Title: **Cover Crop Aerial Seeding and Sensor Thresholds for Irrigation Scheduling in Soybean Production Project # 49-2021**

2021-2022 MSPB Final Report

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Background and Objectives

Aquifer depletion is a major issue in the Mississippi Delta because more water is pumped out from the Mississippi River Valley Alluvial Aquifer than what is replenished with recharge. Mississippi ranks among the top eight states where row crops are irrigated, with soybean accounting for the highest number of irrigated acres in the state. Therefore, irrigation scheduling is critical for improving the irrigation water use efficiency of soybean. A season-long static threshold of -85 kPa from soil moisture sensors for irrigation scheduling was recommended to Mississippi farmers for early-planted soybean without adversely affecting yield. In addition, the inclusion of cover crops in monoculture soybean production systems might impact soil moisture dynamics and improves irrigation water use efficiency. Cover crops reduce soil crusting and improve the infiltration of water in the soil, thus decreasing runoff and erosion losses. Cover crops reduce soil evaporation, soil bulk density, and compaction. Cover crop residues left as mulch after termination conserves soil moisture by reducing evaporative losses. The effects of cover crops on the factors influencing water balance (evaporation, transpiration, soil water storage, runoff) makes it difficult to reach a consensus on their impact on water drainage and water availability to the subsequent cash crop. The impact of cover crop species (single cover crop species or multiple species mixture) on water balance is not well understood and their effect on annual drainage can be debated. Cover crops in soybean rotation might influence irrigation scheduling, irrigation water use, and soybean yields and quality. It is possible that irrigation can be delayed in cover crop fields as cover crops increase water infiltration, and improve soil properties by reducing compaction, and soil crusting. Declining water levels in the MRVAA is of great concern, and it necessitates the need for improved management practices that reduce agricultural water use and improve water use efficiency to sustain higher yields for soybean producers in the MS Delta region.

Objective 1: Evaluate the impact of irrigation thresholds (-40 kPa and -90 kPa) and cover crops on soybean yield and yield components, seed quality, irrigation water used and water use efficiency, and net returns above irrigation costs.
Objective 2: Evaluating the effects of cover crops on soil available nutrients, soil physical properties, and subsurface water quality.

Report of Progress/Activity

Objective 1: Evaluate the impact of irrigation thresholds (-40 kPa and -90 kPa) and cover crops on soybean yield and yield components, seed quality, irrigation water used and water use efficiency, and net returns above irrigation costs.

The cover crop biomass production and N uptake was greater in hairy vetch then the other cover crops and no cover crop control in 2021 (Table 1). Soybean biomass production, plant population, and seed yield was not affected by the irrigation and cover crops in 2021. The soybean protein content was greater in the -40 kPa irrigation threshold treatment than the -90 kPa irrigation threshold and no irrigation treatment. However, the soybean oil content was not impacted by the cover crops and irrigation thresholds in 2021.

The water productivity of soybean was greater in the -90 kPa irrigation threshold treatment than the -40 kPa irrigation threshold and non-irrigated/dryland treatments. Water productivity for each treatment was calculated as the ratio of soybean yield and total water (rainfall + irrigation water applied). The irrigation water use efficiency was calculated as ratio of soybean yield and total irrigation water applied. The irrigation water use efficiency was highest in the cereal rye followed by hairy vetch (Table 1). Irrigation water use efficiency was statically different between the wheat-radish-turnip mix and no cover crop treatment.

In 2021, all cover crops reduced the net returns above total specified expenses compared to the no cover crop treatments (Table 2). In all three irrigation treatments, the no cover crop control had higher net returns above total specified expenses than the cover crop treatments. However, among cover crops, the cereal rye had the higher returns than the hairy vetch and wheat-radish-turnip mix under the no irrigation treatments. Under the irrigated treatments, the wheat-turnip-radish mix had greater returns than hairy vetch and cereal rye.

Objective 2: Evaluating the effects of cover crops on soil available nutrients, soil physical properties, and subsurface water quality.

We took the soil samples last week for soil nutrient analysis before cover crop termination. These soil samples along with post-harvest soil samples from 2021 has been sent to lab for analysis. We are still collecting the water quality samples and analysis them in our lab at this time.

Cereal rye, hairy vetch, and wheat-turnip-radish mix reduced the NO_3-N concentration by 69, 82, and 57% compared to the no cover crop treatment under irrigated conditions. However, only hairy vetch and wheat-turnip-radish mix reduced NO3-N concentration by 73 and 65% than the no-cover crop treatment under the dryland conditions. Cereal rye showed significantly higher NO3-N concentrations than other cover crops but similar to no cover crop treatment (Figure 1). No-cover crop treatment had higher NH_4-N concentration than cereal rye and hairy vetch under irrigated condition. However, only hairy vetch and wheat-turnip-radish mix had lower NH_4-N concentration than no- cover crop treatment among dryland treatments (Figure 2).

Impacts and Benefits to Mississippi Soybean Producers

One year of data shows that cover crops reduced net returns. The study will be continued for more years to provide any strong recommendations to producers.

End Products–Completed or Forthcoming

Graduate Student Advising: *Dillon Russell worked on this project. He is a M.S. degree graduate student in the Department of Plant and Soil Sciences, Mississippi State University. He successfully defended his thesis in March and will be graduating in May 2022. His thesis is currently with the Mississippi State University Library for final review.*

Presentations:

1. *Russell, D., G. Kaur, and G. Singh. 2021. Optimizing Irrigation Scheduling Thresholds with Cover Crops for Soybean Production in the Mississippi Delta. American Society of Agronomy-Crop Science Society of America- Soil Science Society of America International Annual Meeting, Salt Lake City, UT.*

https://scisoc.confex.com/scisoc/2021am/meetingapp.cgi/Paper/134434

2. *Singh, B., G. Kaur, and G. Singh. 2021. Multi-Species Cover Crops and Irrigation Interaction Effects on Nutrient Dynamics in Soybean Production System. American Society of Agronomy-Crop Science Society of America- Soil Science Society of America International Annual Meeting. Salt Lake City, UT, Nov. 7-10. https://scisoc.confex.com/scisoc/2021am/meetingapp.cgi/Paper/134514*
3. *Russell, D., G. Kaur, and G. Singh. 2021. Irrigation scheduling and cover crop interactions on soybean production in the Mississippi Delta. 23rd Annual Arkansas Soil and Water Education Conference, Virtual. 27 January. https://arkswec.wixsite.com/aswec / and https://voicethread.com/share/16677919/*
4. *Russell, D., G. Kaur, and G. Singh. 2021. Sensor-based irrigation scheduling thresholds and cover crop effects on soybean production in the Mississippi Delta. American Society of Agronomy Southern Regional Branch. Virtual Conference. 30 Jan-1 Feb, 2021.*

Graphics/Tables

Table 1. Cover crop biomass production, C and N concentration, CN ratio, and N-uptake, soybean seed yield and protein content, water productivity and irrigation water use efficiency as affected by the irrigation and cover crops treatments during the 2020-2021 season.

Irrigation	Cover Crops	Cover crops					Soybean seed		Water Productivity	Irrigation water use efficiency
		Biomass Production	Carbon	Nitrogen	CN Ratio	N-uptake	Yield	Protein		
		-----kg ha^{-1}-----				-----kg ha^{-1}-----			----------kg ha^{-1} mm^{-1}----------	
-40 kPa		2481	40.4	2.07	24	66.3	4132	40.6 a	4.74 c	-
-90 kPa		2652	40.3	2.16	23.8	69.9	4160	40.3 b	6.14 a	-
No Irrigation		2524	40.4	1.99	25.6	63.2	3991	40.3 b	5.89 b	-
										-
	Cereal Rye	1601 b	42.0 a	1.22 c	36.1 a	20.2 b	4044	40.5	5.61	26.6 a
	Hairy Vetch	4931 a	41.4 a	3.76 a	11.5 d	185 a	4083	40.3	5.6	24.4 b
	Wheat-Radish-Turnip Mix	1688 b	39.7 b	1.44 c	29.1 b	24.9 b	4188	40.5	5.67	18.3 c
	No Cover Crop	1989 b	38.3 c	1.87 b	21.2 c	36.0 b	4062	40.4	5.49	17.7 c
										-
-40 kPa	**Cereal Rye**	1462	42.1	1.14	39	17.1	4021	40.8	4.86	-
	Hairy Vetch	5415	41.5	3.59	11.6	194	4261	40.5	5	-
	Wheat-Radish-Turnip Mix	1505	39.5	1.49	26.9	22.3	4183	40.7	4.62	-
	No Cover Crop	1541	38.6	2.07	18.7	31.8	4061	40.5	4.48	-
-90 kPa	**Cereal Rye**	1548	42.1	1.31	34.6	21	4103	40.3	6.06	-
	Hairy Vetch	4531	41.2	3.94	11.3	181	4011	40.1	5.92	-
	Wheat-Radish-Turnip Mix	2070	40.3	1.56	28	32.4	4365	40.5	6.45	-
	No Cover Crop	2460	37.5	1.84	21.1	44.8	4161	40.5	6.15	-
No Irrigation	**Cereal Rye**	1794	41.9	1.22	34.7	22.5	4008	40.3	5.92	-
	Hairy Vetch	4846	41.4	3.74	11.6	179	3976	40.3	5.87	-
	Wheat-Radish-Turnip Mix	1490	39.4	1.28	32.3	20	4016	40.4	5.93	-
	No Cover Crop	1965	38.8	1.7	23.7	31.4	3963	40.4	5.85	-
Source of Variation	**df**	**P-values**								
Irrigation (I)	2	0.7325	0.874	0.6399	0.654	0.7497	0.0802	0.0018	<.0001	-
Cover Crop (CC)	3	<.0001	<.0001	<.0001	<.0001	<.0001	0.3885	0.1661	0.5722	<.0001
I x CC	6	0.1501	0.273	0.9249	0.698	0.942	0.4751	0.6685	0.1006	-

Table 2. Estimated costs and returns above total specified expenses for the 2020-2021 growing season.

Irrigation	Cover Crops	Soybean Yield	Soybean Selling Price	Gross Returns	Total Specified Expenses	Returns Above Total Specified Expenses
-40 kPa	**Cereal Rye**	4021	$0.46	$1,852.07	$1,290.95	$561.12
	Hairy Vetch	4261	$0.46	$1,962.62	$1,379.91	$582.71
	Wheat-Radish-Turnip Mix	4183	$0.46	$1,926.69	$1,322.36	$604.33
	No Cover Crop	4061	$0.46	$1,870.50	$1,201.16	$669.34
-90 kPa	**Cereal Rye**	4103	$0.46	$1,889.84	$1,240.78	$649.06
	Hairy Vetch	4011	$0.46	$1,847.47	$1,320.88	$526.59
	Wheat-Radish-Turnip Mix	4365	$0.46	$2,010.52	$1,254.24	$756.28
	No Cover Crop	4161	$0.46	$1,916.56	$1,132.22	$784.34
No Irrigation	**Cereal Rye**	4008	$0.46	$1,846.08	$1,108.31	$737.77
	Hairy Vetch	3976	$0.46	$1,831.35	$1,189.03	$642.32
	Wheat-Radish-Turnip Mix	4016	$0.46	$1,849.77	$1,241.00	$608.77
	No Cover Crop	3963	$0.46	$1,825.36	$998.74	$826.62

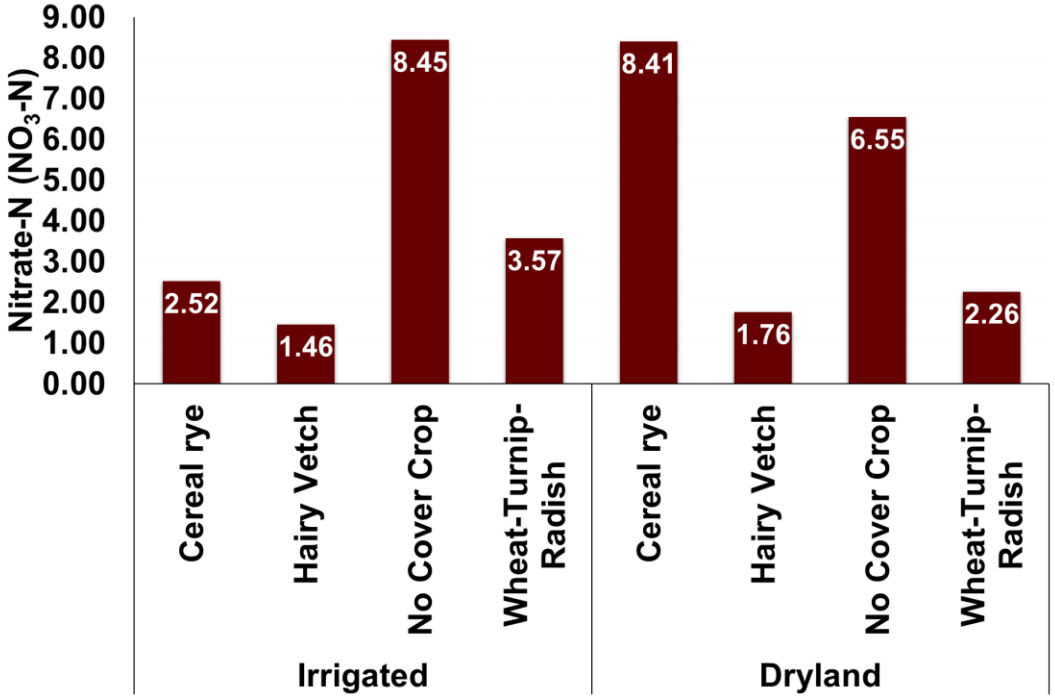

Figure 1. Soil solution nitrate-N concentrations as affected by the irrigation and cover crop treatments.

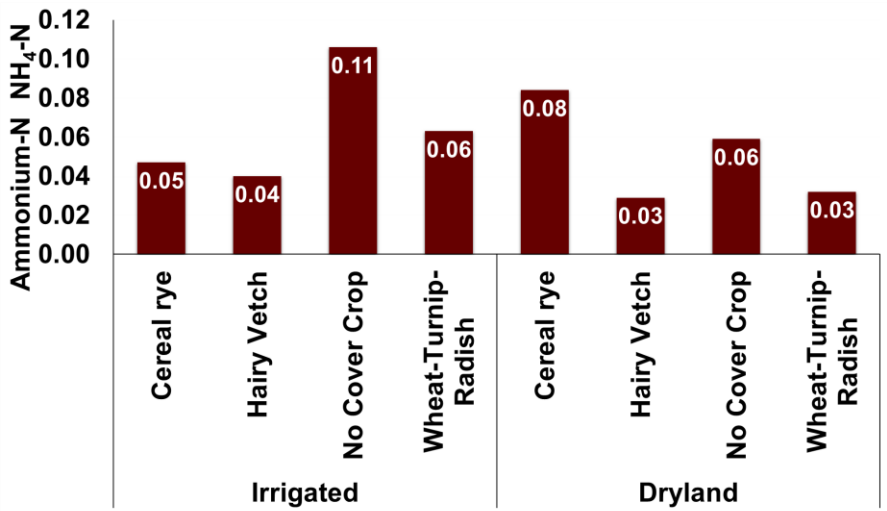

Figure 2. Soil solution Ammonium-N concentrations as affected by the irrigation and cover crop treatments.