CROP WATER USE

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INTRODUCTION

Water use in the Mississippi Delta is dominated by agricultural use. Approximately 85% of all water is used for the flooding of rice, filling of catfish ponds, or irrigation of cotton and soybeans. That water must be used efficiently to ensure the long term availability of water to agriculture. This paper will briefly review some of the research activities completed or underway by scientists of the Mississippi Agricultural and Forestry Experiment Station (MAFES) to improve our understanding of water resources in the region and efficient use of water.

Survey of water used by producers to sprinkler irrigate cotton.

During each year from 1983 to 1988, sprinkler irrigation records were collected from approximately 40 center pivot sprinklers spread across the Delta. From these records it was possible to calculate the amount of irrigation water applied each season for each system. Irrigations were scheduled by the cooperator who owned and operated each individual system. The maximum, minimum, and average amount of water applied per acre for each year for the 40 systems are given in Table 1. Over the 6-year study, an average of 5.25 inches of water per growing season was applied to cotton. Part of the range in applied water in each year may be due to sporadic rainfall events in the summer, management preferences, and soil type.

Year	Avg.	Min.	Max.
83	6.0	2.3	11.0
84	4.3	1.0	8.0
85	3.8	1.0	6.4
86	5.8	2.2	10.4
87	3.9	0.8	7.0
88	7.8	2.3	13.3

Table 1. Acre inches of irrigation water applied to cotton in the Mississippi Delta. Results from survey of about 40 systems each year.

Minimum water requirement of cotton on light textured soil.

Different amounts of irrigation water were applied daily with a drip system to small plots on the Delta Branch Station at Stoneville. Amounts applied to different treatments ranged from 20% more than the crop was estimated to be using to about 40% of that needed by solid planted cotton. Irrigation water and rainfall during the irrigation season (approximately mid-July to mid-August) were recorded for each treatment and are compared to yields in Figure 1. Each year, as the total applied water increased, yields increased until about 6 inches of total water had been applied. The yields then leveled off with no further yield increases resulting from additional water. The exception was the extremely dry 1986 season where yields continued to increase with the highest water rate. These data indicate that on this Bosket very fine sandy loam, about 6 inches of irrigation water and/or rainfall is needed during the irrigation season to obtain optimum cotton yields. This amount is very close to the 5.25 inches of average irrigation water applied by growers to typical cotton soils over the last 6 years as reported in the survey results in Table 1. These two sets of data suggest that growers using center pivot sprinklers are applying approximately the minimum amount of irrigation water needed for optimum cotton yields.

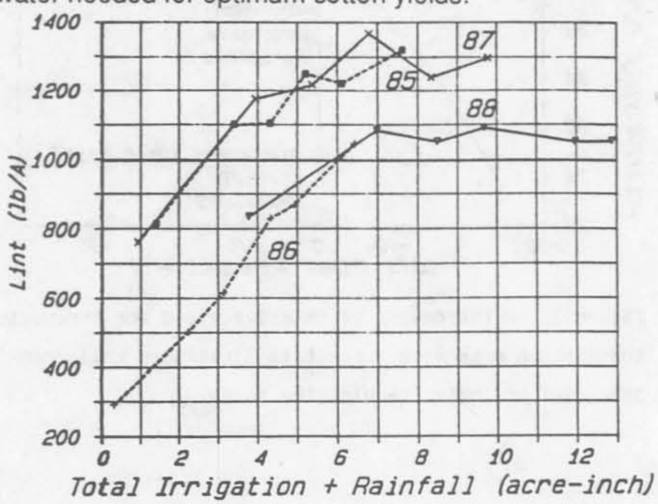

Figure 1. Relationship of lint yield and quantities of water applied by rainfall and irrigation for the irrigation periods of 1985, 86, 87 and 88 (36, 24, 38 and 56 days, respectively).

Timing of last sprinkler irrigation of cotton.

The timing of the last irrigation of cotton can influence yield and harvest timeliness. Stopping irrigation too early in the season can substantially reduce yield. Continuing to irrigate too late in the season will not increase yields, unnecessarily uses water, and can delay harvest.

Defining the best time for the last sprinkler irrigation of cotton has been the objective of research at the Delta Branch Station. In experiments conducted since 1984, different irrigation treatments were managed the same except for the last irrigation. Irrigations of 1 inch were terminated on treatments at different times. Timings of last irrigation were referenced to first open boll rather than a calendar date due to differences in planting dates and rates of crop development associated with different years.

Results showed no differences in yield among treatments where the last irrigations were made at first open boll or later. A delay in harvest was associated with irrigations which were made 3 to 4 weeks after first open boll. Data from 1984 to 1987 are given in Figure 2. In this figure, relative yield is plotted as a function of days before or after first open boll. Relative yield is the yield of an individual treatment divided by the yield of the highest yielding treatment in each test and expressed as a percent. The best-fit regression curve through the data is included in Figure 2. These results indicate that the last one-inch irrigation to cotton should be applied within the two week interval immediately after first open boll.

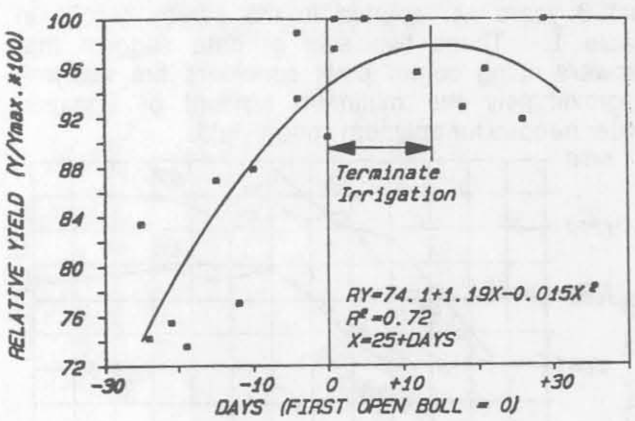

Figure 2. Relationship of relative yield and irrigation termination date with respect to first open boll from 1984-1987 sprinkler termination study.

Reducing cotton transpiration with a growth regulator.

Three years of research have been conducted with an experimental material that partially closes cotton stomata. Water is lost from leaves through the stomata in the process of transpiration. Apparently, partial closing of the stomata resulting from the use of the growth regulator increases water use efficiency of cotton. Improving water use efficiency results in yield increases when water is limiting production. Yield increases of 10 to 20% were commonly obtained with cotton grown on heavy textured soils which are frequently water deficient. Use of this chemical in the future could replace irrigation in some situations. This in turn would help reduce demands on limited water supplies.

Variability of seasonal water use of rice during flood.

Rice in the Mississippi Delta is flooded continuously from the 30-day old seedling stage to about 2 weeks prior to harvest. The normal length of flood is about 90 to 100 days, and starts in late May and ends near the first of September. During this time, water must be pumped onto the field to make up for water losses from the field. Water is unavoidably lost from a field by evapotranspiration (ET), percolation, and seepage through outside levees. Other than properly constructing levees, management can do little to reduce these losses.

ET is controlled by weather conditions over the field. This atmospheric demand for water is greater on hot, windy, clear, low relative humidity days than on cool, still, cloudy, humid days. Because of its dependence on weather, ET varies from year to year. A better understanding of the expected range of water demand (ET) by the atmosphere will allow for more intelligent management of water resources.

Computer models based on weather data have been developed from published reports to estimate ET from rice fields during the flood period. The required weather data are available for the past few years at many locations in Mississippi and a long history is available at Stoneville, MS. By using these models, it is possible to estimate differences in seasonal water demand for many years and locations.

These models were run with Stoneville weather data from 1966 to 1988. Data from each year were used to calculate ET by assuming that the flood began June 1 and ended August 31. The variability from year to year was relatively small. Three different models gave an average ET during flood of about 28 inches with a standard deviation of about 1.5 inches. The deviations from the 23 year average for one model are given in Figure 3. Seasonal variations in ET will usually be within 10% of the long term average.

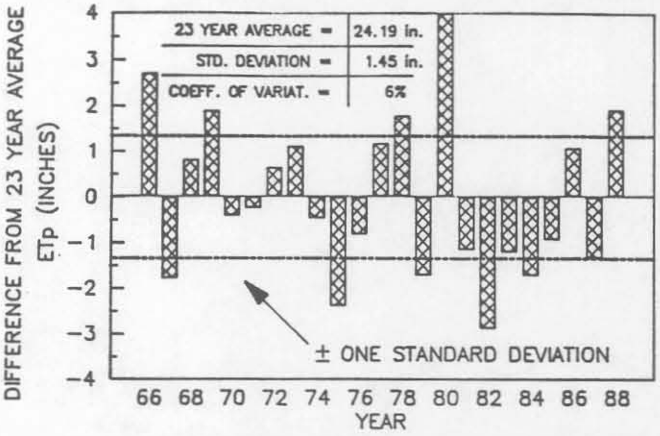

Fig. 3. Deviation from 23-year mean ET calculated as ET = 1.2*Ep , where Ep = pan evaporation.

Potential for use of rainfall during permanent flood in rice.

The alluvial aquifer under the Delta is the major source of irrigation water. Each year pumpage from the aquifer exceeds recharge and as irrigation needs expand the amount of the overdraft will increase. Rainfall during the summer represents an alternative source of water for irrigation. However, very little rain is retained and used in rice fields of the Delta. Almost all rain is lost as runoff from the flooded fields. Careful management of water levels in rice fields could allow for capture of rainfall, thereby reducing pumping and the amount of water withdrawn from the heavily used alluvial aquifer.

The ET model described in the previous section was modified to calculate the amount of rainfall captured if water levels were controlled to improve the capacity of a rice field to hold rainfall.

The average rainfall during the 3-month period of June, July, and August for the 23 years evaluated was only 9.5 inches. This amount represents the long term upper limit of rainfall capture potential. The model simulations indicate that the field design commonly used now (one inlet supply of water for the entire field) could capture about 1/2 of the summer rainfall for a water savings of only 5 inches. With multiple inlets (an inlet supply of water for each levee) the average rainfall capture was about 7 inches. These water savings represent a small amount of the total pumpage currently applied to rice and therefore provide little incentive to make major modifications in rice water management just to capture rainfall.

Scheduling irrigations in a field with variable soil types.

Soils in many fields of the Mississippi Delta are highly variable. Very fine sandy loams, silty clay loams, and clay loams often can be found in the same management unit. Different soil types have different irrigation requirements. Generally it is difficult to water different areas of the same field specifically for the soils in that part of the field. The simplest management approach is to apply irrigation water based on the water needs of the most common or most prominent soil type in the field. However, for areas of the field with different soil types, application amounts may be too high or too low. A grower should apply water according to the needs of the field based on a scheme that will maximize his returns. Applying irrigation for the needs of the most common or average soil type may not be the best approach.

Research was conducted in 1986 and 1987 at the Delta Branch Station, Stoneville, MS, to determine the best approach for irrigating fields with variable soils. The research was conducted in a field that gradually changed from a fine-textured, heavy soil to a much lighter, coarser-textured soil. The soil change ran across the rows so that a single row was on a constant type of soil. The field was divided into 3 blocks each 40' long that ran across the entire soil gradient (Fig. 4). Each block was irrigated with a linear-move irrigation system that covered the entire field width (80 40-inch rows covering 267'). As the irrigation system moved down the rows, all soil types within a given block were irrigated at the same time and with the same amount of water. However, the amounts of water applied to the different blocks varied based on the soil type used to schedule irrigations. One treatment (block) was a non-irrigated check that received no irrigation. The second treatment was irrigated based on the water needs of cotton growing on the lighter soil, whereas the third treatment was irrigated based on the water needs of cotton growing on the heavier soils within the block. The treatment irrigated for the water requirements of the cotton on lighter soil received about one-half to two-thirds as much water as the treatment irrigated for the heavy soils. Each row from each treatment was harvested separately.

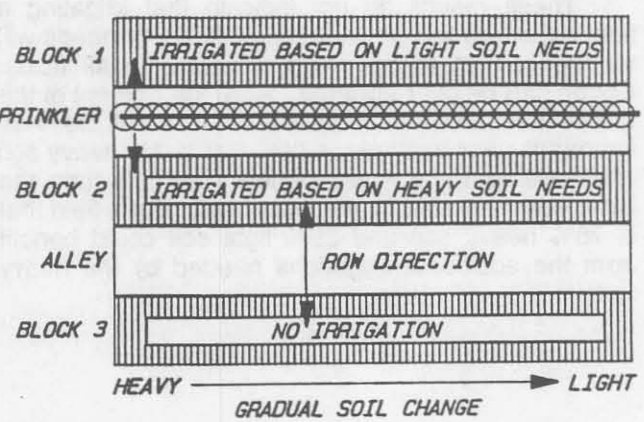

Fig. 4. Layout of experimental field.

The average lint yields across the soil gradient for 1986 and 1987 are shown in Figure 5. Yields from the non-irrigated check were lowest, whereas the very highest individual row yields were obtained on the lighter soils watered for the irrigation requirements of lighter soils (right side of figure). The water applied based on the light soil needs was approximately adequate for the light soils, but was insufficient for the heavy soils. Irrigation based on heavy soils produced more uniformly high yields across all soil types and more total cotton from the treatment. The extra water applied to the treatment irrigated for the heavy soils did substantially improve the yields of the cotton on heavy soils without significantly depressing the yields on the light soils. The highest overall yield was obtained with the treatment irrigated based on the water requirements of cotton on the heavier soil. In this case, scheduling irrigations for the lighter soils in a management unit did not produce the highest overall yield for that management unit.

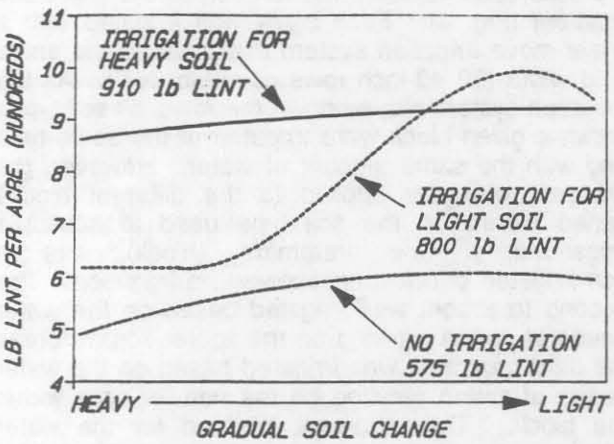

Fig. 5. Two-year average lint yields. Treatments irrigated based on the irrigation needs of cotton grown on heavy or light soils.

These results do not indicate that irrigating a field based on the heavier soil or hot-spot needs will be the correct management program in all fields. Cotton can be over-irrigated. Also, the percent of the soil in the field that is heavy or light will be very important. For example, a field that is 1% heavy soil and 99% light soil would benefit very little from the extra water needed by the heavy soil. But a field that is 75% heavy soil and 25% light soil could benefit from the additional irrigations needed by the heavy soils.