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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 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 2004 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 19 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 yield and degree day heat units (DD60) after NAWF=5 for various cotton lint prices. Value-of-marginal product (marginal yield * cotton lint price) (VMP) equations were set equal to the cost of an additional irrigation and solved for optimal termination points. For prices ranging from \$0.35 to \$0.75 per pound of lint, the optimal termination point was 605 ± 23 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 uppermost first-position white flower (NAWF) on a plant. Research has shown that as developing bolls require more plant resources, 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. 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 crop maturity. 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 application of defoliants based on physiological cutout, or NAWF=5. Research projects underway in several cotton-producing states are focused on ways to use 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 timing of the final irrigation are often based on appearance of the first open boll. Such recommendations ignore maturity of later-maturing bolls and often reflect as much fear of promoting boll rot as providing for water needs of maturing bolls or the economics of irrigation. A recommendation that relates 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 Mid-South 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; Vories et al. (2004) reported on seven mid-South studies in 2003; and seven additional mid-South studies were conducted in 2004. Data from 19 studies spanning five years (a total of 331 data points) were included in this analysis. Final irrigations occurring before NAWF=5 were removed from the data set.

Upon a visual examination of the data, large variability in data set values can be observed. This variability may be the result of different year's soil and climatic conditions. Figure 1 shows the data plotted accompanied by a third degree polynomial trend line. Additional (marginal) yield due to an additional irrigation was computed for each of the treatments and used as the dependent variable of the model. Initial estimation of the marginal yield function allowed for inclusion of a planting date variable and a north-south effect binary variable in the model. However, parameter estimates for both variables were insignificant and random effect of year was not significant. Since the purpose of this study was to develop simple decision rules for irrigation termination, the model was re-estimated with both 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 yield as a function of the number of DD60 heat units past NAWF=5 as shown in (1)

(1) $$MY = 0.8 * DD^3 - 11.5 * DD^2 + 43.2 * DD + 2.6,$$

where *MY* is the marginal yield, *DD* is the number of DD60 heat units past NAWF=5 average for the field / 100.0. SAS version 8.1 was used to model the equation shown in (1). The R^2 for the model was 0.04; R^2 is typically low when dealing with economic data. However, the overall regression was significant and all terms were significant at the $\alpha = 0.10$ level.

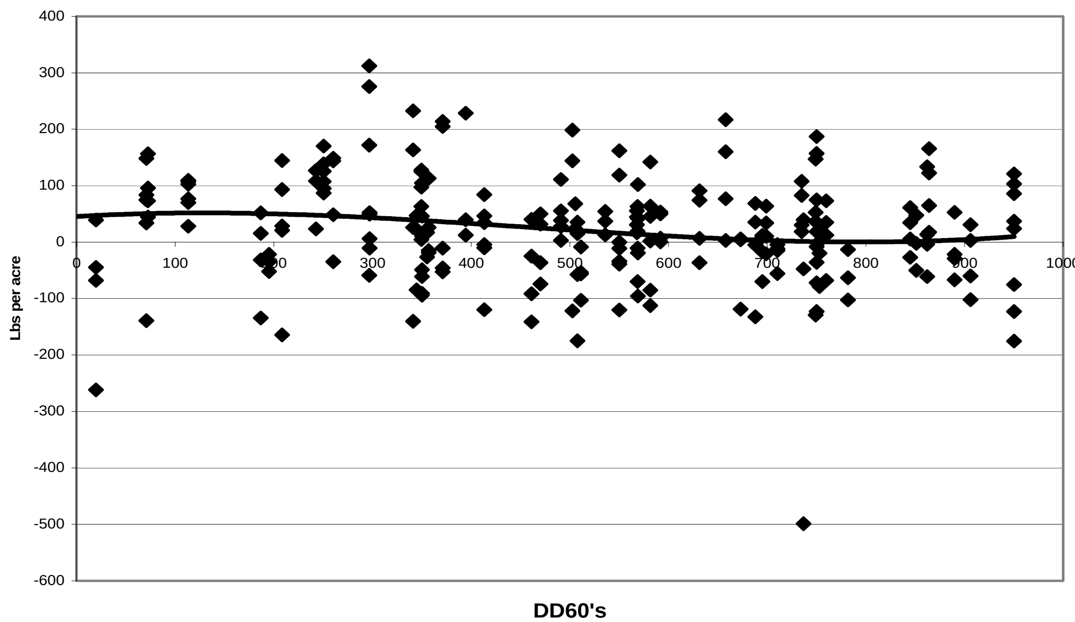

Figure 1. Marginal lint yield vs. accumulated DD60 heat units past NAWF=5 with third degree polynomial trend line.

Economic theory states that the level of optimum net revenue will occur at that point where value-of-marginal product derived from an extra irrigation treatment is equal to the cost of that treatment. Value-of-marginal product is computed as marginal yield times cotton lint price. Lint prices used in the calculations were 0.35, 0.45, 0.55, 0.65, and 0.75 dollars per pound. Input 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) $$VMP_i = P_x = \$4.14\,,$$

where P_x is a constant input cost of an additional irrigation 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.

Table 1. Optimal solution points for irrigation termination model.

Cotton Price	DD60 past NAWF=5
$0.35	583
0.45	602
0.55	614
0.65	623
0.75	630

Each value-of-marginal product equations were graphed with the cost of an additional irrigation (Figure 2). The optimal points in DD60 past NAWF=5 were plotted against the corresponding cotton price (Figure 3). These points were then modeled as the simple linear function

(3) $$DD = 546.6 + 116.39 * Price\,,$$

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

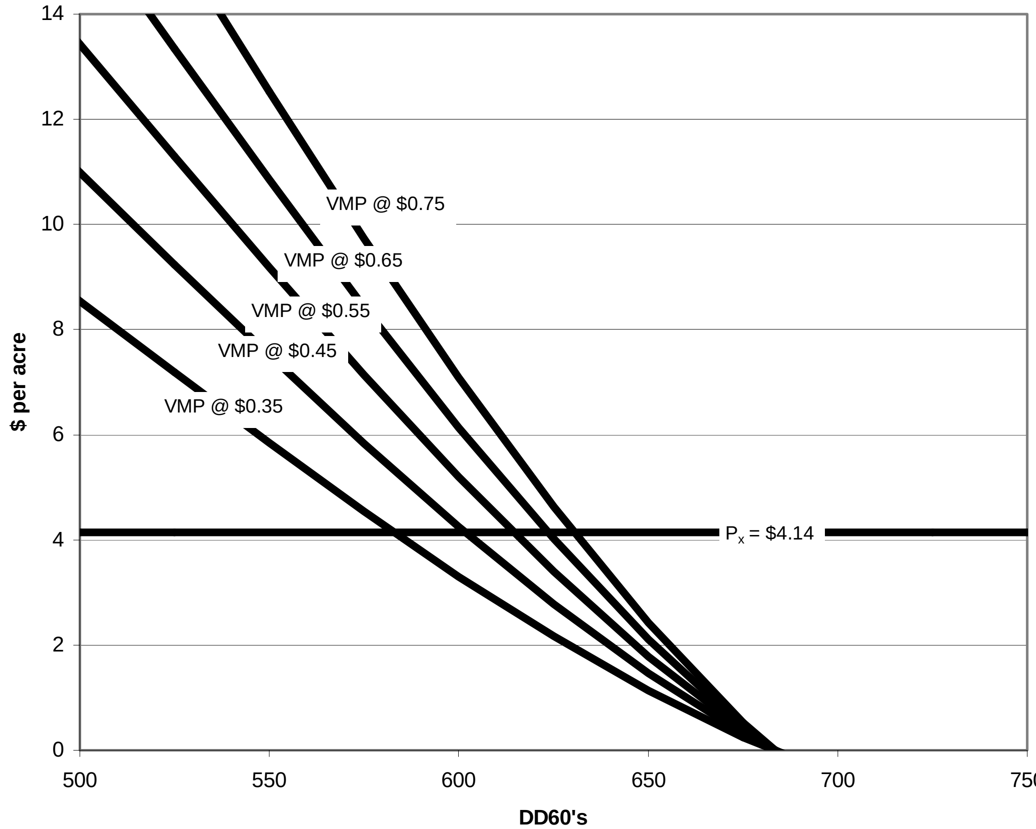

Figure 2. Value of marginal product vs. input cost at various cotton prices.

Summary and Conclusions

The conclusions reached by this study seem fairly robust. Change in optimal termination points varied from a low of 583 to a high of 630, a difference of 43 heat units past 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 rapidly.

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 605 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. It should be noted that although this analysis shows 605 heat units to be the optimal point, some studies have shown late irrigation delays crop maturity (Vories et al. 2002). This was an issue the authors were not able to address in this study but should be addressed at a later date.

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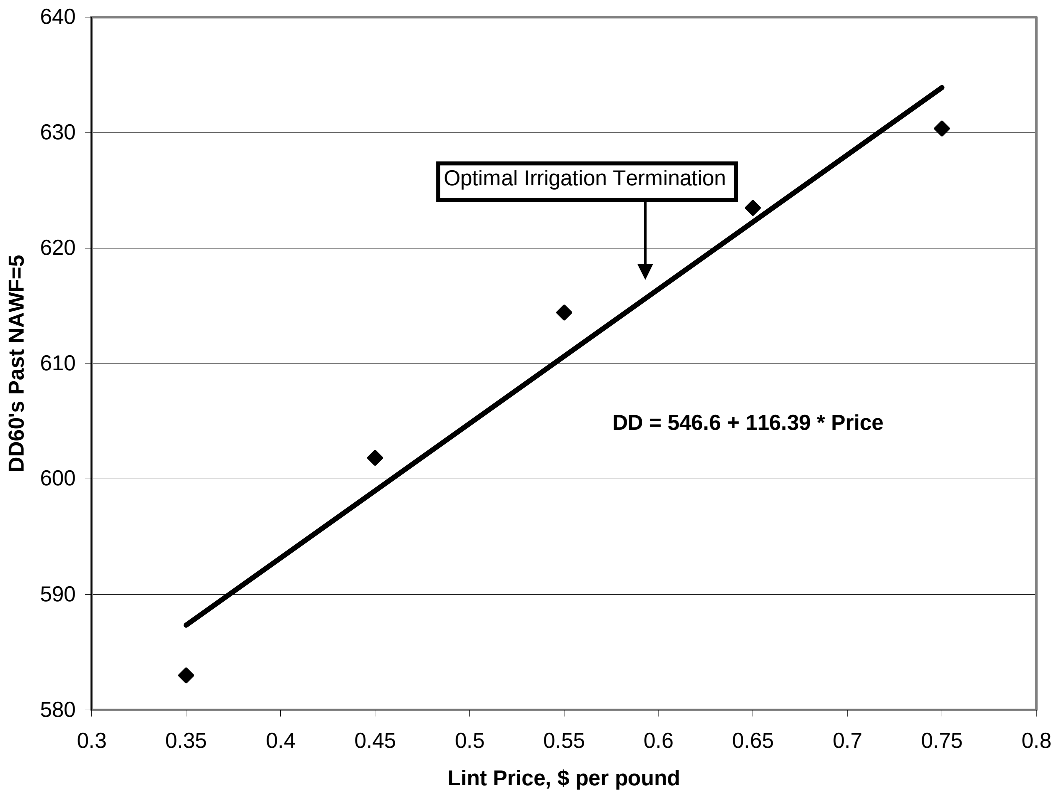

Figure 3. Cotton price vs optimal irrigation termination points.

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