Stress Emergence in Corn

The early season seedbed can be an inhospitable environment for corn seeds and seedlings. As planting dates have moved earlier, the potential for cold, wet conditions after planting has increased. When unfavorable weather persists in the spring, planted corn may be exposed to cold, saturated soil conditions for three weeks or longer before emerging.

Two recent trends, early planting and reduced tillage, have introduced early season cold stress into areas not usually affected by this problem. Even in southern and western regions of the US, corn grown in these production systems can experience similar stress levels to those of colder northern regions. Although there are many advantages to reduced tillage, the level of early season stress has increased along with its adoption. This is due primarily to lower soil temperatures, water retained in crop residue, and slower seedbed drying. Corn grown under irrigation can also experience significant stress if the irrigation water is sufficiently cold.

Although corn, with its tropical origins, displays a general sensitivity to early season stress, research has shown that hybrids differ in their ability to emerge in stress environments. This genetic variation is reflected in the DuPont Pioneer stress emergence rating, which is applied to all Pioneer® brand hybrids to help customers select appropriate products for cold-stress fields. This article discusses key factors that impact early season performance and stress emergence ratings.

Impact of Cold Stress on Stand Establishment

The optimal temperature for corn emergence is in the range of 80 to 90ºF. Emergence is greatly reduced at lower temperatures and is effectively halted around 50 to 55ºF or below. Since soil temperatures in the early season are almost never optimal, emerging seeds will experience a degree of stress almost everywhere in North America. The degree of stress and potential damage from stress is determined, to a large extent, by soil and water temperatures during imbibition and seedling emergence.

For successful emergence to occur, all parts of the shoot (roots, mesocotyl, coleoptile and leaf within) must work in a coordinated way to push the coleoptile above the soil surface and allow the first leaf to unfurl. Damage to any one of these structures will likely result in loss of the seedling and its yield potential. The section below describes some of the common causal events.

The Critical First Hours: When the dry seed imbibes cold water (typically 50ºF or below), imbibitional chilling injury may result. The degree of damage ranges from seed death to abnormalities such as corkscrews or fused coleoptiles (Figures 1 and 2). The potential for cold-water damage generally decreases as the seedlings emerge. It also decreases if the initial imbibition takes place at temperatures above 50ºF. This may help explain observations where early planted corn that was followed by favorable weather emerged better than corn planted later and followed by a cold spell or snow cover.

Damage to the emerging root usually has less severe consequences on seedling survival. This is because the primary root, which is the first structure to emerge, plays a relatively minor role in seedling establishment compared to the lateral and nodal roots. Seedling establishment can usually progress normally if the lateral and nodal roots are intact. Any damage to the roots, however, will likely reduce vigor and increase the potential for disease and insect injury (see sections on disease and insect effects). It is important to note that cold damage to emergence is generally irreversible. It is also difficult to diagnose since it usually occurs below the soil surface, long before the crop emerges. Above-ground symptoms of damage may take weeks to become apparent.

Figure 1. Abnormal mesocotyl and coleoptile development due to prolonged cold stress in an early planted Illinois field.

Figure 2. Common symptoms of cold damage during imbibition and seedling emergence.

Stress Emergence Ratings

Pioneer's stress emergence rating helps categorize hybrids for their genetic potential to emerge under stressful environmental conditions (including cold, wet soils or short periods of severe low temperatures) relative to other Pioneer hybrids. Stress emergence ratings are assigned on a 1 to 9 scale. Ratings of 6 to 9 indicate above-average potential to establish normal stands under such conditions; a rating of 5 indicates average potential to establish normal stands under stress conditions; and ratings of 1 to 4 indicate below-average potential to establish normal stands under stress. These definitions are intended as a general guideline; growers should take into consideration specific field conditions in making hybrid decisions.

Stress emergence is an agronomic rating and is not a rating for seedling disease susceptibility. Also, stress emergence should not be confused with early growth ratings, which refer to seedling vigor after emergence. It should be noted that the level of early season stress tolerance is limited in corn. Thus, even hybrids with strong stress emergence will experience some level of injury and stand loss if the conditions are sufficiently severe.

Stress Emergence Testing at DuPont Pioneer

To generate stress emergence ratings, DuPont Pioneer tests hybrids over multiple years and environments beginning several years before commercialization. The goal is to test under many different types of early season stress before assigning ratings. Hybrids are tested in several early planted field sites across North America including no-till, corn-on-corn locations. Testing sites in the US are located in MN, WI, IA, NE, SD, ND, MI, IN, IL and other states. Testing sites in Canada are located in Quebec and Manitoba.

Testing sites are chosen to reflect the various seedbed and environmental conditions likely to be experienced by growers. These testing sites, with their diverse and unique conditions, provide a more thorough understanding of hybrid responses to early season stress. A typical testing site is characterized by large amounts of residue, cold soil (below 50ºF) at planting followed by cold rain or snow, and emergence usually requiring three to four weeks.

Hybrids are also tested in DuPont Pioneer lab assays that simulate stressful field conditions. These tests, validated by multi-year field trials, provide consistent and reproducible test conditions coupled with the flexibility of year-round testing. These lab assays are used to support hybrid advancement decisions and also to support breeding efforts to improve early season stress tolerance through maker-assisted selection.

Seedling Disease and Stress Emergence

Stress emergence is an agronomic trait intended to reflect genetic variability for tolerance to **abiotic stress** in the early season. It is not a rating for disease resistance. Early season stress can promote seedling disease if certain conditions are met, including inoculum presence and prolonged cool, wet conditions. Injury to emerging seedlings will also promote seedling disease. Injury can be caused by chilling, such as imbibitional damage, or by feeding of insects such as seedcorn maggots, white grubs and wireworms.

In environments with heavy inoculum pressure, disease progression is often in a race with seedling growth. Conditions that promote rapid soil warming will generally favor seedling growth and reduce disease incidence. On the other hand, extended cool, wet conditions will generally favor disease progression (Figure 3). Many soil pathogens, including some Pythium species, are most active at temperatures in the 40s and 50s (ºF). Low temperatures such as these can injure emerging seedlings and facilitate infection. Low temperatures also retard stand establishment and increase the window of vulnerability to infection. Seed treatment fungicides generally provide good efficacy against target organisms for 10 to 14 days after planting. However, protection will be diminished if emergence and stand establishment are delayed beyond this period.

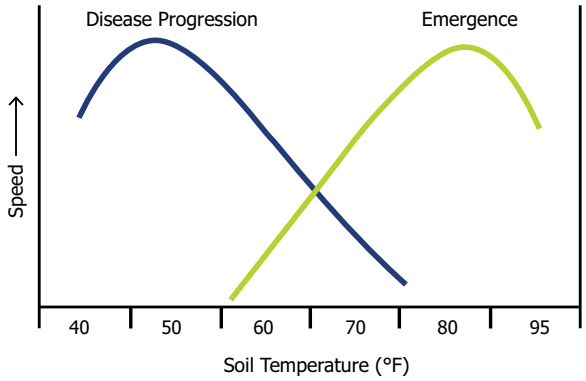

Figure 3. Theoretical responses of disease progression and seedling emergence to soil temperature.

Seed Treatments and Stress Emergence

Seed treatments can help protect stands from both disease and insect pests in stressful environments.

Pioneer Premium Seed Treatment: PPST 250 is the standard treatment package for all Pioneer® brand corn products for the 2013 planting season. It consists of a fungicide, insecticide and biological. The fungicide component of PPST 250 includes a four-way fungicide formulation that, according to the manufacturer, provides a new standard for broad-spectrum protection against seed and seedling diseases, including Fusarium and Pythium. The insecticide component offers proven insect protection to enhance early season plant health. The biological component helps promote early-season plant growth and increases nutrient uptake and yield.

Poncho® 1250 + VOTiVO® Seed Treatment: Growers can also choose Poncho® 1250 + VOTiVO® seed treatment on selected Pioneer hybrids where nematode or enhanced insect protection is needed. According to Bayer, growers get increased protection from wireworm, black cutworm, white grub and other early-season pests and protection from corn rootworm and billbug with the 1250 rate of Poncho. In addition, this treatment provides a biological mode of action to protect corn seedlings and roots against nematodes.

Conclusion: Choosing hybrids with strong stress emergence helps reduce genetic vulnerability to stress, and planting seeds with a premium seed treatment helps provide critical protection in stressful environments where seeds are vulnerable to attack, as demonstrated below.

Figure 4. Corn seedlings emerging in a high-residue, early-planted field.