Highlights of the Project

- Surge irrigation for furrow irrigation demonstrated water savings of about 18% compared to standard furrow irrigation.
- Integrated irrigation approach with surge irrigation, soil moisture sensors and crop growth stage demonstrated potential to minimize irrigations with no significant effect on crop yields.
- Water quality monitoring showed that appreciable amounts of nutrients lost through surface runoff signifying need for minimized runoff losses to lower irrigation costs as well as soil fertility loss.
- Long-term demonstrations to show the full benefits of integrated irrigation management are needed to convince the producers to adopt these technologies because the water savings alone were not encouraging enough to put additional investment and labor.

INTRODUCTION

Frequent dry spells during the sensitive growth stages of crops led to the increased irrigation acres in Louisiana. According to the Farm Service Agency, about 40% of the row crops were under irrigation in 2016. Due to the very low cost and ease of use, majority of these irrigated acres are under furrow irrigation using poly pipe. However, furrow irrigation’s water use efficiency is estimated as low as 40% and has great potential to improve. Further, low irrigation/water use efficiency also lead to deterioration of soil health through the loss of soil, organic matter and nutrients; lower nutrient efficiency from nutrient run off and leaching; and higher environmental pollution. Extensive past research has developed various techniques to improve furrow irrigation efficiency that includes use of surge irrigation and skip-row irrigation methods. In addition to lower efficiency of furrow irrigation, water use efficiency tends to low with poor irrigation timing. While early irrigation leads to excessive water loss, late irrigation could significantly lower the grain yields. Further, it is difficult to guestimate the effective amount of rainfall that saved in the crop root zone. Currently, producers depend on the nonscientific soil touch and feel or visual symptoms of crop or calendar based irrigation lead to improper timing of irrigation.

Overall, there is a great need to improve furrow irrigation potential for optimum crop yields, resource use efficiency and minimize impact on the environment. Despite the availability of different technologies to improve furrow irrigation efficiency, their adoption by the producers’ is low due to lack of awareness of technology or technical knowhow.

OBJECTIVE OF DEMONSTRATION

The objective of this project was to demonstrate integrated use of surge irrigation, skip-row furrow irrigation, soil moisture sensors, PHAUCET for polypipe hole selection and crop growth stage specific water needs so to significantly improve water use efficiency while minimizing nutrient and sediment losses.

ON-FARM PROJECT DEMONSTRATIONS
On-farm field demonstrations were conducted for 3 years beginning 2016 in in two locations, one each in Northwest Louisiana and Northeast Louisiana. At each location, two furrow irrigation treatments/practices were carried out to compare their efficacy to produce optimum crop yields and total water use per season. The irrigation practices compared were 1. Producer’s standard practice of furrow irrigation (FP) and 2. Furrow irrigation integrated with surge irrigation, and soil moisture sensors and crop growth stage to determine the optimum time to initiate irrigation (IIMS).

Irrigation for FP practice: Crop was furrow irrigated using poly pipe as per the standard irrigation practice of the participating producer. Total quantity of irrigation water was measured using a flow meter at the riser (Figure 1).

![Flowmeter installed between the riser and polypipe to monitor the quantity of irrigation water](image)

Irrigation for IIMS practice: Surge irrigation was provided using poly pipe connected to the surge valve (Figure 2). Surge irrigation program was developed using PHACET program that considers well/riser outflow, width of the field, length of rows, and slope of the fields. Time of irrigation was determined by the readings of soil moisture sensors installed at the halfway of the row length. Total of four GS1 soil moisture sensors (Meter Group, Pullman, WA) were installed in the middle of the row at 8”, 14”, 20” and 26” depth of soil that encompasses more than 80% of effective root zone (Figure 3). Changes in volumetric soil moisture was monitored for every 30 minutes and data was monitored remotely using EM50G telemetry datalogger (Meter Group, Pullman, WA). Depending on the stage of the crop, either one or multiple sensors readings were used to determine the time of irrigation.
Figure 2: Surge valve system that automatically controls the surge irrigation cycles

Figure 3: Soil moisture sensor installation for IIMS practice
Northwest Louisiana Site

In Northwest Louisiana, the demonstration was conducted in all 3 years at Belcher located in Caddo parish. Supporting producer at this location was Mr. Ryan Kirby. The demonstration site/field was same for the years 2016 and 2018 while the site/field for 2017 was different. This was due to lack of yield monitoring equipment for the cotton crop that was planted in that site. However, in 2017, no irrigation was provided due to sufficient rainfall.

Year-1, 2016: The experimental site was about 30 acres with Coushatta silt loam. The site was divided into two sections to compare the FP and IIMS irrigation practices. Corn was planted on Mar 28, 2016, and harvested on Aug 11, 2016. Both FP and IIMS practices received total of two irrigations each during the entire crop season. Both practices used skip-row furrow irrigation. At both the irrigation events, IIMS practice received irrigation later than the FP practice, as suggested by the soil moisture sensors’ readings. Overall, use of soil moisture sensor readings saved 14 additional days without irrigation for IIMS practice compared to FP. However, IIMS practice did not minimize number of irrigations due to sufficient rainfall during the rest of the crop season. For both irrigation events, even though the surge program recommended time of 18.4 hours of irrigation, producer irrigated IIMS practice for 24 hours similar to his FP practice. However, surge irrigation generate more uniform application of water on the field compared to standard continuous furrow irrigation, which generally benefit the crop yields by avoiding excessive or insufficient irrigation. Average corn grain yields for the FP and IIMS practice were 146.1 and 156.76 bu/ac, respectively. Higher yield in IIM treatment by 7.3% could be partly attributed to the optimum timing of irrigation along with more homogenous wetting of root zone throughout the field.

Year-2, 2017: This year, the demonstration field received sufficient rainfall throughout the crop season eliminating any need for irrigation.

Year-3, 2018: Corn was planted on Mar 14, 2018 and harvested on Aug 13, 2018. This year, there were total of four irrigations for both FP and IIMS practices. Being the same field as 2016, the PHAUCET program suggested 18.4 hours of irrigation for IIMS practice; however, farmer still irrigated the field for 24 hours, similar to his practice. This could have led to higher runoff water losses from IIMS treatment as surge irrigation minimizes deep percolation losses ultimately leading to no water savings from the use of surge irrigation. Corn grain yield from FP and IIMS practice was 194 and 188 bu/ac. This was 3% lower yield in IIMS compared to FP practice, which was mostly insignificant. One of the reasons for the slightly low grain yield from IIMS practice could be occurred from limiting the depth of irrigation at the section of the field nearest to the irrigation pipe.

Northeast Louisiana Site

In Northeast Louisiana, the irrigation demonstration was carried out in either Tensas or East Carrol parish due to different participating producers in each year.

Year-1, 2016: This year participating producer was Mr. Chuck Tucker from Waterproof located in Tensas parish. Soybean was planted on May 15, 2016, and harvested in the 2nd week of October 2016. Both the farmers practice and IIMS practice received only one irrigation during the season and both practices used skip-row irrigation. The producer irrigated his section of the field on the same day same as IIMS practice. Using surge irrigation, the IIMS practice received 66,527 gallons of water per acre, while the FP
practice received 80,104 gallons of water per acre. Soybean grain yields for the FP and IIMS practices were 96.2 and 93.7 bu/ac, respectively. Slightly lower yield in IIMS practice by 2.6 % could have been due to poor drainage conditions on south half of the field rather than the lower quantity of irrigation water under IIMS practice.

Year-2, 2017: This year participating farmer was Mr. Robert Warren from East Carrol parish. Demonstration was initially established in a cornfield, however, due to sufficient rainfall for corn the experiment was moved to soybean field. Soybeans in both the practices received just one irrigation. Besides, the demonstration site had good rainfall two days after the irrigation, eliminating any possible differences in grain yield between the treatments. Due to the use of surge irrigation, IIMS practice took 18% less number of hours to irrigate than the FP practice. Overall, IIMS practice conserved over 11% of water as compared to FP practice. Since there was good rainfall 2 days after both fields were irrigated, yield differences were not expected between the practices.

At the end of the season, despite the no difference in the soybean grain yield between the two treatments, the water savings were significant. The improved WUE from IIMS practice was highly significant to maintain the long-term health of the field.

Year-3, 2018: Demonstration was initiated in a soybean field located in Lake Providence of East Carrol parish with Mr. Glen Brown as a participating producer. However, neither practices got irrigation due to sufficient soil moisture.

Overall, out of six demonstration site years on the producers’ fields, during four site years’ fields received at least one irrigation. Among all those four site years, IIMS with surge irrigation and soil moisture sensors that helps determine optimum time of irrigation has shown opportunity to lower the consumption of irrigation water either with no significant differences in grain yields compared to the producers field.

**Skip-row Furrow Irrigation**

Since we could not carry out the comparison of skip-row irrigation comparison to all furrow irrigation, we carried out that work at Red River and Northeast Research Stations of LSU AgCenter. In this work, we compared the skip row furrow irrigation with all furrow irrigation in different soil types (Mooreland and Sharky clays, Commerce Silt loam, and Caplis very fine sandy loam soil) for corn and soybeans. The major findings of the study were: 1. In clay soils, skip-row irrigation saved about 20 % water compared to all furrow irrigation while producing similar or slightly higher grain yields in both corn and soybeans due to well distribution of water. 2. In very fine sandy loam soils, skip-row irrigation saves as much as 40% water compared to all furrow irrigation; however, this has detrimental effect on grain yield by reducing as much as 46% depending on crop growth stage and rainfall distribution.3. If skip-row irrigation is adopted in light textured soils, shortening the irrigation intervals by 2 to 3 days at critical growth stages (flowering to early seed fill) could eliminate the yield loss. Hence, Skip-row irrigation is recommended for heavy to medium textured soils while adoption of skip-row furrow irrigation in light textured soils needs either shortening of irrigation intervals or adopting all furrow irrigation at critical growth stages, especially under dry spells longer than 3 weeks.
Soil Health

Soil health parameters of soil organic matter, soil bulk density, pH, Electric conductivity, and soil water infiltration changes takes longtime to show any differences. Since, only one demonstration site undergone only two years of recommended practice of irrigation, no differences were determined between the practices. In order to demonstrate the soil health benefits, though the project is ended, we are planning to continue the demonstration specifically surge irrigation to determine its impact on soil health parameters.

WATER QUALITY

Dr. Changyoon Jeong monitored the runoff water quality at the Northwest Louisiana demonstration site. He monitored the loss of total suspended solids (TSS), NO$_3$-N, PO$_4$-P, total-N, and total-P

Nutrient Losses through Surface Runoff

Surface runoff water samples were collected through the ESCO water sampler in the edge of field after irrigation and rain events. The analyzed parameters were TSS, total nitrogen (TN), NO$_3$/NO$_2$-N, total phosphorus (TP) and soluble reactive phosphorus (SRP).

Field Instrumentation and Calibration

Runoff water quality monitoring site was fully instrumented with flowmeters (4250 model Bubble Flow Meters) and automated samplers (ISCO 6712 Samplers), which were powered by 12V batteries and 20V solar panels. Sampling site had 46 cm H-Flumes (86.4 cm wide, 172.7 cm long, and 46 cm high) and bubbler gauges. Surge protector lightening rods were installed at site.

Figure 4. Schematic diagram for the field instrumentation.
Runoff Water Sampling and Analysis:

Flow interval-based surface runoff water samples were collected. The sampler was set to sample at various flow intervals (e.g. 3785 liters, 15142 liters). Prior to mixing runoff samples from all the collection bottles (a maximum of 24 in ISCO sampler) in lab for a composite sample. Water sample bottles were put in ice chests with ice packs and were transported to the laboratory.

Nutrient Loading Estimation

Nutrient loading was calculated by multiplying the total runoff volume and the nutrient concentration (Table 1). We collected 3 irrigation event water samples in 2016 and collected 2 irrigation events (6/15/2018 & 6/28/2018) and 3 runoff water under rain events in 2018. Nutrient losses on nitrate, soluble reactive P (SRP), total Kjeldahl N (TKN), total P (TP) under irrigation were on average 0.093, 0.402, 0.648, and 0.449 kg ha\(^{-1}\), respectively in 2016 (Table 1).

Water Quality Findings

Nitrate losses through surface runoff were significantly increased up to the event of June 22, 2018 (Fig.5). This may be due to the farming activity. Additionally, TKN also showed a similar trend of nutrient losses compared with the results of nitrate losses (Fig.6). However, measured SRP and TP showed an increasing trend until July 13, 2018 (Fig. 7 & 8). It is possible that SRP and TP losses are significantly impacted by the disturbed surface soils and farming activities during crop growing season.

Table 1. Nutrient runoff concentration and loading from monitored site in Belcher, LA.

<table>
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<th>Date</th>
<th>Concentration</th>
<th>Loading</th>
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</table>
Figure 5. Nitrate losses in the monitoring sites after irrigation and rain events.

Figure 6. Total N losses in the monitoring sites after irrigation and rain events.
Figure 7. Soluble reactive P losses in the monitoring sites after irrigation and rain events.

Figure 8. Total P losses in the monitoring sites after irrigation and rain events.

OUTREACH

The findings of the on-farm demonstrations, and skip-row furrow irrigation findings will be soon published as extension publications through LSU AgCenter and will be shared with the producers through giving talks at field days and producers’ meetings to increase their adaptation.