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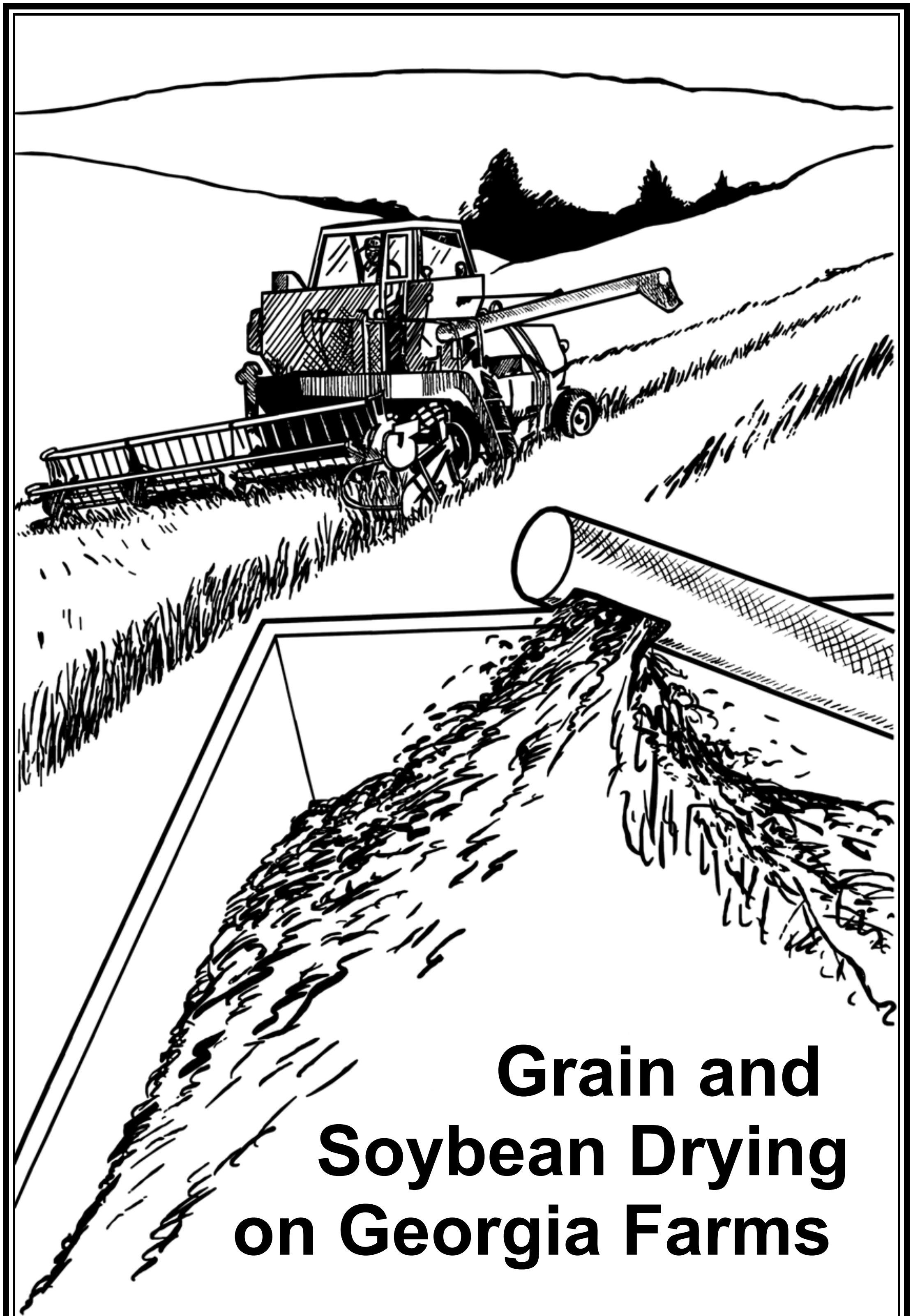

Grain and Soybean Drying on Georgia Farms

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Grain and Soybean Drying on Georgia Farms

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Principles of Grain Drying

Drying is one of the oldest methods of preserving food and feedstock. It is simply the removal of moisture from a product, usually by forcing dry air through the material.

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 type drier you use. The amount of moisture that can be removed from grain depends on the moisture content of the grain, and the relative humidity and temperature of the drying air.

Air temperature determines to a large extent the total water-carrying capacity of the drying air. Hot air can hold more moisture than cold air. For example, a pound of air at 40 degrees F can hold only 40 grains of moisture (7,000 grains = 1 pound), while a pound of 80 degrees F air can hold 155 grains — almost a four-fold increase.

The temperature of the drying air also affects the dried grain quality. Grain to be fed or milled can be dried at 150 degrees F or higher, while grain for seed should not be heated above 110 degrees F or reduced germination occurs. High heat often cracks the seed coat leading to grain breakage in handling.

Relative humidity also plays an important part in the drying process. Air at 100 degrees F and 50 percent relative humidity can absorb 60 more grains of moisture per pound of air than it can at 75 percent humidity.

When grain is placed in a drier 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 air flow at a rate depending on the volume, temperature and relative humidity of the air and the moisture content of the grain.

Forcing air through deep layers of grain is more difficult and requires more fan capacity and horsepower than forcing air through thin layers of grain. The pressure built up by the fan due to the resistance of air flow through grain is called *static pressure* and is normally measured in inches of water. The pressure increases as grain depth and air flow rate increases. Grain such as wheat or grain sorghum has less void space than corn. Less void space for air to move through requires more static pressure.

Drying Methods

Layer-in-Bin Drying

This method is frequently called layer drying; it involves drying deep layers of grain (3-6 feet deep) with low heat, usually less than 110 degrees F. When the first layer is dry, another layer is added on top of the first dry layer and the next layer is dried. When the second layer is dry, a third layer is added and dried. This process is continued until the bin is filled and dried. The filling process may require up to two weeks with up to three weeks required for the drying process. Fan requirements: medium (25 CFM/sq. ft. @ 2 inches static pressure). Heat requirements: low (90 – 110ºF).

Batch-in-Bin Drying

In this method a two to four foot layer of grain is placed in a drying bin. The layer (batch) is rapidly dried then cooled and removed. A new batch is then

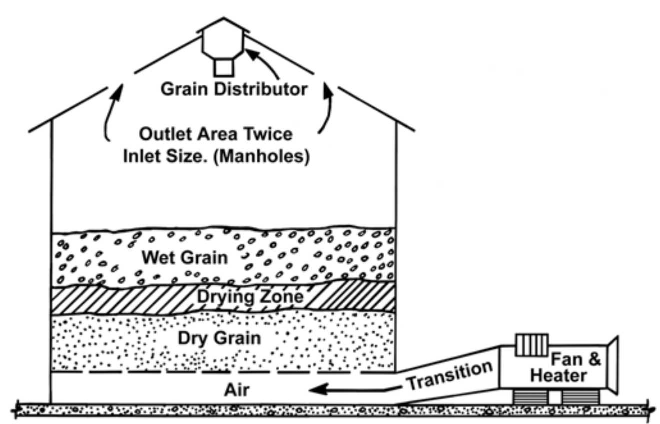

Figure 1. Grain is dried from the point of air entry, with the drying front moving in the direction of air flow. The wetter grain occurs where the air leaves the grain layer.

placed in the bin and the process repeated. Fan requirements: medium to high (40 CFM/sq. ft. @ 3 inches static pressure). Heat requirements: medium (120–140ºF.).

Batch Drying

Batch drying involves special drying equipment that holds a relatively thin layer of grain (1-2 feet).

Some models re-circulate the grain during drying for uniform moisture removal. Grain is normally dried, cooled and then removed. Fan requirements: very high (50-100 CFM/sq. ft.). Heat requirements: medium high (160-180ºF).

Continuous Flow Drying

A thin layer of grain (⅔-1½ ft.) moves continuously through the drier, first through a drying section then a cooling section. Continuous loading and unloading is required. Fan requirements: very high (75-125 CFM/sq. ft.). Heat requirements: very high (180-200ºF).

Low Temperature Drying

Low temperature drying is similar to layer-in-bin drying but with less heat and extended drying time. The heater provides only 5–7 degrees heat rise. Drying time is normally 35-40 days depending upon air flow rate. The extended drying time limits this method to cold climates; cooler temperatures prevent spoilage during drying. The bin is normally filled to capacity in only a few days. **This method is not recommended for Georgia conditions.**

Moisture Levels for Safe Storage

Crops to be sold or used for seed should be dried to a safe storage level. The moisture content recommended for safe storage of various crops is in Table 1. This table assumes storage through the warm months with aeration to cool the grain during fall and winter to prevent moisture migration.

Table 1. Percent moisture content recommended for safe storage, assuming 12-month storage.

Crop	North Georgia	South Georgia
Shelled Corn	12	11
Soybeans	11	10
Wheat	12	11
Oats	12	11
Grain Sorghum	12	11

Seed crops should be dried at temperatures at or below 110 degrees F to prevent seed damage and reduction of germination.

Grain to be stored a short time and then marketed can be stored at higher moisture levels. The safe storage level depends on moisture content and temperature, as shown in Table 2. The time interval in days indicates the time required for the corn to drop one grade.

Storage time exceeding those given in Table 2 will lead to loss in corn quality and will result in a lowering of grade. Do not infer that corn within these limits will suffer no loss in quality.

Table 2. Safe storage time in days for corn at various temperatures and moisture.

Storage Air Temperature °F	Corn Moisture Content			
	15%	20%	25%	30%
	Days			
80	109	10.0	3.4	2.1
75	116	12.1	4.3	2.6
70	155	16.1	5.8	3.5
65	207	21.5	7.6	4.6
60	259	27.0	9.6	5.8
55	337	35.0	12.5	7.5
50	466	48.0	17.0	10.0
45	725	75.0	27.0	16.0
40	906	94.0	34.0	20.0

Allowable Storage Time for Soybeans (seed)

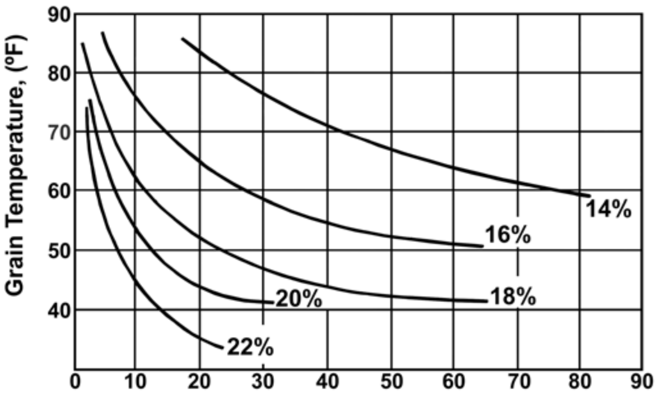

Figure 2. Storage time with respect to moisture and temperature for short-term soybean storage.

Other grains are similar to corn in storage time. For example, corn held at 24 percent moisture and 80 degrees F can be stored only four days before deteriorating to the next lower grade. If this 24 percent corn is held for two of the four days at these conditions, 50 percent of the allowed storage time will be consumed even if the crop is then dried and cooled.

The relationship between moisture and temperature as it affects the storage life of soybeans is shown in Figure 2.

Equilibrium Moisture Content

Grain can be dried in many areas (except along the coast) of our state using natural air if the drying layer is limited to 3 to 4 feet and a sufficient volume of air with the proper relative humidity and temperature is circulated through the grain. If, for example, corn is to be dried to 12 percent moisture, air must be circulated that will remove moisture from the corn rather than adding moisture to it. When the air circulating through the corn neither absorbs moisture nor adds moisture, the air and corn are said to be at the *equilibrium moisture content*.

Table 3 shows 12 percent moisture corn to be in equilibrium with air at 50 degrees F and 50 percent humidity. If the humidity increases to 60 percent and the air temperature remains at 50 degrees F, it is not possible to dry the corn below 13.3 percent. If the relative humidity dropped below 50 percent and remained at 50 degrees F, drying to 12 percent or below would be possible.

A small amount of heat raises the drying air temperature and reduces the humidity which increases the drying capability of the air. A 20 degrees F temperature rise reduces the relative humidity by 50 percent. For example, air at 60 degrees F and 70 percent relative humidity heated to 80 degrees F. (20 degrees F temperature rise) reduces the relative humidity to 35 percent (50 percent of the 70 percent). With shelled corn, the original air (60 degrees F and 70 percent humidity) would reach equilibrium at 14.2 percent, while the 80 degrees F and 35 percent relative humidity would reach equilibrium at 8.3 percent. This would result in more drying capability (Table 3). If the air were heated 10 degrees F (one half the 20 degrees F above), the relative humidity would drop only 25 percent, or one half the above value, to about 50 percent.

Equilibrium moisture content of soybeans is given in Table 4 on page 6.

Increasing air temperature increases the drying capability often making drying possible when it is not possible to dry grain with natural air.

Field drying can be costly in terms of field losses and weather hazard, but it is an alternative, and fuel savings are possible if one is willing to take the risk.

Air Temperature

Keep drying temperatures below 110 degrees F for seed, 140 degrees F for market corn and 200 degrees F

Table 3. Equilibrium moisture content of shelled corn at various relative humidity and air temperature.

Air Temperature °F	Relative Humidity									
	30	34	40	45	50	55	60	65	70	75
30	10.3	10.8	11.3	12.2	13.1	13.8	14.6	15.5	16.4	18.7
50	9.6	10.1	10.6	11.3	12.0	12.7	13.3	14.1	14.8	16.9
60	9.2	9.7	10.2	10.9	11.6	12.1	12.7	13.4	14.2	16.2
70	8.4	9.0	9.7	10.4	11.1	11.5	12.0	12.8	13.5	15.4
80	7.5	8.3	9.1	9.8	10.5	10.8	11.2	12.1	13.0	14.8

Table 4. Equilibrium moisture content of soybeans at various temperatures and humidity.

Air Temperature (°F)	Relative Humidity (%)								
	50	55	60	65	70	75	80	85	90
30	8.9	9.8	10.8	12.1	13.2	15.1	17.1	20.1	22.9
40	8.7	9.6	10.5	11.8	13.0	14.9	16.8	19.7	22.5
50	8.5	9.4	10.2	11.5	12.8	14.7	16.5	19.3	22.1
60	8.3	9.2	10.0	11.3	12.6	14.5	16.3	19.0	21.7

for feed. Temperatures higher than 110 degrees F reduce germination, while exceeding 140 degrees F for market corn makes it difficult to separate the constituents of the corn such as sucrose and starch. Temperatures exceeding 200 degrees F also cause stress in the grain kernels, a condition that produces cracking and splitting and increases damage potential from insects. Cool grain after drying; high temperatures can spoil the grain. To cool, turn off the heater and allow the fan to operate until the grain is cooled to within 10 degrees F of outside air. Some drying will occur during cooling and should be included in the desired drying time.

Higher air temperatures produce greater spread in moisture between top and bottom grain layers in bins. No more heat should be used in bin driers than necessary. Adjust the heat to dry the batch in the available time before spoilage. Stirrers are sometimes used in bins to allow uniform drying from bottom to top and allow the use of higher temperatures without excessively drying the bottom layer. Moving the grain after drying also aids in evenly spreading the moisture throughout the grain.

Bin Batch Drying

In the bin batch drying system, grain is dried and cooled in a layer usually fewer than 4 feet deep before being transferred into final storage. In operation, the fan and heater are turned on as soon as the floor of the drying bin is covered with grain. Additional grain is added and leveled throughout the day as harvesting progresses while the drying continues, usually in a 24 hour cycle.

Drying starts at the bottom of the grain bin where the drying air enters the grain (Figure 1, page 3). As the flow of air continues, drying progresses upward in the direction of air travel, which is from the bottom upward. As the drying air enters the grain, the air picks up moisture from the bottom layer and the air comes into equilibrium with the grain above this layer without picking up additional moisture from the layers above. Thus a drying zone moves up through the grain from the bottom upward. The rate at which this drying zone moves upward depends on the moisture content of the grain, the condition (temperature and humidity) of the air and volume of drying air. The greater the air flow, the faster drying progresses.

The depth of material to be dried in a batch-in-bin system should not exceed 4 feet, and a minimum air flow of 6 cubic feet of air per minute per bushel of grain to be dried should be maintained. Static air pressure will range from 1 to 1½ inches of water when drying shelled corn or beans, and from 1½ to 2½ inches when drying sorghum and small grains at a depth of 4 feet. Table 5 gives the capacity of different diameter bins for each foot of depth.

Table 5. Bin capacity data.

Bin Diameter (Feet)	Bushels per Foot of Depth	Floor Area (Square Feet)
14	125	154
18	205	258
21	280	358
24	360	452
27	460	591
30	565	707
33	685	882
36	815	1,020

Level the grain after each load is placed in the drying bin for uniform drying. Grain distributors available for leveling grain will save considerable labor as well as distribute fine materials more evenly. Screen out fine material as soon as possible, since these materials encourage spoilage and slow drying by restricting air flow. This material can cause channeling if not uniformly distributed in the grain.

Match Drier to Harvesting Rate

In selecting drying equipment with capacity to meet the harvest rate, one must know the amount of moisture to be removed, the time allowed for drying, the volume of grain and type of grain, temperature allowable, air flow rate, heat required, fan motor size and the size of the drier or drying bin.

As an example, assume 2,700 bushels of soybeans at 20 percent moisture are to be dried to 12 percent in 20 hours in the fall of the year using a batch-in-bin drier with a maximum soybean depth of 4 feet and 110 degrees F drying air. What size bin is required? Note that in Table 5, a bin 33 feet in diameter will hold 685 bushels per foot of depth or 2,740 bushels when 4 feet deep, which is the bin size necessary in this example.

The weight of water per bushel of grain is shown in Table 6. To obtain the water loss of a bushel of grain or soybeans drying from 20 to 12 percent, take the difference in weight of these moisture contents.

In the soybean example, the difference in weight of beans at 20 to 12 percent (Table 6) is (12.9 - 7.0) = 5.9 pounds of water per bushel to be removed. The total moisture removed per hour must be the total moisture removed (2700 bushels X 5.9 pounds per bushel in the example) divided by the time in hours, which is 20 in this case, yielding about 800 pounds per hour.

Table 6. Pounds of water per bushel[1] of grain or seed at different moisture-content percentages.[2]

Grain Moisture Content	Amount of Water per Bushel			
	1 Soybeans, Wheat (Dry matter per Bu. = 51.6 lbs.)	2 Shelled Corn (Dry matter per Bu. = 47.3 lbs.)	3 Oats (Dry matter per Bu. = 27.6 lbs.	4 Grain Sorghum (Dry matter per Bu. = 48.2 lbs.)
Percent	Pounds	Pounds	Pounds	Pounds
35	27.8	25.4	14.8	26.0
30	22.1	20.2	11.8	20.6
28	20.1	18.4	10.7	18.7
26	18.2	16.6	9.7	16.9
24	16.4	14.9	8.7	15.2
22	14.6	13.3	7.8	13.6
20	12.9	11.8	6.9	12.0
18	11.4	10.4	6.0	10.6
16	9.8	9.0	5.2	9.2
14	8.4	7.7	4.5	7.8
12	7.0	6.5	3.8	6.6
10	5.8	5.3	3.1	5.4
8	4.5	4.1	2.3	4.9

[1]Figured at following weights per bushel and moisture content:
- Soybeans - 60 lbs. at 14 percent
- Wheat - 60 lbs. at 14 percent
- Shelled corn - 56 lbs. at 15.5 percent
- Oats - 32 pounds at 14 percent
- Grain sorghum - 56 lbs. at 14 percent

[2]To determine pounds of grain required to make a bushel at any one moisture percentage listed, add the pounds of water given for that particular moisture content and the pounds of dry matter (shown at head of each column).

Example: To figure 1 bushel of shelled corn at 35 percent moisture content, add 25.4 pounds (Col. 3) to 47.3 pounds dry matter = 72.7 pounds.

Air Volume Required for Moisture Removal

The amount of moisture removed by the drying air at various drying temperatures and humidity is given in Table 7.

Table 7. Moisture removal by air at various drying temperatures and humidities.

Temperature of Air (°F)	Humidity of Air (Percent)	Lbs. of Water Removed per 1,000 CFM in 1 hr.
60	65	7
70	45	12
80	32	18
100	18	31
110	11	38
140	5.8	60
180	2.2	78

*Initial condition of air, 60°F and 65 percent humidity.

Air flowing at a rate of 1000 CFM and heated from an average design temperature of 60 degrees F and 65 percent humidity heated to 110 degrees F will remove 38 pounds of moisture per hour (Table 7). The air flow rate required to dry a given quantity of grain is given by the expression below where:

CFM = capacity of drying fan in cubic feet of air per minute

Q = pounds of moisture to be removed from wet grain in 1 hour

H = pounds of moisture removed each hour by 1000 CFM of drying air, Table 7

E = efficiency of drying air in removing moisture (0.75 for average fall condition)

$$CFM = \frac{Q \times 1{,}000}{E \times H}$$

The efficiency of drying depends upon the efficiency of heat utilization, which drops as the outside temperature drops. For average design conditions of 60 degrees F and 65 percent relative humidity, the drying efficiency can be assumed to be 0.75 and would be typical for fall conditions in Georgia. If harvest is delayed into cold weather, efficiency could go to 0.6. In summer the drying efficiency may be as high as 0.85.

In the soybean example problem, Q = 800 pounds per hour as discussed earlier, E = 0.75, and H is 38 pounds (Table 7) when the drying air is 110 degrees F. So the air volume needed in this example is:

$$DFM = \frac{800 \times 1{,}000}{0.75 \times 38} = 28{,}070 \text{ cu. ft. per min.}$$

The bin has 882 square feet of floor area (Table 5, 33 feet diameter bin) or 32 CFM of air per square foot of floor (28,070/882 = 32).

Fan Capability and Horsepower

Pressure is required to force air through grain. This pressure is normally expressed as *static water pressure*. The term *static* comes from the fact that the pressure is measured perpendicular to the direction of air flow and gets none of the dynamic or velocity effect from moving air. The static pressure developed by air flowing through grain or beans can be determined if the air flow in CFM per square foot of drier surface (or bin floor) and grain depth is known. Figure 3 shows the relationship between air flow and static pressure in inches of water for beans and common grains.

In the soybean example, 32 CFM of air was required for each square foot of floor and the soybean depth was 4 feet. From Figure 3, note static pressure to be 0.25 inch of water per foot of soybean depth if the 32 CFM per square foot is forced through soybeans. This gives a static pressure of 1 inch for the 4 feet depth.

Fans must be sized based upon volume of air delivery and static pressure. Fan motors must be sized on the same criteria as fans. The expression below gives the fan motor horsepower required if it is assumed that most fans are about 50 percent efficient in moving air. The constant 3,178 is a conversion factor.

$$\text{Fan HP} = \frac{\text{CFM} \times \text{Static pressure in inches of water}}{3{,}178}$$

In the example, the total air flow was 28,070 CFM and the total pressure is 1 inch of water.

$$\text{Fan HP} = \frac{28{,}070 \times 1.0}{3{,}178} = 8.8 \text{ (10 to get the next standard motor size)}$$

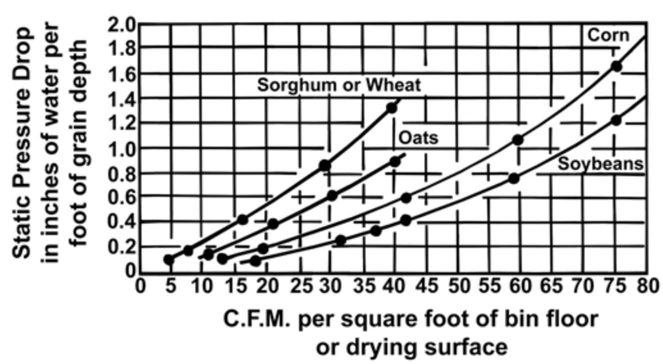

Figure 3. Resistance of grains to air flow as shown by pressure drop in inches of water per foot of grain (if fines are present in the crop, multiply this data by 1.5).

Heat Required

The heat required to raise the temperature of the drying air depends upon the volume of air and the temperature rise as given by the expression:

BTU per hour = 1.1 X temperature rise X CFM of drying fan

The temperature rise is the drying air temperature minus the initial design condition which is 60 degrees F (see footnote under Table 7).

In the example, the total heat required to heat the 28,070 CFM of air from 60 to 110 degrees F is given as follows:

BTU per hour = 1.1 X (110 - 60) X 28,070 = 1,543,850

Natural Air Drying

Many small farmers prefer to dry crops using unheated or natural air drying in bins in layers 3 to 6 feet deep. This process works for crops such as soybeans, which are not prone to have aflatoxin buildup and when good management practices are followed. However, it is desirable to have heat available on standby, which will allow safe drying in any weather. Significant aflatoxin buildup can occur in 48 hours in grain if the air leaving the grain is between 55 and 105 degrees F and relative humidity is more than 85 percent.

Table 8 (page 10) gives the maximum quantities of grain that can be dried per batch per fan horsepower for minimum air flow rates and maximum depths using natural air under favorable conditions.

The air flow rate in Table 8 is the minimum flow rate with grain depth being the maximum for clean grain with little or no fines using unheated air. (Heat should be available on standby.) The static pressure on the fan is given in inches of water. The approximate drying time for grains and seeds at different initial moisture contents and seasons (in Georgia) is shown in Table 9 (page 11) for unheated air. Notice drying with natural air is quite slow. For this reason, many farmers will not find natural air drying acceptable since faster methods will usually be needed. Drying rate can be increased by adding heat (limited to 110 degrees F for seed) or increasing air flow rate, or both. Slow drying is not desirable to maintain grain quality and reduce risk from aflatoxin (See Aflatoxin section).

Adding low levels of heat (10-15ºF) allows faster drying and the drying process becomes less sensitive to the weather. A good method for controlling the supplemental heat is to install a humidistat in the blower discharge air stream or near the top of the storage bin. The humidistat, set at the desired humidity level, provides almost perfect control if three conditions are met. First, the heating unit should have a modulating valve so heat output changes will be gradual. Second, the humidistat must be able to operate in a dusty environment. Third, reaction time of the humidistat and heater should be such that there is little if any overrun of the heater.

Aflatoxin

The mold *aspergillus flavus* grows on most grains, particularly corn, in a temperature range of 55 to 105 degrees F in an environment of high humidity (85 percent and higher). The mold is present throughout the Southeast and is commonly found on grain at harvest.

To minimize the potential for aflatoxin buildup, harvest early and dry grain with greater than 17 percent moisture within 48 hours or less. Also, store only clean, dry grain, keeping seed coat damage to a minimum, and aerate.

For further information on aflatoxin, see Georgia Cooperative Extension Bulletin 1231, *Reducing Aflatoxin in Corn During Harvest and Storage.*

Shrinkage

Over-drying grain results in loss of weight (water) that could have been sold, since grain is usually sold on a weight basis. If the initial weight, initial moisture and final moisture contents are known, the final weight can be calculated as follows:

$$\text{Initial weight} \times \frac{100 - \text{initial \% moisture}}{100 - \text{final \% moisture}} = \text{final weight}$$

To find the increase in value due to drying, multiply the selling price of dry grain by the volume and compare it with the selling price of wet grain with discount.

Table 10 on page 11 shows the loss in weight in percent due to drying grain.

To use Table 10, multiply the initial weight by 1.00 minus (the percent shrinkage given in the table divided by 100). For example, if grain is dried from 25 percent down to 12, take the initial weight X (1.00 - 0.148) = final weight.

Some people prefer to use a shrinkage chart as in Figure 4 to determine weight loss in grain drying.

Example: Grain dried from 30 to 12 percent = 20.4 percent loss from original weight.

Table 8. Estimated maximum quantities of grain that can be dried per batch per fan horsepower for minimum air flow rates and grain depths using natural air.

Grain	Air Flow Rate per Bu. (CFM)	Initial Moisture Content (%)	Grain Depths (ft.)	Static Pressure (inches water gage)	Maximum Quantity that Can Be Dried per Fan Hp (Bu)
Corn (shelled)	6	25	3	0.60	885
			5	1.50	360
			7	3.20	170
	5	22	5	1.00	635
			7	2.40	265
			8	3.40	190
	3	18	7	1.27	835
			9	2.14	495
			10	2.65	400
	2	15	7	0.81	1,965
			9	1.33	1,200
			11	1.95	815
Corn (ear)	8	25	5	0.67	595
			10	3.25	120
	4	18	10	0.41	1,940
			20	1.50	545
Grain sorghum	6	25	3	1.09	485
			4	1.89	280
	5	22	3	0.97	655
			5	2.50	255
	3	18	3	0.66	1,610
			5	1.45	730
			7	2.70	395
	2	15	5	1.00	1,590
			7	1.72	925
			9	2.77	575
Oats	3¾	25	5	1.50	565
			7	3.05	280
	3	22	5	1.15	925
			7	2.21	480
			8	3.05	350
	2¼	18	5	0.90	1,570
			7	1.65	860
			10	3.35	425
	1½	15	7	1.09	1,950
			9	1.69	1,255
			11	2.56	830
Soybeans	6	25	5	1.10	480
			8	2.97	180
	5	22	5	0.90	710
			7	1.72	370
			9	3.04	210
	3	18	7	0.95	1,120
			9	1.51	705
			11	2.45	435
	2	15	7	0.66	2,410
			9	0.97	1,640
			11	1.57	1,015

Table 9. Approximate drying time for grains and seeds at different initial moisture contents and months of the year.

Kind of Grain or Seed	Initial Moisture Content (Percent)	Month	Rate of Air Flow (CFM/Bu.)	Total Time in Drying Beans (Days)
Corn, shelled	25	September	6	12
	25	September	10	8
	25	October	6	16
	25	October	8	12
	16	October	8	5
	15	Nov. - Jan.	2	70
Grain sorghum	25	Sept. - Oct.	6	28
	21	Nov. - Dec.	5	55
Oats	25	May - June	5	7
	17	May - June	2	21
Wheat	15	May - June	2	33

Table 10. Weight loss due to drying grain.

Initial Moisture Content (%)	Final Moisture Content (Percent)				
	15½	14	13	12	10
	Percent Shrinkage				
30	17.2	18.6	19.6	20.4	22.2
25	11.2	12.8	13.6	14.8	16.7
20	5.4	7.0	8.1	9.0	11.0
17	1.8	3.5	4.6	5.7	7.8

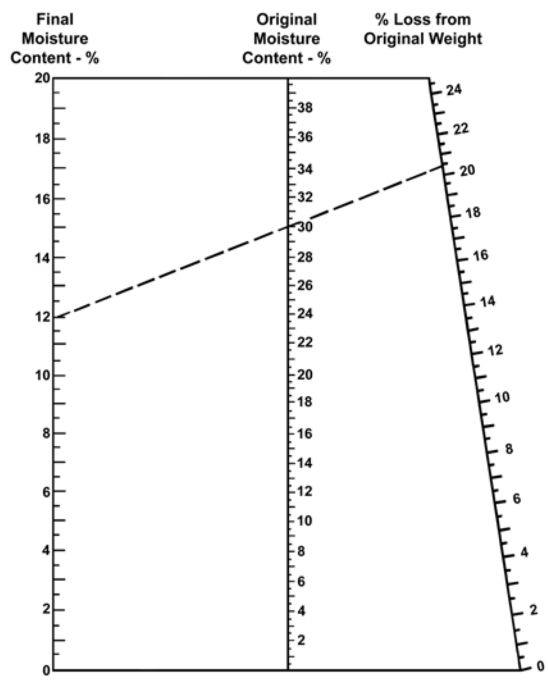

Figure 4. Guide for estimating percent weight loss in grain drying. To use chart, place straight edge at final and original moisture content and read off the percentage loss.

Moisture Control in Grain Tanks

The Problem: Grain stored in metal tanks 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, all of which are directly related to moisture.

Grain or beans harvested in the summer or fall and placed in storage produce air currents within the tank that cause moisture condensation. The process can occur within a completely enclosed and sealed tank and is caused by temperature differences within the grain. As the outside air temperature decreases, the bin walls cool which cools the grain layer near the walls and roof. Air next to the walls cools and becomes dense, settling toward the bottom of the tank. The interior holds heat and warms the air, making it expand and become light, which causes this air to rise. As this warm, moist air rises, it passes through the cooler top layer of grain, causing the warm moist air to cool and produce condensation. As this warm moist air continues to rise, it comes in contact with a cold roof and further condensation occurs. This condition, known as

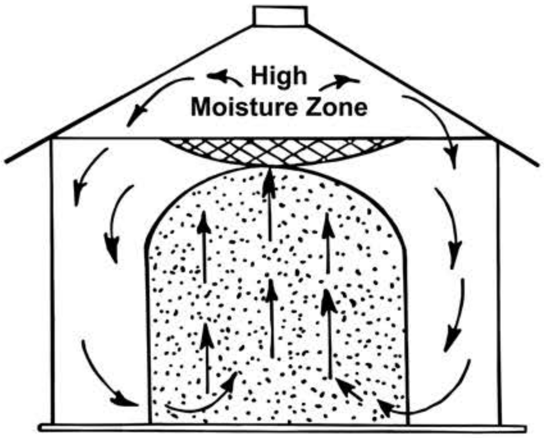

Figure 5. Convection air currents caused by differences in temperature produce moisture condensation in top layers of grain.

moisture migration, creates a wet zone in the top of the tank. This process is shown in Figure 5. Mold and insects thrive in the warm moist areas.

The Solution: Moisture migration can be prevented in grain tanks by forcing low volumes of air through the tank contents, producing uniform temperatures throughout the mass. This process is called *aeration* and requires from $^1/_{10}$ to $^1/_{20}$ cubic foot of air per minute per bushel of contents.

Aeration fans should be installed to draw the cold air down through grain, reversing the natural trend of the warm air to rise. Drawing the cold air down discharges the warm moist air outside and prevents condensation on the top surface of the grain.

Begin fan operation as soon as grain is placed in storage and the fan should be operated whenever the warmest grain is 10 degrees F warmer than the outside air. Fans should not be operated when fog, rain and high humidity exist. In late fall and winter, the fans should be operated during daylight hours when the humidity is near or below 60 percent. A grain temperature of 50 degrees F is generally satisfactory. Grain stored more than one year should be cooled below 50 degrees F if possible, giving better insect and mold control.

High volume drying fans can be used to aerate grain by operating two to three hours several times a week when the relative humidity is as discussed above. Air forced upward through grain in high volumes usually does not cause moisture to accumulate in the top layers. Of course, no heat should be added when aerating.

Regular inspection of grain tank contents is a must for successful management. Inspect the grain for moisture, insects and spoilage at least every 30 days. For further details on aeration, see Georgia Cooperative Extension Bulletin 712, *Aeration of Grain in Storage*.

Safety Considerations

Grain drying and handling can be dangerous. Transport augers can hit power lines, unguarded augers catch hands or feet and fans and shafts can possibly grab 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 who can offer assistance and summon help.

Air pockets sometimes form when grain bridges over unloading augers due to spoiled grain or moisture. Never walk on this crusted surface, the pocket can collapse leaving a big hole.

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

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

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