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What are the lasting impacts of early-season problems in corn?
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Do early season problems ‘disappear’ in corn? Plant-to-plant and in-field variability was a concern across numerous corn fields in 2007. In addition, fields had uneven seeding depths, shallow nodal root systems, sidewall compaction, and other problems were common. We will discuss the importance of uniformity in fields relative to yield partitioning and yield determination in corn. First we present a primer of early season root systems and then we present a list of 9 early-season management/environmental factors that affect plant-to-plant and in-field variability and reduce yield potential. Anything that disrupts early-season growth can have a negative impact on yield. Here we will discuss only nine.

Corn root formation (a primer)
Root development during the first few weeks following corn emergence is critical to the success of the crop. Corn has two identifiable root systems both visible early in the growing season. The initial root system is comprised of the radicle and lateral seminal roots. The seminal roots help anchor the young seedling and provide it with nutrients and water. See Figure 1.

The second root system, the nodal roots, develops at the base of the coleoptile. The location of the nodal roots is typically the same (3/4 to 1 inch below the soil surface) unless the seed was planted extremely shallow or some other factor prevails. Nodal root formation is triggered by light interception by the growing point. Mesocotyl length will vary depending on seeding depth. The mesocotyl connects the kernel and the coleoptile.

Seminal roots cease new growth shortly after the coleoptile emerges from the soil surface. Once the plant is approximately V1, the nodal root system is visible. The nodal root system becomes the dominant system by V6.

A healthy mesocotyl is extremely important since it transports nutrients from the kernel to the developing seedling. The plant primarily depends on the kernel’s contents for its nutrients and energy until the nodal roots are developed. Therefore, it is possible that seedlings may be stunted or die if their nodal roots do not develop before the kernel reserves are exhausted.

Management/environmental factors that affect root formation and early-season growth and their impacts on yield
Many factors affect root formation and early-season growth. We discuss here some issues Iowa corn faced in 2007 as well as a few short comments on management options and potential yield impacts.
1. **Seeding depth**

Ideal planting depth varies with soil and weather conditions although a 2 inch depth is ideal for most conditions. Planting depth should never be shallower than 1.5 inches. When the surface soil is dry, especially when planting has been delayed until mid- or late May, planting depth may need to be increased to 2 inches or more. Careful control of planting depth will improve stands and produce more even plant emergence. Variable seeding depths can result in variable emergence which will affect corn yields.

2. **Early-season cold stress**

Frost and highly variable soil temperatures are two factors that can place corn under significant stress after planting. The amount of stress experienced will vary based on whether the corn seed has imbibed (absorbed) water, started growth but not yet emerged, or if the seedling has emerged above the soil surface.
Variable soil temperatures have little effect on the first phase of corn germination, water imbibition. Seed will absorb about 30 percent of its weight in water. However, the time required for radicle emergence is directly related to temperature; it increases linearly if soil temperatures are between 46 and 90°F. Little, if any, mesocotyl or coleoptile growth occurs in soils cooler than 60°F. A constant soil temperature of 86°F optimizes seed germination and seedling emergence.

Other researchers (Buckle and Grant. 1974. Rhodesian Journal of Agric. Research. 12:149-161) have determined that a swing of soil temperatures of 27°F (soil high temperature-soil low temperature = 27°F) will particularly affect mesocotyl growth. Corn planted in early April will possibly experience this range in temperatures. Seedlings adversely affected by wide swings in soil temperatures will have stunted and distorted leaves and may or may not emerge from the soil.

3. Early-season frost
Emerged corn seedlings are relatively resistant to cold weather. Air temperatures near 30°F may kill or damage exposed above-ground tissue, but the growing point of the seedlings remains below the soil surface until approximately the V6 stage of development (six collared leaves visible). Recovery from a moderate freeze is usually rapid and nearly complete when the growing point is below ground. Frost injury on very young corn plants surprisingly has very little effect on yield if the plants survive the frost. When poor growing weather follows an early season frost, corn seedlings may occasionally die. A hasty decision to replant would be ill advised. If the growing point is not damaged, a new leaf should emerge in 3 to 4 days.

4. Corn survival in flooded or saturated soils
How long can corn survive in flooded or saturated soils? If plants are emerged, then smaller seedlings are more susceptible than larger seedlings. A germinating seed will be even more susceptible as it requires oxygen to survive. In flooded soil conditions, the oxygen supply will become depleted within approximately 48 hours. Cool air temperatures do help to increase the possibility of survival. Yet, we would not expect survival of germinating seeds to be greater than that of young plants; they should not be expected to survive more than four days at the most and may not be more than two days.

Only make replant decisions after assessing stands and considering the economics of replanting or converting the acreage to another crop. An Iowa State University Extension resource on determining when to replant is the Corn Planting Guide. If stands are extremely poor, replanting would be a good option; although, be aware that conditions can quickly change with several good days of weather.

5. Nodal roots system placement (rootless corn)
Corn that is placed into a wet seed furrow can have restricted root growth, resulting in "rootless" corn (also referred to as rootless corn syndrome) among other problems that will become apparent as the season unfolds. See Figure 2.
Rootless corn occurs in plants with poorly developed root systems and is usually observed in plants from about the three- to eight-leaf stage of development. During this time, corn exhibiting rootless symptoms have either lodged and are laying on the ground or are about to lodge. Sometimes the corn will only be anchored in the soil by a single nodal root or by seminal roots. Before the problem is evident, corn plants may appear vigorous and healthy but can fall over due to limited or no support later. Affected plants lack all or most nodal roots; existing nodal roots may appear stubby, blunt, and not anchored to the soil. Due to a lack of root mass, the affected plants can wilt, have stunted growth, or die in extreme conditions.

Although certain types of herbicide injury and insect feeding may cause lodging to occur in corn plants during vegetative development, generally there has been little evidence of their involvement in causing rootless corn. Nevertheless, there may be situations where insect feeding and/or growth regulator herbicides (e.g. 2,4-D and dicamba) appear to contribute to rootless corn problems. Wait to apply herbicides if significant portions of the field show this rootless syndrome.

Can rootless corn recover? Yes, after plants lodge, adequate rainfall will promote nodal root development and many plants can recover. Recovery is severely hampered if conditions are dry. Cultivation to move soil around exposed roots will aid the corn's recovery, yet this is extremely difficult if plants are laying on the ground or in a no-till situation.
6. Sidewall compaction

Many factors contribute to sidewall compaction. While wet soil is often given as the main reason, planting too shallow is the primary problem. In most conditions, corn seed should be planted 2 to 3 inches deep for proper root development. Most corn planters were designed for this planting depth, especially those with angled closing wheels. When you properly close the seed-vee, the sidewalls of the furrow should be fractured as the soil closes around the seed, eliminating the sidewalls and providing seed-to-soil contact.

Most sidewall compaction problems on wet soils occur when the press wheels are set with too much downpressure, overpacking the seeds into the soil. When planting shallow, this press wheel compaction is below the seeding depth, making it difficult for the seedling roots to penetrate the soil. ... Make sure that the planter is properly leveled, or even slightly tail down, for the angled closing wheels to have a pinching action to close the seed-vee.

Another contributor to sidewall compaction is the lack of soil structure in many tilled fields. Producers may put extra pressure on the closing devices to close the seed-vee when in wet conditions. Without soil structure, the standard closing wheels "pinch" the sidewalls closed over the seed, particularly in heavier soils. However, as the soil dries, it shrinks and the seed-vee may open back up, exposing the seeds. This often occurs when there is a hot, windy period after planting, drying out the seed zone and reducing the stand. This is less of a problem in higher organic matter soils and in continuous no-till soils with improved soil structure. … If there is a dry layer on top of the soil at planting time and good soil moisture at planting depth, don't use residue movers or furrow openers to remove the dry soil … Also, when possible, leave residue over the row to reduce drying of the soil and protect the seed zone from raindrop impact.

7. Planter speed impact on plant spacing variability and yield

How critical is plant to plant spacing for corn? And how does planter speed impact that spacing? Past research has shown plant spacing to have variable impact on yield. Some research shows that for every 1 inch in variation from the targeted spacing, yields were reduced 2.5 bushels per acre. Other researchers report even higher losses, while others report significantly less. National yield contest winners often state that slow planter speeds improve plant spacing uniformity and are part of their formula for success.

In 2001, fifteen Nebraska producers compared grain yields across different planter speeds. How would planter speed affect plant spacing uniformity? Each location had three to four replications of three planter speeds: 2, 4, and 6 mph. The same study was conducted in 2002 with faster planting speeds, 4, 5.5, and 7 mph.

Planter speed did not affect corn grain yield but it did affect plant spacing accuracy. Grain yields were excellent at all locations with averages around 200 bu/acre. Generally the faster speeds resulted in less accuracy than the slower speeds. This meant that there were more doubles and more skips with faster planting speeds.

8. Uneven corn heights & yield loss calculation tools

Uneven emergence and plant heights are caused by several factors, including variation in soil temperature, seeding depth, residue distribution, soil crusting, and soil moisture (as mentioned above). How much can plant height vary before it causes a real yield loss?
In general, non-uniform stands result in lower yields because the smaller, late-emerging plants cannot capture enough sunlight. Unfortunately, the yield loss from the “late” plants is not made up by the “normal” plants.

Wisconsin and Illinois researchers concluded that even though late-emerging plants reduce yield, replanting would not increase yield potential unless more than half of the plants were delayed by three weeks or more. Although most producers will not need to replant fields due to variable heights and unevenness it does not negate the effect that will have on yield. A two-leaf differential between neighboring plants can reduce yields by approximately 5%.

9. **Plant density**

Seeding rates were evaluated across 10 locations in Iowa for the last two years. Seeding rates ranged from 25,000 to 45,000 seeds per acre. In 2006, optimum seeding rate, averaged across all locations, was approximately 35,000 seeds per acre. Yield at four of the 10 locations significantly dropped off past 30,000 or 35,000 seeds per acre though, whereas six of the 10 locations obtained highest yields with 35,000 to 45,000 seeds per acre. It is interesting to note that there were 200-bushel yields in both of these groupings. Early-season vegetative growth (items that we are addressing in this list of factors) and conditions surrounding pollination no doubt were factors influencing which seeding rates were best.

**Resources associated with each category**


Management/environmental factors

1. [http://www.extension.iastate.edu/Publications/PM1885.pdf](http://www.extension.iastate.edu/Publications/PM1885.pdf)