combinations. Other grains exhibit a similar pattern.

Drying Temperature and Relative Humidity

Air is a mixture of several gases, and it contains heat. When air is dry, it occupies a given space. As it occurs naturally, air is rarely completely dry. Air shares space with water vapor. The amount of space occupied by the water vapor is a major concern when drying grains. The heat content of air is also important because heat is needed to change liquid water (in the grain) to vapor. The vapor then mixes with the drying air and is removed.

Air serves two basic functions in grain drying. First, the air supplies the necessary heat for moisture evaporation; second, the air serves as a carrier of the evaporated moisture. Both functions are essential, regardless of the drying system used. The amount of moisture which can be removed from grain depends on the relative humidity and temperature of the drying air, the airflow rate, and the moisture content of the grain.

Air temperature determines heat content and to a large extent the total water-carrying capacity of the drying air. As air is heated, the heat content and the water-carrying capacity both increase. Relative humidity is an indication of the amount of water vapor in the air. Low relative humidity indicates the air has high water vapor holding capacity (high drying potential), whereas high relative humidity indicates low water vapor holding capacity (low drying potential).

The temperature of the drying air also affects dried grain quality. Grain to be fed or milled can be dried at 150°F or higher, while grain for seed should not be heated above 110°F to prevent reduced germination. High heat often cracks seed coats, leading to grain breakage in handling. Maximum safe drying air temperatures for several grains are listed in Table 1.

Grain Response to Drying

When grain is placed in a drying or storage structure and air is forced through the grain, a drying zone is established at the point where the air enters the facility (Figure 1). The drying zone moves uniformly through the grain in the direction of airflow. The rate at which it moves depends on the volume, temperature, and relative humidity of the air and on the moisture content of the grain. The same phenomenon occurs in all types of dryers, although it is better defined in batch-in-bin and in-storage drying.

The grain next to the air entry point normally dries almost to its equilibrium moisture content with the entering air. In many cases, the grain at the bottom overdries because the relative humidity of the air is extremely low. Grain where the air leaves the dryer is the last to dry, assuming width of drying

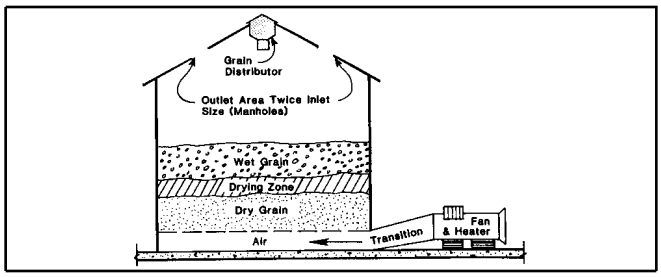

Figure 1 .

column and depth of grain are uniform. One of the greatest problems in on-farm, in-bin drying systems is that of overdrying the grain near the perforated floor. A simple solution is to control the relative humidity of the drying air to obtain the desired equilibrium moisture content level. In addition to an upper temperature limit set on a thermostatic control, many installations have a humidistat wired in series with the thermostat to cut off heat when relative humidity drops to 55%. This arrangement is very effective in preventing overdrying and loss of quality, provided the calibration of the humidistat remains correct. Unfortunately, humidistats generally must be calibrated at least once every season.

Proper Airflow and Drying Depth

Air must be forced through the grain mass at rates sufficient to remove moisture fast enough to prevent mold and stay ahead of spoilage. This rate varies, depending upon the type of drying system used, and is normally expressed in units of cubic feet per minute (c.f.m.) for each square foot of drying floor. The fan or fans selected must be capable of providing this airflow rate while operating against the static pressure head created by the grain resistance to airflow.

The drying fan is the key to drying capacity for all dryers. Insufficient fan capacity is a common problem in bin drying systems. Extra initial investment for adequate fan capacity will improve dryer performance and may avoid the necessity of purchasing a bigger fan later. Fan selection for grain drying and aeration will be covered in the extension publication entitled *Fan Selection for Grain Drying and Aeration.*

The rate of airflow and the depth of the grain are also factors which affect the width of the drying zone. A high rate of airflow or a shallow grain depth can

greatly increase the width of the drying zone. The zone can be made so extensive that it includes the entire depth of grain being dried. In reality this is what is done with many commercial dryers, where the drying column depth is only about 18 inches and the airflow rate is as high as 80 or more c.f.m. per bushel.

There are several other methods used to minimize the effects of the drying zone. Reducing grain depths to 2 feet or less (which automatically allows greater airflow) is one method already mentioned for bin drying. The use of stirrers is another method which has been employed recently. Bin recirculators are also used to keep the grain mixed during drying. Constant movement of the grain or recirculation, thin columns, high airflow rates, and directional airflow are used singly or in combination in commercial dryers to obtain uniform drying and to avoid problems with drying zones.

Systems for Grain Drying

The best known methods of drying are batch-in-bin, in-storage or layer fill, column batch, and continuous flow (Figure 2 and Figure 3). In addition, there are modifications like in-bin stirrers, in-bin recirculators, dryeration, low-temperature, and natural air-drying. Solar drying combines supplemental heat and natural air-drying similar to in storage or low-temperature drying. Trailer and wagon driers are classed as batch-in-bin dryers.

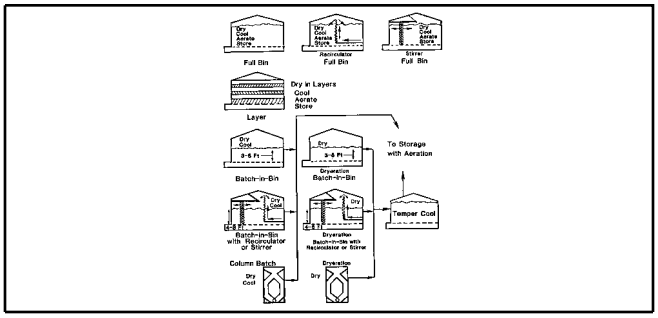

Figure 2 .

With so many different methods and combinations of drying equipment, it is difficult to arrive at the one best system for a farm. Many factors influence the selection, such as volume to be dried, harvesting rate, volume to be stored, various grains and other crops to be handled, and available labor. Selecting a storage system depends on

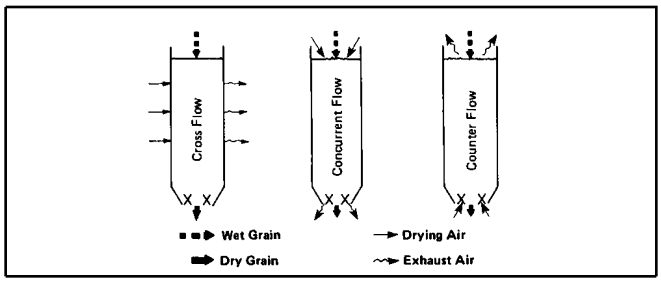

Figure 3 .

- The type and size of farm operation- cash grain, beef feeding, swine production, etc.
- Total annual production
- Harvesting methods and rates
- Existing storage facilities
- Personal experience and preference
- Future plans
- Economics

The producer is faced with the problem of drying grain as rapidly as it can be harvested. The system selected or available for his use will greatly influence drying rate. Sometimes a combination of drying systems using existing equipment or a relatively small investment in new equipment will enable the farmer to reach his harvesting goals.

Studies have shown that equipment which will do the required job at the lowest fixed cost per bushel dried annually will in the final analysis be the most economical for the producer. Planning on-farm drying and storage will be covered in an extension publication entitled *Planning On-Farm Drying and Storage.*

Batch-in-Bin Drying

When a bin is used to dry a batch of grain, usually not more than 2 to 3 feet in depth, it is called batch-in-bin drying (Figure 2). The batch of grain is placed in the bin, leveled, dried in a relatively short period of time, and removed. Temperatures of 120°F to 160°F are generally used with only thermostatic control. In the case of seed drying, the maximum temperature permitted is around 110°F Airflow per bushel of grain in the batch is fairly high

since the depth of grain in the bin is limited. The batch of grain is cooled before removal from the bin.

In-Storage or Layer-Fill Drying

In-storage drying is used almost exclusively in metal storage bins (Figure 2). The bin is filled, one layer at a time. After a layer is almost dry, another layer is placed in the bin and the process continues until the bin is filled. Generally, bins are equipped with fans to move a minimum of 5 c.f.m. per bushel at 1.5 inches static pressure. This is the necessary airflow for 5 feet of shelled corn at 25% moisture content. The depth of grain in a layer should be varied based on moisture content. The higher the grain moisture content, the shallower the grain depth should be. Consequently, the airflow rate will also vary.

A limitation of heat rise and a humidistat are used with in-storage drying. The burner is normally set to give from 10 to 20°F temperature rise over ambient, or outside, air temperature. The humidistat, located in the air plenum, is set at 55 to 60% relative humidity for grain that is to be stored or at a higher level for grain that will remain in the bin only a short time before marketing.

In-storage drying is a slow drying process which might fit well into an operation where less than 10,000 bushels are dried and stored for farm use or later sale. Generally only about 4 feet can be dried per level layer, and more grain should not be added until the preceding layer has begun to dry on top. Most manufacturers give more specific guides on depth of layers, based on grain moisture content as related to size of equipment used.

Batch Drying

A batch dryer is usually a portable or stationary unit made specifically for drying grain (Figure 2 and Figure 4). There is little or no storage capacity associated with the dryer. Drying capacities may range from 70 to 750 bushels per hour. The capacity of the dryer is often rated at 5 percentage points of moisture removal. The airflow rate is high at up to 100 c.f.m. per bushel or more. The shallow drying columns are 12 to 24 inches thick. Operating temperatures generally are 140 to 180°F Batch dryers are designed to remove about 10 percentage points of moisture from an 18-inch thick layer of grain in approximately 3 hours when operating at 140°F.

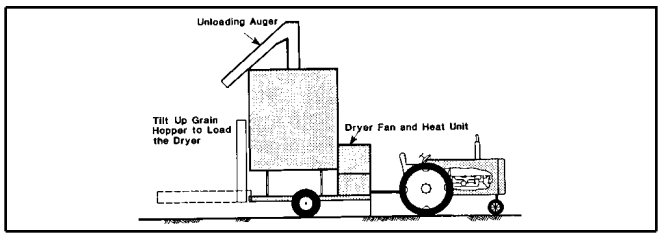

Figure 4 .

An additional 30 to 45 minutes is required to cool the grain if cooling facilities are not provided. In recirculating batch dryers the grain is constantly being turned, recirculated, or mixed during the drying operation. Some batch dryers are equipped with electronic controls to operate the loading and unloading equipment. Some dryers also require a surge bin to keep the dryer filled as the grain shrinks in volume during drying.

Continuous-Flow Drying

For large grain producers and commercial grain dryers the continuous-flow dryer is the most popular method of drying. Approximately half of all dryer models commercially available are continuous-flow. The drying capacity of continuous-flow dryers generally ranges from 100 to 3000 bushels per hour for 5 percentage points of moisture removal.

As with some of the batch dryers, the grain is dried in relatively thin columns of 12 to 24 inches. Dry grain is automatically discharged at the bottom as wet grain is continuously added at the top of the columns. Air of quite high temperature, up to 250°F, is forced through the lower section. The grain remains in the dryer from 2 to 3 hours.

There are three basic designs for continuous-flow dryers (Figure 3). These designs are based on the direction of airflow relative to the flow of grain. The basic designs are cross flow, concurrent flow, and counter flow. Anyone interested in a discussion of the advantages and disadvantages of these designs should contact a specialist on grain drying equipment.

Dryeration

Using fast-drying or high-temperature methods of drying generally causes quality deterioration in grain. The damage is done when high heat is used to dry the grain completely. Fast moisture removal (below 18%) can increase kernel breakage, impair milling properties, and increase chances for mold development and insect damage in storage.

To overcome these problems and save energy a dryeration process was developed which makes use of a combination of the drying procedures already discussed (Figure 2). The dryeration process is described below.

1. Stop rapid- or high-temperature drying in batch, batch-in-bin, or continuous-flow dryers without cooling sections when the grain reaches a moisture level of 16 to 18%.

2. Transfer the hot grain to a bin for tempering 8 to 12 hours.

3. After the grain has tempered, cool very slowly using only 1/2 c.f.m. per bushel for approximately 12 hours.

In the process the grain will give up from 2 to 3% of its moisture, since nearly all the heat in it is used in evaporation. **The process will not work if the grain is cooled too fast.** Because of condensation problems, it cannot be cooled where it is stored unless the bin is insulated. Using the dryeration process helps gain additional drying capacity, in addition to maintaining grain quality. With two supplemental tempering-cooling bins, the capacity of a high-temperature batch or continuous-flow drier can be increased about 50%.

Stirring and Recirculating Additions to Bin Drying

The problems associated with batch-in-bin and in-storage drying have been somewhat alleviated by equipment to move the grain within the bin (Figure 2). Two types of equipment are available to mix or move the dry grain in the bin to prevent overdrying.

Grain-stirring devices are the more common of this in-bin equipment. They simply consist of one or more vertical auger screws which lift the grain from near the perforated floor upward toward the top of the grain mass. The vertical-auger screw, powered from a horizontal radial arm near the top of the bin, is moved from near the center of the bin to the walls and then returned. As the auger screw moves outwards and returns, it also revolves around the center of the bin.

This stirring device reduces overdrying problems and permits the drying of deeper batches of grain at temperatures above those normally used to minimize overdrying. Airflow in the bin may be increased by as much as 10%, which in turn increases the rate of water removal. Limited research seems to indicate little advantage until grain depth reaches 3 feet or more. Stirring devices cause the fines in the bin to move to the bottom. The fines are not appreciably scattered at the bottom of the bin if the grain was placed in the bin without the aid of a spreader. However, the stirrer does break up areas where wet grain, fines, or trash have accumulated. The stirrer does not cause mechanical damage to grain. Major field problems have been reported concerning mechanical breakdown of equipment, but these problems should lessen with time. Just above the bin floor, there is an approximately 4-inch layer of grain which is overdried, and grain damage near the bin wall has been reported where the grain was left in storage. Also, there has been concern about bin wall failure, especially at the bolted joints.

Grain recirculators have been developed to overcome problems with limited batch size and overdrying of lower layers in bins. A horizontal revolving auger on the bin floor draws grain from the bottom of the bin and delivers it to the boot of a vertical center auger. The vertical auger elevates the grain to the top, where it is redistributed in the bin or elevated by another auger to an adjoining cooling bin. Recirculators in batch-in-bin drying work on the counter-flow principle, as discussed above: air moves upward as the grain moves downward. The grain is exposed to the hottest air while it is still losing appreciable moisture, which results in less damage. As with stirrers, the same movement of fines and mechanical problems might be expected.

Low-Temperature, Natural-Air, and Solar Drying

None of these methods are recommended for Florida conditions. Low- temperature, natural-air, and solar drying are all slow drying processes aimed primarily at saving energy and reducing drying cost. As mentioned earlier, these are not the only methods of reducing energy use.

Low-temperature drying is similar to in-bin layer drying, except very low amounts of heat are added, usually 5 to 7°F. Airflow rates are usually between 1 and 3 c.f.m. per bushel. Average outside air temperature should be below 50°F before heat is added, which limits this process to late October for most of Florida. Drying time will generally run over a month, depending on the moisture content of the grain and other factors.

Unheated or natural air-drying is similar to low-temperature drying, except that no heat is added other than approximately 2°F from the fan motor. Application of this slow drying process is limited, since the high airflow rates required are almost economically prohibitive.

Solar heat drying involves some combination of supplemental heat, low-temperature, and natural air-drying. The system consists of large areas of flat black plates or surfaces covered by one or more transparent cover plates of glass or plastic. Radiant energy from the sun is absorbed directly by the uncovered surface or passes through the transparent cover to be absorbed. Air is forced or drawn over and/or under the black surface to pick up heat. Typical installations, which provide 3 c.f.m. of air per bushel of grain (dried in layers 2 to 4 feet deep), will generate 9°F elevation in temperature, depending on weather conditions.

Greater temperature elevations can be achieved with commercial solar panels, but larger panels may be prohibitively expensive. More information about solar grain drying will be covered in an extension publication entitled *Solar Crop Drying* .

Storage

High average humidities and temperatures are a cause for great concern in the storage of grain crops in Florida. This combination is ideally suited to the growth of molds and production of aflatoxin in stored grains. Levels of aflatoxin above 20 parts per billion may cause serious health problems in livestock and poultry, especially younger animals and birds.

To keep grains in good condition over a period of time, steps must be taken to control temperature and moisture content during storage. To do this, the grain must be placed in storage at an acceptable moisture content and should be free of trash and fines, as well as cracked kernels, which can cause "hot spots" and/or "wet spots."

Storage facilities for grains should be weatherproof and free from insect and disease bearing litter. These facilities should be equipped with properly designed aeration systems capable of moving a sufficient volume of air through the mass of grain to control temperature and moisture levels within desired limits.

Grains stored in metal bins without aeration can spoil in storage even though the grain was originally dried to the recommended level. This is caused by moisture migration, insects, and molds. Problems associated with all three can be significantly reduced through proper moisture control.

Stored grains or beans harvested in the summer or fall produce air currents, within the bin, which results in moisture condensation. The process can occur within a completely enclosed and sealed bin and is caused by temperature differences in the grain. As outdoor air temperature decreases, the bin walls cool, which in turn cools the grain layer near the walls. As the air near the walls cools and becomes heavier, it moves toward the bottom of the bin. The interior holds heat and warms the air. This makes the air expand and become light, causing it to rise. As this warm, moist air rises, it passes through the cooler top layer of grain. This causes the warm, moist air to cool and produce condensation. As this warm, moist air continues to rise, it comes into contact with the cold roof and further condensation occurs. This condition, known as moisture migration, creates a wet

zone in the top of the bin. This process is shown in Figure 5 . Mold and insects thrive in the warm, moist areas.

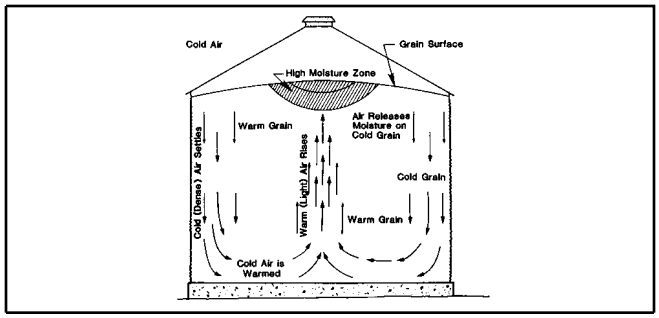

Figure 5 .

Moisture control of stored grain will be covered in an extension publication entitled *Moisture Migration in Stored Grains.*

Moisture migration can be prevented in grain bins by forcing low volumes of air through the bin contents, producing uniform temperatures throughout the mass. This process is called "aeration." The aeration fan should be operated when the outside temperature is 10°F or more below the temperature of the grain in the bins. If it is desirable to lower the moisture content level, the fan should be operated when humidity of the outside air is 65% or below. Operation of the fans on a clear day immediately following a cold front is highly recommended.

Aeration fans should have a capacity of 1/4 to 1/2 c.f.m. per bushel capacity of the bin. Fans should deliver this volume of air at the maximum static pressure developed by the stored grain (normally 1 to 3 inches of static pressure, depending upon the size of the bin, moisture content, and depth of the grain).

Aeration systems should direct the airflow downward (see Figure 6). This will allow for warm, moisture-laden air to be exhausted to the outside from the bottom of the bin. Using a downward airflow will prevent condensation from forming on the inside of the storage bin roof, from where it could fall back on the grain and cause spoilage.

The best aeration system is one that incorporates a moisture tester and a grain probe. Weekly checks of the bin should be made. The bin should never go unchecked for over a month. A weekly check will detect hot spots and moisture buildup before

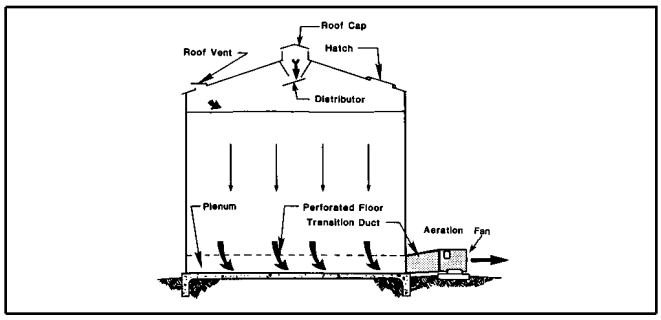

Figure 6 .

extensive harm can be caused to the grain. Start the fans immediately if any moisture or heat buildup is detected. If a batch drying bin is used for grain storage, the high volume drying fans may be used to aerate the crop. Fans should be operated 2 to 3 hours, or longer, 2 to 3 times a week, on clear days when the relative humidity is below 65%. High volumes of air moving upward through the stored grain generally do not cause moisture to accumulate in the top layers of the stored product. Of course, no heat should be added when aerating.

Adequate air space should be provided between the surface of the stored grains and the roof or ceiling of the storage building. Storage of seed grain in buildings where temperatures may become too high should be avoided.

The latest recommendations on amount and type of insecticides to use on stored grains should be checked and followed carefully. This is extremely important for grain intended for human consumption. Additional information on sanitation and insect control can be found in the extension publication entitled *Pest Management Strategies for Storing Grain in Florida* .

Machinery and handling methods must be carefully planned to maintain grain quality and to provide convenient, efficient, and economical grain conveying. Conveying equipment for filling and emptying bins and transferring grain from one bin to another may be either portable or stationary. Portable equipment works better for systems with a few small, individual bins. Stationary equipment is usually better for larger storage systems.

For most systems, auger conveyors and elevators are the most practical choices. They are easily moved, reasonably priced, and relatively trouble free.

They can be bought in 10 to 40 foot lengths. Single-tube, 6-inch diameter elevators move up to 1500 bushels of grain per hour, depending on the height of lift and auger speed. Portable auger conveyors in short lengths and small sizes can be moved about by hand. When in operation, they may be leaned against a building or grain conveying truck or trailer. Larger sizes should be mounted on wheels and raised with a windlass or other device.

Improperly selected or operated conveyors and elevators may crack or crush the grain, which invites insect infestation and lowers both grade and germination. If pneumatic conveyors are used, they should be constructed to prevent cracking of the grain kernels by impact. Sharp turns in conveyor ducts must be avoided and air speed must be carefully controlled. Pneumatic conveyors and grain conveying in general will be covered in the extension publications entitled *Grain Conveying and Pneumatic Conveyors* .

Storage Tips

- Employ preharvest preventive management practices to insure proper grain bin sanitation and insect control.
- Do not dry grain to a moisture content below that required for safe storage. First, the extra drying takes longer and costs more. Second, the extra water removed from the grain could have been sold at the price of grain.
- Aerate grain to help maintain quality in storage. Aeration is low-volume ventilation (about 1/4 c.f.m. per bushel) to maintain uniform temperature throughout a grain mass and to prevent moisture migration.
- Monitor grain during storage to head off storage problems. Check every week or two for musty or spoiled odors, crusting, moisture condensation, elevated temperature, insects, rodents, etc.

Safety Considerations

Grain drying and handling can be dangerous. Transport augers can hit power lines, unguarded augers can catch hands or feet, and fans and shafts can catch unsuspecting victims.

A deadly hazard exists for anyone in a grain bin when the unloading auger is started. Deaths occur every year from suffocation and injuries caused by unloading augers. Many of these victims are children.

Disconnect power to the unloading auger before entering bins. A knotted safety rope hanging near the center of the bin offers great protection. Have a second person standing by to offer assistance and summon help.

Air pockets sometimes form when grain bridges over unloading augers because of spoiled grain or moisture. Never walk on this crusted surface; the pocket can collapse and leave a big hole.

Wear an effective dust mask when exposed to grain dust. Avoid breathing dust from moldy or spoiled grain.

Fumigants are dangerous and should be applied only by trained, experienced operators working in pairs.

Insecticides are poisonous. They should be used only when needed, and they should be handled with extreme care. Directions and precautions on container labels should be carefully followed.

When there are children on the farm, never engage any machinery before checking on the possible presence of a child.

Table 1.

Table 1. Drying and Storage Recommendations

			Oats	Shelled Corn	Soybeans	Sorghum	Wheat
Maximum moisture content of crop at harvesting for satisfactory drying with heated air			25%	35%	25%	25%	25%
Maximum moisture content of crop for safe storage in a tight structure			13*	13%	11%	12%	13%
		30%		13.1			
Moisture content (%) at harvest and pounds of water per bushel which must be removed for safe storage		25%	5.0	8.7	11.0	9.2	
		20%	2.7	4.7	6.6	5.3	5.2
		18%	1.9	3.3	5.1	3.9	3.7
		16%	1.1	1.9	3.5	2.5	2.1
Maximum safe temperature of heated air entering crop for drying when crop is to be used for:							
	Seed		110¡ F	110¡ F	110¡ F	110¡ F	110¡ F
	Commercial Purposes		140¡ F	130¡ F	120¡ F	140¡ F	140¡ F
	Animal Feed		180¡ F	180¡ F		180¡ F	180¡ F

Table 1.

Preferred depth of crop for batch drying with heated air		16-24"	16-24"	16-24"	16-24"	16-24"
* 12% for seed						

Table 2.

Table 2. Grain Moisture Content (Percentage Wet Basis) in Equilibrium with Air at 77°F and Various Relative Humidities.

	Relative Humidity, Percentage									
	10	20	30	40	50	60	70	80	90	100
Material	Equilibrium Moisture Content, Percentage Wet Basis									
Oats	4.1	6.6	8.1	9.1	10.3	11.8	13.0	14.9	18.5	24.1
Shelled Corn	5.1	7.2	8.5	9.8	11.2	12.9	13.9	15.5	18.9	24.6
Soybeans	-	5.5	6.5	7.1	8.0	9.3	11.5	14.8	18.8	-
Sorghum	4.4	7.3	8.6	9.8	11.0	12.0	13.8	15.8	18.8	21.9
Wheat	5.2	7.5	8.6	9.4	10.5	11.8	13.7	16.0	19.7	26.3

As an example of how this table may be used, select an average relative humidity of 40% for the 77¡F temperature. In the table it is noted that 9.8% is the equilibrium moisture content for sorghum.

Table 3.

Table 3. Equilibrium Moisture Content of Shelled Corn for Various Air Temperatures and Relative Humidities									
	Relative Humidity, Percentage								
	10	20	30	40	50	60	70	80	90
Temp. deg. F	Equilibrium Moisture Content, Percentage, Wet Basis								
20	9.4	11.1	12.4	13.6	14.8	16.1	17.6	19.4	22.2
25	8.8	10.5	11.9	13.1	14.3	15.6	17.1	19.0	21.8
30	8.3	10.1	11.4	12.7	13.9	15.2	16.7	18.6	21.1
35	7.9	9.6	11.0	12.3	13.5	14.8	16.3	18.2	20.8
40	7.4	9.2	10.6	11.9	13.1	14.5	16.0	17.9	20.5
45	7.1	8.8	10.2	11.5	12.8	14.1	15.7	17.6	20.5
50	6.7	8.5	9.9	11.2	12.5	13.8	15.4	17.3	20.2
55	6.3	8.2	9.6	10.9	12.2	13.5	15.1	17.0	20.0
60	6.0	7.9	9.3	10.6	11.9	13.3	14.8	16.8	19.7
65	5.7	7.6	9.0	10.3	11.6	13.0	14.6	16.5	19.5
70	5.4	7.3	8.7	10.0	11.4	12.7	14.3	16.3	19.3
75	5.1	7.0	8.5	9.8	11.1	12.5	14.1	16.1	19.1
80	4.6	6.7	8.2	9.6	10.9	12.3	13.9	15.9	18.9

Table 3.

85	4.6	6.5	8.0	9.3	10.7	12.1	13.7	15.7	18.7
90	4.4	6.3	7.7	9.1	10.4	11.9	13.5	15.5	18.5
95	4.1	6.0	7.5	8.9	10.2	11.7	13.3	15.3	18.4
100	3.9	5.8	7.3	8.7	10.0	11.5	13.1	15.1	18.2

As an example of how this table may be used, select an average temperature and relative humidity for a given period, say 60% relative humidity and 50 ¡F. In the table it is noted that 13.8% is the equilibrium mositure content. This means that for these conditions the 13.8% shelled corn will neither lose nor gain moisture from the air.