

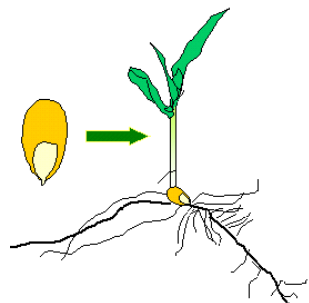
Diagnosing Chilling and Flooding Injury to Corn Prior to Emergence

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Summary

- Farmers often plant corn very early to increase yield potential and to avoid weather delays late in the season.
- This early planting offers potential advantages, but it also carries significant risks related to cold injury and damage from pests.
- Ultra-early planted corn may require up to five weeks to emerge, depending on soil and weather conditions.
- During this time, the seed and emerging seedling are highly vulnerable to damage from insects, diseases and herbicide exposure. The emerging seedling may also encounter adverse field conditions such as crusting or ponding.
- In addition, chilling temperatures caused by rain, melting snow or cold soils can damage the seed during imbibition or injure the delicate structures of the emerging seedling.
- These stresses are often compounded under no-till conditions due to lower soil temperatures and excess water in the crop residue.

Introduction



Very early-planted corn faces challenges in producing a healthy emerged plant.

Choosing corn planting date is an important management practice for increasing corn yield potential. Too often, that date is dictated by prevailing weather and soil conditions, as well as the size of acreage to be planted. To avoid the possibility of delayed planting and resultant yield reductions, farmers have moved average corn planting dates ever earlier,

and in some cases, too early. This corn is subsequently at increased risk of encountering cold temperatures and adverse weather systems normally expected for those early spring dates.

Corn is a warm-season crop with tropical origins. It is not surprising then, that corn is susceptible to stresses that result from early planting under cool soil conditions. When corn is planted extremely early, and soil temperatures are below 50 F, it is likely that corn seeds will remain in the soil at least

three to four weeks prior to emergence. The length of this period will depend on the soil temperature and its water holding properties. During this time, corn may encounter a number of problems, including herbicide, insect and disease pressure. But even more problems may result from the physical properties of the seedbed, including crusting, ponding or saturated soils. In addition, cold temperatures resulting from cold rain or even snow can severely impact the seed. This Crop Insights will discuss effects of cold soils and water on germination and emergence of corn, including diagnosing plant injury symptoms caused by chilling and flooding.

Effect of Cold Soils and Water

The early spring seedbed is a very unfavorable environment for corn seeds. Though dry seeds can be stored unharmed for many years at -20 F or below, corn planted very early is at risk to cold injury and even death.



1. Good spring weather in Quebec, Canada in 2002 allowed for planting on April 24. **2.** Snow occurring five days later covered the field. Cold imbibition resulted in seedling damage and stand loss like that shown in pictures **3** and **4**, respectively.

Early planting often exposes seeds to hydration with cold water, which can cause direct physical damage. In addition, prolonged exposure to low temperatures reduces seed and plant metabolism and vigor, increases sensitivity to

herbicides and seedling blights and causes oxidation damage due to the effects of free radicals in the cell (Figure 1). Free radicals are unstable molecules that damage cells and organs. This damage is similar to that which occurs in mammals during aging and sun exposure.

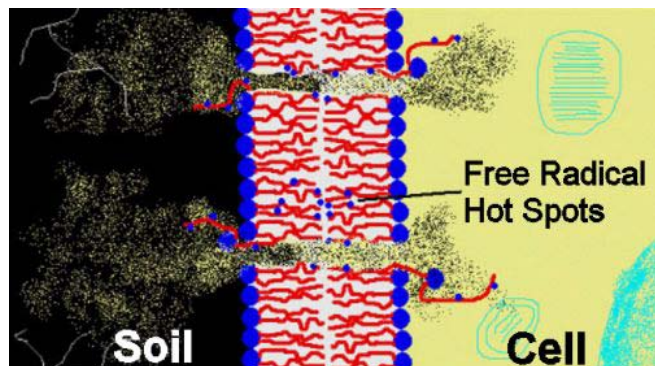


Figure 1. Free radicals can disrupt cell membranes leading to cracking during cold imbibition. Leaked cell contents can attract soil fungi leading to seedling disease.

When the dry seed imbibes cold water as a result of a cold rain or melting snow, imbibitional chilling injury may result. The cell membranes of the seed lack fluidity at low temperatures, and under these conditions, the hydration process can result in rupture of the membranes. Cell contents then leak through this rupture and provide a food source for invading pathogens. Cold water can similarly affect seedling structures as they begin to emerge.

Research has shown that temperatures at or below 50 F are most damaging to the germination and emergence process, especially if they persist long after planting (Table 1.)

Table 1. Final stand counts, planting dates and soil temperatures in research plots in 2002.

Location	Planting Date	Ave. Soil Temp. 4 Weeks Post-plant	Final Stand (%)
Michigan	Apr 16	56 °F	90
Minnesota	Apr 23	48 °F	81
North Dakota	Apr 11	41 °F	61

* Data for 100 hybrids across all CRMs.

As the table indicates, the percent final stand varied considerably depending on the average soil temperature during the four weeks following planting. In Michigan, an average soil temperature of 56 F produced an acceptable final stand of 90%. However, a soil temperature of 48 F resulted in only 81% of plants emerging, and a soil temperature of 41 F produced only a 61% stand in other northern environments. These data suggest that prolonged soil temperatures below 50 F after planting can have serious

consequences for stand establishment. However, the degree of damage will vary with soil type and is generally greater in heavier or poorly drained soils.

Flooding Effects on Emergence

Flooding can have an equally devastating effect on seedling emergence and survival as cold soils. Most corn hybrids can only survive for 24 to 48 hours under water, with smaller seedlings suffering the most damage.

Flooding damages corn biochemically. By impairing mitochondria, it causes release of free radicals which damage cell membranes. Flooding also causes oxygen starvation and shifts the plant's metabolic processes to anaerobic fermentation. Resulting acidosis (low pH) can kill the cells. At the minimum, flooding reduces the plant's metabolic rate, making seedlings more sensitive to disease, insects and herbicides. In fact, many disease-causing fungi such as *Pythium* thrive in standing water. Seedlings that are weakened by flooding or cold damage usually succumb to disease if the pathogen is present in the soil.

Flooding damage does not only occur in obvious ponded areas of a field. If fields are completely saturated to the soil surface and remain that way due to continual rain or limited drainage, seeds and non-emerged seedlings are under water. Flooding damage may occur in these areas just as in ponded areas.

Diagnosing Stand Establishment Problems

Careful examination of damaged seedlings can provide clues into the likely causes of stand establishment problems following early planting or abnormally cold weather conditions. Table 2 lists the main symptoms and likely causes of early season damage. Table 3 shows diagnostic images of chilling and flooding damage to corn seedlings during germination and emergence.

Pioneer Research

For decades, Pioneer plant breeders have selected within the natural variation expressed by corn genotypes to develop hybrids with strong emergence and vigor characteristics under cool soil conditions. Pioneer has recently introduced a new early-season trait called Stress Emergence. Stress emergence refers to the genetic potential of a hybrid to germinate and emerge under stressful conditions associated with early planting including cold, wet soils or short periods of severe weather. Stress emergence is not a rating for seedling disease and should not be confused with the "early growth" rating, which refers to seedling vigor after emergence.

Pioneer research scientists are continuing to work to improve early season corn performance through conven-







tional and molecular breeding, as well as through rigorous testing of research and commercial hybrids. By identifying molecular markers and pathways associated with superior cold germination, Pioneer researchers are beginning to develop an understanding of the genetic basis of stress emergence. This knowledge should eventually lead to even stronger early-season performance in elite Pioneer corn hybrids.

Table 2. Corn seedling symptoms and likely causes*.

Symptom*	Likely Cause	Result
Stubby coleoptiles Leaves emerging prematurely	Imbibitional chilling or cold damage	Death, unless unprotected leaf reaches the surface
Brown tissue behind root tip Adventitious roots	Chilling damage Flooding	Chance for survival unless shoot meristem is damaged
Leafing underground Leaves growing along soil crust	Mechanical damage Soil crusting	Usually death, as seedlings lose ability to penetrate soil
Corkscrew mesocotyl or coleoptile	Temperature fluctuations Herbicide injury	Seedling death
Fused coleoptile or bursting on side	Cold damage Genetic tendency	Seedling death
Rotted seed or mesocotyl Spotty wilting	Seedling disease	Seedling death or stunting
Bleached leaves	Herbicide or cold injury	Seedlings can grow out of it unless impairment of photosynthesis is extensive
Pruned roots	Insect damage	Weak seedlings, wilting

*See Table 3 for diagnostic images.

Table 3. Diagnostic images of chilling and flooding damage to corn seedlings during germination and emergence.

		
		
<p>Top, Bottom: Imbibitional chilling and cold injury. Note club-shaped coleoptile and underground emergence.</p>	<p>Top: Corkscrew seedling Bottom: Fused coleoptile/bursting on the side.</p>	<p>Top: Flooding damage – note necrotic area of each root above root tip. Bottom: Flooding/chilling damage – note dead primary root (above seed) and adventitious roots on mesocotyl (below, left of seed).</p>