ECONOMIC EFFECT OF LATE IRRIGATION ON ARKANSAS COTTON


RESEARCH PROBLEM

Studies have been conducted throughout the mid-South since 2000 to determine the optimal time for the last irrigation on cotton based upon nodes above white flower. This report presents a methodology to combine the results from different studies at different locations in different years and develop a recommendation. Data from 12 Arkansas studies spanning four years were included in this analysis.

BACKGROUND INFORMATION

Cotton growers across the Cotton Belt 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 (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. Bourland et al. (1992) found that a first-position white flower five nodes below the plant terminal represented the last effective flower population. Based on their findings, NAWF=5 is generally accepted as physiological cutout (Oosterhuis et al., 1999). 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. Research projects underway in Arkansas and other cotton-producing states are focused on using the information from COTMAN to aid in additional management decisions, including when to stop irrigating the crop. Developing a recommendation that reliably relates the timing of the final irrigation to physiological cutout will require combining the data from many different studies conducted under different environments.

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RESEARCH DESCRIPTION

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 Arkansas 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. 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.

RESULTS

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

\[ MY = 1.7*DD^3 - 24.3*DD^2 + 86.7*DD - 20.8, \]

where \( MY \) is the marginal yield, and DD is the number of DD60 heat units after NAWF=5 average for the field. SAS version 8.1 was used to model the equation shown in (1) and the estimates of the parameters. The \( R^2 \) for the models was 0.13; though this number may seem low in some scientific disciplines, it is satisfactory when dealing with economic data.

Marginal revenue (MR) is the product of marginal yield and lint price. The level of optimal 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 points can be computed by solving the following equation for \( DD \).

\[ MR = MC = 4.14, \]

where \( MR \) is the marginal yield determined from (1) times the price of lint and \( MC \) is a constant marginal cost. The optimal solution points for each of the prices are also shown in Table 1.
Each of the marginal revenue equations was graphed along with the marginal cost of an additional irrigation (Fig. 1). The optimal points in DD60 past NAWF=5 were plotted against the corresponding cotton price (Fig. 2). These points were then modeled as the simple linear function

\[
DD = 512 + 63.3 \times \text{price},
\]

where \(\text{price}\) is the respective cotton lint price in dollars per pound of lint. 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 Arkansas during the summer, this range can occur within about one day.

PRACTICAL APPLICATION

The data set used in this analysis is fairly limited for this type of study. Further verification and refinement of these conclusions by continued research and farm verification are needed and the analytical procedure can then be repeated as more data become available. Additional investigation of a possible north-south effect must be conducted as more data are collected throughout the mid-South region. Based on these limited data, 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. This research will continue in 2004.

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LITERATURE CITED


Table 1. Optimal irrigation termination points based on lint price.

<table>
<thead>
<tr>
<th>Cotton price ($/lb)</th>
<th>Heat units past NAWF=5 (DD60)</th>
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<tbody>
<tr>
<td>0.35</td>
<td>529</td>
</tr>
<tr>
<td>0.45</td>
<td>552</td>
</tr>
<tr>
<td>0.55</td>
<td>541</td>
</tr>
<tr>
<td>0.65</td>
<td>553</td>
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<tr>
<td>0.75</td>
<td>560</td>
</tr>
</tbody>
</table>

Fig. 1. Marginal cost versus marginal revenue at various cotton prices.
Fig. 2 Cotton price versus optimal irrigation termination point.