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Drying and Conditioning Seeds

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Until the last few years, drying grain and seeds with forced ventilation was considered only as an emergency measure for handling high-moisture crops. Now, it is rapidly becoming a standard practice in most areas.

Artificial drying has the following advantages: (1) Makes it possible to harvest earlier, thus reducing chance of losses in field from weather, insects and birds; (2) Reduces storage losses since it removes the hazard of damage caused by storing high-moisture seed; (3) Crops can be harvested faster, by operating combines more hours per day; and (4) Reduces losses due to shattering.

Principles of Drying

Before we go into a discussion of methods and procedures used for drying seed, it may be a good idea to review the basic principles involved in drying.

Drying grain consists of at least two stages - the evaporation of sur- moisture and the removal of internal moisture (1)*. As pointed out by Barre (2) and Fenton (3), many of the problems connected with drying are easier to understand when approached from the standpoint of vapor pressures. Two basic principles are involved:

1. Grain will gain or lose moisture when there is a difference in vapor pressure between the grain and the surrounding water vapor. When

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* Numbers in parenthesis refer to appended references.

the vapor pressure of the grain is higher than the pressure in the air surrounding it, moisture will move from the grain and cause a reduction in moisture. When the opposite condition exists, moisture will flow into the grain and there will be a gain in moisture.

2. The rate at which grain will lose its moisture will depend primarily on the magnitude of the difference in pressures between the grain and the surrounding space. This rate is affected by the resistance to the movement of water vapor through the surface layers of grain.

In order to dry grain or seed effectively with forced air circulation, the vapor pressure of the air flowing around the seed must be lower than the vapor pressure of the moisture in the kernels of the grain itself. To obtain fast drying, large vapor-pressure differences are required. This can be accomplished with heated air. Drying rates are usually low at ordinary temperatures since vapor-pressure differences are relatively small.

Methods of Drying

There are three methods of drying being used today. They are: (1) unheated-air drying; (2) unheated-air drying with supplemental heat; and (3) heated-air drying.

Unheated-air drying refers to the use of forced ventilation with normal atmospheric air for the removal of moisture. Drying with unheated air is a rather slow process, but when grain is to be held in storage for a period longer than is required for drying, the time element is not so important.

When crops are harvested in the fall of during prolonged periods of high humidity, it may be desirable to use supplemental heat in conjunction with unheated-air drying installations. By supplemental heat we mean adding a small amount of heat to the atmospheric air, usually a maximum of 15 degrees, in order to increase the water holding capacity of the drying air and thus accomplish drying before spoilage occurs.

Heated-air drying is the use of forced ventilation with the addition of large amounts of heat for removing moisture.

Un-Heated-Air Drying

When the subject of drying with unheated air is discussed, it immediately associates itself with a method of drying known as bin drying. By bin drying, we mean the drying of grain or seed in the same bin in which it is to be stored; or, drying in storage.

The advantages and disadvantages of unheated-air drying are:

Advantages:	Disadvantages:
1. Less investment in equipment.	1. Dependent on weather conditions.
2. Reduces fire hazards.	2. Slow drying rate.
3. Less supervision required.	3. Prolonged drying may cause damage by mold growth.

Equipment required for drying with unheated air consists of a structure for holding the seed, an air distribution system and a fan driven by an electric motor or gasoline engine.

Properly constructed conventional steel, wood or concrete buildings and bins are satisfactory. A false floor drying system is recommended for drying grain to be used as seed. Centrifugal and axial flow fans are suitable for drying seed in storage.

An important consideration in drying seed with unheated air is the maximum time permissible to complete drying without allowing damage by molds (4). The maximum permissible time varies with the conditions of the drying air and with the moisture content of the seed. There appears to be a definite time limitation for reducing the moisture content of grain and seeds to 15 to 16 percent. Research conducted by the Texas Agricultural Experiment

Station in South Texas (5) showed that the moisture of the wettest portion of sorghum grain at 78° F. must be reduced to 15 to 16 percent in 6 to 8 days, or less, to prevent undesirable mold development. In Central Indiana, Foster (6) found that shelled corn dried satisfactorily when it was reduced to 15.5 percent moisture in 18 to 27 days. Drying seed from a moisture content of 15 to 16 percent to moisture level considered safe for storage can be accomplished over a longer period of time since mold growth is greatly reduced below this level.

In South Texas, a minimum air flow rate of 3.0 cubic feet per minute (cfm) per bushel (5.4 cfm per 100 pounds of grain), with a recommended rate of 4.0 cfm per bushel (7.2 cfm per 100 pounds), is needed for drying seed with a maximum initial moisture content of 18 percent. In Georgia (7), a minimum air flow rate of 4.5 cfm per bushel is recommended for drying seed at this moisture content.

Static pressures against which fans must operate to develop an air flow rate of 4.0 cfm per bushel for various crops at 6 and 8 foot depths are given below:

	Static pressure, inches water	
Crop	6'	8'
Wheat	3.25	5.80
Sorghum grain	3.00	5.00
Oats	2.25	4.10
Shelled corn	1.50	2.50

It is important to provide drying equipment of sufficient capacity to insure drying seed without loss in germination under different weather and moisture conditions as they occur from year to year. One way to accomplish this is to have a uniform standard for design basis and then vary the depth of the seed to increase or decrease the air flow rate as needed for the different conditions encountered. For example, suppose you design a condition of 3.0 cfm per bushel through an 8 foot depth of 16 percent moisture seed; then, if the initial moisture was above 16 percent the depth could be decreased to increase the air flow rate, as shown in Figure 1. If you intend to dry several different crops, the system should be equipped with a fan and motor of sufficient capacity to supply the required air flow rate through the crop that offers the greatest resistance to the flow of air.

Unheated-Air Drying With Supplemental Heat

Bin drying with supplemental heat has the following advantages and disadvantages:

Advantages

1. Can dry regardless of weather.
2. Reduces drying time.

Disadvantages:

1. Increases fire hazard.
2. Increase initial equipment cost.
3. Requires close supervision.
4. Possibility of overheating which may result in loss in germination.

A structure for holding the seed, a fan and an air distribution system as described for bin drying with unheated air are satisfactory for bin drying with supplemental heat. In addition, a heating unit is required to heat the air to the desired temperature.

Recommendations for Using Supplemental Heat

Based on results of research conducted in the Gulf Coast Area of Texas, supplemental heat is recommended for use during cool and humid weather or during prolonged periods of high humidity (above 75 percent). The temperature of the air entering the seed may be raised 10 to 15 degrees, but should not exceed 90^{o} F. after heating. Supplemental heat should be used until the moisture content of the top foot of seed is reduced to 14 to 15 percent. After the moisture is reduced to this level, use unheated air to complete the drying to a safe storage level. During the time unheated air is used, operate the fan only when the relative humidity is less than 75 percent (usually during daylight hours on clear, bright days).

Heated-Air Drying

Advantages and disadvantages of using heated air for drying seed are as follows:

Advantages:	Disadvantages:
1. Short drying time.	1. Higher initial equipment costs.
2. Can dry regardless of weather conditions.	2. Fire hazard.
3. High drying capacity.	3. Close supervision required.
	4. Possibility of overheating which may result in loss in germination.

Types of Dryers

Three types of heated-air dryers in common use are: (1) sack dryers; (2) batch dryers; and (3) continuous-flow dryers.

A sack dryer is one which dries seed in sacks.

A batch dryer is one which dries a fixed quantity of seed at one time, with additional batches dried on a repeating basis. Usually seed is dried in layers 4 to 12 inches thick. High drying capacities are obtained by using large volumes of heated air.

Drying is accomplished in a continuous-flow dryer by continuous movement of seed through heated air.

Sack Dryer. A sack dryer is suitable for drying a small quantity of seed, but is not applicable where a large amount of seed is to be dried. It is particularly suited for drying seed since it eliminates the problem of mixing with other seeds. The chief disadvantages of this type of dryer are the high labor and equipment costs involved in sacking and handling seed, the low drying capacity and the close supervision required.

The following recommendations and operating procedures for sack dryers are based on experiments conducted with seed rice in Texas:

1. To obtain good germination, use a maximum air temperature of 110°F.
2. The fastest rate of drying is obtained with an air volume per sack of 200 cubic feet per minute for large sacks (162 pounds of dried seed) and 140 cubic feet per minute for small sacks (100 pounds of dried seed).
3. Turn the bags of seed once during the drying operation for best results.

Batch Dryer. A batch dryer consists of two basic parts - a bin or container to hold the seed and a fan-burner combination. In some cases, round, steel bins equipped with unloading augers and perforated floors have been used as containers in batch drying set-ups.

Another type of batch dryer used to some extent is known as a wagon dryer. With this method, the drying wagons usually are equipped with perforated floors over some type of air chamber. A fan and heater unit, connected to the wagon, forces heated air through the seed.

The most common type of batch dryer is the column-type dryer. It consists of two columns of seed with an air chamber between or a column of seed around a central air chamber. Heated air is forced into the air chamber and out through the columns of seed.

There are two general types of fan-burner units used on batch dryers - the direct heating system, where the gases from the burning fuel pass through the seed being dried and the heat exchanger system, where only heated air passes through the seed. Both systems should be equipped with automatic controls to eliminate fire hazards caused by fan stoppage and flame failure. In addition, each should have a device to shut off the fuel supply if the temperature goes too high.

Continuous-Flow Dryer. Continuous-flow dryers can be classified as: (1) nonmixing type; (2) mixing type; (3) belt type. The nonmixing and mixing types are most commonly used and will be discussed in this paper.

In both types seed is usually fed in at the top and flows through the dryer by gravity. The rate of discharge is mechanically regulated at the bottom. Drying is accomplished by forcing heated air through the seed as it flows downward. Fan-heater units used for these dryers are usually the direct-heat type with automatic safety controls.

In the nonmixing dryer, seed descends between two parallel screens set 4 to 6 inches apart while heated air is blown through the screens and intervening seed.

The most popular mixing-type dryers are the baffle design and the Louisiana State University (LSU) design. In the baffle design seed flows downward in a zigzag path by means of baffles while heated air is forced through the seed. The LSU design consists of a bin with alternating layers of air-inlet and air-exhaust channels. Each layer is offset so that the tops of the inverted channels divide the streams of seed. Seed flows downward between channels in a crooked path. Heated air passes from the air-inlet channels through the seed and out through the air-exhaust channels.

Cooling Seed After Drying

Seed should be cooled with unheated air as the last step in drying. In a batch dryer this usually is done by cutting off the burner and operating the fan 20 to 30 minutes. In some cases, an increase in drying capacity is obtained by using a separate cooling bin in connection with batch dryers. Most of the continuous-flow dryers on the market today have separate sections for cooling seed as it flows through the dryer.

Even though seed is cooled as a part of the drying operation, the temperature of the seed is usually above normal when it is placed in storage. For this reason, some provision should be made to cool seed after it is stored. A practical and economical method of doing this is with an aeration system using a motor driven fan to move air through the stored seed.

Aeration refers to the moving of air through stored seed at low air flow rates, for purposes other than drying, to maintain or improve its value. Aeration provides a quick method of removing dryer heat and is effective in applying fumigants to seed while in storage. It also provides a fast method of reducing seed temperatures during cool weather and thus reduce insect activity.

Air flow rates ranging from 1/10 to 1/4 cfm per bushel are suitable for aeration. These small amounts of air are not costly to provide. For example, a 9-1/2 inch diameter centrifugal fan driven by a 1/4 horsepower electric motor will deliver air at a rate of 1/4 cfm per bushel through a 14 foot depth of sorghum seed in a 2,750 bushel capacity bin.

Effect of Heated-Air Drying on Germination

An important consideration in determining the maximum temperature for drying seed is the time required for drying, since this determines the length of time the seed remains in contact with heated air. Under similar weather and moisture conditions, the time required to dry seed depends to a large extent on the type of dryer and the rate of air flow.

Large volumes of heated air can be used economically in both batch and continuous-flow, column-type dryers with seed columns 4 to 10 inches thick. For this reason, seed can be dried at a faster rate in these dryers than in bin dryers with seed 4 to 8 feet deep. Therefore, higher air temperatures can be used for drying 4 to 10 inch layers of seed than for drying seed at greater depths.

Results in tests in Texas (1) indicate the following recommendations for drying 10 inch layers of sorghum seed in a column-type batch dryer when aeration is provided to cool the seed to atmospheric temperature as soon as possible after the seed is removed from the dryer. These recommendations are based on a minimum air flow of 90 cubic feet per minute per square foot of column area.

Initial moisture content, percent	Maximum drying air temperature, degrees F.
15 - 18	150
18 - 20	125

Summary

Three methods of drying are: (1) unheated-air drying; (2) unheated-air drying with supplemental heat; and (3) heated-air drying.

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When crops are harvested in the fall or during prolonged periods of high humidity, it may be desirable to use supplemental heat in conjunction with unheated-air drying installations. The temperature of the air entering the seed may be raised 10 to 15 degrees, but should not exceed 90° F. after heating.

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The most common type of batch dryer is the column-type. These dryers are used to dry a fixed quantity of seed at one time, with additional batches dried on a repeating basis. Usually seed is dried in layers 4 to 12 inches thick. High drying capacities are obtained by suing large volumes of heated air.

Nonmixing and mixing types of continuous-flow dryers are in common use. In both types, seed is usually fed in at the top and flows through the dryer by gravity. The rate of discharge is mechanically regualted at the bottom. Drying is accomplished by forcing heated air through the seed as it flows downward.

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