SDSU Extension

iGrow Soybean

BEST MANAGEMENT PRACTICES

Chapter 52: Producing High Soybeans, Corn, and Wheat Yields In A Water-stressed Environment

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In most years, South Dakota crops are never more than two weeks a way from a drought. Planning for a drought is a continuous process and involves planting at an appropriate date, careful management of your soil nutrients, managing pests, and using a tillage system that reduces evaporation (Table 52.1 and Fig. 52.1). In drought planning, it is imperative to select the correct maturity group for your area and select genetics that include stress tolerance traits (e.g., iron chlorosis, root knot nematode). The purpose of this chapter is to discuss techniques that can be used to reduce your drought risk. Selected tips for pre-plant management of water stress are available in Table 52.1.

Table 52.1. Tips for increasing drought tolerance resistance.

1. There is no-magic bullet that overcomes drought.
2. Use rotations and tillage systems that increase water storage and increase soil organic matter, which helps conserve water.
3. Do not harvest crop residues.
4. Apply sufficient rates of P and K fertilizer.
5. Control pests.
6. Optimize the planting date that minimizes the chance of early frost damage, but maximizes season length.
7. Use a realistic yield goal to match seeding rates and fields.
8. Select the cultivar with the proper maturity, for your area,that has drought tolerance and pest resistance.
9. In dry soil, consider seeding deeper.
10. Consider using an innovative seeding strategy.

Figure 52.1. Drought affected soybean crop. (http://corn.osu.edu/newsletters/2012/2012-21/symptoms-and-effects-of-water-stress-on-soybean-production, Ohio State Extension)

Water stress impact on crop growth

In many South Dakota fields, the most limiting factor for plant growth and high yields is water. Understanding water stress impacts on crop growth and development is the first step toward creating a resilient system. Plants have predictable responses to water stress, and when soybean plants are stressed they slow growth and abort flowers and pods. Under extreme drought, the plant will drop leaves to save water.

Under drought conditions, less water is available for the plants to use, which causes the plant to close its stomata and wilt. When the stomata are closed, atmospheric CO_2 which is needed for photosynthesis, no longer enters the plant. This first limits, and then finally stops, the plants ability to convert CO_2 into stored chemical energy.

Research conducted over the past several years in corn shows that in response to water stress corn plants up-regulate their genes associated with managing water stress, and down-regulate their genes associated nutrient uptake and disease and insect management. Soybean plants likely have similar responses. These results suggest that under water-stressed conditions, management of soil nutrients and pests is crucial.

Saving soil water through reduced tillage

The amount of water available for the plant depends on the soil depth, soil quality, the amount of plant-available water in the soil, and management. Over the past 25 years, many producers have changed from the moldboard plow to the no-tillage system. No-tillage, when compared to a moldboard plow system, increases snow catch and water infiltration, and reduces runoff and evaporation from the soil surface (Triplett and Dick, 2008). In addition, no-till reduces erosion and reduces the risk of detached soil particles forming impermeable crusts or seals, and decrease erosion.

Soil moisture leaves the soil profile through evaporation, transpiration, and leaching. Transpiration represents the water that is used by the plant. Evaporation is water lost from the soil surface (not through the plant). Water lost through evaporation does not contribute to higher yields. Water-use efficiency (grain produced/inch water) can be increased by reducing evaporation, thus increasing the amount of water available for transpiration. This can be accomplished by reducing the tillage intensity and leaving residue on the soil surface. For example, Hatfield et al. (2000) reported that evaporation following cultivation in Iowa was four to five inches over a three-day period, while evaporative water losses in no-tillage was less than one inch.

Reduced evaporation is attributed to crop residues that remain on the soil surface (Klocke et al., 2009) and increased reflection of the sun's energy back into the atmosphere. The resulting impact on plant available water and yields can be significant. One inch of stored (saved) water can increase corn yield 8 to 14 bushels. http://www.ag.ndsu.edu/pubs/plantsci/rowcrops/a1130-8.htm

Soil water-holding capacity

Not all water contained in soil is available to the plant. A portion of the soil water is bound to the soil particles and will never be available to plants. As the soil moisture content increases, pores are filled with water. A portion of this water is available to the growing plant. Based on the amount of energy required to extract the water it can be categorized into three categories: **gravitational water, plant-available water,** and **non-available water**.

Gravitational water is the amount of water lost between the point when all of the pores are filled with water (saturated conditions) and the water content when free drainage stops (between -0.1 and -1/3 bars). When free drainage stops, the soil is at field capacity. Plant-available water is the difference in the water contained in the soil at field capacity and the point when the plant permanently wilts (-15 bars). Gravitational water can be removed through tile drainage, while plant-available water is not removed by tile drainage.

The ability of soil to store **plant-available water** is related to its soil organic matter content and texture. Generally, available water increases with soil organic matter content and amount of silt contained in the soil. Silt loam soils have more available water than sandy soils (Table 52.2). The amount of soil organic matter contained in the soil is related to tillage intensity and amount of crop residue returned to the soil annually. Reducing the tillage intensity reduces the rate that organic matter is lost through microbial breakdown (mineralized).

Over the past 25 years, decreases in tillage intensity and increases in crop yields have contributed to a 24% increase in the South Dakota soils organic matter content (Clay et al., 2012). Leaving crop residues on the soil surface can increase soil organic matter content and reduce evaporation. The bottom line is that building the soil organic matter content improves drought resilience.

Table 52.2. Soil texture impact on plant-available water.

Soil Texture	Available Water (inch water per foot soil)
Sandy loam	1.3-1.8
Loam and silt loam	2.0-2.8
Silty clay and clay	1.6-2.2

Following winter and spring rains, many South Dakota soils are at or near field capacity, i.e., the soil water content after free drainage. If the soil is below field capacity at planting, consider reducing your yield potential. Yield potentials, which is a function of available water, can be used to estimate the seeding populations (Chapter 10). For corn, Carlson et al. (2011) determined the relationship between a practical corn yield goal and seeding rate. This relationship is:

$$\text{Population (seeds/acre)} = 16{,}900 \text{ seeds/acre} + 74.2 \times (\text{corn yield goal in bu/acre})$$

Based on this relationship, a corn yield goal of 180 bu/acre should have a seeding rate of 30,300 seeds/acre, whereas a yield goal of 120 bu/acre should have a seeding rate of 25,800 seeds/acre. This analysis indicates that the corn seeding rate should be decreased with increasing expected water stress. Similar analysis needs to be conducted in soybeans.

The amount of stored soil moisture is dependent on the amount of available water contained in the soil. For example, a four-foot deep profile that is a silt loam with 2.5 inches of available water per foot contains 10 inches of water in the entire profile, whereas a sandy loam soil with 1.5 inches of available water per foot contains six inches of available water in the entire profile.

Water stress and crop growth

In soil, water moves from wet to dry areas and roots cannot grow through dry soil to reach wet soil. Planting a crop early is key toward providing an opportunity for creating an effective root system that can use water stored deep in the profile. Row crops grown in South Dakota (corn, soybean, and wheat) are moderate to deep rooted and can produce root systems that can penetrate to four feet or more.

In many situations, water and heat stress can combine to reduce crop growth. In soybeans, the combined impact of water and heat stress can cause leaf wilting (or if severe enough, leaf drop), reduced growth, reduced N fixation, and yield reductions. Corn, soybeans, and wheat are very sensitive to water stress during pollination and grain filling. In soybeans, water stress reduces the number of pods, the number of beans per pod, and the size of the beans.

Under extreme water stress conditions, soybeans and corn crops can be harvested for hay or silage. If you decide to harvest the crop for forage or produce silage, you should communicate with your crop insurance agent and you must read and follow the pesticide label instructions about using the crop as a feedstock. For example, soybeans treated with Poast® (Sethoxydim)/Poast Plus® (used to control many grasses in soybean) can be harvested for hay, but not for silage. http://www.cdms.net/ldat/ld00F009.pdf

When deciding on how much and which crop residues can be used for livestock feed, it is important to consider the livestock nutritional requirements and the nutrient content of the plant. Drought-affected plants may have very high protein contents and other chemicals, such as nitrate, that may cause problems in livestock. Evans and Foweld (1921) suggest that soybeans should be considered a high protein hay crop. A good approach for determining the nutrient content of drought-affected crops is to collect a plant sample and send it to a laboratory for analysis.

Drainage

Drainage is being installed in many South Dakota fields. Many details about drainage are provided in Chapter 47. When installing drainage, it is important to consider that drainage may remove water that could be used by your crop. Controlled drainage is a tool that can be used to reduce water lost after the crop has been planted. Information about control drainage systems is available at http://admcoalition.com/latest-research/.

Design an appropriate nutrient package

Providing an appropriate nutrient package is critical for increasing the plants ability to withstand water stress. For example, starter fertilizer stimulates early-season growth, P fertilizers stimulate root development, and N promotes above ground growth. When using starter fertilizers, care should be followed to insure that seed germination is not reduced. Details on starter fertilizer are provided in Chapter 21.

Skip-row seeding

Skip-row planting has been used to increase corn and sorghum yields and water-use efficiency.
http://www.ianrpubs.unl.edu/epublic/pages/publicationD.jsp?publicationId=1226

In skip-row planting, rows are skipped, while the plant population per acre remains the same. This configuration results in very high populations within the seeded rows. Three approaches tested in Nebraska are:

1. Plant 2 and skip 2.
2. Plant 1 and skip 1.
3. Plant 2 and skip 1.

Skip-row seeding works best: 1) in low rainfall environments where there are frequent stresses during reproductive stages; 2) in deep soils with high plant-available water; 3) in fields that use a good pest control strategy; and 4) when using realistic yield goals. For this approach to be effective, good weed control is essential since the “between” rows are not covered and vulnerable to weed emergence and growth. Research conducted in Nebraska suggests that if your corn yields are less than 100 bu/acre, then you may benefit from skip-row seeding. http://www.tsln.com/article/20090602/TSLN01/906029923

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Twin-row seeding

Twin-row seeding has been used to increase soybean yields in the Southern states. In the research conducted in Mississippi, twin-row soybean seeding (10-inch rows spaced 40 inches apart) out yielded (5% increase) conventional seeding (rows 40 inches apart) (Bruns, 2011). Twin-row seeding provides the opportunity to take advantage of narrow rows without the requirement to purchase specialized equipment. Benefits from twin-row seeding are dependent on the characteristics of the cultivar. http://www.lewishybrids.com/files/File/Lewis%20University%20Issues/MON%20Tech%20Development%20-%20Twin%20Row%20Summary%20Final.pdf

Use cultivars with drought tolerance

Many current cultivars contain drought tolerance. In many situations, seeding plants with a genetic capacity to reduce the impacts of water stress on yield makes sense. However, care should be used to select varieties that do not reduce yields under a high yield environment. Information on selecting varieties is available in Chapter 10.

Crop rotations

In many areas of South Dakota, yields are influenced by the moisture left behind by the previous crop. Early maturing, shallow root crops like field peas leave more moisture than deep-rooted full season crops like sunflowers (Table 52.3).

Table 52.3. Rules of thumb for rotations.

1. Do not follow like-with-like. For example, “good” results have been observed when soybeans follow corn or vice versa, and winter wheat follows peas. When like-following-like, pathogens may be more prevalent and other problems may occur.
2. Cropping intensity should match available water. If a field consistently has too much water, then the intensity should be increased. If a field is consistently dry, then the intensity should be decreased. Guidelines for determining the rotational intensity are available at http://www.dakotalakes.com/Publications/Div_Int_FS2pg5.PDF.
3. Crop rotations are very effective at reducing pest and weed problems. By reducing pest pressures, the plant is better able to withstand water stress. http://www.ag.ndsu.edu/pubs/plantsci/crops/eb48-1.htm
4. Water-use efficiency can be increased by accounting for differences in plant rooting depth. For example, small grains may deplete soil water to a depth of three to four feet deep, while sunflower, safflower, and corn may deplete soil water to depths of five to six feet. Following sunflowers after wheat provides an opportunity to utilize water that was positionally unavailable to wheat.

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