HARVEST ALERT

MICHIGAN STATE UNIVERSITY EXTENSION

FACT SHEET # 2 - revised Fall, 2000

Potential for Frost Damage and Other Effects in Corn

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Delayed planting and below normal accumulative heat units results in delayed growth and development in corn. This makes the corn crop more vulnerable to early frost damage before it reaches physiological maturity. Even if not damaged by frost, immature corn will exhibit higher moisture which will increase drying costs and lower test weight (weight per bushel at 15.5% moisture), a key indicator of quality in corn.

This fact sheet discusses several factors to be considered for harvest, including:

- potential for frost damaged corn
- effect of delayed maturity on corn
- lessons on hybrid selection

Potential for Frost Damaged Corn

The key to assessing potential frost damage is to predict *what stage of kernel development frost damage is likely to occur.* The closer the crop is to physiological maturity, the lesser the impact of a killing frost (the first killing freeze in the fall is defined as the first occurrence of 30ºF or lower). Listed below are stages of kernel development referred to in the harvest alert fact sheets:

Stage	Description
Silk	Silks are emerged and tassel is shedding pollen.
Blister	Within two weeks after silking, kernels are white on the outside and resemble a blister in shape. The cob is close to or at full size.
Milk	By end of the third week after pollination, kernels display a yellow color on the outside and the inner fluid is milky-white due to accumulation. Kernels taste like "sweet corn".
Soft Dough	Starch accumulation continues into the fourth week as the milky inner fluid now thickens to a pasty consistency. Kernels have accumulated close to half their mature weight. Some dents are now visible at the attachment end of the ear. The interface between the hard starch above and the milky liquid material below is termed the milk line.
Early Dent	Visible dent on 95% of the kernels.
Full Dent	All kernels are dented. Kernels easily cut with fingernail. It takes approximately 10 days to go from full dent to 1/2 milk line.
1/2 Milk Line	Milk line is about 1/2 the distance between the kernel crown and tip. About 95% of the grain yield potential has been achieved. Whole plant moisture is ideal for ensiling in a tower silo at approximately 63-68% moisture.
	(Continued on next page)
Mature (Black layer)	All milk has disappeared from the kernel. The hard starch has advanced completely to the cob with a brown or black abscission layer developing at the tip of the kernel. The black layer formation occurs progressively from the tip ear kernels to the basal kernels of the ear.

(Adapted from *How a Corn Plant Develops*. Special Report No. 48. Iowa State University Cooperative Extension Service. 1984. Available from MSU Bulletin Office as E-1933.)

The stages of kernel development are affected by the amount of heat accumulation or growing degree day (GDD) units available. The GDD formula is commonly used as a guide to predict physiological maturity. For corn, GDD are computed by this formula: growing degree days = [(maximum temperature + minimum temperature) /2] - 50 summed for each day from planting to physiological maturity. Daily maximum temperatures greater than 86 degrees F are set at 86 degrees F in formula; minimum temperatures less than 50 degrees F are set at 50 degrees F.

Most hybrids require about 1100-1200 GDD to develop from silk stage to physiological maturity (hybrid maturity differences in development time occur primarily from emergence to silking, not from silking to maturity).

Table 1 shows the average time and GDD to physiological maturity after silking, as well as grain and whole plant yield and moisture content in relation to kernel development. Late-planted corn requires 50 to 70 less GDD to reach maturity *after silking* than early-planted corn.

Table 1. Relationship Between Kernel Growth Stage and Development.

Stage	Calendar Days to Maturity (Average)	Growing Degree Days (GDD) to Maturity	% of Max. Yield		Moist. Content %	
			Grain	Whole Plant	Grain	Whole Plant
Silk	50-55	1100-1200	0	50-55	--	80-85
Blister	40-45	875-975	0-10	55-60	85-95	80-85
Late milk-dough	30-35	650-750	30-50	65-75	60-80	75-80
Early dent	20-25	425-525	60-75	75-85	50-55	70-75
Fully dented*	10-15	200-300	90-95	100	35-40	65-70
Phys. mat.**	0	0	100	95-100	25-35	55-65

*Kernel milk-line moved 0.5 to 0.75 the distance between crown and base.

**Black layer formation and milk disappearance from kernel under normal development. Premature frost or extended cold temperatures may cause black layer formation at earlier stages and wetter moisture.

(Adapted from *Kernel Development: Will Corn Mature Before Harvest? What Will Happen if it Doesn*t?* Paul Carter, Wisconsin Pest Manager, Vol. 15, No. 19, 1992.)

Most concern exists when corn does not reach silk stage until early August or later. With average daily high and low temperatures of 80 and 60ºF, 20 GDD accumulate each day. At these temperatures, it would take at least 55 days from silking to maturity (1100 divided by 20). Therefore, corn silking in early August would not be safe from major yield reductions due to frost until late September.

With cooler high and low temperatures of 75 and 55ºF, only 15 GDD accumulate daily, requiring more than 70 days to maturity from early-August silking. This would require warm, frost-free weather until early to mid-October, which is past the average frost-date for much of the state.

At early dent stage, corn has accumulated 60 to 75 percent of maximum grain yield and needs about 20 to 25 days with daily high temperatures above 75ºF to avoid significant yield reductions due to frost (Table 1). Corn should reach early dent stage by September 1 to consistently avoid yield reductions caused by early frost.

What is the potential for corn to reach maturity before the first killing freeze in the fall?

Table 2 shows the 30 year average normal first killing freeze date (30ºF or below) in several locations in Michigan, and the estimated base-50 GDD remaining at each location.

Table 2. Date of first killing freeze date (30ºF or below) — 50% probability and the estimated base-50 GDD. 1961-1990.

Station	Date of normal first killing freeze	Estimated GDD remaining from September 16 through first killing freeze in Michigan
Alma	10/15	265
Alpena	9/27	131
Bad Axe	10/18	264
Caro	9/29	183
Chatham	9/24	95
Coldwater	10/10	253
Eau Claire	10/27	377
Grand Rapids	10/16	278
Hesperia	9/27	128
Lansing	10/08	226
Lapeer	10/08	246
Monroe	10/22	358
Saginaw	10/20	261
Sandusky	10/15	243
Stephenson	9/21	84
Traverse City	10/10	203

How can the information in the tables be used to determine if a corn crop will reach physiological maturity before the first killing freeze? Assume that a corn crop reaches early dent stage on September 15th. From Table 1, we estimate that the crop will need about 23 days to mature, with about 450 GDD s required. By looking at Table 2, it is apparent that very few locations come close to the required GDD before a probable killing frost. However, also consider that late planted corn has shown the ability to reach maturity in 200-300 less GDD than normally required.

Other Effects of Delayed Maturity on Corn

If an immature corn crop is not completely killed by frost, what other effects can be expected?

High moisture — Grain moisture levels at maturity (black layer) are normally between 30-35%. Slow maturing corn may have moisture levels above 35%, increasing drying costs to reach 15.5% moisture. Also, immature corn may have tightly bound husks, which further delays drydown. The longer the crop is delayed, the lower the drydown rate in the field.

Low test weight — Test weight is a measure of the weight per bushel at 15.5% moisture. High test weight indicates kernels contain a high proportion of hard, flinty starch or endosperm that is highly valued in dry milling operations. As corn dries, test weight increases. High kernel moisture that is characteristic of immature corn may not shrink uniformly when dried. This results in dull, chaffy grain with low density per volume, hence low test weight. Low test weight corn also has lower digestibility when used as feed. Differences in test weight influence USDA grading of shelled corn. The Federal Grain Standards test weight values for grades are as follows:

Grade	Test Weight (lbs)
1	56.0
2	54.0
3	52.0
4	49.0
5	46.0

Corn with test weights below those for Grade No. 2 are often discounted at the elevator.

Lessons on Hybrid Selection

It cannot be overemphasized that a key tool in reducing losses due to frost damage and immature grain crops is the selection of the proper hybrid for a particular growing area. Table 3 lists approximate GDD requirements according to the relative maturity rating. Check with seed companies before selecting hybrids for a particular growing area of the state, and also the Corn Hybrids Compared bulletin (E-431), published each year by Michigan State University.

Table 3. Estimates of the relationship between relative maturities of corn hybrids and growing degree days.

Relative maturity (days)	GDD requirements (planting to physiological maturity)
70-80	1800-2000
80-90	2000-2300
90-100	2300-2500
100-110	2500-2700
110-120	2700-2800

Adapted from *Using Climatological Information for Corn Hybrid Selection in Michigan.*
J.A. Andresen, O.B. Hesterman, D.D. Harpstead, M.J. Staton, F.V. Nurnberger. MSU Extension Bulletin E-2471, March 1994.

Hybrid selection in cool, wet growing seasons becomes increasingly significant. Later maturing, higher yielding hybrids may not always be the most profitable scenario. Although they may produce higher yields, it is likely that later maturing hybrids will incur higher drying costs in years where maturity is delayed.

An evaluation was conducted at MSU comparing the yield and profitability of early and late maturing hybrids grown in the 1990 through 1998 growing seasons. As a class, the late-maturing hybrids exhibited an increase in total grain production. However, the long-term averages indicated an economic benefit from the production of superior hybrids in the group classified as early maturing. The drying costs associated with the higher moisture of the late maturing varieties reduced their profitability.