Effects of Irrigation Timing and Rate on Cotton Boll Production

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Introduction

• We’ve been interested in timing of water deficit for decades, but most of the testing has been done in the past ten years.

• How does water deficit affect cotton growth?
  • Prior to first bloom
  • During the middle of flowering
  • Later in the season
• How does water deficit affect cotton growth?
  • Prior to first bloom
    • Short plants, big bolls
  • During the middle of flowering
    • Tall plants, small bolls, few bolls
  • Later in the season
    • Tall plants, range of boll size, poor fiber quality
Irrigation Unknowns

• Irrigation research on rate is easy; research on timing and rate gets messy
• Less irrigation applied at precise intervals may yield equal or more efficient boll production
• Rate*timing not well-characterized
Objectives

• Learn to maximize cotton boll production efficiency by testing the following:

• Discern and quantify the effects of 3 rates and 3 timings of irrigation on end-of-season boll distribution of FiberMax® 9680 B2RF cotton

• Test the interaction between irrigation timings and the effect they have on each other
Materials and Methods

Conducted in Halfway, Texas in 2011-2013
- Pullman clay loam
- Continuous cotton with conventional tillage
- Annual precipitation: 44 cm; 28 cm during season

3 irrigation periods based on growing degree days (GDD)

\[
Daily \ GDD_{15.5} = \frac{(T_{\text{max}} + T_{\text{min}})}{2} - 15.5
\]

- 1\textsuperscript{st} Period (P1): prior to flowering (<950 GDD)
- 2\textsuperscript{nd} Period (P2): early flowering (950-1350 GDD)
- 3\textsuperscript{rd} Period (P3): late flowering and fruit maturation (>1350 GDD)

Each irrigation period had three levels or rates of irrigation
- Low (L) 0 in/day
- Medium (M) 1/8 in/day
- High (H) ¼ in / day

Resulted in 27 different irrigation treatments
• Irrigation applied using variable rate LEPA at Texas A&M AgriLife Research Center, Halfway, Tex., 2011-2013.

• The position of letters in treatment names indicate the 1\textsuperscript{st}, 2\textsuperscript{nd}, and 3\textsuperscript{rd} irrigation periods with the letters representing the maximum irrigation capacity during those periods.

\begin{align*}
L &= 0 \text{ in d}^{-1} \\
M &= 1/8 \text{ in/day} \\
H &= \frac{1}{4} \text{ in / day}
\end{align*}
Growing Environments

- Hot, dry in 2011
  - Record breaking weather extremes in 2011
- Hot, dry in 2012 after soaking rain
  - High intensity in June, too late in September
- Near average seasonal rain in 2013
  - Below average rain for the year (17 in) but above average for growing season
  - Timely rains and moderate temps

<table>
<thead>
<tr>
<th>Time Period</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 1 to Emergence</td>
<td>1.5</td>
<td>1.6</td>
<td>2.5</td>
</tr>
<tr>
<td>Emergence to P1</td>
<td>0</td>
<td>5.4</td>
<td>1</td>
</tr>
<tr>
<td>P1 (&lt;525 GDD)</td>
<td>0</td>
<td>0.4</td>
<td>6</td>
</tr>
<tr>
<td>P2 (525-750 GDD)</td>
<td>0.8</td>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>P3 (&gt;750 GDD)</td>
<td>0.1</td>
<td>0.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Post P3 to Sept 30</td>
<td>0.9</td>
<td>3.6</td>
<td>1.6</td>
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<tr>
<td>Oct 1 to Dec 31</td>
<td>2.1</td>
<td>1.5</td>
<td>0.9</td>
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<tr>
<td><strong>Annual Total</strong></td>
<td>5.4</td>
<td>13.7</td>
<td>13.6</td>
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</table>
Plant Mapping Methods

• Prior to harvest, 1-m samples were mapped from each plot
  • Bolls were counted by mainstem node and sympodial position
  • Number of plants were recorded per sample
  • Bolls on vegetative branches were also counted

• Sampling locations had certain restraints
  • At least ten plants were required per square meter
  • Plants needed to be of same height as those in the same treatment
  • Samples had to be good representatives of treatment
Results - LLX

• As irrigation was increased late in season (P3), typically increased boll number at top of plant with low response in middle and bottom of plant.

• In 2013 (rainy) boll number was increased throughout plant.

• With low irrigation and low amount of rainfall, years 2011 and 2012 exhibited similar reactions, until high rate (6.4 mm d^{-1}) of irrigation during later period (>750 GDD).
Boll Distribution - LMX

- Medium irrigation rate (3.2 mm d\(^{-1}\)) during flowering resulted in greater number of bolls from nodes 10-15
- Low P3(>750 GDD) irrigation resulted in substantially decreased upper boll setting and retention
- Only a subtle difference in fruiting pattern when end of season irrigation rate was increased from medium (3.2 mm d\(^{-1}\)) to high (6.4 mm d\(^{-1}\))
Boll Distribution LH\textsubscript{X}

- Medium (3.2 mm d\textsuperscript{-1}) treatment had a subtle impact in the middle of the plant and low impact on top of the plant boll production.
- High (6.4 mm d\textsuperscript{-1}) treatment significantly helped late boll production at the top of the plant compared to the other treatments.
- Late season irrigation had little effect on boll production in 2013 when timely rain events occurred.
Middle Irrigation (525-750 GDD)
<table>
<thead>
<tr>
<th>Year</th>
<th>Irrigation</th>
<th>Micronaire</th>
<th>Length (mm)</th>
<th>Strength (g tex⁻¹)</th>
<th>Uniformity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>High</td>
<td>3.82 a†</td>
<td>26.2 a</td>
<td>28.6 a</td>
<td>78.7 a</td>
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<td></td>
<td>Med</td>
<td>3.72 a</td>
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<td>2012</td>
<td>High</td>
<td>4.10 a</td>
<td>26.9 a</td>
<td>30.1 a</td>
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<td></td>
<td>Med</td>
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<td>2013</td>
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<td>3.20 a</td>
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<td>31.5 a</td>
<td>80.8 ab</td>
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<tr>
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## Period 2 Fiber Quality

<table>
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<th>Micronaire</th>
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<th>Strength (g tex(^{-1}))</th>
<th>Uniformity (%)</th>
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<tr>
<td></td>
<td>Med</td>
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<tr>
<td>Year</td>
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<td>Micronaire</td>
<td>Length (mm)</td>
<td>Strength (g tex(^{-1}))</td>
<td>Uniformity (%)</td>
</tr>
<tr>
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<td></td>
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<td>3.11</td>
<td>24.9 c</td>
<td>28.8 c</td>
<td>79.6 c</td>
</tr>
</tbody>
</table>
- Nodes 12-15 interactions in all 3 years
  - 2011: Low irrigation early positively impacted boll retention at the top of the plant when combined with mid- and high levels of irrigation later in the season.
  - 2012: no advantage of low irrigation early; minor disadvantage in some treatments at the top of the plant – early-season rainfall followed by P1 deficit.
  - 2013: decreased boll retention at top of the plant among low P1 irrigation treatments
- Nodes 7-11 in 2012
  - P2 irrigation: major effect on boll retention in the middle of the plant
    - Low P1 resulted in retention penalty at mid- and high P2 rates
    - Low P1 resulted in retention advantage at low P2 rates
Conclusions

• Early season irrigation may be stored to for use later in the season to achieve good boll production and retention
  • Significant decrease in upper plant boll production when low irrigation treatments were administered during the middle irrigation period
    • LLH, MLH, HLH all had poor plant boll retention compared to LMH, MMH, HMH
  • Minimal decrease in upper plant boll production when low irrigation treatments were administered during the early irrigation period
    • LMH, LMM, LHH all had good boll retention compared to MMH, MMM, MHH

• Watering in excess of evapotranspiration early in the season does not seem to benefit cotton boll production later in the season
  • May be detrimental, especially in case of late season irrigation loss or decline
Conclusions

• How does water deficit affect cotton growth?
  • Prior to first bloom
    • Short plants, big bolls
    • Relatively small yield impact
  • During the middle of flowering
    • Tall plants, small bolls, few bolls
    • Big yield impact
    • Fiber quality impact if severe
  • Later in the season
    • Tall plants, range of boll size, poor fiber quality
    • Yield impact
    • Fiber quality impact even with moderate irrigation