Surface irrigation management in Alabama cotton

Mark Dougherty, Biosystems Engineering Dept., Auburn University, Asst. Professor, 203 Corley Bldg., Auburn University, AL 36849-5417, doughmp@auburn.edu
Larry M. Curtis, Biosystems Engineering Dept., Auburn University, Professor, 200 Corley Bldg., Auburn, AL 36830, curtilm@auburn.edu
John P. Fulton, Biosystems Engineering Dept., Auburn University, Asst. Professor, 200 Corley Bldg., Auburn University, AL 36849-5417, fultojp@auburn.edu
Hugh D. Harkins, Tennessee Valley Research & Extension Center, Asst. Director, P.O. Box 159, Belle Mina, AL 35615, harkihd@auburn.edu
B.E. (Chet) Norris Jr., Tennessee Valley Research & Extension Center, Director, P.O. Box 159, Belle Mina, AL, norribe@auburn.edu

Abstract: Fluctuations in cotton yield in the Tennessee Valley of North Alabama are common and are usually related to drought or irregular rainfall. A sprinkler irrigation study established in 1999 evaluated a range of irrigation application intervals to identify the minimum design flow rate that will produce optimum yields. Treatments included four sprinkler irrigation intervals ranging from one inch every 12.5 days (1.5 gpm per acre) to one inch every 3.1 days (6.0 gpm per acre) and a non-irrigated treatment. Irrigation was managed using soil moisture sensors and a spreadsheet-based scheduling method. Significant yield differences between irrigated and non-irrigated were noted in most years, with rainfall variability and treatment effects accounting for a wide range of yield responses between irrigated treatments.

Introduction: While the southeastern U.S. has plenty of water available on an average annual basis, large inter-annual variability in rainfall and sporadic convective rainfall during the growing season makes purely rain-fed agriculture a poor competitor to the efficiency of irrigated agriculture. Figure 1 shows the annual distribution of rainfall in Alabama, averaging about 1320mm (52 inches) per year. The research presented in this paper is located in northern Alabama in the Tennessee Valley, an area of widespread cotton production (Figure 2).

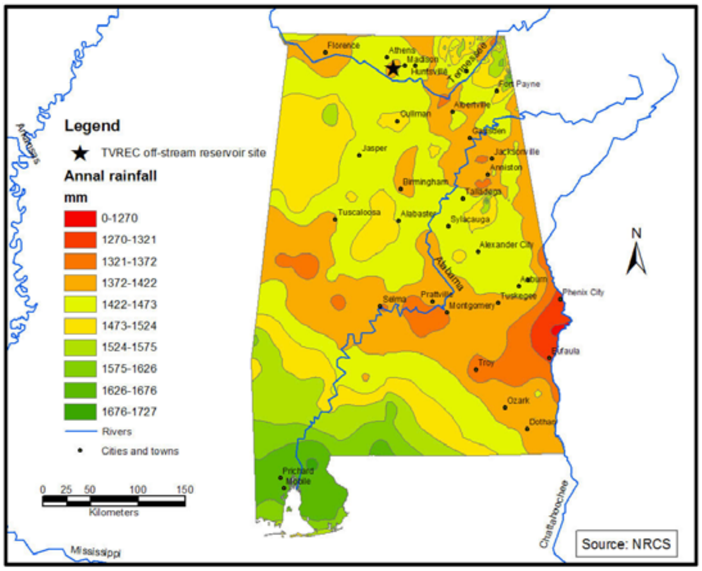

Figure 1. Annual precipitation distribution in Alabama showing location of study area (denoted by a star).

This system design capacity experiment was established in 1999 to evaluate a range of irrigation application capabilities in order to identify the minimum design flow rate that will produce optimum cotton yields. Figure 2 shows the research area and 5.3 ha (13 ac) off-stream water storage reservoir located adjacent to the study site.

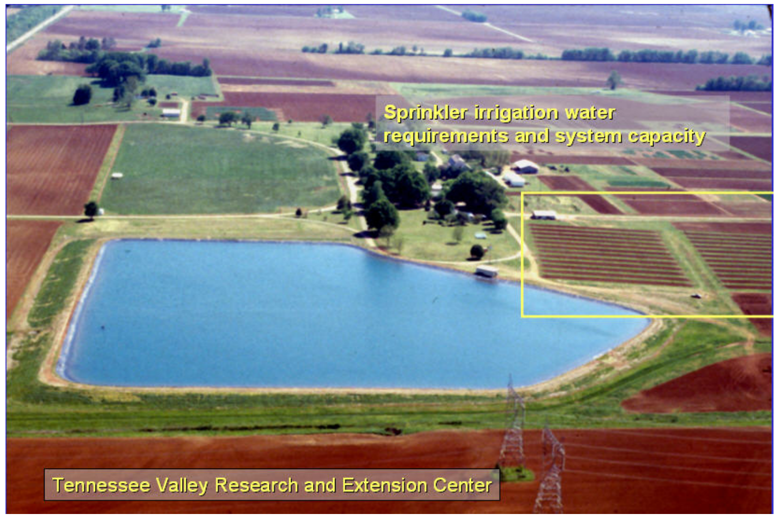

Figure 2. Oblique view south of system capacity test plots and adjacent irrigation storage reservoir, Tennessee Valley Research and Extension Center, Belle Mina, AL.

During the six years of this study, precipitation and evaporation fluctuated across a wide range, providing representative wet and dry years for comparative study (Figure 3).

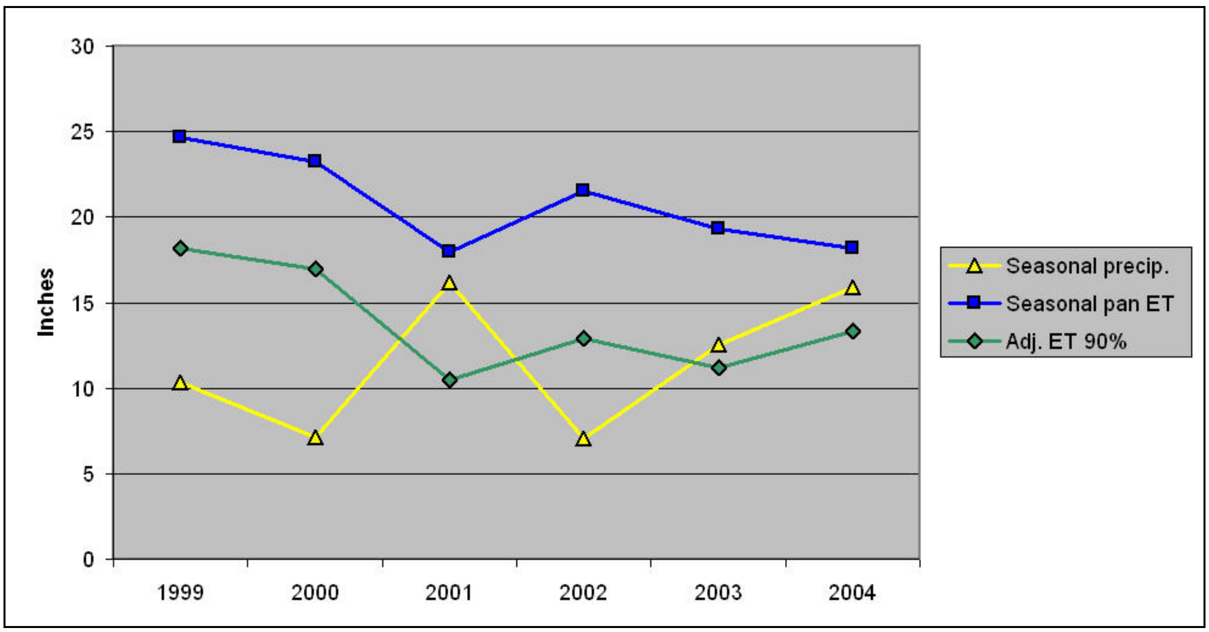

Figure 3. Seasonal precipitation (June, July, and August), pan evaporation, and adjusted evapotranspiration at Belle Mina, AL, during the 6-year study period.

Methods: Treatments included four sprinkler irrigation system capacities and a nonirrigated treatment for cotton. Cotton irrigation was managed using soil moisture sensors and a spreadsheet-based scheduling method. The irrigation system capacities tested were (1) one inch every 12.5 days, (2) one inch every 6.3 days, (3) one inch every

4.2 days, and (4) one inch every 3.1 days. These irrigation capabilities are equivalent to 1.5, 3, 4.5, and 6 gallons per minute per acre. The one-inch amount represents the maximum amount of irrigation applied in the time indicated. Figures 4 and 5 show the location and setup of the replicated treatments used in this study.

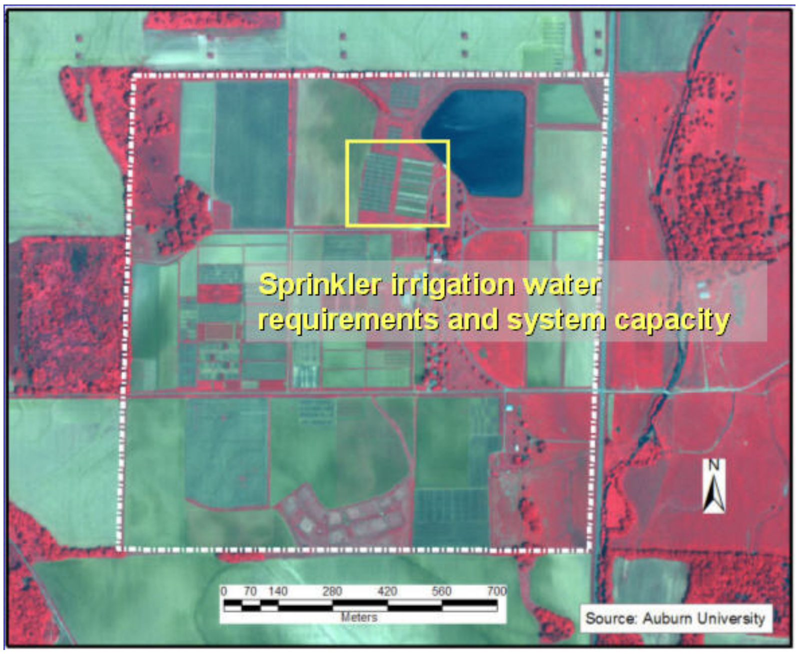

Figure 4. Location of sprinkler system capacity plots, Tennessee Valley Research and Extension Center, Belle Mina, AL.

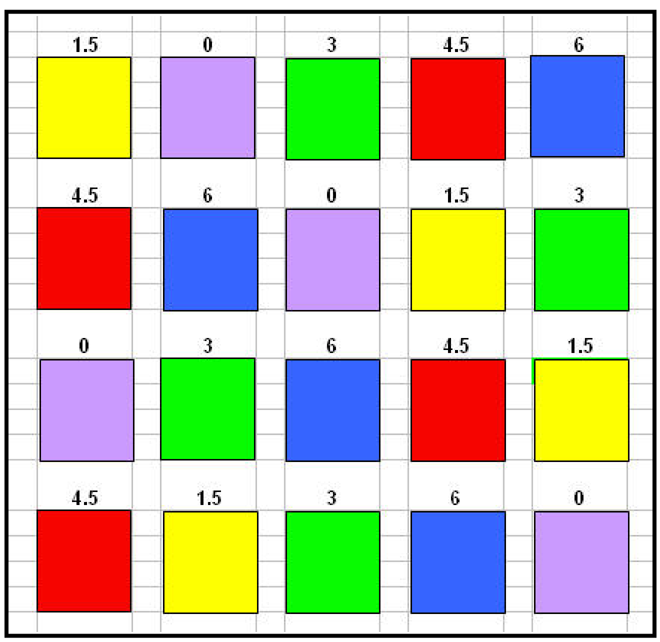

Figure 5. Sprinkler plot layout, beginning of 2002 growing season (0, 1.5, 3, 4.5, and 6 denote dryland treatment, and 1.5, 3.0, 4.5, and 6.0 gpm/ac irrigated treatments).

Individual plots were arranged as a randomize block of five treatments. Each 13.3-foot x 39-foot plot was irrigated with four quarter-throw sprinklers programmed with a "soak-and-cycle" feature to limit runoff. From 1999 to 2000, three replications of each treatment were used. In 2001, a fourth replication was added, as shown in Figure 5. Moisture management and irrigation scheduling was accomplished using Watermark ™ soil moisture sensors, and weekly data entry into a spreadsheet program, Moistcot, developed by Alabama Cooperative Extension (Tyson et al, 1996).

Results: Table 1 presents average yields for the six-year study period in pounds of seed cotton per acre. Average turnout of lint from seed cotton ranged from 35 to 38 percent during the study period.

Table 1. Yearly and average seed cotton yields for system capacity treatments, pounds per acre.

Year	Dryland	1.5gpm/ac	3.0gpm/ac	4.5gpm/ac	6.0gpm/ac
1999	1700	2637	2984	3708	3920
2000	1236	2444	3688	3603	3627
2001	3061	3387	3466	3595	3371
2002	1759	2530	2871	2853	2925
2003	3288	3579	3802	3764	3739
2004	3530	3300	3208	3505	3367
Average	2429 a	2980 a,b	3337 b,c	3505 c	3492 c

Dryland = nonirrigated
1.5gpm/ac is equivalent to 1 inch every 12.5 days.
3.0gpm/ac is equivalent to 1 inch every 6.3 days.
4.5gpm/ac is equivalent to 1 inch every 4.2 days.
6.0gpm/ac is equivalent to 1 inch every 3.1 days.
Similar subscripts (a, b, c) denote 6-year averages not significantly different at alpha value 0.10 (using standard two sample t-test).

In 2004, rainfall was plentiful throughout the growing season, and dryland and irrigated yields were not substantially different. In 2003, rainfall was near optimum through much of the growing season, but a 26-day dry period occurred between August 7 and September 4. A total of only 0.61 inches of rain occurred during this period, and this rainfall was measured in seven minor rainfall events. Three timely one-inch irrigation applications during this period boosted irrigated yields, with 476 additional pounds of seed cotton per acre on the optimum irrigation treatment (one inch every 4.2 days).

In 2002, irrigated yields were significantly higher than nonirrigated yields, but the highest yields were less than in other years for most treatments. The reason for this is unclear but may be related to shutdown of irrigation prior to sufficient boll maturity. Only very small yield differences were noted in 2001, while significant differences were measured in 1999 and 2000. Rainfall variability and treatment effects accounted for the wide range of yield responses for each of these years.

Discussion and summary: Figure 6 shows comparative seed cotton yields from each treatment from1999 to 2004. For the lowest irrigation design flow, 1.5 gpm/ac (1 inch every 12.5 days) yields track those of dryland cotton and in fact are not signicantly different from dryland yields (Table 1). The next highest irrigation design flow, at 3.0 gpm/ac (1 inch every 6.3 days) does not have yields significantly different from 1.5 gpm/ac, but has average 6-year yields significantly higher than dryland cotton. The highest irrigation design flow rates, 4.5 and 6.0 gpm/ac (1 inch every 4.2 and 3.1 days, respectively) result in yields significantly higher than both dryland and 1.5 gpm/ac treatments.

Graphical results (Figure 6) reveal that yields from dryland cotton and the lowest irrigation design flow (1.5 gpm/ac) track seasonal precipitation. The data from this study suggest that the minimum design flow rate that will produce optimum yields in irrigated cotton is 4.5 gpm/ac, which is equivalent to approximately one inch every 4.2 days. This information can be used to optimize the design of pivot irrigation pumping plants by matching pump and storage facility size to the total area irrigated.

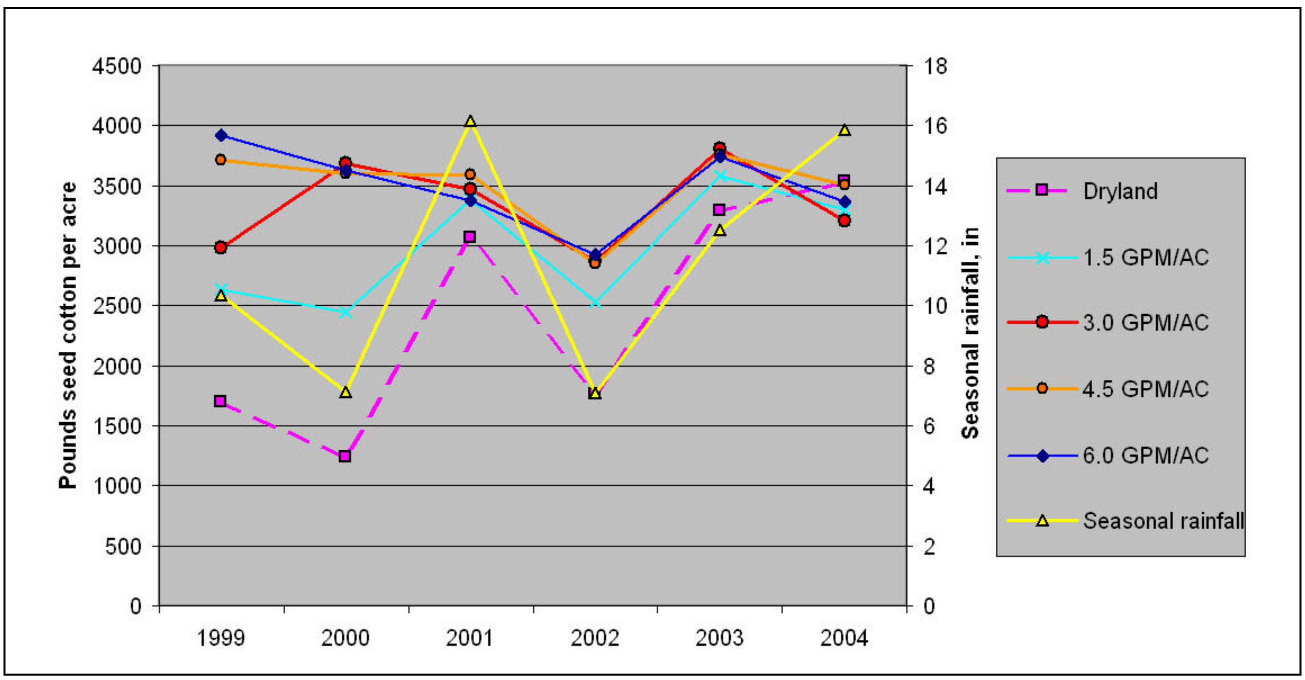

Figure 6. Yield response, pounds of seed cotton, of four irrigated system capacity treatments versus one nonirrigated treatment, 1999-2004, Belle Mina, AL.

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