Soybean Irrigation Initiation Timing Using Evapotranspiration and Soil Moisture Sensor Cues

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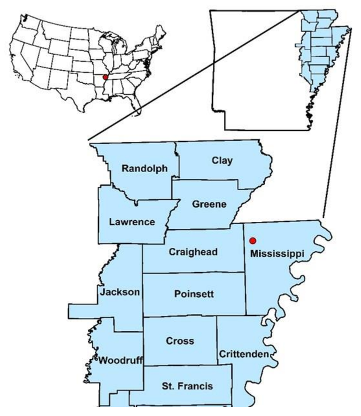
Introduction: Soybean (*Glycine max*) is an important cash crop across the Midsouth. About 3.3 million acres of soybeans were planted in Arkansas in 2014 with an average yield of 48 bushels per acre, or 3228 kg/ha. 65% of the soybean acreage in Arkansas is irrigated. With proper application timing, irrigation can increase yield. Groundwater is the primary source for irrigation water for Arkansas row crops; however, aquifers are being used at an unsustainable rate.

Problem Statement: Expanded use of irrigation management tools is needed to improve irrigation management efficiency. Current recommendations have not been validated in northeast Arkansas.

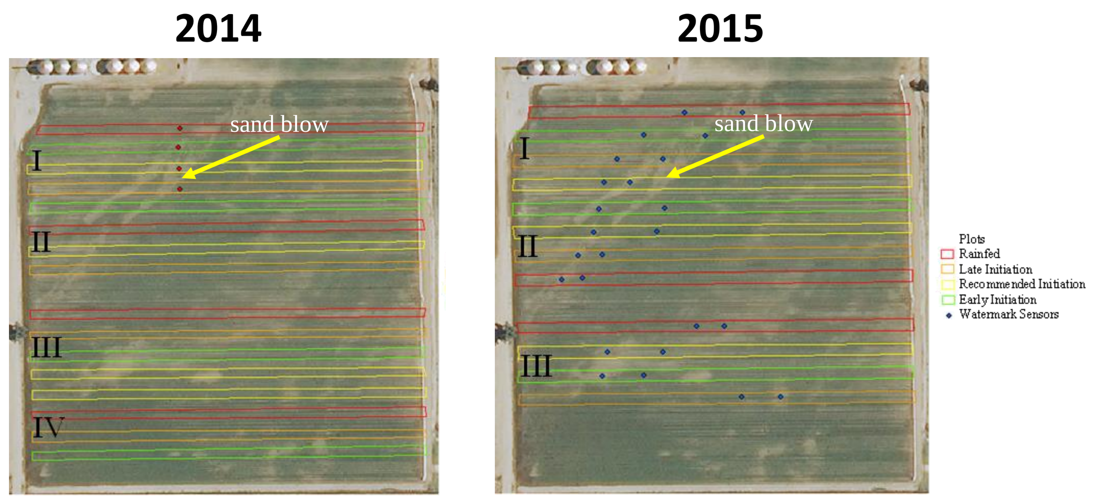


Objectives:
1) Develop irrigation initiation timing cues from weather station data & field-specific soil moisture measurements in sandy soils.
2) Use plant maturity measures and ET to cue irrigation initiation.
3) Quantify crop and insect pest response to irrigation.

Material & Methods: The research site was a commercial farm located in Mississippi County, Arkansas. A 40 acre furrow irrigated field was used with a coarse sand/sandy loam soil type. The field was designed as an irrigation initiation timing study, with an early, recommended, and late start, and a rainfed control. The experiment was arranged in a randomized complete block with 4 replications in 2014 and 3 replications in 2015. An ET gauge, soil moisture sensors of varying depths and locations in relation to soil textural zone, and a weather station was installed to determine timing and effectiveness of irrigation events.

Treatments:
1) Early Start (ET Deficit = 3 cm)
2) Recommended Start (ET Deficit = 6.1 cm)
3) Late Start (ET Deficit = 7.6 cm)
4) Rainfed

Early Soybean Production System:
2014 Asgrow 4633 (MG IV) planted 24 April
2015 Asgrow 3735 (MG III) planted 23 April
19 cm twin rows on raised beds spaced at 1 m



Scheduling Irrigation using an Atmometer (ET Gauge) for Arkansas Soybeans

Table 1. Allowable Deficits-Soybeans

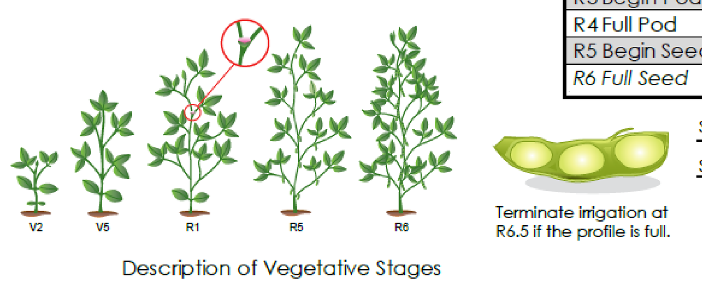
Predominant Soil	Flood, Furrow, Border (inches)	Sprinkler/ Center Pivot (inches)
Clay	2	1.5
Silt loam w/pan	1.75	1.25
Silt loam wo/pan	2.5	2
Sandy loam	2.25	1.75
Sandy	2	1.5

Use alfalfa ET reference #54 canvas for this chart.

Table 2. Atmometer Setting — Set Atmometer to this value based on soil type

Move to this value if canopy closes before growth stage is reached

Stage of Growth	1.25	1.5	1.75	2	2.25	2.5
V1 1st Node	5.4	6.5	7.6	8.7	9.8	10.9
V2 2nd Node	3.1	3.8	4.4	5.0	5.6	6.3
V3 3rd Node	2.1	2.5	2.9	3.3	3.8	4.2
V4	1.9	2.3	2.7	3.1	3.5	3.8
V5	1.7	2.0	2.3	2.7	3.0	3.3
V6	1.6	1.9	2.2	2.5	2.8	3.1
R1 Begin Bloom	1.5	1.8	2.1	2.4	2.6	2.9
R2 Full Bloom	1.4	1.7	1.9	2.2	2.5	2.8
FULL CANOPY	**1.3**	**1.6**	**1.8**	**2.1**	**2.4**	**2.6**
R3 Begin Pod	1.3	1.6	1.8	2.1	2.4	2.6
R4 Full Pod	1.3	1.6	1.8	2.1	2.4	2.6
R5 Begin Seed	1.3	1.6	1.8	2.1	2.4	2.6
R6 Full Seed	1.3	1.6	1.8	2.1	2.4	2.6

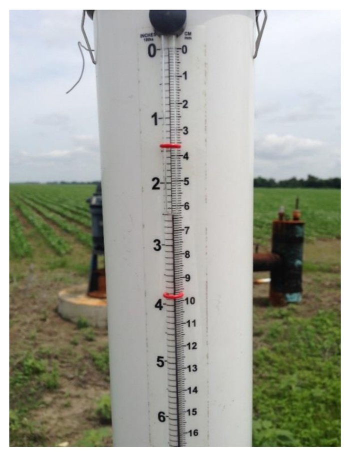


Step 1. Select Allowable Deficits based on soil type and irrigation system (Table 1).

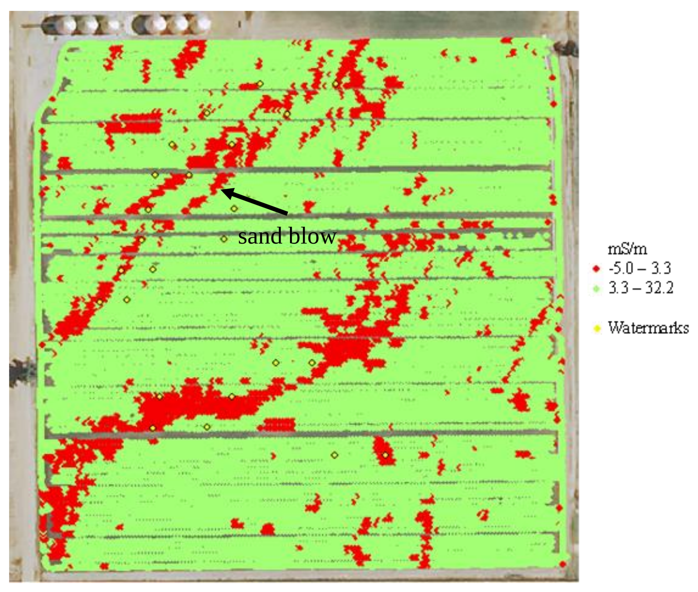
Step 2. Select deficit based on growth stage of crop (Table 2). Set upper orange ring on gauge sight tube to water level just after last irrigation or when the profile is full (such as a rain that fills the soil profile and brings deficit to zero). For example for furrow irrigated clay soil at the V4 stage, the deficit is 3.1 inches. As growth stage changes, adjust deficit accordingly on the atmometer.

Stage of Growth	Allowable Deficit (cm)
V1 1st Node	24.9
V2 2nd Node	14.2
V3 3rd Node	9.7
V4 4th Node	8.9
V5 5th Node	7.6
V6 6th Node	7.1
R1 Begin Bloom	6.6
R2 Full Bloom	6.4
Full Canopy	6.1
R3 Begin Pod	6.1
R4 Full Pod	6.1
R5 Begin Seed	6.1
R6 Full Seed	6.1

Current Cooperative Extension recommendations for irrigation scheduling in soybean using an atmometer (Henry et al., 2014); recommended irrigation timing for a furrow irrigated sandy loam soil is highlighted.

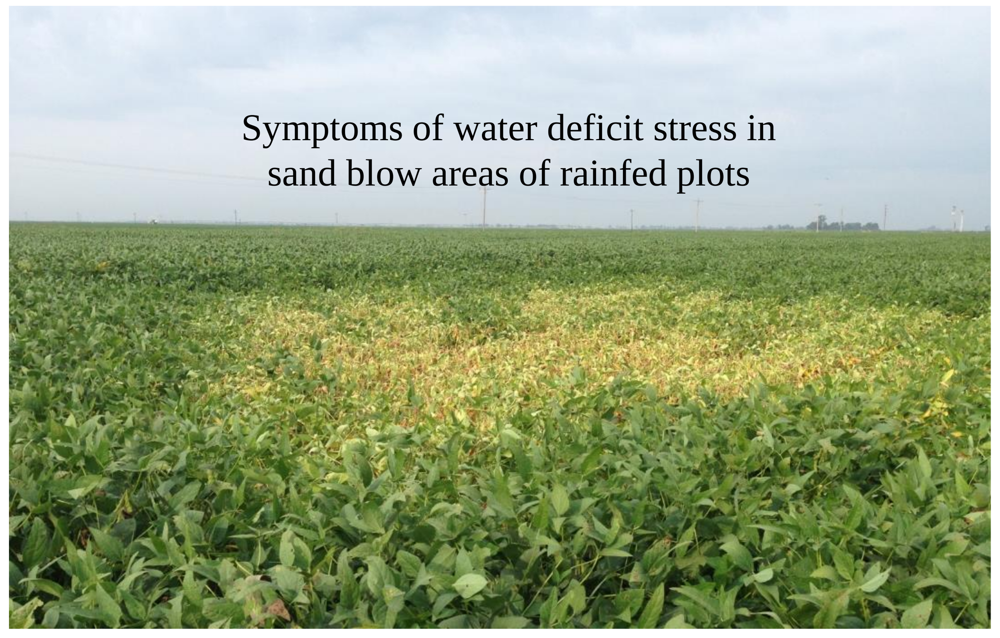


An atmometer (left) was installed to complement weather station data. The producer punched 15/16" holes in the poly-pipe in each row for furrow irrigation (middle). A Veris 3150 dual depth (Veris Technologies; Salina, KS) soil surveyor was used to map EC of the study site (right).



Soil EC map (top 90 cm) for the field site. Red signifies sand blows, green signifies sandy loam.

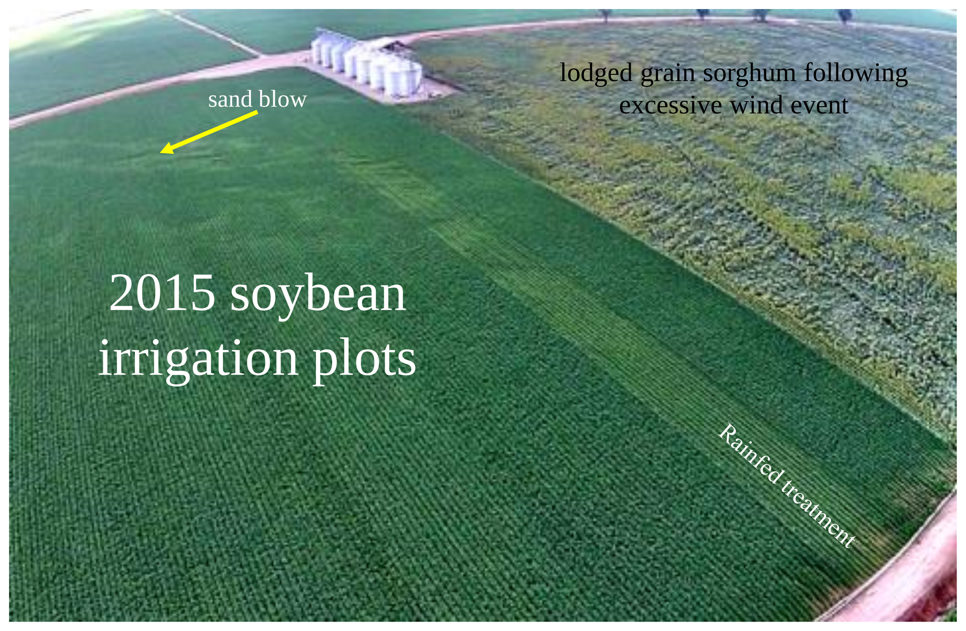
Pest Monitoring: In each treatment, insects were sampled periodically to determine the possible effects of irrigation timing on insect pest infestations. No significant insect pest effects were measured.

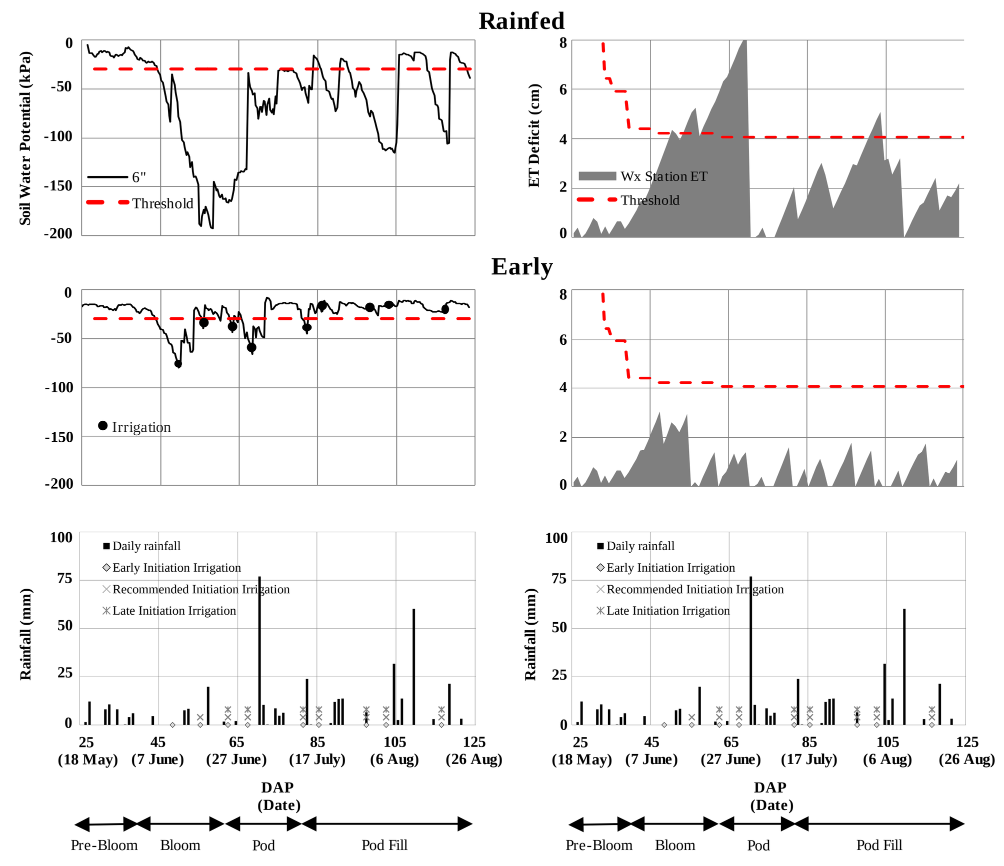


Results: Weather data was collected throughout the season using a weather station 1 km from the study site. Also, the crop was monitored for growth and pest response on a weekly basis. As expected, growth was greater in earlier initiated irrigation treatments. Alternatively, there was no pest response to irrigation treatments. Yield was determined using catch weights from load cells on the producers' grain cart, obtained yield monitor data, and 1 m grab samples taken from the field 2 days before machine harvest.

Variable and Year	May	June	July	Aug.	Season
Mean Air Temperature			°C		
2014	21.7	25.3	24.3	26.2	24.4
2015	21.3	26.3	27.5	24.5	24.9
1981-2010	21.3	25.8	27.3	26.4	25.2
Total Precipitation			cm		
2014	11.5	16.2	11.9	20.8	60.4
2015	16.0	4.4	17.8	13.4	51.7
1981-2010	13.6	10.1	10.3	6.0	40.0

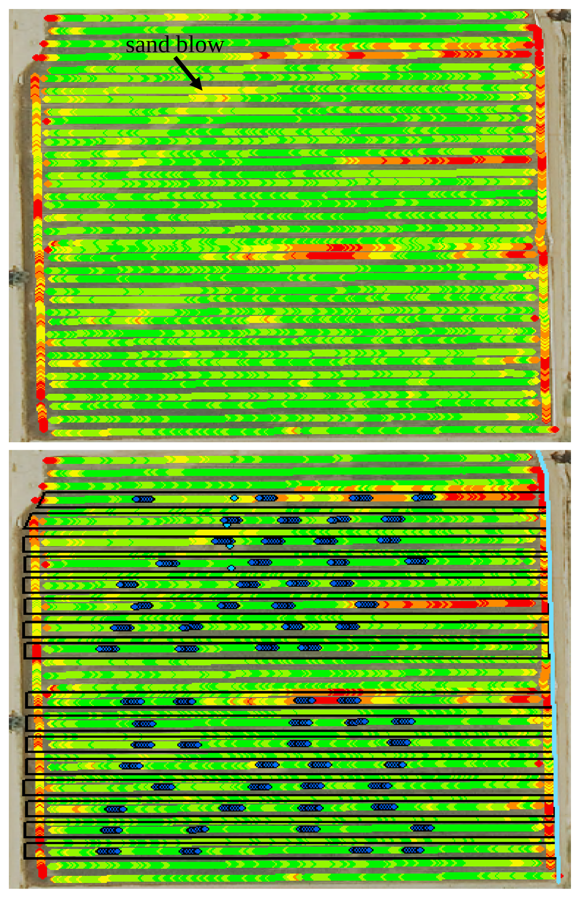
Seasonal temperatures and precipitation at Wildy Family Farms compared to long-term (30 yr) averages from Keiser, AR

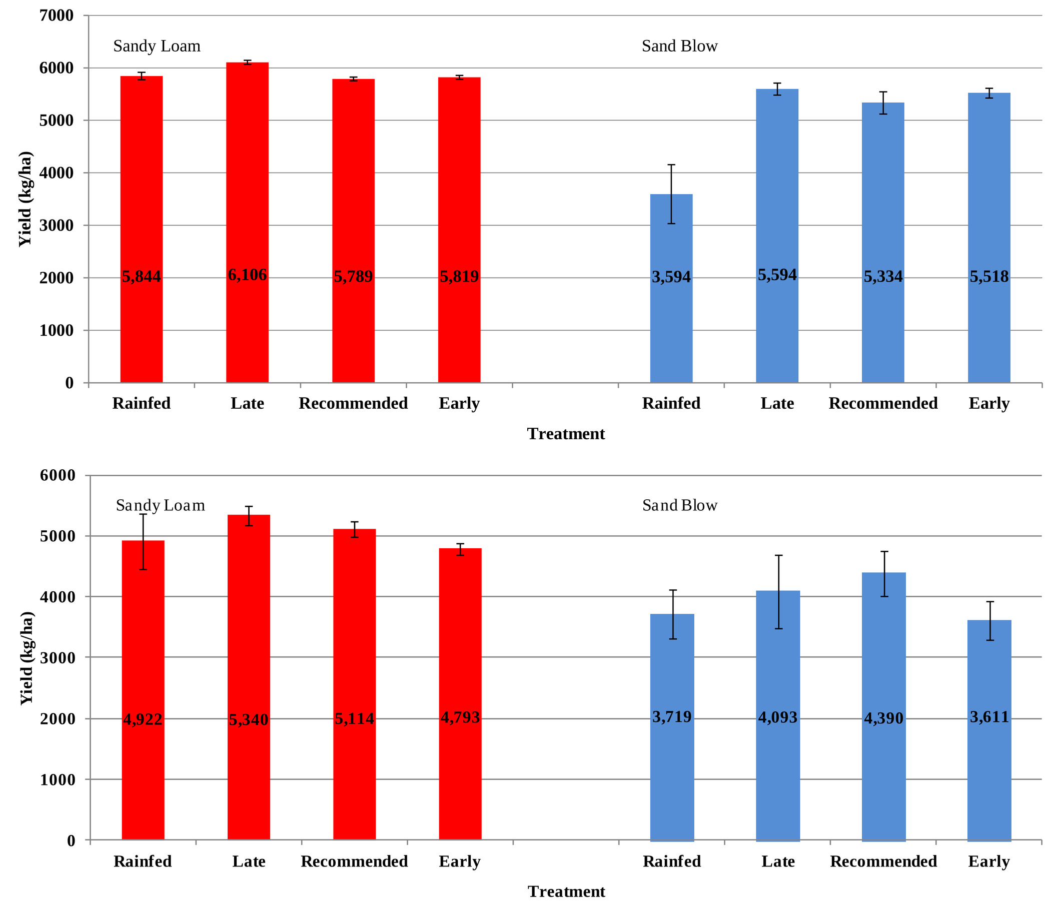




The watermark sensor readings at 15 cm were averaged and graphed on the left, including a threshold of -30 kPa. Accumulated ET deficit is plotted on the right with its accompanying threshold based on extension recommendations. Rainfall and irrigation events are plotted below to show the uptake of the water into the soil.

Mean yields from georeferenced yield monitor (YM) sample points selected in sandy loam and sand blow soils, showing that irrigation boosted yield in late initiated sandy loam soil and suppressed yield in rainfed sand blows in 2014, while no differences existed in 2015.





Soil Texture	Irrigation treatment	2014 Main stem length	2014 Branch stem length	2014 Lodging Rating	2015 Main stem length	2015 Branch stem length	2015 Lodging Rating
		cm	cm	0-5	cm	cm	0-5
Sandy Loam	Rain-fed	72.5	34.3	**0.3**	59.7	22.1	**0.0**
	Late	68.7	26.9	**0.5**	69.3	36.6	**1.0**
	Recommended	80.3	32.3	**1.5**	70.6	41.7	**2.3**
	Early	76.5	37.1	**1.3**	65.8	46.7	**2.7**
	LSD_{05}	6.6	7.1	1.0	3.6	5.6	0.7
	P > F	<0.01	0.03	0.05	<0.01	<0.01	<0.01
Sand Blow	Rain-fed	52.7	20.8		46.2	12.4	
	Late	49.4	20.3		56.1	21.1	
	Recommended	63.7	30.5		57.1	27.2	
	Early	76.4	39.3		57.4	29.7	
	LSD_{05}	5.1	4.3		4.3	6.1	
	P > F	<0.01	<0.01		<0.01	<0.01	

Increased lodging was associated with treatments that received more irrigation; significant differences in main stem and branch stem lengths were detected in these treatments.

There was no yield penalty with delayed irrigation initiation prior to pod fill

ET-based irrigation scheduling is practical for Midsouth soybean production

Conclusions: Water is "a resource that must be better priced" (Dyson, 1999). The 2014 Arkansas water plan indicates that 10.2 billion m^3 will be needed for irrigation in 2050, while only 2.2 billion m^3 of groundwater will be available. More efficient use of irrigation water must become priority. This study showed that a reduced number of irrigations is possible on the front end with no yield difference and that a possible yield penalty exists for over-watering. The use of ET gauge/soil moisture sensors can help accomplish this; however, more work is needed on different soils.

Acknowledgments

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Arkansas Soybean Promotion Board