Final Irrigation Timing 2013 in Northeast Arkansas Cotton

T.G. Teague 1 and M.L. Reba 2

RESEARCH PROBLEM

Uncertainty on irrigation termination timing based simply on plant maturity arises when managers lack confidence that their plants have access to adequate available soil moisture to complete maturity of the last effective bolls. Soil moisture sensors may provide the needed cue to give managers confidence in the decision to stop irrigating. In this 2013 on-farm study, we compared cotton yields with termination timing based on seasonal cutout compared to an extended irrigation. Soil moisture sensors were used to reference soil water availability in the furrow-irrigated field. We hypothesized that if maturity of the last effective bolls indicate that the crop has reached the irrigation termination threshold, and soil moisture sensors indicate adequate plant-available soil water, further irrigation would be unnecessary.

BACKGROUND INFORMATION

The perennial nature of the cotton plant (Gossypium hirsutum) often complicates end-of-season decision-making. The question of when to quit has been the focus of a longstanding research effort that includes work on termination timing of insect control and irrigation, and for defoliation (Oosterhuis and Bourland 2008, Vories et al., 2011). A key component for decision-making on termination timing is identification of the final population of bolls that effectively contribute to yield (Bourland et al., 1992). The date of cutout is the flowering date of that last economically significant boll population. Subsequent termination timing decisions are based on maturity of those bolls measured using accumulated heat units. Irrigation termination timing studies in the mid-South conducted over a 10-year period by Vories et al. (2011) suggests little to no benefit to applying furrow irrigation applications after the crop has accumulated 350 heat units following cutout. If a field reaches physiological cutout (average number of main stem sympodial nodes above white flower = 5 (NAWF = 5)) in late July or early August in Arkansas, then heat units are accumulated from the NAWF = 5 date. Otherwise, heat units are accumulated from a seasonal cutout date based on historical weather for that production region. The weather restricted, seasonal cutout date is the calendar

1Professor, Arkansas State University, University of Arkansas Agricultural Experiment Station, Jonesboro.
2Research Hydrologist, USDA-ARS-Watershed Physical Processes Research Unit, Jonesboro, ARUSDA-ARS.
date on which there is a 50% probability that the crop will have the benefit of late season temperatures sufficient to develop a mature boll. Seasonal cutout dates range across the state from 8 August in northernmost parts of Arkansas (Clay County) to 21 August in the most southern portions of the state (Ashley County). Heat units, often referred to as Growing Degree Days, are calculated using the base temperature for cotton, 60 °F, expressed as DD60s. Users calculate DD60s values by subtracting 60 from the mean daily temperature, an average of daily maximum and minimum air temperatures. Typically a boll needs 850 DD60s to mature with acceptable size and quality.

Efficient timing of irrigation termination in cotton can result in early and high yields along with reduced late season irrigation water use. Benefits to timely irrigation termination include reduced pumping costs, typically more expensive in late season due to the increased depth to groundwater after a full crop year of irrigation. Producers who identify and avoid unproductive late season irrigation applications can reduce lush fall plant growth that exacerbates risks of boll rots, makes defoliation more complex and costly, and delays harvest. Rank plant growth also can increase control costs for insect pests attracted to late-season squares in still actively growing plant terminals. Subsequent high pest numbers typically trigger expensive insecticide sprays to protect upper canopy, immature fruiting forms that do not contribute to economic yield (Teague, 2011). With timely irrigation termination, producers can reduce these insect pest control risks (Monge et al., 2007). Thus, optimum irrigation termination practices are an important component to cultural control in an overall integrated pest management (IPM) system.

RESEARCH DESCRIPTION

The experiment was carried out in a commercial field on Wildy Family Farms, Manila, Ark. The latest possible cutout dates for this production area—that date with a 50% or 85% probability of attaining 850 DD60s from cutout—are August 11 and July 31, respectively (Oosterhuis and Bourland, 2008). There were two treatments: irrigation termination based on seasonal cutout timing and a final late season irrigation. The strip plots were 600 ft long, 18 rows wide, and there were 3 replications. The field had been continuously planted in cotton for more than 10 years. Raised beds were spaced at 38 inches, and the row grade was 0.1%. Cotton cultivar, Deltapine L1311B2R, was planted 9 May. On 21 June, at 43 days after planting (DAP), the producer cleared row middles for irrigation using a V-shaped plow. The first furrow irrigation using poly-pipe was applied 48 DAP with subsequent irrigations applied 61, 69 and 104 DAP. For the experiment, irrigation was withheld in the termination treatment plots at 104 DAP (21 August). Irrigation timing and schedule of production activities in relation to crop cutout are listed in Table 1.

Soils in the field were classified as a Routon Dundee – Crevasse Complex. The heterogeneous soils range from fine sandy loam to smaller isolated areas of “sand blows” (coarse sands related to historic seismic events). Both soil moisture and plant monitoring sampling activities were stratified based on soil textures iden-
tified using soil electrical conductivity (EC) measurements. A Veris® 3150 Soil Surveyor (Veris Technologies, Inc., Salina, Kan.) was used to map soil textures in a 10-acre portion of the field where studies were located. Approximately 11% of the field was identified with extremely low soil EC values (< 5 mS/M determined at shallow depth), and these areas were categorized as sand blows. We categorized the remainder of the field broadly as sandy loam. Plant monitoring sample sites within each strip plot among soil textures were randomly selected for weekly sampling from squaring period through cutout using COTMAN™ sampling protocols (Oosterhuis and Bourland, 2008). Sampling for insect pests also was conducted in each site. Soil moisture measurements were made using Watermark sensors (Irrometer Company, Inc., Riverside, Calif.) with data recorded using AM 400 M.K. Hanson data loggers (M.K. Hanson Company, Wenatchee, Wash.). Watermark sensors were installed at the top of the bed between plants. A set of three soil moisture sensors were installed within 18 inches of each other with one sensor positioned at 16-inch depth and located between two 8-inch deep sensors. In early season, at the time of installation, we had not anticipated this irrigation termination trial, and therefore we installed watermarks only in the portions of the field receiving extended irrigation. Yield data were acquired with the yield monitor on the cooperating producer’s cotton picker. Data were post-calibrated, and lint yields determined from the center 6 rows of each strip. Crop monitoring and yield data were analyzed using analysis of variance (ANOVA) with mean separation using Fisher's protected least significant different (LSD).

RESULTS AND DISCUSSION

The 2013 production season in Northeast Arkansas was characterized by high rainfall early and in mid-season during the effective flowering period followed by late August dry period (Fig. 1). COTMAN growth curves show plant response to the favorable early-season conditions with the pace of sympodial development for plants growing in sandy loam soil comparable to the COTMAN standard Target Development Curve (TDC) through the first flowers, ~ 60 DAP. Plants growing in sand blows were delayed in relation to the TDC. The apogee of the TDC occurs at first flower with 9.25 mean no. squaring nodes (NAWF = 9.25). In our samples from the week of first flowers, plants in coarse sand and sandy loam had a mean of 6.8 and 9.0 main stem sympodia, respectively, indicating a likely difference in yield potential for plants in these two soil texture classes. First position square shed levels at first flowers were 20% and 38% for sand blows and sandy loam, respectively. These are relatively high levels of injury resulting from feeding damage from pre-flower infestations of tarnished plant bug adults.

Plant maturity delays for the 2013 crop were documented using NAWF monitoring. Plants in all treatments reached physiological cutout (mean NAWF = 5) on 94 DAP, two days after the latest possible cutout date using an 50% probability of attaining 850 DD60s and 11 days after the latest possible cutout date for 85% probability of attaining 850 DD60s. Plant maturity delays in 2013 likely were related to reduced fruit retention associated with pre-flower feeding injury by
tarnished plant bugs as well as cloudy, rainy weather that occurred during weeks 2 through 4 of the effective flowering period. The final irrigation on 21 August occurred 366 DD60s after seasonal cutout (85% probability).

Soil moisture measurement results indicate great variability in the wetting pattern among the two soil textures (Fig. 2). Following rain events, there was accelerated dry-down observed in the coarse sand compared to the sandy loam. It also appeared that capillary rise (upward movement of water) and lateral movement from the furrow into the bed was less consistent with the sandy loam following furrow irrigation compared to the coarse sand. For the first and final irrigations, the sensors in the sandy loam at 8 or 16 inches did not detect the irrigation events. Poor infiltration has been previously observed in soils of this region and is likely due to surface seals and crusting that can reduce infiltration. Soil moisture sensors indicated that there was sufficient moisture at the timing of the final irrigation with soil water potential values at both 8 and 16 inches in sandy loam and sand blow soil ranged ˃-10 kPa and ˃-50 kPa, respectively. Currently there are no established irrigation triggers recommended in Arkansas; however, recommendations from other mid-South and SE states suggest irrigation when soil moisture readings in the rooting zone range between -30 to -60 kPa (Lieb and Fisher, 2012) depending on soil texture.

Rainy fall weather delayed harvest until 25 October (169 DAP). We observed no yield penalty from the early irrigation termination timing compared to the additional late August application with mean yields of 1047 and 1036 for the early and extended irrigation treatments, respectively ($P = 0.60$). In hand-harvested 10-ft plots associated with watermark sensors, mean yield of cotton with the extended irrigation was 1036 compared to 717 lb lint/ac for plants in sandy loam compared to sand blow soils ($P < 0.01$).

**PRACTICAL APPLICATION**

Research results reported by Vories et al. (2011) suggest evaluating the crop for timing the final irrigation at 350 after cutout. We had similar findings in 2013. Extending the irrigation season with an additional irrigation on 21 August at seasonal cutout + 366 DD60s had no effect on yield. Based on Watermark sensors, soil moisture appeared sufficient at the crop stage appropriate for termination. Soil moisture dropped below those values prior to harvest. It is unknown if additional irrigations would have impacted yield, although in previous research with multiple extended end-dates for final irrigation at the same production farm, this has not been shown (Vories et al., 2011).

Soil moisture sensors should inform irrigation managers on not only when to schedule irrigations but also the effectiveness of their irrigations. The Watermark sensors failed to detect irrigation events in sandy loam soils. These data suggest a lack of capillary rise in the raised beds. The apparent lack of plant-available water resulted due to reduced infiltration and greater runoff. Expanded research is needed in improving irrigation water availability to plants and also on placement of sensors to detect plant-available water. Efficient use of soil sensor information
ultimately should provide irrigation managers with greater confidence in using plant-based irrigation termination timing. Adoption of irrigation best management practices in irrigation will help conserve precious groundwater supplies and will benefit Arkansas’s cotton growers by reducing production costs without sacrificing yield.

ACKNOWLEDGMENTS

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LITERATURE CITED


Table 1. Dates and timing of phenological crop endpoints for furrow irrigation termination trial at Wildy Family Farms, Manila, Ark. 2013.

<table>
<thead>
<tr>
<th>End-of-season production activity</th>
<th>Heat Units (DD60s) from cutout</th>
<th>Days after planting</th>
<th>Seasonal-85%&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Seasonal-50%</th>
<th>NAWF=5&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final irrigation</td>
<td></td>
<td>21 August</td>
<td>104</td>
<td>366</td>
<td>175</td>
</tr>
<tr>
<td>Defoliant application</td>
<td></td>
<td>17 September</td>
<td>131</td>
<td>870</td>
<td>677</td>
</tr>
</tbody>
</table>

<sup>a</sup>The weather restricted, seasonal cutout date is the calendar date based on historical weather on which there is a 50% or 85% probability that the crop will have the benefit of late season temperatures sufficient to develop a mature boll.

<sup>b</sup>Physiological cutout (NAWF = 5) was not observed until after the latest possible cutout dates, 31 July and 11 August.

Fig. 1. COTMAN growth curves for plants in irrigated sandy loam soil and coarse sand (sand blow areas) in 2013 irrigation trial at Wildy Family Farms, Manila, Ark.; daily rainfall (inches) also is shown.
Fig. 2. Soil water potential measurements in two different soil textures, sandy loam and coarse sand (sand blow area) in 2013 irrigation trial at Wildy Family Farms, Manila, Ark.