GRAIN QUALITY

Task Force

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Low-Temperature Drying of Corn in Southwestern Indiana

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With the new Azteca corn masa milling plant in operation near Evansville, farmers now have the opportunity to raise food grade white and yellow corn and receive higher premiums than are available for river export. However, processors of food-grade corn demand higher quality, including less than 20% stress cracks. Unfortunately, most on-farm drying systems in Southwestern Indiana are set up for high temperature drying, which causes higher levels of stress cracks (usually more than 50%). Stress crack formation in corn kernels during drying can essentially be avoided by adopting less detrimental drying methods such as in-bin natural air or low-temperature (NA/LT) drying. This fact sheet summarizes procedures for NA/LT drying of shelled yellow and white corn. It is based on historic Evansville, Indiana, weather data.

What Is Low-Temperature Drying?

Low-temperature drying is in-bin drying of corn using airflow rates of 1 to 2 cfm/bu, and natural air, or air heated by 5-15 F. Generally, low-temperature drying of a single batch of corn in a deep bed (up to 18 feet) is not recommended for moisture contents above 20-22%. However, weather conditions, equipment and practices of individual farmers significantly influence this recommendation. To provide more specific guidelines, we used the Purdue low-temperature drying computer program to generate tables which list maximum filling depths for layer drying with low air temperatures at two harvest moisture contents (19 and 22%) and four airflow rates (1, 1.2, 1.5 and 2 cfm/bu) during good, average, and poor drying years for Evansville weather data (1979-1989). The tables apply when natural air is used without any supplemental heat, and when a minimum amount of supplemental heat is used to complete drying before the end of the current calendar year. The specific recommendations are summarized in table format.

The recommended filling depths can be used regardless of bin diameter as long as the design airflow rate is maintained. Airflow is the key to successful low-temperature drying. When more air is moved through the grain, more water will be carried out. If you do not know the airflow rate from your fan for a particular grain depth, contact the manufacturer of your fan, or your Purdue CES County Office (ask for publication AE-106 “Fan Sizing & Application for Bin Drying/Cooling of Grain,” or for a copy of the FANS computer program).

How to Decide What a Good, Average or Poor Drying Year Is?

It is difficult to predict whether a particular fall season will be a good, average or poor drying year. It appears that using some supplemental heat may be the safest strategy, particularly for corn around 22% moisture content. It must be noted, however, that supplemental heat often leads to overdrying of the bottom corn layers. For example, adding 15 F of heat can dry corn in the bottom of a bin to below 9% moisture. Overdrying means weight loss and higher breakage susceptibility. Thus, adding just the right amount of heat is critical to optimize the drying process.

Furthermore, overloading the low-temperature bin dryer can lead to significant corn spoilage problems. Grain at the top of the corn mass is the last to dry, and it will usually increase in moisture content before drying begins. The conditions in this part of the bin can easily lead to mold and myctoxin (such as aflatoxin) development. It is generally better to add a layer of grain that is too thin than one that is too thick. Spoilage potential is reduced by adding the new layer only after the corn at the top surface has begun to dry.

How Can I Maximize the Capacity of My Low-Temperature Drying System?

High harvest moisture contents will result in more fines and broken corn, and slower drying. This creates an extra challenge for farmers who depend solely on low-temperature drying systems. Pre-cleaning the corn is a must, even though it can be difficult to separate the wet fines and broken kernels. Removing fines and trash ahead of the drying bin routinely improves airflow, and thus drying capacity. Bins must be filled using a good spreader to assure level filling. Another option is to increase the airflow through the grain by installing a larger fan or a second fan. However, proper fan selection is critical to optimize airflow while minimizing horsepower requirements, and thus operating costs.

How Do I Use These Recommendations?

A typical full-bin depth of 18 feet was used to determine the number of days to fill the bin and the thickness of the grain layer to add each fill period. Continuous fan operation was assumed from the start of bin filling through the end of November (or longer if needed to allow the maximum moisture to drop below 18%). The fan operation was changed to 4 hours per day once a week starting December 1 (or after the maximum moisture dropped below 18%) for winter carry-over. Continuous operation was resumed March 1 until the grain dried to below 15% moisture. This management strategy is appropriate because corn can be safely stored during the winter months at low temperatures (preferably below 30 F) and at moisture levels of 18% or below. The drying time specified is the estimated time of achieving a maximum moisture of 15% in the corn mass. The criterion used to ensure safe drying is a dry matter loss of less than 0.5%, which is the level before a reduction in market grade of the corn occurs.

Many farmers use supplemental heat in their low-temperature systems to complete drying without excessive dry matter loss. Although it is wise to have supplemental heat available, there are many years in which it is not needed. The use of supplemental heat often leads to over-drying of the bottom layers of corn. However, supplemental heat is an advantage when it is used during a poor drying year, in a year when harvest is delayed until after November 1, or when the corn moisture content is above 22%. Fan and heater operation for the recommendations summarized here were assumed to be continuous until the corn had dried to 15% maximum moisture content.

Example 1. Low-Temperature Drying without Supplemental Heat (Refer to Table 1b)

When corn is harvested at 22% moisture on October 15 of an average year, and the design airflow rate for the full bin is 1.0 cfm/bu, the maximum filling depth is 6.0 ft. each on days 1, 4, and 7 (i.e., three layers added over 7 days fill the entire bin). [Note that the day numbers when the layers should be added are summarized in Table 3.] It would take until December (i.e., December 2) to complete drying at 1 cfm/bu, while drying would be complete by November 30 at 1.2 cfm/bu, by November 18 at 1.5 cfm/bu, and by November 10 at 2 cfm/bu. The energy used to dry the corn is the electric energy to operate the fan. For the October 15 starting date, it would take 0.90 kWh/bu at 1.0 cfm/bu to dry 22% moisture corn to 15%. [Note that the energy consumption increases with airflow rate.]

Example 2. Low-Temperature Drying with Supplemental Heat (Refer to Table 2b)

When corn is harvested at 22% moisture after November 1 of any year, and is to be dried before the end of the calendar year, supple-mental heat of 5 F is always needed. For example, in an average year with a November 1 harvest date and a design airflow rate in the full bin of 1.0 cfm/bu, 5 F of heat should be added to successfully complete drying. It would take until December 13 to complete drying at 1 cfm/bu, while drying would be complete by December 3 at 1.2 cfm/bu, by November 27 at 1.5 cfm/bu, and by November 22 at 2 cfm/bu. The energy used to dry the corn is the electric energy used to operate the fan plus the heat added by a burner or electrical heater. For the November 1 starting date, it would take 4.86 kWh/bu at 1.0 cfm/bu to dry 22% moisture corn to 15%.

Table 1a. Recommendations for Layer Filling, Estimated Drying Time and Energy Use for In-bin Low Temperature Drying of Corn Harvested at 19% Moisture during Good, Average and Poor Drying Years in Evansville, Indiana. When Necessary, Drying Is Completed in the Spring. No Supplemental Heat Used.

Harvest Date (m/d)	Airflow When Bin Full (cfm/bu)	Drying Year	Maximum Grain Fill per Day (ft)	Number Days to Fill 18ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)
9/15	1	Good	18.0	1	10/16	0.42
		Average	18.0	1	10/19	0.46
		Poor	18.0	1	10/29	0.59
	1.2	Good	18.0	1	10/05	0.69
		Average	18.0	1	10/10	0.85
		Poor	18.0	1	10/17	1.80
	1.5	Good	18.0	1	10/01	0.89
		Average	18.0	1	10/04	1.05
		Poor	18.0	1	10/12	1.47
	2.0	Good	18.0	1	9/25	1.15
		Average	18.0	1	9/30	1.67
		Poor	18.0	1	10/07	2.41
10/1	1	Good	18.0	1	10/28	0.52
		Average	18.0	1	11/03	0.63
		Poor	18.0	1	3/17	1.53
	1.2	Good	18.0	1	10/21	0.69
		Average	18.0	1	10/26	0.85
		Poor	18.0	1	11/10	1.41
	1.5	Good	18.0	1	10/16	0.84
		Average	18.0	1	10/21	1.10
		Poor	18.0	1	11/10	2.15
	2.0	Good	18.0	1	10/11	1.15
		Average	18.0	1	10/16	1.67
		Poor	18.0	1	11/04	2.23*
10/15	1	Good	18.0	1	11/15	0.59
		Average	18.0	1	11/28	0.83
		Poor	18.0	1	3/23	1.38
	1.2	Good	18.0	1	11/09	0.85
		Average	18.0	1	11/21	1.24
		Poor	18.0	1	3/18	2.39
	1.5	Good	18.0	1	11/05	1.15
		Average	18.0	1	11/11	1.47
		Poor	18.0	1	3/13	3.41
	2.0	Good	18.0	1	11/01	1.88
		Average	18.0	1	11/09	2.72
		Poor	18.0	1	11/17	3.34*

Table 1a (cont'd)

Harvest Date (m/d)	Airflow When Bin Full (cfm/bu)	Drying Year	Maximum Grain Fill per Day (ft)	Number Days to Fill 18ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)
11/01	1	Good	18.0	1	12/04	0.63
		Average	18.0	1	3/19	1.00
		Poor	18.0	1	4/02	1.31
	1.2	Good	18.0	1	11/23	0.75
		Average	18.0	1	3/07	1.38
		Poor	18.0	1	3/23	1.90
	1.5	Good	18.0	1	11/18	0.94
		Average	18.0	1	2/28	1.84
		Poor	18.0	1	3/20	2.89
	2.0	Good	18.0	1	11/13	1.36
		Average	18.0	1	12/02	3.35
		Poor	18.0	1	2/17	4.56
11/15	1	Good	18.0	1	3/15	0.94
		Average	18.0	1	3/22	1.01
		Poor	18.0	1	4/06	1.31
	1.2	Good	18.0	1	3/10	1.28
		Average	18.0	1	3/20	1.38
		Poor	18.0	1	3/22	1.70
	1.5	Good	18.0	1	3/16	1.53
		Average	18.0	1	3/14	1.90
		Poor	18.0	1	3/26	2.62
	2.0	Good	18.0	1	3/05	2.74
		Average	18.0	1	3/12	3.58
		Poor	18.0	1	3/20	4.32*

* - Drying is stopped before the maximum moisture content reaches 15% because the high airflow rate of 2 cfm/bu tends to pump moisture into the bin and thus prolongs the drying time unnecessarily. The maximum moisture in the top layer was between 15.0 - 15.5% when drying was stopped.

Table 1b. Recommendations for Layer Filling, Estimated Drying Time and Energy Use for In-bin Low Temperature Drying of Corn Harvested at 22% Moisture during Good, Average and Poor Drying Years in Evansville, Indiana. When Necessary, Drying Is Completed in the Spring. No Supplemental Heat Used.

Harvest Date (m/d)	Airflow When Bin Full (cfm/bu)	Drying Year	Maximum Grain Fill per Day (ft)	Number Days to Fill 18ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)
9/15	1	Good	6.0	7	10/13	0.53
		Average	4.5	13	10/18	0.63
		Poor	3.6	21	10/24	0.74
	1.2	Good	9.0	3	10/08	0.79
		Average	6.0	7	10/13	0.95
		Poor	4.5	13	10/14	0.98
	1.5	Good	18.0	1	10/05	1.10
		Average	9.0	3	10/10	1.36
		Poor	4.5	13	10/08	1.26
	2.0	Good	18.0	1	9/19	1.67
		Average	18.0	1	10/05	2.20
		Poor	4.5	13	10/01	1.78

Table 1b (cont'd)

Harvest Date (m/d)	Airflow When Bin Full (cfm/bu)	Drying Year	Maximum Grain Fill per Day (ft)	Number Days to Fill 18ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)
10/1	1	Good	9.0	3	11/11	0.77
		Average	6.0	7	11/10	0.76
		Poor	4.5	13	3/18	1.55
	1.2	Good	9.0	3	11/01	1.05
		Average	6.0	7	10/30	0.98
		Poor	4.5	7	3/17	2.71
	1.5	Good	18.0	1	10/25	1.31
		Average	18.0	1	10/29	1.52
		Poor	6.0	7	11/10	2.15
	2.0	Good	18.0	1	10/21	2.20
		Average	18.0	1	10/29	3.04
		Poor	9.0	3	11/15	3.92*
10/15	1	Good	18.0	1	11/25	0.77
		Average	6.0	7	12/02	0.90
		Poor	4.5	13	3/22	1.36
	1.2	Good	18.0	1	11/15	1.05
		Average	18.0	1	11/30	1.54
		Poor	6.0	7	3/21	2.39
	1.5	Good	18.0	1	11/10	1.42
		Average	18.0	1	11/18	1.84
		Poor	6.0	7	11/21	1.99
	2.0	Good	18.0	1	11/05	2.30
		Average	18.0	1	11/10	2.83
		Poor	6.0	7	11/19	3.78*
11/01	1	Good	18.0	1	3/10	0.88
		Average	18.0	1	4/01	1.62
		Poor	9.0	3	3/27	1.79
	1.2	Good	18.0	1	12/04	1.11
		Average	18.0	1	3/18	1.60
		Poor	18.0	1	3/22	2.48
	1.5	Good	18.0	1	11/25	1.31
		Average	18.0	1	3/04	2.11
		Poor	18.0	1	3/17	3.19
	2.0	Good	18.0	1	11/18	1.88
		Average	18.0	1	3/02	4.00
		Poor	18.0	1	3/08	5.57
11/15	1	Good	18.0	1	3/15	1.32
		Average	18.0	1	3/18	1.57
		Poor	18.0	1	4/15	1.98
	1.2	Good	18.0	1	3/06	1.65
		Average	18.0	1	3/19	2.37
		Poor	18.0	1	4/11	2.83
	1.5	Good	18.0	1	3/02	2.13
		Average	18.0	1	3/14	2.97
		Poor	18.0	1	3/17	3.02
	2.0	Good	18.0	1	3/14	4.19
		Average	18.0	1	3/15	4.61
		Poor	18.0	1	3/17	5.58

* - Drying is stopped before the maximum moisture content reaches 15% because the high airflow rate of 2 cfm/bu tends to pump moisture into the bin and thus prolongs the drying time unnecessarily. The maximum moisture in the top layer was between 15.0 - 15.5% when drying was stopped.

Table 2a. Recommendations for Layer Filling, Estimated Drying Time and Energy Use for In-bin Low Temperature Drying of Corn Harvested at 19% Moisture during Good, Average and Poor Drying Years in Evansville, Indiana. Drying Is Completed Before the End of the Calendar Year. Supplemental Heat Used When Necessary.

Harvest Date (m/d)	Airflow When Bin Full (cfm/bu)	Drying Year	Maximum Grain Fill per Day (ft)	Number Days to Fill 18ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)	Supplemental Heat
9/15	1	Good	18.0	1	10/06	1.23	5
		Average	18.0	1	10/09	1.40	5
		Poor	18.0	1	10/13	1.62	5
	1.2	Good	18.0	1	10/01	1.36	5
		Average	18.0	1	11/21	1.44	5
		Poor	18.0	1	11/11	1.85	5
	1.5	Good	18.0	1	9/27	1.44	5
		Average	18.0	1	9/29	1.66	5
		Poor	18.0	1	10/03	2.10	5
	2.0	Good	18.0	1	9/23	1.62	5
		Average	18.0	1	9/25	1.98	5
		Poor	18.0	1	9/27	2.35	5
10/1	1	Good	18.0	1	10/22	1.23	5
		Average	18.0	1	10/25	1.40	5
		Poor	18.0	1	10/29	1.62	5
	1.2	Good	18.0	1	10/17	1.36	5
		Average	18.0	1	10/19	1.53	5
		Poor	18.0	1	10/22	1.77	5
	1.5	Good	18.0	1	10/14	1.55	5
		Average	18.0	1	10/15	1.66	5
		Poor	18.0	1	10/18	1.99	5
	2.0	Good	18.0	1	10/09	1.62	5
		Average	18.0	1	10/11	1.98	5
		Poor	18.0	1	10/13	2.35	5
10/15	1	Good	18.0	1	11/09	1.45	5
		Average	18.0	1	11/12	1.62	5
		Poor	18.0	1	11/18	1.95	5
	1.2	Good	18.0	1	11/04	1.69	5
		Average	18.0	1	11/06	1.85	5
		Poor	18.0	1	11/08	2.01	5
	1.5	Good	18.0	1	10/30	1.77	5
		Average	18.0	1	10/31	1.88	5
		Poor	18.0	1	11/02	2.10	5
	2.0	Good	18.0	1	10/25	1.98	5
		Average	18.0	1	10/27	2.35	5
		Poor	18.0	1	10/29	2.71	5
11/01	1	Good	18.0	1	11/25	1.40	5
		Average	18.0	1	12/04	1.90	5
		Poor	18.0	1	12/11	2.29	5
	1.2	Good	18.0	1	11/18	1.44	5
		Average	18.0	1	11/25	2.01	5
		Poor	18.0	1	11/28	2.25	5
	1.5	Good	18.0	1	11/15	1.66	5
		Average	18.0	1	11/19	2.10	5
		Poor	18.0	1	11/21	2.32	5
	2.0	Good	18.0	1	11/10	1.80	5
		Average	18.0	1	11/13	2.35	5
		Poor	18.0	1	11/16	2.89	5

Table 2a (cont'd)

Harvest Date (m/d)	Airflow When Bin Full (cfm/bu)	Drying Year	Maximum Grain Fill per Day (ft)	Number Days to Fill 18ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)	Supplemental Heat
11/15	1	Good	18.0	1	12/15	1.73	5
		Average	18.0	1	12/24	2.23	5
		Poor	18.0	1	1/02	2.74	5
	1.2	Good	18.0	1	12/08	1.93	5
		Average	18.0	1	12/14	2.41	5
		Poor	18.0	1	12/21	2.97	5
	1.5	Good	18.0	1	12/02	1.99	5
		Average	18.0	1	12/08	2.65	5
		Poor	18.0	1	12/12	3.09	5
	2.0	Good	18.0	1	11/27	2.35	5
		Average	18.0	1	12/04	3.61	5
		Poor	18.0	1	12/09	4.51	5

Table 2b. Recommendations for Layer Filling, Estimated Drying Time and Energy Use for In-bin Low Temperature Drying of Corn Harvested at 22% Moisture during Good, Average and Poor Drying Years in Evansville, Indiana. Drying is Completed before the End of the Calendar Year. Supplemental Heat Used When Necessary.

Harvest Date (m/d)	Airflow When Bin Full (cfm/bu)	Drying Year	Maximum Grain Fill per Day (ft)	Number Days to Fill 18ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)	Supplemental Heat
9/15	1	Good	6.0	7	10/07	1.37	5
		Average	6.0	7	10/12	1.65	5
		Poor	4.5	13	10/10	1.64	5
	1.2	Good	9.0	3	10/04	1.64	5
		Average	9.0	3	10/08	1.96	5
		Poor	4.5	13	10/04	1.83	5
	1.5	Good	18.0	1	10/01	1.88	5
		Average	18.0	1	10/04	2.21	5
		Poor	4.5	13	10/01	2.14	5
	2.0	Good	18.0	1	9/27	2.35	5
		Average	18.0	1	9/29	2.71	5
		Poor	6.0	7	9/28	2.69	5
10/01	1	Good	9.0	3	10/31	1.76	5
		Average	6.0	7	10/28	1.65	5
		Poor	6.0	7	11/03	1.99	5
	1.2	Good	18.0	1	10/24	1.93	5
		Average	6.0	7	10/21	1.79	5
		Poor	6.0	7	10/26	2.19	5
	1.5	Good	18.0	1	10/18	1.99	5
		Average	18.0	1	10/20	1.99	5
		Poor	9.0	3	10/24	2.69	5
	2.0	Good	18.0	1	10/13	2.35	5
		Average	18.0	1	10/15	2.71	5
		Poor	18.0	1	10/19	3.43	5
10/15	1	Good	18.0	1	11/16	1.84	5
		Average	9.0	3	11/19	2.04	5
		Poor	6.0	7	11/19	2.10	5

Table 2b (cont'd)

Harvest Date (m/d)	Airflow When Bin Full (cfm/bu)	Drying Year	Maximum Grain Fill per Day (ft)	Number Days to Fill 18ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)	Supplemental Heat
	1.2	Good	18.0	1	11/09	2.09	5
		Average	18.0	1	11/11	2.25	5
		Poor	9.0	3	11/09	2.91	5
	1.5	Good	18.0	1	11/05	2.43	5
		Average	18.0	1	11/05	2.43	5
		Poor	9.0	3	11/09	2.91	5
	2.0	Good	18.0	1	10/31	3.07	5
		Average	18.0	1	10/31	3.07	5
		Poor	18.0	1	11/03	3.61	5
11/01	1	Good	18.0	1	12/07	1.52	5
		Average	18.0	1	12/13	2.34	5
		Poor	18.0	1	12/25	3.05	5
	1.2	Good	18.0	1	11/25	2.01	5
		Average	18.0	1	12/03	2.65	5
		Poor	18.0	1	12/11	3.29	5
	1.5	Good	18.0	1	11/19	2.10	5
		Average	18.0	1	11/27	2.98	5
		Poor	18.0	1	12/03	3.64	5
	2.0	Good	18.0	1	11/14	2.53	5
		Average	18.0	1	11/22	3.97	5
		Poor	18.0	1	11/28	5.30	5
11/15	1	Good	18.0	1	12/29	2.51	5
		Average	18.0	1	1/05	2.90	5
		Poor	18.0	1	1/11	3.24	5
	1.2	Good	18.0	1	12/16	2.57	5
		Average	18.0	1	12/24	3.21	5
		Poor	18.0	1	12/31	3.77	5
	1.5	Good	18.0	1	12/10	2.87	5
		Average	18.0	1	12/15	3.42	5
		Poor	18.0	1	12/20	3.98	5
	2.0	Good	18.0	1	12/09	4.51	5
		Average	18.0	1	12/10	4.69	5
		Poor	18.0	1	12/18	6.13	5

Table 3. Layer Fill Day Calculator

blkb

Number of Days to fill 8' deep bin	Day # when layer should be added						
1	1						
3	1	3					
7	1	4	7				
13	1	5	9	13			
21	1	6	11	16	21		
31	1	7	13	19	25	31	
43	1	8	15	22	29	36	43

World Wide Web (Mosaic or Netscape) URL address:
http://hermes.ecn.purdue.edu:8001/server/purdue/acspub.html (select) Grain Quality
or http://pasture.ecn.purdue.edu/~grainlab
(select) On-Line Extension Publications (select) Grain Quality Fact Sheets

or Almanac:
send e-mail to: almanac@ecn.purdue.edu
message:
send grain guide or
send grain catalog or
send grain factsheet#12 (for example) or
send acsonline GQ-12