1985

G85-760 Natural Air Corn Drying

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G85-760-A

NebGuide

Published by Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln

Natural Air Corn Drying

This NebGuide discusses factors affecting natural air corn drying system performance, and gives recommendations for bins filled over a one- to two-day period.

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Natural air drying is an energy efficient drying method that is particularly well suited to Nebraska weather conditions. A high quality dried product, with little of the stress cracking or heat damage associated with high temperature drying, is an added attraction. However, good management practices must be followed to achieve satisfactory drying results.

A major concern with this method is overloading the bin with corn too wet to be dried without spoilage or deterioration, especially when the bin is filled within a one- or two-day period. Once the bin is filled, drying fans need to be operated in a manner that allows the corn to be safely dried to the desired moisture level while minimizing energy use. An understanding of how drying occurs in a bin is helpful in relating management recommendations to the achievement of these goals.

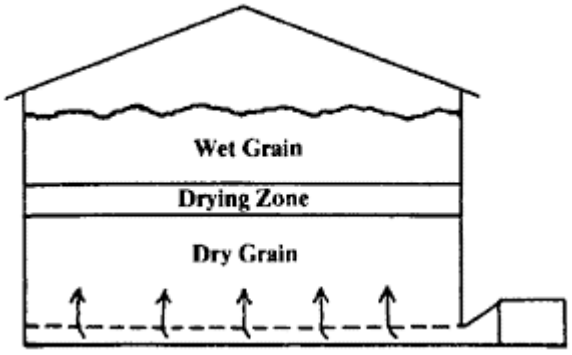

Figure 1. Moisture profile established during the natural air drying process.

The Drying Process

A well-defined moisture profile develops within the bin during the drying process as shown in *Figure 1*. The actual drying takes place in a 1- to 2-foot thick drying zone which moves up through the corn as it dries. The corn behind the drying zone approaches moisture contents in equilibrium with the drying air. The moisture content of the corn ahead of the drying zone remains relatively unchanged. It is the corn

nearest the grain surface that is most likely to spoil if drying zone movement is too slow.

The rate of movement of the drying zone largely depends on the drying air conditions, the moisture content of the corn in the bin, and the airflow rate supplied by the fan. Of these factors, drying zone movement is most directly related to airflow amount. If the airflow rate is doubled, the rate of movement of the drying zone will also be doubled. If the fan is not run continuously, the drying rate will be reduced by a proportional amount. Therefore, it is usually desirable to run the fan continuously until the initial drying zone has been moved through the grain and all of the corn is dried to at least 18%.

Weather conditions have less of an effect on drying zone movement. Drying air conditions do affect the moisture content of the corn below the drying zone. The information in *Table I* can be used to determine the moisture content to which corn will dry for a given air temperature and relative humidity. For example, 50°F and 70% relative humidity air will dry corn to a moisture content of 15.4%.

Table I can also be used for rewetting by reducing the moisture contents by one percentage point. This reflects the fact that it is harder to add moisture back to a kernel than it is to remove it. Thus, 50°F and 70% relative humidity air will only rewet corn to approximately 14.4%, not 15.4%.

Rewetting normally affects only a small amount of corn at the bottom of the bin. This corn can be rewet and dried several times as the drying zone is moved through the grain. Since movement of the drying zone is the primary consideration, operating the fan during short periods of poor weather has little effect on overall drying performance.

Table I. Equilibrium moisture contents for shelled corn.

Temperature (°F)	**Air Relative Humidity (%)**					
	40	50	60	70	80	90
	----------Moisture content (%) ----------					
30	12.7*	13.9	15.2	16.7	18.6	21.1
40	11.9	13.1	14.5	16.0	17.9	20.5
50	11.2	12.5	13.8	15.4	17.3	20.2
60	10.6	11.9	13.3	14.8	16.8	19.7
70	10.0	11.4	12.7	14.3	16.3	19.3
*Subtract one percentage point for rewetting.						

Harvest Moisture Limitations

Maximum allowable corn moisture contents for natural air drying largely depend on the amount of airflow delivered by the drying fan. A minimum of 0.75 cf/bu is recommended. Typically, natural air drying systems are designed for an airflow rate of 1.0 cf/bu. Full perforated drying floors are needed to accommodate these airflow rates and to allow for uniform airflow distribution.

Table II. Maximum corn moisture contents for a bin filled in one or two days.

Airflow Rate	Harvest Date			
(cfm/bu)	9/15	10/1	10/15	11/1
Sioux City				
0.75	18.5	19.5	20.0	21.5
1.00	19.0	20.0	21.5	23.0
2.00	20.5	21.5	23.5	24.5
Lincoln				
0.75	19.0	19.5	20.0	22.0
1.00	19.5	20.0	20.5	23.0
2.00	21.0	21.5	22.0	25.5
Grand Island				
0.75	19.5	20.5	21.5	23.0
1.00	20.0	21.5	22.0	24.5
2.00	22.0	23.0	24.5	26.0
North Platte				
0.75	20.5	22.0	22.5	24.5
1.00	21.0	22.5	23.0	25.5
2.00	23.0	25.0	25.0	26.0
Scottsbluff				
0.75	22.0	23.0	24.0	25.0
1.00	22.5	24.0	24.5	26.0
2.00	24.0	26.0	26.0	26.0

Weather conditions affect both drying rate and the rate of mold growth and development. Thus, maximum allowable moisture contents will vary with harvest date as well as for different locations across the state. *Table II* gives recommended harvest moistures for several combinations of location, harvest date, and airflow rate. Note that corn may be harvested and dried at higher moisture contents later in the fall when temperatures are cooler. Also, harvest moistures can be increased as you move from the warmer, higher humidity conditions of southeast Nebraska to cooler, dryer conditions in the panhandle. Be aware, however, that harvesting higher moisture corn will require longer periods of fan operation with increased energy use. Drying performance is generally most satisfactory when 20 to 22% corn is harvested around the middle of October.

The moisture limitations shown in *Table II* assume that the fan was run continuously until all the corn in the bin was dried. This may not be practical when drying is not completed before winter. There is little advantage to running the fan over the cold winter months. During this period, temperatures are low enough that the air has little moisture carrying ability. The low air temperatures also result in higher relative humidities that further limit drying capacity. Thus, continuous fan operation is not

recommended during these months UNLESS the drying zone has not yet been moved completely through the bin.

Drying Times

Drying times will vary depending on harvest date, corn moisture content, airflow rate, and local weather conditions. Fan operating procedures also affect the amount of time required to complete the drying process.

Example drying times are shown in *Table III* for five locations across the state. These results are for corn harvested at 20% on October 15 and dried to 15% using an airflow rate of 1.0 cf/bu.

For a warmer than average fall, drying was generally completed by mid-November for all five locations. This was accomplished by running the fan continuously for a 4- to 5-week period. For cooler than normal weather conditions, drying was generally not completed in the fall for the locations studied. In most instances, over twice as many hours of fan operation were needed to complete drying. Be aware that it is normal for drying times to vary considerably from one year to the next. Do not make the mistake of trying to cut drying costs by skimping on fan operation during years with poor drying conditions.

Table III. Example drying times for 20% corn harvested on October 15 and dried using an airflow rate of 1.0 cfm/bu.

Location	Warm Fall		Cool Fall	
	Date drying is completed	Hours of fan operation	Date drying is completed	Hours of fan operation
Sioux City	November 20	888	April 19	2380
Lincoln	November 15	768	April 12	2212
Grand Island	November 16	792	April 3	1996
North Platte	November 14	744	April 16	2308
Scottsbluff	November 11	672	December 6	1272

Fan Management

As noted in the previous section, the hours of fan operation required to complete drying can vary considerably depending on harvest conditions. Fan management procedures need to reflect this variation in drying conditions. A general fan operation schedule is:

- Run the fan continuously during the fall until all of the corn has been dried below 18%.
- If drying cannot be completed in the fall, maintain cool grain temperatures over the winter by running the fan 4 hours a day every 1 to 2 weeks. Try to run the fan when air temperatures are about 32°F to maintain grain temperatures at this level.
- Resume continuous fan operation in the spring when average daily temperatures reach 45°F, usually by mid-March, and complete drying.

These basic procedures work well for most natural air drying situations. There is generally little

advantage in trying to outguess the weather and turning the fan on and off accordingly. On the contrary, there are many instances when the fan should not be turned off because it greatly increases the chances for spoilage. *Figure 2* can be used to help identify these critical fan operation periods, based on the moisture content of the wettest corn in the bin and the time of year.

Three general fan operation periods are identified in *Figure 2*. The first of these is a continuous fan operation period (I) where the fan should run day and night regardless of weather conditions. Temperatures are normally warm enough during this period that grain deterioration is of much greater concern than any rewetting that might occur because of high humidity. In fact, continuous fan operation during this period often results in overdrying of the corn at the bottom of the bin.

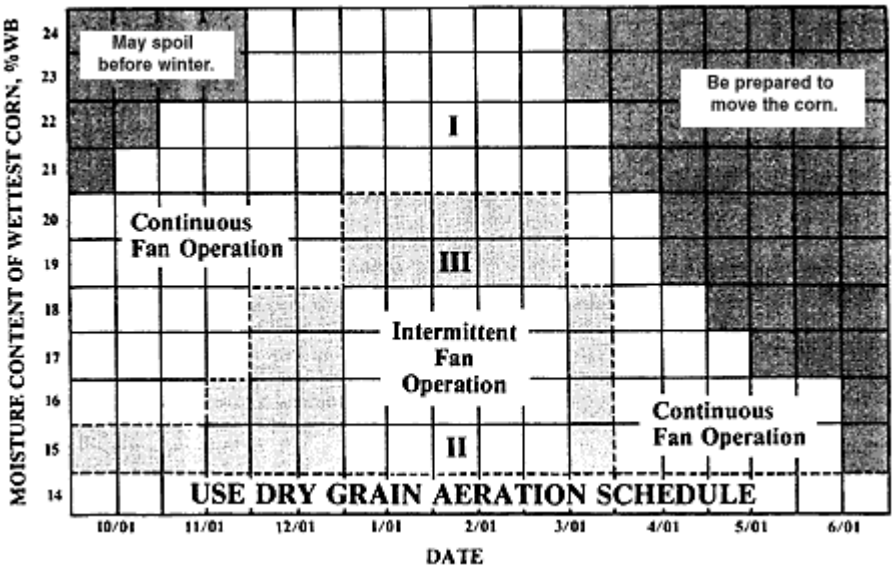

Figure 2. Fan management recommendations as affected by corn moisture content and time of year.

A "winter holding" or intermittent fan operation period (II) is also identified. Long-term weather records indicate that little drying is possible during this period. The higher the corn moisture content, the shorter the length of the holding period with more frequent fan operation required. Remember that it is best to have moisture contents below 18% before shutting the fan off for the winter. A weekly checking schedule is recommended if corn is held over the winter at moisture contents above this level. In any event, check grain condition at least once every two weeks.

The final fan operation period (III) is basically one of transition between the continuous and intermittent (or holding) fan operation periods. While running the fan continuously may still be the best management alternative, the fan can now be turned off during periods of unusually cold or humid weather without greatly increasing the risk of mold damage. For example, the fan might be operated only during the day and turned off at night as temperatures get colder late in the fall. In the spring, intermittent fan operation is less desirable and the two-week transition period shown in *Figure 2* is only intended to indicate that there is some flexibility as to when continuous fan operation should be resumed.

The fan management previously described is based upon the movement of drying zones through the grain. Management practices may need to be altered if the drying bin is equipped with either a supplemental heater or a stirring device.

Example Problem. To illustrate the use of *Figure 2*, consider a situation where 22% corn was loaded

into a natural air drying bin on November 7. The drying setup consists of a 30-foot diameter bin equipped with a 10 HP fan capable of delivering 1.0 cfm/bu through 10,000 bushels of corn (17.7 feet deep). The fan was managed according to the moisture content of the corn at the top of the bin as shown in *Figure 3* and described below:

1. The fan was run continuously from November 7 to January 1, at which time the top 2.0 feet of corn was still at 20%.
2. The management alternatives at this point were to continue to run the fan and push the drying zone on through the grain, or to hold the corn over the winter and resume continuous fan operation early in the spring. In this case it was decided to continue fan operation because of milder than normal temperatures.
3. The drying zone was moved through the corn by January 9 and fan operation was reduced to 4 hours per week.
4. Continuous fan operation was resumed on March 1 when average temperatures reached 45°F.
5. The spring drying zone was moved all the way through the corn by March 29. The corn at the top of the bin was at 15% and the bottom was dried to 13%.

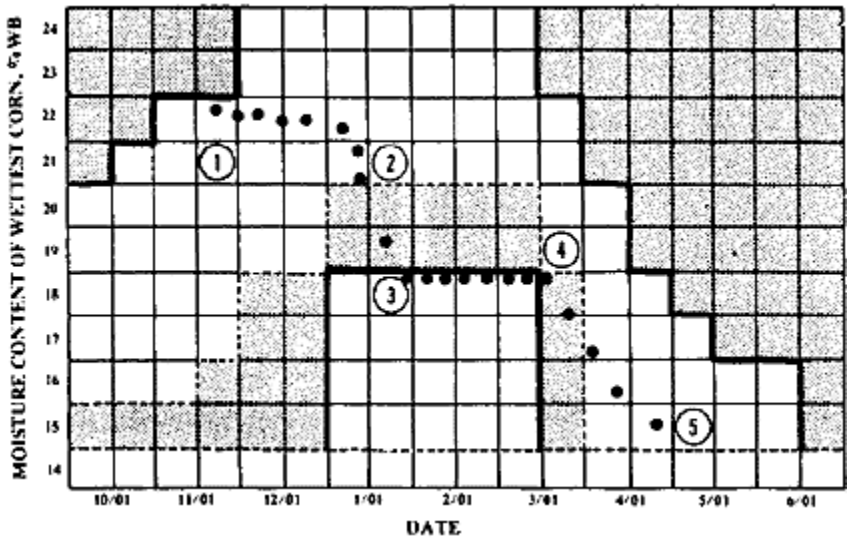

Figure 3.

Supplemental Heat

Adding supplemental heat late in the fall may help to prevent rewetting of the corn behind the drying zone. This can eliminate the need for moving a second drying zone through the grain in the spring. However, adding heat does not significantly speed the rate of movement of the drying zone. Rather, the higher temperatures cause the corn behind the drying zone to be dried to a lower moisture content. Overdrying occurs if heat supplementation levels are too high for the existing airflow rate. At the same time, the higher air temperatures may actually create mold problems in the wet corn at the top of the bin. It is generally more economical and less risky to speed drying front movement by increasing the air-flow rate rather than adding supplemental heat.

Stirring

Little stirring management is required for heated air in-bin drying systems. The stirring device is simply run continuously for the 5 to 7 days required to complete drying. This is not true for natural air drying where drying times are typically extended to 6 to 12 weeks. Stirring for this length of time is not energy

efficient .and may result in higher levels of grain damage. Rather, the maximum benefit is derived from stirring the corn once every 1 to 2 weeks.

The following general management procedures are recommended when stirring natural air drying bins:

- While the bin is being filled, run the stirring device to loosen the grain and allow easier starting of the stirring augers at a later date.
- Stir the grain every 2 weeks as drying progresses during the fall. Stir more frequently as drying nears completion.
- If the drying front has not been moved through the grain by mid-December, stir the grain before reducing fan operation for the winter.
- If additional drying is needed in the spring, stir the grain once a week until drying is complete. This more frequent stirring will make it easier to check average grain moisture contents.

The use of a stirring device allows changes in fan management practices to take better advantage of favorable drying weather. Since overdrying is no longer a concern, fan operation can be avoided during rainy or humid conditions if all of the corn is below 18%.

File G760 under: FARM BUILDINGS
D-7, Crop Storage and Drying
Issued August 1985; 12,000 printed.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Elbert C. Dickey, Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.