Several factors can work together to result in corn leafing out prior to emergence. Other terms for leafing out include unfurling, corkscrew, or twisted mesocotyl. Understanding what the most likely cause was, can potentially help in future situations.

Emerging vs. Leafing Out

Emergence. Visual signs of germination include swelling of the seed, elongation of the radical, then growth of the coleoptile. Roots grow down and the shoots (the coleoptile and mesocotyl) grow up due to geotropism, which is plant growth in response to gravity (Figure 1). The coleoptile is a shield that protects the contained leaves as the shoot is pushed through the soil due to elongation of the mesocotyl, which is the white internode tissue between the seed and the coleoptile (Figure 1). When the coleoptile senses red wavelength light, hormones sent from the coleoptile to the mesocotyl are altered, halting growth of the mesocotyl. The coleoptile normally senses light approximately 3/4 inch below the surface, where the nodal roots form. The processes of germination and emergence are highly dependent upon several types of plant hormones. One type thought to be instrumental in geotropism is auxins. Auxins are similar to the synthetic plant hormones in herbicides, such as 2,4-D, and cause cell elongation. Hormones can be greatly affected by temperature and other environmental conditions.

Leafing Out. If the coleoptile is damaged or mesocotyl has irregular growth prior to emergence, the leaves can break through the coleoptile (Figure 2). Without the protection from the intact coleoptile, it is very difficult for the leaves to penetrate the soil surface. Often, there are multiple factors that can contribute to problems with leafing out, including: chilling injury, soil compaction, soil crusting, planting depth, and saturated soil conditions.

Chilling or Cold Temperature Injury

Chilling injury can occur at different stages of germination and emergence. If kernels have adequate seed-to-soil moisture contact and imbibe cold water or experience cold temperatures in the 24 to 36 hours after planting, imbibitional chilling injury can occur, potentially resulting in failed germination and/or hindered growth of the radical or coleoptile. Chilling injury during the emergence process can result in corkscrewed mesocotyls and/or leafing out below the soil surface. Environmental conditions that favor chilling injury include extended exposure to soil temperatures under 50°F, and/or large swings (25° to 30°F) in daily soil temperatures. Planting in dry soil conditions can result in inadequate seed-to-soil moisture contact within the seed furrow. These conditions can amplify the differences in emergence between seedlings. Planting deeper is often needed in dry soil conditions to reach soil moisture. However, planting deeper can increase leafing out underground as the length of time from germination to emergence is often greater, increasing the chances for coleoptile and/or mesocotyl damage.

Symptoms of chilling injury can also be caused by other factors and may be compounded by additional stresses during germination. These stresses may include herbicide injury, disease, or soil crusting. Since symptoms are not unique to chilling injury, they can be hard to decipher.

Other Causes of Leafing Out

Soil Compaction and Sidewall Compaction. Physical resistance from compaction, including sidewall compaction, can result in coleoptile damage or inadequate elongation of the mesocotyl.

Soil Crusting. As wet soils dry, a crust layer can form on the soil surface, potentially delaying or preventing seedling emergence. Crusting may be more common in fields with fine textured soils, low organic matter, and little surface residue, especially where excessive tillage has taken place. A rotary hoe can break up the crust and aid seedling emergence. Timing is essential and breaking the crust as soon as possible is most beneficial. If seeds

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### Germination Tests: A Few Basic Principles

**Warm Germination Test.** A standardized Warm Germination Test was established by the Association of Official Seed Analysts (AOSA). The Federal Seed Act requires seed companies to report these Warm Germination Scores for all seed lots. Since all seed is tested using the same standardized testing procedures, a 96% Warm Germination Score means the same thing, regardless of which company, lab, or seed regulatory agency conducted the test.

**Cold Germination Test.** Contrastingly, Cold Germination or “Vigor” tests are not required for compliance with state and federal seed law; nor is there a standardized test across the seed industry. Many companies, universities, and independent seed testing labs have developed and implemented various forms of Cold Germination tests to help establish and differentiate the quality of their seed beyond the legal testing requirements. Monsanto has developed and deployed a proprietary, internal vigor (Cold Germination) test in an effort to better predict emergence potential across environments. The results of this test are used internally as an integral part of the quality management system to help provide only the highest quality seed to our customers. This information is not shared outside of the quality review team, as the scores generated by the test are ultimately irrelevant in the context of other tests. For example, an 85% test result from the proprietary test Monsanto utilizes may be an equivalent or better indication of stress emergence compared to a 90% test result from a different, less rigorous test. Unfortunately, even if all of the variables were fully understood for each testing procedure, making a comparison of results across the tests could be misleading since it would be based on making various assumptions. The bottom line - there is no way to know the actual difference between Cold Germination scores from various testing sources in the absence of an industry standard. Similar to a Cold Germination test, there is not a procedure standardized across the industry for “Saturated Cold Germination” tests. Therefore, testing procedures and test results are likely to vary by lab.

Monsanto has a great deal of confidence in the Cold Germination test utilized internally. The validity of this test has been proven across millions of acres for numerous seasons. That being said, germination scores are only indicators of potential and not absolute measures of performance. They are the best indicators available to predict the experience a grower will ultimately have when seed is planted; however, they are not perfect and there will always be exceptions. Monsanto takes seed quality very seriously and strives to deliver the most consistent, highest quality seed a farmer can buy.

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**Are not infected with disease, cooler soils will allow seedlings to survive longer when trying to break through the crust.**

**Herbicide Injury.** Cool and stressful conditions can increase the risk for herbicide injury, particularly from herbicides such as 2,4-D. Risk of leafing out from herbicide injury would likely be more evident in overlapped areas.

**Cloddy or Sandy Soils.** If the coleoptile senses light the mesocotyl is signaled to stop elongating. This normally occurs when the mesocotyl is approximately 3/4 inch below the soil surface. Cloddy or sandy soils can allow light to hit the coleoptile when the mesocotyl is more than 3/4 inch below the soil surface. The leaves continue to expand below the coleoptile causing it to rupture. The exposed leaves then struggle to penetrate through the soil for successful emergence (Figure 3).

### Effect of Seed Size on Emergence and Early Growth

**Effect of Endosperm Size in Different Field Conditions.** Minor differences in emergence can happen under adverse planting conditions. Large seed can have slightly decreased emergence rates in dry soil conditions as the amount of moisture needed for germination and emergence is relative to the size of the seed. Small seed can have slightly decreased emergence in cool or crusted soils, as the amount of energy needed in those situations may exceed the amount stored in the endosperm. It has also been reported that differences in early growth related to seed size are not apparent by tasseling or soon after1. Even with the potential effect on emergence and reduced early vigor, the effect of seed size on yield potential was not significant if harvest populations were similar2.

**Effect of Processing on Emergence and Vigor of Different Grade Sizes.** All Monsanto seed sold to our customers goes through cleaning, processing, and quality testing, which includes germination and vigor tests. While some seed sizes and shapes may be more susceptible to mechanical damage during cleaning and processing, the sample for germination and vigor tests is taken after all of the cleaning and processing is complete. All seed, regardless of grade, is subject to the same industry leading quality standards in place at Monsanto. The box to the left includes some basic principles of the germination testing.

### Sources


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**Figure 3. Cloddy soils can allow light to reach the coleoptile, hindering elongation of the mesocotyl, resulting in premature rupture of the coleoptile and leafing out below the soil surface.**

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Individual results may vary, and performance may vary from location to location and from year to year. This result may not be an indicator of results you may obtain as local growing, soil and weather conditions may vary. Growers should evaluate data from multiple locations and years whenever possible. ALWAYS READ AND FOLLOW PESTICIDE LABEL DIRECTIONS. Leaf Design℠ is a servicemark of Monsanto Company. ©2012 Monsanto Company. 05012012EJP