

## Managing for Delayed Corn Crop Development

by Steve Butzen, Agronomy Information Manager

---

### Summary

---

- Delayed planting has delayed corn development in some areas of the eastern Corn Belt. Crop maturity is expected to be delayed by two to three weeks in those areas.
- In northern states and areas with late-May and June-planted corn, freezing temperatures may occur before normal crop maturity.
- The impact on corn yield from an early freeze depends on stage of corn growth, low temperature reached, duration of the low temperature period, and other factors.
  - Corn leaf tissue can be killed by a few hours near 32 F, and in even less time at temperatures below 32 F.
  - Temperatures below 32F for several hours would likely kill all the leaves and may stop ear development.
- Grain quality would also be affected by an early, killing freeze. Subsequent harvest, handling, drying and storage of lower quality grain requires extra care to prevent further quality reductions.
- Cylinder/rotor speed and concave clearance are the combine adjustments most critical to reduce grain damage and threshing losses with wet/immature grain.
- Drying temperatures need to be limited on corn of 25-30% moisture content or higher to avoid scorching grain and causing stress cracks that increase kernel breakage.
- Follow optimum grain storage procedures to minimize quality issues with wet or immature grain.
  - Screen grain. “Core” bin and level grain mass after filling.
  - Maintain aeration until grain mass equilibrates.
  - Monitor grain in storage by checking every two weeks.

---

### Introduction

---

Corn planting was delayed until early to mid-June in some areas of the eastern Corn Belt this year; Ohio and bordering states were most affected (Figure 1). As a result, corn pollination occurred two to three weeks later than normal, and crop maturity is lagging by a similar time span. In these areas, normal or earlier freeze dates are likely to occur before crop maturity. Although detrimental to this year's

crop, such an occurrence may have limited yield and grain quality consequences in most cases. This is because a first frost would likely be light enough to only affect corn leaves, allowing the plant to continue to fill grain from stalk carbohydrate reserves.

A worst-case scenario of a hard freeze prior to crop maturity means that growers should be prepared for a more abrupt end to corn development and consequently, dealing with possible yield and test weight reductions and wet, lower quality grain. This article will discuss the possible impacts of an early freeze on corn development, field dry-down, yield, harvest, artificial drying and storing of grain.



**Figure 1.** Continual rainfall resulted in ponded field conditions throughout the spring in many areas of the eastern Corn Belt, most notably, in Ohio.

---

### Impact of Late Planting on Field Drying

---

When corn reaches maturity late in the season, field dry down is slower due to cooler air temperatures. In the northern Corn Belt, field drying rates are often two to three percentage points per week in October and only about one point per week in November (Anonymous, 2009).

Generally, it takes approximately 15-20 GDU's to lower grain moisture each point from 30% down to 25%, 20-25 GDU's per point of drydown from 25% to 22%, and 25-30 GDU's per point from 22% to 20% (Pioneer Hi-Bred,

unpublished). If a hard freeze occurs that stops corn development prior to maturity, these field drying rates may be affected. For example, corn frosted as early as the dough stage may require 4 to 9 extra days to reach the same harvest moisture as corn not frosted (Maier and Parsons, 1996).

### Yield Reduction Caused by an Early Freeze

The impact on corn yield from an early freeze is dependent on stage of corn growth, low temperature reached, duration of the low temperature period, and other factors (Lauer, 2004). A freeze event with temperatures below 32F for several hours would likely kill all the leaves and may stop ear development entirely. Should this occur, growers need to determine the ear development stage at the time of the freeze to estimate percent yield loss (Table 1 and Figures 2 and 3).

**Table 1.** Potential grain yield losses after frost.






Corn development stage	Killing frost (leaves, ear shank and stalk)	Light frost (leaves only)
	----- percent yield loss -----	
R4 (Soft dough)	55	35
R5 (Dent)	40	25
R5.5 (50% kernel milk)	12	5
R6 (Black layer/no milk line)	0	0

Derived from Afuakwa and Crookston (1984)



**Figure 2.** (Left) Kernel stages R3 (milk), R4 (dough) and R5 (dent)<sup>1</sup>. (Right) Kernel stages R5.5 (1/2 milk line), R5.75 (3/4 milk line) and R6 (black layer or no milk line)<sup>2</sup>.

Corn leaf tissue can be killed by a few hours near 32 F, and in even less time at temperatures below 32 F. At temperatures between 32 to 40 F, the extent of damage may vary considerably, depending on microclimate, aspect of the field slope, and whether or not atmospheric conditions favor a radiation frost. In such cases, it is possible that only upper leaves in the canopy would be killed, while leaves lower in the canopy survive and remain photosynthetically active. If the leaf tissue is killed, it will be evident in 1 to 2 days as a water-soaked appearance, which will eventually turn brown. Therefore, it is best to wait 5 to 7 days before making an assessment of percentage leaf damage for purposes of estimating yield reduction.

	<p><b>Stage R 5</b> Beginning Dent Milk line just starting to appear. Grain Moist.~50-55% ~400 GDU's remaining to maturity Yield Loss ~ 35-40%</p>
	<p><b>Stage R 5.25</b> 1/4 Milk line Grain Moist.~45-50% ~300 GDU's remaining to maturity Yield loss ~ 25-30%.</p>
	<p><b>Stage R5.5</b> 1/2 milk line Grain Moist.~40-45% ~200 GDU's remaining to maturity Yield loss ~ 12-15%.</p>
	<p><b>Stage R 5.75</b> 3/4 milk line Grain Moist.~35-40% ~100 GDU's remaining to maturity Yield loss ~ 5-6%.</p>
	<p><b>Stage R6</b> Black Layer or "No Milk Line" Grain Moist.~30-35% 0 GDU's remaining to maturity Yield loss = 0%</p>

**Figure 3.** Kernel growth stages and approximate grain moisture, GDU's to maturity (black layer or "no milk line"), and yield loss from a hard, killing frost that stops kernel development<sup>2</sup>.

---

## Pre-Harvest Tips

---

Even where this year's corn crop approaches maturity, many growers will still have to deal with wetter than normal grain at harvest. Several steps can be taken prior to harvest to make this job go more smoothly (Lauer 2009).

- If you have recorded silking dates by field, use these notes to predict the order in which fields will reach black layer and harvestable moisture. This will help in setting up a harvest schedule. However, be sure to base the schedule on crop condition as well as grain moisture, taking into account stalk quality and insect or disease damage.
- Where such options exit locally, consider harvesting (or selling) more of your crop as silage or high moisture corn.
- Explore locking in a price for the additional fuel needed for grain drying. Compare the fuel costs vs. possible dockage for shrink if wet corn is delivered to the elevator.
- Consider some field drying if grain moisture levels are high, but don't wait too long! Wet field conditions can keep combines out of the field as crops deteriorate, and snow and ice may increase harvest losses due to ear droppage and stalk breakage.

---

## Harvest Management of Wet/Immature Grain

---

**Combine Adjustments:** Grain above 30% moisture can be difficult to remove from the cob and is easily cracked and damaged by over-threshing in the cylinder or rotor of the combine. Cylinder/rotor speed and concave clearance are the adjustments most critical to reduce grain damage and threshing losses. At high grain moisture growers may have to strike a balance between damaged grain and higher than normal grain loss from unshelled cobs.

With very wet grain, some ag engineers suggest beginning harvest with combine settings that would likely under-thresh a typical, lower moisture crop (Brook and Harrigan, 1997):

- Set cylinder/rotor speed near the low end of the suggested range
- Set concave clearance near the widest recommended setting
- Open the chaffer and sieve to the maximum recommended openings
- Check with the combine manufacturer for machine-specific recommendations. (Combine mechanics or other dealership staff are often a good source for this information).
- Begin with above settings but check immediately and re-adjust as necessary to achieve best results. Continue to check and readjust as crop conditions change.
- For more tips on combine settings for wet grain, go to: <http://www.ipm.msu.edu/pdf/HarvGrain&Dmg.pdf>

---

## Drying Wet/Immature Grain

---

Properly drying this year's very wet, lower quality corn will be essential to avoid further quality reductions. Growers should screen lower quality grain prior to drying, using a rotary screen, gravity screen or perforated auger housing section. This will prevent foreign material and broken kernel fragments (or "fines") from blocking air flow essential to uniform grain drying and storage. Next, growers should plan to dry lower quality grain 1 or 2 points lower than the normal 14 to 15% often recommended for long-term storage. This is because of greater variations of moisture content within the grain mass and increased physical kernel damage and broken cobs, which could magnify mold problems. One consolation to delayed maturity this year is that natural gas prices are at 8-year lows in many areas.

According to extension specialists at North Dakota State University, energy efficiency is increased at maximum temperatures in high temperature drying systems, but these temperatures could scorch very wet or immature kernels. In addition, high temperature drying causes stress cracks in the kernel which allows more breakage during handling and storage. The amount of stress cracking depends on initial grain moisture, rate of moisture removal, maximum grain temperature reached in the dryer, and rate of grain cooling. Therefore, drying temperatures need to be limited on corn of 25 to 30% moisture content (or higher).

With natural-air or low-temperature drying systems it will be difficult to adequately dry corn wetter than 26% grain moisture. The maximum moisture content for natural air drying of corn is 21 percent using an airflow rate of at least one cubic foot per minute per bushel of corn (Anonymous, 2009).

**Consider these investments to help manage harvest, drying and storing wet, lower-quality grain:**

Moistures tester – \$300 to \$2000

"Bee's wings" and fines cleaner – \$1500 to \$3000

Moisture controllers for the grain dryer – \$2500 to \$5000

Temperature cables in the grain bin – \$2500 to \$5000

Lauer (2009) gives these additional grain drying tips:

- Fine-tune your dryer so that over- or under-drying does not occur. Over-heating the grain in the dryer or filling the bin too fast for drying to occur will increase costs and decrease grain quality, thus reducing profitability.
- Hire and train the skilled labor that will be required to monitor dryers, fans, augers, and other equipment during the drying process.



To reduce drying time and speed harvest, some growers have discussed partially drying and aerating corn while holding it for further drying after completion of harvest. This strategy requires skill and intensive management, especially with low quality grain. For more tips on grain drying to maximize grain quality, see Appendix I on page 6.

---

## Storing Wet/Immature Grain

---

Low test weight, lower quality grain is harder to store because it is breakage-prone and subject to mold and “hot spot” occurrence in the bin. Because the storage life of this grain may be only half that of normal corn at the same moisture content, consider selling this grain early rather than storing long-term.

To minimize storage problems, begin by screen-cleaning grain before binning to remove as much of the fine material, cob pieces and broken kernels as possible. After filling, “core” the bin (remove up to 10% of the total bin capacity) to eliminate broken kernels and fines that accumulate in the center. Next, level the grain in the bin to minimize moisture accumulation at the top of the grain. Finally, cool grain as soon as it is dry to within 10 degrees of air temperature, and continue to aerate for 10 to 14 days to ensure grain moisture “equilibrium” has been achieved.

Monitoring lower quality grain on a twice-monthly basis is essential to ensure that grain condition is maintained. For more tips on grain storage and monitoring procedures, see Appendix I and II on page 6.

---

## Conclusions

---

Because many growers will have wet or immature corn in October, deciding when to start combining will be difficult. Experiences during several late harvest years suggest that excessive delays may not be a good idea, for these reasons:

- Delaying starting may also delay finishing at a reasonable date. Most growers require about 6 weeks to harvest the entire crop in a normal year, and another 2 weeks to complete fertilization and tillage. This means growers must start the first week of October to finish before December.
- Drying corn with ambient temperature in the 20’s requires more energy than drying corn with ambient temperatures in the 40’s.
- Harvesting in the winter limits fall tillage and fertilization, reducing options for crop rotation the following spring.
- Finally, there are safety concerns and potential for increased damage to machinery when harvesting on frozen soils and driving on snow or ice-covered roads.

For these reasons, timely harvest is usually advantageous, even though drying costs may be increased.

---

## References

---

Afuakwa, J.J. and R.K. Crookston. 1984. Using the kernel milk line to visually monitor grain maturity in maize. *Crop Sci.* 24:687-691.

Anonymous. 2009. NDSU Extension Service to provide corn drying information at Big Iron. North Dakota State University Extension Service News Release. Online: <http://www.ag.ndsu.edu/news/newsreleases/2009/aug-31-2009/ndsu-extension-service-to-provide-corn-drying-information-at-big-iron/view>

Brook, R. and T. Harrigan, 1997. Harvesting and handling high moisture, frost-damaged grain. Harvest Alert Fact Sheet #5. Field Crops Team, Michigan State University. Online: <http://www.ipm.msu.edu/pdf/HarvGrain&Dmg.pdf>

Jeschke, M. and S. Paszkiewicz. 2008. Hybrid maturity switches based on long-term research. *Crop Insights* Vol. 18, no. 6. Pioneer Hi-Bred International. Online: <http://www.pioneer.com/web/site/portal/menuitem.683e661c8aed591aa9fbff5d10093a0/>

Lauer, J. 2004. Guidelines for handling corn damaged by frost prior to grain maturity. In *Issues in Agriculture*. University of Wisconsin Extension. Online: <http://www.uwex.edu/ces/ag/issues/winterfeed2004/frost.html>

Lauer, J. 2009. Will corn mature in 2009? *Agronomy Advice – Field Crops* 28:491-70. University of Wisconsin Extension. Online: <http://corn.agronomy.wisc.edu/AA/pdfs/A070.pdf>

Maier, D. and Parsons, S. 1996. Harvesting, drying, and storing frost-damaged corn and soybeans. Grain Quality Task Force Fact Sheet #27. Purdue University. Online: <http://www.ces.purdue.edu/extmedia/GQ/GQ-27.html>

Nafziger, E. 2009. Can this "turtle" 2009 corn crop get to the finish line? *University of Illinois Bulletin* No. 22, Article 5. Online: <http://ipm.illinois.edu/bulletin/article.php?id=1221>

Nield, R.E. and J.E. Newman, 1986. Growing season characteristics and requirements in the Corn Belt. *National Corn Handbook*. Chapter 40. Purdue University. Online: <http://www.ces.purdue.edu/extmedia/NCH/NCH-40.html>

Nielsen, R.L. 2009. Cool days, cold nights, slow corn, what's next? *Corny News Network*, Purdue Univ. Online: <http://www.agry.purdue.edu/ext/corn/news/articles.09/CropProgress-0901.html>

Pope, R. and E. Taylor. 2009. The 2009 season in degree days through late August. In Integrated Crop Mgmt. News, Aug. 24, 2009. Iowa State University. Online: [www.extension.iastate.edu/CropNews/2009/082409pope2.htm](http://www.extension.iastate.edu/CropNews/2009/082409pope2.htm)

Thomison, P. 1999. Corn harvest losses and grain drydown rates. Crop Observation and Recommendation Newsletter 99:25. Ohio State University Extension. Online: <http://corn.osu.edu/archive/1999/sep99/99-25.html#linkc>

Thomison, P. and A. Geyer. 2008. Assessing the risk of frost injury to late maturing corn. Crop Observation and Recommendation Newsletter 2008-31. Ohio State University Extension. Online: <http://corn.osu.edu/index.php?setissueID=255#A>

<sup>1</sup> Images courtesy of Steven Ritchie, from How a Corn Plant Develops, Iowa State University, Ames, IA. Online: <http://www.extension.iastate.edu/hancock/info/corn.htm>

<sup>2</sup> Images courtesy of Dr. Dennis TeKrony, Dept. of Agronomy, University of Kentucky.

---

## Appendix I - Optimal Management Practices for Drying and Storage (John Gnadke, AGS, Inc.)

---

### Continuous Flow Grain Dryers<sup>1</sup>

	Operating Plenum Temp. <sup>2</sup>	Grain Temp. Maximum
Food Corn	130 – 140 F	100 F
Wet Milling Corn	170 – 190 F	130 F
Livestock Feed	170 – 190 F	130 F

<sup>1</sup>To maintain high capacity and grain quality, keep your grain dryer clean! <sup>2</sup>Temperature ranges must be within 15 – 20 F anywhere within your plenum.

### InBin Drying

InBin with stirring equipment - for best results, the operating temp should be 95-105 F.

InBin with low temp heaters (LP or electric) should be operated on a Humidity Controller. This will condition the ambient air to the proper relative humidity (RH). For best results, the RH setting is approximately 70%.

### Natural Air InBin

Fan Size: 1.5 CFM of air per bushel.

Clean grain to 2% or less BCFM.

Wet grain moisture: 20% for best results

Roof Venting: 1.5 sq. ft. per fan HP.

### InBin Continuous Flow

Clean Grain to 2% or less BCFM.

Operating Temp: 130-160 F.

Keep grain depth from 4'-6' for highest capacity of this unit.

Proper roof vent is a must (1.5 sq. ft. per fan HP).

Grain discharge temp will be 95-115 F.

### InBin Cooling

If stress fractures are a part of a grain contract, take special steps to prevent this from occurring (grain temp: 95-105 F).

If wet grain is 20% or less, steep for 12 hours before cooling.

If wet grain is 22-24%, steep for 18-24 hours before cooling.

If ambient air temps fall below 40 F at night, then DO NOT operate cooling fans.

Operating cooling fans at 40 F or above will reduce stress on grain (may require day-time operation of these cooling bins.)

### Cooling Grain to Proper Storage Temperatures

Cool grain to 35 F (DO NOT freeze food corn as it can cause additional stress on the grain.)

Freezing grain at 18-20% moisture can cause ice crystals to form on the kernels.

When temperature rises in Feb. or March, ice crystals will melt and cause grain to go out of condition very quickly.

### Final Note

All stored grain should be checked every two weeks!

---

## Appendix II - Grain Storage Principles (John Gnadke, AGS, Inc.)

---

### Initial Storage

- Dry grain to the “equilibrium” moisture level (15%).
- Use LOW temperature drying to minimize stress cracks.
- For ideal grain storage target 2% cracked/broken
- Level the grain in the bin to minimize moisture accumulation at the top of the bin (core or use a mechanical “spreader”).
- “Core” the bin by removing 10% of the total bin capacity after filling to remove fines that accumulate in the center. In the coring process try to keep the bin as level as possible.
- Cool grain as soon as it is dry to within 10 degrees of air temperature.
- Aerate the grain for 10 to 14 days after filling to ensure grain “equilibrium” has been achieved – based on ¼ CFM.
- Monitor grain temperature and moisture regularly (minimum every two weeks, preferably on a continuous basis with “in-bin” probes and visual inspection).
- Monitor grain for insect and rodent infestation on a regular basis (minimum every two weeks).

### Long-Term Storage

- Keep cooling grain on a regular basis until grain temp reaches 35 F. Never cool grain below 32 F.
- Check grain regularly (minimum every two weeks) while in storage. 1) Lock out power. 2) Climb into the bin, look, feel, smell, and walk on the surface. 3) If automated controls are used, bi-weekly inspections are still recommended to ensure controls are functioning properly.
- Aerate on a regular basis while in storage, discontinue fan run-time when temperatures fall below 32 F.
- Additional questions call John Gnadke 515 964-9885