Irrigation Water Management Practices that Reduce Water Requirements for Mid-South Furrow-Irrigated Soybean

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Abstract

Withdrawal for agricultural uses has decreased water levels in the Mississippi Alluvial River Valley aquifer (MARVA), and Mississippi state regulators have responded by requiring withdrawal permits, establishing permitted withdrawal limits, and instituting required minimum levels of irrigation water use efficiency (IWUE) practices. The objective of this research was to determine the effect of integrating irrigation water management (IWM) practices—including computerized hole selection (CHS), surge flow irrigation (SURGE), and sensor-based irrigation scheduling—on irrigation water use, soybean grain yield, IWUE, and net returns above irrigation costs at the production scale. The experiment was conducted in the Prairie region of Arkansas and the Delta region of Arkansas and Mississippi from 2013 through 2015. The research consisted of 20 paired fields, with the same cultivar, soil type, planting date, and management practices. One field was randomly assigned as the control (conventional, CONV) and the other was instrumented with CHS, SURGE, and soil moisture sensors, that is, IWM. Flowmeters were installed in the inlets to both fields, and the farmers provided yield data. Soybean grain yield averaged 69.0 bu/acre and did not differ between CONV and IWM (P = 0.6703). Relative to CONV, IWM reduced water use 21% (P = 0.0198) and increased IWUE 36% (P = 0.0.0194). Net returns for soybean production above irrigation costs were not different between CONV and IWM, even when pumping depth ranged from 18 ft to 400 ft and diesel costs ranged from \$1.60/gal to \$3.70/gal ($P \geq 0.5376$). These results demonstrate that implementation of integrated IWM at the production scale reduces the demand on depleted groundwater resources without adversely affecting soybean grain yield or on-farm profitability.

Groundwater from the MARVA is the primary irrigation source in the Mid-South where, during the past three decades, the number of agricultural wells has increased exponentially (Mississippi Dep. of Environ. Quality, pers. comm., 20 Apr. 2017). Agricultural withdrawal from MARVA exceeds the aquifer recharge rate, thus causing a decline in groundwater levels (Guzman et al., 2014). Regulators have responded to the overdraft on MARVA by

Crop Management

Core Ideas

- Irrigation water management practices reduced total water use 21%.
- Irrigation water management practices increased irrigation water use efficiency 36%.
- Sensor-based scheduling reduced irrigation by 50%.

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Received 3 Apr. 2017.
Accepted 30 May 2017.

Abbreviations: CHS, computerized hole selection; CONV, conventional; IWM, irrigation water management; IWUE, irrigation water use efficiency; MARVA, Mississippi Alluvial River Valley aquifer; MG, maturity group; SURGE, surge flow irrigation.

Conversions: For unit conversions relevant to this article, see Table A

Published in Crop Forage Turfgrass Manage.
Volume 3. doi:10.2134/cftm2017.04.0025

Table A. Useful conversions.

To convert Column 1 to Column 2, multiply by	Column 1 Suggested Unit	Column 2 SI Unit
3.8	gallons per minute, gpm	liters per minute, lpm
2.54	inch	centimeter, cm
0.405	acre, ac	hectare, ha
10.2616	acre-inch, ac-in	hectare-millimeter, ha/mm
67.25	bushels/acre, bu/acre	kilograms/hectare, kg/ha
6.535	bushels/acre-inch, bu/acre-in	kilograms/hectare-millimeter, kg/ha-mm

requiring withdrawal permits, instituting permitted withdrawal limits, and establishing required minimum levels of acceptable agriculture water use efficiency practices. To date, no fines have been levied against producers for exceeding the permitted withdrawal values.

The majority of the irrigated acres in the Delta region of Arkansas and Mississippi are planted to maturity group (MG) IV soybean (*Glycine max* L.), which is furrow irrigated without IWM practices using a conventional continuous-flow delivery system (CONV). Producers initiate irrigation on group IV soybean at the R1-R2 growth stage, and thereafter default to a 7- or 10-day irrigation cycle until termination at approximately the R7 growth stage. Moreover, in this region, CONV irrigation utilizes lay-flat polyethylene tubing that is attached to the well or riser head and then laid perpendicular to the furrows at the upper end of the field. Holes that are the same size are punctured in the tubing to allow water to continuously flow down each furrow. Conventional continuous flow irrigation is the quickest method to move water over large amounts of land, but the irrigation application efficiency for this delivery system is low, approximately 55% (Israeli, 1988). Depending on soil texture, the low irrigation application efficiency of CONV is attributed to deep percolation losses and/or tailwater runoff (Goldhamer et al., 1987a; Varlev et al., 1995; Eid et al., 1999; Matter, 2001). Applying water uniformly, efficiently, and timely to maximize soybean grain yield and net returns will minimize the amount of water applied, which is imperative for the continuation of furrow irrigation in the Mid-South.

Computerized hole selection (CHS) is a tool that improves CONV irrigation application efficiency by computing flow and pressures along the length of the lay-flat polyethylene tubing and selecting hole sizes so that down-row uniformity is improved across the irrigation set regardless of furrow length. Improved down-row uniformity means that all rows are watered more evenly, thereby reducing tailwater runoff, irrigation time, and water applied to the irrigation set. For example, Krutz (2016) reported that CHS reduced irrigation water use in soybean 17% relative to CONV.

Similarly, surge irrigation (SURGE) is a delivery technique that improves irrigation application efficiency through the intermittent application of water to surface-irrigated furrows in a series of relatively short, on-and-off time periods. During the first "on" cycle, for example, the advance phase, the wetting front advances progressively down the furrow. During the "off" cycle, water is applied to a second portion of the field while the water supplied to the first portion infiltrates into the soil profile. Water applied during a subsequent "on" cycle advances rapidly across the wetted soil due to a reduced infiltration rate. Once the water has advanced to the end of the furrow, runoff is reduced using short cycles in a cutback mode, for example, a soak phase, allowing the field to be irrigated to the desired depth. The intermittent application of water with SURGE increases furrow advance time, reduces deep-percolation losses, decreases total irrigation water applied, and improves irrigation application efficiency (Bishop et al., 1981; Izuno et al., 1985; Goldhamer et al., 1987b; Musick et al., 1987; Testezlaf et al., 1987; Israeli, 1988; Eid et al., 1999).

Improved irrigation application timing through the use of scientific irrigation-scheduling tools can reduce the number of irrigation events and/or the amount of irrigation water applied to a production-scale irrigation set without adversely affecting soybean grain yield. Relative to a producer standard, irrigation events were reduced by 50%, and soybean grain yield was not adversely affected when irrigation scheduling was based on soil-moisture sensor data (Krutz et al., 2014). However, the adoption of scientific irrigation-scheduling tools, even in regions with severe water shortages, is less than 2% (Frisvold and Deva, 2012).

To date, CHS, SURGE, and sensor-based irrigation scheduling have not been evaluated at the production scale. The objective of this research was to determine the effect of IWM practices that included CHS, SURGE, and sensor-based irrigation scheduling on water use, soybean grain yield, IWUE, and net returns above irrigation cost at the production scale.

Research Location and Design

The water requirement for soybean when furrow irrigated with disposable, thin-walled, polyethylene tubing was evaluated during the 2013 through 2015 growing seasons on the production scale in the Prairie region of Arkansas and the Delta region of Arkansas and Mississippi. The research consisted of 20 paired fields with the same cultivar, soil texture, planting date, and management practices at each site (Table 1). One field was randomly assigned as IWM and the adjacent field was assigned as CONV. Total irrigation water applied to IWM and CONV fields was determined with a McCrometer

Table 1. Fields used in the research comparing integrated irrigation water management (IWM) with conventional (CONV) continuous flow irrigation of soybean in the Prairie Region of Arkansas and the Delta region of Mississippi and Arkansas during the 2013 through 2015 growing seasons.

Year	Paired fields	State	County	Soil texture	Irrigation method	
					CONV	IWM
					— acres —	
2013	1	Mississippi	Washington	clay	40	40
	2	Mississippi	Washington	clay	40	40
2014	1	Mississippi	Humphreys	clay	29	26
	2	Mississippi	Leflore	clay	30	29
	3	Mississippi	Quitman	silt loam	79	94
	4	Mississippi	Bolivar	clay	40	40
2015	1	Mississippi	Bolivar	clay	26	26
	2	Mississippi	Tallahatchie	clay	40	29
	3	Mississippi	Washington	silty clay	45	28
	4	Mississippi	Quitman	silty clay loam	27	29
	5	Mississippi	Sunflower	silty clay loam	45	53
	6	Mississippi	Sharkey	very fine sandy loam	77	77
	7	Mississippi	Sharkey	silt loam	40	35
	8	Mississippi	Sunflower	silt loam	52	44
	9	Arkansas	Clay	loam	80	80
	10	Arkansas	Arkansas	silt loam	31	41
	11	Arkansas	Arkansas	silt loam	84	27
	12	Arkansas	Lee	silt loam	24	19
	13	Arkansas	White	silt loam	32	33
	14	Arkansas	Lonoke	silt loam	6	28

flow tube with attached McPropeller bolt-on saddle flowmeter (McCrometer, Hemet, CA) placed at the inlet of each field. No IWM practices were implemented in the CONV fields, while irrigation application efficiency and timing were optimized in IWM fields.

Computerized Hole Selection

Computerized hole selection was integrated into IWM fields to improve irrigation uniformity and application efficiency. Input parameters for CHS include accurate elevation of the crown profile where lay-flat irrigation pipe will be installed, accurate water output (gal/min), furrow spacing (ft), length of irrigated furrows (ft), and diameter of lay-flat irrigation pipe (inch) (Kebede et al., 2014). Pad elevation was determined every 100 ft with a Topcon self-leveling slope-matching rotary laser level (Topcon Positioning Systems, Livermore, CA), while furrow and pad length were obtained from aerial imagery. Furrow spacing was determined as the width between planted rows, since every furrow was irrigated. Computerized hole selection was calculated with the Pipe Hole and Universal Crown Evaluation Tool (PHAUCET) version 8.2.20 (USDA-NRCS, Washington, DC).

Surge Flow Irrigation

Surge flow irrigation was assimilated into IWM fields to improve irrigation application efficiency by reducing deep percolation losses and tailwater runoff. Surge flow was applied with a P&R STAR surge valve (P&R Surge Systems, Lubbock, TX). For clay-textured soils, four advanced phases were used and soak phases were eliminated. Irrigation was terminated on clay-textured soils when the wetting front reached the tail-ditch, with approximately 3 acre-inches applied. For coarse-textured soils, both the advance and soak phases were used. Irrigation was terminated on coarse-textured soils when 2.5 to 3 acre-inches were applied. University personnel optimized the SURGE advance-and-soak cycle to minimize tailwater runoff.

Irrigation Scheduling

Irrigation scheduling for IWM fields was based on soil moisture monitoring. Three Watermark 200SS soil moisture sensors (Irrometer Company, Riverside, CA) were installed at 6-, 12-, and 24-inch depths in the lower-third of the irrigation set, and irrigation was applied when the weighted average of the soil water potential over the 24-inch depth was between −85 and −100 cbar. Irrigation for IWM fields was terminated when soybean reached the R6.5 growth stage. Producers harvested and reported soybean yield using calibrated onboard yield monitors.

Irrigation water use efficiency was calculated as described by Vories et al. (2005):

$$IWUE = \frac{Y}{IWA},$$

where $IWUE$ is irrigation water use efficiency (bu/acre-inch), Y is soybean grain yield (bu/acre), and IWA is irrigation water applied (acre-inch).

Economic Analysis

The model used to project irrigation costs in this research incorporates irrigation enterprise budgets developed utilizing the Mississippi State University Budget Generator for CONV and IWM technologies at four different depths: Relift of 18 ft, standard well depth of 140 ft, deep well depth of 200 ft, and Sparta Depth of 400 ft. The model develops estimates of total receipts, total direct expenses, total fixed expenses, total specified expenses, and net returns above total specified expenses on a per-acre basis. The cost estimates were adjusted on an annual basis for the 2013, 2014, and 2015 crop years for changes in variable input costs other than diesel prices. Diesel costs were estimated for each observation based on the amount of water pumped at a baseline diesel cost of $2.83/gal, the average price used in developing MSU budgets for the 2013, 2014, and 2015 crop years. Soybean prices were held constant across all scenarios at $11.11/bu, the average price reported by USDA at Greenville, MS for the August, September, and October harvest periods for the

Table 2. Estimated purchase price, annual use, useful life, and costs per year based on pumping 9 acre-inches per year and 2015 input prices.

Item name	Unit of measure	Purchase price	Useful life	Fuel use	Costs: Fuel	Costs: R&M†	Costs: Direct	Costs: Fixed	Costs: Total
		$	yr	gal/h	$/yr				
Land forming ($390)	acre	450	25	0	0.00	0.00	0.00	31.92	31.92
Surge valve, 10-inch	each	3,483	10	0	0.00	0.00	0.00	348.30	348.30
Pipe elbows	each	127	20	0	0.00	0.00	0.00	6.35	6.35
Soil moisture sensors	each	39	3	0	0.00	0.00	0.00	13.00	13.00
Irrometer datalogger (package)	each	450	10	0	0.00	0.00	0.00	45.00	45.00
Relift tractor: 75 hp	acre-inch	21,113	10	3.86	1924.09	1055.56	2979.74	1894.94	4874.68
Engine: 100 hp, 140 ft	acre-inch	20,000	20	3.6	2346.13	750.00	3096.13	1604.85	4700.98
Engine: 100 hp, 200 ft	acre-inch	20,000	20	3.6	2592.00	750.00	3342.00	1604.85	4946.85
Engine: 100 hp, 400 ft	acre-inch	20,000	20	3.6	3732.48	750.00	4482.48	1604.85	6087.33
Relift pump	each	6,670	25	0	0.00	160.08	160.08	473.25	633.33
Well and pump: 140 ft	each	20,250	25	0	0.00	486.00	486.00	1436.78	1922.78
Well and pump: 200 ft	each	25,150	25	0	0.00	603.60	603.60	1784.45	2388.05
Well and pump: 400 ft	each	43,150	25	0	0.00	1035.60	1035.60	3061.59	4097.19

† R&M, repairs and maintenance.

2013, 2014, and 2015 crop years (see Mississippi portal for soybeans at https://www.ers.usda.gov/data-products/commodity-costs-and-returns/commodity-costs-and-returns/#Recent Costs and Returns: Soybeans). To test the sensitivity of both technologies to differences in the major variable cost associated with pumping, a high diesel price and a low diesel price were evaluated. Prices for the scenarios were taken from the USDA Prices Paid Survey for the 2006–2015 timeframe for the Delta States region. The maximum annual average reported diesel price for the 2006–2015 timeframe of $3.70/gal was used in the high-diesel-price scenario, and the lowest price of $1.60/gal was used in the low-diesel-price scenario.

Assumptions related to equipment used in each enterprise budget are reported in Table 2. The values for purchase price and fuel consumption are based on personal communications with Mississippi Delta–region irrigation equipment input and service providers. The Relift alternative utilizes a 75-hp tractor as a power unit, with all other alternatives using a 100-hp stationary diesel engine for power. Irrigation water is assumed to be supplied at 2600 gal/min for the Relift alternatives, 2000 gal/min for the 140-ft Standard Depth well alternatives, 1800 gal/min for the Deep Depth 200-ft well alternatives, and 1250 gal/min for the Sparta Depth 400-ft well alternatives.

Statistical Analysis

Irrigation water applied, soybean grain yield, IWUE, and net return above irrigation costs were analyzed using the MIXED procedure of SAS (Statistical Analytical System Release 9.4; SAS Institute Inc., Cary, NC), with year and field (year) as random effects.

General Site Statistics

During the 2013 through 2015 growing seasons, data for IWM comparisons were collected from 20 paired sites from the Prairie region of Arkansas and the Delta region of Arkansas and Mississippi, an area encompassing more than 9000 mi^2 (Table 1). Paired irrigation sets ranged in size from 6 to 80 acres. The primary soil texture contained in the boundary of paired irrigation sets included silt loam, clay, silty clay loam, and loam, which represented 45, 40, 10, and 5% of the sites, respectively.

Irrigation Water Applied

Integrated IWM had a significant effect on irrigation water applied in season ($P \leq 0.0003$). Eighty-five percent of the irrigators applied more water using CONV than IWM, and relative to CONV, 21% less water was applied to IWM fields (Table 3). Reduced water use in IWM at the field scale was equivalent to values observed for individual IWM practices at the meso-plot scale. For example, relative to CONV, CHS reduced irrigation water use in soybean 17% (Krutz 2016), and surge flow reduced irrigation water use in soybean from 24% to 80% relative to the control (Izuno et al., 1985; Musick et al., 1987; Testezlaf et al., 1987; Rodriguez et al., 2004). Additionally, sensor-based scheduling reduced the number of irrigations applied to soybean 50% compared with CONV (Krutz et al., 2014. These data indicate that integrated IWM reduces water use in furrow-irrigated soybean.

Advantages of integrated IWM extend beyond reduced irrigation water use in soybean. Foremost, from a regulatory perspective, the permitted water withdrawal limit for row crops in Mississippi was not exceeded in IWM fields, while 10% of the CONV fields exceeded the permitted withdrawal limit, which is 18 acre-inch/year. These data indicate that integrated IWM will reduce the probability of producers

Table 3. Estimated least squares means for irrigation water applied, soybean grain yield, and irrigation water use efficiency for irrigation water management (IWM) fields compared with conventional (CONV) fields with no IWM practices in Arkansas and Mississippi from 2013 through 2015 growing seasons.

Parameter	Irrigation method		P value
	CONV	IWM†	
Irrigation water applied (acre-inch)	11.5‡	9.1	0.0198
Yield (bu/acre)	69.3	68.6	0.6703
Irrigation water use efficiency (bu/acre-inch)	7.2	9.8	0.0194

† IWM implemented with computerized hole selection, surge irrigation, and soil moisture sensors.

‡ Least squares mean of 20 replicates.

exceeding permitted withdrawal limits established by the Mississippi Department of Environmental Quality. Second, at the farm scale, improved irrigation application efficiency and timing provided by integrated IWM reduces the period of time required for a well to be committed to an irrigation set. In effect, integrated IWM improves on-farm irrigation capacity, thereby allowing more acres to be irrigated by a well in a timelier manner. Improved timeliness of irrigation reduces the potential for yield loss associated with drought stress. Finally, the water savings afforded by IWM are scalable and have regional implications. For instance, the agricultural overdraft on the MARVA in the Delta of Mississippi is estimated at 300,000 acre-ft/year (Wax et al., 2009). Our data denote that 50% of the agricultural overdraft in the Mississippi Delta will be eliminated if integrated IWM is implemented on CONV soybeans.

It is plausible that these data underestimate the potential for integrated IWM to reduce irrigation water use in furrow-irrigated soybean, primarily because of the Hawthorne effect. The Hawthorne effect states that "human subjects of an experiment change their behavior, simply because they are being studied" (Roethlisberger, 1941). Under the conditions of this research, we noted that by 2014, approximately 50% of the producers scheduled and terminated irrigation for the CONV field on the basis of recommendations for the adjacent IWM field. The Hawthorne effect may explain why the mean water savings with integrated IWM was not greater than water savings reported for discrete IWM practices alone, namely CHS, SURGE, and sensor-based irrigation scheduling.

Soybean Grain Yield

The principal concept of integrated IWM is to ensure adequate moisture for optimum grain yield while improving irrigation application efficiency. Consequently, soybean grain yield pooled across site years averaged 69 bu/acre and was not different between IWM and CONV ($P = 0.6703$). The yield data for soybean produced under IWM agree with others who reported that neither CHS, SURGE, nor sensor-based irrigation scheduling alone adversely affected soybean grain yield relative to the control (Krutz et al., 2014; Krutz, 2016; Wood et al., 2016). Mid-South producers associate IWM practices with reduced grain yield; however, our production-scale IWM data indicate that CHS, SURGE, and sensor-based irrigation scheduling can be adopted concurrently without adversely affecting soybean grain yield.

These production-scale soybean grain-yield data have implications for practitioners debating the number and location of soil moisture sensors required in an irrigation set to ensure no yield loss from drought stress. From 2013 through 2015, soybean grain yield in Arkansas and Mississippi was maintained relative to the CONV by installing three Watermark 200SS soil-moisture sensors at 6-, 12-, and 24-in depths at one location on the lower-third of an irrigation set. Irrigation sets varied in size from 6 to 80 acres and encompassed soil textures ranging from very fine sandy loam to clay. Results demonstrate, therefore, that one sensor location in a production-scale furrow irrigation set is sufficient to maintain soybean grain yield equivalent to that of current producer practices.

Soybean Irrigation Water Use Efficiency

A hypothesis of this research was that integrated IWM improves irrigation application efficiency and subsequently improves soybean IWUE. Integrated IWM at the production scale had an effect on soybean IWUE ($P = 0.0194$). Pooled across site years, soybean IWUE was 36% higher in IWM than CONV. The IWM results for soybean IWUE are in agreement with those reported for individual IWM practices. Relative to the control, CHS and SURGE improved soybean irrigation water use 21 and 29%, respectively (Krutz, 2016; Wood et al., 2016).

Economic Simulations

The estimated irrigation costs per acre calculated at the average acre-inch of water pumped at the baseline diesel price of $2.83/gal for CONV (11.1 acre-inches) and IWM (8.8 acre-inches) technologies are reported in Table 4. The higher values for the other direct costs for the IWM technology are attributed to the extra cost associated with transfer-pipe and surge-valve batteries. The higher values for the total fixed costs for IWM are attributed to the capital recovery cost for the surge valves, elbows, soil moisture sensors, and data-logger package. As would be expected, the advantage of the CONV technology in lower total specified cost declines as the depth that water is being pumped increases.

The estimated least squares means for net returns above total specified irrigation costs for the CONV and IWM at the baseline soybean price of $11.11/bu and baseline diesel price of $2.83/gal are reported in Table 5. While estimated least squares means of net returns for CONV were higher at Relift and standard well depths, and IWM were higher at 200-ft and 400-ft depths, no significant difference was found between least squares means for the CONV and IWM technologies at any irrigation water-lifting depths.

Table 4. Estimated irrigation costs per acre by system for producer conventional (CONV) and integrated irrigation water management (IWM) at average quantities of water pumped and baseline diesel prices.

Depth	Diesel	Other direct	Total direct	Total fixed	Total specified
			$		
CONV technology for 11.1 acre-inch applied at $2.83/gal diesel					
Relift	22.82	21.55	44.37	54.98	99.35
Standard well	27.42	21.76	49.18	59.22	108.40
200 ft	30.10	22.52	52.62	61.41	114.03
400 ft	42.55	25.39	67.94	69.46	137.40
IWM† technology for 8.8 acre-inch applied at $2.83/gal diesel					
Relift	18.46	24.30	42.76	60.43	103.19
Standard well	22.11	24.51	46.62	64.67	111.29
200 ft	24.23	25.27	49.50	66.86	116.36
400 ft	34.10	28.14	62.24	74.91	137.15

† IWM implemented with computerized hole selection, surge irrigation, and sensor-based irrigation scheduling,

Table 5. Estimated least squares means for net returns above irrigation costs for four water-lifting depths at a baseline soybean price of $11.11 per acre and a baseline diesel price of $2.83 per gallon.†

Depth	CONV	IWM	*P* value
	$/acre		
Relift	671.53	670.30	0.9173
Standard well	663.25	662.90	0.9758
200 ft	657.96	658.27	0.9789
400 ft	636.11	639.38	0.7761

† Control fields (CONV) not instrumented with integrated irrigation water management (IWM) practices. IWM fields implemented with computerized hole selection, surge irrigation, and sensor-based irrigation scheduling.

The estimated least squares means for net returns above total specified irrigation costs for the CONV and IWM technologies at the baseline soybean price of $11.11/bu and high diesel price of $3.70/gal are reported in Table 6. While higher diesel prices, relative to the baseline, resulted in estimated least squares means for the IWM technology being higher at all well depths, no statistically significant difference was found between least squares means for the CONV and IWM technologies at any irrigation water-lifting depths.

The estimated least squares means for net returns above total specified irrigation costs for the CONV and IWM technologies at the baseline soybean price of $11.11/bu and low diesel price of $1.60/gal are reported in Table 7. The pattern of results for estimated least squares means changed from the baseline results, with CONV resulting in higher estimated least squares means for all cases except the 400-ft well. However, as with the other two scenarios, no statistically significant difference was observed between least squares means for the CONV and IWM technologies at any irrigation water-lifting depths.

Table 6. Estimated least square means for net returns above irrigation costs for four water-lifting depths at a baseline soybean price of $11.11 per acre and a high diesel price of $3.70 per gallon.†

Depth	CONV	IWM	*P* value
	$/acre		
Relift	660.65	661.30	0.9557
Standard well	650.15	652.10	0.8670
200 ft	643.51	646.37	0.8036
400 ft	615.70	622.64	0.5376

† Control fields (CONV) not instrumented with integrated irrigation water management (IWM) practices. IWM fields implemented with computerized hole selection, surge irrigation, and sensor based irrigation scheduling.

Table 7. Estimated least squares means for net returns above irrigation costs for four water-lifting depths at a baseline soybean price of $11.11 per acre and a low diesel price of $1.60 per gallon.†

Depth	CONV	IWM	*P* value
	$/acre		
Relift	677.55	674.97	0.8303
Standard well	670.49	668.49	0.8673
200 ft	665.85	664.35	0.9002
400 ft	647.25	647.93	0.9540

† Control fields (CONV) not instrumented with integrated irrigation water management (IWM) practices. IWM fields implemented with computerized hole selection, surge irrigation, and sensor-based irrigation scheduling.

These economics data have implications for Mid-South producers considering implementing IWM technologies at the farm scale. The additional costs for utilizing integrated IWM associated with the purchase of surge valves, elbows, soil moisture sensors, data-logger packages, transfer pipe, and batteries for surge valves and data loggers is offset by reduced water use and total irrigation costs, regardless of the pumping depth, diesel costs, or soil textures analyzed in this research. Essentially, one may infer from this research that integrated IWM could be implemented across the Mid-South without adversely effecting on-farm profitability.

Conclusion

The objective of this research was to determine the effect of the integrating CHS, SURGE, and scientific irrigation scheduling tools on water use, soybean grain yield, IWUE, and net return above irrigation costs. Our results indicate that adoption of IWM on soil textures ranging from very fine sandy loam to clay have no adverse effect on furrow-irrigated soybean grain yield or irrigation costs. However, IWM will reduce irrigation water use and improve soybean IWUE. In essence, integrated IWM can be adopted by Mid-South soybean producers without adversely affecting on-farm profitability while concurrently reducing the demand on depleted groundwater resources.

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