Fact Sheet #5
October 28, 1992
Purdue University

GRAIN QUALITY Task Force

Low-Temperature Drying of The 1992 Indiana Corn Crop

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The Indiana Agricultural Statistics Service estimates that as of Monday, October 26, only about 32 percent of the corn has been harvested. This is more than three weeks behind last year, and more than two weeks behind the 5-year average. The average moisture content reported for the incoming corn across the state is 24%, significantly higher than commonly encountered in Indiana at this time of year. The field drying rate will be progressively slower as we move into November. Proper operation of corn drying equipment becomes critical to prevent significant grain quality problems during subsequent storage. This fact sheet summarizes procedures for low-temperature drying of high-moisture corn.

What Is Low-Temperature Drying?

Low-temperature drying is in-bin drying of corn using airflow rates of 1 to 3 cfm/bu, and natural air, or air heated by 5^{o} to 15^{o} 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 three harvest moisture contents (22, 25, and 28%) and three airflow rates (1, 1.5, and 2 cfm/bu) during good, average, and poor drying years for central Indiana weather conditions. 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 the

Appendix of this Fact Sheet, which is available at each county Extension office.

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 Agent (ask for publication AE-106 "Fan Sizing & Application for Bin Drying/Cooling of Grain").

Is 1992 a Good, Average or Poor Drying Year?

It is difficult to predict whether the 1992 fall season will be a good, average or poor drying year. The current 30-day forecast predicts lower than normal temperatures and higher than normal precipitation. Thus, it appears that, at best, this season may be an average drying year. This means that using some supplemental heat may be the safest strategy, particularly for corn above 22% moisture content. It must be noted, however, that supplemental heat often leads to over drying of the bottom corn layers. For example, adding 15^{o} F of heat can dry corn in the bottom of a bin to about 9% moisture. Overdrying means weight loss and higher breakage susceptibility. Thus, adding just the right amount of heat is critical.

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 development. A few cases of aflatoxin detection were reported from Kentucky just last week. Overloaded bin dryers are the suspected source for this contamination. It is generally better to add too thin of a layer than too thick a one. Spoilage potential is reduced by adding the new layer only after the corn at the top surface begins 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 will create an extra challenge for farmers who depend solely on low-temperature drying systems. Pre-cleaning the corn is a must, even though it will 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.

One option that will increase the capacity of a low-temperature drying system, and reduce the potential that high-moisture corn will spoil, is to convert it to a combination drying system. This would require at least two low-temperature grain drying bins and an installed burner that can heat the air above 100^{o} F (preferably to 120^{o}-160^{o} F). The first bin could be converted to a high-temperature, in-bin dryer, which dries corn in a 2.5 to 4 ft. deep layer to about 20-22% moisture content. After this first drying stage, the hot batch is moved into a second low-temperature drying bin. There, drying is completed to 15% moisture. Additional layers are added as corn is moved from the high-temperature to the low-temperature drying bin. During this transfer, the corn should be

screened again to further reduce fines and broken kernels. After all storage bins (i.e., low-temperature drying bins) are full, the high-temperature, in-bin batch dryer is reconverted to a deep-bed, low-temperature drying bin for drying the last of the corn harvested.

APPENDIX – GRAIN QUALITY TASK FORCE FACT SHEET #5

How Do I Use These Recommendations?

A typical full-bin depth of 18 ft. 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 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 25%. 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 25% 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 4.5 ft. each on days 1, 5, 9, and 13 (i.e., four layers added over 13 days fill the entire bin). [Note that the day numbers of when the layers should be added are summarized in Table 3.] It would take until the following spring (i.e., March 12) to complete drying at 1 cfm/bu, while drying would be complete by November 28 at 1.5 cfm/bu, and by December 17 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 1.48 kWh/bu at 1.0 cfm/bu to dry 25% moisture corn to 15%. Note that the energy consumption increases with airflow rate.

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

When corn is harvested at 28% moisture after November 1 of any year, and is to be dried before the end of the calendar year, supplemental heat 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, 10^{o} F of heat should be added to successfully complete drying. The maximum filling depth is 3.6 ft. each on days 1, 6, 11, 16, and 21 (i.e., five layers added over 21 days fill the entire bin). It would take until December 21 to complete drying at 1 cfm/bu, while drying would be complete by December 3 at 1.5 cfm/bu, and by December 7 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 28% 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 22% Moisture during Good, Average and Poor Drying Years in central 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 18 ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)
10/15	1	Good	18.0	1	2/4	1.03
		Average	18.0	1	3/8	1.23
		Poor	4.5	13	4/7	1.84
	1.5	Good	18.0	1	11/13	1.67
		Average	18.0	1	11/21	2.11
		Poor	6.0	7	4/1	4.51
	2	Good	18.0	1	11/9	3.04
		Average	18.0	1	11/29	5.39
		Poor	18.0	1	3/12	7.16
11/1	1	Good	18.0	1	3/16	1.37
		Average	18.0	1	3/30	1.79
		Poor	6.0	7	4/3	2.45
	1.5	Good	18.0	1	3/7	2.17
		Average	18.0	1	3/9	2.45
		Poor	18.0	1	4/11	4.87
	2	Good	18.0	1	11/23	2.69
		Average	18.0	1	3/15	5.52
		Poor	18.0	1	3/28	7.96
11/15	1	Good	18.0	1	3/29	1.90
		Average	18.0	1	3/28	2.13
		Poor	18.0	1	4/6	2.59
	1.5	Good	18.0	1	3/12	2.87
		Average	18.0	1	3/18	3.42
		Poor	18.0	1	3/21	4.62
	2	Good	18.0	1	3/12	5.13
		Average	18.0	1	3/21	5.86
		Poor	18.0	1	3/25	8.94

Table 1b. Recommendations for Layer Filling, Estimated Drying Time and Energy Use for In-bin Low Temperature Drying of Corn Harvested at 25% Moisture during Good, Average and Poor Drying Years in central 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 18 ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)
10/15	1	Good	6.0	7	12/14	1.29
		Average	4.5	13	3/12	1.48
		Poor	3.0	31	4/8	2.07
	1.5	Good	9.0	3	11/20	2.05
		Average	6.0	7	11/28	2.50
		Poor	3.6	21	4/1	4.51
	2	Good	18.0	1	11/16	3.87
		Average	18.0	1	12/17	5.56
		Poor	6.0	7	3/10	6.93
11/1	1	Good	6.0	7	3/18	1.78
		Average	4.5	13	3/19	1.89
		Poor	3.0	31	4/3	2.57
	1.5	Good	18.0	1	3/7	2.78
		Average	6.0	7	3/21	3.66
		Poor	3.6	21	3/28	5.18
	2	Good	18.0	1	3/6	4.82
		Average	18.0	1	3/12	5.86
		Poor	4.5	13	3/28	9.23
11/15	1	Good	9.0	3	3/18	2.43
		Average	6.0	7	3/19	2.00
		Poor	4.5	13	4/7	2.90
	1.5	Good	18.0	1	3/12	3.57
		Average	18.0	1	3/18	4.51
		Poor	9.0	3	3/21	5.10
	2	Good	18.0	1	3/21	6.05
		Average	18.0	1	3/16	6.99
		Poor	18.0	1	3/21	9.51

Table 1c. Recommendations for Layer Filling, Estimated Drying Time and Energy Use for In-bin Low Temperature Drying of Corn Harvested at 28% Moisture during Good, Average and Poor Drying Years in central 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 18 ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)
10/15	1	Good	3.6	21	3/7	1.47
		Average	3.0	31	3/12	1.75
		Poor	2.6	43	4/4	2.58
	1.5	Good	4.5	13	11/26	2.39
		Average	3.6	21	3/5	3.01
		Poor	3.0	31	4/1	4.77
	2	Good	6.0	7	11/19	4.22
		Average	6.0	7	3/5	6.34
		Poor	3.6	21	3/28	9.04
11/1	1	Good	3.6	21	3/17	2.11
		Average	3.0	31	3/29	2.26
		Poor	2.6	43	4/6	2.92
	1.5	Good	4.5	13	3/7	3.04
		Average	3.6	21	3/5	3.31
		Poor	3.0	31	3/21	5.39
	2	Good	6.0	7	3/7	5.50
		Average	4.5	13	3/5	5.95
		Poor	3.6	21	3/22	10.11
11/15	1	Good	3.0	31	3/19	2.10
		Average	3.0	31	3/19	2.48
		Poor	3.0	31	4/7	3.04
	1.5	Good	4.5	13	3/18	4.34
		Average	4.5	13	3/18	4.99
		Poor	4.5	13	3/28	6.20
	2	Good	9.0	3	3/15	7.55
		Average	6.0	7	3/16	8.35
		Poor	6.0	7	3/21	11.22

Table 2a. 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 central Indiana. Drying is Completed Before the End of the Calendar Year. Supplemental Heat is 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 18 ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)	Supplemental Heat (^{o}F)
10/15	1	Good	18.0	1	11/29	0.97	-
		Average	9.0	3	11/27	1.99	5
		Poor	6.0	7	11/24	1.89	5
	1.5	Good	18.0	1	11/13	1.67	-
		Average	18.0	1	11/21	2.11	-
		Poor	9.0	3	11/11	2.57	5
	2	Good	18.0	1	11/9	3.04	-
		Average	18.0	1	11/29	5.39	-
		Poor	9.0	3	11/5	3.65	5
11/1	1	Good	18.0	1	12/16	2.06	5
		Average	18.0	1	12/24	2.42	5
		Poor	9.0	3	12/13	3.68	10
	1.5	Good	18.0	1	11/29	2.64	5
		Average	18.0	1	12/4	3.10	5
		Poor	9.0	3	12/25	5.03	5
	2	Good	18.0	1	11/23	2.69	-
		Average	18.0	1	11/30	4.94	5
		Poor	18.0	1	12/25	9.05	5
11/15	1	Good	9.0	3	12/24	3.42	10
		Average	9.0	3	12/27	3.68	10
		Poor	9.0	7	12/19	4.58	15
	1.5	Good	18.0	1	12/21	3.37	5
		Average	18.0	1	12/24	3.64	5
		Poor	18.0	1	12/17	4.96	10
	2	Good	18.0	1	12/16	5.27	5
		Average	18.0	1	12/19	5.76	5
		Poor	18.0	1	12/12	6.82	10

Table 2b. Recommendations for Layer Filling, Estimated Drying Time and Energy Use for In-bin Low Temperature Drying of Corn Harvested at 25% Moisture during Good, Average and Poor Drying Years in central Indiana. Drying is Completed Before the End of the Calendar Year. Supplemental Heat is 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 18 ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)	Supplemental Heat (^{o}F)
10/15	1	Good	6.0	7	12/14	1.29	-
		Average	4.5	13	12/4	2.41	5
		Poor	3.6	21	12/6	2.59	5
	1.5	Good	9.0	3	11/20	2.05	-
		Average	6.0	7	11/28	2.50	-
		Poor	4.5	13	11/15	3.08	5
	2	Good	18.0	1	11/16	3.04	-
		Average	18.0	1	12/17	5.56	-
		Poor	6.0	7	11/12	4.87	5
11/1	1	Good	4.5	13	12/21	2.41	5
		Average	3.6	21	12/26	2.72	5
		Poor	3.6	21	12/17	4.52	10
	1.5	Good	18.0	1	12/8	3.46	5
		Average	6.0	7	12/9	3.63	5
		Poor	4.5	13	11/29	4.80	10
	2	Good	18.0	1	12/10	6.58	5
		Average	18.0	1	12/5	5.76	5
		Poor	4.5	13	12/27	9.60	5
11/15	1	Good	4.5	13	12/28	4.03	10
		Average	4.5	13	12/22	5.23	15
		Poor	4.5	13	12/28	5.97	15
	1.5	Good	9.0	3	12/17	5.03	10
		Average	6.0	7	12/16	5.02	10
		Poor	6.0	7	12/25	6.37	10
	2	Good	18.0	1	12/22	6.25	5
		Average	18.0	1	12/10	6.58	5
		Poor	6.0	7	12/13	7.33	10

Table 2c. Recommendations for Layer Filling, Estimated Drying Time and Energy Use for In-bin Low Temperature Drying of Corn Harvested at 28% Moisture during Good, Average and Poor Drying Years in central Indiana. Drying is Completed Before the End of the Calendar Year. Supplemental Heat is 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 18 ft Deep Bin	Estimated Drying Completion Date	Energy Use per Dry Bushel (kWh/bu)	Supplemental Heat (^{o}F)
10/15	1	Good	3.6	21	12/8	2.67	5
		Average	3.6	21	11/27	4.27	10
		Poor	3.6	21	11/16	4.99	15
	1.5	Good	4.5	13	11/26	2.39	-
		Average	3.6	21	11/23	3.93	5
		Poor	3.6	21	11/23	3.93	5
	2	Good	6.0	7	11/19	4.22	-
		Average	6.0	7	11/23	6.68	5
		Poor	4.5	13	11/21	6.47	5
11/1	1	Good	3.6	21	12/16	4.44	10
		Average	3.6	21	12/21	4.86	10
		Poor	3.0	31	12/12	6.37	15
	1.5	Good	6.0	7	12/3	5.17	10
		Average	4.5	13	12/3	5.40	10
		Poor	3.6	21	12/8	6.48	10
	2	Good	6.0	7	12/11	6.85	5
		Average	4.5	13	12/7	6.31	5
		Poor	4.5	13	12/4	8.86	10
11/15	1	Good	3.6	21	12/26	6.11	15
		Average	3.0	31	12/31	7.22	15
		Poor	3.6	21	12/27	8.28	20
	1.5	Good	6.0	7	12/23	6.07	10
		Average	4.5	13	12/24	6.45	10
		Poor	4.5	13	12/17	7.63	15
	2	Good	4.5	13	12/27	7.18	5
		Average	4.5	13	12/31	7.95	5
		Poor	4.5	13	12/19	9.10	10

Table 3. Layer fill day calculator

Number of Days to fill 18' 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