Stress & the Common Corn Plant

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Corn’s maximum yield occurs while it is still in the seed bag. Once the seed is planted in the ground, the crop’s yield potential is at risk from a wide array of biotic and abiotic stresses.

The effect of stress on yield is, ultimately, equal to the effects on the components that define grain yield. These yield components are plants per unit area (population or stand), ears per plant (degree of barrenness), kernels per ear (potential vs. actual), and weight per kernel. Number of kernels per ear can be further broken down into number of kernel rows per ear and number of kernels per row.

Stress can affect corn grain yield both directly and indirectly. Direct yield effects include such examples as outright plant death, interference with pollination, abortion due to cloudy weather, ear rots, and ear drop due to European corn borer damage. Indirect yield effects of stress include those that reduce the “factory” size (plant stunting), “factory” output (e.g., leaf diseases or hail damage), and harvestability of the crop (stalk lodging).

As with good comedy, timing means everything when it comes to determining the yield effects of stress in corn. Similar stresses occurring at different developmental crop stages can cause very different levels of crop damage. The earlier the stress, the more likely the crop can compensate. BUT, prolonged early stress may result in a crop less able to tolerate later occurring stresses.

The critical times for stress effects in corn can be described in terms of the stand establishment phase, the rapid growth phase, the pollination phase, and the grain filling phase. Because each phase involves varying physiological processes, the effects of stress on yield can be different.

The stand establishment phase occurs from the time the seed is planted until the plants are roughly knee-high or about leaf stage V6 (six visible leaf collars). Under ideal conditions, this phase should be complete by about five weeks after planting. Stresses that injure the kernel or mesocotyl before the permanent nodal roots are well established can easily kill or stunt young corn seedlings. Stress that affects the first few sets of nodal roots can also stunt corn seedlings before they are well established.

Rapid and uniform germination and emergence require adequate and uniform soil moisture, temperature and seed-to-soil contact; as well as pest-free conditions. Uniform emergence is important because delayed plants cannot compete with older, more established plants. At best, delayed emergers will contribute little to yield. Potential grain yield losses due to uneven emergence range from 8 to 20 percent depending on the magnitude of the emergence delay and percent of stand affected.

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Successful emergence (fast & uniform) does not guarantee successful stand establishment. The next crucial phase is establishment of a vigorous nodal root system. Success at this stage is largely dependent on the initial nodal root development from about the 2-leaf to 6-leaf stages of development. Until the nodal roots are established, seedlings depend primarily on the energy reserves of the kernel. These energy reserves are translocated from the kernel through the connecting mesocotyl ‘pipeline’ to the young stalk and leaf tissues. Therefore, a healthy kernel, seed roots, and mesocotyl are vital until nodal roots are well established.

At about leaf stage V5 (five visible leaf collars) the corn plant shifts from vegetative to reproductive modes and enters what is termed the rapid or “grand” growth phase. At that leaf stage, the tassel & final ear initiate at the apical and uppermost axillary meristems, respectively. The ear size determination period thus begins at about leaf stage V5 also. Prior to about V5, there is little effect of stress on ear size because the final ear has not yet been initiated. From about V5 to V15, however, severe stress can limit ear size potential.

The size of ‘factory’ will be largely determined during the rapid growth phase. Overall plant growth accelerates during this period and nutrient uptake skyrockets. Severe stresses during the rapid growth phase can greatly limit the ability of the corn crop to “take off”. Conditions prior to flowering determine the eventual size and efficiency of the photosynthetic ‘factory’. Conditions after flowering determine the actual output of that ‘factory’ during grain filling.

The critical pollination phase includes tassel & silk emergence and pollen shed. Severe stress during this period can have the greatest yield effects per day of stress. Normal plant-to-plant developmental variability within a field often results in 10 to 14 day duration of pollen shed. Unsuccessful pollination results in varying degrees of poor kernel set on the ears. Poor kernel set may be caused by persistent silk clipping by insects during pollen shed, silk delay from drought stress, silk dessication by heat & low humidity, ‘balling’ or ‘knotting up' inside the husk leaves due to cool weather, or herbicide injury to tassel or ear development.

The grain filling phase occurs from the end of pollination until the kernels become physiologically mature with visible kernel black layers. Yield losses during this phase can occur from stand losses, kernel abortion, lightweight kernels and premature plant death. The effect of stand loss during grain is more severe than earlier in the season because the crop can only compensate for missing plants by increasing kernel weight.

Kernels may abort early in the grain filling period due to stress that occurs from blister to the early milk stages of kernel development. The primary causes of kernel abortion or lightweight kernels are severe drought stress, heat stress, nutrient deficiency, leaf diseases, hail damage, European corn borer stalk tunneling, excessively warm nights during or shortly after pollination, and consecutive cloudy days shortly after successful pollination.

The severity of yield loss due to premature plant death depends on the timing and magnitude of death to the plant tissue. Yield losses will be less if only leaves are killed and greater if the whole plant dies prematurely because of the consequences to the plants’ abilities to remobilize stored carbohydrates from the stalk tissue to the immature ear. Once kernels are physiologically mature, they are safe from further effects of physiological stress.

A PDF-formatted version of the Microsoft™ Powerpoint™ presentation from which this summary was developed can be viewed on the Web at: http://www.agry.purdue.edu/ext/pdf/Stress & the Corn Plant_2002.pdf.