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DETERMINING THE OPTIMUM TIMING FOR THE FINAL FURROW IRRIGATION ON MID-SOUTH COTTON

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Abstract

US Cotton growers are adopting COTMAN, a COTton MANagement system used 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 the optimal dates for safe termination of insect control and application of defoliants based on the occurrence of a first-position white flower five nodes below the terminal (NAWF=5). Another 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. Data sets from 26 Mid-South cotton irrigation termination studies during the 2000 through 2005 growing seasons, a total of 432 data points, were fit to a quadratic equation. However, the residual yield values were correlated due to the fact that different studies had quite different yields. To avoid the serial correlation, data from each study were normalized such that the average lint yield for the study was adjusted to 1,000 lb/acre and again fit to a quadratic equation. The resulting equation had a maximum yield of 1021 lb lint/acre at 692 DD60 after NAWF=5. At NAWF=5, generally associated with physiological cutout, the yield was 963 lb lint/acre, 58 lb lint/acre below the maximum. Additional work will be necessary before a recommendation for irrigation termination can be added to COTMAN, including investigating: functions other than the quadratic; the possibility of differences in the northern and southern portions of the Mid-South; and any possible effects on fiber quality, particularly micronaire, and crop maturity.

Introduction

Cotton growers across the Cotton Belt are adopting COTMAN, a COTton MANagement system 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 addition of new main-stem 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 indications of the pace of crop development and the maturity of the crop. Early-season stress often results in first flower at a relatively low NAWF value and physiological cutout occurring at 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 the accumulation of growing degree days after physiological cutout, or NAWF=5. Research projects underway in several cotton-producing states are focused on other ways to use the information from COTMAN to aid in management decisions regarding the crop (e.g., growth regulator applications). One area of cotton production that may benefit from COTMAN is the decision of when to stop irrigating the crop. Recommendations 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. 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. Vories et al. (2001) reported on irrigation termination studies at three northeast Arkansas locations in 2000; Vories et al. (2002) reported on eight Mid-South studies in 2001; Vories et al. (2003) reported on ten Mid-South studies in 2002; Vories et al. (2003) reported on ten Mid-South studies in 2002; and Vories et al. (2004) reported on eight Mid-South studies in 2003. Additional studies in Texas addressed terminating drip (Biles et al., 2003; Multer et al., 2004) and LEPA (Doederlein et al., 2004) irrigation. However, rainfall interrupted many of the studies. Several of the studies were not completed due to excess rainfall, and several others that were completed were greatly influenced by late-season rainfall. Hogan et al. (2004) and Hogan (2005) performed economic analyses on the combined data from several of the Mid-South studies to determine the time when the cost of an additional irrigation was equal to the income from additional yield.

Objective

The objective of this project was to investigate a crop-based recommendation for timing the final irrigation on cotton. This report deals with the studies conducted in the Mid-South states of Missouri, Arkansas, Mississippi and Louisiana. Additional studies in Texas using drip (Biles et al., 2003; Multer et al., 2004) and LEPA (Doederlein et al., 2004) irrigation were reported separately.

Materials and Methods

Cotton irrigation studies were conducted in five states (Arkansas, Louisiana, Mississippi, Missouri, and Texas) during the 2000 through 2005 growing seasons to determine the optimal time to terminate irrigation. For each study, NAWF data were collected weekly from early flower until NAWF<5. With the exception of irrigation termination, cultural practices followed Cooperative Extension Service (CES) recommendations for the area. Information about the crops in each of the mid-South studies is included in Table 1. For each site, the first termination treatment was generally targeted for approximately NAWF=5 (physiological cutout). An additional treatment was terminated with each subsequent irrigation. The Mid-South cotton was planted on 38-inch rows and furrow irrigated. An assumed gin turnout of 35% was used to calculate lint yield at each location.

Previous analyses of the studies (e.g., Vories et al., 2001; 2002; 2003; 2004) looked at each study separately as a randomized complete block experiment, with date of the final irrigation as treatment. Tests for significant treatment effects were conducted with analysis of variance procedures. However, Hogan et al. (2004) and Hogan (2005) used linear regression on a combined data set and that method was used for this report. Data were fit using a quadratic function:

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$$LY = a(DD60\_5)^2 + b(DD60\_5) + c \quad (1)$$

where LY is lint yield (lb/acre, assuming a 35% gin turnout); DD60_5 is growing degree days, 60° F base (DD60), after NAWF=5; and a, b, and c are regression coefficients. The quadratic function, fit using the Regression tool in Microsoft Excel 2002 (Microsoft Corp., Redmond, WA), was used because yield from many of the studies tended to decrease with later irrigations.

Results and Discussion

Complete data sets were available from 26 Mid-South studies during the 2000 through 2005 growing seasons (Table 1), for a total of 432 data points. As a first step, all 432 data points were fit to equation 1 (Table 2, data set 1). However, as Figure 1 demonstrates, the residual yield values were correlated due to the fact that different studies had quite different yields. To avoid the serial correlation evident in Figure 1, data from each study were normalized such that the average lint yield for the study was adjusted to 1,000 lb/acre. In other words, if the average yield from all plots in a study was 900 lb/acre, then the yield from each plot was multiplied by 1.11 (i.e., 1,000/900). After normalizing each study, all 432 normalized data points were fit to equation 1 (Table 2, data set 2) and the resulting graph is shown in Figure 2.

Table 1. Individual studies included in dataset.

Field	Location	Cultivar*	Planting Date	NAWF=5 Date
		2000		
NEREC	Keiser, AR	SG 747	16 May	27 July
Wildy 89	Manila, AR	DP 425R	9 May	10 Aug.
Wildy 27	Manila, AR	BXN47	13 May	12 Aug.
		2001		
NEREC	Keiser, AR	SG 747	26 Apr.	30 July
Wildy 89	Manila, AR	Stv 4892 BR	30 Apr.	3 Aug.
Wildy 78	Manila, AR	Stv 4892 BR	8 May	11 Aug.
Stevens E Pond	Rohwer, AR	DP 451 B/RR	25 Apr.	20 July
Stevens Barrett	Rohwer, AR	Stv 4892 BR	29 Apr.	8 Aug.
		2002		
CBS	Mariana, AR	PM 1218	22 May	6 Aug.
Stevens Barrett	Rohwer, AR	PM 1218	20 Apr.	26 July
Stevens E Weaver	Rohwer, AR	PM 1218	29 Apr.	27 July
		2003		
Peel	Monette, AR	DP 451 B/RR	30 May	15 Aug.
NEREC	Keiser, AR	SG 105	16 May	17 July
CBS	Mariana, AR	PM 1218	10 May	1 Aug.
NRS	St. Joseph, LA	Stv 5599 BR	22 Apr.	20 July
Stevens S Wayne	Rohwer, AR	Stv 5599 BR	1 May	26 July
Stevens Barrett	Rohwer, AR	DP 451 B/RR	29 Apr.	24 July
		2004		
CBS	Mariana, AR	PM 1218	8 May	11 July
Stevens Ross Bean	Rohwer, AR	Stv 5599 BR	20 Apr.	20 July
Stevens Barrett	Rohwer, AR	Stv 5599 BR	19 Apr.	24 July
		2005		
Peel	Monette, AR	Stv 5242 BR	5 May	31 July
Stevens Grant	Rohwer, AR	Stv 5599 BR	26 Apr.	31 July
Stevens Barrett	Rohwer, AR	Stv 5599 BR	25 Apr.	26 July
Jack	Tchula, MS	Stv 5599 BR	7 May	20 July
Judd Hill	Trumann, AR	Stv 5242 BR	4 May	22 July
NRS	St. Joseph, LA	DP 555 B/RR	29 Apr.	28 July

* Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

Table 2. Results from regression analyses.

Data set	a*	b	c	R^2
1. All 432 points, unchanged	-0.000092	0.214	926	0.040
2. All 432 points, normalized**	-0.000121	0.167	963	0.075
3. Normalized data set - 10 outliers***	-0.000080	0.125	970	0.068

* Data fit using quadratic function: $LY = a(DD60\_5)^2 + b(DD60\_5) + c$; where LY is lint yield (lb/acre, assuming a 35% gin turnout); DD60_5 is growing degree days, 60° F base, after NAWF=5; and a, b, and c are regression coefficients.
** All yield data in a study multiplied by a constant value so that the mean lint yield for the individual study was 1,000 lb/acre.
*** Outliers removed and calculations repeated until -3 < all standardized residual < 3.

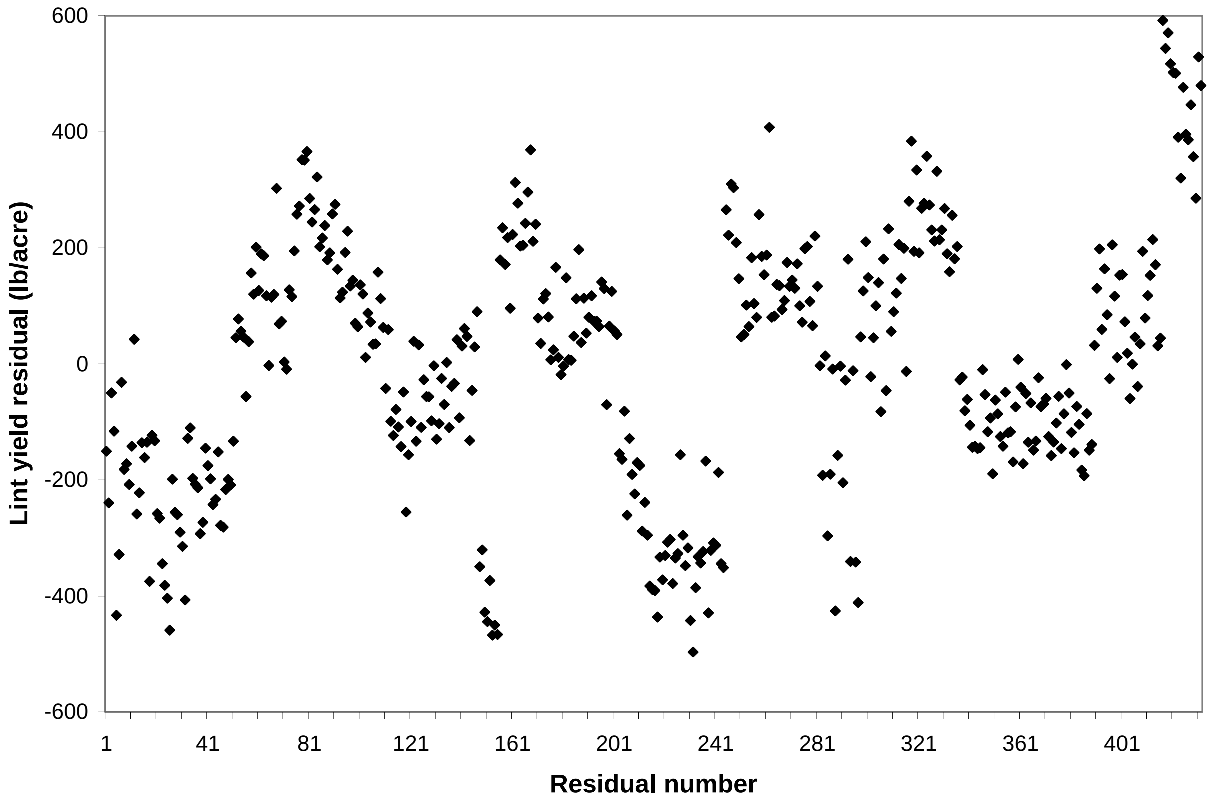

Figure 1. Lint yield residuals showing serial correlation from quadratic fit of lint yield versus growing degree days, 60° F base, after NAWF=5 for combined data from 26 Mid-South studies during the 2000 through 2005 growing seasons.

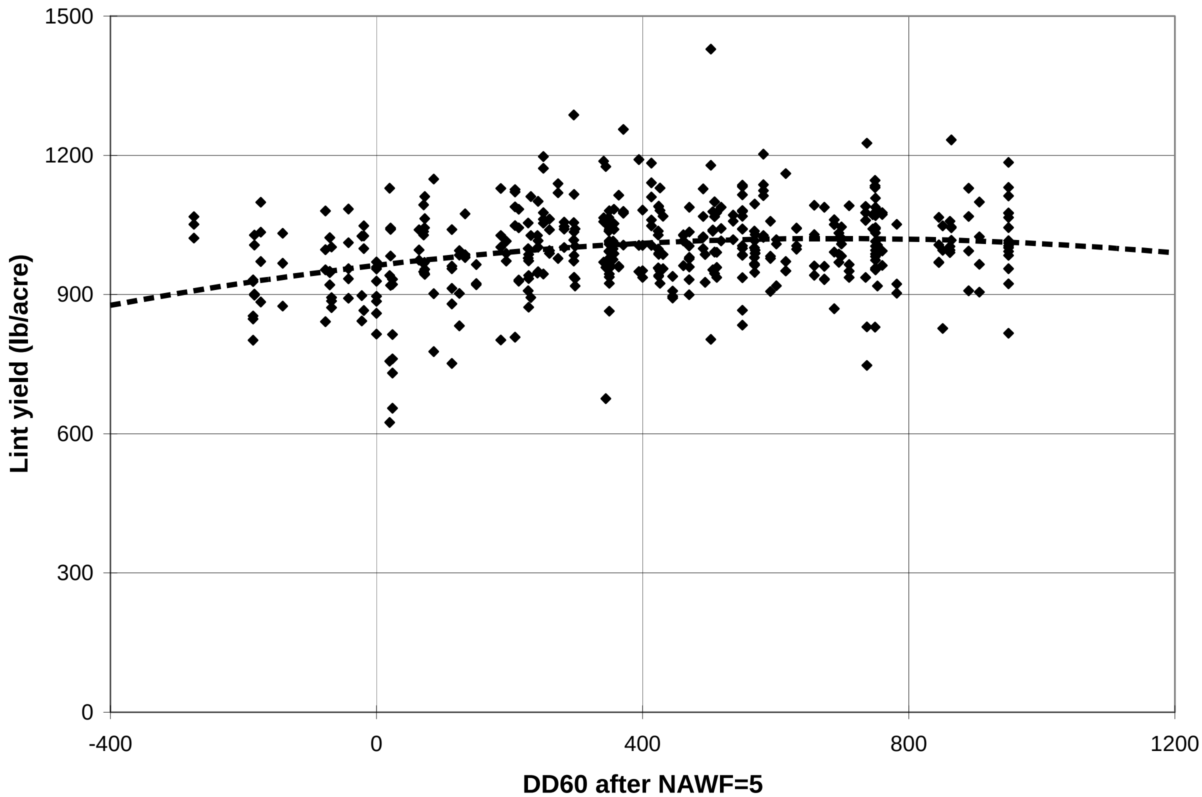

Figure 2. Lint yield versus growing degree days, 60° F base, after NAWF=5 for combined data from 26 Mid-South studies during the 2000 through 2005 growing seasons, normalized so that the mean lint yield for each individual study was 1000 lb/acre.

Residual analysis was used to determine whether one or more outliers excessively influenced the resulting equation. Data points were removed corresponding to -3 > standardized residual or standardized residual > 3 and the normalization and regression operations were repeated. The process was repeated until ten data points were removed and -3 < standardized residual < 3 for all remaining data (Table 2, data set 3). Removing the ten points did not appear to have very much effect on the resulting equation and did not improve the fit; therefore, the points were not removed from the data set.

The resulting equation (Table 2, data set 2) had a maximum yield of 1021 lb lint/acre at 692 DD60 after NAWF=5. At NAWF=5, generally associated with physiological cutout (Bourland et al., 1992), the yield was 963 lb lint/acre, 58 lb lint/acre below the maximum. However, additional work will be required to ensure that this equation best fits the data before a recommendation for irrigation termination can be added to COTMAN. Other functions, besides the quadratic (equation 1), must be tested. In addition, the possibility of a difference in the northern and southern portions of the Mid-South, with differences in the lengths of growing seasons, must be investigated. Finally, any possible effects on fiber quality, particularly micronaire, and any affects on crop maturity must be addressed.

Conclusions

Data sets from 26 Mid-South cotton irrigation termination studies during the 2000 through 2005 growing seasons, a total of 432 data points, were fit to a quadratic equation. However, the residual yield values were correlated due to the fact that different studies had quite different yields. To avoid the serial correlation, data from each study were normalized such that the average lint yield for the study was adjusted to 1,000 lb/acre and again fit to a quadratic equation. The resulting equation had a maximum yield of 1021 lb lint/acre at 692 DD60 after NAWF=5. At NAWF=5, generally associated with physiological cutout, yield was 963 lb lint/acre, 58 lb lint/acre below the maximum. Additional work will be necessary before a recommendation for irrigation termination can be added to COTMAN, including investigating: functions other than the quadratic; the possibility of a difference in the northern and southern portions of the Mid-South; and any possible effects on fiber quality, particularly micronaire, and crop maturity.

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