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Corn Drying and Storage Tips for 2011

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An early frost creates another challenging year for corn in the region. The first step is to determine the corn maturity and expected harvest condition. The National Agricultural Statistics Service indicated on September 18th that 83% of the corn in North Dakota was dented and 20% was mature. South Dakota and Minnesota were at about 90 and 92% dented and 28% and 30% mature.

Corn Maturity

Based on the crop progress report, there will be a large variation in corn test weight and moisture content. Corn that was only in the dough stage would have extremely low test weight and yield losses would be severe. Even corn that had just reached dent stage may have low test weight and yield. There would be only minimal yield loss and it would have a reasonable test weight if the corn was at 50% milk stage.

Corn Kernel Stage	Frost Damage		Test Weight	Grain Moisture
	Leaves & Stalk	Only Leaves		
	Grain Yield Loss (%)	Grain Yield Loss (%)	(lb./bu)	(%)
Dough	66	41	---	70
Dent	55	23	47	60
75% Milk	35	18	50	52
50% Milk	10	5	53	40
25% Milk	3	2	54-55	37
Mature	0	0	56	32

Yield and Harvest Considerations for Frost Damaged Corn, September 15, 2011
http://blog.lib.umn.edu/efans/cropnews/2011/09/yield-and-harvest-consideratio.html

Field Drying

The amount of drying in the field depends on parameters such as corn maturity, hybrid, and moisture content, air temperature and relative humidity, solar radiation, and wind speed. The moisture content to which corn will dry is determined by the corn's equilibrium moisture content, EMC, which is based on air temperature and relative humidity. A predictor of the drying rate might be potential evapotranspiration, PET, which is based on parameters similar to those that affect drying. Values for PET calculated by the North Dakota Agricultural Weather Network for 2008 are shown in the following table. There appears to be a good correlation between PET and field drying experience. The table shows these EMC, GDD, PET values and the estimated percentage points of field drying for each month.

"Estimated" Corn Field Drying

Month	EMC (%)	GDD	PET (in.)	Estimated Drying (%-pt.) Month	Week
Sep	15	250-350	4.0-5.0	18	4.5
Oct	16	100-125	2.8-3.5	11-12	2.5
Nov	19	20-30	0.8-1.2	4-5	1
Dec	20	0	0.5-0.8	2	0.5
Jan	21	0	0.5-0.8	2	0.5
Feb	21	0	0.5-0.9	3	0.8
Mar	19	0	1.3-1.6	5	1
Apr	16	50-90	3.2-4.5	16	4
May	14	200-300	6.5-8.5	30	7

PET=Potential Evapotranspiration
(NDAWN, Weather, Total PET, Estimate: 1-inch ≈ 4% drying)
EMC-equilibrium moisture content, GDD-growing degree-days,
%-pt. - percentage point of moisture reduction, for example from 20% to 15% are 5%-pts.

The following table provides field drying rates for corn in Minnesota.

Field drying rates for corn in Minnesota

Date	Grain moisture loss (% per day)
September 15-25	0.75-1.00
September 26-October 5	0.50-0.75
October 6-15	0.25-0.50
October 16-31	0.00-0.33
After October 31	>very little

Source: Hicks (2004)
http://www.extension.umn.edu/cropenews/2008/08MNCN26.html

Standing corn in the field may dry about 0.5 to 0.7 percentage points per day during September, about 0.3 to 0.5 percentage points per day during October, and 0.15 to 0.2 per day or less during November, assuming normal weather conditions. Field drying is normally more economical until mid to late October and mechanical high temperature drying is normally more economical after then.

Corn at 40% moisture content on September 15 might be expected to dry to about 31% by October 1 and 20% by November 1. However, corn at 60% moisture content on September 15 might only be expected to dry to about 50% by October 1, 40% by November 1 and to about 35% by December 1. Therefore, corn moisture content at harvest will likely range from low to mid-20% range for corn near maturity to extremely wet if it had just reached the dent stage.

Immature corn may dry more slowly in the field than mature corn and frosted high moisture corn can mold on the stalk.

Field drying is extremely slow during winter months and corn will only dry to about 20% moisture content based on the equilibrium moisture content for average monthly air temperature and relative humidity conditions. Corn in the field over winter in 2008-2009 dried from 25%-30% moisture in November to 17%-20% when harvested in February and early March. Corn that is not harvested until late spring is expected to dry to 14% - 16% moisture. Leaving corn in the field over winter has been done to reduce the drying cost particularly with light test weight corn with moisture contents in late fall exceeding 30%.

Corn losses have generally been small if the corn stalk was strong in November. Frosted corn typically will have weaker stalks, so field losses might be much greater this year than in previous years. Examine the stalks and push on them to determine stalk condition, before deciding to leave corn stand over winter. Corn losses can range from very little to very large. Wildlife feeding in the corn can cause large losses. Accumulated snow and cover on the snow and ground from the corn resulted in wet fields in the spring.

Postharvest Management of High Moisture Corn

Corn at moisture contents exceeding about 23% should not be stored in a grain bin because the kernels may freeze together and also may deform and bind together. The corn may not flow from the bin for unloading. Corn above this moisture content should be placed so it can be unloaded with a front-end loader or something else that can mechanically dislodge the corn.

It is critical to provide aeration to keep the corn cool. Wet corn will deteriorate rapidly unless kept cool. Corn will deteriorate even with airflow, but without airflow through the corn it will increase in temperature resulting in rapid deterioration.

Condensation and icing occurs on bin vents at temperatures near or below freezing, so leave bin covers open to serve as a safety opening when operating fans near or below freezing temperature. There have been numerous reports of bin vents freezing over and the fan pushing the roof up and damaging the bin roof.

"Approximate" Allowable Storage Time (Days) for Cereal Grains

	Temperature (°F)					
M.C. (%)	30°	40°	50°	60°	70°	80°
14	*	*	*	*	200	140
15	*	*	*	240	125	701
16	*	*	230	120	70	40
17	*	280	130	75	45	20
18	*	200	90	50	30	15
19	*	140	70	35	20	10
20	*	90	50	25	14	7
22	190	60	30	15	8	3
24	130	40	15	10	6	2
26	90	35	12	8	5	2
28	70	30	10	7	4	2
30	60	25	5	5	3	1

Based on composite of 0.5 percent maximum dry matter loss calculated on the basis of USDA research at Iowa State University; Transactions of ASAE 3330337, 1972; and "Unheated Air Drying," Manitoba Agriculture Agdex 732-1, rev. 1986.

* Approximate allowable storage time exceeds 300 days.

High Moisture Corn Storage by Ensiling

Shelled corn should be at 25 to 35% moisture for anaerobic (without oxygen) high moisture storage in silos or silo bags. Any tears in the plastic bag must be promptly repaired to minimize storage losses. Whole shelled corn can be stored in oxygen-limiting silos, but a medium grind is needed for proper packing in horizontal or conventional upright silos. A bunker needs to be air tight - covered with plastic on top and sides, sealed at seams, etc. In addition, it needs to be managed to seal any punctures in the plastic that occur during the storage period. Exposure to air will result in spoilage and loss. Wet grain exerts more pressure on the silo than corn silage, so conventional concrete stave silos may require additional hoops or the silo must not be completely filled. Corn at moisture contents below 25% will not ensile, so it will need to be dried for storage. If oxygen is not adequately removed as the corn ensiles, heating and severe deterioration will occur.

Storage in a Poly Bag

Even though the bag is sealed, it does not prevent mold growth or insect infestations. At moisture contents exceeding about 25% ensiling may occur at temperatures above freezing and prevent the corn from being dried and sold in the general market. Grain temperature in the bag will follow average outdoor temperatures, unless respiration heating causes the temperature to increase. Corn needs to be at an appropriate moisture content and temperature to limit the potential for heating and grain quality losses during storage. Corn above 24% moisture should be placed in the bags when average outdoor temperatures are staying near or below freezing and the corn should be dried by early February before outdoor and grain temperatures increase and permit spoilage. Corn at moisture contents up to 24% should be dried by early March. Corn stored during the summer needs to be below 14% moisture. Select an elevated well drained location for the bags and run the bags north and south so solar heating is similar on both sides of the bag. Wildlife can puncture the bags creating an entrance for moisture and releasing the grain smell which attracts more wildlife. Monitor the grain temperature at several locations in the bags.

Natural Air and Low Temperature Corn Drying

Corn above 21% moisture should not be dried using natural air and low temperature drying to minimize corn spoilage during drying. An airflow rate of 1.0 to 1.25 cfm/bu is recommended to reduce drying time. Because the drying capacity is extremely poor at temperatures below 35 to 40 degrees, little drying may be possible during the fall using a natural air system. Cool the corn to 20 to 25 degrees for winter storage and start drying in early April. Adding heat does not permit drying wetter corn and only slightly increases drying speed. The primary effect of adding heat is to reduce the corn moisture content. Natural air drying in the spring is the most energy and cost effective method of drying. Corn depth should be limited to about 20 to 22 feet to obtain the desired airflow rate for drying. Turn fans off during extended rain, fog or snow to minimize the amount of moisture moved into the bin by the fan.

High Temperature Drying

Using the maximum drying temperature that will not damage the corn increases the dryer capacity and reduces energy consumption. The amount of energy required to remove a pound of water is about 20% less using a drying air temperature of 200ºF than at 150ºF. Typical recommended drying temperatures are 210ºF to 230 ºF. Be aware that excessively high drying temperatures may result in a lower final test weight and increased breakage susceptibility. In addition, as the drying time increases with high moisture corn, it becomes more susceptible to browning.

Housekeeping during drying is more critical when outside air temperatures are cold due to condensation occurring on the dryer creating a wet surface for debris to accumulate. The debris may reduce airflow through the dryer reducing drying capacity and creating a fire hazard.

Minimize Heat Damage While Drying Corn

Research indicates that exposure to drying air temperatures above 200 degrees for time periods in excess of 2 hours will likely result in some degree of browning. For corn above 30% moisture, browning is likely to occur. Dryer temperatures may need to be limited to prevent scorching or browning. The darkening during drying can also be due to sugar in the kernels that becomes caramelized, which is a sign of incomplete development.

Corn may be discolored without being graded as dryer heat damaged. Dryer heat damaged kernels are almost entirely black in color and are different than dryer damaged kernels. A picture is available on the USDA Grain Inspection web site
http://www.gipsa.usda.gov/GIPSA/webapp?area=home&subject=grpi&topic=sq-isd-c50

The potential for discoloration is related to both the drying temperature and length of time the corn is exposed to the heat. The temperature reduction required to reduce the damage will need to be determined by trial and likely will vary from field to field. Reports from producers indicate a variation in the potential for darkening, with softer, higher starch kernels possibly being more affected.

In a typical cross-flow dryer, corn near the inside of the drying column will approach the plenum temperature as it dries. A plenum temperature of 160 to 180 degrees is still hot if the corn approaches the air temperature. A dryer that moves the corn from the inside of the column to the outside of the column, varies the corn flow rate across the drying column or varies the exposure of the corn to the drying air should be less prone to cause kernel discoloration.

Decreasing the temperature in the lower portion of a multistage dryer also will decrease the potential for heat damage.

Since, the potential for heat damage is related to the kernel temperature, which is related to the drying temperature, length of time the kernel is exposed to the heat and the kernel moisture, drying the corn to 20 percent instead of 15 percent moisture content should reduce the potential for heat damage. More evaporative cooling still is occurring at the higher kernel moisture content and the kernel will not be exposed to the heat as long if drying is stopped at a higher moisture content.

Drying the corn in two passes may be necessary to reduce the amount of heat damage. Only about one-half of the moisture is removed on the first pass through the dryer. For example, corn might be dried from 28 percent to 20 percent moisture content on the first pass through the dryer. The corn could be cooled and stored as long as an entire winter at 20 percent moisture. In addition to reducing the potential for heat damage to the kernels, dryer capacity (bushels per hour) is greatly increased when the corn is dried only partially. The corn then could be dried to storage moisture at some time in the future.

Much of the kernel breakage associated with high-temperature drying occurs because the outside of the kernel dries more rapidly than the moisture transfers from within the kernel to the surface. Stopping drying at higher corn moisture contents can reduce the amount of stress cracks and breakage susceptibility. In addition, some of the breakage potential is developed during rapid cooling in the high-temperature dryer. Partial drying and cooling in the bin should reduce the amount of kernel breakage.

In-Storage Cooling

Use in-storage cooling instead of in-dryer cooling to boost capacity of high-temperature dryers. Cooling corn slowly in a bin rather than in the high temperature dryer will also reduce the potential for stress cracks in the kernels.

In-storage cooling requires a positive-pressure, airflow rate of about 0.20 cfm/bu to cool the corn in about 75 hours or 12 cfm/bu-hr. of fill rate to cool at the rate of filling. Cooling should be started immediately when corn is placed in the bin from the dryer and occur rapidly to reduce the condensation potential. Dryer capacity is increased 20 to 40% and about one percentage point of moisture is removed during corn cooling. Condensation problems can be reduced by cooling the corn in the dryer to about 90 degrees before placing it in storage. There is more condensation at cold outdoor temperatures than when outdoor temperatures are above 50 degrees.

Dryeration

Dryeration will increase the dryer capacity about 50 to 75%; reduce energy used by about 25% and remove about 2 to 2.5 points of moisture. (0.25% for each 10 degrees the corn is cooled.) With dryeration, hot corn from the dryer is placed in a dryeration bin with a perforated floor, allowed to remain hot for 4 to 6 hours, cooled, and then moved to a storage bin. There will be a tremendous amount of condensation during the steeping and cooling process, so the corn must be moved to a different bin for storage or spoilage will occur along the bin wall and on the top grain surface.

Dryer Energy Efficiency

A dryer that captures the heat from cooling the dry corn and a portion of the air from the final drying portion of the dryer can reduce the energy used to dry the corn by about 20% or more depending on outdoor temperature. Newer dryers typically have incorporated features to make them more energy efficient than previous dryers.

Estimating High Temperature Drying Cost

Propane cost for high temperature drying corn can be estimated using the following formula. Cost/bu. – pt. = 0.022 x propane price/gal. This is based on it taking 2,500 Btu of heat to remove a pound of water. More energy efficient dryers require about 2,000 Btu/lb., so the cost is only 80% of the calculated value. For example, the drying cost is $0.033/ bu.-pt. if the cost of propane is $1.50, 0.022 x $1.50. It will cost about $39.00 for propane to remove 10 percentage points of moisture from 120 bushels of corn using $1.50 propane.

Estimating Drying Fuel Requirement

The estimated quantity of propane needed to dry is 0.02 gallons per bushel per point of moisture removed. For example, 24 gallons of propane is needed to dry 120 bushels of corn from 25% to 15%. (0.02 x 120 bu. x 10 pts.) This is based on 0.72 pounds of water being removed per point of moisture per bushel, 2,500 Btu of heat required to remove a pound of water in a high temperature dryer, and a propane heat content of 91,500 Btu/gallon.

Moisture Shrink

Moisture shrink is the reduction in weight as the grain is dried. The moisture shrink (%) = [(Mo-Mf) / (100-Mf)] x 100. Mo=Original Moisture Content, Mf=Final Moisture Content. The moisture shrink drying corn from 25% to 15% is [(25-15)/ (100-15)] x 100 = 11.76%

Moisture shrink factor is the reduction in weight as the grain is dried one percentage point. Moisture Shrink Factor = 100 ÷ (100 – final moisture content). The shrink factor drying corn to 15.5% is 1.1834. The moisture shrink drying corn from 20.5 to 15.5 would be 5 x 1.1834 = 5.92%.

Obtaining an Accurate Moisture Content Measurement

Moisture meters will not provide accurate readings on corn coming from a high temperature dryer. The error will vary depending on the amount of moisture removed and the drying temperature, but the meter reading may be about 2% lower than true moisture. Check the moisture of a sample, place the sample in a closed container for about 12 hours, and then check the moisture content again to determine the amount of error.

Moisture meter errors increase as corn moisture contents increase, so readings above 25% should only be considered estimates.

In addition, moisture meters are affected by grain temperature. If the meter does not automatically measure the grain temperature and adjust the value, then it must be done manually. Even if the meter does it automatically, it is recommended to allow a sample in a sealed container to reach room temperature before measuring the moisture content. Then compare the moisture content of the room temperature sample to the initial sample to verify that the adjustment is done accurately.

Moisture meters normally are not accurate when grain temperatures are below about 40 degrees. Place the corn sample in a plastic bag or other sealed container, warm it to room temperature, and then measure the moisture content.

Corn Test Weight

Normally, corn test weight increases about 0.25 pound for each point of moisture removal during high temperature drying. However, the increase in test weight is affected by the amount of mechanical damage during harvest and the gentleness of the drying. Due to the high mechanical damage involved with harvesting 25% to 30% moisture corn and high drying temperatures typically used on high moisture corn, frequently there is no increase in test weight during drying. There will be little or no increase in test weight on immature or frost-damaged corn.

Corn Storage

More fines are produced when corn is wet, because more aggressive shelling is required, which causes more kernel cracking and breaking. There is also more potential for stress cracks in kernels during drying, which leads to more breakage potential during handling. In addition, immature corn contains more small and shriveled kernels. Fines cause storage problems because they spoil faster than whole kernels, they have high airflow resistance, and they accumulate in high concentrations under the fill hole unless a spreader or distributor is used. Preferably, the corn should be screen-cleaned before binning to remove fine material, cob pieces, and broken kernels.

Corn with damage to the seed coat and immature corn has a shorter storage life than mature corn. Therefore, cooling the grain in storage to about 20 to 25 degrees for winter storage is more important than for mature corn. It is recommended to dry the corn a percentage point lower in moisture content. More frequent checking of the storage is also recommended, and immature or damaged corn is not recommended for long-term storage.

Safety

Ice accumulation on fans leads to imbalance and vibration. Fans disintegrated in 2008-09 due to this problem. Monitor fans for ice accumulation and remove the ice if it is observed. Bridging of corn in a bin transfers more of the load to the bin wall that may lead to bin failure. Follow recommended storage management to minimize the potential for crusting or bridging and watch for the grain flow when unloading. Never enter a bin while unloading grain. Also, do not enter a bin to break up grain bridging. Several lives have been lost due to grain engulfment and there have been numerous entrapments where people needed to be rescued.

For more information do an internet search for NDSU corn drying.