2004 BELTWIDE COTTON CONFERENCES, SAN ANTONIO, TX – JANUARY 5-9

ECONOMIC EFFECT OF LATE IRRIGATION ON MID-SOUTH COTTON

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Abstract

US cotton growers are adopting COTMAN, a COTton MANagement system developed at the University of Arkansas, to monitor crop development and aid in making end-of-season decisions. Currently, research-based decision guides have been developed to aid in identifying the last effective boll population and determining dates for safe termination of insect control and the application of defoliants based on physiological cutout, or NAWF=5. An area of cotton production that may benefit from COTMAN is the decision of when to stop irrigating the crop. The objective of this research was to investigate a crop-based recommendation for timing the final irrigation on cotton. Studies were conducted during the 2000 through 2003 growing seasons in four mid-South states (Missouri, Arkansas, Mississippi, and Louisiana) to investigate the response of upland cotton to late-season irrigation. Irrigation treatments consisted of different irrigation termination dates at each site, with the first termination treatment targeted for approximately NAWF=5 or physiological cutout. Data from 12 experiments were included in this analysis. Marginal yield was calculated for treatments and the resulting data was modeled with a cubic polynomial to indicate the relationship between marginal revenue and degree day heat units (DD60) after NAWF=5 for various cotton lint prices. The resulting marginal revenue equations were set equal to the marginal cost of an additional irrigation and solved for the optimal termination points. For prices ranging from \$0.35 to \$0.75 per pound of lint, the optimal termination point was 545 ± 16 DD60 past NAWF=5.

Introduction

Cotton growers across the Cotton Belt are adopting COTMAN, a COTton MANagement system developed at the University of Arkansas, used to monitor crop development and aid in making end-of-season decisions (Danforth and O'Leary, 1998). The later-season portion of the system is based on monitoring the number of nodes above the uppermost first-position white flower (NAWF) on a plant. Research has shown that as the developing bolls require more of the plant resources, the development of new nodes slows and the first-position white flower "moves" progressively toward the plant apex. Bourland et al. (1992) found that a first-position white flower five nodes below the plant terminal represented the last effective flower population. Their work indicated that flowers set after NAWF=5 have a higher shed rate and lower mass, resulting in only a minor contribution to final yield. Based on their findings, NAWF=5 is generally accepted as physiological cutout.

The COTMAN system uses a target development curve (TDC) as a reference to compare with actual crop development. The TDC has flowering beginning at 60 days after planting (DAP) and NAWF=5 at 80 DAP. Comparisons of actual crop development to the TDC provide an indication of the maturity of the crop. Early-season stress often results in first flower at a relatively low NAWF value and physiological cutout occurring in less than 80 DAP. Currently, research-based decision guides have been developed to aid in identifying the last effective boll population and determining dates for safe termination of insect control and the application of defoliants based on physiological cutout, or NAWF=5. Research projects underway in several cotton-producing states are focused on ways to use the information from COTMAN to aid in additional management decisions regarding the crop (e.g., growth regulator applications). One area of cotton production that may benefit from COTMAN is the decision when to stop irrigating the crop. Recommendations in Arkansas and other states concerning the timing of the final irrigation are often based on the appearance of the first open boll. Such recommendations ignore the maturity of later-maturing bolls and often reflect as much fear of promoting boll rot as providing for the water needs of the maturing bolls or the economics of irrigation. A recommendation that relates the timing of the final irrigation to physiological cutout should better fit the needs of the crop and follows the approach taken with other management recommendations.

Objective

The objective of this research was to investigate a crop-based recommendation for timing the final irrigation on cotton.

Methods

Since 2000, Cotton Incorporated has sponsored studies in four mid-South states (Missouri, Arkansas, Mississippi, and Louisiana) to determine the optimal time to terminate furrow irrigation of cotton. Vories et al. (2001) reported on studies at three northeast Arkansas locations in 2000; Vories et al. (2002) reported on another eight mid-South studies in 2001; Vories et al. (2003) reported on eleven mid-South studies in 2002; and Vories et al. (2004) reported on seven mid-South studies in 2003. Data from 12 studies spanning four years (a total of 201 data points) were included in this analysis. Final irrigations occurring before NAWF=5 were removed from the data set. In addition, data from some of the studies were not available at the time of this report.

Additional (marginal) yield due to an additional irrigation treatment was computed for the treatments. Additional (marginal) revenue was then calculated based on a series of possible market cotton lint prices (e.g., \$0.35, 0.45, 0.55, 0.65, and 0.75 per pound of lint). Additional revenue will be called marginal revenue and additional cost will be called marginal cost hereafter.

The initial estimation of the marginal revenue function allowed for the inclusion of a planting date variable and a north-south effect binary variable in the model. However, parameter estimates for both variables were insignificant. Since the purpose of this study is to develop simple decision rules for irrigation termination, the model was re-estimated with both the planting date and north-south binary variables excluded. This should not result in a loss in any properties of the estimator.

The model was specified as a cubic polynomial with marginal revenue as a function of the number of DD60 heat units past NAWF=5 as shown in (1)

(1) $$MR_i = \beta_{0i} + \beta_{1i} * DD + \beta_{2i} * DD^2 + \beta_{3i} * DD^3 ,$$

where MR_i is the marginal revenue of the i^{th} cotton price, DD is the number of DD60 heat units after NAWF=5 average for the field, and $\beta_{0i}, ..., \beta_{3i}$ are the cubic equation parameter estimates for the i^{th} lint price. SAS version 8.1 was used to model the equation shown in (1) and the estimates of the parameters ($\beta_0, ..., \beta_3$) for various lint prices are shown in Table 1. The R^2 for the models was 0.13; though this number may seem low in some science disciplines it is satisfactory when dealing with economic data.

The level of optimum net revenue will occur at that point where marginal revenue derived from an extra irrigation treatment is equal to the marginal cost of that treatment. Marginal cost of furrow irrigation was assumed to be \$4.14 per acre (Bryant et al. 2001) based on conditions typical for Arkansas. Thus the optimal irrigation termination point can be computed by solving the following equation for *DD*.

(2) $$MR_i = MC = \$4.14 ,$$

where *MC* is a constant marginal cost for each of the *i* cotton prices shown in Table 1. The optimal solution points for each of the *i* prices are also shown in Table 1.

Each of the marginal revenue equations was graphed along with the marginal cost of an additional irrigation (Figure 1). The optimal points in DD60 past NAWF=5 were plotted against the corresponding cotton price (Figure 2). These points were then modeled as the simple linear function

(3) $$DD = 512.33 + 63.265 * price ,$$

where *price* is the respective cotton lint price in dollars per pound of lint.

Summary and Conclusions

The conclusions reached by this study seem fairly robust. The change in optimal termination points varied from a low of 529 to a high of 560, a difference of 31 heat units after NAWF=5 from a low cotton price of $0.35 to a high of $0.75 per pound. In the mid-South in summer, this range can occur within about one day.

The data set used in this analysis is fairly limited for this type of study. Further verification of these conclusions by continued research and farm verification is needed and the procedure can then be repeated as more data become available. Although the north-south binary effect proved to be insignificant, there needs to be more research on this issue as more of the data were taken from the northern portion of the mid-South region.

Based on these findings, in the area covered by this study, optimal irrigation termination should occur at NAWF=5 plus 550 DD60 heat units if the estimated market price of cotton is between $0.35 and $0.75 per pound of lint. A wide range in price had little effect on the optimal termination point.

Acknowledgements

Cotton Incorporated provided funding and technical assistance for this research. Additional assistance was provided by Wildy Farms, Stevens Farms, Frankel Farms, Peel Farms, Guedon Farms, and Goldmine Plantation. Individual assistance was additionally provided by Ray Benson, Chuck Capps, Al Coco, Bob Glover, Jimmy Hornbeck, Shawn Lancaster, Andrea Phillips, and Dale Wells.

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Table 1. Coefficients for cubic irrigation termination model and optimal points.

Cotton Price[a]	β_0[b]	β_1[b]	β_2[b]	β_3[b]	NAWF=5 plus DD60's[c]
$0.35	-7.27118	0.30328	-0.00085131	0.0000006027455	529
0.45	-9.34866	0.38993	-0.00109000	0.0000007749585	552
0.55	-11.42614	0.47658	-0.00134000	0.0000009471714	541
0.65	-13.50362	0.56323	-0.00158000	0.0000011200000	553
0.75	-15.58109	0.64989	-0.00182000	0.0000012900000	560

[a] Dollars per pound of lint.
[b] R^2 for all five models equals 0.13.
[c] The values are DD60 heat units after NAWF=5.

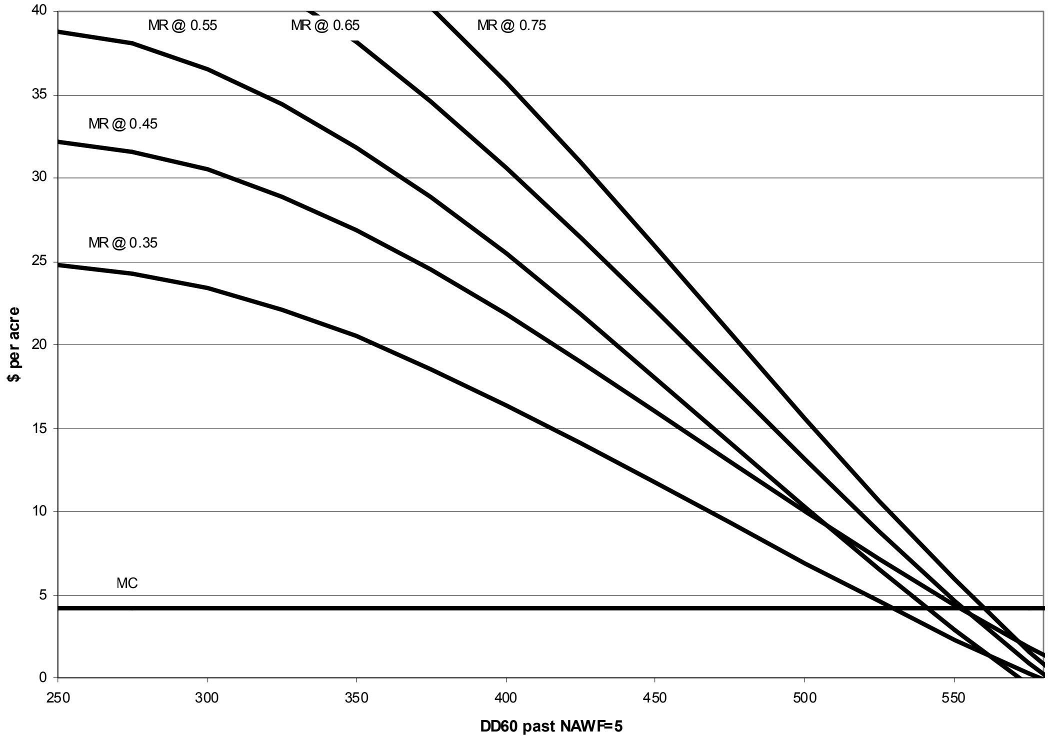

Figure 1. Marginal cost vs. marginal revenue at various cotton prices.

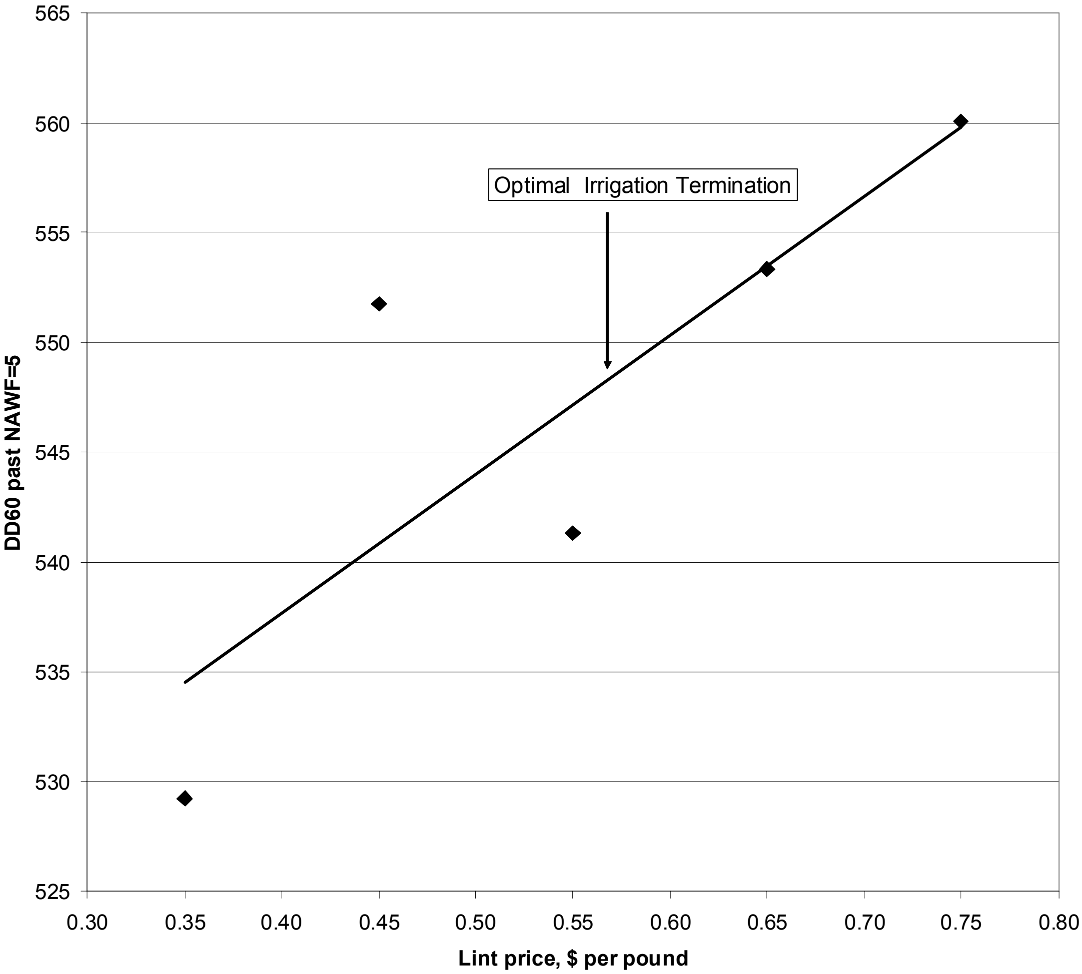

Figure 2. Cotton price vs optimal irrigation termination point.