IOWA STATE UNIVERSITY
Extension and Outreach

Soybean Response to Drought

Severe drought is a serious, albeit infrequent, stressor affecting Iowa soybean production. Severe statewide drought in Iowa has occurred in 1956, 1988, and 2012. However, soil water deficits caused by brief periods of low rainfall occur more frequently and can occur more than once during the growing season. During these periods soybean can experience drought-like conditions when available soil water becomes short. Soybean appears to be somewhat resilient to brief periods of drought, or water deficit, but the timing, duration, and severity of the stress plays a major role in determining the impact on yield. Soybean is most susceptible to water deficits during germination and the reproductive growth stages.

The soybean seed needs to imbibe 50 percent of its weight in water to germinate and begin to elongate the radicle and hypocotyl. Once plant growth begins, plant tissues consist of about 90 percent water. Water plays an important role in plant developmental and respiratory systems, helps regulate leaf temperature, and carries nutrients and sugars to key metabolic systems.

Soybean can respond to a water deficit as early as two days after germination (20). Laboratory experiments showed that hypocotyl elongation was progressively inhibited as available soil water decreased while root elongation was unaffected. As plants age, the response to a water deficit is similar. In fact, there have been several reports that show continued root growth after soil water deficits slow or stop shoot growth in several crops (7,10,15,18). This response to drought stress enables the roots to grow deeper into the soil profile to access additional available soil water.

Soybean wilting in response to drought.

Short term, moderate water deficits during vegetative growth stages generally do not impact soybean yield. Shoot growth rate reduction during short-term drought can be followed by compensatory growth during periods of rainfall (5). However, severe and/or long-term water deficits can cause irreversible dehydration of vegetative tissue resulting in low grain yield or plant death.

Soybean yield is most sensitive to water deficits during the pod filling stage of development (19). A reduction in pod number, as much as 20 percent, as a result of flower abortion, is often reported as being highly affected by soil water deficits (1,17). Seeds per pod and seed size are also impacted (2) but to a lesser extent than pod number. Stressed plants often mature earlier, shortening the grain filling period causing reduced seed weight and yield (17).

ROOT RESPONSE TO WATER DEFICITS

More than 76 percent of soybean roots grow in the top 16 inches of soil with more than 50 percent growing in the top eight inches (6). Soybean rooting depth has been measured at 4.9 to 6.5 feet under normal field conditions (9,12,20). Under ideal conditions, soybean roots can grow downward at a rate of 0.5 inches per day from planting to R1 (beginning bloom) (3) and 2.3 inches per day from R1 to R3 (beginning pod) (9). Downward growth continues through growth stages R5 to R6 (seed fill) under normal field conditions. However, downward growth after R5 appears to be variety specific (9).

Soybean roots in the upper soil profile grow slowly under water deficit conditions. Soybean compensates by partitioning photosynthates to roots to enable them to grow more rapidly in the lower soil profile (4,12). The increased root growth rate appears to coincide with water-deficits encountered three to five days previously (6). Growth rates of water stressed plants return to normal when soil water levels return to normal.

KEY POINTS

- Moderate water deficits during vegetative growth stages generally do not impact yield.
- Soybean yield loss from water deficits is caused by a reduction in flower number, pod number, and seed fill. Yield loss can also occur from reduced N fixation by nodules.
- Management practices that leave low amounts of residue on the soil surface and increase water runoff can increase soil water deficits.
- Adopting production practices that reduce soil compaction and promote increased water infiltration rate can improve yield when drought conditions occur.

IMPACT ON NITROGEN FIXATION

Water deficits reduce symbiotic nitrogen fixation of soybean roots. Biological N fixation accounts for 25 to 75 percent of the annual N uptake for the soybean crop (21) and is essential to producing high yielding soybeans. A decline in nitrogen fixation causes yield reduction by restricting nitrogen (N) used for protein production, which is critical for seed fill. The decrease in N fixation during water deficits is associated with limited water (11) and oxygen supply to the nodules, a decrease in rhizobia (13), and nodule carbon shortage (8). Oxygen limitation is not the sole factor in reducing nitrogen fixation and seems to be involved only in the initial stages of water-deficit related stress in decreasing nodule activity (14).

SUMMARY

Soybean appears to be somewhat resilient to brief periods of drought, or water deficit, but the timing, duration, and severity of the stress plays a major role in determining the impact on yield. Soybean is most susceptible to water deficits during germination and the reproductive growth stages.

Soybean yield loss from water deficits is caused by a reduction in flower number, pod number, and seed fill during the reproductive stages of growth. Yield loss can also occur from reduced N fixation by nodules.

Management practices that leave high amounts of residue on the soil surface and improve soil structure can increase can increase water infiltration rate and increase soybean yield. Adopting production practices that reduce soil compaction also can improve soybean yield when drought conditions occur by improving root growth and nodule function.

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