COTTON: FROM FIELD TO FABRIC AND MORE

Gaylon Morgan
Extension Cotton Agronomist
Texas AgriLife Extension Service
979-845-2425; gmorgan@ag.tamu.edu
What do you want to get from this workshop?

Do not let me forget the cotton gin demonstration this afternoon
Acknowledgements

Cotton Incorporated
Fiber and Biopolymer Inst.
Texas Farm Bureau
Cotton

A bale of cotton weighs around 480 pounds.
Types of Cotton

- Upland (Gossypium *hirsutum*)
  - TX eastward
- Acala
  - 7.5 -15 million acres

- Pima (G. *barbadense*)
  - CA, AR, TX)
  - 200 thousand acres

- Egyptian cotton
Cotton Acreage and Production History

1920s
- 44 million acres
- 300 hr/bale

2007
- 14 million acres
- 3 hr/bale

2010 - estimated at 18.3 million bales
Texas = 5.7 million acres
Georgia = 1.2 million acres
North Carolina = 570 thousand acres
Yield evolution (average world)

Yield = 9.11 Year - 17,560
$R^2 = 0.95$

Source: ICAC
Eric F. Hequet – Fiber and Biopolymer Research Institute
Production evolution (world)

Production = 308.8 Year – 595,792
R² = 0.92

Source: ICAC
Eric F. Hequet – Fiber and Biopolymer Research Institute
Cotton production

Millions of 480-lb. bales

Crop year

- China
- USA
- India

U.S. All Cotton Acres

Million Acres

- Red: Planted
- Green: Harvested


10.9

U.S. All Cotton Yield

Pounds/Acre


USDA NASS
5-11-10
Texas in % of US production

Texas is the largest cotton producer in the nation.
TEXAS COTTON PRODUCTION - 1850

46,076 BALES

BALES/COUNTY:
- < 100
- 100 - 5,000

NUMBERS WITHIN COUNTIES = THOUSANDS

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TEXAS COTTON PRODUCTION - 1880

805,284 BALES FROM 2,178,435 ACRES

BALES/COUNTY:
- < 100
- 100 - 5,000
- 5,001 - 25,000
TEXAS COTTON PRODUCTION - 1899

2,584,810 BALES FROM 6,960,867 ACRES

BALES/COUNTY:
- < 100
- 100 - 5,000
- 5,001 - 25,000
- 25,001 - 50,000
- 50,001 - 100,000

© T. Isakeit
TEXAS COTTON PRODUCTION - 1920

2,971,757 BALES FROM 11,522,537 ACRES

BALES/COUNTY:
- < 100
- 100 - 5,000
- 5,001 - 25,000
- 25,001 - 50,000
- 50,001 - 100,000

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TEXAS COTTON PRODUCTION - 1939

2,723,842 BALES FROM 8,104,577 ACRES

BALES/COUNTY:
- < 100
- 100 - 5,000
- 5,001 - 25,000
- 25,001 - 50,000
- 50,001 - 100,000

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TEXAS COTTON PRODUCTION - 1960

4,346,000 BALEs FROM 6,325,000 ACRES

BALES/COUNTY:
- < 5,000
- 5,001 - 25,000
- 25,001 - 50,000
- 50,001 - 100,000
- > 100,001

© T. Isakeit
TEXAS COTTON PRODUCTION - 2007

8,250,000 BALES FROM 4,700,000 ACRES

BALES/COUNTY:
- < 5,000
- 5,001 - 25,000
- 25,001 - 50,000
- 50,001 - 100,000
- > 100,001

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Cotton Growth and Development
Cotton is a perennial tree - that thinks it will live for Years.

Priorities:
1. Survival
2. Seed production
3. Lint production
ABOUT 90 DAYS -- SQUARES, BLOOMS AND BOLLS
Impact of Cotton Growth on Management

- Perennial growth
  - slow shoot development
    - weed competition
  - indeterminate growth
    - plant growth regulators

- Long fruiting period
  - stress avoidance
  - insect management
  - fiber quality
Fruiting Timeline

Leaves and branches 3/8 alternate phyllotaxy

Ritchie, Bednarz, et al. 2007
# Heat Units for Growth

<table>
<thead>
<tr>
<th>Stage</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 (~3 days)</td>
</tr>
<tr>
<td>Matchhead Square</td>
<td>550</td>
</tr>
<tr>
<td>First Flower</td>
<td>1000</td>
</tr>
<tr>
<td>First Open Boll</td>
<td>1900</td>
</tr>
<tr>
<td>Flower – Open boll</td>
<td>(~ 750)</td>
</tr>
<tr>
<td>One bale crop</td>
<td>– 1900</td>
</tr>
<tr>
<td>Two bale crop</td>
<td>– 2500 +</td>
</tr>
</tbody>
</table>
Germination and Emergence
Avg. Soil Temperature and Emergence Rate

Days to 45% Final

Average Daily Minimum Seed Level Temperature (Wanjura)
# Sequence of Growth

**Planting to 50% open - 135 Days**

110 days from planting to 1st open boll

<table>
<thead>
<tr>
<th>55 Days</th>
<th>55 Days</th>
<th>25 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 Days Planting to 1st Square</td>
<td>23 Days 1st Square to bloom</td>
<td>1st Flower to 1st open boll</td>
</tr>
<tr>
<td>25 Days 1st open boll</td>
<td>1st open boll to 50% open</td>
<td></td>
</tr>
</tbody>
</table>
Early Season Cotton Development

Note: Image source credit to Derrick M. Oosterhuis Ph.D. University of Arkansas
Plant Growth Monitoring

Terminal Growth

Highest node with unfolded main stem leaf

Nodes above White flower = 6

6 5
4
3
2
1

Monopodial (vegetative) branch

Main stem

Sypodial (fruiting) branch

Main stem nodes

Cotyledonary node

(Fromme, 2008)
Cotton Plant

5-6 vegetative nodes
8-9 NAWF at first bloom
5 NAWF at cutout
20-22 nodes at harvest

Monopodial or veg. branches
Sympodial or fruiting branches

Usually about 10 day younger than the first position square on the first fruiting branch

Node=branch
Internode
About 3 days elapse between the formation of a square on a given branch and the formation of a square at the same relative position on the next higher fruiting branch (known as vertical flowering interval).

On the other hand, the time interval for the development of two successive squares on the same branch is about six days (horizontal flowering interval).
Note: Image source credit to Derrick M. Oosterhuis Ph.D. University of Arkansas
Heat Units for Growth

- **Planting** - 10/day before planting
- **Emergence** 75-100
- **Each new node/leaf** 55 (~3 days)
- **Matchhead Square** 550
- **First Flower** 1000
- **First Open Boll** 1900
  - Flower - Open boll (~ 750)
  - One bale crop - 1900
  - Two bale crop - 2500 +
“Normal” Cotton

- 5-6 Vegetative nodes
- 13-15 Fruiting nodes, branches
  - 98% of fruit is set on the first 12 fruiting branches
- 18-20 Mainstem nodes
- At first bloom, most fruiting forms that will produce a boll are already on the plant
- The size of the plant (nodes) at first bloom determines the yield potential
Fruiting Timeline

Leaves and branches 3/8 alternate phyllotaxy

Cotyledons opposite

Ritchie, Bednarz, et al. 2007
Cotton Bud from Square to Bloom (~21 days)

Pinhead Square  Match-Head Square  Square Growth Midpoint  Candle  White Bloom

Ritchie, Bednarz, et al. 2007
Stages of Flowering

Day 1

Day 2

Days 3-4

Days 5-7

Ritchie, Bednarz, et al. 2007
Boll Maturation
(~50 days from pollination to open boll)

Ritchie, Bednarz, et al. 2007
The balance between vegetative and reproductive structures is closely regulated by the carbohydrate and nitrogen status of the plant.

The balance is achieved by over-production of fruiting forms - then abortion to equal the carrying capacity at any given time.
Fruit Production/Retention

• Production of fruiting forms is dependent upon vegetative growth
• Balance between vegetative and reproductive growth is carbohydrate regulated
• The retention of immature fruiting forms is extremely dynamic and responsive to variations in water supply
• Fruiting forms exhibit a greater sensitivity to water stress than vegetative growth.
Plant Growth Regulators:

- Management tool for suppressing plant growth (reduces internode length)
  - increase management efficiency
  - increase harvest efficiency

8 NAWF
1.5”
ANLAWF
Early Bloom

Carbohydrate production

Seed and lint demand
Fruit Shed

• Squares do not shed except from extreme stress

• Young bolls shed from
  - insufficient nitrogen
  - water stress;
    • too much or too little
  - insufficient carbohydrates

[Graph showing the relationship between bloom and small squares]

14 days after bloom
Late Bloom

Carbohydrate production

Seed and lint demand
Declining NAWF

- A declining NAWF is indicative of a decrease in photosynthetic activity
- An increased carbohydrate demand by the boll load
- Water stress
Nodes Above White Flower
NAWF

1. Water and nitrogen management
2. Indication of boll load
3. Indication of cutout
4. Vigor of the plant
Impact of Cotton Growth on Management

- Perennial growth
  - slow shoot development
    - weed competition
  - indeterminate growth
    - plant growth regulators

- Long fruiting period causes challenges
  - stress avoidance
  - insect management
  - fiber quality
Harvest-aids

- Removal of leaves
- Fiber quality
- Ginning techniques
- Harvest efficiency
Harvest-aids

- Removal of leaves
- Fiber quality
- Ginning techniques
- Harvest efficiency
Defoliation:

- Balancing the yield potential with the need to preserve quality
- Somewhat dependent on harvest method
- Target timing of 60-70% open bolls

Types:
- Hormonal - defoliants and boll opener
  - more temperature dependent
- Herbicidal - dessicates
Yield distribution
- ~70% from 1\textsuperscript{st} position
- ~20% from 2\textsuperscript{nd} position
Harvesting Methods

Picker - removes primarily lint

Stripper - removes all plant parts (lint, burs, limbs, etc.)

- Fiber quality
- Ginning techniques
- Harvest efficiency
COTTON FIELD READY FOR HARVEST
HARVESTING USING A COTTON PICKER
COTTON IS DUMPED INTO A MODULE BUILDER

FINISHED MODULE
NEXT STOP----THE COTTON GIN!
AT THE GIN

SEEDS GO ONE WAY

FIBER GOES ANOTHER
A bale of cotton weighs around 480 pounds.
NEARLY 12 MILLION BALEs WERE PRODUCED IN THE U.S. IN 2009 AND WAS EQUIVALENT TO $3.735 BILLION

U.S. EXPORTED OVER 9 MILLION BALES
For each 480 pound bale of cotton lint, an average of 790 pounds of cottonseed are produced.
AT THE TEXTILE MILL

BALES ARE OPENED AND THE PROCESS BEGINS

FIBER IS CARDED AND MADE INTO A SLIVER
The sliver is drawn and twisted until it becomes twine and thread.

Thread can then be dyed and woven or knitted into cloth.
100% cotton fabric
(same variety, same field)

Mature cotton

Immature cotton
Shiny nep on fabric
From One Bale of Cotton
You can make...

215 Jeans
249 Bed Sheets
690 Terry Bath Towels
765 Men's Dress Shirts
1,217 T-Shirts
3,085 Diapers
6,436 Women's Knit Briefs
U.S. paper currency is made of 75% cotton and 25% linen.

Each pound of dollar bills contains $\frac{3}{4}$ pound of cotton.

Over 30,000 bales of cotton were used for printing paper bills in one year.
Non-woven household materials
- Harzardus materials clean-up
- Insulation
- Wall paper
Cotton annually stimulates the U.S. economy in excess of $120 billion.
Cottonseed
COTTONSEED OIL IS A HIGH QUALITY VEGETABLE OIL USED IN COOKING
Cottonseed Oil

- U.S. production has averaged about 877 million pounds, or about 117 million gallons, over the last five years.

- Typically one third of CSO supply goes into snack food production.

- CSO has a 2:1 ratio of polyunsaturated to saturated fatty acids.

  ~70% unsaturated fatty acids
  ~18% monounsaturated (oleic acid)
  ~52% polyunsaturated (linoleic acid)
COTTON SEED HULLS AND COTTON SEED MEAL GO INTO FEED FOR LIVESTOCK
Cottonseed meal:
- 38% and 44% protein
- 70-80% TDN

Whole cottonseed or Fuzzy seed:
- 20% Crude protein

Cottonseal hulls
- comparable to good hay
Gossypol-free Cotton

- Seed can be used for human consumption
  - snacks
  - increased use as an ingredient in other foods

- Will change the entire economics of cotton production
Renewed Interest

- Natural fibers
- Grown locally
  - seed to shirts
- Energy and carbon benefits

![Bar chart showing energy input and cottonseed production](image)
Acknowledgements

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