Effects of Heat Stress on Cotton Production in the Low Deserts of Arizona

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The University of Arizona
2020 Fall Virtual Field Day

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Rayner Field Day — University Variety Trial

• Virtual
  • Some time in November
  • Perhaps right after Thanksgiving
Arizona Cotton Production

- Characterized by hot, dry climate
  - High yield potential
  - Relatively low disease pressure

- Seed production
  - Observed effects on fruiting patterns on new un-tested varieties
  - Observed correlations to L2 heat stress events
Heat Stress in Cotton

- Brown and Zeiher (1998) - Documented other floral abnormalities
  - Smaller flowers
  - Asynchronous development of male and female structures
  - Failure of anthers to release pollen (indehiscence)
  - Presence of elongated stigmas and shortened anthers/filaments
Cotton Heat Stress

• Well characterized by Crop Canopy Temperature (CCT)

• Crop Canopy Temperature (CCT)
  • L1 heat stress: 82.4°F – 86°F
  • L2 heat stress: greater than 86°F
  • CCT calculated based upon AT, RH, VPD
  • Correlation between calculated and measured
  • https://cals.arizona.edu/azmet/cot-HSrpt.htm
Objectives

• Establish protocol for in-field measurements to determine a specific cultivars’ ability to tolerate heat stress
  • Correlation of observations to meaningful outcomes
    • Seed set/production
    • Fruit retention
    • Yield
2019-2020 Heat Stress Evaluation Protocol

- Maricopa Ag Center - 2020
  - Flower and Fruit
    - Pollen dehiscence
    - Flower morphology
    - Abortion/Cavitation – plant mapping
    - Incidence of abnormal bolls
    - Flower tagging – follow through to boll development (percent retained and symmetry)
  - Seed and yield
    - Seed count – seed per boll
    - Seed index – grams per 100 seed
    - Lint Yield
- Evaluate commercial controls (DP1044B2RF and DP1549B2XF)
- 39 Entries – same entries as UCAST at Maricopa
CCT Maricopa – 2018/2019/2020

HEAT STRESS 2018/2019 (Maricopa Ag Center)

Canopy Temperature (°F)

LEVEL 1 (82.4)
LEVEL 2 (86)
2018
2019

CCT Maricopa – 2018/2019/2020

HEAT STRESS 2018/2019/2020 (Maricopa Ag Center)

Canopy Temperature (°F)

LEVEL 1 (82.4)
LEVEL 2 (86)
2018
2019
2020

CCT Maricopa – 2020

2020 CROP CANOPY TEMPERATURE
Maricopa Ag Center

Crop Canopy Temperature (°F)

Heat Stress – Maricopa 2019

Maricopa Ag Center - 2019

1st Square 1st Bloom Peak Bloom Cut-out

Air Temperature (°F)

Heat Units Accumulated After Planting (86/55°F)
Heat Stress – Maricopa 2020

Maricopa Ag Center - 2020

Air Temperature (°F)

Heat Units Accumulated After Planting (86/55 °F)

1st Square 1st Bloom Peak Bloom Cut-out


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Flower Morphology

- Flowers given a rating of 1-5
- Dependent upon separation of female and male floral components

2 3 5
Pollen Dehiscence

- Flower given a rating of 0-4
- Dependent on level of pollen dehiscence

0 3 4
Fruit Data Summary

- Flower Morphology
- Pollen Dehiscence

- Flowers Retained
- Asymmetry

2019 data still yet to come for 2020
## Final Plant Map

### Percent Retention

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev</th>
<th>Maximum</th>
<th>Minimum</th>
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</thead>
<tbody>
<tr>
<td>Percent</td>
<td>47.1</td>
<td>10.8</td>
<td>23.5</td>
<td>65.8</td>
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</tbody>
</table>

### Height to Node Ratio

<table>
<thead>
<tr>
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<th>Mean</th>
<th>Std Dev</th>
<th>Maximum</th>
<th>Minimum</th>
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<tr>
<td>Ratio</td>
<td>1.4</td>
<td>0.2</td>
<td>2.0</td>
<td>1.1</td>
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### Mainstem Nodes

<table>
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<tr>
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<th>Std Dev</th>
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<th>Minimum</th>
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<tr>
<td>Nodes</td>
<td>26.8</td>
<td>1.7</td>
<td>22.8</td>
<td>30.4</td>
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### Percent Asymmetrical Bolls

<table>
<thead>
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<th>Mean</th>
<th>Std Dev</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolls</td>
<td>29.3</td>
<td>15.6</td>
<td>67.6</td>
<td>2.9</td>
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# Seed and Yield Data

<table>
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<tr>
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<th>Mean</th>
<th>Std Dev</th>
<th>Maximum</th>
<th>Minimum</th>
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</thead>
<tbody>
<tr>
<td>Percent Lint</td>
<td>0.42</td>
<td>0.02</td>
<td>0.46</td>
<td>0.36</td>
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<tr>
<td>Seed Index (g/100 seed)</td>
<td>9.6</td>
<td>0.9</td>
<td>11.5</td>
<td>8.0</td>
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<tr>
<td>Seed weight per boll (g)</td>
<td>2.1</td>
<td>0.3</td>
<td>2.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Number of seed per boll</td>
<td>21.6</td>
<td>2.8</td>
<td>26.3</td>
<td>15.9</td>
</tr>
<tr>
<td>Seedcotton Yield (lb/acre)</td>
<td>3668.3</td>
<td>604.5</td>
<td>4865.9</td>
<td>2321.6</td>
</tr>
</tbody>
</table>
Flower Morphology – 26 Aug

26 August

Pearson’s $r = -0.4015$
Pollen Dehiscence – 31 Jul

Pearson’s $r = 0.5206$

![Graph showing Pollen Dehiscence](image URL)
Asymmetrical Bolls

Pearson’s $r = -0.2527$
Conclusions – 2019

- Variability among varieties with respect to:
  - Flower morphology
  - Pollen dehiscence
  - Seed attributes
  - Final Plant Map
  - Yield

- Poor to moderate correlation among measured values to yield

- Many more factors controlling yield than just heat tolerance

- Relatively low heat stress year – no extended periods of L2 heat stress
  - Not a representative year for heat stress effects
Conclusions – 2020

• Variability among varieties with respect to:
  • Flower morphology
  • Pollen dehiscence
  • Seed attributes
  • Final Plant Map
  • Yield
Moving Forward...

- Need for additional years of evaluation
  - Capture variability in heat stress years
- Flower tagging
  - Follow an evaluated bloom to determine fate
- Funding and support
  - Participating seed companies:
    - Bayer
    - BASF
    - Corteva
    - Americot