Cotton Growth & Development in Southern Kansas & Northern Oklahoma (including the panhandle)

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NE Region Extension Specialist, Crops & Soils
Cotton Culture

- **Drought tolerant crop?**
  - heat tolerant
  - perfect complete flower
  - effective flowering period is rather short
  - excess flower production
  - flowers inside canopy
  - taproot system

- **Excellent rotation crop**
  - herbicide rotation
  - dicot
Kansas Cotton Gins

- Kansas Cotton Gins
  - 15”-20”
  - 20”-25”
  - 25”-30”
  - 30”-35”
  - 35”-40”
  - 40”-45”

- Southern Kansas Cotton Growers Coop, 1998
- OK-Kan Gin, 1999
- High Plains – High Tech Gin, 2004
- NW Kansas Cotton Growers, COOP, 2002
## Cotton in Kansas

<table>
<thead>
<tr>
<th>Year</th>
<th>Planted (acres (1,000))</th>
<th>Harvested (lb/a)</th>
<th>Yield</th>
<th>Production (bales (1,000))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>4.5</td>
<td>4.0</td>
<td>492</td>
<td>4.1</td>
</tr>
<tr>
<td>2000</td>
<td>40.0</td>
<td>37.0</td>
<td>288</td>
<td>22.2</td>
</tr>
<tr>
<td>2002</td>
<td>80.0</td>
<td>68.0</td>
<td>539</td>
<td>76.3</td>
</tr>
<tr>
<td>2006</td>
<td>115.0</td>
<td>110.0</td>
<td>511</td>
<td>117.0</td>
</tr>
<tr>
<td>2007</td>
<td>47.0</td>
<td>43.0</td>
<td>639</td>
<td>57.2</td>
</tr>
<tr>
<td>2011</td>
<td>80.0</td>
<td>65.0</td>
<td>510</td>
<td>69.0</td>
</tr>
<tr>
<td>2012</td>
<td>57.0</td>
<td>52.0</td>
<td>415</td>
<td>45.0</td>
</tr>
<tr>
<td>2015</td>
<td>15.0</td>
<td>16.0</td>
<td>1050</td>
<td>35.0</td>
</tr>
<tr>
<td>2016</td>
<td>32.0</td>
<td>31.0</td>
<td>852</td>
<td>55.0</td>
</tr>
<tr>
<td>2017</td>
<td>93.0</td>
<td>91.0</td>
<td>1051</td>
<td>185.0</td>
</tr>
<tr>
<td>2018</td>
<td>156.0</td>
<td>152.0</td>
<td>1177</td>
<td>335.0</td>
</tr>
<tr>
<td>2019†</td>
<td>175.0</td>
<td>153.0</td>
<td>910</td>
<td>290.0</td>
</tr>
</tbody>
</table>

† Predicted, January 10, 2020 *Crop Production Report* news release.
Planting Conditions for Rapid Germination and Emergence

- Minimum soil temperature 60-62 degrees
- Favorable 5 day forecast
  - minimum temperature 50 degrees
  - maximum temperature > 75 degrees
- Plant in a firm moist seedbed
- Proper and uniform seeding rate (30” rows)
  - 3-4 seeds per foot irrigated
  - 2.5-3.5 seeds per foot dryland/fallow
- Seed should have a Warm Germ test of 80+ and a Cool Germ test of 60+
Relationship Between Emergence and Yield

Wanjura
Early Season Root Development of the Cotton Plant

Source: Oosterhuis, 1990
## Phenological Development of Cotton

<table>
<thead>
<tr>
<th>Growth Stage</th>
<th>Days</th>
<th>Heat Units – DD60s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planting to Emergence</td>
<td>4 to 9</td>
<td>50 to 60</td>
</tr>
<tr>
<td>Emergence to First Square</td>
<td>27 to 38</td>
<td>425 to 475</td>
</tr>
<tr>
<td>Square to Flower</td>
<td>25 to 30</td>
<td>300 to 350</td>
</tr>
<tr>
<td>Planting to First Flower</td>
<td>60 to 70</td>
<td>775 to 850</td>
</tr>
</tbody>
</table>

Modified from Oosterhuis, 1992

\[
\text{Max Temp} + \frac{\text{Min Temp}}{2} - 60
\]
## Heat Units for Growth

<table>
<thead>
<tr>
<th>Event</th>
<th>Heat Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planting</td>
<td>10/day before planting</td>
</tr>
<tr>
<td>Emergence</td>
<td>75-100</td>
</tr>
<tr>
<td>Each new node/leaf</td>
<td>55</td>
</tr>
<tr>
<td>Match head Square</td>
<td>550</td>
</tr>
<tr>
<td>First Flower</td>
<td>1000</td>
</tr>
<tr>
<td>First Open Boll</td>
<td>1800</td>
</tr>
<tr>
<td>Flower – Open boll</td>
<td>≈ 650</td>
</tr>
<tr>
<td>One bale crop</td>
<td>1800</td>
</tr>
<tr>
<td>Two bale crop</td>
<td>2300 +</td>
</tr>
</tbody>
</table>
Developmental Stages of a Cotton Crop Overlap

- **Early Season**:
  - Seedling/Root Establishment
  - Leaf Area Expansion and Canopy Closure

- **Mid Season**:
  - Flowering and Boll Development
  - Boll and Fiber Maturation

- **Late Season**:

**Numbers/acre (X 1000)**

- 1000
- 800
- 600
- 400
- 200

**Days After Planting**

- May 1
- June 1
- July 1
- August 1
- September 1
- October 1
2018 Growing Season GDD60’s

Cumulative GDD 60's

- Viola
- Moscow

Soil Temperatures, Moscow, KS
2018 Growing Season GDD60’s
2019 Growing Season GDD60’s

Soil Temperatures, Moscow, KS

GDD 60's

Series 1

Series 2

Series 3

Moscow

St. John

Haysville

1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct

GDD 60's

0 500 1000 1500 2000 2500

Haysville • St. John • Moscow
How Fast is a Cotton Crop Set

- Assume 8 days to establish a stand
  - 7 nodes x 3 days per node + 8 days (emergence) = 29

- 29 Days to first square
  - at first visible square the plant has formed approximately 4 other squares (microscopically) in its terminal

- Assume May 20 as the planting date

- 23 percent of the fruiting potential has been set by June 18

- 55 percent of the fruiting potential has been set by July 13
WATER USE EFFICIENCY
COTTON

TOTAL BIOMASS
POUNDS PER ACRE

LINT YIELD
POUNDS PER ACRE

WATER SUPPLY (INCHES)

TOTAL BIOMASS
LINT WEIGHT

25-30 lbs/inch
40-50 lbs/inch
60-70 lbs/inch

Dryland

Kreig, et al., Texas Tech
Rate of Water Use As Related To Cotton Development

Water use, inches/day

Days after planting

Emergence

Squaring

First white bloom

Peak bloom

First open boll

Harvest

< 0.10 per day

0.10 to 0.25 per day

0.25 to 0.40 per day

Days after planting:

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
Ideal Cotton Plant

- Pre-square: $\text{AIL}^\dagger = 1"$; 8 nodes
- Square stage: $\text{AIL} = 1.5 - 1.75"$; 8-9 nodes above white flower and 15 total nodes; 90% square set
- Bloom period - 8 fruiting branches; boll set $\approx 60%$??
- Harvest - 15 nodes; 30” tall; $\text{AIL} = 2"$

$^\dagger$AIL=Average Internode Length
Use of Plant Growth Regulators – PGR’s

The length of the fourth internode from the terminal or the combined length of the top five internodes can be used to gauge vigor. Plants in which the third internode exceeds 3 to 4 inches or the top five internodes exceed 7 to 9 inches may be experiencing excessive vegetative growth and should be evaluated for using a growth inhibiting PGR.
## Growth & Development to Flowering

<table>
<thead>
<tr>
<th>Days Before Flower</th>
<th>Size of Bud</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>Microscopic</td>
<td>Square initiation can occur as early as 2\textsuperscript{nd} true leaf expansion. Hot weather induces 4-bract squares, cool weather delays square initiation.</td>
</tr>
<tr>
<td>32</td>
<td>Microscopic</td>
<td>Lock numbers determined. Carbohydrate stress decreases number from 5 to 4.</td>
</tr>
<tr>
<td>23</td>
<td>2 mm PHS\dagger</td>
<td>Ovule number determined. Carbohydrate stress decreases potential seed number.</td>
</tr>
<tr>
<td>22</td>
<td>2 mm PHS</td>
<td>Pollen cells divide.</td>
</tr>
<tr>
<td>19</td>
<td>3 mm MHS\ddagger</td>
<td>Pollen viability reduced by high nighttime temperatures.</td>
</tr>
<tr>
<td>5</td>
<td>13 mm</td>
<td>Squares start expanding rapidly</td>
</tr>
<tr>
<td>3</td>
<td>17 mm</td>
<td>Fibers begin to form</td>
</tr>
<tr>
<td>0</td>
<td>Flower opens</td>
<td>Pollen sheds and fibers start to elongate. Extremes of humidity or water disrupts pollen function.</td>
</tr>
<tr>
<td>+1</td>
<td>Flower</td>
<td>Fertilized ovules are now referred to as seeds.</td>
</tr>
</tbody>
</table>

Modified from Stewart, 1986
Bracts
Tending leaf for 1st square

Tending leaf for 3rd square

2nd square

Tending leaf for 2nd square

3rd square

1st square
## Fiber Development Timeline

<table>
<thead>
<tr>
<th>Pre-bloom</th>
<th>Bloom</th>
<th>Post Bloom</th>
</tr>
</thead>
<tbody>
<tr>
<td>20d</td>
<td>0</td>
<td>10d 20d 30d 40d 50d</td>
</tr>
<tr>
<td>10d</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Pre-bloom
- **4th to 5th leaf**
- **Locks/boll**
- **Pinhead Square**
- **# Ovules set**

### Bloom
- Matchhead Square
- Pollen viability determined
- Fibers begin to form
- Bloom opens
- Ovule fertilized, now a seed

### Post Bloom
- Fiber lengthens for 15-16 days
- Micronaire develops from 16-18d after bloom until 40-45d post bloom
- Each day one layer is laid down on inside of fiber tube

### PHS
- 7 d
- 14 d
- 21 d

### Age of Bolls in Days
- Bolls reach full size in about 24 days but require another 24 to 40 days to mature.
Fibers Originate from the Seed

Fibers at Anthesis

Fibers at 1 day after anthesis

C Bendnarz
## Fiber Development Timeline

### Pre-bloom
- 20d
  - 4<sup>th</sup> to 5<sup>th</sup> leaf
  - Locks/boll
  - Pinhead
  - Square
  - # Ovules set

### Bloom
- 0
  - Matchhead
  - Square
  - Pollen viability determined
  - Fibers begin to form
  - Bloom opens
  - Ovule fertilized, now a seed

### Post Bloom
- 10d
- 20d
- 30d
- 40d
- 50d
  - Fiber lengthens for 15-16 days
  - Micronaire develops from 16-18d after bloom until 40-45d post bloom
  - Each day one layer is laid down on inside of fiber tube

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- PHS 7 d
- 14 d
- 21 d

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- Age of Bolts in Days
  - Bolts reach full size in about 24 days but require another 24 to 40 days to mature.
  - 4
  - 8
  - 12
  - 19
  - 24
Nodes Above White Flower - NAWF

- Growth of the mainstem terminal relative to the progression of flowering toward the terminal
- Number of fully developed nodes above the highest 1st fruiting branch with a white flower
- At 1st flower (beginning bloom) KS cotton normally has 8-10 NAWF
- NAWF decreases as boll load increases or stress increases – boll load is faster than vegetative growth of the mainstem terminal
NAWF

Number of fully developed nodes above the highest 1\textsuperscript{st} fruiting branch with a white flower.
Nodes Above White Flower

NAWF

NAWF5 = Cutout

Potential last boll that will ripen before killing frost

\[ \approx 650-850 \quad \text{GDD}_{60} \]
Flower Value and Boll Retention vs. Nodes Above White Flower (NAWF)

Note: Flower value = flowers required to produce a pound of seed cotton (Bourland, 1992)
Early boll matures ≈ 45 days after bloom
A new node develops ≈ every 3 days
Number of nodes to mature a boll is 15
(45 days/3 days/node = 15 nodes)
100% growth/node = 100%/15=6.67%
1st position boll 2 nodes up is 13% less mature!

How is this useful?

Fields can be **safely defoliated** when the **topmost**
1st position harvestable boll is only 4 nodes above
the 1st position cracked boll.

<table>
<thead>
<tr>
<th># Nodes</th>
<th>Weight loss if defoliated prematurely for a 1st position boll above cracked node</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.0 %</td>
</tr>
<tr>
<td>3</td>
<td>1.3 %</td>
</tr>
<tr>
<td>4</td>
<td>8.0 %</td>
</tr>
<tr>
<td>5</td>
<td>14.6 %</td>
</tr>
<tr>
<td>6</td>
<td>21.3 %</td>
</tr>
<tr>
<td>7</td>
<td>28.0 %</td>
</tr>
<tr>
<td>8</td>
<td>34.7 %</td>
</tr>
</tbody>
</table>