W 944

Variable Rate Irrigation Scheduling for Soybeans: Large Plot Evaluation

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Background

Agriculture irrigation accounts for approximately 80 percent of the consumptive ground and surface water use in the United States (Schaible and Aillery, 2012). Recently, acreage of irrigated land for row crop production has increased in humid regions (Figure 1), leading to the need for optimizing water use in these systems to conserve water resources and bring economic benefit to producers. Soybean water use varies with growth stage (Figure 2). Soil water sensors are one tool that can be utilized to better assess soil water availability in the soil profile and schedule irrigation appropriately during soybean growth stages.

Sensor placement

Soil water sensors should be installed as soon as the crop is established but before plants get too large (about V3 in soybean). Carefully place sensors in the row using a soil probe or auger to achieve correct depth. One thing to consider when placing and installing the sensors/logger stations is to select representative areas of the whole field. Typical sensor depth can be 6 to 36 inches which may vary depending on sensor and crop types.

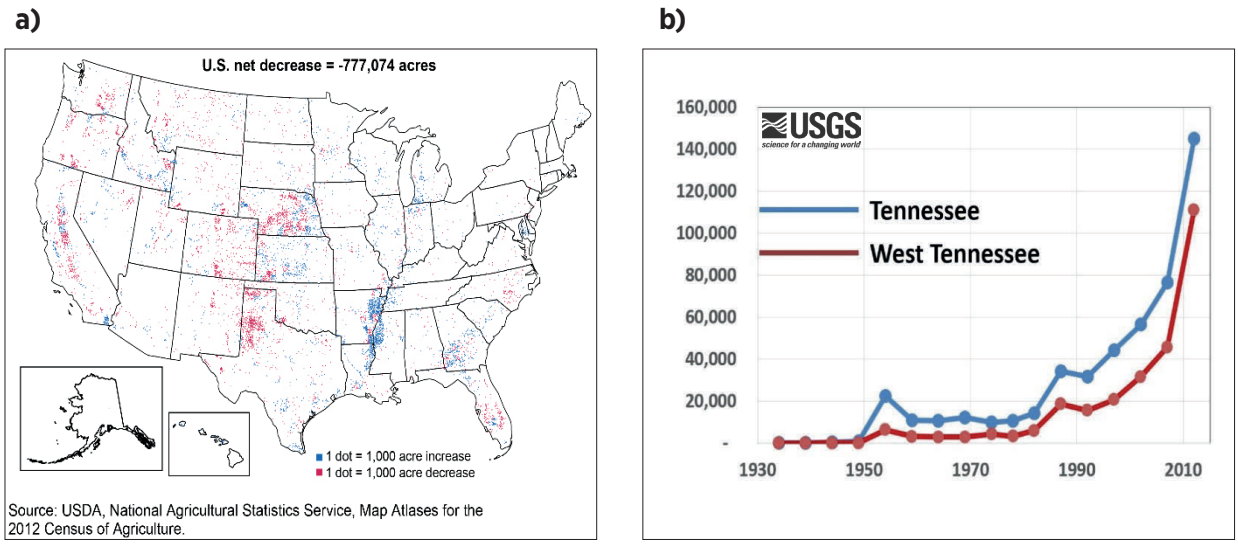

Figure 1. *Change in acreage of irrigated cropland, 2007-2012 (USDA) (a) Tennessee and West Tennessee, 1930-2012 (b).*

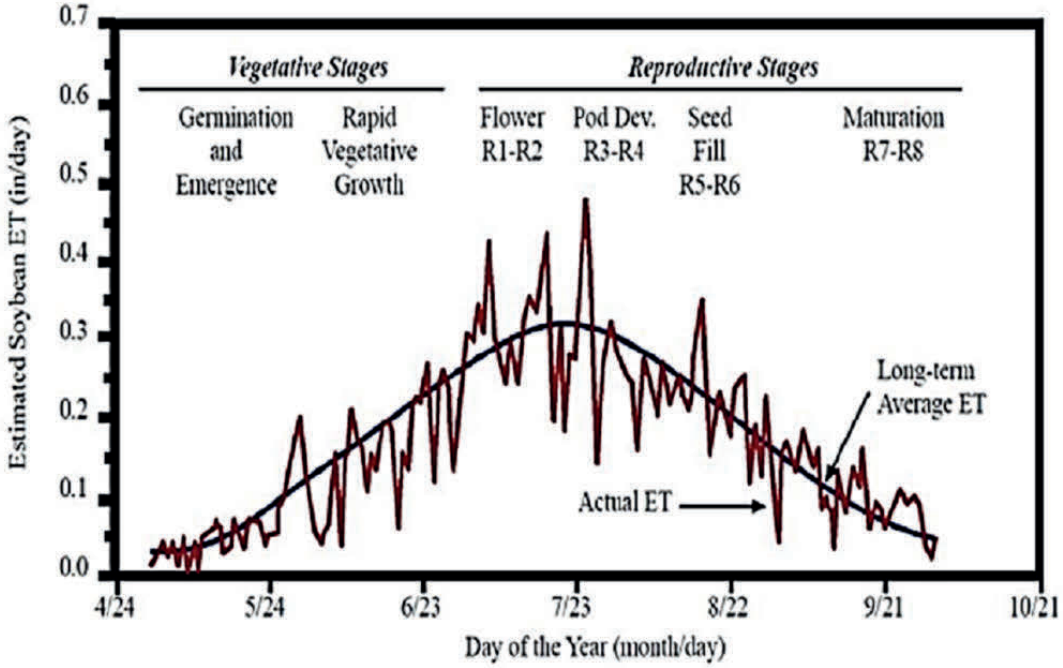

Figure 2. *Soybean water use across growth stages.*

http://www.mafg.net/NewsDetail.aspx?NewsID=6170 (Shekoofa 2018)

There are several brands of soil water sensors on the market, and it is important to interpret their measurements correctly. The University of Tennessee (UT) has used sensors designed by Meter Inc. and Watermark, which are able to measure soil water potential and water holding capacity (i.e., soil water tension) based on centibars (cb), also represented as kilopascals (kPa). There are many other soil water sensor types and manufacturers available and UT is not endorsing any specific brands. A value of -65 to -70 cb (kPa) 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. A few tips on interpreting soil moisture data are included in a previous article by Shekoofa (2020) that can be accessed here (https://news.utcrops.com/2020/06/why-irrigation/).

Objective: The objective of this study was to determine the latest effective soybean growth stage to initiate irrigation and maximize yield for soybean plants.

Research activities

Large plots (110 feet by 77-105 feet) accommodated a variable rate irrigation (VRI) equipped center pivot at the Milan AgResearch and Education Center, in Milan, Tennessee, (Figure 3) in 2017, 2018 and 2019. Soil water loggers (Figure 4) equipped with Teros-21 soil water sensors and rain gauges were used to monitor precipitation and guide irrigation decisions. The soil type at the study location was a silt loam, a Providence silt loam soil (Fine-silty, mixed, active, thermic Oxyaquic Fragiudalfs).

A maturity group (MG) 4.8 variety (Pioneer P47T36) was planted in early to mid-May and subjected to three irrigation initiation timings (R1, R3, R5), one irrigation termination timing (R6) (Figure 5), and one rainfed (zero irrigation) treatment; irrigation was withheld if soil matric potential was greater than -65 to -70 cb (kPa), based on soil water sensor readings. Treatments were replicated four times. Soybean plots were harvested with a Case IH combine equipped with a yield monitor; yield data were excluded from an area 10 feet from the edges of each plot to remove the irrigation transition zones (Figure 3). Yield data were analyzed with JMP Pro 13.2 and means were separated using the student's t-test. Differences were considered significant for $\alpha = 0.05$.

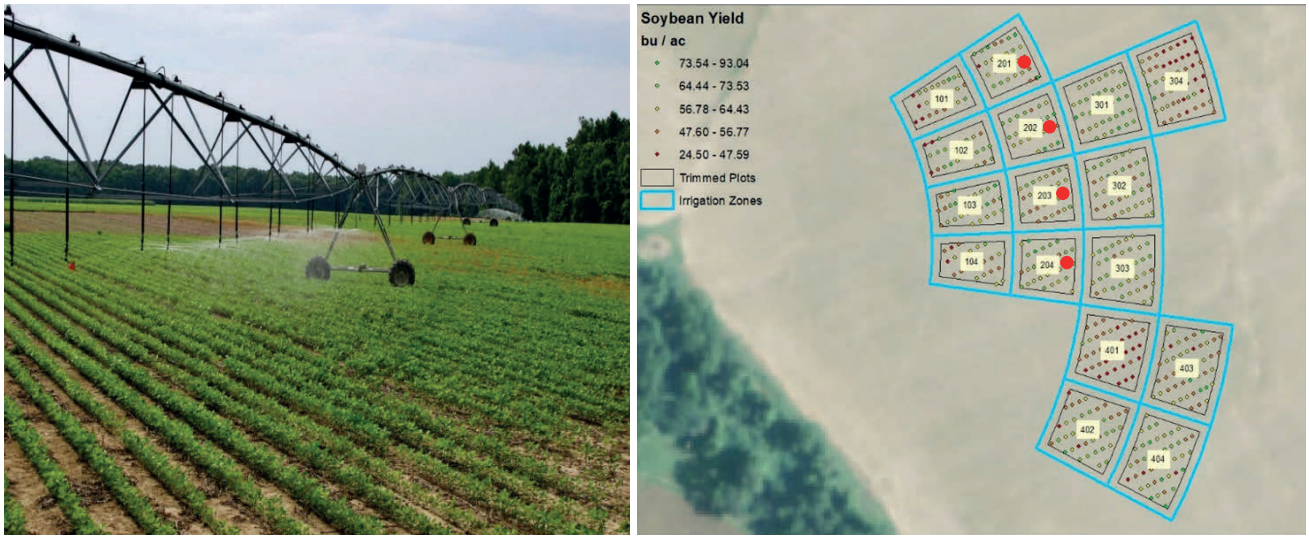

Figure 3. *Irrigation zones on a VRI equipped center pivot (left) and plots layout showing yield points, trimmed plot, and water loggers/ sensors station (●) areas (right) in Milan, Tennessee (2018).*

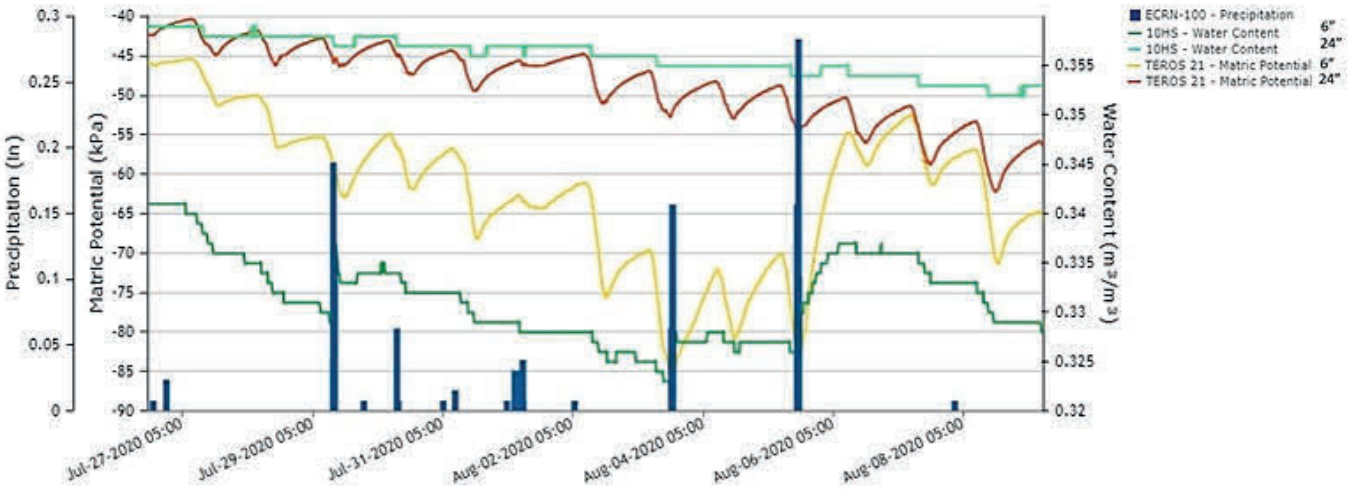

Figure 4. *Monitoring soil water and water usage to aid irrigation strategies. Teros 21 matric potential sensor (top right), 10 HS soil moisture sensor (bottom right) (Meter Inc.), a screenshot of ZENTRA-Cloud app (top middle), and a soybean large plot equipped with Meter Inc. ZL6 logger (top left). Example graph (bottom) of the graph illustrates 2020 growing season soil water potential and precipitation measured via soil water sensors (Teros 21 and 10 HS in two different depths 6 inches and 24 inches). The blue bars represent the precipitation events. The precipitation events for August 4 and 5 represent the irrigation that was applied.*

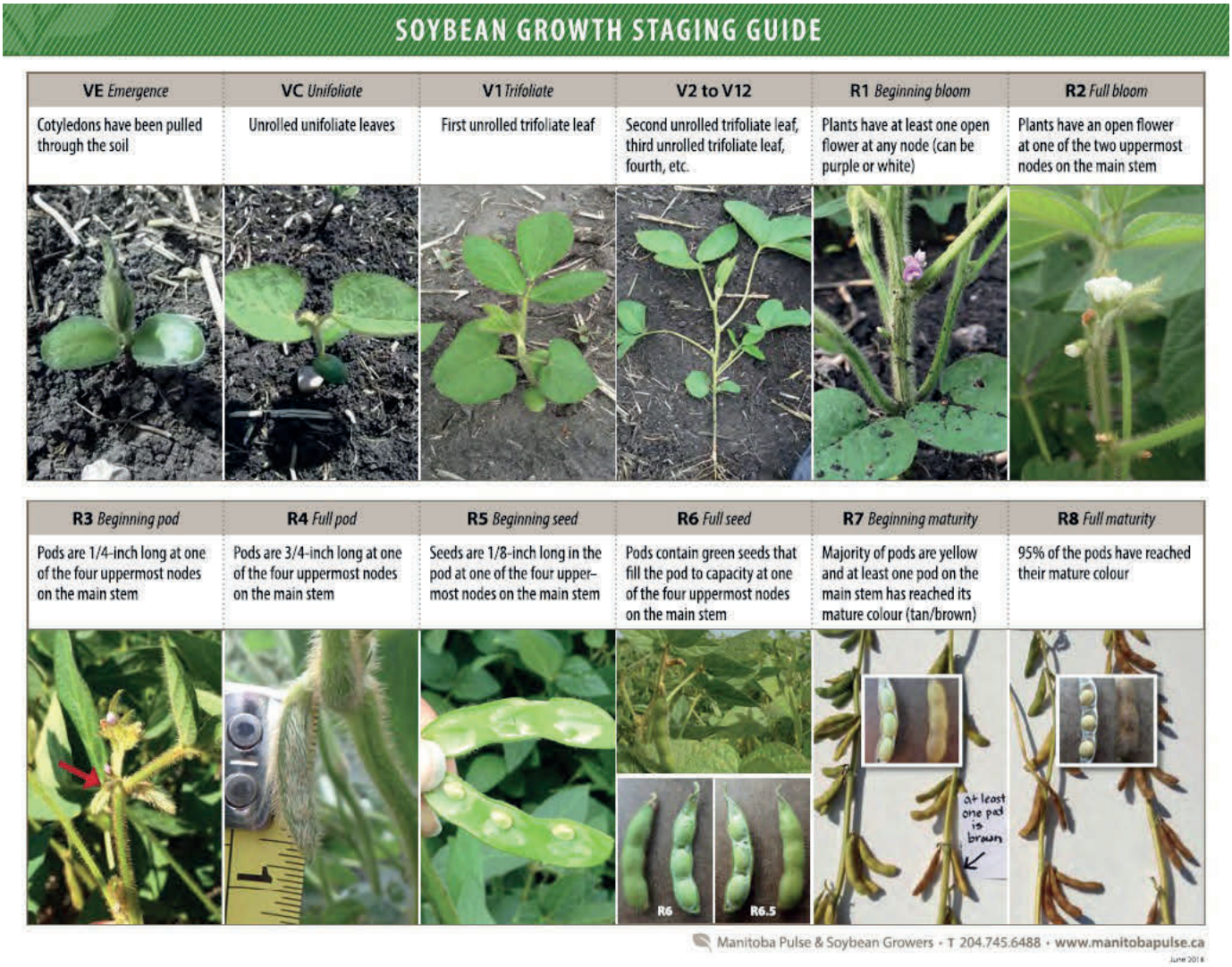

Figure 5. *Soybean growth stages from emergence to full maturity.*

https://www.manitobapulse.ca/2015/03/soybean-staging-guide/

Significant findings

The study site received 7.24 inches and 7.41 inches more rain from June through August in 2017 and 2019, respectively, compared to 2018 (Table 1). In 2017 and 2019, no significant difference was observed between the yield of irrigated or rainfed treatments, and this was attributed to the high amount of rainfall received at the site (Figure 6).

An early irrigation initiation at soybean growth stages (Figure 5), such as beginning bloom (R1) or beginning pod (R3), would be expected to promote bloom or pod retention, while a late irrigation initiation at early seed (R5) should increase seed number and size. In 2018, all irrigated plots yielded similarly to each other but had significantly higher yields than rainfed plots (Figure 6). Based on results from two wet years and one drier year, delaying irrigation initiation until R5 was as effective as an early initiation at either R1 or R3 (Figure 6). Overall, using soil water sensors for real time monitoring of the soil water status enables more informed irrigation decisions and potential water and energy savings, and prevents potentially negative effects of overwatering if irrigation is begun too early in the season.

Irrigation decisions are based on the needs of the crop and may vary from one year to the next. Furthermore, environmental factors such as diverse rainfall patterns, soil type, soil water availability, heat waves and high evaporative demand need to be considered. For example, in sandy soils, soybeans are more likely to require irrigation in the late vegetative and early reproductive stages (V4 to R3), and providing adequate soil water in the later reproductive stages (R4 to R6) is even more critical.

Table 1. The rainfall and amount of water added (irrigation) to each treatment at AgResearch and Education Center at Milan

		Rainfall (inches)		
		2017	2018	2019
Month	May	4.01	3.00	2.50
	June	4.84	4.37	3.48
	July	6.93	3.06	7.47
	August	4.80	1.90	5.79
	September	4.41	11.27	0.34
	October (week one)	1.01	4.36	3.37
		Irrigation (inches)		
Treatment	R1R6	2.35	6.56	2.87
	R3R6	2.05	5.33	2.05
	R5R6	2.05	3.28	0.82
	No irrigation	0.00	0.00	0.00

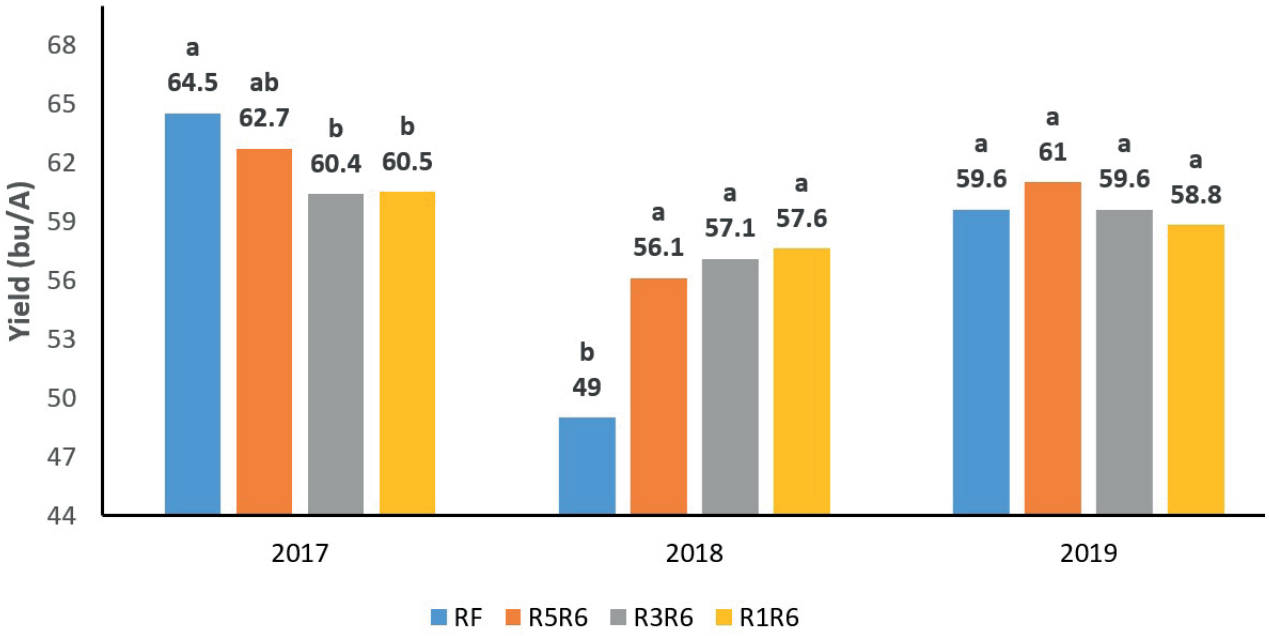

Figure 6. *Soybean yield for each irrigation treatment (RF = rainfed, R1, R3, R5 = initiation timing and R6 = termination timing) in 2017, 2018 and 2019. Means of the same year followed by the same letter are not significantly different.*

Where do we go from here?

The distribution of rainfall within a growing season was an important factor in determining the efficacy of irrigation timing. In our study, the site received adequate rainfall early and mid-season that supported yields that were similar to our R5R6 irrigation regime. An explanation for significantly lower soybean yield under R1R6 and R3R6 irrigation treatments in 2017 compared to rainfed (i.e., outside the pivot) is prolonged periods of saturation which likely reduced the production (Figure 6). Further study during years with both above and below average rainfall is necessary in order to refine our soybean irrigation recommendations.

Soil type also affects plant-soil-water relations, and in 2017, experimental plot layout resulted in within field variation of soil (i.e., silt loam) texture and fertility that may have resulted in no differences between irrigation timing reflected in the data. Soil types with different water-holding capacities will require different irrigation strategies.

Previous research findings indicate in silt loam soils with higher than average rainfall, soybean yield was sometimes optimized with supplemental irrigation lower than the standard rate of 1.5 inches per week during seed fill (R5 to R6). In drier years and sandier soils, the supplemental irrigation plus rainfall rate of 1.5 inches per week will most likely be required before R5, perhaps requiring water at an R1 or a vegetative growth stage; more information can be accessed here (https://extension.tennessee.edu/publications/Documents/W809-B.pdf).

Our work was conducted using a late MG 4 soybean variety, which reflects a large percentage of planted acres in Tennessee. Ongoing studies with MG 3 and 5 varieties will indicate whether MG should be a consideration when timing irrigation in soybean.

Acknowledgments

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Resources

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- https://www.manitobapulse.ca/2015/03/soybean-staging-guide/
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