



# Increasing Water Use Efficiency of Irrigated and Dryland Cotton

MS Row Crop Short Course  
5<sup>th</sup> Dec 2017, Starkville, TN

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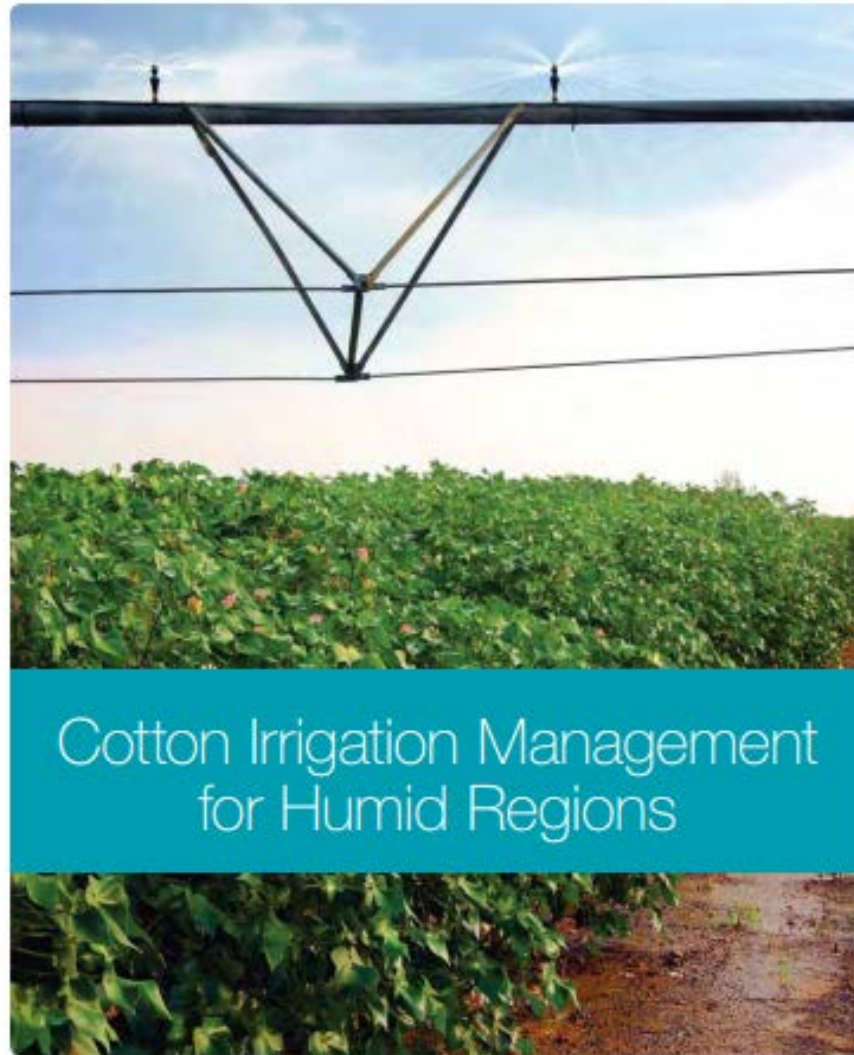
# Take Home

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- Cotton Agronomics
  - Cotton is an indeterminate, drought tolerant plant which does not like saturated soils
  - Increase infiltration, water holding capacity with cover crops
  - Target less frequent, more thorough irrigation events
- Scheduling
  - We have a number of tools to help us understand plant water status and guide our irrigation events
  - Still need boots on the ground to calibrate ALL of these instruments
  - Provide valuable insight on when to start, how long we can wait between events, and when to terminate







## Cotton Irrigation Management for Humid Regions



# Outline

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- Overview of Water Management
  - Cotton water use
  - Rainfall patterns and atmospheric demand
- Increasing WUE with Covers
- Increasing WUE with Sensors
- Increasing WUE through variety selection





- Framework for understanding crop water use:
  - Crop Coefficient approach for estimated evapotranspiration (ET):

$$ET_c = ET_o \times K_c$$

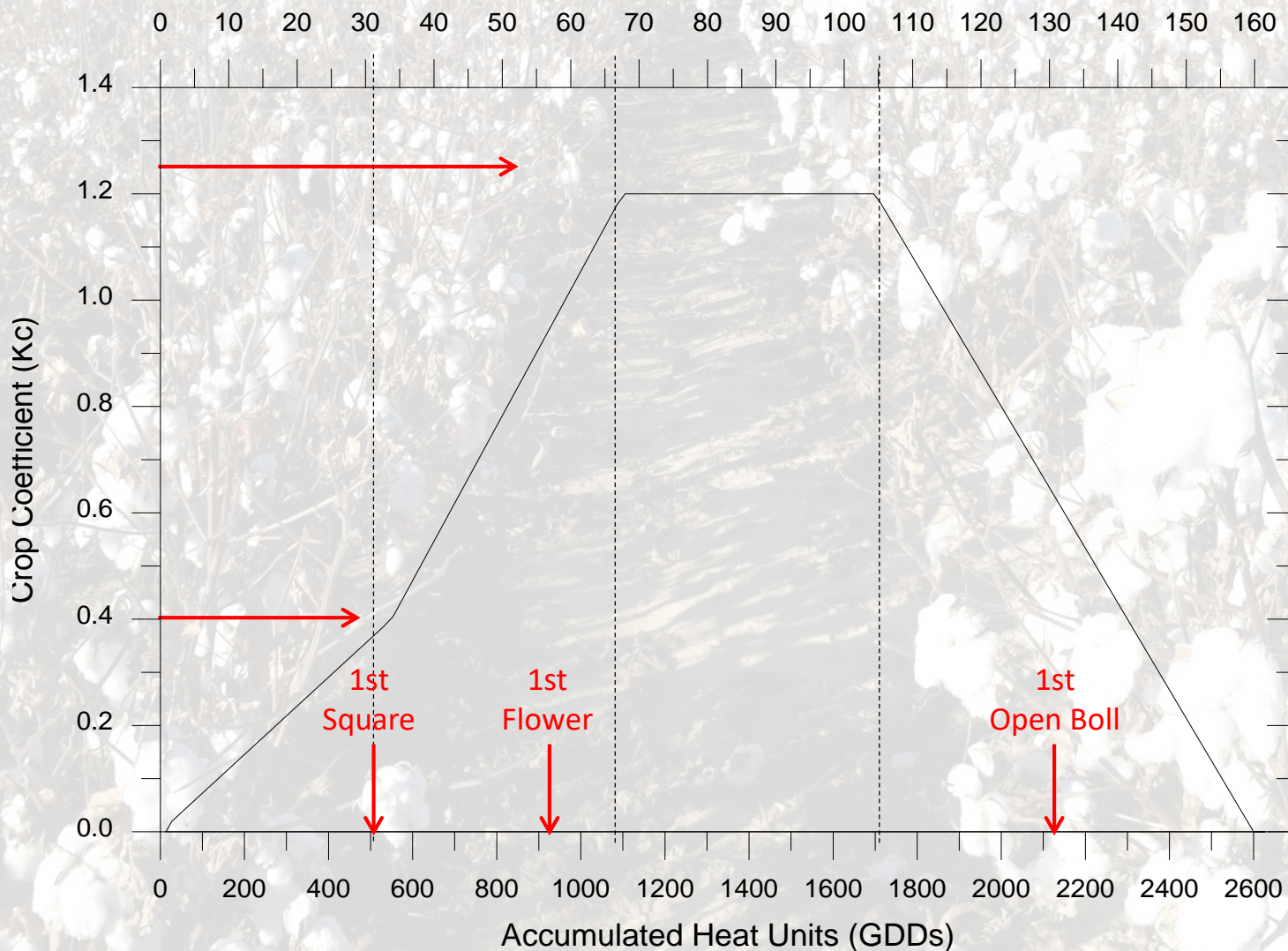
- Where:
  - $ET_c$  = estimated crop ET
  - $K_c$  = crop coefficient
  - $ET_o$  = Penman-Monteith reference ET (FAO-56)



# Crop Water Use

$$ET_c = ET_o \times Kc$$

Days After Planting (DAP)

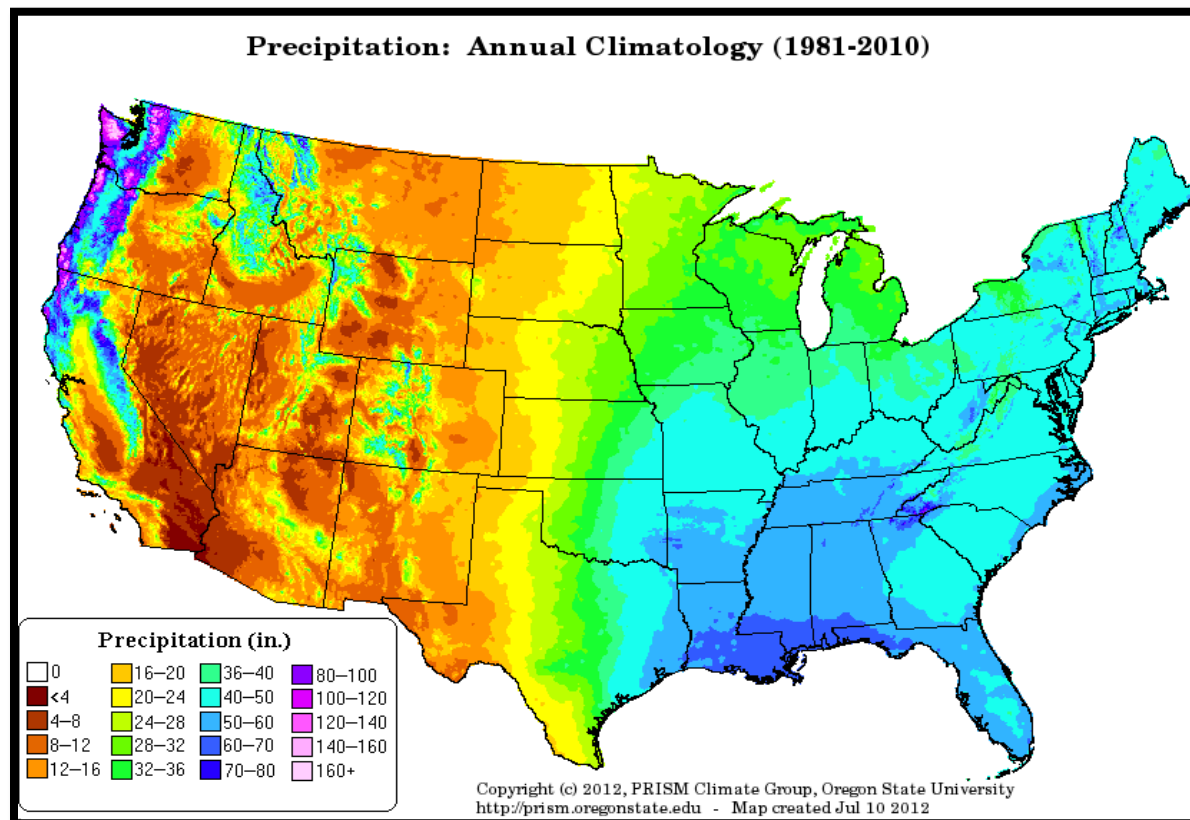




# Environmental Demand

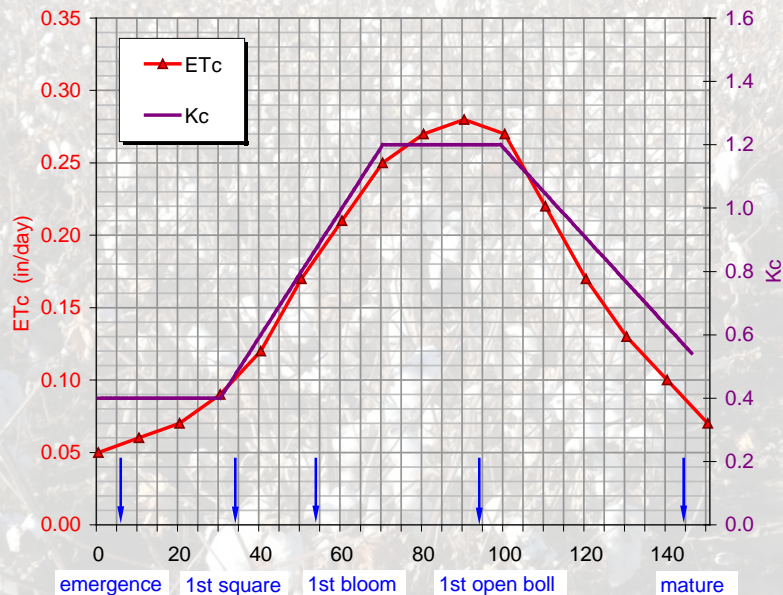
$$ET_c = ET_o \times K_c$$

- 40 -50 in. per year in dry, hot environments
- 20-30 in. per year in humid, moderate environments

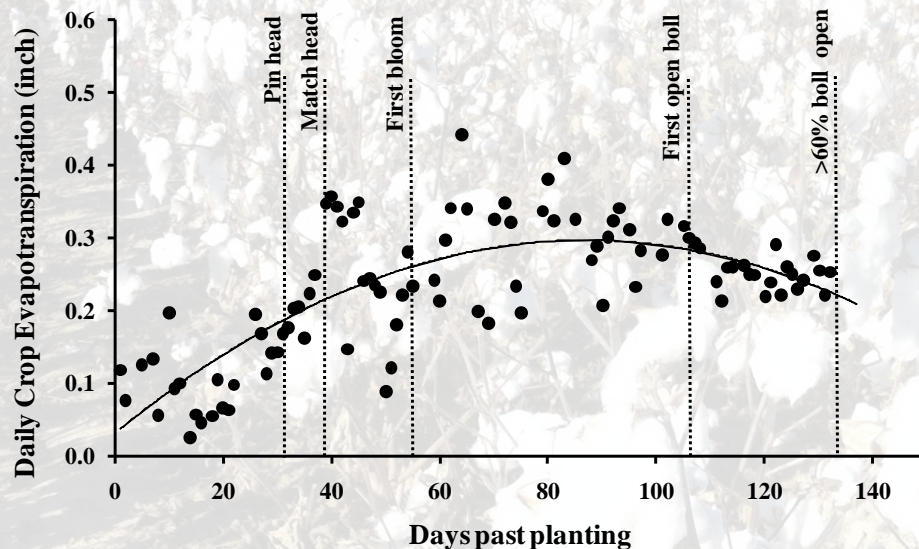


# Crop Water Use

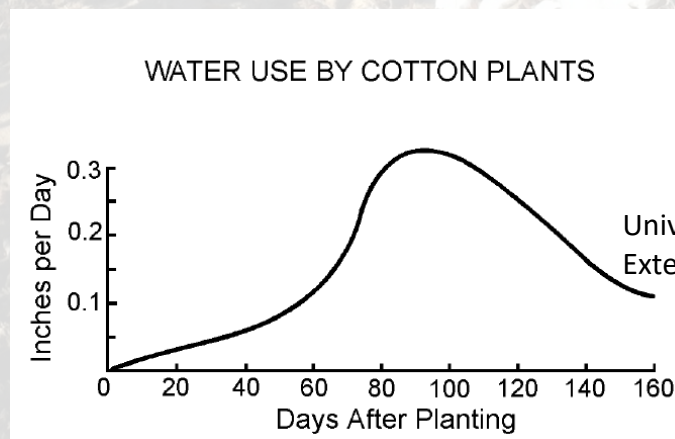
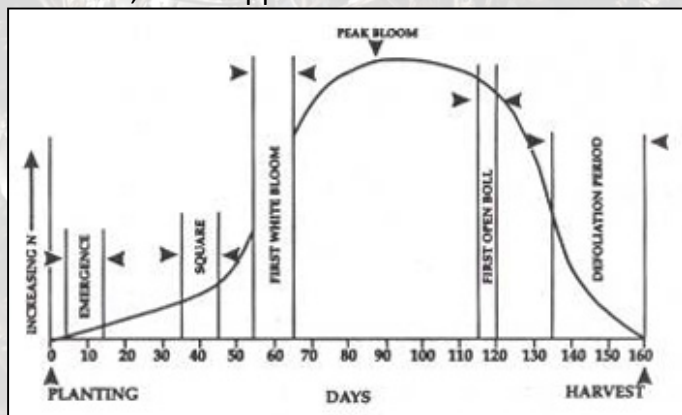
$$ET_c = ET_o \times K_c$$



Water use and crop coefficient function for cotton in Stoneville, Mississippi.



Measured crop water use from a cotton field in Louisiana over the growing season.

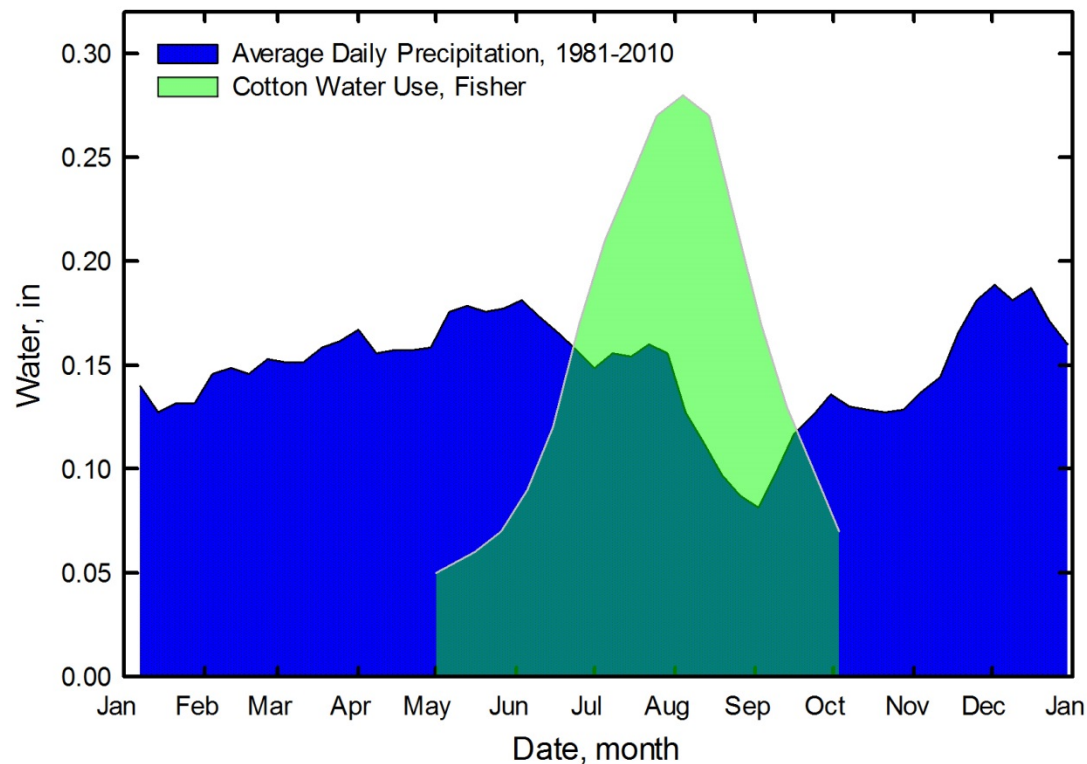
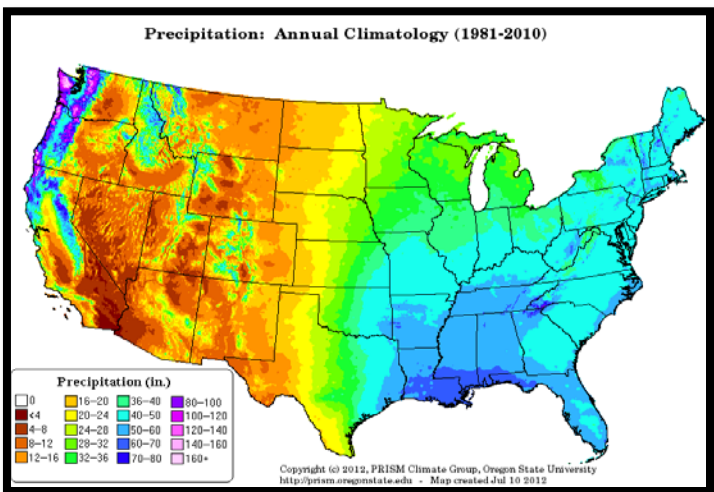


University of Georgia  
Extension publication.



- Discrepancy between rainfall pattern and crop demand

Rainfall and Cotton Water Use Pattern  
WTREC Jackson, TN  
GHCN:USC00404561



# Meeting Crop Demands

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# Meeting Crop Demands

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1. Agronomic Components
  1. Yield
  2. Stand establishment
  3. Herbicide activation
  4. N movement
  5. Canopy development
  6. Earliness
  7. Potential to fertigate
  
2. Economic Components
  1. Increase land value
  2. Utilize inputs in a timely manner
  3. Minimize risks
  4. Improve sustainability of operation
  
3. Additional Components
  1. Reduce pressure from regulators
  2. Better public perception of cotton production



# Water and Cotton



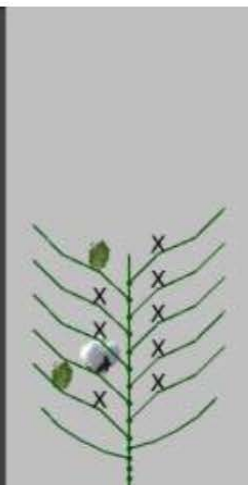


## 2012 Surface Drip Study

Shallow/sandy soil

Date: 9/4/12  
Plot: 301  
No. plants: 10  
Avg. height: 23.2  
Avg. no. nodes: 14  
Avg. NAWF: 1  
Avg. NACB: 7

Node	Pos. 1	Pos. 2	% shed / % int
5	83/60	0/50	
6	58/90	67/30	
7	30/100	32/30	
8	70/100	0/10	
9	60/100	NA/0	
10	70/100	NA/0	
11	70/100	NA/0	
12	60/100	NA/0	
13	50/80	NA/0	
14	66/70	NA/0	



rainfed - 506 lb/A

Date: 9/6/12  
Plot: W204  
No. plants: 10  
Avg. height: 18.6  
Avg. no. nodes: 16  
Avg. NAWF: 8  
Avg. NACB: 8

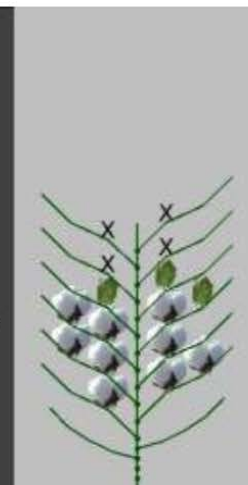
Node	Pos. 1	Pos. 2	% shed / % int
6	10/100	NA/0	
7	20/100	0/10	
8	30/100	0/10	
9	60/100	NA/0	
10	70/100	NA/0	
11	100/100	NA/0	
12	90/100	NA/0	
13	100/100	NA/0	
14	100/100	0/10	



1"/wk - 703 lb/A

Date: 9/4/12  
Plot: 201  
No. plants: 10  
Avg. height: 26.3  
Avg. no. nodes: 15  
Avg. NAWF: 4  
Avg. NACB: 6

Node	Pos. 1	Pos. 2	% shed / % int
5	17/60	25/40	
6	33/90	0/60	
7	16/100	25/60	
8	30/100	100/20	
9	20/100	20/50	
10	30/100	0/60	
11	44/90	50/40	
12	11/90	0/20	
13	56/90	0/10	
14	71/70	0/10	
15	67/60	NA/0	
16	80/50	NA/0	

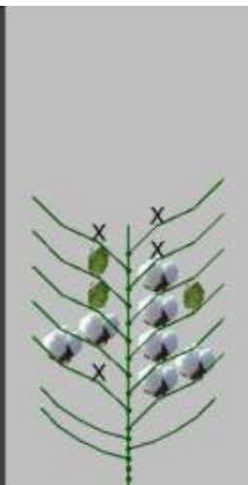


1.5"/wk - 1635 lb/A

Deep silt loam

Date: 9/4/12  
Plot: 403  
No. plants: 10  
Avg. height: 26.1  
Avg. no. nodes: 16  
Avg. NAWF: 3  
Avg. NACB: 4

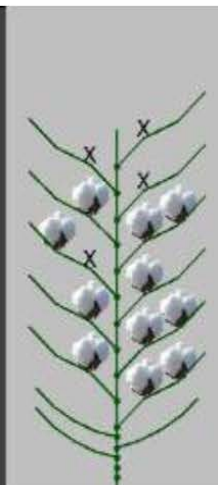
Node	Pos. 1	Pos. 2	% shed / % int
6	44/90	50/60	
7	60/100	20/50	
8	20/100	0/20	
9	10/100	0/10	
10	20/100	0/50	
11	26/100	0/20	
12	60/100	100/10	
13	30/100	0/10	
14	90/100	NA/0	
15	71/70	NA/0	
16	67/60	NA/0	



rainfed - 1579 lb/A

Date: 9/6/12  
Plot: W405  
No. plants: 10  
Avg. height: 35.5  
Avg. no. nodes: 13  
Avg. NAWF: 3  
Avg. NACB: 3

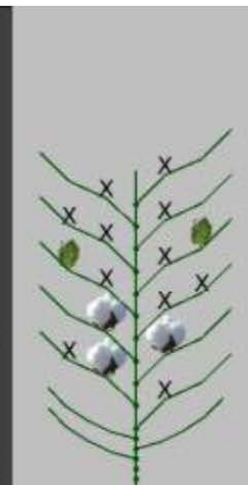
Node	Pos. 1	Pos. 2	% shed / % int
6	29/70	20/50	
7	36/60	26/40	
8	33/90	20/50	
9	44/90	100/40	
10	50/100	67/30	
11	60/100	40/50	
12	20/100	17/60	
13	20/100	100/20	
14	70/100	0/30	



1"/wk - 1982 lb/A

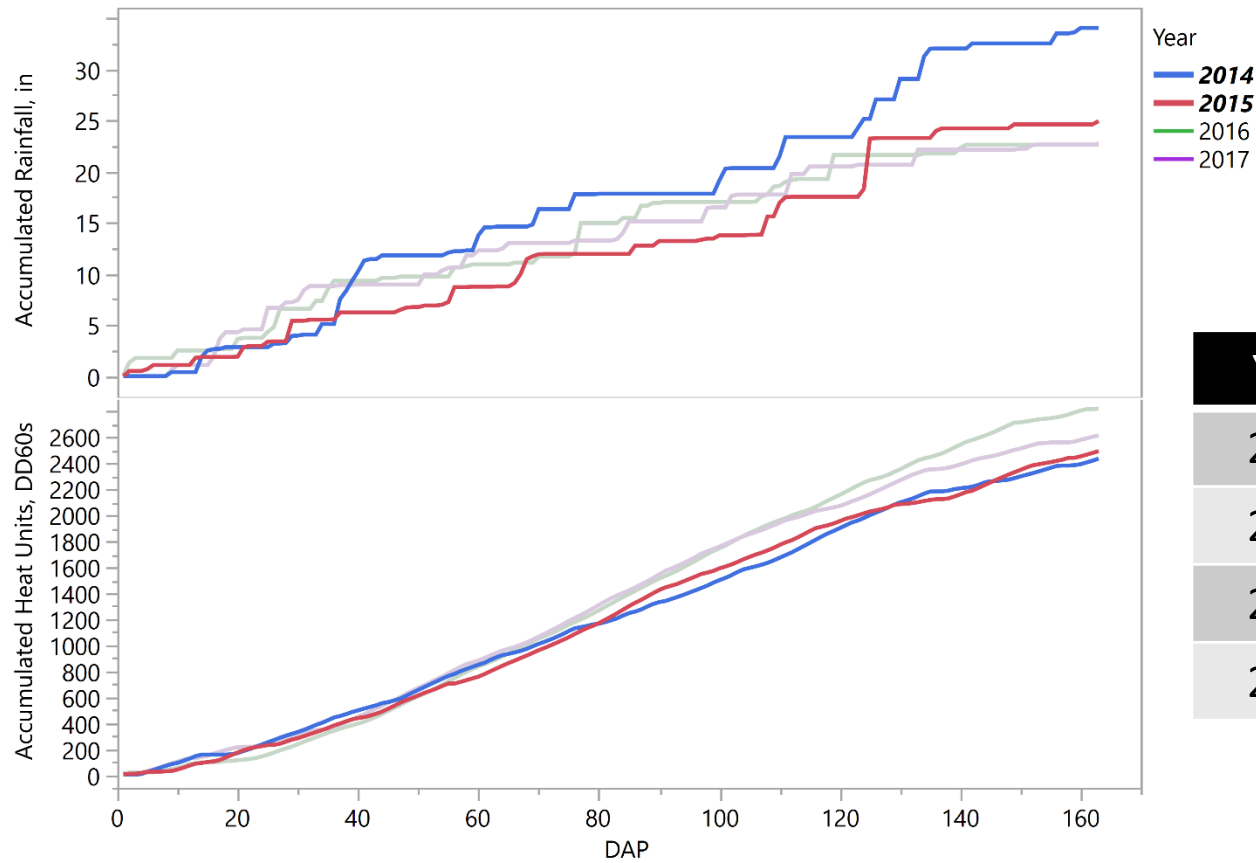
Date: 9/4/12  
Plot: 404  
No. plants: 10  
Avg. height: 31.5  
Avg. no. nodes: 16  
Avg. NAWF: 4  
Avg. NACB: 7

Node	Pos. 1	Pos. 2	% shed / % int
6	75/80	50/20	
7	40/100	57/70	
8	30/100	75/40	
9	40/100	50/40	
10	60/100	100/50	
11	70/100	38/80	
12	60/100	43/70	
13	60/100	60/50	
14	70/100	0/20	
15	70/100	50/20	
16	70/100	100/10	



1.5"/wk - 1466 lb/A

# Water and Cotton



Year	Yield (lb/ac)
2014	878
2015	1,046
2016	1,104
2017	1,065





## Cotton Incorporated's Water Strategy



Maximize Rainfall Capture



Optimize Irrigation Water



Increase Plant Water Use Efficiency



Evaluate with Credible Metrics



# Water Use Efficiency

- Approaches to increase WUE in the Mid-South and Southeast:
  1. Maximize Rainfall Capture

Cotton Incorporated's Water Strategy



1 Maximize Rainfall Capture

2 Optimize Irrigation Water

3 Increase Plant Water Use Efficiency

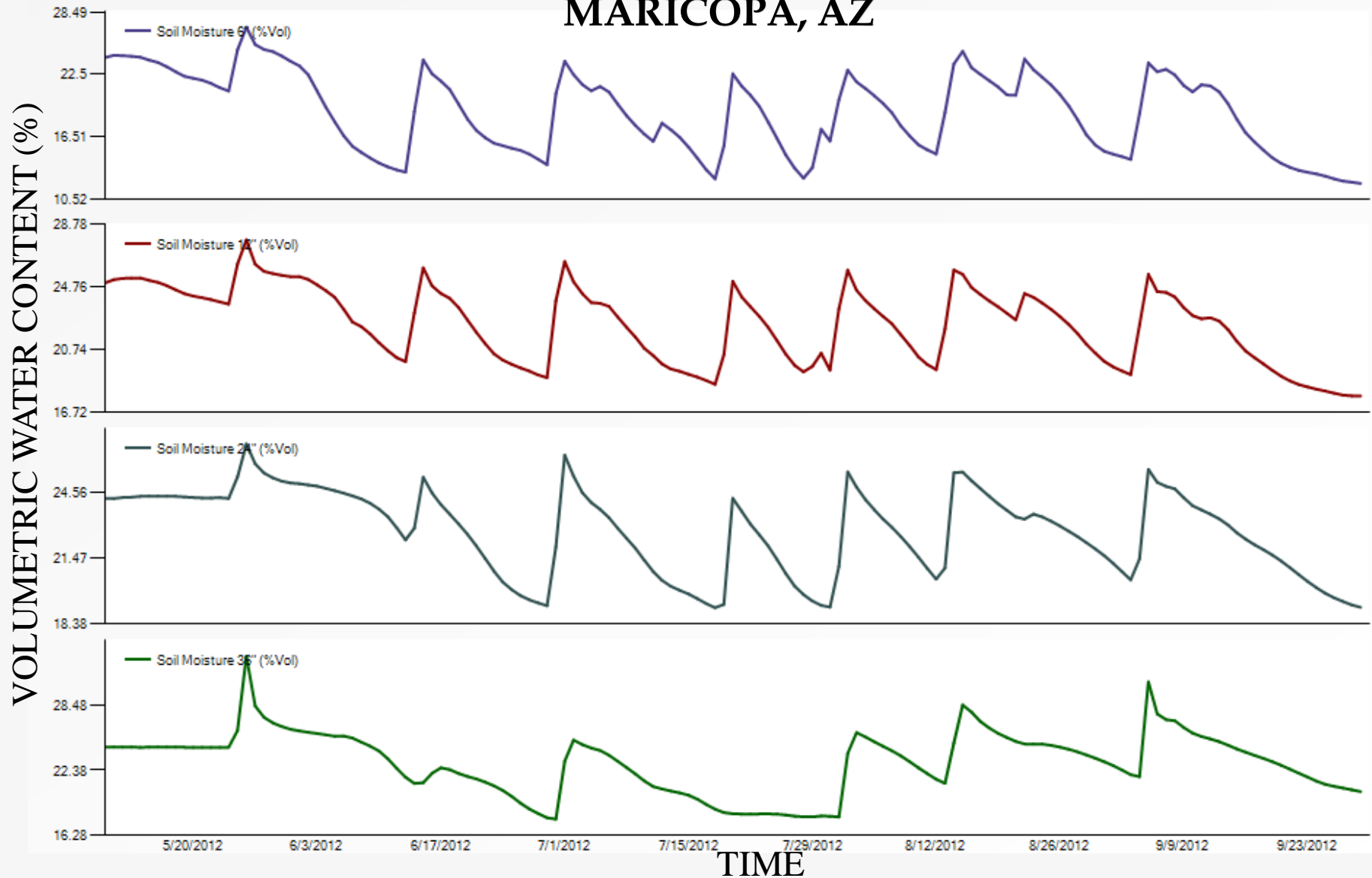
4 Evaluate with Credible Metrics



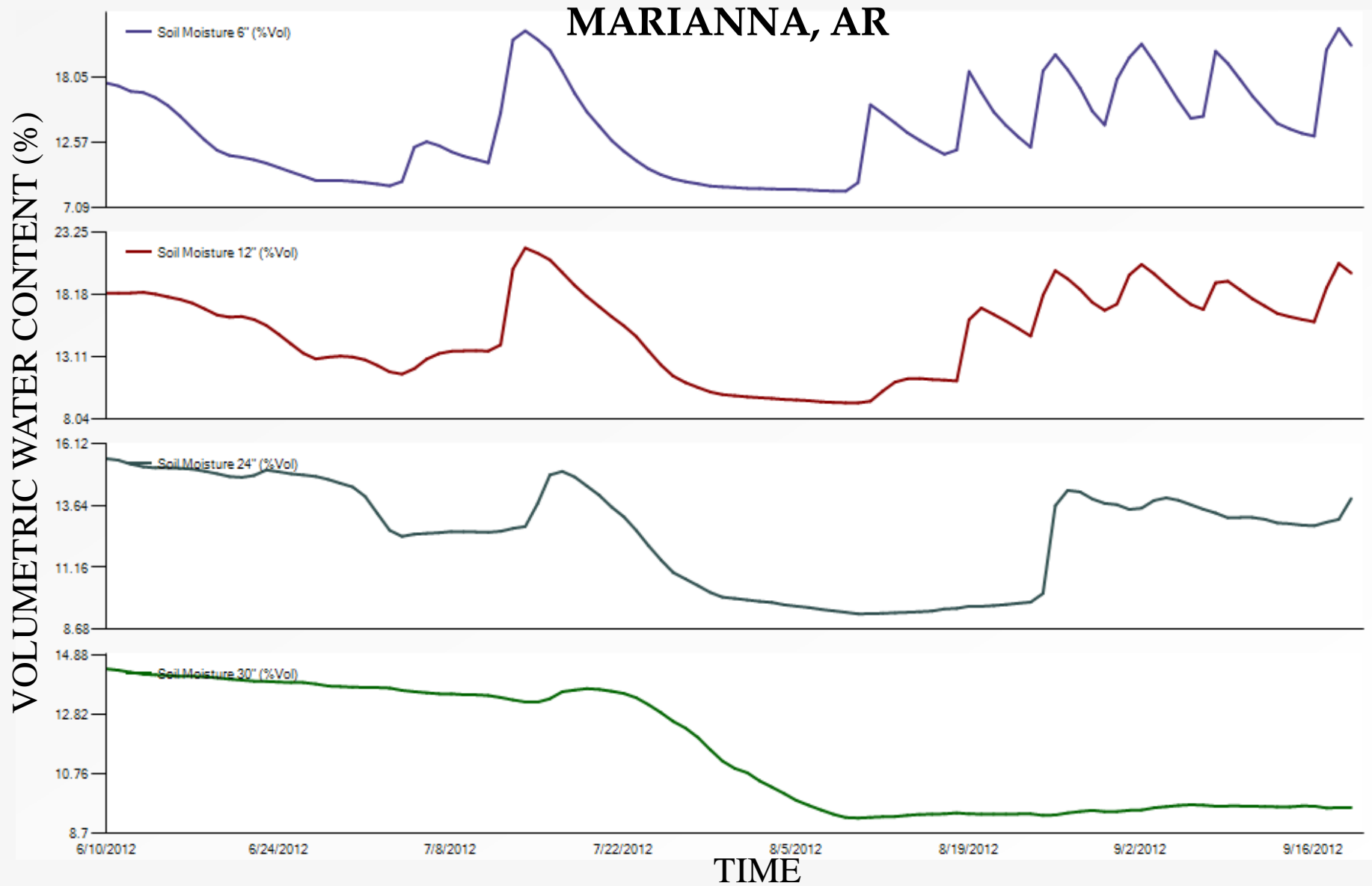


# Maximize Water Capture

## MARICOPA, AZ



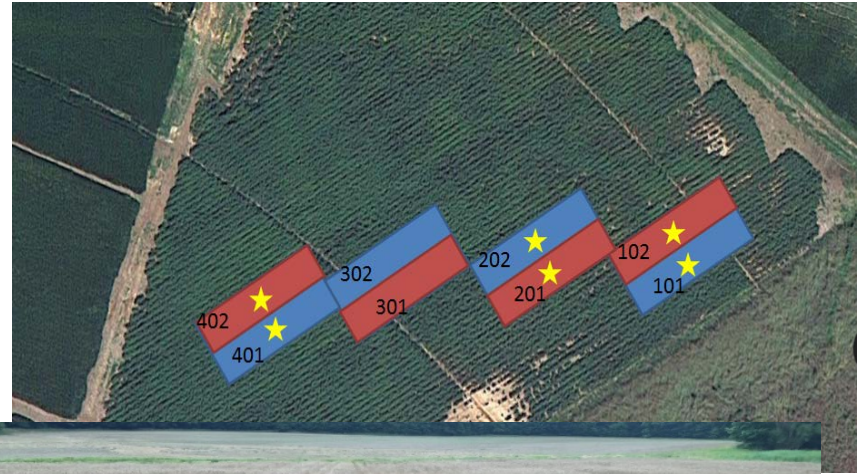
# Maximize Water Capture



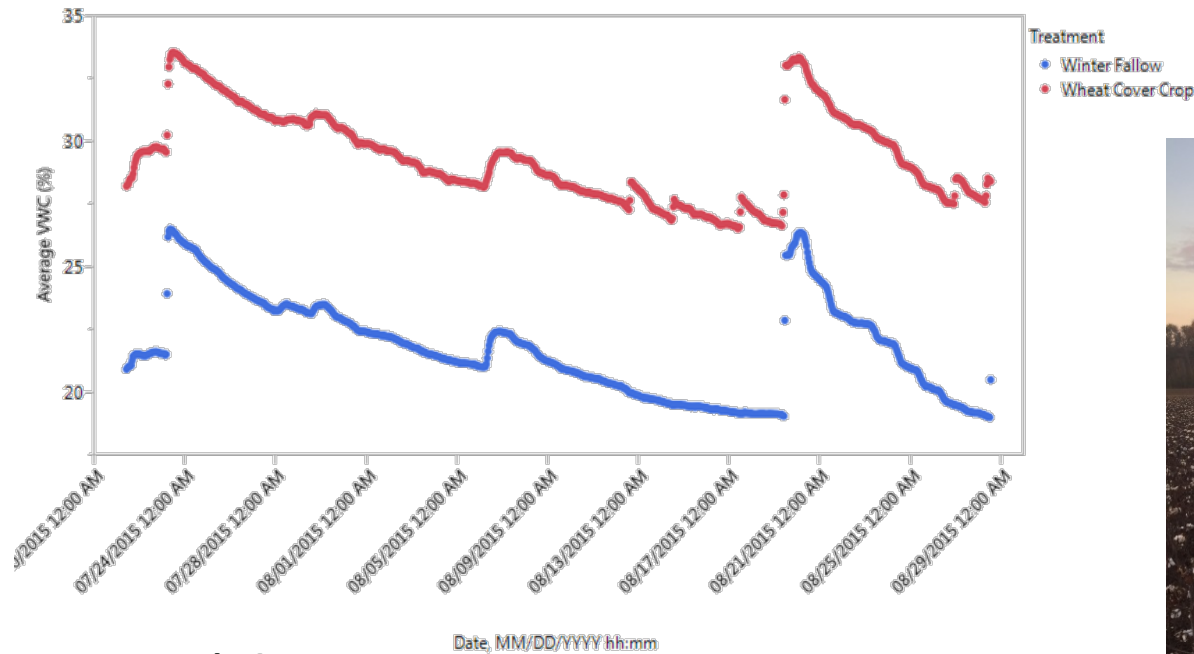


# Maximize Water Capture

- Cover (wheat) vs no cover
- Soil moisture sensors placed at 4 depths in 3 replications
- Terminated 2 weeks prior to planting



# Maximize Water Capture



- Result?
  - 111 lb increase in lint yield per acre!
- Why?
  - Increased water holding capacity during effective flowering window





# Maximize Water Capture



- Dryland Production
  - Increased infiltration and water holding capacity IN YEAR ONE
- Irrigated production
  - Increase in macropores? Increase hydraulic conductivity of the soil
  - Reduce time in which soil stays saturated after irrigation
- Species
  - Heavy monocot mixtures. . . Greater C:N ratios



# Water Use Efficiency

- Approaches to increase WUE in the Mid-South and Southeast:
  1. Maximize Rainfall Capture
  2. Optimize Irrigation Water
    - Checkbook, time-interval methods currently used
      - May not take into account water use of crop and/or atmospheric demand
    - Use of some in-season measurement could increase WUE
      - Soil Moisture
      - Canopy Temperature
      - Atmometer
      - Modeled, extrapolated weather data





# Optimize Irrigation Water

Instrumentation capable of giving insight to drought stress:

- Soil Moisture
  - Difficult to install
  - Very small sphere of influence
  - Good relationship with soil moisture, plant water status
  - Gives insight into water availability even under cloudy conditions





Instrumentation capable of giving insight to drought stress:

- Soil Moisture
  - What type of sensor should I use?
  - What does the reading mean?
  - How many do I need to install?
    - What depths?
  - Are readings similar from sensor to sensor?





Instrumentation capable of giving insight to drought stress:

- Canopy Temperature
  - Easy to install
  - Large spheres of influence
  - Can interfere with row-traffic
  - Good relationship with drought stress





# Optimize Irrigation Water

Instrumentation capable of giving insight to drought stress:

- Canopy Temperature
  - Challenge in Mid-South/Southeast?
    - Variable atmospheric conditions. . . clouds





# Optimize Irrigation Water

Instrumentation capable of giving insight into drought stress:

- Atmometer
  - Mini-weather station
  - Capable of providing a reference ET (ET<sub>o</sub>)
  - Very easy to install
  - Can be extrapolated across several fields (miles?)
  - Basically allow water to evaporate out of a ceramic cup
  - Rate of evapotranspiration indicates atmospheric demand, with addition of crop coefficient can be used to calculate ET<sub>c</sub>

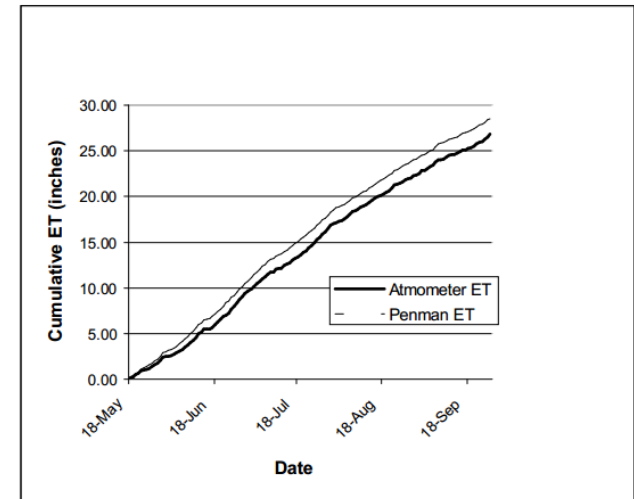


Figure 1: Comparison of Atmometer ET to Penman ET. Source: Bausch and Altenhofen.

# Optimize Irrigation Water



- Does not recommend irrigation amounts
- Advises user of Root Zone Water Deficit in terms of inches and % total
- Maximum Recommended Deficit is 50%
- Provides weekly (Monday-Sunday) estimated  $ET_c$





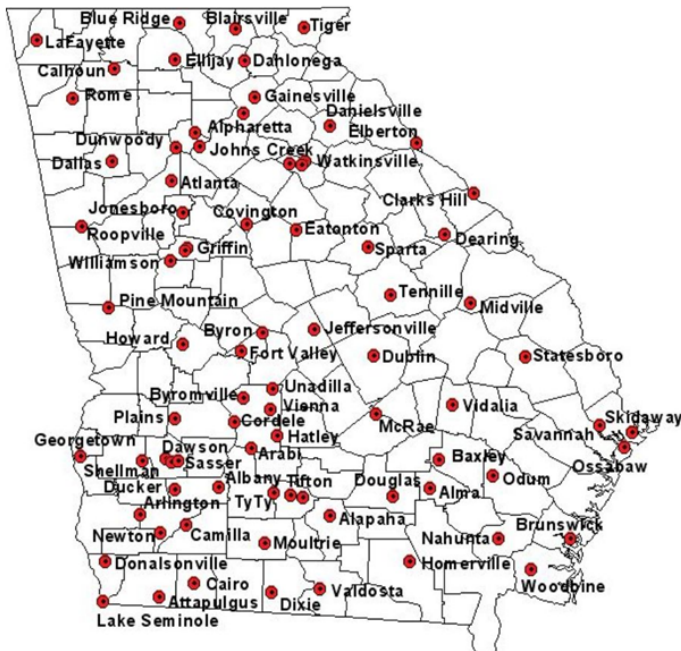
# Optimize Irrigation Water

## GAEMN - Georgia Automated Environmental Monitoring Network

## FAWN - Florida Automated Weather Network



For current weather conditions, historical weather data and applications, please select a site on the map:



Enter a GA ZIP Code for the nearest weather station

UF | University of Florida IFAS Extension

**Florida Automated Weather Network**

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FAWN UF\_FAWN

UF\_FAWN We've received an inquiry questioning ALACHUA's rain reading for 12/29; the data is inconclusive & is still under investigation. 23 hours ago · reply · retweet · favorite

UF\_FAWN Ho! Ho! Ho! All sensors @ all sites are working & reporting for Santa's trip!

Temperature

Min Temperature

Wind

ET

Total Rain

**Temperature**

Monday December 31, 2012 2:54 PM EST

Rollover measurement for complete station data

Click on measurement for graphical display of station data



# Water Use Efficiency

- Approaches to increase WUE in the Mid-South and Southeast:
  1. Maximize Rainfall Capture
  2. Optimize Irrigation Water
  3. Increase plant water use efficiency
    - What does that mean for you?
      - Select drought tolerant varieties
      - Very large variety testing program conducted within MS/TN/AL



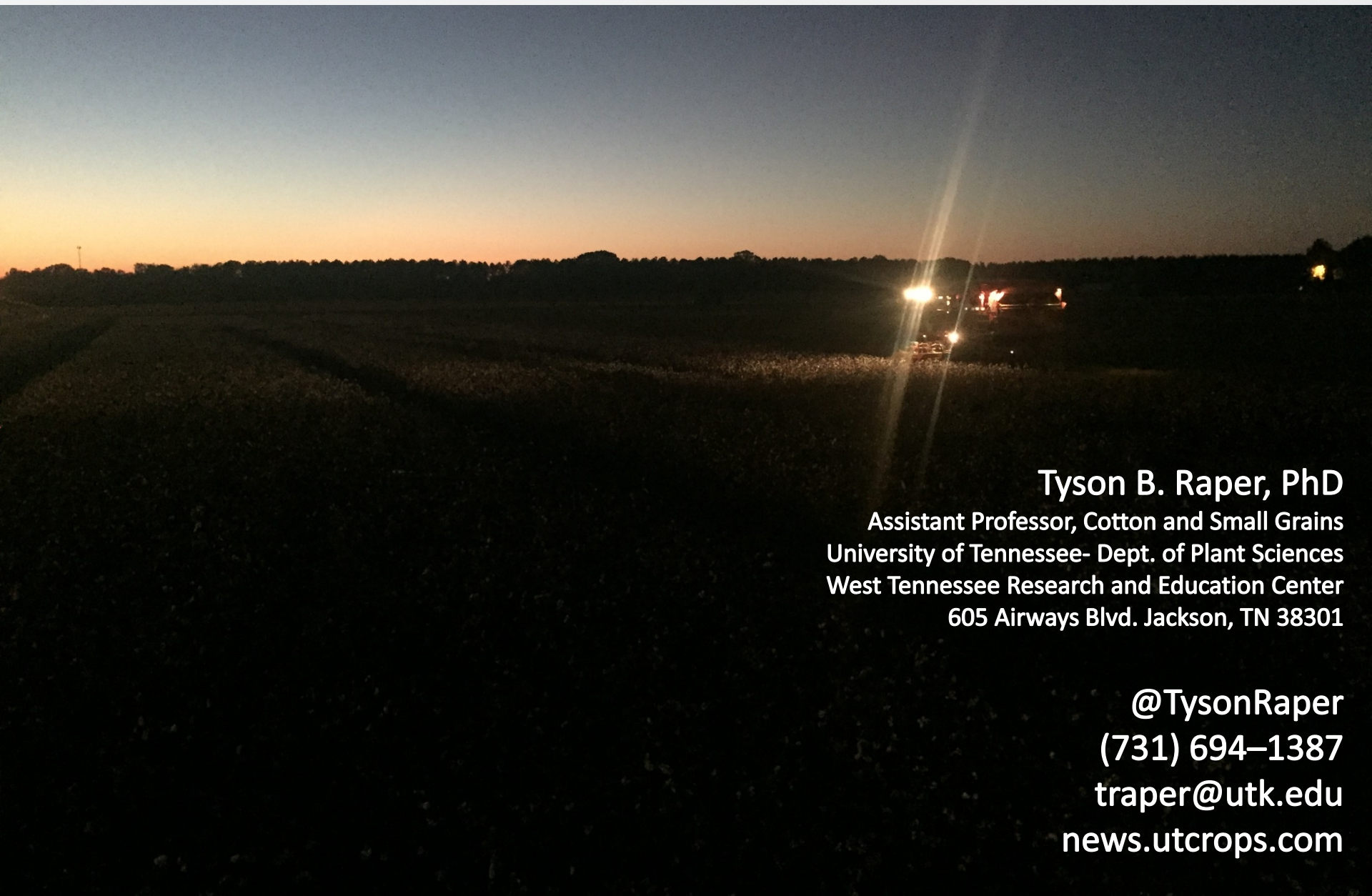


# Take Home

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  - Cotton is an indeterminate, drought tolerant plant which does not like saturated soils
  - Increase infiltration, water holding capacity with cover crops
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- Scheduling
  - We have a number of tools to help us understand plant water status and guide our irrigation events
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  - Provide valuable insight on when to start, how long we can wait between events, and when to terminate





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