Scheduling Irrigation for Soybean

Key Points
- Farmers should regularly monitor soil water and crop conditions to best predict crop water needs and appropriate irrigation timing.
- About 65% of soybean water use occurs during reproductive stages.
- The period from growth stage R3 (beginning pod) through R6 (full seed) is the most important time for irrigation application as soybean plants are most sensitive to moisture stress during this period.

Irrigation scheduling is the management of when and how much water to apply to keep a crop healthy throughout growing season. It involves planning, measuring, and decision making to meet the following criteria: 1) meet the crop’s water needs without causing water stress related losses, 2) help maximize water use efficiency, and 3) minimize leaching of nitrates and pesticides. Regardless of the scheduling method used, farmers should regularly monitor soil water and crop conditions to best predict crop water needs and appropriate application timing. Both timing and the amount of irrigation applied are crucial; too little water applied can result in yield losses, whereas applying too much water can waste time, water, money, and increase leaching risk.

Crop water use is determined by the amount of water lost to the atmosphere due to evapotranspiration (ET), or the sum of soil and plant surface evaporation and plant transpiration. ET varies by crop species, growth stage, climatic conditions, and soil moisture. Listed below are some other factors influencing irrigation management:

- **Plant available water** is the water held by the soil between field capacity and the permanent wilting point. The amount of plant available water differs greatly by soil texture.
- **Maximum allowable depletion (MAD),** also known as management allowed depletion, is the soil water level at which plant stress (and potential yield losses) will occur. This is the threshold that indicates when irrigation should be applied. The MAD will vary by crop species and crop developmental stage.
- **Field capacity** is the water content of a soil that has been saturated by rainfall or irrigation and allowed to drain by gravity.
- **Pumping capacity** determines the ability of the irrigation system to refill the soil profile.\(^1\) This allows a farmer to better know when to start irrigation so as to avoid any part of the field becoming depleted.

**Soybean Irrigation Needs**

Irrigating soybean differs from some other crops due to the soybean plant’s growth stage specific water needs. Soybean plants need more water later in reproductive stages; about 65% of water use occurs from growth stage R1 (beginning flower) through maturity.\(^2\) In most regions, soybean plants do not require irrigation during vegetative stages unless field conditions were extremely dry at or shortly after planting. In fact, too much water from irrigation or a precipitation event can stimulate excess vegetative growth that does not result in increased yield, and may actually lead to lodging problems.

Full-season irrigation scheduling could be defined as irrigating any time MAD reaches 50%.\(^2\) Fully irrigated soybean uses around 21-24 inches of water per year.\(^3\) The average peak water use is around 0.3 inches/day near full flower (R2) and through pod development, whereas during seed fill (R5-R6), the average rate is 0.25 inches/day.\(^3\) Crop water use can be higher during hot, dry, windy conditions; plants can transpire up to 0.5 inches/day on a hot, windy day in late July or August.\(^2\)

Because of soybean’s specific water needs during reproductive stages, some scheduling methods focus specifically on growth-stage targeted irrigation versus measuring soil water deficiencies. One common recommendation is to schedule irrigation either to coincide with critical reproductive growth stages or based on crop water use, depending on the soil type and water holding capacity.\(^2\) Generally, scheduling based on reproductive growth stage works well on medium- to fine-textured soils, whereas scheduling based on crop water use is an ideal method for sandy loam or coarser soils.
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Reproductive Growth Stage Scheduling

Because soybeans generally respond well to delayed irrigation, it is common to withhold irrigation until the R3 growth stage (beginning pod). In many cases, water is not needed prior to R1, and from R1-R3, moisture deficits may be too small to trigger the need for irrigation. However, once soybean reaches full flower (R2), it is important to pay close attention to growth staging and ensure that a plan is in place for soybean crops to receive adequate moisture. The time from R3 through R6 (full seed) is the most important time for irrigation application as soybean plants are most sensitive to moisture stress during this period.\(^2,4,5,6\) Research has shown that irrigation during R3-R5 growth stages encourages flower and pod retention, thus increasing the number of seeds per acre, while irrigation beyond R5 goes toward increasing the size of seeds present and final yield.\(^4\) In some cases, with adequate rainfall, optimum yields can be obtained with 2 irrigations of 3 inches each, one at full flower or beginning pod and the other at beginning seed fill.\(^2\) University research suggests that if irrigation can only be applied once during the season, it should be done at R5.\(^4\)

Watering during flowering helps increase the number of seeds produced per plant. Therefore, if irrigation is applied (or a major rain event occurs) at flowering, it is extremely important that the field be supplied with adequate water throughout the rest of the growing season. Moisture stress after ample water at flowering can result in the size of the existing seeds being reduced so much that, even with more seeds, the yield response may be the same or less than if there had been no irrigation at flowering.\(^2,4\) Another risk associated with applying irrigation during flowering is increasing the potential for white mold due to the humid canopy.

Scheduling Based on Crop Water Use

Under some conditions, soybean irrigation scheduling becomes a more complicated process than timing by growth stage. When the following conditions exist, irrigation should be monitored according to soil moisture depletion:\(^2,7\)

- Sandy loam or coarser soil
- Shallow root zone
- Irrigation system capacity is 1.5 inch per week or less

Generally, the goal on coarse soils is to allow no more than 50% depletion of plant available water in the top 2 feet from vegetative growth through flowering (R1-R2) and then no more than 50% depletion in the top 3 feet during pod elongation (R3-R4) and seed fill (R5-R6).\(^2\) Methods for determining when to irrigate include pulling soil samples from near the root zone, using soil moisture sensors, and/or utilization of a moisture deficit accounting system. Physical soil sampling can be reliable with experience and when samples are taken from the root zone at different depths and throughout several locations across a field. The use of soil sensors is generally a more accurate method. Using an accounting system requires monitoring of crop growth and daily weather conditions, selection of daily ET estimation from tables, measurement of rainfall and irrigation, and regular calculation of the soil water balances. The effectiveness of this method depends on the accuracy and regularity of in-field observations and measurements made by the farmer. Check with local Extension services for irrigation scheduling charts or software applications to help with scheduling. A website for soybean irrigation scheduling is SoyWater from the University of Nebraska-Lincoln. This program uses daily weather data and other inputs to estimate daily soybean crop ET values and provide a cumulative measurement of soil water depletion indicating when irrigation will be needed.

Terminating Irrigation

Many universities recommend that the final irrigation should generally be applied at the beginning of R7 with a soil moisture of around 60% capacity.\(^4\) At this point, soybean seeds should have completely filled the pod cavity. Terminating irrigation too soon could result in smaller seed, and thus lost yield potential.\(^8\) Regardless of the cost of the last 1.5 to 2 inches of water, ending irrigation too soon can be a costly mistake. This is especially true in soybean systems where the full seed stage is occurring from mid-July through late August when drought conditions tend to be the greatest.\(^8\) More information about terminating irrigation in soybean can be found at www.channel.com.

Sources:

3 Kranz, B. and Benham, B. Does irrigation improve soybean yields? University of Nebraska. www.ksre.ksu.edu
9 Web sources verified 3/17/15.

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