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TENNESSEE SOYBEAN PRODUCTION HANDBOOK

CHAPTER 6: Irrigating Soybean

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Irregular rainfall patterns characterize the soybean growing conditions in Tennessee and the Mid-South. That means not all rainfall can be considered effective. When rains are inadequate or untimely for the crop, farmers with irrigation have to manage water as an input. Overall, the acreage of irrigated land for row crop production has increased in humid regions (***Figure 6-1***). In Tennessee, about one-third of farmers have at least one irrigated field, according to a recent University of Tennessee survey of farmers in 30 counties (***Figure 6-1c***).

As soybean plants grow and develop, transpiration (i.e., water loss through plant leaves) increases, and soil water depletion happens more rapidly. Thus, soybean water use varies with **plant growth stage**, **weather conditions** and **soil water–holding capacity of a field**.

Seasonal rainfall may be adequate to excessive in subhumid areas such as West Tennessee, making irrigation scheduling more difficult. Proper irrigation involves monitoring soil water levels through use of soil water sensors to potentially conserve water resources and bring economic benefit to producers. Yield loss from water stress and from overwatering soybean can be avoided.

SOYBEAN GROWTH STAGE AND IRRIGATION

Water use in soybean is lowest (0.05 to 0.10 in/day) at germination and during vegetative or seedling growth stages and highest (0.20 to 0.30 in/day) during flowering through pod fill (R1 to R6.5) (***Figure 6-2***). In good rainfall years, irrigation may only be needed when weather conditions are dry during peak demand times such as pod set and seed fill (R3 through R6).

SOIL WATER SENSORS

Soil water sensors allow producers to better assess soil water availability in the soil profile and schedule irrigation when needed during key soybean growth stages. Use of irrigation scheduling technologies and tools, such as soil water loggers/sensors and/or crop growth and development models for irrigation scheduling, require some knowledge and preparation before making an irrigation decision to apply water effectively.

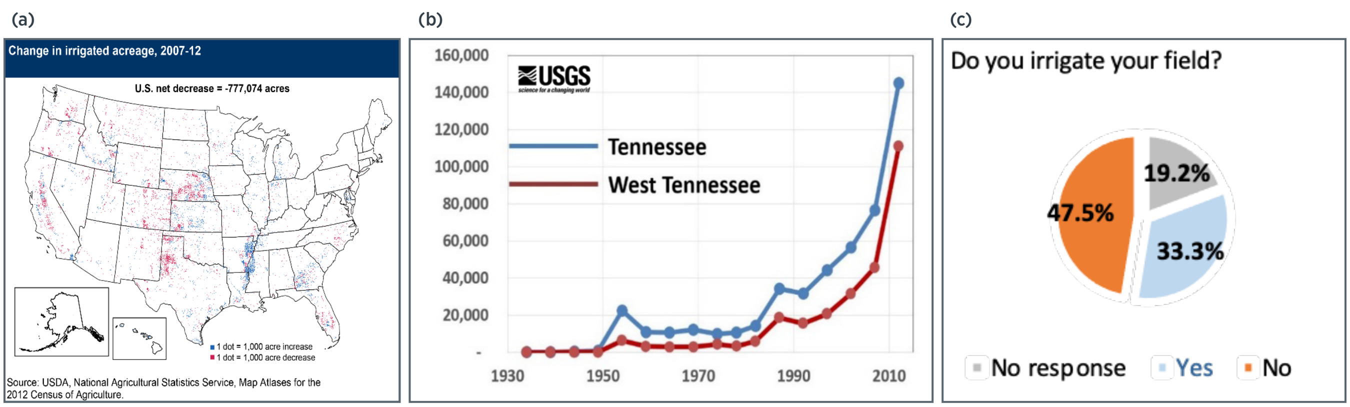


Fig. 6-1. *Change in acreage of irrigated cropland, 2007-2012 (USDA) (a)[(1)] Tennessee and West Tennessee, 1930-2012 (b)[(2)] University of Tennessee irrigation survey of farmers in 30 counties, 2020 (c)[(3)].*

(1) Source: USDA-NASS, 2022.

(2) Source: A. Shekoofa et al., 2020.

(3) Source: A. Shekoofa, unpublished data, 2022.

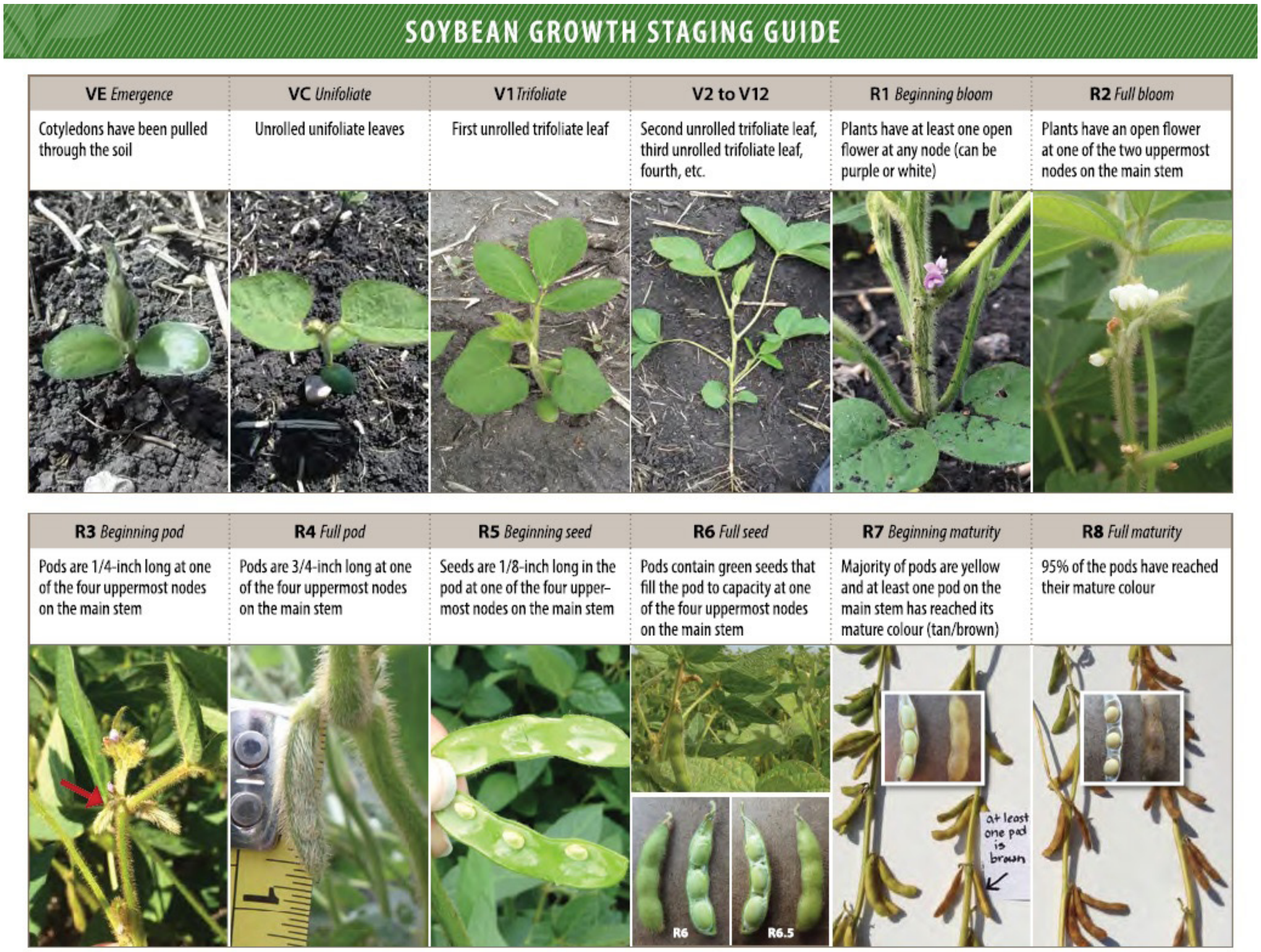


Fig. 6-2. *Soybean growth stages from emergence to full maturity. Source: Adapted from "Soybean Growth Staging Guide"* *https://www.manitobapulse.ca/2015/03/soybean-staging-guide/*

Fig. 6-3. *Installing and placing the soil water sensors in a soybean field in Milan, TN; sensor installation (above & lower left); soil water station or logger (lower right). Source: A. Shekoofa, 2022.*

SENSOR INSTALLATION

Install soil water sensors as soon as plant stand is established and before plants get too large (about V3 in soybean). The sensors should be carefully located beside the row using a soil probe or auger (***Figure 6-3***). One thing to remember while installing sensors and the data collection station is to select representative soil types of the whole field to avoid under- or over-watering the crop. The majority of soybean roots exist in the upper 1 to 2 feet of soil; therefore, typical sensor depth can be 6 to 24 inches depending on sensor type. Place sensors in at least 2 soil depths per installation location. Crop growth stage and soil compaction determines the active rooting zone from which water is absorbed during the season.

USING SENSORS TO INITIATE IRRIGATION

There are several brands of soil water sensors on the market, and it is important to interpret the value representing water deficit stress correctly. A range of 65 to 70 centibars (cb) or kilopascals (-kPa) for soil matric potential/soil suction sensors can be interpreted as the onset of plant stress for most soil types and crops, including soybean. It is critical to evaluate the sensor values throughout the rooting zone for proper irrigation scheduling. The sensor reading values will fluctuate day by day due to plant growth stage, soil type and plant rooting depth that utilizes water from varying depths. A few tips on interpreting soil moisture sensor data are included in a previous article "Why Irrigation?" by Shekoofa (2020).

Irrigation systems take time to move across large fields. Installing and using soil water sensors can help with proper initiation of irrigation before the field reaches a critical water depletion and give farmers adequate time to complete irrigation before any yield is lost. During peak demand, soybeans may require irrigation of an inch or more of water per week. Subsequently, farmers may need to run the pivot several times at less than half an inch per turn to get the amount of water needed during high usage.

Soil water sensors help guide irrigation decisions. ***Table 6-1*** presents an example of how sensors are used to determine need for irrigation in a Milan, TN, soybean field for crop at growth stage R1 (i.e., beginning bloom) (***Figure 6-2***). In this example, the rooting zone consists of the top 24 inches (~100 percent) of the soil profile with one sensor at 6 inches (~50 percent rooting area) and one at 24 inches (~50 percent of rooting area). Sensor reading value cb (-kPa) is corrected for (percent) rooting area for both sensors (sensor reading -kPa X percent of rooting area) and then totaled under "Actual value" in cb (-kPa):

Assuming the range 65-70 cb (-kPa) is the stress range for our silt loam soil and our soybean plant 32.5 cb (-kPa) is not even close to an initiation trigger of 65 or 70 cb (-kPa). Thus, there is no need to irrigate at this time.

DELAYING START OF SOYBEAN IRRIGATION: YIELD AND PROFITABILITY

Multi-year large plot irrigation studies under a variable rate irrigation center pivot in silt loam soil and typical Tennessee conditions showed in both dry and wet years that delaying irrigation initiation until R5 (i.e., beginning seed) produced yield that was similar to yield when irrigation was started earlier at either R1 or R3.[1]

The average soybean yield between 2017 to 2021 when irrigation was initiated at R5 was 60 bushels per acre, while the rainfed plots yielded 56 bushels per acre (***Figure 6-4***).

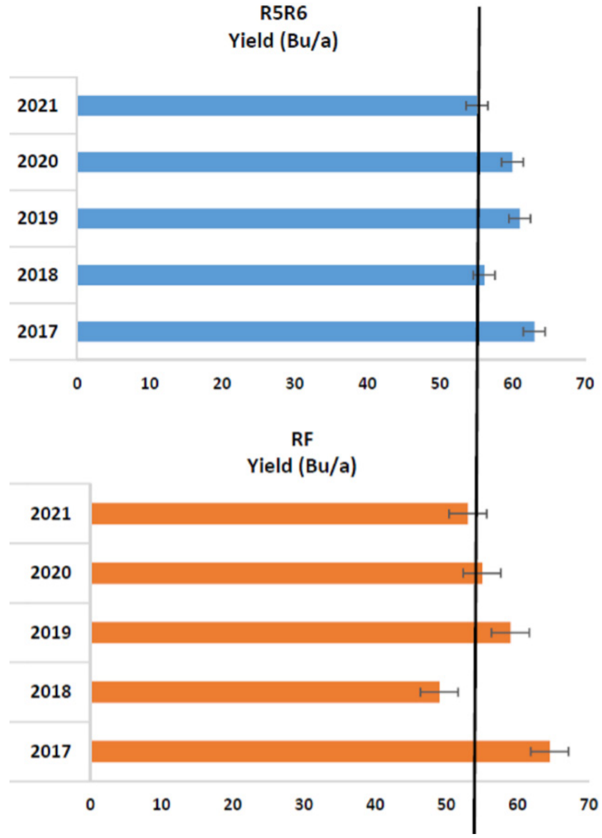


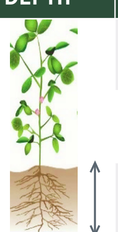
Fig. 6-4. *Average soybean yield under irrigation started at R5 was 60 bu/A, compared to 56 bu/A for rainfed plots. The black line represents the soybean yield stability of both treatments over years. Source: Shekoofa, 2022.*

The calculated cost of irrigation included labor, energy, pumps, sensors and other equipment under varying scenarios in our research field. Irrigation cost for maturity group (MG) 5 soybeans in Tennessee was $6.49/A water when irrigation was initiated at R5, compared to $14.17/A water when irrigation began at R1.

Net return data showed the cost savings from delaying the initiation of irrigation in soybean (growing in silt loam

[1] See A. Shekoofa et al. "Variable Rate Irrigation Scheduling for Soybeans: Large Plot Evaluation."

Table 6-1. *Calculating irrigation need based off sensors depth and available soil water.*

ROOTING DEPTH	SENSOR DEPTH *(in)*	SENSOR READING VALUE CB *(-kPa)*		(%) OF ROOTING AREA	ACTUAL VALUE CB *(-kPa)*
 R1	6	40	x	50%	20.0
	24	25	x	50%	12.5
					32.5 cb (-32.5 kPa)

Source: Roach and Gholson, 2016.

soil) until R5 was significant, while there was no statistical difference in yield among irrigation initiation treatments (i.e., R1, R3 and R5).

These results support the University of Tennessee's recommendation to delay irrigation initiation in soybeans until the R5 growth stage in most years. An exception to this recommendation would be for soybeans grown in drought or in sandy soils. In coarse textured soils, soybeans are more likely to require irrigation earlier during late vegetative and early reproductive stages (V4 to R3), and irrigation during the later reproductive stages (R4 to R6) (***Figure 6-2***) would be even more critical.

IRRIGATION TERMINATION IN SOYBEAN

When it comes to **terminating irrigation** for soybeans, a significant amount of Tennessee research indicates irrigation should be terminated at the R6 or R6.5 (full seed) growth stage (***Figure 6-2***). Continuing to irrigate during R7 adds to the cost of irrigation and can reduce soybean yields, presumably due to increased stalk lodging and late season diseases.

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