Soybean and Corn Pod and Grain Fill During Drought Stress

- Soybean yield potential is most at risk from drought stress from the 2nd to the 4th week of seed fill[1]; soybean flowering stops and plants cannot compensate for lost pods when drought occurs during the full pod through full seed.
- Pollination and fertilization is a very important phase of corn development; heat and drought stress during this time can result in decreased yield potential.
- Yield loss during corn grain fill may be 3.0 to 5.8 percent per day of stress.[2]

Soybean: Drought Impacts

Soybean plants can produce flowers over a wider window of time, compared to corn, thus plants can typically withstand drought stress reasonably well. However, plants are most sensitive to intense and prolonged stress during the flowering and early pod fill growth stages. Drought stress can cause floral abortion, reduced pod number, fewer seeds per pod, and reduced seed size. A moderate drought stress can significantly reduce or irreversibly stop nitrogen fixation, disrupting seed development.[6] Drought stress during R4 through R6 (full pod through full seed) can have a devastating effect on yield potential because flowering stops and plants cannot compensate for lost pods.[5] Table 1 shows that from the second through the fourth week of seed fill a 39 to 45 percent yield decrease can occur when there are four days of visible moisture stress.[1]

Heat Impacts

It can be difficult to separate effects of high temperature from the effects of water stress on soybean plants. Often these stresses occur together and magnify the effects of each other. Extension Soybean Specialist Jim Dunphy, North Carolina State University, indicated that "when temperatures get above about 95° F, soybean plants simply cannot pump enough water to keep up with transpiration and evaporation. The plants close the stomata in their leaves and water cannot get out. That also means carbon dioxide (CO_2) can't get in and plants can no longer get the carbon they use to make the sugars that fuel everything that goes on inside the plant."

Managing Stressed Soybean Plants

If soybean leaves begin to curl or drop, it is time to decide whether to leave the plants in the field and hope for the best or cut them for hay. This decision depends on the stage of growth and condition of the plant.[11] Plants with 30 percent of the leaves still attached, may be considered for hay. These plants can produce 0.75 to 1.25 tons dry matter per acre with 13 percent protein and 48 percent in-vitro dry matter digestibility.[11] If adequate rainfall occurs and photosynthate is available after R5, the plant may compensate for earlier losses by producing larger seeds (within its genetic capacity).[5] Once the plant reaches R6, pods are not normally aborted. Managing stress from insect, disease, or nutrient sources can also help reduce the overall stress load on the plant and potentially limit yield losses.

Table 1. Effect of 4 Days of Visible Moisture Stress on Soybean Yield.

Soybean Stage of Development	Yield Decrease (%)
1st week of flowering	8
1st week pod development (2nd week of flowering)	19
1st week of seed filling (3rd week pod development, 4th week of flowering)	36
2nd to 4th week of seed filling	39-45
5th week of seed filling	12

Source: [1] Wright, J., et al.

Corn: Drought Impacts

Stand loss, incomplete kernel set, reduced kernel weight, and premature plant death can potentially reduce yield.[10] Moisture stress during corn grain fill increases the chance for leaves to die and plants to lodge, while reducing kernel weight and the time period for grain fill. Corn is most sensitive to drought stress during the pollination process; however, yield loss during grain fill may still be 3.0 to 5.8 percent per day of stress.[2] Kernel abortion and reduced dry weight accumulation in the kernels can occur after pollination. Developing kernels, especially those near the tip of the ear, can be prone to abortion if temperatures are high and moisture is limited during the two weeks following pollination.

Cell division that occurs in the endosperm, during the first seven to ten days after pollination, can determine the potential number of cells that accumulate starch.[2] Dry weight accumulation is the yield component that is affected after the kernels have reached the dough stage.

Soybean and Corn Pod and Grain Fill During Drought Stress

Severe stress that causes premature death of leaves can result in yield losses because photosynthate is greatly reduced. Limited amounts of photosynthate to nourish the developing kernels can cause kernels to be smaller and lighter, or "shallow kernels". Additionally, severe stress during the grain fill period can cause premature kernel black layer formation, which can also reduce grain fill because further kernel development is terminated.

Heat Impacts

Even with sufficient moisture, high temperatures can cause a high degree of stress on the plant. Both high day and night temperatures can have an effect on corn yield potential. Iowa State University reports a one percent corn yield loss can occur after four consecutive days of temperatures at 93° F or greater.[3] On the fifth day of these high temperatures, another two percent yield loss can occur, and on the sixth day another four percent can be expected. A heat wave that lasts longer than six days often results in firing of leaves and lower yield potential is expected, especially when the heat wave coincides with silking.

High temperatures stimulate respiration, and sugars that could have been stored in grain are burned up. This can be especially true when nighttime temperatures remain high and sugars are being used while no photosynthesis takes place. Thus, high nighttime temperatures can reduce yield without plants showing visible signs of stress on plants.[7] High humidity can compound problems from high daytime temperatures by slowing temperature cool down that occurs in the evening.

Managing Stressed Corn Plants

Future management decisions should be made based on the success of pollination (Figure 1). If kernel set is good, the crop has some potential to produce grain. However, if potential yield is less than 25 bushels per acre, harvesting for silage/hay may be the best option.[4]

Figure 1. Poor pollination due to drought stress.

Corn for silage is preferred over hay, and plants should have 65 to 75 percent moisture.

Fields that are drought stressed to the point plants have lost some bottom leaves, and the top leaves have browned off or turned white may be candidates for chopping or haying the crop. However, plants that do not grow normally can have high nitrate levels, especially in the lower portion of the stalk. Haying high nitrate corn will not reduce the level of nitrates, and cutting height should be at least six to eight inches above the ground to help avoid nitrate toxicity.

It is strongly recommended that the hay be tested for nitrates before feeding. The level of nitrates in corn can be estimated by a test kit purchased on the internet or from Extension offices. Samples can be taken before harvest or in the corn after ensiling.[8] Additional samples can be sent to a lab for further analysis, if kit results indicate high levels of nitrate.

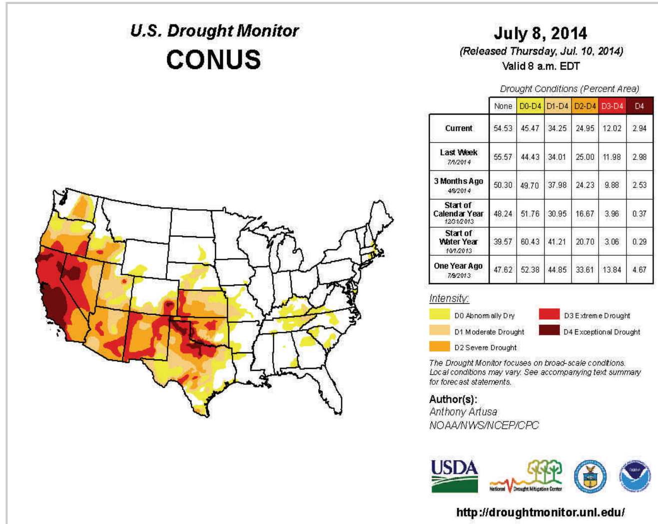

Figure 2. The U.S. Drought Monitor is a partnership between the National Drought Mitigation Center, United States Department of Agriculture, and National Oceanic and Atmospheric Administration. Map courtesy of NDMC-UNL.[9]

Summary

Soybean. Floral abortion, reduced pod number, and fewer seeds are the result of drought stress on soybean plants during flowering and early pod fill. A management decision should be made when leaves start to curl and defoliate but based on the condition and growth stage of the stressed plants.

Corn. Reduction in photosyntahtes during drought stress can lead to smaller kernels. Stressed corn plants should be managed according on the success of pollination; if kernel set is good, plants may have some potential to produce grain. If potential yield is less than 25 bushels per acre, plants should be harvested for silage/hay; however, stressed plants should be cut at more than six inches above the ground to avoid nitrate toxicity.

Sources:

[1] Wright, J., et al. 2006. Predicting the last irrigation for corn and soybeans in Central Minnesota. University of Minnesota, Minnesota Crop eNews; [2] Lauer, J. 2006. Concerns about drought as corn pollination begins. Field Crops 28.493—42; [3] Elmore, R. and E. Taylor. 2011. Corn and "a big long heat wave on the way". Iowa State University. www.extension.iastate.edu (verified 7/5/2014); [4] 2011. Crunch time for Kansas corn crop. The Pratt Tribune. ww.pratttribune.com (verified 7/5/2014); [5] Hall, R.C. and E.K. Twidwell. 2002. Effects of drought stress on soybean production. South Dakota State University. ExEx8034; [6] Lenssen, A. 2012. Soybean response to drought. Iowa State University. www.extension.iastate.edu (verified 7/5/2014); [7] Wiebold, W.J. 2012. None like it hot. University of Missouri. http://ipm.missouri.edu (verified 7/6/2014); [8] Wright, D.L. and H.E. Jowers. Using drought-stressed corn for silage, hay, or grazing. University of Florida. Publication #SS-AGR-274; [9] U.S. Drought Monitor. July 6, 2014. http://droughtmonitor.unl.edu (verified 7/6/2012); [10] Nielsen, R.L. 2013. Effects of Stress during grain filling in corn, Purdue University. http://www.agry.purdue.edu (verified 7/6/2014); [11]Roozeboom, K. 2011. Drought –stressed soybeans means decisions for producers. Kansas State University. http://www.ksre.ksu.edu (verified 7/5/2014).