

What Happens Within The Corn Plant When Drought Occurs?

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Many areas of Wisconsin had reduced rain this summer and corn is showing signs of stress. Many are concerned about how this might affect corn yields. To begin talking about water influences on corn growth and development and yield we must begin with the concept of evapotranspiration.

Evapotranspiration is both the water lost from the soil surface through **evaporation** and the water used by a plant during **transpiration**. Soil evaporation is the major loss of water from the soil during early stages of growth. As corn leaf area increases, transpiration gradually becomes the major pathway through which water moves from the soil through the plant to the atmosphere.

Yield is reduced when evapotranspiration demand exceeds water supply from the soil at any time during the corn life cycle. Nutrient availability, uptake, and transport are impaired without sufficient water. Plants weakened by stress are also more susceptible to disease and insect damage. Corn responds to water stress by leaf rolling. Highly stressed plants will begin leaf rolling early in the day. Evapotranspiration demand of corn varies during its life cycle (Table 1). Evapotranspiration peaks around canopy closure. Estimates of peak evapotranspiration in corn range between 0.20 and 0.39 inches per day. Corn yield is most sensitive to water stress during flowering and pollination, followed by grain-filling, and finally vegetative growth stages.

Vegetative development

Water stress during vegetative development reduces stem and leaf cell expansion resulting in reduced plant height and less leaf area. Leaf number is generally not affected by water stress. Corn roots can grow between 5 and 8 feet deep, and soil can hold 1.5 to 2.5 inches of available soil water per foot of soil, depending upon soil texture. Ear size may be smaller. Kernel number (rows) is reduced. Early drought stress does not usually affect yield in Wisconsin through the V10-V12 stages. Beyond these stages water stress begins to have an increasing effect on corn yield.

Pollination

Water stress around flowering and pollination delays silking, reduces silk elongation, and inhibits embryo development after pollination. Moisture stress during this time reduces corn grain yield 3-8% for each day of stress (Table 1). Moisture or heat stress interferes with synchronization between pollen shed and silk emergence. Drought stress may delay silk emergence until pollen shed is nearly or completely finished. During periods of high temperatures, low relative humidity, and inadequate soil moisture level, exposed silks may desiccate and become non-receptive to pollen germination.

To assess the success or failure of pollination, two methods are commonly used: counting attached silks and counting developing ovules. Each potential kernel on the ear has a silk attached to it. Once a pollen grain "lands" on an individual silk, it quickly germinates and produces a pollen tube that grows the length of the silk to fertilize the ovule in 12 to 28 hours. Within 1 to 3 days after a silk is pollinated and if fertilization of the ovule is successful, the silk will detach from the developing kernel. Unfertilized ovules will still have attached silks. By carefully unwrapping the husk leaves from an ear and then gently shaking the ear, the silks from the fertilized ovules will readily drop off. Developing ovules (kernels) appear as watery blisters (the "blister" stage of kernel development) about 10 to 14 days after fertilization of the ovules. The proportion of fertilized ovules (future kernels) on an ear indicates the progress and success of pollination.

Silk elongation begins near the butt of the ear and progresses up toward the tip. The tip silks are typically the last to emerge from the husk leaves. If ears are unusually long (many kernels per row), the final silks from the tip of the ear may emerge after all the pollen has been shed.

Another cause of incomplete kernel set is abortion of fertilized ovules. Aborted kernels are distinguished from unfertilized ovules in that aborted kernels had actually begun development. Aborted kernels will be shrunken and mostly white.

Kernel development (grain-filling)

Water stress during grain-filling increases leaf dying, shortens the grain-filling period, increases lodging and lowers kernel weight. Water stress during grain-filling reduces yield 2.5 to 5.8% with each day of stress (Table 1). Kernels are most susceptible to abortion during the first 2 weeks following pollination, particularly kernels near the tip of the ear. Tip kernels are generally last to be fertilized, less vigorous than the rest, and are most susceptible to abortion. Once kernels have reached the dough stage of development, further yield losses will occur mainly from reductions in kernel dry weight accumulation.

Severe drought stress that continues into the early stages of kernel development (blister and milk stages) can easily abort developing kernels. Severe stress during dough and dent stages of grain fill decreases grain yield primarily due to decreased kernel weights and is often caused by premature black layer formation in the kernels. Once grain has reached physiological maturity, stress will have no further physiological effect on final yield (Table 1). Stalk and ear rots, however, can continue to develop after corn has reached physiological maturity and indirectly reduce grain yield through plant lodging. Stalk rots are seen more often when ears have high kernel numbers and have been predisposed to stress, especially drought stress.

Premature Plant Death

Premature death of leaves results in yield losses because the photosynthetic 'factory' output is greatly reduced. The plant may remobilize stored carbohydrates from the leaves or stalk tissue to the developing ears, but yield potential will still be lost. Death of all plant tissue prevents any further remobilization of stored carbohydrates to the developing ear. Whole plant death that occurs before normal black layer formation will cause premature black layer development, resulting in incomplete grain fill and lightweight, chaffy grain. Grain moisture will be greater than 35%, requiring substantial field dry down before harvest.

Table 1 - Estimated corn evapotranspiration and yield loss per stress day during various stages of growth.

Growth Stage	Evapotranspiration inches per day	Percent yield loss per day of stress (min-ave-max)
Seedling to 4 leaf	0.06	---
4 leaf to 8 leaf	0.10	---
8 leaf to 12 leaf	0.18	---
12 leaf to 16 leaf	0.21	2.1 - 3.0 - 3.7
16 leaf to tasseling	0.33	2.5 - 3.2 - 4.0
Pollination (R1)	0.33	3.0 - 6.8 - 8.0
Blister (R2)	0.33	3.0 - 4.2 - 6.0
Milk (F3)	0.26	3.0 - 4.2 - 5.8
Dough (R4)	0.26	3.0 - 4.0 - 5.0
Dent (R5)	0.26	2.5 - 3.0 - 4.0
Maturity (F6)	0.23	0.0

Derived from Rhoads and Bennett (1990) and Shaw (1988)