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Drying and Aeration of Seed

R. K. Matthes

DRYING AND AERATION OF SEED

R. Kenneth Matthes[1]

Time was, not long ago, when seed farmers depended on Mother Nature to do their drying, and few are convinced that old Mother Nature ever needed artificial assistance; but, those days are about gone--forever.

Several factors have worked together to make Mother Nature obsolete; particularly, high capacity combines and new plant varieties which are extremely susceptible to field losses at low moisture content. University research and farmer experience have both proven the significant economic advantages to harvesting at high moisture to reduce field losses. Most corn harvesting is started at moisture contents of twenty-five to twenty-seven or even thirty percent. By the time seed has passed the dough stage and moisture content is down to thirty percent or so it has reached its maximum maturity. In other words, it has reached top quality as a seed crop and is at ideal conditions for harvesting. If the moisture content is decreased, an increase in field loss will result and also an increase in mechanical damage due to, harvesting, conveying, and processing,will also result.

The answer is harvesting at maturity at a high moisture content before heavy field losses occur. Get the seed out of the field and into safe storage, then utilize modern drying techniques to remove the excess moisture.

Drying Properties of Seed

The process of removing the moisture from a seed takes place in two stages:

1. The surface moisture of the seed is initially removed by the drying air.

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[1] Dr. Matthes is Assistant Agricultural Engineer, Agricultural and Biological Engineering Department and Seed Technology Laboratory, Mississippi State University.

2. The removal of surface moisture causes an imbalance in the moisture potential in the surface of the seed and the inner portion of the seed which causes a moisture movement to the surface of the seed.

The moisture holding capacity of the seed and the ease with which moisture can move through a seed determines the effect of the drying air and the speed in which a seed can be dried.

The difficulty encountered in removing moisture from biological materials even when it is finely ground, seems to be due principally to the fact that the water is present in different forms. When an inorganic material such as wet sand is heated at 100^{o} C. or higher at atmospheric pressure, the moisture is lost at a rapid and essentially uniform rate until the material is completely dry. In drying seed however, a much longer time is required to remove the moisture. The rate of moisture lost decreases rapidly as the drying progresses, and the ultimate loss in weight differs with different temperatures employed for drying.

In biological materials, such as seed, part of the moisture present appears to be tightly held or "bound", by powerful physical forces of proteins, high molecular weight carbohydrates, and perhaps collodial substances. This moisture, sometimes spoken of as bound water, is much more difficult to remove than the free water. The tenacity with which water may be held to collodial substances probably varies with the nature of the collodial material and with the amount of water so held. Thus, in the case of wet seed there is probably encountered a graduation between free water that is removed by heat as rapidly as water from wet sand and water that is so tightly held that it can be removed only under conditions of temperature and pressure that may permit volatization or decomposition of other constituents.

Bound water is water which is tightly linked within the molecular structure of starch, protein, and other components of grain to such an extent that it is essentially a part of the physical structure although not the chemical structure of the molecules. Free water is defined as water which is capable of acting as a solvent and is found in the interstitial spaces between the larger molecules.

Equilibrium Moisture Content

When seed are freely exposed to the air they will gradually lose or gain in moisture content until they reach a moisture content level in equilibrium with the relative humidity of the air to which they are exposed. Likewise, the interstitial air in unventilated stored seed will tend to become stabilized at a relative humidity in equilibrium with the moisture content of the seed.

The equilibrium moisture content is useful to determine whether a product will gain or lose moisture under a given set of temperature and relative humidity conditions. A product is in equilibrium with its environment when the rate of moisture loss from the product to the surrounding atmosphere is equal to the rate of moisture gain of the product from the surrounding atmosphere. The atmospheric conditions are defined by temperature and relative humidity. The moisture content of the product when it is in equilibrium with the surrounding atmosphere is called the equilibrium moisture content or hygroscopic equilibrium. The relative humidity of the surrounding atmosphere is known as the equilibrium relative humidity at the particular temperature. Thermodynamically, equilibrium is reached when a free energy change from a material is zero. The equilibrium moisture content of a particular product varies with the relative humidity and the temperature, and it may be expressed on either a wet or a dry basis.

The relationship between the moisture content of a particular material and its equilibrium relative humidity at the particular temperature can be expressed by a means of equilibrium moisture curves. These curves are sometomes referred to as isotherms, because the values plotted for each curve usually correspond to a specific temperature.

The composition of a product determines the absorption of moisture. With seed stuffs the relative amount of solubles carbohydrate and protein largely determine the equilibrium moisture curve. At 63 percent relative humidity the water absorption varies directly with the carbohydrate content and inversely with the protein content. At 90 percent relative humidity the relationship is reversed.

The equilibrium moisture content information can be used for determining the vapor pressure of the material. If the vapor pressure of the surrounding atmosphere moisture will move from the material to the atmosphere. Conversely, if the vapor pressure of the material is lower than the surrounding atmosphere, moisture will move from the atmosphere to the material . The vapor pressure of the material in question can be readily determined by superimposing the equilibrium moisture content data on a psychometric chart. If the vapor pressure of the product is below that of the atmosphere the product will gain moisture and sometimes may gain enough moisture so that mold growth in storage increases to an extent that the produce is damaged. Figure 1 gives the equilibrium curves for several types of seed at 75°F.

Drying Methods

There are three major methods of drying with forced air. These are:

1. Natural air drying, using unheated air as nature supplies it.

2. Drying with supplemental heat, providing small amounts of heat to the drying air in quantities; just sufficient to reduce the relative humidity so drying can take place. The temperature increases in the air about 10 to 20° F.

3. Heated air drying, where the drying area is heated considerably perhaps as much as 100°F. or more.

The first two methods which may require one to three weeks or even more to reduce the seed moisture content to safe levels are generally used to dry seed which will be stored for some period on the farm. Heated air drying is commonly favored when time is a limitation and the drying facilities must be made available for freshly harvested seed.

Which of these methods is to be preferred will depend upon the individual operation. All three can be used on all seed; although, for certain crops one or the other may be strongly favored.

MOISTURE EQUILIBRIUM CURVES

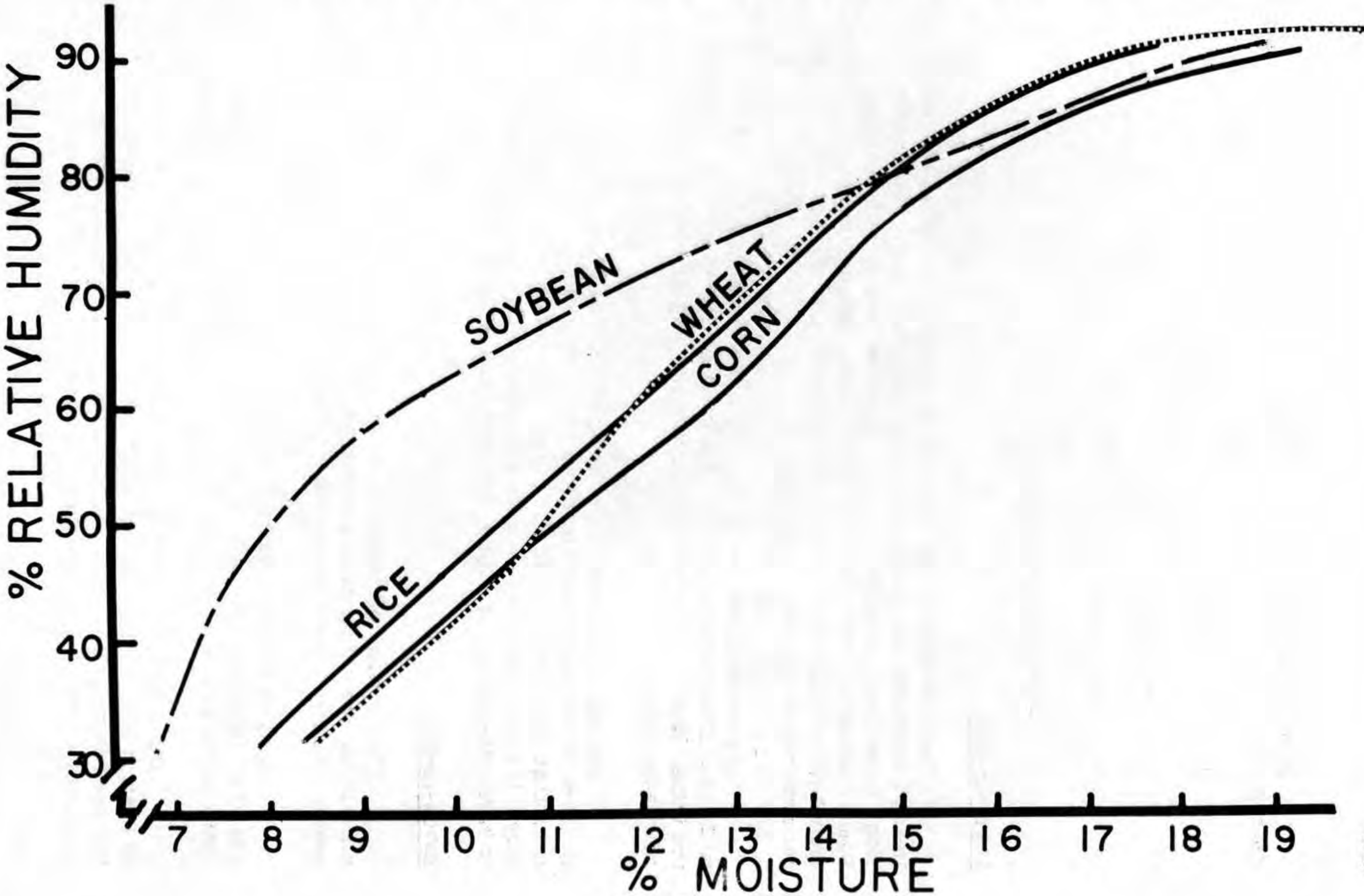


FIGURE I

Heated air drying can be further broken into four more catagories.

1. Layer-in-bin

2. Batch-in-bin

3. Batch dryers

4. Continuous dryers

Layer-in-bin

The components that make a bin perform as a dryer are fan, heater, operating and safety controls, transition duct, foundation ring, false floor, seed leveler, sweep unloader and unload auger. Some dealers sell bin dryers on the basis of getting something more than with batch or continuous dryers--storage. You pay for storage and drying.

Layer-bin dryers range from 21 to 40-ft. diameter and 5 to 20 hp. It's the most efficient but slowest drying method. After the initial layer, fills must be separated by 3-4 days while each new layer dries.

Handling requirements consist of one flight elevator or auger with wet corn receiving rates of 600 to 1,200 bu./hr. If more than one drying bin is used, the conveyor is moved periodically. If additional storage units are needed, consider shifting to batch-in-bin drying with a permanent handling system.

Batch-in-bin

This drying equipment is similiar to layer drying. Main differences are higher capacity heaters and fan, grain levelers, sweep unloaders (with backshild) and unload auger equipment.

Seed depths are typically 2 1/2 to 4 ft.; the deeper the seed bed, the lower the airflow and the slower the drying. Seed between the bottom and top of the layer will vary from 6 to 8 points.

Most operators use the dryer operator's manual as a guide to heating and cooling time for each batch, then start the dryer so the seed is cooled out at a specified time the following morning. A time clock can be used to shut the heater off at a pre-set time, allowing the fan to cool the seed until unload time. Typical times are 9 to 12 hours of heating, two hours of cooling.

Handling should be either semi-permanent (stationary, inclined conveyors) or permanent (belt-cup elevator leg, mechanized dump pit, and gravity spout or auger transfer from leg.) Wet corn receiving rates of 900 to 1,800 bu./hr. (15 to 30 bu./min.) are recommended for total corn volumes of 15,000 to 50,000 bushels with dry corn unloaded from the bin in one to 1.5 hours. A high capacity shielded sweep unloader is a must.

Batch Dryers

Batch dryers are bins with an inner air chamber or plenum surrounded by two parallel perforated steel walls to contain a designed thickness of seed. The fan-heater unit is connected to one end or side of the plenum as heated air for drying and natural air for cooling can be forced through the seed.

Batch dryers, generally rectangular or cylindrical, are uaually described by the volume in bushels that a dryer will hold per fill, i.e., 300 bushel dryer. Sizes range from 72 to 750 bushels; 250 to 500-bu. sizes are typical. Fan power ranges from 3 to 30-40 hp. The number of batches per day may be 8 to 10 for small dryers but only two or three for large units. Dryer capacities are rated on an average moisture removal of 10 points.

All batch dryers depend on fast handling. Wet holding capacity is needed to avoid seed receiving bottlenecks. Total cycle time includes heating and cooling plus load and unload time. Handling capacity must be matched to dryer speed to minimize downtime. About 1,500 bu./hr. for small dryers (250 bu. in 10 min.) and 3,000 bu./hr. for large dryers (600 bu. in 12 min.) are good load and unload handling rates.

Batch drying requires close management to coordinate moisture sampling, wet seed receiving, dry seed transfer, and dryer operating cycles. The operator usually cannot operate both harvest and manual batch drying. Mechanized automatic dryer control allows periodic dryer supervision by the field sheller operator. Moisture testing in field gives closer control of both operations.

Continuous Dryers

Continuous flow dryers move seed through heating and cooling sections of the seed column continuously. Seed flow is controlled by volume metering devices at the lower side of the seed column. Heated air is forced through the upper 2/3 to 3/4 of the seed column at 100 to 150 + cfm/bu. Continuous dryer sizes are usually given in bu../hr. capacity at 10 points moisture removal. Power needs are from 7 1/2 hp. to 60 hp. Some dryers use multiple-sequence start fan motors to keep starting loads low.

Wet-holding is necessary for both one-and two-leg systems. With one leg, seed from the dryer is accumulated in a dry holding bin for periodic manual transfer. With two legs a low capacity elevator leg moves dry seed to storage continuously.

Seed "Mixer" Aids Drying

The seed stirrer is a relatively new and unique device that stirs every bushel of stored seed in a bin, thus helping to make sure that drying air reaches all the seed. The unit consists of an auger or pair of augers extending vertically down into the seed. As the auger revolves it is spiraled slowly around the bin by the supporting arm. Each complete cycle takes 4 to 8 hours, depending on bin size.

Advantages offered by the device are: loosening of seed for even drying from top to bottom, center to sidewall; elimination of hot spots; no top crusting, and no overdrying at bottom of bin. Mixers are used mainly for in-storage drying operations with small dryer units and slow drying. Stirring in a batch-drying operation is seldom practical unless the seed layer is unusually thick (more than four feet) . The purpose of stirring deep batches is to prevent overdrying at the bottom.

Caution is urged when using stirring devices because of their possible damage to bin sidewalls. Be sure the auger is always near the center of the seed bin when starting to minimize concentrated pressure and possible damage to sidewalls.

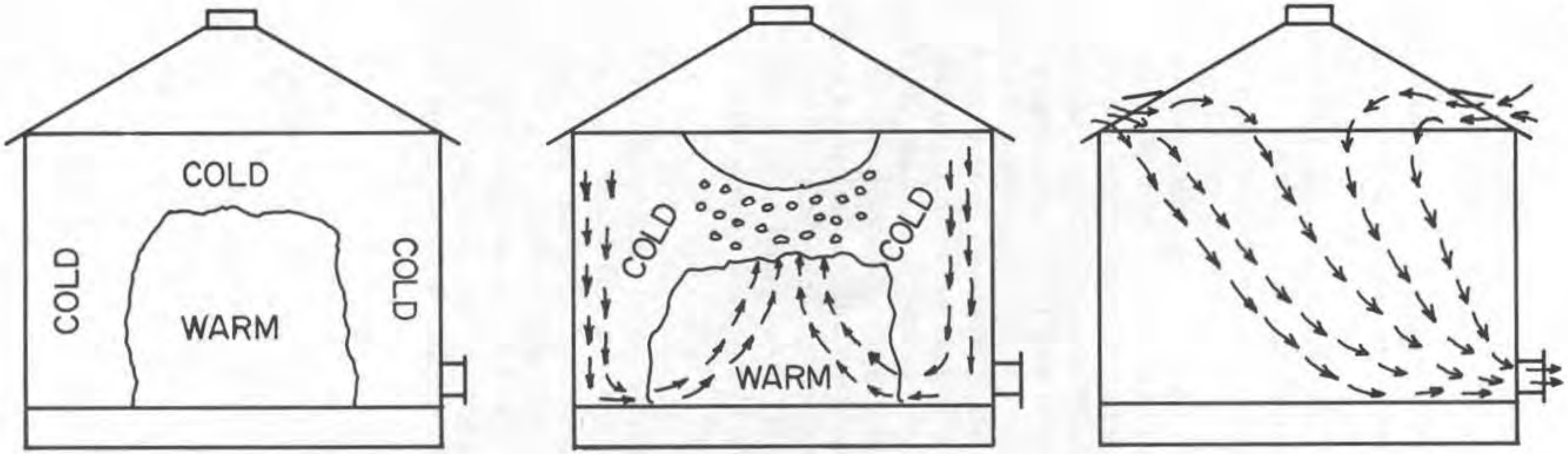
Aeration of Stored Seed to Prevent Excess Moisture

It's not at all uncommon for the seedsman to put dry, clean seed into storage in the fall and then be rudely disappointed in the spring when they find portions have become wet and spoiled. Their immediate reaction is to look for leaks in the bin roof or walls. But the actual source of trouble is, in all probability, moisture migration from warm seed to cold seed within the bin.

Seed is a good insulator. Because of this only the seed near the outside walls will vary in temperature with the season of the year. This variation of temperature causes small convection air movements within the mass of seed. During winter months, cold air currents move down along the outside walls to the floor and then toward the center of the storage where it warms and picks up moisture. Relatively warm moist air in the center of the seed mass moves up through the seed. When this air mass contacts the cold layer of seed at the top of the storage, moisture is condensed out. Condensation may develop very slowly but over a period of several months it will cause a substantial increase in the moisture content of the seed at the top center of the bin. Cases of moisture increasing from 13% to as much as 25% have been reported due to this air movement within moderate-sized storages.

Aeration is the positive solution to this moisture migration problem. Aeration is simply movement of a small amount of air through the seed so as to produce a uniform temperature throughout, thus halting a moisture migration. Aeration requires a very small amount of air--from 1/10 to 1/20 cfm per bushel of stored seed. The aeration fan equipment is very small compared to drying equipment. Aeration cannot be depended upon to do any appreciable drying.

Aeration fans should be operated in the fall when outside air temperatures are at least 10 to 15^{o} cooler than the warmest seed. Fans should be operated continuously during fall months except for rainy or foggy weather. Later, the fans should be operated during daylight on days with relative humidity below 75% until seed cool down to between 35 to 40^{o}. Fans should not be operated during freezing weather.



CAUSE
---Outer grain exposed to cold outdoors cools, grain in center of bin remains warm setting up a temperature differential in mass of stored grain.

EFFECT
---Convection air currents move through warm relatively moist center of grain mass, carrying moisture which condenses on upper layer of cool grain.

CURE
---Aeration fan draws cool air downward through grain mass, equalizing temperature throughout, thus eliminating any tendency for convection air movements.

FIGURE 2

In the spring when outdoor temperatures are consistently above seed temperature, aeration should be used to warm the seed gradually at the rate of 5 to 10^{o} each month. The seed should be gradually but steadily warmed to temperature of about 70^{o}.

Aeration equipment should be installed so as to draw the cold air down through the seed and not upward as in many drying installations. In this way the warm, moist air is discharged directly from the bin to the outside and does not condense on the seed.

The only positive way to prevent quality deterioration of conventionally stored seed is to reduce the moisture content to a safe level for storage , and maintain that moisture level with aeration.