Irrigation Water Conservation Through Use of Level Basins in Louisiana

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ABSTRACT

Irrigation is standard practice for rice production in Louisiana. It is increasingly used to provide yield enhancement and insurance against periods of inadequate rainfall for cotton, corn and soybeans, even though drainage is the primary water management issue for crop production. Most irrigation pumps in Louisiana are powered by diesel engines and producer interest in improving irrigation efficiency is increasing as energy prices increase.

Land owners in many Southern states have been grading fields to low (<0.2%) slope to improve drainage and increase machine and irrigation water use efficiency. Some land owners are grading fields to zero slope (level-basin) for use in growing rice.

Measurement by the YMD Joint Water Management District, Stoneville, MS, (Epting, 2003-2004, Powers 2005-2006) of water used in irrigating rice indicates significant water savings on level basin fields compared to other rice field irrigation designs. Louisiana growers have also successfully used level-basin rice fields for crawfish production and for duck hunting. Growers would like the option of growing cotton, corn or soybeans on level-basin fields when market prices, input costs or weed conditions support these crops in preference to rice.

Cotton growers in Arizona have used level basins and have achieved high irrigation water use efficiencies. (Clemmens, 2000)

One of the advantages of level basins for rice, crawfish or ducks is the low flow rate pump capacity required to manage the system. Flood irrigation of cotton, corn or soybeans requires getting the water on the field and draining it quickly to avoid damage to the crop. Low pump capacity requires more time to irrigate, thus possibly leaving the root zone saturated too long and reducing yields of these crops.

Keywords: agriculture, conservation, economics, irrigation

Irrigation water use in the United States and in Louisiana

USGS, 1998, reports water use for irrigation in the United States peaked at 150,000 MGD in 1980 and declined to 134,000 MGD (about 10%) by 1995 even though total area irrigated remained about the same (58,000,000 acres). This decline in water use was attributed to increased irrigation efficiency and shifting acreage from dryer western states to eastern states with higher average rainfall.

USGS, 2004, reported a 2% increase in water use for irrigation to 137,000 MGD in 2000 with a 6% increase in acres irrigated to 61,900,000.

The US Department of Commerce, 1996, reported water use for irrigating agronomic crops in the conterminous states in 1988 as 84,182,177 acre-feet applied to 46,199,161 acres and in 1994 as 79,627,392 acre-feet applied to 46,418,380 acres. These data suggest a reduction in water use of 5.7% on 0.5% more acres. They report water use for irrigation in 1979 at 93.1 million acre feet, or 17% more than in 1994.

The USDA, 2004, reported water use for agronomic crops in the United States in 2003 as 86,894,031 acre-feet applied to 52,583,431 acres and in 1998 as 97,335,291 acre-feet applied to 54,249,965 acres. These data suggest a reduction in water use of 12% on 3% fewer acres.

These surveys by three different agencies of different agricultural irrigation populations over different time frames continue to suggest increasing irrigation efficiencies. As competition for limited water supplies drives up the price of water in some states, irrigation water use for agronomic crops in those states should continue to decline. Whether or not that translates into increased demand for irrigation of those crops in states with plentiful supplies of water remains to be seen, especially in view of increased energy costs.

USDA, 2004, reports Louisiana as the 16th largest state in terms of acres of agronomic crops irrigated and the 19th largest state in terms of water used for irrigation. Surrounding states irrigate more acres and use more water. Texas irrigates the 3rd largest number of acres with the 4th largest amount of water. Arkansas irrigates the 4th largest number of acres with the 5th largest amount of water. Mississippi irrigates the 13th largest number of acres with the 18th largest amount of water.

DOTD, 2002, reported 890 MGD of water used to irrigate 620,000 acres of rice and 135 MGD of water used to irrigate 317,000 acres of crops other than rice in Louisiana in 1999. They report peak water use for irrigating rice at over 2000 MGD in 1980 and for other crops at nearly 80 MGD in 1975.

USDA, 2004, reports rice accounted for 9.8% of irrigation water used on agronomic crops in California in 2003, 11.9% in Texas, 40.5% in Mississippi, 56% in Arkansas, and 80.7% in Louisiana.

Rice irrigation water conservation

Table 1 provides a summary of the annual data reported by Epting (2003, 2004) and Powers (2005, 2006) for irrigation water used on a large number of Mississippi rice fields by type of irrigation. "Contour" and "Straight" in the column headings refer to levees used for flood irrigation. The straight levees result from precision-graded fields. "MIRI" refers to multiple inlet rice irrigation where a polyethylene tube is run over the interior levees and delivers water to each paddy at the same time as opposed to contour and straight levee irrigation where water is delivered to the first paddy and from there to lower paddies in succession through gates installed in the levees. Data include annual "feet" of water used for irrigation and number of "fields" surveyed in the four years.

Table 1 Average feet of water used on rice fields in Mississippi by type of irrigation.

Contour levee		Straight levee		Multiple inlet		Level basin	
feet	fields	feet	fields	feet	fields	feet	fields
3.69	39	3.06	67	2.34	20	1.48	21

Introduction to level-basin design and performance

Dedrick, Erie and Clemmens, 1982, provide a comprehensive discussion of level basin design, maintenance and operation.

Clemmens, 2000, states that smaller basins are needed for heavier soils and that under some soil and climatic conditions, surface drainage is needed. He refers to drain-back designs which reduce both the initial earth moving cost to establish the fields and the time required to complete an irrigation while not reducing drainage capabilities. He mentioned common flow rates of 350 l/s to 500 l/s (5400 gpm to 8000 gpm) for a series of 4-hectare (10 acre) basins.

Numerous papers provide detail on designing fields for level-basin irrigation. Clemmens and Strelkoff, 1979, extended existing solutions for irrigation stream advance to level basins. Clemmens and Dedrick, 1981, 1982, discuss distribution uniformity calculations appropriate to the infiltration characteristics of the soil. They provide design limits for level basins where soil infiltration characteristics are matched with basin length and unit flow rate. Their solutions are for flat basins with no furrows, beds or corrugations irrigated from a line source along one side of the basin.

Bucks and Hunsaker, 1987, measured water use on wheat irrigated at three levels (replacement of 100%, 75% and 50% of expected ET) on 12 blocks each of two different lengths-251 m and 190 m (825' and 625'). The soil varied from a sandy loam to a sandy clay loam. The water delivery rate ranged from 153 L/s to 164 L/s (2,425 gpm to 2,600 gpm). A total of about 4 hectares (9.2 acres) was irrigated. Water distribution uniformity was above 85% for all three irrigation levels with variations in land elevation more significant than length of block irrigated. The irrigation application efficiency was higher for the dry treatment while crop water use was more efficient in the wet treatment. Spatial differences suggested that soil water variables should be measured at distances less than 15m to 30m (50' to 100'). In a separate paper on this research, Hunsaker and Bucks, 1987, reported significantly increased yields for the wetter treatments and no effect on yields from length of irrigated blocks. Yield variability within the irrigated blocks was less for the wetter treatments. Their recommendation for irrigating a heterogeneous soil in an efficient level-basin field was to schedule irrigations at near full ET.

Martin and Eusoff, 2000, reported on irrigation of seven level basins designed with drain back capability. The first six basins were 3.6 ha to 4 ha (9 acres - 10 acres) in size and the seventh basin contained 6.0 ha (14.7 acres). The soil was a mix of silt loam and silty clay loam. Flow into basin 1 was 0.24 m^3/s (3850 gpm) and required 4.5 hours to complete the irrigation. Flows into lower basins were as high as 0.84 m^3/s (13,470 gpm). Irrigation of basins 1-6 required 21.5 hours.

Flow rates of the wells monitored by Powers, (2006), ranged from 242 gpm to 2,819 gpm (15.3 l/s to 178 l/s). Flow rates per acre irrigated averaged 16.32 gpm-acre (2.54 l/s-ha) for 141 observations.

Concerns over use of level basins to irrigate crops sensitive to water logging

Cautions on use of level basins for irrigation of crops other than rice are numerous. Burt, 1995, suggests that level basins are not suitable for soils with very low intake rates. He reports level basins have been primarily used for fields ranging from 2 acres to 15 acres and up to 30 acres in size, because of the high water flow rate requirements. CAST, 1988, reports that level basins are generally not used in areas with high rainfall except for rice, although for crops sensitive to ponded water, furrows might be used.

Hardjoamidjojo, Skaggs and Schwab (1982) compared studies in Ohio, India and Iowa of corn yield effects from inundation using DRAINMOD to calculate a stress day index.

Evans, Skaggs and Sneed (1990) added a normalizing approach to reduce the effect of the crop susceptibility factor to the level of stress induced by inundation for corn and soybeans. Evans and Skaggs (1993) tested relative yield and stress day index models for corn and soybeans to predict yield response to excess or deficient soil moisture conditions. Evans, Skaggs and Sneed (1997) developed relative yield models for corn and soybeans subjected to high water tables. Hester and Nussbaum, (2006) reported use of DRAINMOD in Missouri to estimate 25% and 26% yield loss in soybeans for each day of water logging at pod fill and pod development stages of growth.

Griffin, 1990, subjected MG 7 soybeans at the Rice Research Station near Crowley, Louisiana, to flooding for varying lengths of time to determine effects on yield. He concluded that flooding longer than 48 hours could result in significant yield loss.

Linkemer, 1995, found 30% to 90% yield reductions in Louisiana soybeans at the V2, R1, R3 and R5 growth stages due to water logging.

Level-basin experience in Louisiana

Rice has traditionally accounted for 60% of the irrigated acreage of agricultural crops grown in Louisiana, and for 75% or more of the irrigation water used. Cotton, corn and soybean acreage accounts for most of the irrigated acreage not devoted to rice. Annual average rainfall in Louisiana ranges from 55 inches in the Southeast to 45 inches in the Northwest, so that rapid drainage of excess rainfall from fields planted to cotton, corn and soybeans has always been the primary concern. Irrigation for these crops is seen as insurance against no-rainfall periods during the growing season.

Most of the cotton, corn and soybean acreage is in Northeast Louisiana between the Ouachita and Atchafalaya Rivers on the west, the Mississippi River on the east and the Arkansas state line to the north. Many of the farmed soils are cracking clays, labeled by USDA NRCS as Alligator, Sharkey, and Tensas. Soil texture variability within each field is high. Field capacity may be above 50% and wilting point near 35%. The terrain is usually flat. Rice has been planted on a significant acreage in this area during the last 30 years.

Much of the land has been precision graded to enhance drainage and irrigation. Field sizes typically range from 40 acres to 80 acres. Most irrigation is from wells. Typical wells are 120′ deep and deliver 2000 gpm to 2500 gpm. Static water levels are about 50′ below the surface and seasonal drawdown is about 1′. Concerns with salinity of ground water raise concerns about irrigating rice, corn and some soybean varieties.

Some fields have been graded to a zero slope in both directions (level basin). Several thousand acres of level basin fields are in use in Concordia Parish between the Tensas, Black and Mississippi Rivers. These fields were designed for rice production and some are also used for crawfish production and for duck hunting.

Field Design and Operation

Farm managers in Concordia Parish have worked with the County Agent for many years to host soybean, rice and wheat variety and pesticide trials, research verification fields, and educational workshops and tours for county agents, agricultural agency and agri-business staff, and farmers. Their field layouts typically include one well to supply four 80-acre fields. The level fields have interior water supply ditches on three sides. One long side is left open for machine traffic. A typical field is depicted in Figure 1.

This design provides a very high level of machine and cropping efficiency. Net area inside field roads, exterior levees and interior supply ditches is about 76 acres out of a gross 80 acre block. By comparison, the net acreage on the same fields graded to a slope may range from 72 acres to 74 acres after deducting land required for the interior levees.

Water is supplied from a diesel engine-powered well through underground pipe to a 12″ riser and alfalfa valve in each field. The riser supplies water to the interior perimeter supply ditches. Water in the perimeter ditches then flows into "spin" ditches which are dug with a PTO-powered rotating blade and connect the perimeter supply ditches. Once all the perimeter supply ditches and the spin ditches are full, water flows out onto the field surface. The opposite sequence occurs when the field is being drained.

Well pump capacities usually range from 1700 gpm to 3200 gpm. The 1700 gpm well supplies 320 acres at a rate of less than 6 gpm-acre. The "stronger" 3200 gpm well supplies 10 gpm-acre. Each field has one to three 15″ drains. Some drains discharge to lower fields and others to natural drains. These pumping flow rate capacities work well for rice, crawfish and duck hunting but are far less than those recommended for level basin irrigation of crops sensitive to water logging, such as cotton, corn or soybeans.

In some fields, the slopes on the 80 acre fields are in the ¼ mile direction and in some fields the slopes are in the ½ mile direction. An 80 acre sloping field may have as few as two or as many as 15 interior levees when used for rice production.

Soils are typically classed as Alligator silty clay, or Tensas and Sharkey clays (USDA SCS, 1988), with 40% to 90% clay. Surface cracks begin to appear within days of irrigation or rainfall.

Allen and Braud, 1965, reported on infiltration tests of a cracked Sharkey clay soil. Most of the soil moisture change took place in the top 8″ (203 mm) to the depth of the cracks. At an initial soil moisture content of 34.8%, one inch (25.4 mm) of water was applied in less than one minute and two inches (50.8 mm) of water required 18 minutes. When the initial soil moisture content was 40%, one inch of water was applied in 30 minutes and two inches required more than 26 hours.

USDA-NRCS, 1997, provides average intake time on an intake family 0.1 soil for one inch of water as 170 minutes and for 2 inches as more than 10 hours, with up to a 40% decrease in intake time for a cracked soil. They suggest fur-

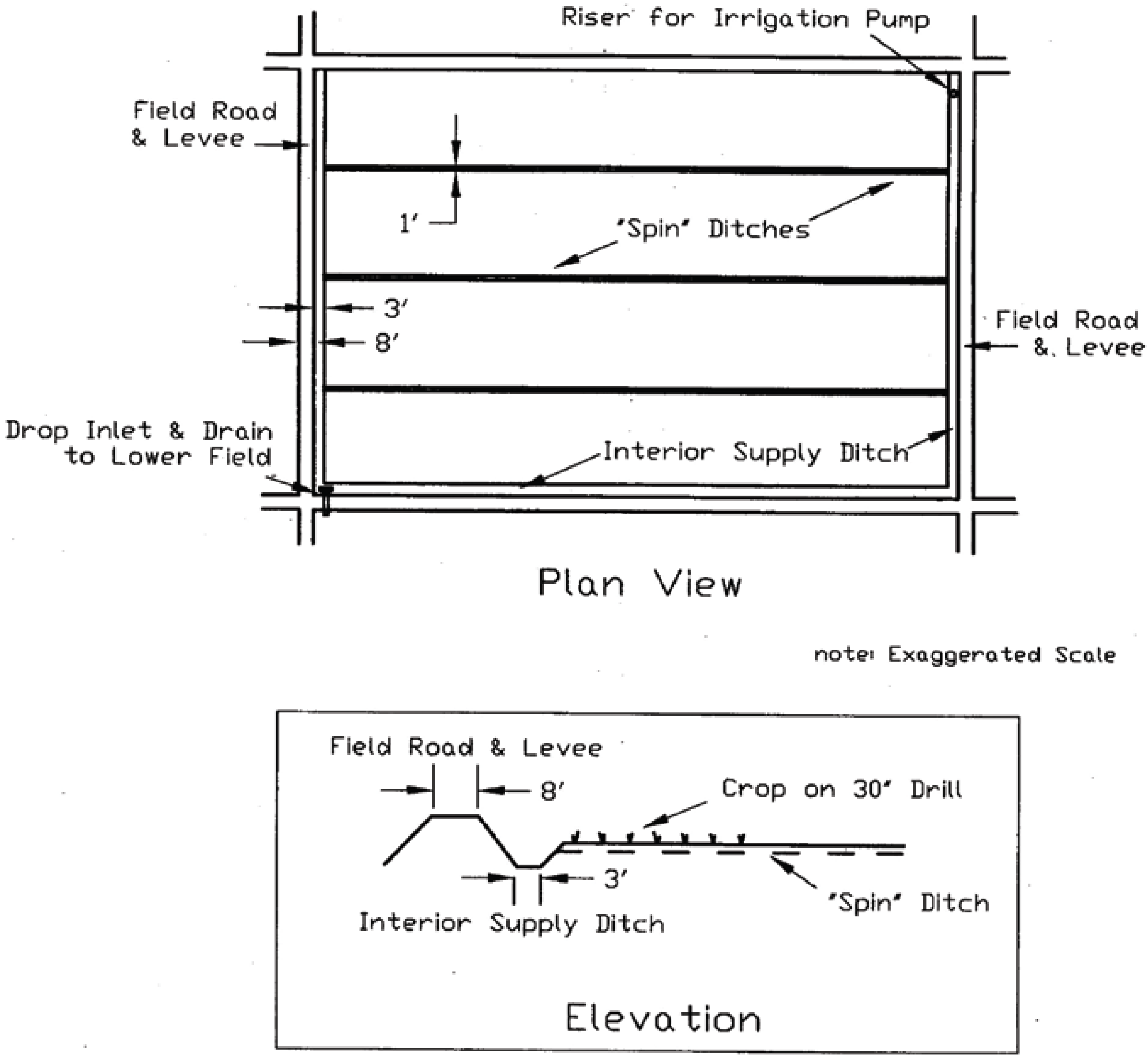

Figure 1. Field design.

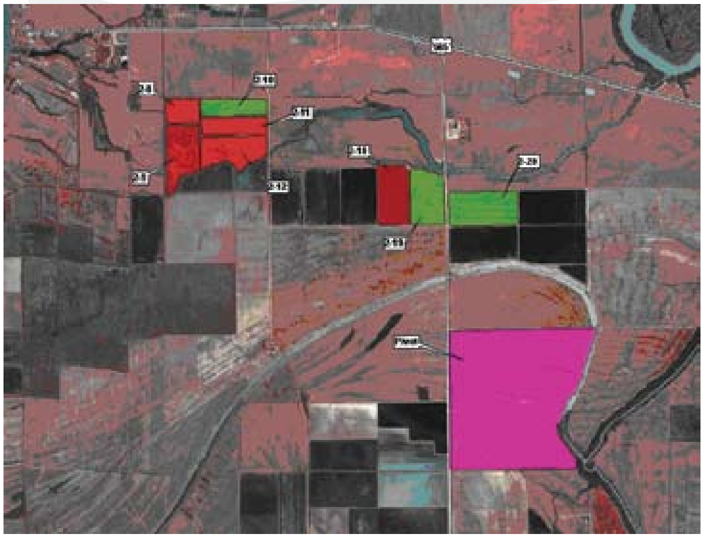

Figure 2. Location of fields used in 2005-2006.

rows on level basins for cotton and corn. Factors opposed to use of level-basins are humid climate, low continuous flow rate and variable infiltration rate.

Results of Cotton Irrigation Trials

For the 2005 and 2006 crop years, cotton was grown on the 25 acre field depicted in Figure 1 and labeled 2-8 in the northwest corner of Figure 2. The County Agent secured assistance from LSU AgCenter faculty, area farm consultants, agribusiness managers and farmers to grow the crop. The well supplies two fields (2-8 and 2-10) totaling 65 acres with a flow rate of 1,600 gpm. For the 25 acre cotton field, this results in a 64 gpm-acre capacity. Shallow (3″ furrows) were pulled in the 900 foot direction on 38″ centers and three spin ditches were pulled across the field perpendicular to the rows at about 225′ intervals. The Arkansas Irrigation Scheduler was used to initiate irrigations at a soil moisture depletion of 2″.

For the 2005 crop season, the field was irrigated as it would have been for rice. The pump delivered water through a riser in the northeast corner of the field. The water spilled into the interior supply ditch, over 4,000′ long, and began to fill it. Water was over the top of the cotton row adjacent to the riser while it was still a foot lower than the cotton on the far northwest corner of the field. The first irrigation used 5.3″ of water to cover the field in 38 hours. The second irrigation used 4.6″ of water in 32 hours.

For the 2006 crop season, a 15″ diameter polyethylene tube was attached to the riser and strung across the north side of the field (the side with no interior ditch). Sliding gates were installed on 114″ centers and used to "border" irrigate. A backhoe was used to try and block the spin ditch outlets into the interior supply ditches and force irrigation water to flow down the row across the spin ditches. Water tended to move around the dirt and flow into the supply ditches. The dirt was removed after the first irrigation to avoid blocking drainage in case of a heavy rain. The first irrigation used 5.4″ of water to cover the field using multiple sets in a total of 38 hours. The second irrigation used 4.5″ in 32 hours and the third irrigation used 5.1″ in 36 hours. Water flow rate down each bay was on the order of 120′/hour to 150′/hour so that each set watered out in less than 8 hours.

Table 2. Water used irrigating cotton during 2005 and 2006 seasons.

	Irrigation	1	2	3
Irrigate by filling supply ditches as designed	Inches	5.3	4.6	
	Hours	38	32	
Poly tubing and gate for border irrigation	Inches	5.4	4.5	5.1
	Hours	38	32	36

Results of Soybean Irrigation Trials

Six fields totaling approximately 324 acres were instrumented with flow meters for the 2006 season. Two fields (2-19 and 2-20) and a temporary weather station are located approximately 1 mile east of the other four fields (2-9, 2-10, 2-11 and 2-12). All fields were drilled on 30″ centers. Poly tubing (15″ diameter) was used to distribute irrigation water in each field. Sliding gates were installed to aid in controlling irrigation water flow in multiple sets on every other middle on one sloping field (2-20), every third middle on two sloping fields (2-10, 2-19) and one level-basin field (2-12) and at different locations on two of the level-basin fields (2-9 and 2-11). Pump flow rates averaged 1600 gpm. Flow rates through the gates ranged from 10 gpm to 30 gpm. Each set used 50 to 80 gates depending on distance from the pump. One field was irrigated once (2-12), two fields were irrigated twice (2-9 and 2-11), and three fields were irrigated three times (2-10, 2-19 and 2-20). Irrigation was begun on three fields (2-12, 2-19 and 2-20) one or two additional times and stopped because of rainfall. The sets where irrigation was started and stopped before completion, received more water than the sets in the rest of the field. Subsequent irrigation of each field would then have begun with differing soil moisture depletions in the field. The Arkansas Scheduler was used on each field to trigger the need to irrigate modified by observed condition of soil and beans. The first irrigation on each field occurred at a soil moisture depletion of less than 2″ and the second at 2″ to 4″. Multiple rain gages were used to increase accuracy of and to reduce spatial variability of rainfall data. Sand bags were used on field 2-9, 2-11 and 2-12 in an effort to try and force water down the drill over the spin ditches to no avail. Unsuccessful attempts were made to measure water leaving fields 2-10, 2-11 and 2-12.

Field 2-20 is rectangular, contains 74.1 acres and is graded to a 0.2% slope in the ¼ mile direction. It was in rice in 2005. The 8 interior ½ mile long levees used for rice were pulled down and the beans were drilled in the ¼ mile direction. The rice levees were not adequately removed so some ponding occurred on the high side of each with some damage to the beans resulting from water ponding after each irrigation or rain. This field was used for variety trials with resulting variation in maturity and differing harvest dates. A half mile of poly tubing was used with sliding gates in every other middle. Irrigation was begun five times but terminated when rain occurred at the end of the first day on three occasions. Four days were required to complete each full irrigation at a pump flow rate ranging from 1200 gpm to 1700 gpm. The gates allowed irrigating in sets so that no set took more than 12 hours. The two full irrigations used 4.5″ and 5.3″. The first irrigation occurred at a soil moisture depletion of 1.83″ and the second at 2.79″. The three additional irrigations which were begun and halted because of rainfall used a total of 2.2″ of water. More tail water ran off in the second irrigation and the soil was drier and soil cracks were wider. Two manual rain gages were used.

Field 2-19 is rectangular on three sides and irregular on the end next to a natural drain. It contains 56.2 acres. It is graded to 0.2% in the ½ mile direction, was drilled in the half mile direction and was in rice last year. The 15 interior rice levees were fairly well pulled down but some ponding occurred on the high side with minor damage to the beans from water ponding after each irrigation and rainfall event. The weather station and an et gage were installed at the down stream end of the field. A ¼ mile of poly tubing was run in the ¼ mile direction with gates installed in every third middle. Three irrigations used 4.3″, 4.2″ and 4.3″ of water. The first irrigation occurred at a soil moisture depletion of 1.51″, the second at 4.01″ and the third at 4.78″. Two additional irrigations were begun and halted because of rainfall using a total of 1.9″ of water. Three days were required for each full irrigation.

Field 2-10 is rectangular, contains 37.8 acres and is sloped in two directions. The slope in the ½ mile direction is 0.01% and in the 1/8 mile direction is 0.03%. There was some high ground in the center of the field so the grades were not completely uniform, but this did not seem to negatively affect the irrigation. Beans were drilled in the 1/8 mile direction. A half mile of poly tubing was installed with gates in every third middle. This field was in soybeans last year. It took 2.5 days to irrigate. The first irrigation used 3.8″, the second used 2.9′ and the third used 2.4″ of water. The three irrigations occurred at a soil moisture depletion of 1.63″, 2.06″ and 2.12″. Tail water from Field 2-10 flowed out to a drain on the first irrigation but was directed to field 2-11 which is downstream for the second and third irrigation.

Field 2-11 is a level-basin field and is a mirror image of the upstream Field 2-10. It has an irrigation water supply ditch running on three sides. A half mile of poly tubing was installed along the only side (south) with no supply ditch. Beans were drilled in the half mile direction. Ten spin ditches were dug in the 1/8 mile direction at different spacings. Three gates were installed at each spin ditch. Sand bags were used to plug the other ends (north) of the spin ditches for the first irrigation. This did not prove effective. Water continued to seep out of the riser and kept several drills near the poly tubing wet after the irrigation was finished. Because the poly tube was on the undrained side of the field and the drills were parallel to the poly tubing, these rows stayed wet with subsequent yellowing and probable yield loss. The end of the poly tube was opened to drain the tubing and partially alleviate the wet area. The second irrigation was run with the end of the tubing open discharging some water into the supply ditch. This increased the time and amount of water required for the irrigation. Some of the water pumped into Field 2-11 flowed into the ditches for Field 2-12. The first irrigation used 3.6″ of water and the second used 5.3″. The first irrigation was begun at a soil moisture depletion of 1.59″ and the second at 3.72″. Each full irrigation required about 30 hours. A third irrigation was begun but halted because of rainfall after using 1.9″.

Field 2-12 is level and includes 58.42 acres. It is ½ mile wide. One end is less than 1/4 mile long and the other is more than ¼ mile long because of a natural drain on one side. Beans were drilled in the short direction. This field was used for variety trials with resulting variation in maturity. There were some low areas in the field which held water longer than the rest of the field. There were 5 spin ditches traversing the field in the half mile direction and a sixth spin ditch covering about half the field next to the natural drain. The low areas allowed water to stand on some of the beans resulting in yellowing and probable yield loss. The irrigation required three days and used 4.1″ of water. It was begun at a soil moisture depletion of 1.51″. A second irrigation was begun at a soil moisture depletion of 3.73″ and used 2″ of water before being halted for rainfall.

Field 2-9 is a level field containing 61.2 acres. It borders the same natural drain and shares a levee with Field 2-12. It is ¼ mile wide and varies from ½ mile long on the long side to about 3/8 mile long on the short side. The beans were drilled in the long direction. Six spin ditches were run in the ¼ mile direction across the drill and four shorter ditches run across the short end of the field. The riser was located at the third spin ditch from the top of the field. A poly tube was laid in this spin ditch and gated to irrigate the top 1/5 of the field or the bottom 4/5 of the field. Sandbags and scoops of dirt from a backhoe were used to try and plug the ends of the spin ditches and force the water down the drill across the spin ditches. The water ran over the sand bags and washed around the piles of dirt. Three days were required to irrigate this field and some of the beans, especially on the ½ mile long drills were wet for the entire irrigation with probable loss of yield. The first irrigation was begun at a soil moisture depletion of 1.51″ and used 4.1″ of water. The second irrigation was begun at a soil moisture depletion of 4.51″ and required 4.4″ of water.

Summary-Cotton

The use of poly tubing and gates to “border” irrigate a level basin cotton field in 2006 made little difference in the amount of water used and the time required to complete an irrigation as compared to the same field irrigated as designed for rice in 2005. The advantage to using the poly tubing and gates was in limiting time that cotton in each set was in standing water. For the 2007 season, consideration is being given to spacing spin ditches at 100′ centers or plowing spin ditches parallel to the rows to act as “water furrows”, pulling the rows higher or planting on a 60″ bed, and to filling the interior supply ditches at a lower flow rate until they are full, then increasing flow rate to complete the irrigation. Water flows through the cracks in the soil at least 15′. It may be possible to irrigate water furrows spaced at 30′ centers. For the same reason, there appears to be no need to run water closer to the side ditches than 15′.

Summary-Soybeans

The sloping fields were easier to irrigate than the level fields. The two sloping fields in rice last year (2-19 and 2-20) had some ponding above the old rice levees. The field with two slopes (2-10) was the easiest to irrigate.

Flow rates per acre on two level fields (2-9 and 2-12) and on two sloping fields (2-19 and 2-20) ranged from 22 to 28 gpm-acre. These fields required multiple sets of 12 hours to 36 hours over 3 days to 4 days and sustained probable yield loss due to ponding. Flow rates on one level field (2-11) and one sloping field 2-10) ranged from 42 to 44 gpm-acre.

Sets were as short as 6 hours and irrigations took 2 days to 3 days. Some ponding and probable yield loss occurred on 2-11 because of the location of the poly tube.

The first irrigation on each of the six fields occurred at a soil moisture depletion of 1.58″ to 1.83″ and required 3.6″ to 4.5″ of water. Water required for the first irrigation on the level fields averaged 4.02″ at depletions of 1.51′ to 1.59″. Water required on the first irrigation of the sloping fields averaged 4.2″ at depletions of 1.51′ to 1.83″. While the highest water use occurred at the highest depletion of 1.83″, there was little difference in water use at the lower depletions.

The second irrigation on five fields occurred at soil moisture depletions of 2.06′ to 4.51″. Water used on the two level fields averaged 4.85″ at depletions of 3.72″ to 4.51″. Water used on the three sloping fields averaged 4.13″ at depletions of 2.06″ to 2.79″. The third irrigation of two sloping fields averaged 3.13″ at depletions of 1.86″ to 2.12″. Using higher soil moisture depletions as the crop matures increased water use per irrigation but reduced the number of irrigations thus lowering total irrigation cost. Allowing soil moisture depletion to reach higher levels may have reduced yields.

Filling the perimeter supply ditches on the level fields prior to irrigating, locating spin ditches at a closer (100′) spacing, and pulling up wide beds (60″ to 72″) with a deeper "middle" to serve as a water furrow, or pulling water furrows parallel to the drill rather than using spin ditches across the drill, appear to be the best practices to reduce irrigation set times on level fields.

Using a marginally higher pump flow rate reduced set time, labor and management, but not the amount of water used.

If sliding gates are used, they need to be spaced no closer than every 4 drills (120″) and could probably be spaced further apart, up to 30′ on cracking clays.

Yield effects from water logging or higher soil moisture depletions are unknown. Use of DRAINMOD may allow prediction of yield effect from various periods of inundation at specific growth stages.

References

Allen, J. B. and H. J. Braud, Jr. 1967. 'Buckshot' Soils: a peculiar problem in irrigation. Louisiana Agriculture, 10, pp 6-7.

Bucks, D. A. and D. J. Hunsaker. 1987. Water use variability in irrigated level basins. Transactions of the ASAE 30(4):1090-1098.

Burt, C. M. 1995. The Surface Irrigation Manual. Waterman Industries, Exeter, CA. Rose Printing Co., Inc. p 3.7

Clemmens, A. J. and T. Strelkoff. 1979. Dimensionless advance for level-basin irrigation. Journal of the Irrigation and Drainage Division, ASCE, Vol 105, No. IR3, pp 259-273.

CAST. 1995. Effective use of water in irrigated agriculture. Report No. 113, p 27.

Clemmens, A. J. and A. R. Dedrick. 1981. Estimating distribution uniformity in level basins. Transactions of the ASAE. Vol 24, No. 5, pp 1177-1180, 1187.

Clemmens, A. J. and A. R. Dedrick. 1982. Limits for practical level-basin design. Journal of Irrigation and Drainage Engineering, ASCE, 108(2):127-141.

Clemmens, A. J. 2000. Level-basin irrigation systems: adoption, practices, and the resulting performance. Proceedings of the 4th Decennial National Irrigation Symposium, ASAE, St. Joseph, MI. pp 273-282.

Dedrick, A. R., L. J. Erie and A. J. Clemmens. 1982. Level-basin irrigation. In Advances in Irrigation, Volume 1, pp 105-145. Edited by Daniel Hillel. Academic Press, New York.

DOTD, 2002. Water use in Louisiana, 2000. Department of Transportation and Development Water Resources Special Report No. 15. Baton Rouge, LA.

Epting, Josh. 2003. Irrigation water use and water level survey annual report. YMD Joint Water Management District. Stoneville, MS.

Epting, Josh. 2004. Water use in the Mississippi Delta. YMD Joint Water Management District. Stoneville, MS.

Epting, Josh. 2004. Water use in the Mississippi Delta. YMD Joint Water Management District. Stoneville, MS.

Evans, R. O., R. W. Skaggs and R. E. Sneed. 1990. Normalized crop susceptibility factors for corn and soybean to excess water stress. ASAE Vol 33(4): July-August.

Evans, R. O., R. W. Skaggs and R. E. Sneed. 1991. Stress day index models to predict corn and soybean relative yield under high water table conditions. ASAE Vol 34(5): September-October.

Evans, R. O. and R. W. Skaggs. 1993. Stress day index models to predict corn and soybean yield response to water table management. 15th International Congress of ICID, Workshop on Subsurface Drainage Simulation Models.

Griffin, J. L. 1990. Effect of flooding on soybeans. LSU AgCenter, Crowley.

Hardjoamidjojo, S., R. W. Skaggs and G. O. Schwab. 1982. Corn yield response to excessive soil water conditions. Transactions of ASAE, Vol 25(4)922-927, 934.

Hester, J. and M. Nussbaum. 2006. Sub-surface drainage and irrigation. Presentation at the University of Missouri Bootheel Irrigation Workshop, December, 12, 2006. Portageville, MO.

Hunsaker, D. J. and D. A. Bucks. 1987. Wheat yield variability in irrigated level basins. Transactions of the ASAE 30(4):1099-1104.

Linkemer, G. 1995. Quantification of waterlogging stress on late planted soybeans. Unpublished thesis, LSU Department of Plant Pathology and Crop Physiology, Baton Rouge

Martin, E. C. and T. H. Eusoff. 2000. Saving water using drain-back level basins. Proceedings of the 4th Decennial National Irrigation Symposium, ASAE, St. Joseph, MI. pp 567-572.

Massey, J., M. C. Smith and J. Thomas. 2006. Water-saving irrigation for Mississippi rice production. 2006 Annual Report, Mississippi State University.

Powers, Shane. 2005. Water use and irrigation energy cost analysis in the Mississippi Delta. YMD Joint Water Management District. Stoneville, MS.

Powers, Shane. 2006. Water use and irrigation energy cost analysis in the Mississippi Delta. YMD Joint Water Management District. Stoneville, MS.

Smith, M. C., J. H. Massey, J. Branson, J. W. Epting, D. Pennington, P. L. Tacker, J. Thomas, E. D. Vories and C. Wilson. 2006.Water use estimates for various rice production systems in Mississippi and Arkansas. Irrigation Science. Accepted for publication.

USDA-NASS. 2004. Farm and Ranch Irrigation Survey (2003), Volume 3, Special Studies. Washington, D.C.

USDA-NRCS. 1997. National Engineering Handbook, Part 652, Irrigation Guide. Washington, D.C. pp 2-18, 2-23, 3-6, 5-7

USDA-SCS. 1960. Louisiana Irrigation Guide. Alexandria, LA. Chapter 2, pp 9-12.

USDA SCS. 1988. Soil Survey of Concordia Parish, Louisiana.

U.S. Department of Commerce (1996). Farm and Ranch Irrigation Survey (1994). Washington, D.C.

USGS. 1998. Estimated use of water in the United States in 1995. USGS Circular 1200, Denver, CO.

USGS. 2004. Estimated use of water in the United States in 2000. USGS Circular 1268, Denver, CO.

Vories, E. D., P. L. Tacker and R. Hogan. 2005. Multiple inlet approach to reduce water requirements for rice production. Applied Engineering in Agriculture, 21(4): 611-616.