Mississippi Water Resources Research Institute (MWRRI)
Final Project Report

Water-Conserving Irrigation Systems for Furrow & Flood Irrigated Crops in the Mississippi Delta

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Abstract

The goal of this project was to improve irrigation water- and energy-use efficiency in one of the most economically important cropping rotations practiced in the Mississippi delta, the soybean-rice rotation. Combined economic activity for the two crops in the delta can approach $1 billion annually while combined irrigation water use is approximately 1 million A-ft per season. As a result, a modest reduction in the amount of irrigation water used in the soybean-rice rotation could help reduce the current overdraft of the alluvial aquifer. Results from these 2010-2012 on-farm trials indicate soybean irrigation savings using NRCS Phaucet optimization software averaged about 20% compared to non-optimized furrow irrigation while associated energy use reductions ranged from 32 to 20%, respectively. (It is important to note that in order to foster comparison, the soybean fields used in these studies were rectangular in shape; water savings are expected to be greater for more irregular (i.e., hard to irrigate) soybean fields.) Irrigation water used in rice grown using straight-levees with multiple inlets and intermittent flood management averaged 22.1 ± 2.4 A-in/A as compared to 32.4 A-in/A for straight-levee rice using multiple inlets without intermittent flood management. These results indicate that by overlaying an intermittent flood regime on practices that are already familiar to rice producers in Mississippi, rainfall capture is increased and over-pumping is decreased such that overall water use is reduced by ~40% over the standard rice irrigation practices. Field trials comparing rough rice yield and milling quality for up to 15 rice varieties indicated that commercial rice varieties, grown using standard fertility and pest control programs, well-tolerated a carefully-controlled intermittent flooding regime. Each inch of water not pumped from the Alluvial aquifer onto an acre of rice or soybean saves the energy equivalent of ~1 gallon diesel fuel with concomitant reduction in CO_2 emissions by ~200 lbs/A. Assuming a current off-road diesel price of $3.20/gallon, a 9 acre-inch (40%) reduction in rice irrigation translates to a savings of ~$20 per acre while a 1.7 acre-inch (20%) reduction in soybean irrigation represents a savings of ~$3 per acre. By reducing irrigation water and associated energy inputs in soybean and rice production, the producer reduces input costs while reliving pressure on the Mississippi River Valley Alluvial aquifer and also reduces carbon emissions.

Critical Water Problem Addressed

The Mississippi River Valley Alluvial (MRVA) aquifer in the Mississippi delta has been experiencing groundwater declines for over twenty years (Figure 1). Reducing and reversing the decline in is important to the economic and ecological futures of Mississippi and the Nation.

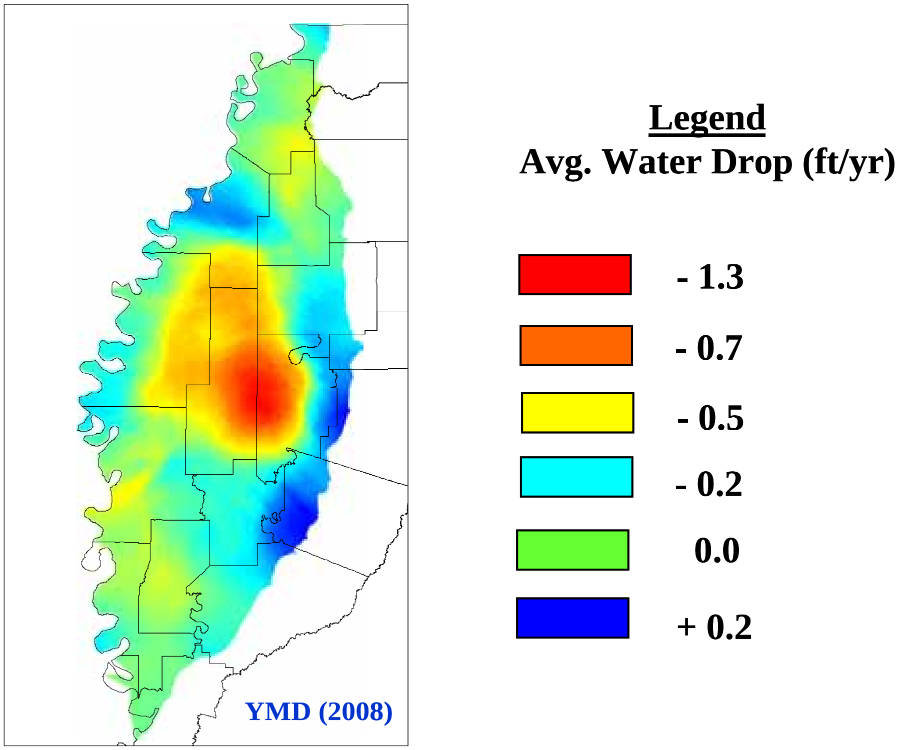


Figure 1. Average 20-yr decline in depth of alluvial aquifer in the Mississippi delta. (YMD, 2008)

Project Objectives

The goal was to develop water-conserving irrigation practices for soybean and rice production to reduce overall withdrawals from the MRVA aquifer. Specific objectives were:

Objective 1: Compare season-long water and energy use, and grain yield for soybean grown using furrow irrigation systems optimized using the NRCS Phaucet program and pump timers to that of non-optimized furrow irrigated soybean.

Objective 2: Compare season-long water and energy use, grain yield, and grain quality for rice grown using multiple-inlet irrigation with intermittent flood management and depth gauges to rice grown using only multiple-inlet irrigation.

Objective 3: Using input from producers and crop consultants, refine approaches developed in Objectives 1 and 2 to create systems that can be readily adopted across the Mississippi delta.

Related Research

The Lower Mississippi River Valley (LMRV) is one of the most productive agricultural regions in the United States. Aquaculture, corn, cotton, rice, soybean and other crops generate nearly $6.8 billion/yr in revenue and employ about 100,000 while transportation on the lower Mississippi River accounts for another $6 billion/yr and 29,000 jobs (Black et al., 2004). Owing to frequent extended periods of dryness during the growing season, supplemental irrigation is necessary for optimal yields and economic returns (Heatherly and Hodges, 1999). More than 3 million ha of irrigated cropland exist in the LMRV (USDA NASS, 2007), making it one of the most heavily irrigated regions in the U.S. (Figure 2). During the mid-1990s to early 2000's, roughly 77,000 ha of new cropland came under irrigation each year (Evett et al., 2003).

The Mississippi River Valley Alluvial (MRVA) aquifer (Figure 1) supplies about 90% of the irrigation in the LMRV. The water withdrawal rate from the aquifer is 9,290 Mgal/d and ranks second only to the High Plains aquifer (17,500 Mgal/d) in terms of irrigation use (Maupin and Barber, 2005). The aquifer is an unconsolidated sand and gravel aquifer at, or near, the land surface that ranges in thickness from about 7 to 45 m (Arthur, 2001). In portions of Arkansas and Mississippi, the aquifer is declining at rates ranging from 0.15 to more than 0.45 m per year (ASWCC, 2010; YMD, 2010). This deficit could potentially be exacerbated by growing future demand for irrigation, for reasons explained below.

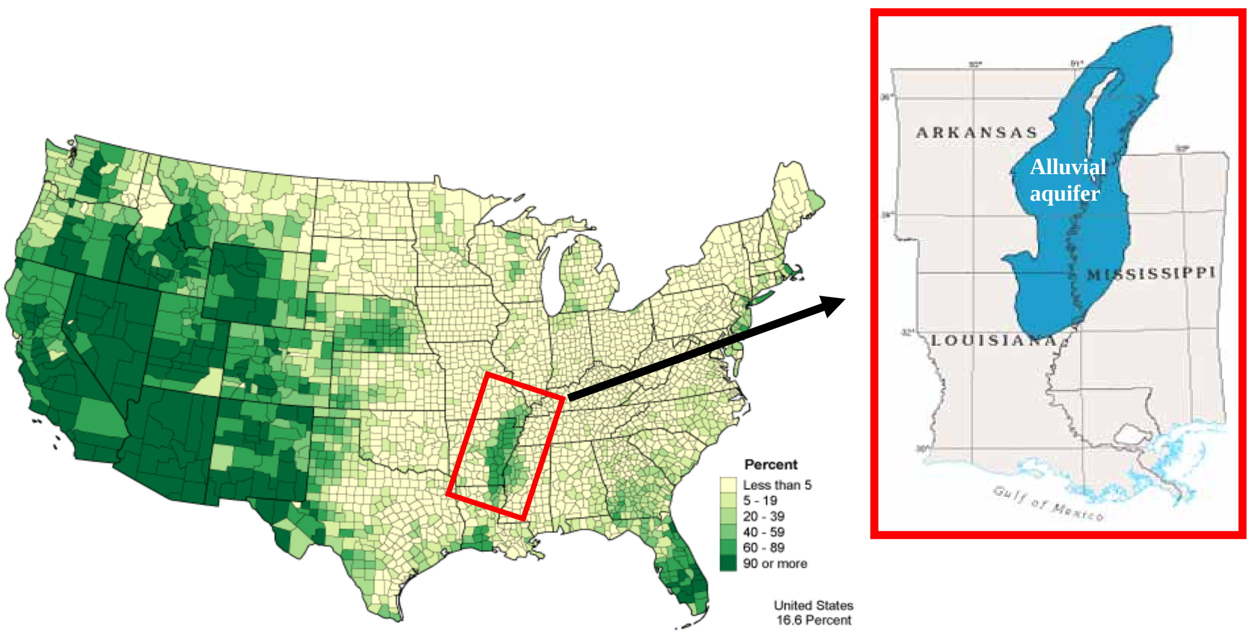


Figure 2. Irrigated harvested cropland in 2007, showing intensity of crop irrigation in the Lower Mississippi River Valley (LMRV) and boundaries of the Mississippi River Valley Alluvial (MRVA) aquifer (inset). **(***Modified using graphs from USDA NASS and USGS).*

Recent climate projections indicate that summers in the LMRV may become hotter and drier and winters will become warmer with above normal precipitation (Kunkel et al., 2011; Fig. 3). The impacts that such changes might have on net aquifer recharge are unknown, but clearly increased summertime temperatures coupled with reduced in-season rainfall could be expected to increase soil moisture deficits and, thus, irrigation demand.

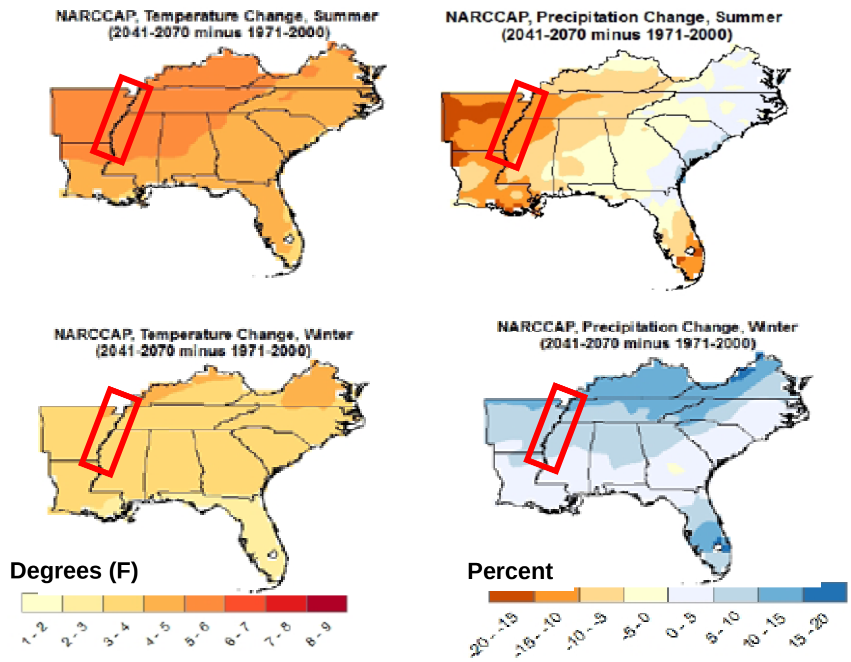


Figure 3. Summer and winter temperature and precipitation projections for the southeastern U.S. (modified using graphs from Kunkel et al., 2011)

In addition to the climate projections for the LMRV, Seager et al. (2007) anticipate that the **southwestern** U.S will undergo progressive warming and drying (Fig. 4), increasing demand for irrigation (Cayan et al., 2010) while decreasing water availability, exacerbating competition for water in a region already experiencing declines in irrigated crop acreages (NASS, 2007). If this occurs, the agricultural and water resources in the LMRV will be increasingly relied upon by a nation seeking to compensate for declines in agricultural productivity in the southwest.

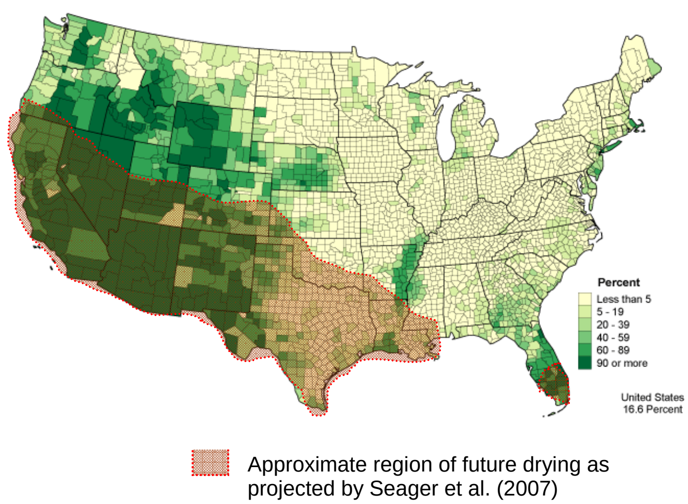


Figure 4. 2007 irrigated harvested cropland with overlay of southwestern region of the U.S. that is projected to progressively dry in the future. (NASS graphic modified using Seager et al. (2007) projections)

Demand for irrigation will also increase as agricultural input costs increase (Figure 5) because farmers will need to protect their substantial investments. Irrigation is one of the surest ways to reduce risk and protect against the vagaries of hot, dry weather that is projected to increase in the LMRV (Fig. 3).

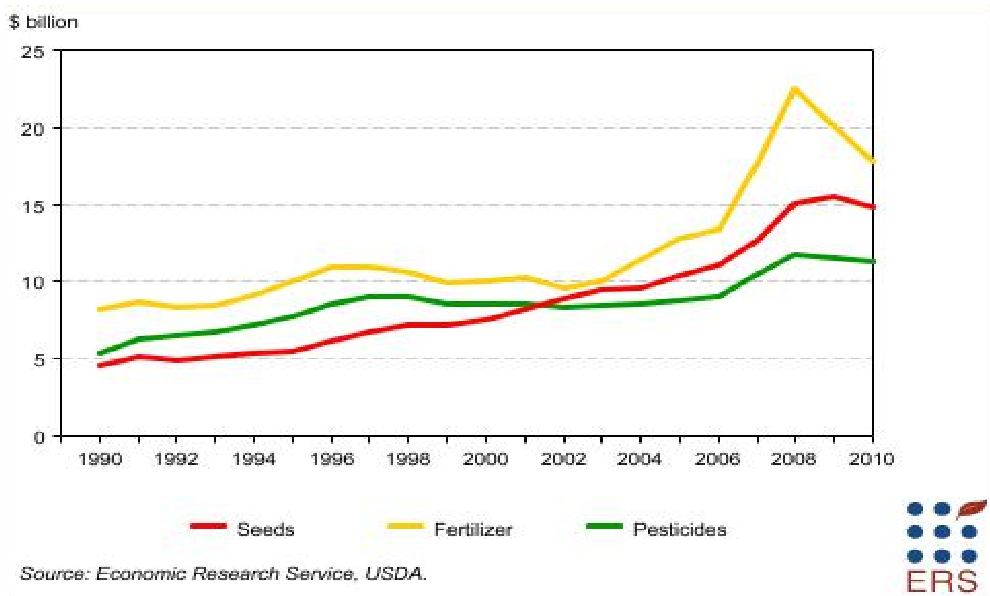


Figure 5. Total expenditures for seeds, fertilizers, and pesticides by U.S. farms. (Source: USDA Economic Research Service.)

The above climate projections and rising input cost and commodity price trends suggest that demand for irrigation water in the LMRV could grow in coming decades. As the areal recharge of the aquifer occurs at a nearly steady rate averaging about 2.5 inches per year (Arthur, 2001), such an increased demand for irrigation will exacerbate the current overdraft of the MRVA aquifer unless the total amount of water withdrawn from the MRVA aquifer is reduced by (a) reducing the total irrigated acreage such as by growing more non-irrigated or drought-tolerant crops, (b) use of significantly more efficient irrigation practices, (c) exploitation of new source(s) of irrigation water, or (d) augmentation of aquifer recharge using surface water. Most likely, combinations of these options will have to be used to meet increasing demands for irrigation while protecting the future viability of the MRVA aquifer.

This WRRI-funded project investigated improved irrigation methods for soybean (*Glycine max.*) and rice (*Oryza sativa*). Irrigation water used in the production of rice and soybean is approximately one million acre-feet per year or approximately one-half the current removal of irrigation water from the alluvial aquifer in Mississippi. The research performed in this project was conducted in the Mississippi delta, but should be generally applicable to other agricultural areas in the LMRV.

Project Description

The 2:1 soybean-rice crop rotation is an approximately three year rotation practiced on nearly one million acres in the Mississippi delta. This rotation can produce a combined economic activity that approaches $1 billion annually but also currently uses approximately one million A-ft of irrigation water per season (Table 1). As a result, a modest reduction in the amount of irrigation water used in the soy-rice rotation could theoretically[1] help to reduce overdraft of the alluvial aquifer.

Table 1. Average irrigation water used by row crops in the Mississippi delta (YMD, 2010).

Crop	**2009 Acres (thousands)**	**Avg. H_2O Use (Ac-ft/Ac)**	**Estimated Seasonal Water Use (Ac-ft)**
Rice	200*	3	600,000
Corn	900	0.8	720,000
Soybeans	2,500* (Delta only: 1,750)	0.7	Delta irrigated only: 796,000
Cotton	270	0.5	135,000
Fish	70	1.9	133,000

* 100% of the rice and ~70% of the soybeans grown in MS occur in the Mississippi delta; approximately 65% of the delta-grown soybeans are irrigated.

Approximately 50% of delta-grown soybeans are produced on raised beds and irrigated down the furrows using plastic tubing as shown in Figure 6. The USDA NRCS *Phaucet* irrigation computer program[2] optimizes hole size and number in plastic tubing, improving irrigation efficiency by 25% or more according to research conducted in Arkansas (Tacker, 2008). The Phaucet program requires that the overall field dimensions (row lengths and widths) and slope of the field (total head pressure, in feet) and flow rate of the irrigation pump (gallons per minute) be known. Using this information and the dimensions of the plastic tubing, the program calculates the optimal hole sizes and numbers to distribute water evenly across irregularly-shaped fields.

Figure 6. The furrow irrigation of crops can be optimized using the NRCS Phaucet program that determines optimal hole sizes and numbers in plastic tubing using row lengths, field slope, flow rate of well, and tubing specifications.

[1] Assumes that water saved by improved irrigation efficiency is not used for other crops or purposes. See Pfeiffer and Lin (2010) for an example where technology used for water conservation led to more actual water use.
[2] The USDA NRCS Phaucet program is available at link below:
(http://www.wsi.nrcs.usda.gov/products/w2q/water_mgt/irrigation/irrig-mgt-models.html)

The majority of rice in Mississippi is produced in straight-levee fields that have been precision-leveled to have uniform slopes of 0.1 to 0.2% (Figure 7) allowing straight levees to be placed perpendicular to the slope at regular intervals of ~ 180 ft. In approximately 20% of the straight-levee fields, plastic tubing is used to distribute floodwaters across the field in a practice called multiple- or side-inlet irrigation. Approximately 5% of rice is grown on zero-grade or "level basin" fields that have no slope and, thus, require no levees. The acres of rice grown using traditional contour levees that follow the natural contour of the field are decreasing with each passing year, but is estimated to be about 30% of production in 2009.

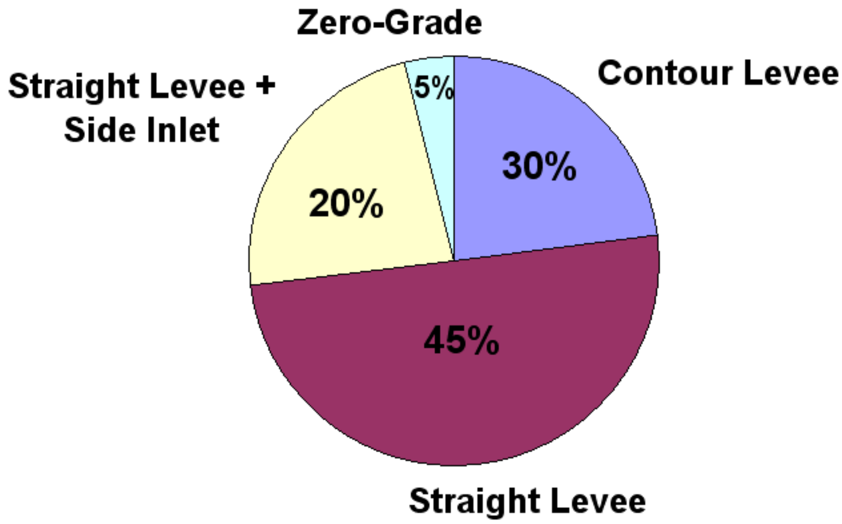


Figure 7. Approximate percentages of rice levee systems used in Mississippi delta in 2009. (Estimates based on MSU extension farmer and consultant surveys, and YMD permitted well meta information.)

Depending on soil series, cultivar, and prevailing weather, rice grown in the Mississippi delta generally needs somewhere between 14 to 25 inches water (1.1 to 2.1 A-ft/A) per 80-day flood. This range, which represents contributions from rainfall and irrigation, are based on research conducted by Pringle (1994) using cultivars (Table 2) and rice soils (Table 3) in Mississippi. Rainfall during these studies conducted in 1991 and 1993 was 66.5% and 97.9% of rainfall average, respectively.

Table 2. Average evaporation-transpiration (ET) losses measured by Pringle (1994) for four rice varieties grown in the Mississippi delta in 1991 and 1993.

Variety	Measured ET (inches)
Rosemont	12.8 ± 3.0
Maybelle	13.6 ± 1.7
Newbonnet	15.7 ± 2.2
Lemont	16.7 ± 2.1

Table 3. Average deep percolation losses measured by Pringle (1994) for four Mississippi rice soils in 1991 and 1993.

Soil Series Name	Inches Water Lost over an 80-day Flood
Sharkey	12.8 ± 3.0
Alligator	13.6 ± 1.7
Forestdale	15.7 ± 2.2
Brittain	16.7 ± 2.1

Zero-grade systems use the least amount of applied irrigation water of the rice levee systems currently in use in Mississippi (Figure 8). However, they still routinely apply more than the 14-25 A-in/A seasonal water requirement determined by Pringle (yellow box) when average seasonal rainfall (10 to 14 in) is taken into account. Moreover, owing to water-logging issues for the soybean rotation, adoption of zero-grade has been limited to approximately 5% of rice acreage (Figure 7). To avoid the issues of water-logging, certain producers grow rice continually without rotation. This may lead to issues such as weed resistance and is generally not recommended. This WRRI project builds upon research conducted at Mississippi State University designed to extend the water savings of multiple-inlet rice irrigation (MIRI) by using intermittent (less-than-full) flood management designed to optimize rainfall capture and reduce over-pumping of rice paddies.

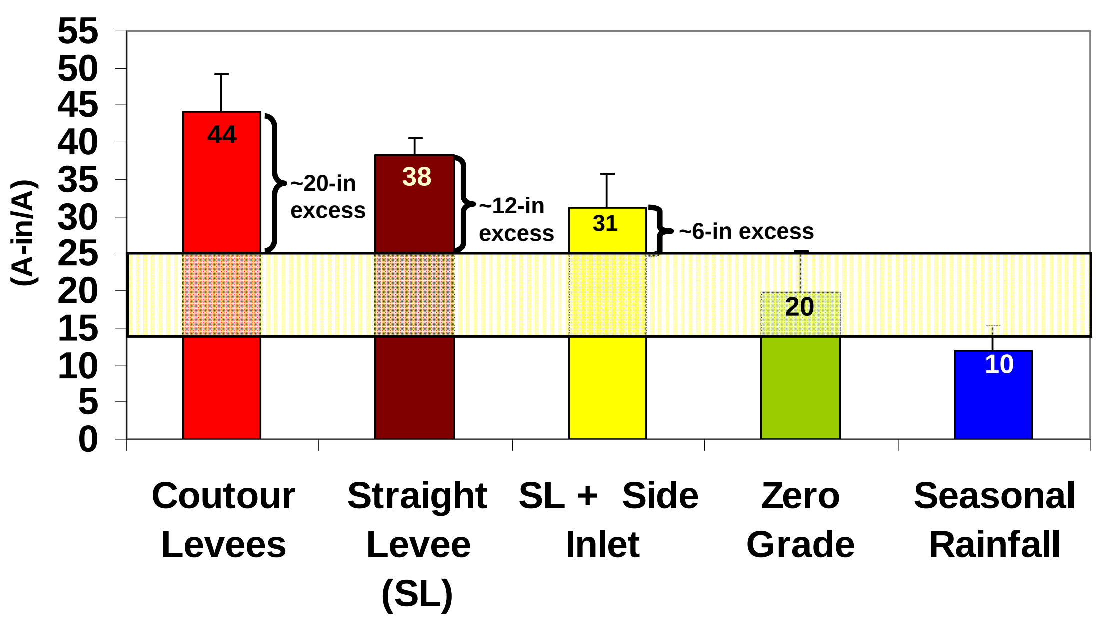


Figure 8. Six year average water use (A-in/A) values for different rice levee systems (YMD, 2010) shown with range (yellow box) of water use requirements (ET plus deep percolation) for rice as determined by Pringle (1994) in Mississippi.

Intermittent irrigation (Bouman and Tuong, 2001) is a method of rice water *management* that, when coupled with multiple-inlet rice irrigation (MIRI) (Tacker et al., 2002), can greatly reduce water use in rice production. Once the initial flood is achieved, pumping is halted and the flood is allowed to naturally subside until approximately one-third to one-half of the soil in the upper rice paddy is exposed as (water-saturated) mud. At this time, irrigation is resumed and the flood reestablished. This cycle may be repeated roughly every 5 to 9 days, depending on prevailing weather and soil conditions (Figure 9). The key benefits are increased rainfall holding capacity and reduced over-pumping that essentially eliminates loss of runoff from the field. The practice of intermittent flooding is greatly facilitated by use of multiple-inlet irrigation as MIRI (a) allows the flood to be quickly reestablished after the drying cycle, thus reducing potential for rice stress, and (b) allows the rice paddies to be managed as separate entities.

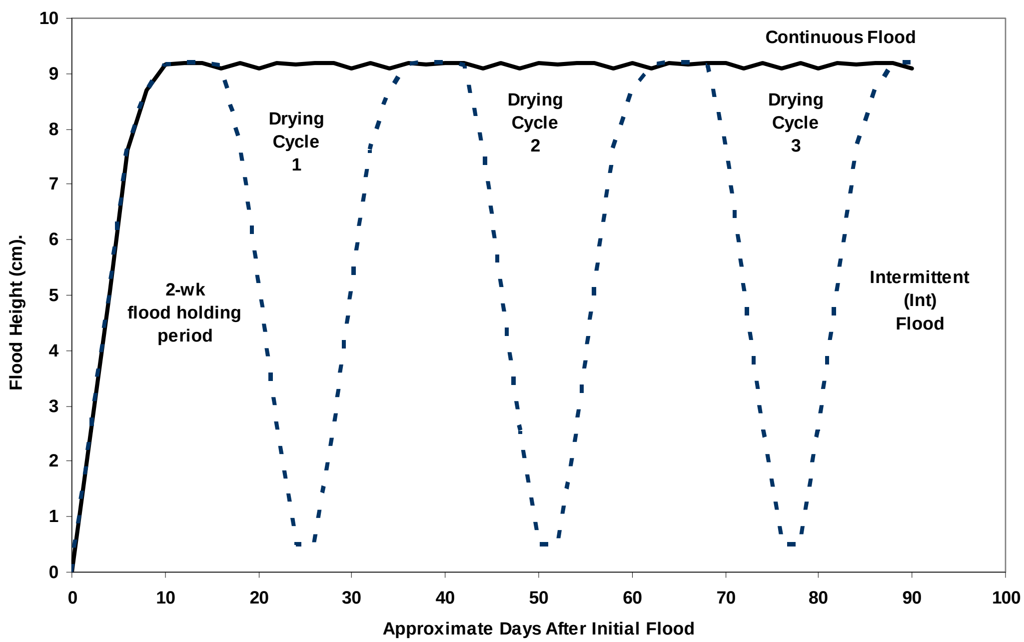


Figure 9. Diagram demonstrating approximate flood patterns and depths in rice paddies maintained using continuous (solid line) and intermittent (dashed line) flooding.

Methods, procedures, and facilities:

Soybean Irrigation Studies

These studies were conducted as on-farm, production-scale studies consisting of side-by-side comparisons between conventionally irrigated (control field) and optimized irrigation systems (treatment field). Three producer sites consisting of four fields per site were studied. The four fields at each field site consisted of two similarly-shaped fields planted to soybean (one control field, one treatment field). The fields were selected to minimize potential differences in soil texture and fertility, field shape and slope, crop cultivar, and irrigation well size and capacity. The control and treatment fields were managed by the producer. All agronomic inputs and management conditions were documented. The specific parameters measured are given in Table 4.

Table 4. Research parameters measured for the soybean irrigation trials.

Parameter	How Measured	Frequency
Seasonal Water Use	McCrometer odometer-type flowmeter.	Weekly readings to harvest for total water use.
Rainfall	Tipping bucket raingauge	Daily total.
Grain yield	Calibrated yield monitor	At harvest
Number of irrigations	Recorded in notes.	As needed.
Energy Consumption (electric only)	Electric meter readouts.	At beginning and end of study.

Rice Irrigation Studies

For the rice studies, between 8 to 15 commercial rice varieties or hybrids were planted via grain drill at the top and bottom of a paddy located in a commercial straight-levee rice field where multiple-inlet irrigation was used to distribute the flood and the flood was managed intermittently. The intermittent flood consisted of the farmer allowing the flood to naturally subside to a point where mud was exposed in the upper one-third to one-half of the paddy. At this point, the farmer would again flood the paddy. This caused the plots planted in the upper portion of the paddy to undergo wetting and drying cycles while the plots in the lower portion of the paddy remained flooded. This facilitated the determination of the effects that intermittent flooding had on yields and milling quality as compared to the continuously-flooded plots. The specific parameters measured are given in Table 5.

Table 5. Research parameters measured for the rice irrigation trials.

Parameter	How Measured	Frequency	Comments
Seasonal Water Use	McCrometer odometer-type flowmeter	Weekly readings to harvest for total water use	
Paddy flood height	Global Water Water Level Logger Sensor	20-min intervals	Used to determine number and extent of dry down periods and estimate rainfall capture.
Grain yield	Calibrated yield monitor	Upper paddy vs. Lower paddy samples	Compare upper paddy vs. lower paddy to highlight potential negative impacts on grain yield and quality.
Grain quality	MSU testing facility or similar	Upper paddy vs. Lower paddy samples	

Results & Discussion

Furrow Irrigation of Soybean Studies

Water use and soybean yield results from the 2010 and 2011 field trials comparing farmer versus Phaucet-optimized furrow irrigation designs are given in Table 6. On average, Phaucet-designed hole sizes and hole spacings reduced water and energy use by approximately 20% while yields were either the same or slightly higher than the farmer irrigation designs. The Phaucet program improves the efficiency of irrigation by improving the evenness in which water is distributed across the field. Using Phaucet, water should reach the end of long rows and short rows at more or less the same time. This saves water and energy because the farmer does not have to run water off shorter rows while waiting for longer rows to finish watering. In those cases where the Phaucet-design yields were higher than the non-optimized designs, reduced water-logging of soils from excessive irrigation is a potential explanation, pointing to another potential benefit of improved furrow irrigation.

It is important to note that:

A. These results were obtained from fields that were regularly shaped (square to rectangular) that were chosen to facilitate comparison between the two irrigation design treatments (i.e., with and without Phaucet optimization). In actual use, one would expect that water savings could be greater for more irregularly-shaped fields that are more difficult to irrigate than the more symmetrical fields investigated in this study.

B. The water and energy savings gained by using Phaucet could be lost if the irrigation set were allowed to run longer than needed. For example, if a farmer expects that a set will finish early in the morning, say at 2 am, but s/he can't return to shut off the well off until 7 am, excess water could runoff the field, reducing the water and energy savings normally associated with a Phaucet-optimized design. By installing a 24-hour spring-wound timer, as some farmers are doing on both electric and non-electric wells, the efficiency gains of Phaucet may be better captured as the farmer can set the timer to shut the well off at say 3 am (to build in a fudge factor). The farmer can then check the field and assess how well the crop was watered at a time more convenient to their schedule. Based on the 20% savings observed in this study and assuming diesel costs of approximately $3.50/gallon, the timers could pay for themselves in about two seasons.

umber of Irrigation, and Soybean Yield Results for Furrow Irrigation Trials Comparing ptimized Design Using the NRCS Phaucet Program.

	Design Treatment	Field Size (A)	Water Use (A-in)	No. of Irrigations	A-in per Irrigation	Soybean Yield (bu/A)
	Farmer	16	20	5	4.0	62
	Phaucet	15	19	6	3.2	62
	Farmer	15	20	5	4.0	50
	Phaucet	16	16	4	4.0	53
	Farmer	19	15	3	5.0	49
	Phaucet	19	12	3	4.0	49
	Farmer	34	17	4	4.3	34
	Phaucet + Timer	41	14	4	3.5	43
	Farmer	52	11	3	3.7	45
	Phaucet + Timer	44	12	4	3.0	48

Rice Irrigation using Intermittent Flooding

As many as 8 wetting-drying cycles have been performed by Mississippi rice growers involve this research, resulting in paddies being maintained in a "less-than-full" status throughout much of growing season (Figure 10). This greatly improves capture of the 10 to 14 inches of rainfall that during an average delta growing season. On average, rice grown using multiple-inlet irrigation intermittent flood management used approximately 5% more water than zero-grade systems (Figure The advantage of the former being that it is applicable to most straight-levee systems under which majority of rice in Mississippi is grown (Figure 7).

Results from 2010, 2011, and 2012 were similar for rice yields and grain milling quality (data shown). Rough rice yields (lbs/A; corrected for moisture) for the upper, intermittently-flooded plots either unchanged ($p > 0.05$) or slightly higher ($p < 0.05$) than those of the bottom, continuously-floo plots (Tables 7 and 8). This is in agreement with research that indicates that rice grown under intermit irrigation often yields higher than when it is continuously flooded (Zhang et al., 2008). These resea further indicate that rice can be grown successfully in the Mississippi delta using multiple-inlet intermittent rice flood irrigation practices.

Table 7. **Representative results from 2011 comparing rice yields for from top of paddy plots (intermit irrigation) and bottom of paddy plots (continuous flood) for eight rice varieties and one hybrid. (Seas rainfall was 7.6 inches. The upper plots underwent eight wetting-dry cycles while the lower underwent cycle in early-July. Total irrigation water applied to this 38-A field was 18 A-in/A. Soil type was Previous crop was soybean.)**

	2011 Rough Rice Yield (lbs/A)		
Rice Variety/Hybrid	**Top of Paddy**	**Bottom of Paddy**	**p-value**
	(8 wet-dry cycles)	(1 wet-dry cycle)	
CL111	**11086**	**10490**	**0.0855**
CL131	**10189**	**9594**	**0.0107**
CL142	**10819**	**11486**	**0.2517**
CL151	**11276**	**10672**	**0.0801**
CL152	**10001**	**9056**	**0.0453**
CL162	**10072**	**10218**	**0.5115**
CL181	**8141**	**8452**	**0.5492**
CLXL745	**11314**	**12246**	**0.1284**
Global Comparison	**10350**	**10277**	**0.8102**

Table 8. **Representative results from 2010 comparing rice yields for from top of paddy plots (intermittent irrigation) and bottom of paddy plots (continuous flood) for eight rice varieties and one hybrid. (Seasonal rainfall was 10 inches. The upper plots underwent five wetting-dry cycles while the lower underwent one cycle in early-July. Total irrigation water applied to this 73-A field was 23 A-in/A. Rainfall was 10 in. Soil type was clay.)**

	2010 Rough Rice Yield (lbs/A)		
Rice Variety/ Hybrid	Top of Paddy	Bottom of Paddy	p-value
	(5 wet-dry cycles)	(1 wet-dry cycle)	
6004	10,548	9,067	0.0326
Bowman	9,838	9,905	0.9004
CL111	10,850	11,380	0.5048
CL131	9,142	9,762	0.2304
CL142	11,605	10,489	0.0643
CL151	11,428	10,852	0.2763
CL181	9,588	9,278	0.6637
CLX745	12,386	11,698	0.1889
Cheniere	10,576	10,124	0.1017
Cocodrie	10,796	10,528	0.2154
Neptune	10,396	9,452	0.0756
Rex	10,481	9,899	0.1846
Taggart	11,486	10,961	0.3535
Templeton	11,083	9,933	0.0618
XL723	12,809	12,808	0.9986
Global comparison	10,888	10,352	0.00677

Figure 10. Representative results from 2011 showing intermittent rice irrigation pumping pattern for variety trial. (Blue line represents flood depth at top of paddy; red line represents depth where mud was exposed in upper 1/3 to ½ of paddy. Seasonal rainfall was 7.6 inches. The upper plots underwent eight wetting-dry cycles while the lower underwent one cycle in early-July. Total irrigation water applied to this 38-A field was 18 A-in/A. Soil type was clay. Previous crop was soybean.)

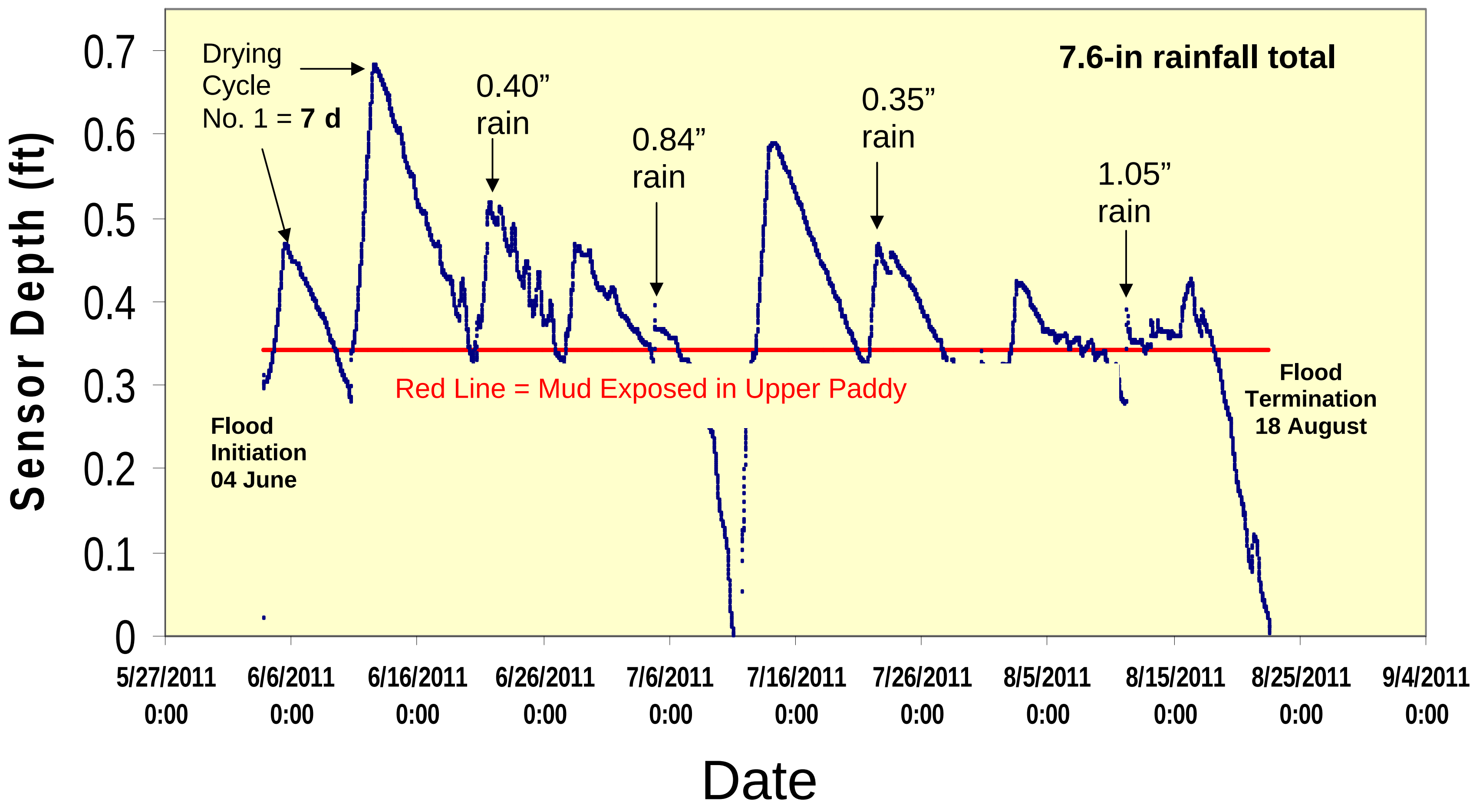
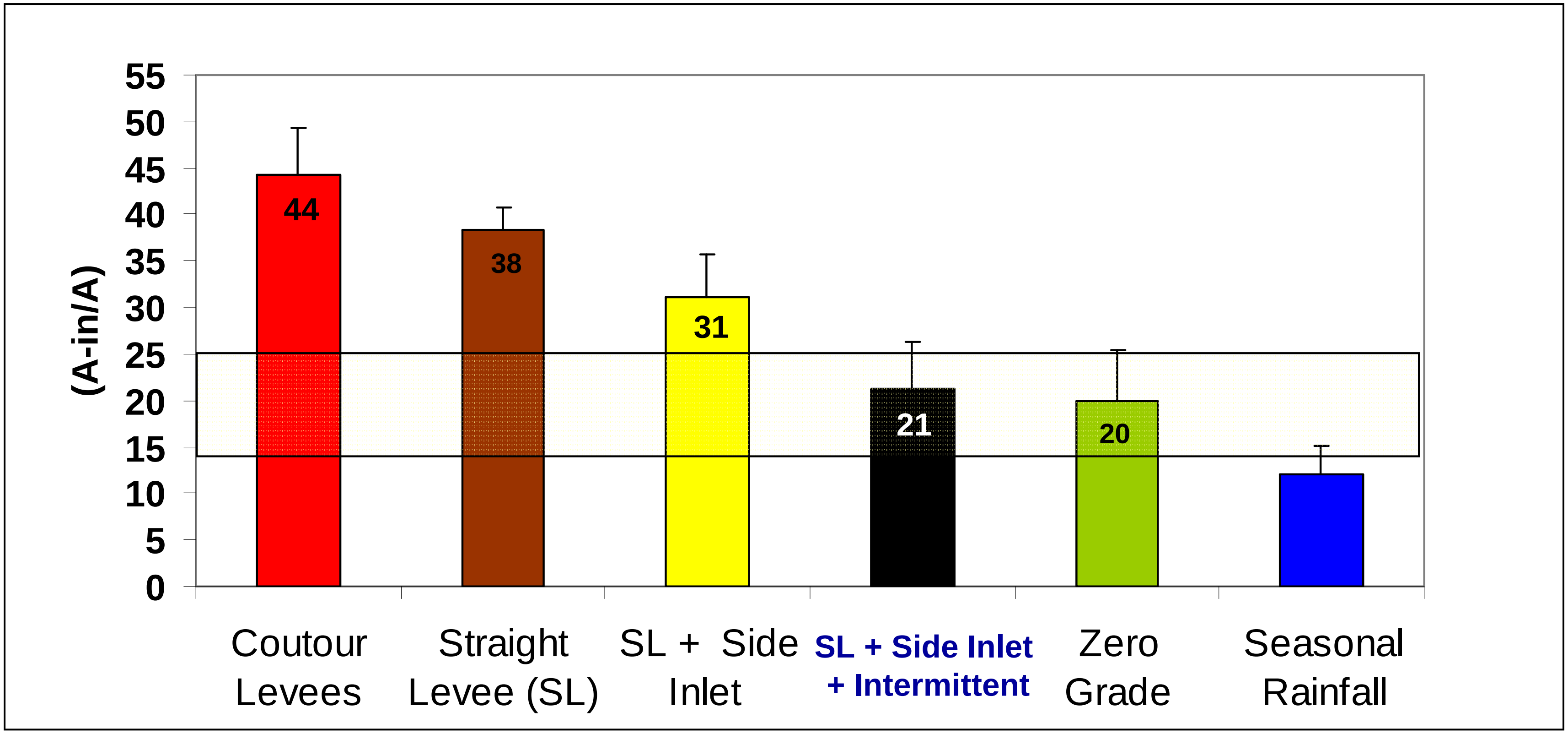


Figure 11. Average water used by intermittent rice irrigation trials (A-in/A) as compared to water use for different rice levee systems (YMD, 2010) shown with range (yellow box) of water use requirements (ET plus deep percolation) for rice as determined by Pringle (1994) in Mississippi.



Conclusions

These data support the premise that readily-available technologies and management strategies such as the NRCS Phaucet furrow irrigation optimization program, improved crop genetics, pump timers, flood depth gauges, and intermittent irrigation practices can be combined within cropping rotations to significantly reduce water and energy use while maintaining economically-viable yields. Each inch of water not pumped from the MRVA aquifer onto an acre of rice or soybean saves the energy equivalent of approximately 1.0 gallon diesel fuel and reduces CO_2 emissions by ~200 lbs per A. Given an off-road diesel price of $3.20/gallon, the 9 acre-inch (40%) reduction in rice irrigation demonstrated in this study translates to a savings of ~$20 per acre while a 1.7 acre-inch (20%) reduction in soybean irrigation represents a savings of ~$3 per acre. By reducing irrigation water and associated energy inputs in the soybean-rice rotation, the producer can reduce input costs, relieve pressure on the MRVA aquifer, and also reduce carbon emissions.

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Student Training

The following MSU undergraduate students participated in the conduct of this research project:

Cameron Olsen (Biological Science)
Cedric Reid (Biochemistry)
John Waldrop (Agricultural Science)

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Presentations & Outreach

PSS Departmental Seminar, 04 Oct 2010. Agriculture and the Mississippi Delta. Mississippi State University.

Earth Day week talk MSU April 19, 2010. Water and Agriculture in the Mississippi Delta. Starkville, MS.

YMD Board of Directors Meeting. 2010. Reducing Water Use in Mississippi Rice Production: Opportunities and Challenges. Leland, MS. 21 April 2010

Yazoo Water Management District Water Meeting. Efficient Irrigation Systems Overview. Stoneville, MS 10 Nov 2010.

Mississippi Water Resources Research Institute Annual Conference. Water-Conserving Irrigation Systems for Furrow & Flood Irrigated Crops in the Mississippi Delta. Bay St. Louis, MS. 04 November 2010.

Crop College-Starkville. Irrigation Efficiency Research: Soybean and Rice. Feb 17, 2011.

Irrigated Rice Congress of Brazil, Balneario Caboriu. Water Conservation Practices for Rice Production in the Mid-South, USA. Santa Catalina, Brazil. 10 August 2011.

Yazoo Water Management District water meeting. September 14, 2011.

First Year Lecture: Conservation Heroes. 21 September 2011. Starkville, MS.

Rice Short Course. Water and Energy Conserving Irrigation Practices. 15 November 2011. Stoneville, MS.

Café Scientifique. Water and Agriculture in the Mississippi Delta. Starkville, MS 15 November 2011

Carbon Trading Kickoff meeting. Intermittent irrigation of rice. Hosted by WinRock International and the White River Irrigation District. Stuttgart, AR. December 6, 2011.

Panel Member on Water Issues in the Delta. AG EXPO Cleveland, MS 17 January 2012.

Rice Consultants Meeting, Cleveland, MS. 19 January 2012.

Arkansas Soil and Water Education Conference. Jonesboro, AR 26 January 2012.

Cotton and Rice Conservation Systems Conference. 31 Jan and 01 Feb 2012. Tunica, MS.

YMD Water Resources Conference. 08 February 2012. Stoneville, MS.

MS Water Resources Research Institute conference. 03 April 2012. Jackson, MS.