METHODS FOR ASSESSING THE IMPACT OF IRRIGATION ON COTTON CROP DEVELOPMENT AND BOLL SHED

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Introduction

Entomologists and crop advisors routinely make recommendations for insecticide applications in early season to protect squares from tarnished plant bugs, bollworms and boll weevils only to see those fruiting forms shed as bolls following physiological stress. In the Mid-South this physiological boll shed often is due to poorly timed irrigation. When the boll shed occurs, it is reasonable to question whether control inputs have been excessive for that system. Cotton specialists in Israel share this experience and have concluded that i*rrigation scheduling and control of pests that damage squares and bolls cannot be optimized independently* (Ungar, Kletter, & Genizi, 1992). We agree.

Better methods are needed to measure the equilibrium between square shedding and plant growth. We have initiated research focused on 1) practical sampling methods that will allow crop managers to anticipate and detect emerging crop stress and 2) decision-aids that allow them to use field data to manage the crop to maintain the appropriate balance between retention and growth.

Our work is a continuation of crop monitoring research using the cotton information management system, COTMAN (Danforth & O'Leary 1998). Data collection in pre-flowering cotton in COTMAN allows calculation of a plant based economic injury level (Mi et al 1997). These data also may be used to provide timely information on crop stresses including aggregate information on the balance between square retention and plant growth. We will refer to this as the Aggregate change in Retention-Growth Balance (ARGB). It represents the change in the number of square sheds for every new fruiting node added between two COTMAN sampling dates. The formula used to calculate the ARGB is the following:

$$ARGB = \frac{X2 * Y2 - X1 * Y1}{X2 - X1}$$

Where: X2 is actual squaring node number on sampling date two; Y2 is actual square shed rate on date two; X1 is actual squaring node number on date one; and Y1 is actual square shed rate on date one.

The ARGB is a seemingly simple variable with a lot of complexities. High values for the ARGB might indicate high shed increase or slow nodal development or a combination of both. Low values for the ARGB might indicate low shed increase or high nodal development or a combination of both.

This report summarizes one season of research using the ARGB calculated in COTMAN as a basis for decision making to time irrigation initiation. To date we have only evaluated ARGB under limited sets of conditions, so we are not yet making irrigation or insect management recommendations. Rather we will discuss methods.

Materials and Methods

The irrigation trial was conducted in cotton 'SureGrow 125' planted 6 May 1998 in a Calloway silt loam soil at the U of A Cotton Branch Experiment Station in Marianna, AR. The 0.14 acre plots were 4 rows (38 inch centers) wide and bordered by 4 non-irrigated rows. The 5 irrigation treatments were arranged in a randomized complete design with three replications. Furrow irrigation was initiated based on 1) the Irrigation Scheduler Program (estimated soil water deficit 2" - University of Arkansas Cooperative Extension Service recommendation), 2) COTMAN – ARGB <0.3), 3) Early Irrigation initiation based on Dr. Vories' visual observation and experience 4) Late irrigation (after layby), 5) Dryland.

Plants were monitored weekly from early squaring until cutout using COTMAN. Square and boll retention in first position after first flower was monitored using an experimental ScoutMap version of COTMAN. All end of season management decisions – crop protection and defoliation - were based on the condition of the latest plots (e.g. insecticides were still applied in plots that were well past spray termination dates). Our season-long insect control program kept insect induced square and boll shed at extremely low levels.

Results

Rainfall levels in the Marianna area in July and July were below normal in 1998, providing excellent conditions for the irrigation initiation comparison. For May, June, July and August, rainfall amounts recorded at the Cotton Branch Station were 1.4, 1.6, 2.6, and 1.7 inches, respectively. No

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:534-536 (1999)
National Cotton Council, Memphis TN

rainfall was recorded between 16 June and 11 July. Visible signs of water stress were apparent in non-irrigated plots during this period.

The first irrigation was applied 23 June with Treatments 2 and 3 receiving water (Table 1). For Treatment 2, COTMAN ARGB values less than 0.3 cued initiation of irrigation; these values on 23 and 30 June were 0.0445 and 0.16895, respectively. The Irrigation Scheduler program did not call for irrigation until 30 June. Irrigation in Treatment 3 was skipped on 30 June. On 8 July all treatment plots except dryland received water.

Slower and reduced nodal development resulting from water stress was tracked using the COTMAN Target Development Curve (Figure 1). Changes in nodal development in response to irrigation were conspicuous with each treatment where irrigation was delayed or skipped (Figure 2). The first separation of the growth curves occurred immediately after the 1st irrigation with the slope of curves for Treatments 2 and 3 showing little change compared to the obvious decline in slope of curves for Treatments 1, 3, 4 and 5. Growth curves separated again in the next week when Treatments 1and 2 received water. The 3rd sample period occurred during the 1st week of flowering, and the typical decline in squaring nodes was apparent for all curves at that point as boll filling began. By the 4th sampling date, growth curves indicated that Treatments 1, 4 and 5 had reached physiological cutout (NAWF $\leq$ 5). In the week of 12 July all treatments showed an increase in nodal accumulation following a ca. 2 inch rain. Plant monitoring was suspended in treatments 4 and 5 after that date because of low numbers of plants with 1st position white flowers (plants with white flowers selected for sampling under such conditions likely are unrepresentative of the dominant plant population). The growth curve for Treatment 1 indicated that terminal growth for those plants increased; NAWF values once again were above 5 after the mid-July rain.

This reinitiating of terminal growth may be related to the extremely high levels (> 70%) of small boll shed noted in the first 2 weeks of flowering in this treatment (Figure 4). Physiological shed of < 10 day old bolls was highest for Treatment 1. Lowest physiological shed was observed in Treatment 2 where irrigation was initiated using the COTMAN ARGB.

Yield data indicate significant crop response to irrigation (Table 2). Highest yields were observed in plots that received the earliest irrigation, Treatments 2 and 3. Lowest yields were observed in Treatments 4 and 5, the late and dryland treatments. No statistical differences in lint quality measures (strength, length and micronaire) were observed between treatments.

Discussion

The current Arkansas Cooperative Extension Service recommendations for irrigation scheduling in cotton suggest that irrigation should be applied any time the soil moisture status is low, regardless of the crop growth stage, until open bolls are observed. We believe that crop monitoring using the COTMAN system will help us improve this recommendation, but we also are working to create a system that allows integration of pest management decisions along with the irrigation decision.

It is reasonable to assume that big cotton plants with many fruiting forms will demand more water than small plants with few fruiting forms, especially as bolls develop. It also seems likely that if plant demands are not met, young bolls will be shed and/or final boll size will be reduced. This leads to a major insect management dilemma because the assumption is that excessive control may be as improper as poor insect control. The methodology outlined in this paper shows promise as a tool for making integrated decisions, but we will make no recommendations based on one season of research. The irrigation timing work with COTMAN will be expanded to included investigations with insect interactions.

Acknowledgments

We thank Mr. Bob Turner and his staff at the Cotton Branch Experiment Station for their excellent assistance in conducting this experiment. We also thank Sha Mi and Steven Bradshaw for their COTMAN support. Funding from the U of A Division of Agriculture and Cotton Incorporated also is gratefully acknowledged.

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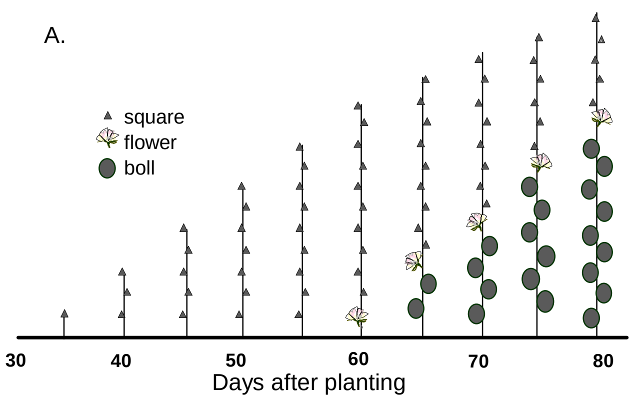
Table 1. Timing of irrigation for each of 5 treatments in 1998 irrigation trial.

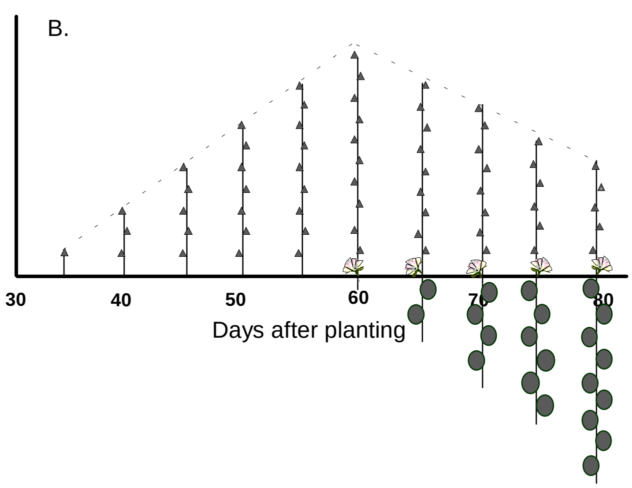
Treatment	23 Jun	30 Jun	8 Jul	21 Jul	28 Jul	5 Aug
1		x	x	x	x	x
2	x	x	x	x	x	x
3	x		x	x	x	x
4			x	x	x	x
5						

Table 2. Mean lint yield from each irrigation initiation treatment.

Irrigation Timing	Lint Yield (lb/acre)
1) 1st Flower	919 b
2) COTMAN RGB	1132 a
3) Early	1059 a
4) Late	757 c
5) Dryland	632 c

Yields followed by the same letter do not differ significantly (AOV, LSD_{05}).





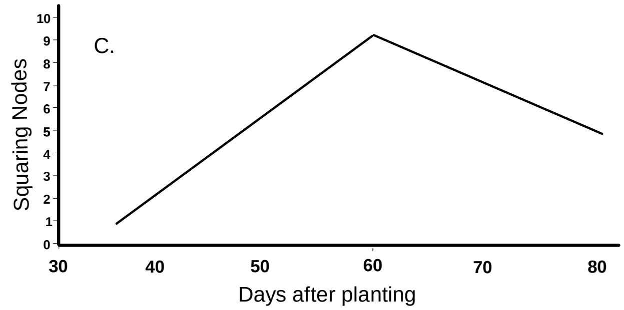


Figure 1. Main stem nodal development of cotton is simple to monitor by tracking the number of fruiting branches that have not yet flowered **(A)**. These are called squaring nodes. When squaring nodes are ploted against days **(B)** we see an abrupt downturn at first flower associated with good stress from boll loading. The resulting curve **(C)** is the basis of the Target Development Curve (TDC) used in COTMAN. In the TDC, squaring nodes are replaced with Nodes above First Square and Nodes above White Flower (NAFS/NAWF).

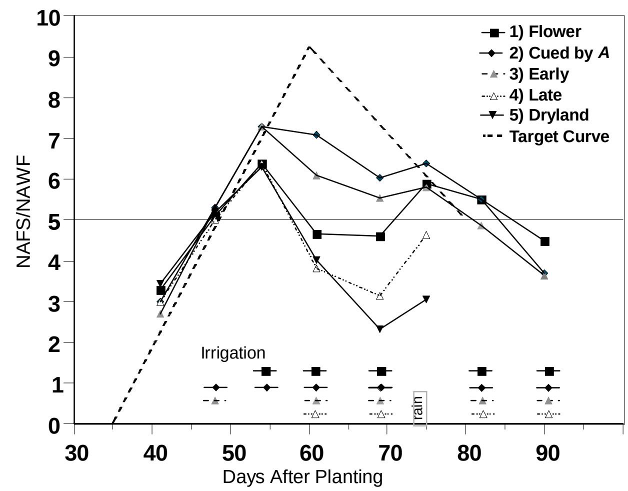


Figure 2. Growth curves for 5 irrigation treatments in 1998 irrigation initiation trial (irrigation timing for each treatment indicated by symbols at the bottom of graph).