Low-Cost Precision Agriculture Solutions for Advancing Irrigation Efficiency, Project 10-2023 Annual Report

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Background and Objectives

Variable-rate irrigation (VRI) is the precision agriculture practice of customizing irrigation amounts to different areas within a field based on the unique characteristics of each area. VRI can be used to compensate for and minimize problems associated with in-field spatiotemporal variability, especially that of soil moisture. However, the initial and maintenance costs of zone control VRI is often daunting, and the fear of managing these systems discourages farmers from adopting this technology. Sector control VRI systems are less expensive and easier to operate because only the revolution speed of the center pivot is adjusted, and most late-model center pivots can be programmed to travel at a different speed (and thus apply a different irrigation amount) in each of several pie-shaped sectors without additional control panel upgrades. On fields where the distribution of wetter/drier areas match well with the geometry of pie-shaped sectors, the use of sector control VRI is an ideal solution for advancing irrigation efficiency beyond what is possible with conventional uniform irrigation.

A sector control VRI prescription was applied to a relatively small 45-acre Noxubee County production field in a soybean/corn/cotton rotation to measure water savings by monitoring water applied, seasonal soil moisture, and resulting yield from two different irrigation treatments. Management zones were delineated on three additional larger fields during the 2023 growing season, and these fields were also monitored for spatiotemporal changes in soil moisture and yield. Finally, a geospatial inventory of OFWS systems in Northeast Mississippi was conducted to quantify the extent of irrigation in this region, help direct educational efforts, and justify potential cost assistance programs. Results of the project were shared throughout the year, and progress was made on the following specific objectives:

1. Create and apply a sector control VRI prescription on a production soybean field and measure the water savings realized.
2. Develop a simple method for evaluating whether production fields would benefit from sector control VRI.
3. Evaluate the economic benefit from VRI adoption.
4. Perform a geospatial inventory of surface water storage systems used for irrigation in Northeast Mississippi, to assess the potential for VRI adoption.
5. Share project results with producers and other stakeholders, especially those in Northeast Mississippi.

Report of Progress by Objective

Objective 1: Create and apply a sector control VRI prescription on a production soybean field and measure the water savings realized.

The VRI prescription from the previous year was used again in the same production field (Figure 1 and Table 1), and Deltapine 2127 cotton was planted on May 10th, 2023. Watermark granular matrix soil moisture sensors were installed at the centroids of each plot on June 14th, 2023 at 12- and 24-inch depths and connected to Irrometer Irrocloud IC-10 dataloggers with a cellular connection, which allowed the producer to access and view the data at any time. The field was monitored continuously to ensure all instrumentation was working properly. The Irrocloud IC-10 dataloggers were also remotely monitored via the Irrocloud IC-10 application on the computer or phone to make sure no datalogger went offline and all granular matrix sensors were reading properly. The producer determined the timing of the three irrigation applications, the first two of which applied 0.75 inches to the full rate plots and 0.6 inches (20% reduction) to the reduced rate plots. He made one final irrigation application of 0.5 inch for the full rate plots and 0.4 inch for the reduced rate plots. On October 3rd, the Watermark 200ss granular matrix sensors and IrroCloud IC-10 data loggers were removed, and the field was harvested. Soil tension data was downloaded from IrroCloud and input into an Excel spreadsheet. Precipitation data was downloaded from the Blackland Prairie station, and irrigation data was gathered from the producer (using FieldNet) and input into the Excel spreadsheet. These data are being analyzed together with yield data. Several malfunctioning dataloggers were sent back to Irrometer to be repaired, and plans are underway for the 2024 growing season. Two years of data have been collected, and preliminary results will be provided in year three.

Objective 2: Develop a simple method for evaluating whether production fields would benefit from sector control VRI.

New Watermark 200ss granular matrix soil moisture sensors were assembled and installed in management zones in three additional, larger fields on the same farm. Management zones were determined based on elevation and soil type, and monitored fields cover three different crops (corn, soybean, and cotton). Field Two was planted in cotton on May 9-10, 2023, and the sensors were installed on June 23rd at four pre-determined locations (Figure 2). Field Three was planted in corn on April 18, 19, 20, 2023, and the sensors were installed on May 31st at five pre-determined locations (Figure 3). A portion of field Four was planted in corn on March 30-31, 2023, and sensors were installed on May 31st at two pre-determined locations (Figure 4). The remainder of Field Four was planted in soybeans on April 24, 25, 26, 2023, and sensors were installed on June 6th at three pre-determined locations (Figure 4). Since Field Three and a portion of Field Four were planted in corn this year, Irrometer Irrocloud IC-10 dataloggers were installed in these areas for easier access to soil moisture data. Data from the Irrometer Watermark 900m dataloggers in the soybean portion of Field Four and the cotton in Field Two were manually downloaded once per week using a data shuttle and visually checked to ensure batteries or soil moisture sensors did not need to be replaced. All other dataloggers using the Irrocloud IC-10 dataloggers were checked once weekly from a computer or phone. Data from the Irrocloud IC-10 dataloggers were also downloaded weekly. Soil moisture sensors in Field Two were removed on September 22nd, 2023. Sensors in Field Three were removed on August 15th and 17th, 2023. Sensors in the corn portion of Field Four were removed on August 15th, 2023, and sensors in the soybean portion of Field Four were removed on September 18th, 2023. The corn in Field Three was harvested on August 21st – 24th, 2023. The corn in Field Four was harvested on August 15th – 16th, 2023, and the soybeans in Field Four were harvested on September 22nd – 26th, 2023. The cotton in Field Two was harvested on October 3rd. All soil moisture data were input into an Excel spreadsheet for analysis along with producer irrigation data (from FieldNet software), yield data, and precipitation data. One year of data has been collected and evaluated for this objective, with preliminary results indicating that the three larger fields have more heterogeneity than the smaller field where the current VRI is applied.

Objective 3: Evaluate the economic benefit from VRI adoption.

A master's student (Gifty Ayela) in Agricultural Economics was hired in August 2023 to work on this objective. Current and historic soil tension data of the VRI field were provided to the master's student. A project meeting with all Co-PIs and students was held on October 17th, where progress on objectives and data collected for 2023 was discussed. Dr. Tagert met with Dr. Li (who is leading the economic analysis) on Feb. 23 to provide him with the soil moisture data and discuss the project, and she has been in communication with him to provide additional data as needed. Preliminary results from the economic analysis will be available in the coming year.

Objective 4: Perform a geospatial inventory of surface water storage systems used for irrigation in Northeast Mississippi, to assess the potential for VRI adoption.

ArcGIS was used to conduct a geospatial inventory of irrigation infrastructure for all 22 counties in Northeast Mississippi, and this inventory was completed on July 13th, 2023. There were 228 on-farm water storage systems identified, which comprise a total of 3,333 hectares of storage area (Figure 5). A total of 413 center pivot irrigation systems that irrigate 43,500 hectares of farmland in Northeast Mississippi were also mapped (Figure 6), and ground-truthing of fifty percent or more of the systems is ongoing. All systems are recorded by county (Table 2), where Noxubee County had more than half of all OFWS and center pivot irrigation systems (132 and 251, respectively).

Objective 5: Share project results with producers and other stakeholders, especially those in Northeast Mississippi.

1. Dr. Tagert gave a presentation showing preliminary project results at the Mississippi Smart Agriculture Extension Agent training, held at the North Mississippi Research and Extension Center on June 21st, 2023, in Verona Mississippi.
2. Dr. Tagert gave a presentation covering surface irrigation and water supplies, which included findings from the project, at the American Society of Agricultural and Biological Engineers (ASABE) 2023 Annual International Meeting on July 11th, 2023.
3. Undergraduate research student Elliott Butler gave a presentation on the geospatial inventory of OFWS systems for irrigation in Northeast Mississippi at the Mississippi Academy of Sciences Summer Science Symposium on July 25th, 2023.
4. Undergraduate research student Elliott Butler also gave a presentation on the geospatial inventory of irrigation infrastructure in Northeast Mississippi at Mississippi State University's Undergraduate Research Symposium on August 2nd, 2023.
5. Dr. Tagert included results from Objective 4 in a presentation titled 'Surface Water Capture and Storage for Irrigation' for the new Master Irrigator educational program.

Additional Notes

The graduate student who had committed to work on this project starting in May 2023 backed out in April 2023, leaving no time to find another student for the past year. However, two outstanding undergraduate students were hired to work on the project during the 2023 growing season and fall semester to continue progress on the objectives. A new student, Sam Theobald, has been recruited and will begin work on the project and pursue a master's program in Engineering Technology starting in May 2024.

Impacts and Benefits to Mississippi Soybean Producers

The preliminary results from evaluating the spatiotemporal variability of soil moisture and elevation across larger fields along with evaluating the water savings from implementing sector control VRI are promising, showing there is potential to save water that may be used to irrigate a greater number of acres with the same amount of water. If sector control VRI is successfully implemented on all pivots in Northeast Mississippi, it has the potential to improve irrigation and save water on 43,500 hectares of farmland in 22 counties across Northeast Mississippi.

Graphics/Tables

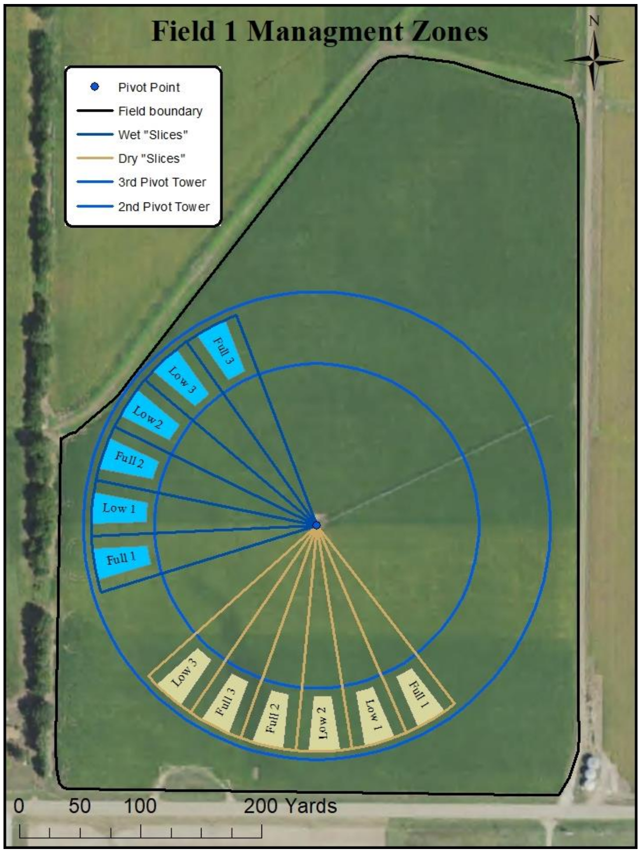

Figure 1. VRI map showing wet and dry zones with plots and irrigation rates.

Table 1. VRI prescription calculated using ArcMap.

Area	Start angle	End Angle	Pivot Speed(%)	Application Rate (in)
1	335	167	26.2	0.75
2	167	196	32.8	0.6
3	196	225	26.2	0.75
4	225	239	32.8	0.6
5	239	278	26.2	0.75
6	278	292	32.8	0.6
7	292	307	26.2	0.75
8	307	335	32.8	0.6

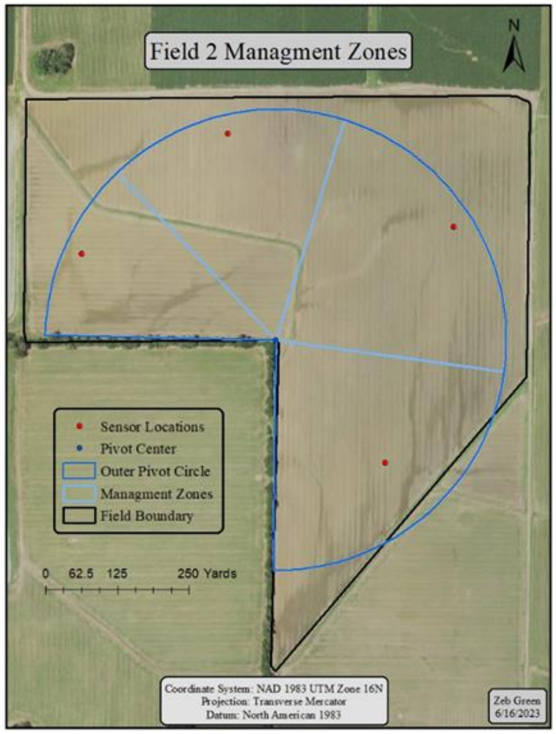

Figure 2. Field Two management zones and sensor locations.

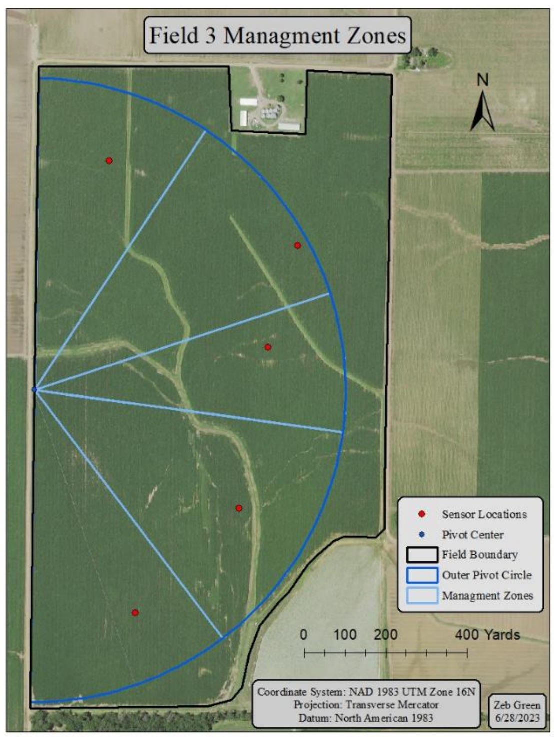

Figure 3. Field Three management zones and sensor locations.

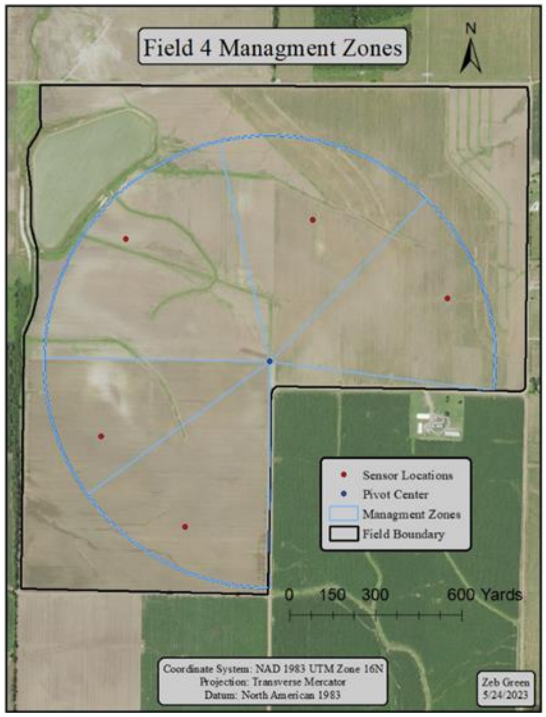

Figure 4. Field Four management zones and sensor locations.

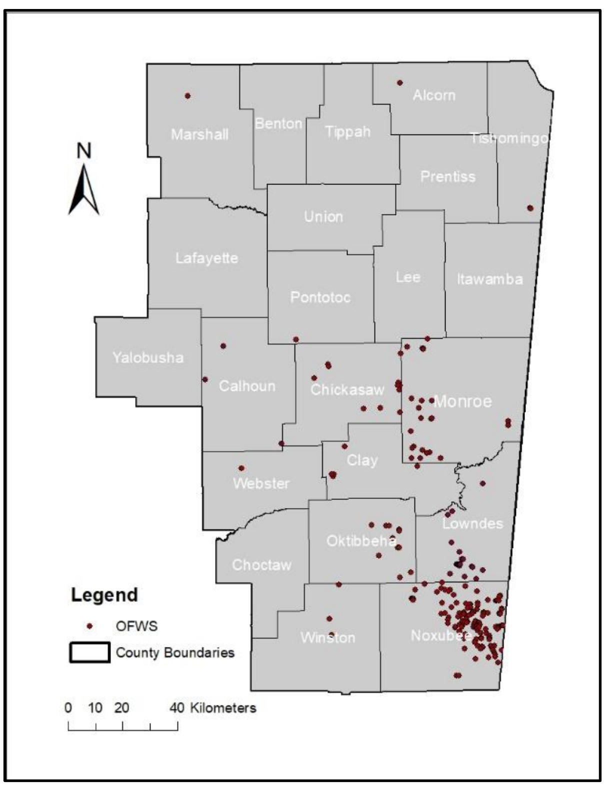

Figure 5. On-farm water storage (OFWS) system locations.

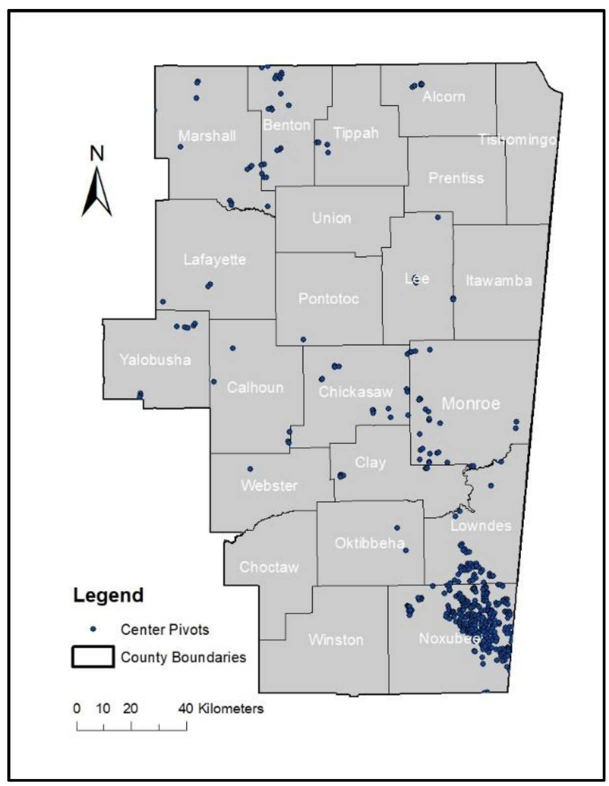

Figure 6. Center pivot locations.

Table 2. OFWS and center pivot irrigation systems by county.

County	# of OFWS	Area (ha) of OFWS	Center Pivots	Area (ha) of CP
Alcorn	1	0.8	5	83.4
Benton	2	0	20	727.6
Calhoun	3	21	5	237.3
Chickasaw	11	36.9	15	467.3
Choctaw	0	0	0	0
Clay	5	14.7	6	120
Itawamba	0	0	2	42.3
Lafayette	1	0	3	166
Lee	2	0	5	226.4
Lowndes	27	187.4	46	2,271.84
Marshall	2	0.7	13	499
Monroe	23	132.8	26	1310.6
Noxubee	132	908.7	251	10,928.83
Oktibbeha	12	20.0	2	17.9
Pontotoc	1	6.9	1	42.7
Prentiss	0	0	0	0
Tippah	0	0	4	149.4
Tishomingo	2	8.5	0	0
Union	0	0	0	0
Webster	1	3.8	1	73.9
Winston	3	6.7	0	0
Yalobusha	0	0	8	239.3
Totals:	**228**	**1,349.10**	**413**	**17,603.84**

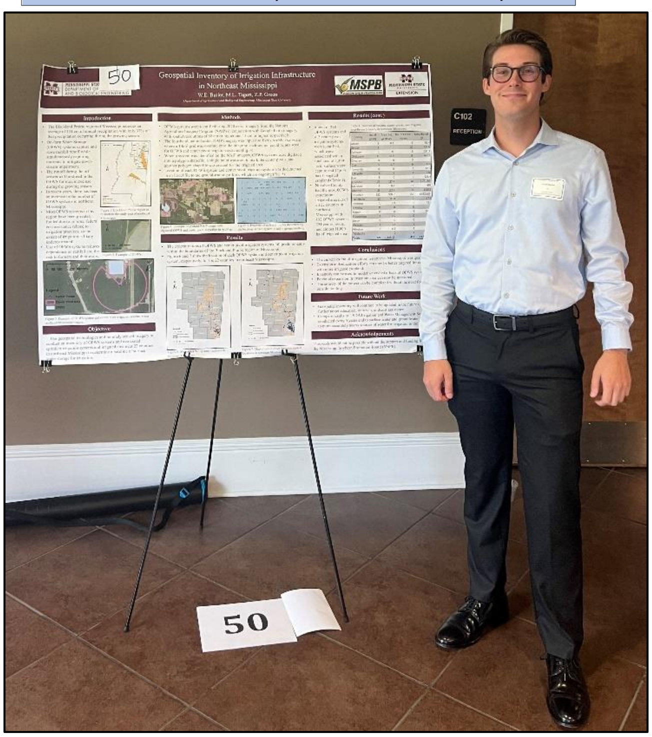

Figure 7. Undergraduate student researcher Elliott Butler with his poster at the MSU Summer Undergraduate Research Symposium on Aug. 2, 2023.