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FURROW VS. FLOOD IRRIGATON OF SOYBEANS

In the lower Mississippi River Valley alluvial plain, clay-textured soils are the predominate type, comprising over 9 million acres. Rice and soybean are typically planted in rotation on a significant acreage of these soils, with rice being flood-irrigated and soybean being furrow- or flood-irrigated. Also, a significant portion of these fields have been graded to facilitate surface drainage and surface irrigation.

Flood irrigation results in inundation of a field area that is contained within a set of levees. Usually, the entire profile of cracking clay soils is completely recharged during flood irrigation. This method requires levees that take away land area for production, take time to survey and construct, and take time to knock down after the irrigation. Generally, levees are surveyed on elevations of no more than 0.4 foot. Flood irrigation is typically 50 to 60 percent efficient.

For rice production, straight levee irrigation is commonly used for flood irrigation. The levees for this system run perpendicular to the slope of a field and confine water to defined areas in fields that have been graded to slope in only one direction. This method requires moderate grading to ensure uniform field slopes. Producers that utilize this method for rice production will often flood-irrigate soybeans as well.

Soybean in the irrigated area is exposed to varying depths of standing water for varying periods of time. The flow rate of the water source and the size of the enclosed area being irrigated determine the time required to complete the flood. During the flooding period, an increasingly larger area is covered with water until the entire area within the levees is finally inundated. Thus, the period of time a particular area within the levees is flooded will vary with its location within an impounded area.

The process should be managed for soybeans so that the entire area that is enclosed by levees is flooded and drained within 2 days. Longer flood irrigation periods will result in a reduced yield increase from irrigation due to prolonged soil oxygen deprivation. The damaging effect of prolonged flooding [more than 2 days] is more severe for soybeans grown on clay vs. silt loam soils.

Water withdrawal for irrigation from the Mississippi River Valley Alluvial Aquifer [MRVAA] is occurring at a rate that is depleting the aquifer—i.e. it is not sustainable. With the decreasing water levels in the MRVAA and regulators responding by requiring minimum levels of irrigation water use and adoption of efficiency practices, the impact of furrow and flood irrigation practices in Midsouth soybean production needs to be evaluated.

The following is a summary of the details of the conduct of and results from research that was conducted as part of the **MSPB-funded RISER project (Projects 55-2016, 55-2017, and 55-2018)** conducted by Mississippi State Univ. scientists and specialists. The objective of this research was to compare soybean grain yield, total water applied, irrigation water use efficiency, and economic net return from optimized furrow [FURROW]- and flood [FLOOD]-irrigated soybean production systems. The research was conducted on producer fields in the Delta region of Mississippi. FLOOD fields were irrigated according to the producer's standard farm practices using straight levees that were constructed perpendicular to the field grade. FURROW employed computerized hole selection [CHS—Pipe Planner], surge irrigation, and soil moisture sensor technology for scheduling irrigation. A detailed presentation of the conduct of and results from this research is in the article titled "Maximizing soybean productivity and profitability by transitioning from flood to furrow irrigation on clay-textured soils" by Bryant et al.

MATERIALS AND METHODS

Site Description and Production Practices

Studies consisted of paired fields with the same variety, soil texture, planting date, and management practices used on both sites at a location. Paired fields on 24 Delta farms in Mississippi were randomly assigned for irrigation with either the FURROW or FLOOD method on each farm. All fields in this study were land-formed clay-textured soils and were side-by-side or in relatively close proximity to each other. All cultural practices were performed similarly on both fields at each site.

Irrigation Protocol

Irrigation of FLOOD fields was based on the producer's standard practices. FURROW fields were irrigated through lay-flat polyethylene tubing with hole sizes punctured according to recommendations made by the Pipe Planner CHS program. Surge valves were installed at each FURROW field, and irrigations were scheduled when the weighted average soil moisture sensor readings in the 0-24 in. soil depth were between -85 and -100 centibars. Both FURROW and FLOOD fields were outfitted with flowmeters to measure flow rate and water usage.

Irrigation was terminated at R6.5 as recommended by the Mississippi State University Extension Service. Treatments were mechanically harvested at physiological maturity and yields were determined with a calibrated onboard yield monitor.

Irrigation water use efficiency (IWUE—soybean yield per acre-inch of irrigation water) was calculated by:

$$\mathrm{IWUE} = \frac{\mathrm{SGY}}{IWA}$$

where SGY is soybean grain yield in bu/acre and IWA is amount of irrigation water applied in acre-inches to a field. Total irrigation water applied, soybean grain yield, IWUE, and net return were analyzed using the MIXED procedure of SAS. Presented results in Table 1 are averages over the 3 years of the research.

Economic Analysis

To investigate the economics of the two irrigation systems, enterprise budgets were developed based on the use of furrow and flood irrigation technologies in a straight-levee field. These budgets are modified versions of budgets in the Mississippi State University Department of Agricultural Economics Crop Enterprise Budgets for the three respective years and the two irrigation technologies. The results in **Table 1** are based on the income, direct expenses, and fixed expenses related to the FURROW and FLOOD methods.

The expected income is based on a soybean price of $9.59 per bushel, which is the average price for the 3 years of the research. The yields for both methods are the average of those obtained in this study. All cultural practices other than irrigation activities are assumed to be identical for both technologies. Other than irrigation-related expenses, the only other difference in cost per acre is related to the grain hauling which is directly related to yield, and was $1.89 per acre higher for FURROW.

The irrigation supply allowance of $19.01 per acre for FURROW includes a $10.76 per acre charge for the water management tools, along with an $8.25 per acre charge for rollout pipe. The irrigation water management tools include surge valves, transfer pipe, soil moisture sensors, batteries, and a data logger package. Estimated irrigation costs for FURROW also include direct expenses for laying out and retrieving the pipe along with labor for three 3-inch irrigation events.

Estimated costs for FLOOD include machinery and labor costs to build inside levees twice, two 4-inch irrigation events, and machinery and labor costs for tearing down the levees twice.

RESULTS

Irrigation Water Use Efficiency and Soybean Grain Yield

Total water applied and irrigation water use efficiency were not significantly affected by irrigation method [**Table 1**]. These data suggest that farmers are managing water use in flood-irrigated fields very well. The majority of farmers implementing flood irrigation have been using this practice for years and have learned when and how to terminate irrigation to minimize runoff. These results indicate that Midsouth producers can implement FURROW on clay-textured soils to achieve greater soybean seed yield and economic net return when compared to FLOOD without negatively affecting the region's groundwater supply.

Soybean seed yield was different between FURROW and FLOOD. The FURROW irrigation method yielded 7.1% more than FLOOD [**Table 1**]. The number of levees, well capacity, saturation, and drainage all played a role in the observed yield reductions in FLOOD. Farmers continuing to flood-irrigate should pay close attention to well capacity, field size, and drainage to avoid soil saturation on any portion of the field.

Economic Return

Irrigation method significantly affected economic net return [**Table 1**]. FURROW resulted in an average advantage of $30.77/acre over FLOOD, or an 18% greater return. These results show that the FURROW method is significantly superior to FLOOD for both soybean seed yield and economic net return.

Table 1. Total irrigation water applied, irrigation water use efficiency, soybean grain yield, and net return for FURROW and FLOOD irrigation methods in a study conducted in 2016-2018 on clay-textured soils in the Mississippi River Delta.

Parameter	Irrigation Method	
	FURROW	**FLOOD**
Total Irrigation Water Applied (acre-inches)	8 A[a]	8 A
Irrigation Water Use Efficiency (bu/acre-inch)	10 A	11 A
Soybean Grain Yield (bu/acre)	75 A	70 B
Net Return ($/acre)	199.29 A	168.52 B

[a]Values in a row followed by the same letter are not different at the α = 0.05 level of significance.

CONCLUSIONS

The objective of this research was to compare soybean seed yield from and amount of irrigation water applied to FURROW- and FLOOD-irrigated soybean production systems. From these data, IWUE in and net returns to the two systems were calculated.

The research was conducted on 24 paired fields in the Delta of Mississippi. Studies consisted of paired fields with the same variety, soil texture, planting date, and management practices used on both sites at each location. Paired fields were randomly assigned as irrigated with either FURROW or FLOOD.

Total water applied and irrigation water use efficiency were not affected by irrigation method. Thus, according to these results, replacing FLOOD with FURROW will have no effect on MRVAA decline in the Mississippi River Delta.

The FURROW irrigation method yielded 7.1% more than FLOOD [75 vs. 70 bu/acre]. The number of levees, well capacity, saturation, and drainage all played a role in the observed lower yield in FLOOD. Farmers continuing to flood irrigate should pay close attention to well capacity, field size, and drainage to avoid soil saturation on the top and bottom of the field.

Average net return to FURROW was $30.77/acre greater than to FLOOD. Thus, FURROW was significantly superior to FLOOD with regard to both soybean seed yield and net return.

Overall, these results indicate that FURROW on clay-textured soils can be implemented to replace FLOOD to achieve greater soybean seed yield and net return without negatively affecting the MRVAA.

Two factors should be considered when assessing these results. 1) From 2017 to 2021, 1.773 to 2.293 million acres of rice were harvested in Ark., La., Miss., and Mo. (NASS), and this acreage likely was annually rotated with soybeans. Producers who regularly use a rice-soybean rotation in the region will likely find it more efficient and just as profitable to use FLOOD to irrigate both crops since the same irrigation setups can be used for both crops when rotated. 2) Producers who grow continuous soybeans or soybeans in rotation with a crop other than rice should certainly consider transitioning to FURROW if they are presently using FLOOD. This will most likely be the preferred irrigation method for corn and cotton crops that may be rotated with soybeans.

These results are especially pertinent when viewed in association with the results from recent research [click here and here] that provide support for an increase in furrow-irrigated rice acreage in the Midsouth.

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