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MISSISSIPPI SOYBEAN PROMOTION BOARD
PROJECT NO. 40-2018
2018 Annual Report

Title: Irrigation Scheduling of Soybean – A Dual Threshold Method to Eliminate Yield Reducing Stresses and Maximize Water-Use Efficiency

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BACKGROUND AND OBJECTIVES

Over the past 30 years, water level surveys have proven that more water is being pumped out of the Mississippi River Alluvial Aquifer than is replenished by recharge in the Mississippi Delta. As new wells are permitted and more water is pumped from the aquifer each year, water levels will decline and the area of greatest concern will continue to expand in the mid-Delta, such that declining water levels in this area will severely affect pump operation to the point that they will eventually fail.

Efficient use of water in crop production is a necessary part of the solution. Increased emphasis is being placed on proper irrigation scheduling for all crops in the Delta using soil moisture sensors so that producers can reach maximum economical yields with the least amount of water. Research and extension has shown that irrigations can be scheduled more efficiently without reducing yield by using soil moisture sensors.

In 2014, in three soybean irrigation initiation field studies, there was no response to irrigation when moisture levels were such that irrigations were recommended. The exception was one later maturing variety that had a small yield increase while experiencing a 10-day extended heat period that occurred after the other varieties had matured. This observation in 2014 along with change in yield data from the four years of this study correlating more with heat than moisture has resulted in a conclusion that soybean in our environment experiences a heat stress or combination of heat and drought stress more than strictly a moisture stress. So a hypothesis was developed suggesting that a dual irrigation threshold for soil water potential sensors may be needed to deal with extended heat periods (Tamax>=95°F) + moisture-induced stress versus simply a moisture deficit-induced stress. For example, on a Sharkey Clay soil, a lower threshold (50 kPa) might be used when an extended heat period + moisture deficit-induced stress is occurring, while a higher threshold (80 – 120 kPa) would be used when only a moisture deficit-induced stress is occurring.

Literature agrees that soybean yield losses are greater when subjected to higher temperatures and limited moisture than when subjected to either higher temperatures or limited moisture alone. Likewise, thresholds need to be identified for volumetric water content sensors under these same conditions. Good irrigation scheduling protocol should tell you "when not to irrigate" as well as "when to irrigate".

Objective(s): The overall purpose of this research is to maximize yield with the least amount of water by identifying thresholds which will alleviate temperature- and moisture-related yield-reducing stresses economically. 1) Determine a dual irrigation threshold (heat- & moisture-induced or moisture-induced) for soybean using soil water potential sensors (Watermarks) in silt loam, silty clay loam, and silty clay textured soils; 2) Monitor and identify irrigation thresholds (heat- & moisture-induced or moisture-induced) in soybean using volumetric soil moisture sensors in silt loam, silty clay loam, and clay textured soils; and 3) Economically evaluate the yields and production costs of each irrigation treatment.

REPORT OF PROGRESS/ACTIVITY

Procedures

Three irrigation x variety field studies were established in 2018 on two different soils on two sites, one being furrow-irrigated and one being sprinkler-irrigated. The Bosket – Dubbs SiL soil at Stoneville, MS was sprinkler-irrigated (**Site 1**). A Sharkey SiCL soil at Stoneville, MS was the location of two furrow-irrigated field studies (**Sites 2 and 3**).

Site 1 was conducted in a randomized complete block design with a split-plot arrangement of treatments with four replicates. Irrigation initiation treatments were randomized within replicates and varieties were randomized within initiation treatments. Plots were eighteen 40-inch-wide rows that were 67 ft long. Sites 2 and 3 were conducted in a randomized complete block design with a factorial arrangement of treatments in four replicates. These plots were six 40-inch-wide rows that were 600-650 ft long. At these sites, two rows were left unplanted between all plots to provide a non-shrinking buffer zone between the irrigation treatments.

The varieties planted, planting date, and irrigation system are given in **Table 1** for each field study. Site 1 was planted on 20 Apr, while Sites 2 and 3 were planted on 2 May and 18 May, respectively. Weeds were managed so that weed competition was not a factor limiting crop production in any study.

Watermark soil water potential (SWP) sensors, resistance type, were installed in each irrigation x variety treatment in two reps of each study. They were installed at three depths (6, 15, 24 inches – sprinkler; 8, 16, 24 inches - furrow). Each site was instrumented with dataloggers and set to read and store the data at 1-hour intervals. Additionally, 18 Sentek volumetric water content (VWC), capacitance type, probes were installed in three treatments in two reps of each study. These 48-inch-long probes had sensors every 4 inches from 2 inches to 46 inches.

Irrigation protocols were as follows:

Protocol
Irr 1--Irrigate at SWP <= -50 kPa
Irr 2--Irrigate at SWP <= -80 kPa
Irr 3--If Temp.<95°F, Irrigate at SWP <= -80 kPa; If Temp.>=95°F, Irrigate at SWP <= -50 kPa
Irr 4--If Temp.<95°F Irrigate at SWP <= -100/120 kPa[a]; If Temp.>=95°F, Irrigate at SWP <= -50 kPa
Irr 5--If Temp.<95°F, Irrigate at SWP <= -100/120 kPa[a]; If Temp.>=95°F, Irrigate at SWP <= -80 kPa
Irr 6--Rain-fed (non-irrigated)
[a] -100 kPa Bosket/Commerce; -120 kPa Sharkey.

Air temperature was obtained from automated weather stations located in the vicinity (within a mile) of each site, while rainfall was collected and measured at each site.

The two middle rows of each plot were harvested with a plot combine at site 1. The middle six rows of each plot at sites 2 and 3 were harvested with a commercial combine and seed were augured into a weigh cart to determine yield. A sample was taken for harvest moisture, test weight, and seed weight. Yields were adjusted to 13% moisture content. Data were subjected to analysis of variance and the means were separated by the least significant difference (LSD) procedure at the 5% level of significance. Water use efficiency (WUE) was calculated from change in yield among an irrigated protocol and the rain-fed treatment divided by the applied water from irrigation. Harvest dates are given in **Table 1**.

The economic analysis for all three field studies is based on partial budgeting of net returns above irrigation and hauling costs since all other factors of production were held constant and no difference in the seed cost by variety was assumed. Irrigation cost estimates are based on MSU budgets for sprinkler irrigation with a ¼ mile center pivot system or for furrow irrigation of a 160-acre tract using roll-out pipe (MSU Department of Agricultural Economics Budget Report 2018-05, Appendix 9 & 10). Fixed irrigation costs were applied to non-irrigation treatment costs. The average reported soybean price for the week including the harvest date in the Delta area (USDA Market News- JK_GR110) is used to set the soybean price in the analysis for each study.

Results and Discussion

Weather

Winter rainfall (1 Oct, 2017 – 31 Mar, 2018) at Stoneville, MS was higher than normal at 32.7 inches for site 1 and 32.9 inches for sites 2 and 3, as compared to the 105-year average of 28.4 inches **(Table 2**). Likely the entire rooting profile was recharged to start the season at all sites.

Although the growing season started a little cool in April, May was warmer and wetter than normal (**Table 2**). Maximum and minimum air temperatures in June, July and August were relatively normal, while minimum air temperatures in September were warmer. Rainfall was wetter than normal in August and September. Most rain events were an inch or less, but were relatively frequent as shown in Figure 1a-b along with daily maximum and minimum air temperature.

Seed Yield and Economic Analysis

Estimated irrigation and hauling costs and soybean prices (**Table 3**) along with yield and water applied were used to calculate expected net returns above irrigation and hauling costs for each treatment at each site.

Yield results and net returns are given in **Table 3a-c**. Rain-fed (non-irrigated) yields ranged from 67 to 81 bu/acre over all locations and varieties; thus, it was not an extremely droughty year. Irrigation increased soybean yield in the 20 Apr planting at Site 1 on Bosket/Commerce VFSL/SiCL and the 18 May planting at Site 3 on Sharkey SiCL soil, while no yield differences were found in the 2 May planting at Site 2 on Sharkey SiCL soil. The only yield differences among irrigated protocols were found in the 20 Apr planting at Site 1 on Bosket/Commerce soil. The later maturing HBK4950 yielded greater than CZ4748 at Sites 2 and 3, while the later-maturing P8A60 yielded greater than P45A23 at Site 1. At Site 1, plant observations indicated that the P45A23 variety was likely more sensitive to drier conditions than P48A60 on the lighter soil in the upper end of the field.

Under sprinkler irrigation at Site 1, net returns were higher where yields were increased over the rain-fed treatment (**Table 3a**). Under furrow irrigation at Site 2 and 3 where yield increases due to irrigation were either small or non-existent and with higher total amounts of water applied per irrigation, net returns were higher where less water or no water was applied (**Table 3b-c**).

At Site 2, no yield differences were found among irrigation protocols and the rain-fed treatment, but Irr 4, Irr 5, and the rain-fed treatments had higher net returns than Irr 1 and Irr 3. At Site 3, no yield differences were found among irrigation treatments (Irr 1-5), but all irrigation protocols yielded better than the rain-fed, while Irr 1 and Irr 2 had lower net returns than Irr 3, Irr 4, Irr 5, and the rain-fed treatments.

Irrigation protocols

Maximum and minimum Ta and rainfall during the growing season can be found in **Figure 1a-c** for Sites 1, 2, and 3, respectively. SWP for the rain-fed (non-irrigated) treatment is plotted along with rainfall for Sites 1, 2, and 3 in **Figure 2a-c**, respectively. The initial irrigation of each of the irrigation protocols is denoted in both **Figures 1 and 2** with the downward arrows.

Dates of irrigation and total amount irrigated for each irrigation treatment for the sprinkler irrigated, Bosket/Commerce soil, Site 1, are given in **Table 3a**. The single irrigation threshold Irr 1 (-50 kPa) was irrigated seven times and Irr 2 (-80 kPa) was irrigated four times. Irrigation for dual threshold protocols Irr 3, Irr 4, and Irr 5 were triggered by Ta>=95°F on 14 July, by Ta<95°F on 18 July for Irr 3, Irr 4, and Irr 5, on 26 July for Irr 3, and on 6 Aug. for Irr 3 and Irr 4. Dual threshold protocol Irr 4 had the least amount of applied water (2.3 inches/acre), while producing yields and net returns that were not different from those of protocols Irr 1, Irr 2, and Irr 3, and producing yields and net returns that were higher than the rain-fed. It also ha the highest numerical water use efficiency (WUE).

At Site 2, furrow-irrigated, Sharkey soil, the single irrigation threshold Irr 1 (-50 kPa) and Irr 2 (-80 kPa) were irrigated six and two times, respectively, for the earlier maturing variety. The later maturing variety was irrigated once more on 1 Sep (**Table 3b**). The dual threshold protocols Irr 3, Irr 4, and Irr 5 were irrigated on 15 Jul by the Ta>=95°F, SWP<= -50 to -80 kPa protocol. Irr 3 was irrigated twice more on 3 Aug and 16 Aug by the Ta<95°F, SWP<=80 kPa protocol. Since, there were no yield differences among the irrigation protocols and the rain-fed (non-irrigated) treatments, Irr 4 and Irr 5 applied the least amount of water while maintaining net returns that were not different from the rain-fed.

All irrigation protocols Irr 1-5 yielded higher than the rain-fed (**Table 3c**) at Site 3, furrow irrigated, Sharkey soil. The single irrigation threshold Irr 1 (-50 kPa) and Irr 2 (-80 kPa) were irrigated four and five times each for the earlier maturing variety and once more for the later maturing varieties. The dual threshold protocols Irr 3 and Irr 4 were triggered July 15 for Ta>=95°F, SWP<= -50 kPa and irrigated once more on 14 Aug for Ta<95°F, SWP<= -80 to -120 kPa. The dual threshold protocols Irr 3, Irr 4, and Irr 5 had less water applied than did Irr 1 and Irr 2, and yielded higher than rain-fed. However, their WUE's were not very high and their net returns were not different from the rain-fed.

Volumetric Water Content (VWC)

Sentek sensor data were collected for approximately 3 months of the growing season starting around early- to mid-June at all three locations. Internally, a universal algorithm is applied to the capacitance readings of the Sentek probes to calculate VWC. No effort was made to calibrate these sensors to specific soils. The manufacturer recommends looking at the data trends to determine where the root activity occurs and indicators of when the soil is not providing the water needed by the plant. Diurnal variations in VWC indicate where and when root activity is occurring at different depths and the composite VWC curves. As VWC is decreasing due to drying of the soil from specific depths or the composite VWC, a change in slope from a steeper to a less steep slope indicates that either the soil is no longer providing all the water the plant needs (a key to irrigate), or the environmental demand (ET_o) has decreased and the soil is still providing all the water the plant needs. More abrupt increases in VWC are due to rainfall or irrigation.

Each set of graphs and charts in **Figure 3a-c** includes a graph of individual sensors at depths from 2 in. to 46 in., a composite graph or summary graph that sums all VWC from all the individual sensors, a chart showing calculated water use or gain on a daily basis from this VWC data, and a chart showing estimated reference evapotranspiration (ETo, grass) using data from a nearby weather station. These graphs depict sensors that were located in the rain-fed (non-irrigated) treatment. Also, on the composite graph, there are arrows corresponding to the date irrigations were initiated for the specified irrigation protocols so comparisons could be made to the moisture conditions at the time of initiation.

Root activity at Site 1 (**Figure 3a**), as denoted by the diurnal variation in the rain-fed treatment of the individual sensors graph, indicates water being removed down to a depth of 46 inches by early July during the growing season. A significant reduction in slope occurred around 20 June, but occurred at the same time where the ET_o demand dropped significantly. After each successive rain event on the composite graph, the slope of the moisture withdrawal appears to get smaller but no significant reduction occurred in slope between rain events until potentially 25 July. Also, the amplitude of the diurnal variation appeared to be reduced after 6 July compared to before 6 July, at which that time moisture was being removed at the 46 inch depth. Irrigations for protocols Irr 2, 3, 4, and 5 were initiated on 15 July when Ta >= 95°F and SWP <= -80 kPa, earlier than 25 July and they all yielded higher than the rain-fed.

At Site 2 (**Figure 3b**), root activity developed down to at least 46 inches by 20 July as denoted by the diurnal variation in the rain-fed treatment of the individual sensors graph. After rain events, the slope of the moisture withdrawal would be steep and then it would change to a lower slope before another rain event occurred. This lower slope was likely not too low of a slope and/or the plants were using some moisture from depths deeper than 46 inches since the rain-fed treatment yielded as well as the irrigated treatments.

At Site 3 (**Figure 3c**), root activity developed down to a depth of 30 inches in late July as denoted by the diurnal variation in the rain-fed treatment of the individual sensors graph. The slope of the moisture withdrawal significantly changed to a lower slope just before and just after a couple of small rain events occurring around 1 Aug. Irrigation protocol Irr 5 received an irrigation on 3 Aug. and yielded similarly to irrigation protocols, Irr 1, 2, 3, and 4, and they all yielded higher than the rain-fed. So, irrigation protocol Irr 5 yielding better than the rain-fed supports the interpretation of a significant lower slope change as an indicator of when to irrigate.

From the data for Sites 1 and 2, it appears that the key to irrigate (when the slope of the moisture withdrawal significantly changes to a lower slope) was not as obvious when root activity was down to at least 46 inches. At Site 3 where the rooting depth was limited to 30 inches (less than the 46 inch depth of the sensor probe), the significant change to a lower slope is more evident.

Summary

In 2018, dual threshold protocols Irr 4 and Irr 5 had less water applied to them than to the single threshold protocols Irr 1 and Irr 2. The dual threshold protocol Irr 4 maintained yields and net returns at each site. Scheduling irrigations with a VWC moisture probe using the irrigation key (an abrupt change in the slope of the moisture withdrawal to a lower slope) was more obvious at Site 3 when the rooting depth appeared to be limited to 30 inches.

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IMPACTS AND BENEFITS TO MISSISSIPPI SOYBEAN PRODUCERS

The overall effort of this study is to more timely apply water to maximize yields economically while using the least amount of water. Results from this project will help determine "trigger value" recommendations on Mississippi soils of when to initiate irrigations with maximum temperature observations/forecasts and soil water potential & volumetric water content sensors, thus potentially saving an irrigation (water and pumping costs) on all irrigated soybean acreage. One less furrow irrigation will save approximately 3 acre-inches and would reduce irrigation operation costs by approximately $9.50/acre.

END PRODUCTS-COMPLETED OR FORTHCOMING

1. A publication will be forthcoming after conclusion of the project.

2. Pringle, III, H. C., Falconer, L. L., Fisher, D. K., Krutz, L. J., & Krutz, L. J. (2019). Soybean Irrigation Initiation in Mississippi: Yield, Soil Moisture, and Economic Response. *Applied Engineering in Agriculture*, *35*(1), 39–50. https://doi.org/10.13031/aea.12883

Graphics/Tables

Table 1. Variety, planting date, irrigation system, and harvest date for study areas in 2018.

Location	Variety	Plant Date	Irrigation System	Harvest Date
Site 1	P45A23	20 Apr	Sprinkler	9 Oct
	P48A60			
Site 2	CZ4748	2 May	Furrow	21 Sep[a], 9 Oct
	HBK4950			
Site 3	CZ4748	18 May	Furrow	9 Oct
	HBK4950			

[a]Harvested Reps 2 and 4, CZ4748, on 21 Sep.

Table 2. Rainfall and Air Temperature for select periods of the crop year for study areas in 2018.

SITE[A]	1	2, 3	STONEVILLE HISTORICAL[B]
	Rainfall (inches)		
OCTOBER-MARCH	32.7	32.9	28.4
APRIL	4.9	5.0	5.2
MAY	1.7[C]	1.7[C]	4.7
JUNE	2.9	3.0	3.7
JULY	2.6	3.2	3.8
AUGUST	7.8[C]	6.8[C]	2.8
SEPTEMBER	6.4[C]	4.9	3.2
	Average Max/Min Air Temperature (°F)		
APRIL	70[C]/47[C]	70[C]/49[C]	75/53
MAY	89[C]/67[C]	90[C]/68[C]	83/62
JUNE	91/72[C]	91/71	90/69
JULY	92/73	91/73	92/72
AUGUST	91/70	91/70	92/70
SEPTEMBER	89/69[C]	89/70[C]	87/64

[A] Site 1 – Bosket VFSL/Commerce SiCL, Stoneville, MS; Site 2 – Sharkey SiCL, Stoneville, MS; Site 3 – Sharkey SiCL, Stoneville, MS
[B] Historical average for Stoneville, Mississippi (Rainfall, 105 years; Air temperature, 90 years, located within 2 miles of each site.
[C] Values are greater than or less than one standard deviation of average.

Table 3. Estimated irrigation and hauling cost and soybean price for furrow and sprinkler irrigation studies in 2018.

		Furrow	Sprinkler
		2018	2018
Irrigation Cost ($ acre^{-1}) [a]		$83.84	$ 103.72
Water Lifting Cost ($ acre^{-1} In.$^{-1}$)		$ 2.60	$ 4.62
Haul Soybean ($ bu^{-1})		$ 0.27	$ 0.27
Soybean Price ($ bu^{-1}) [b] Site[c]	1		$8.01
	2	$ 7.87	
	3	$ 8.01	

[a] Irrigation cost excluding water lifting cost - Mississippi State University Budget Report.
[b] Greenville Farmers Grain Terminal average quote USDA-AMS JK-GR-110 for week of harvest (Site 1 – 8-12 October, 2018; Site 2 – 1-5 October - 2018; Site 3 – 8-12 October 2018).
[c] Site 1 – Bosket VFSL/Commerce SiCL, Stoneville, Mississippi; Site 2 – Sharkey SiCL, Stoneville, Mississippi; Site 3 – Sharkey SiCL, Stoneville, Mississippi

Table 3. Irrigation dates, total water applied by irrigation treatment, yield, and apparent water use efficiency in sprinkler-irrigated irrigation study, Delta Research and Extension Center, Stoneville, MS, 2018.

a). Sprinkler irrigated, Bosket VFSL/Commerce SiCL soil (Site 1) , planted 4/20/2018.

	Irr 1	Irr 2	Irr 3	Irr 4	Irr 5	Rain-fed	Average[b,d]
Irrigation protocol	----------	-----------	--kPa--	-----------	-----------		
	-50	-80	---	---	---	---	
if Ta<95°F SWP<=	---	---	-80	-100	-100	---	
if Ta>=95°F SWP<=	---	---	-50	-50	-80	---	
Irrigation dates	6/7	---	---	---	---	---	
	6/12	---	---	---	---	---	
	7/1	---	---	---	---	---	
	7/12	7/14	7/14[f,g]	7/14[f]	7/14[f]	---	
	7/18	7/18	7/18[g]	7/18[g]	7/18	---	
	7/26	7/26	7/26[g]	---	---	---	
	8/6	8/6	8/6[g]	8/6[g]	---	---	
Water pumped (in/acre)							
	5.2	3.0	3.0	2.3	1.5	0	
Yield (bu/acre)							
P45A23	74	75	76	75	71	67	73b
P48A60	82	85	82	80	78	70	80a
Average[c]	78ab	80a	79a	78ab	75b	69c	
Net Return ($ acre^{-1})							
P45A23	$448	$464	$474	$469	$441	$416	$452b
P48A60	$510	$539	$521	$507	$496	$440	$502a
Average[e]	$479ab	$501a	$497ab	$488ab	$469b	$428c	
WUE (bu/in)							
P45A23	1.38	2.63	3.06	3.62	2.72	---	
P48A60	2.33	4.86	4.07	4.46	5.53	---	

[a] Irrigations were applied to the later maturing variety, HBK4950, only.
[b] Variety treatment yield means followed by a common letter range are not different ($p<0.05$; LSD = 2.3bu acre^{-1}).
[c] Irrigation treatment yield means are not different ($p<0.05$; LSD = 4.2bu acre^{-1}).
[d] Variety treatment return means followed by a common letter range are not different ($p<0.05$; LSD = $17.84 acre^{-1}).
[e] Irrigation treatment return means followed by a common letter range are not different ($p<0.05$; LSD = $32.50 acre^{-1}).
[g] Irrigation was triggered due to Ta>=95°F and corresponding SWP threshold value.
[f] Irrigation was triggered due to Ta<95°F and corresponding SWP threshold value.

Table 3 continued. Irrigation dates, total water applied by irrigation treatment, yield, and apparent water use efficiency in furrow-irrigated irrigation study, Delta Research and Extension Center, Stoneville, MS, 2018.

b). Furrow irrigated, Sharkey SiCL soil (Site 2), planted 5/2/2018.

	Irr 1	Irr 2	Irr 3	Irr 4	Irr 5	Rain-fed	Average[b,d]
Irrigation protocol	----------	-----------	--kPa--	-----------	-----------		
	-50	-80	---	---	---	---	
if Ta<95°F SWP<=	---	---	-80	-120	-120	---	
if Ta>=95°F SWP<=	---	---	-50	-50	-80	---	
Irrigation dates	6/13	---	---	---	---	---	
	7/1	7/5	---	---	---	---	
	7/15	---	7/15[f]	7/15[f]	7/15[f]	---	
	7/27	---	---	---	---	---	
	8/6	8/3	8/3[g]	---	---	---	
	8/16	---	8/16[g]	---	---	---	
	9/1[a]	9/1[a]	---	---	---	---	
Water pumped (in/acre)							
CZ4748	13.6	7.3	10.6	4.0	4.0	0	
HBK4950	17.2	10.9	10.6	4.0	4.0	0	
Yield (bu/acre)							
CZ4748	69	71	71	70	68	70	70b
HBK4950	84	82	82	82	82	81	82a
Average[c]	77	76	76	76	75	75	
Net Return ($ acre^{-1})							
CZ4748	409	436	427	434	424	446	429b
HBK4950	506	509	508	526	527	532	518a
Average[e]	458c	473abc	468bc	480ab	476abc	489a	
WUE (bu/in)							
CZ4748	-0.01	0.16	0.11	-0.04	-0.38	---	
HBK4950	0.14	0.06	0.05	0.15	0.19	---	

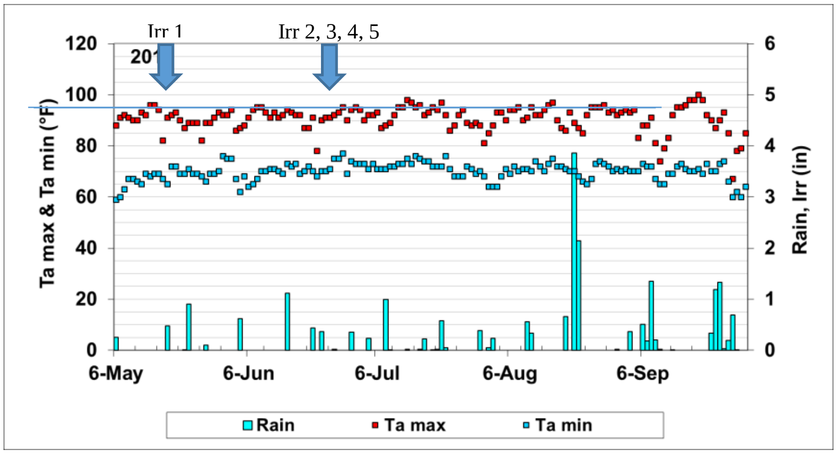
[a] Irrigations were applied to the later maturing variety, HBK4950, only.
[b] Variety treatment yield means followed by a common letter range are not different ($p<0.05$; LSD = 1.6 bu acre^{-1}).
[c] Irrigation treatment yield means are not different ($p<0.05$; LSD = ns).
[d] Variety treatment return means followed by a common letter range are not different ($p<0.05$; LSD = $12.27 acre^{-1}).
[e] Irrigation treatment return means followed by a common letter range are not different ($p<0.088$; LSD = $21.26 acre^{-1}).
[g] Irrigation was triggered due to Ta>=95°F and corresponding SWP threshold value.
[f] Irrigation was triggered due to Ta<95°F and corresponding SWP threshold value.

Table 3 continued. Irrigation dates, total water applied by irrigation treatment, yield, and apparent water use efficiency in furrow-irrigated irrigation study, Delta Research and Extension Center, Stoneville, MS, 2018.

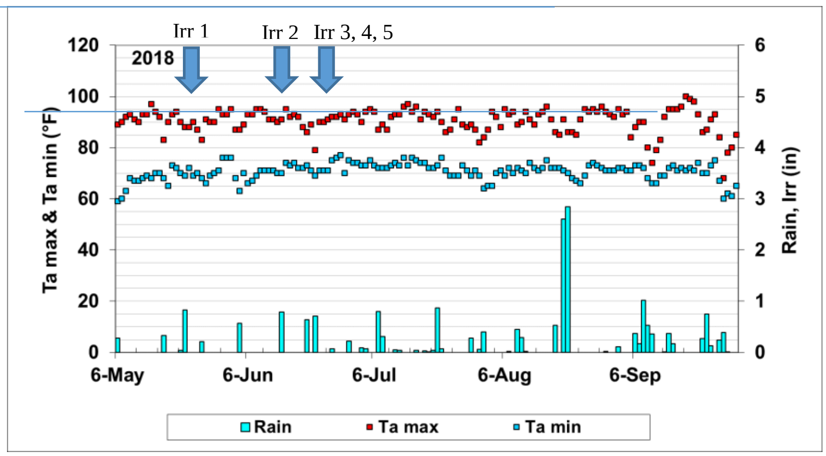
c) Furrow irrigated, Sharkey SiCL soil (Site 3), planted 5/18/2018.

	Irr 1	Irr 2	Irr 3	Irr 4	Irr 5	Rain-fed	Average[b,d]
Irrigation protocol	----------	-----------	--kPa--	-----------	-----------		
	-50	-80	---	---	---	---	
if Ta<95°F SWP<=	---	---	-80	-120	-120	---	
if Ta>=95°F SWP<=	---	---	-50	-50	-80	---	
Irrigation dates	7/4	7/5	---	---	---	---	
	7/18	7/18	7/15[f]	7/15[f]	---	---	
	7/27	7/27	---	---	---	---	
	8/6	---	---	---	8/3[g]	---	
	---	8/14	8/14[g]	8/14[g]	---	---	
	9/1[a]	9/1[a]	---	---	---	---	
Water pumped (in/acre)							
CZ4748	11.4	13.7	8.3	8.3	7.3	0	
HBK4950	16.1	18.4	8.3	8.3	7.3	0	
Yield (bu/acre)							
CZ4748	69	68	69	70	72	67	69b
HBK4950	76	76	78	77	76	72	76a
Average[c]	72a	72a	73a	74a	74a	69b	
Net Return ($ acre^{-1})							
CZ4748	420	409	426	436	451	433	429b
HBK4950	461	459	500	494	486	471	479a
Average[e]	441b	434b	463a	465a	469a	452a	
WUE (bu/in)							
CZ4748	0.19	0.10	0.23	0.37	0.65	---	
HBK4950	0.25	0.25	0.78	0.69	0.60	---	

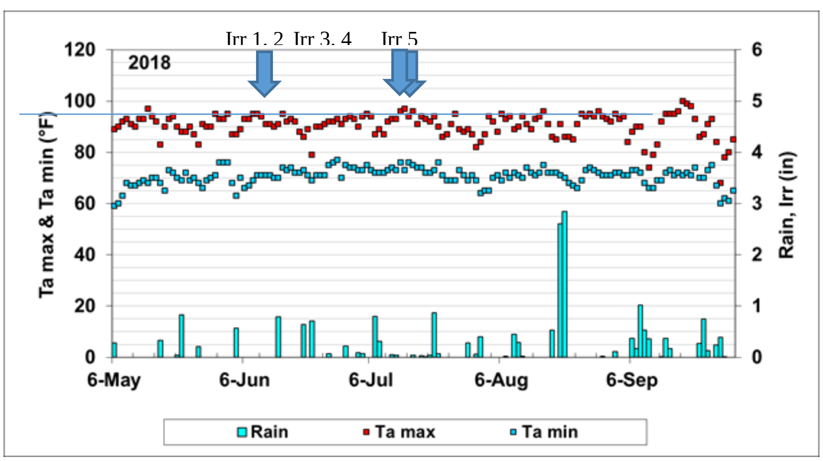
[a] Irrigations were applied to the later maturing variety, HBK4950, only.
[b] Variety treatment yield means are not different ($p<0.05$; LSD = 1.3bu acre^{-1}).
[c] Irrigation treatment yield means are not different ($p<0.05$; LSD = 2.2bu acre^{-1}).
[d] Variety treatment return means are not different ($p<0.05$; LSD = \$9.99 acre^{-1}).
[e] Irrigation treatment return means are not different ($p<0.05$; LSD = \$17.30 acre^{-1}).
[g] Irrigation was triggered due to Ta>=95°F and corresponding SWP threshold value.
[f] Irrigation was triggered due to Ta<95°F and corresponding SWP threshold value.



a) Bosket/Dubbs silt loam (Site 1).

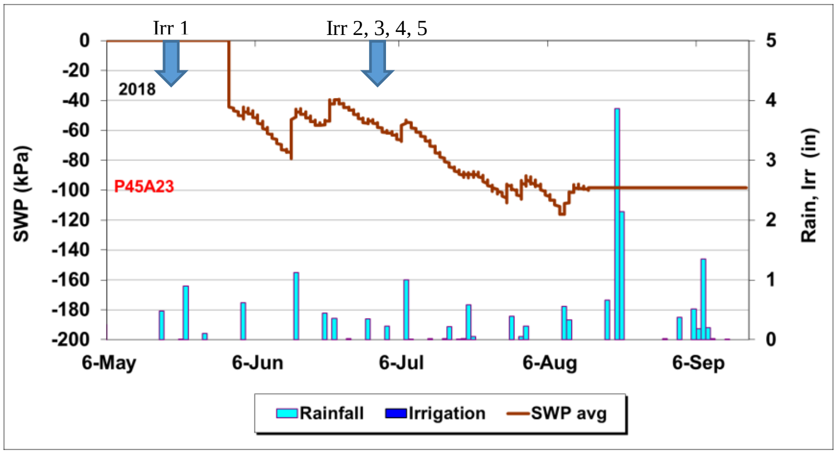


b) Sharkey silty clay (Site 2).

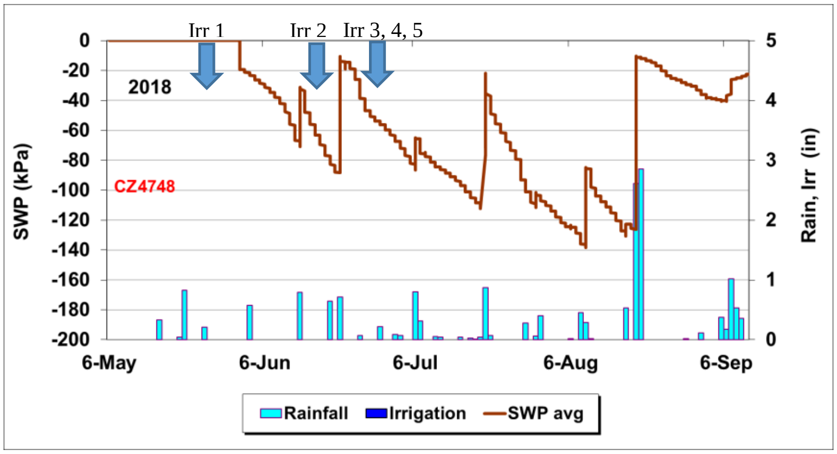


b) Sharkey silty clay (Site 3).

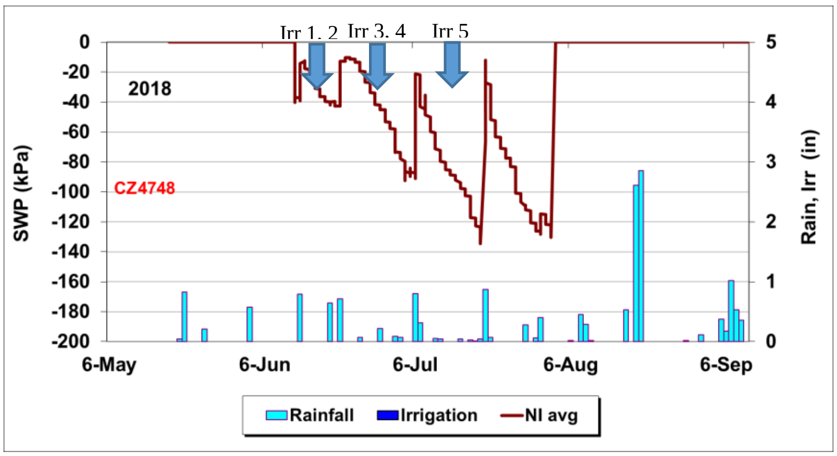
Figure 1. Weather variables (air temperature and rainfall) during growing season at Delta Research and Extension Center, Stoneville, Mississippi, 2018.



a) Bosket/Dubbs silt loam (Site 1).

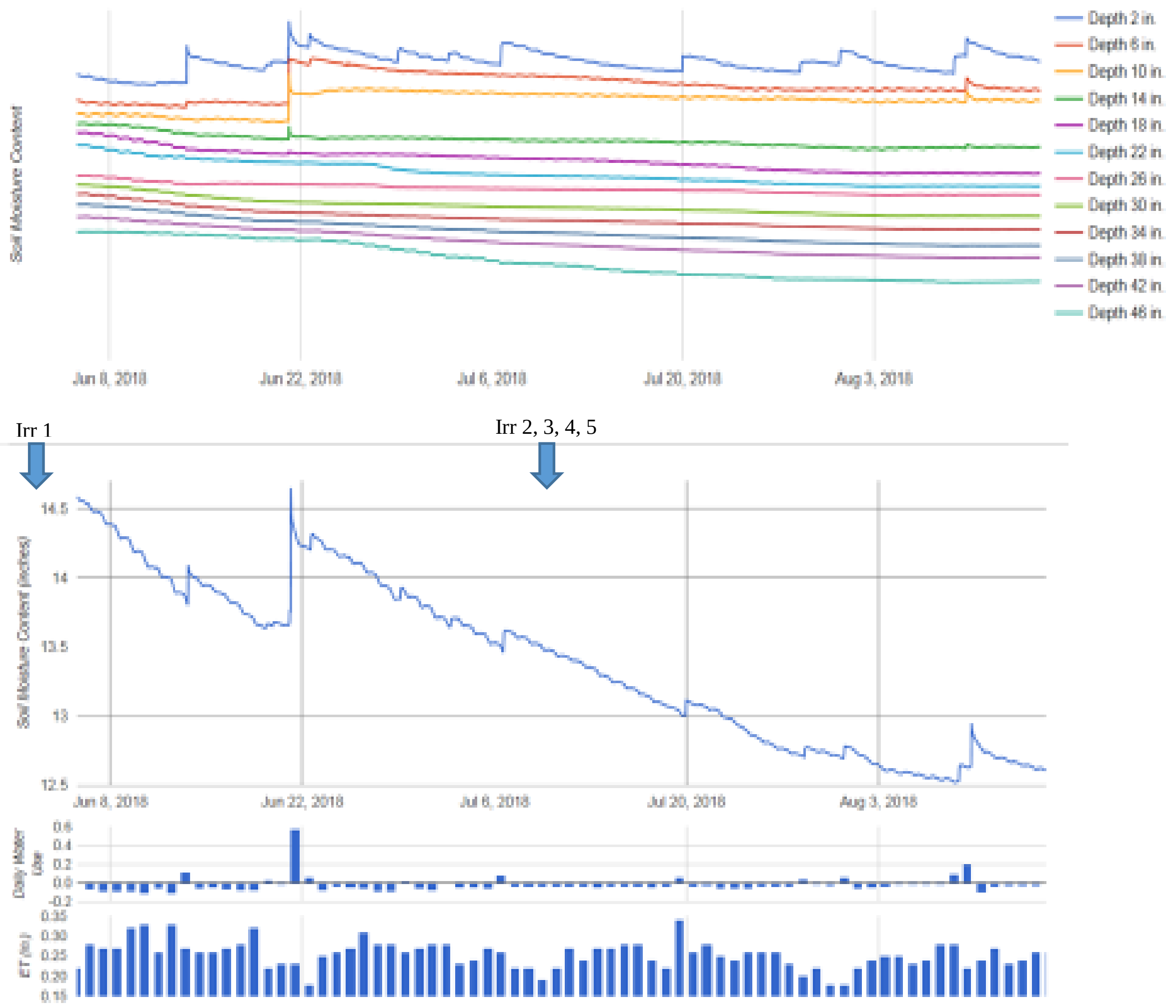


b) Sharkey silty clay (Site 2).



c) Sharkey silty clay (Site 3)

Figure 2. Soil water potential (SWP, Watermark) observations for rain-fed (non-irrigated) soybean during growing season at Delta Research and Extension Center, 2018.



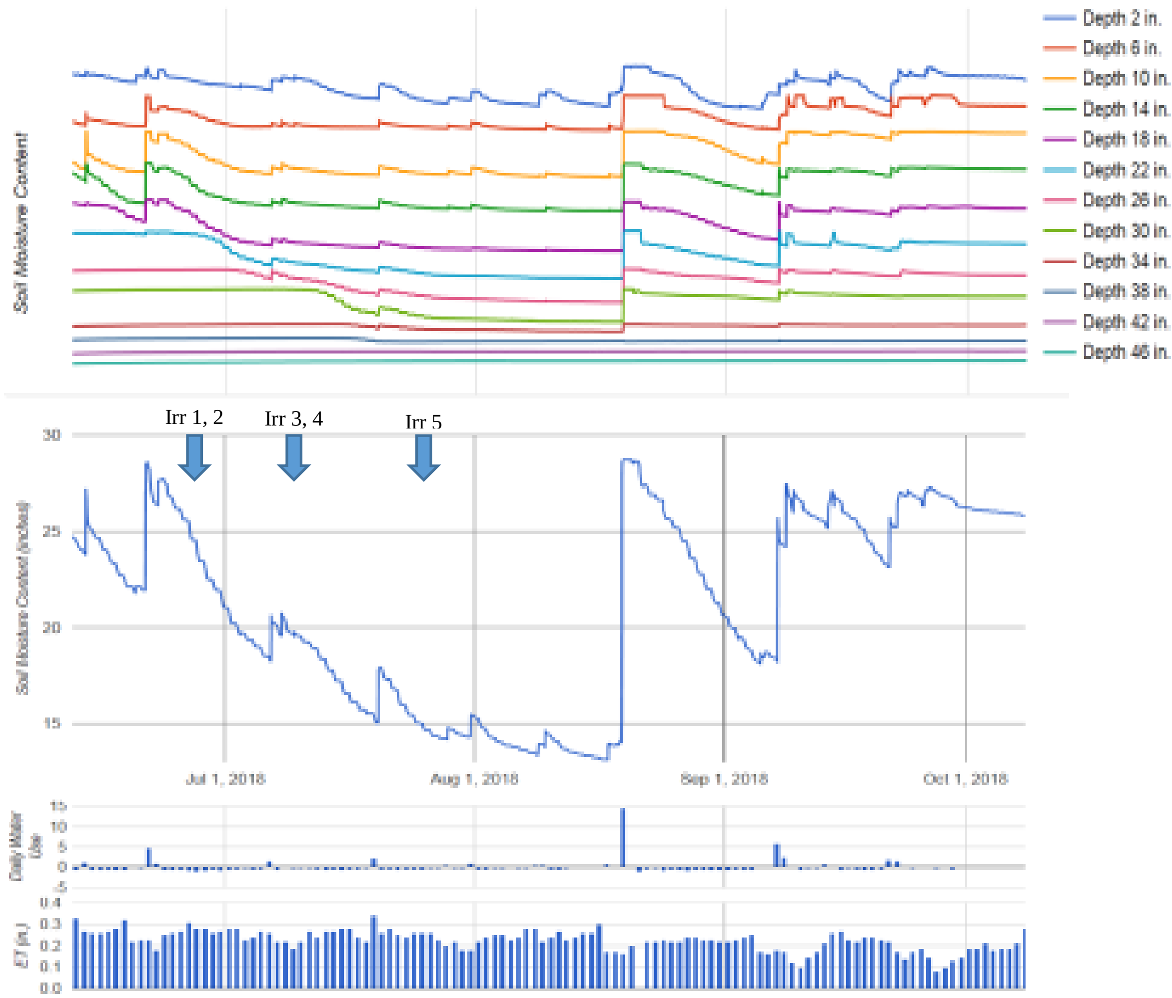
a) Bosket very fine sandy loam/Commerce silty clay loam (Site 1).

Figure 3. Volumetric water content (VWC, Sentek) observations for rain-fed (non-irrigated) soybean during growing season at Delta Research and Extension Center, 2018.

b) Sharkey silty clay loam (Site 2).

Figure 3 continued. Volumetric water content (VWC, Sentek) observations for rain-fed (non-irrigated) soybean during growing season at Delta Research and Extension Center, 2018.

[WWW.MSSOY.ORG](http://www.mssoy.org) ➡ MSPB WEBSITE WITH UP-TO-DATE SOYBEAN PRODUCTION INFORMATION



c) Sharkey silty clay loam (Site 3)

Figure 3 continued. Volumetric water content (VWC, Sentek) observations for rain-fed (non-irrigated) soybean during growing season at Delta Research and Extension Center, 2018.