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Water Management: Precision Irrigation Scheduling and Site Drought Characterization

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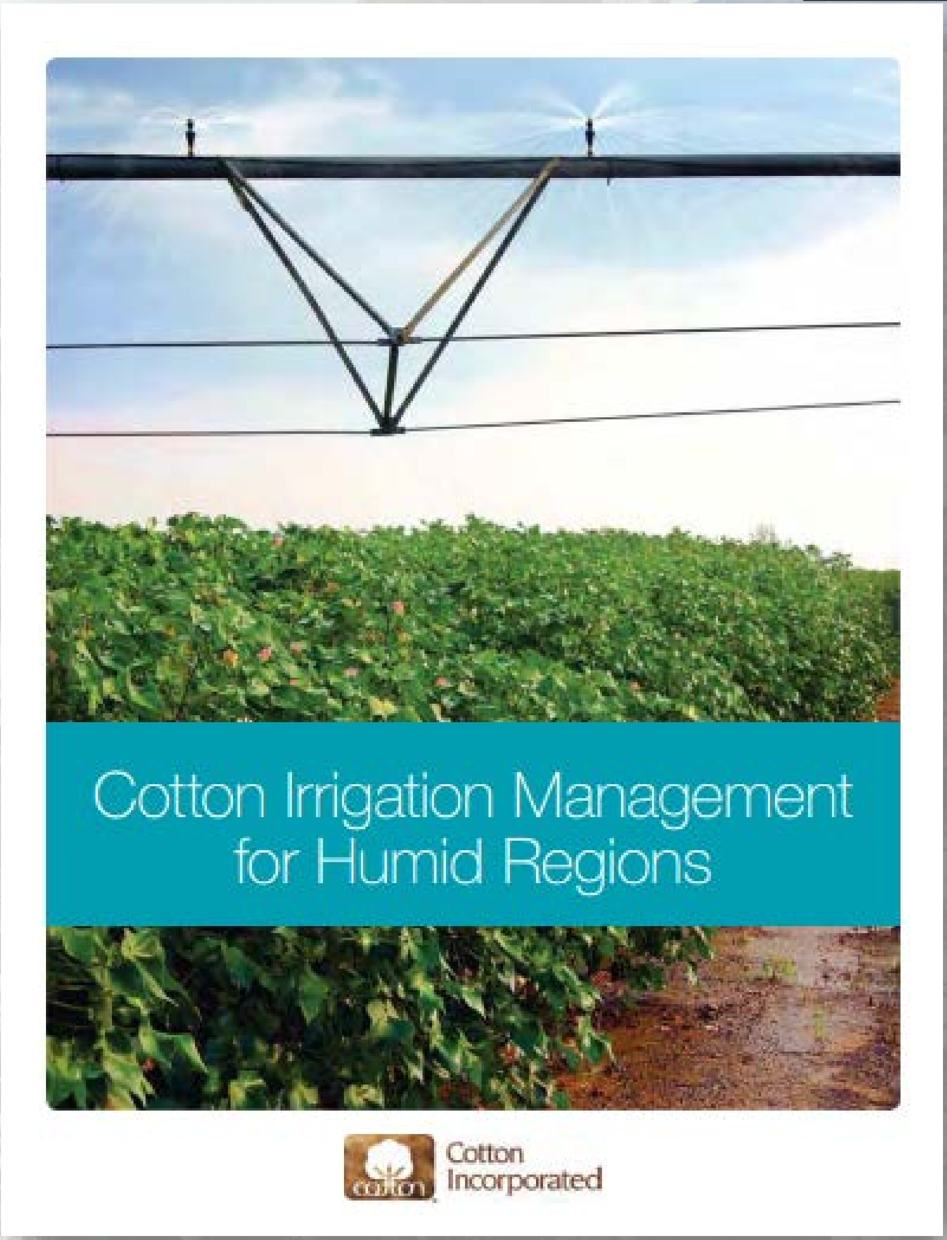
University of Tennessee

Outline

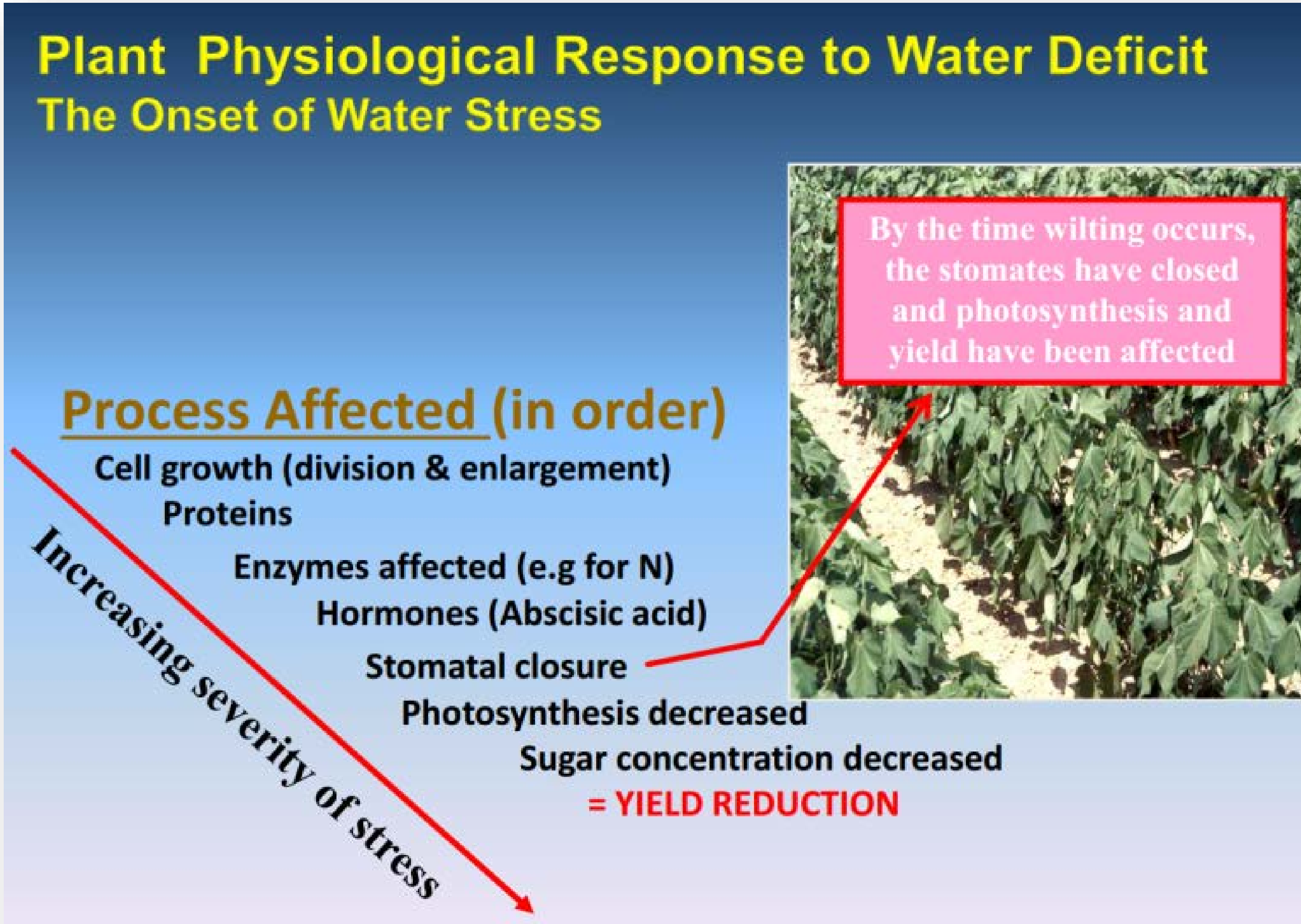
- Overview of Water Management
  - Cotton water use
  - Rainfall patterns
  - Pressure for increasing WUE
  - Benefits to irrigation

- Cotton Incorporated's Water Strategy
  - Use of in-season measurements for irrigation scheduling
  - Drought Stress Index
  - Observations from on-farm and station work with these sensors



www.cottoninc.com/fiber/AgriculturalDisciplines/Engineering/Irrigation-Management/cotton-irrigation-web.pdf

Introduction

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Water Use Efficiency

- The ratio of yield produced per unit water used is referred to as water use efficiency (WUE).
- Modern, high WUE varieties tend to provide 150 pounds of seed cotton or more for every inch of water used.
- On a smaller scale in a limited study in South Georgia, the addition of 4 to 6 inches of supplemental irrigation above seasonal rainfall increased lint yield by 250 to 620 lbs. of lint per inch of irrigation above rainfall.

Crop Water Use

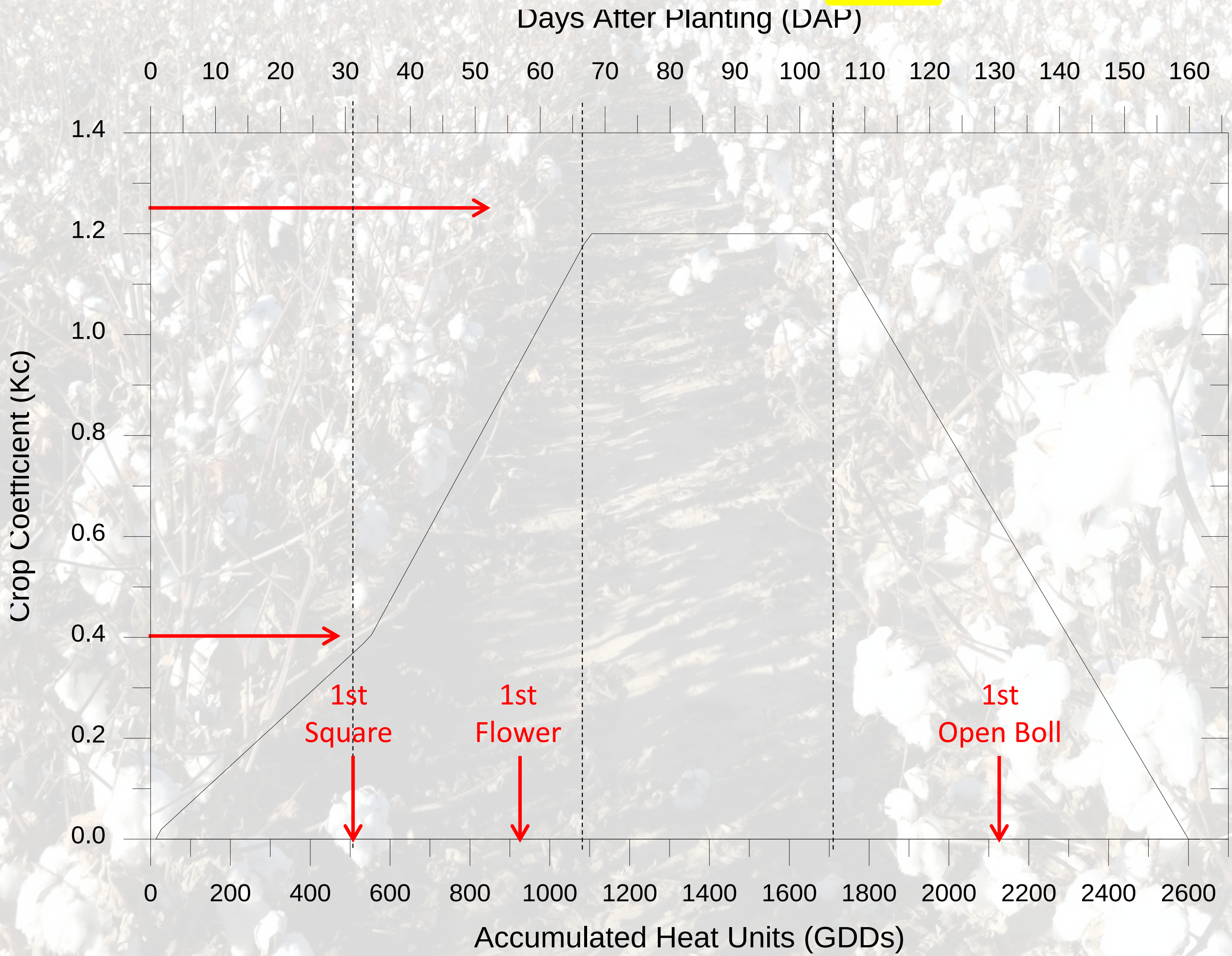
- Framework for understanding crop water use:
  - Crop Coefficient approach for estimated evapotranspiration (ET):

$$ETc = ETo \times Kc$$

  - Where:
    - ET_C = estimated crop ET
    - K_C = crop coefficient
    - ET_O = Penman-Monteith reference ET (FAO-56)

Determining the Kc Curve

$$ET_c = ETo \times Kc$$

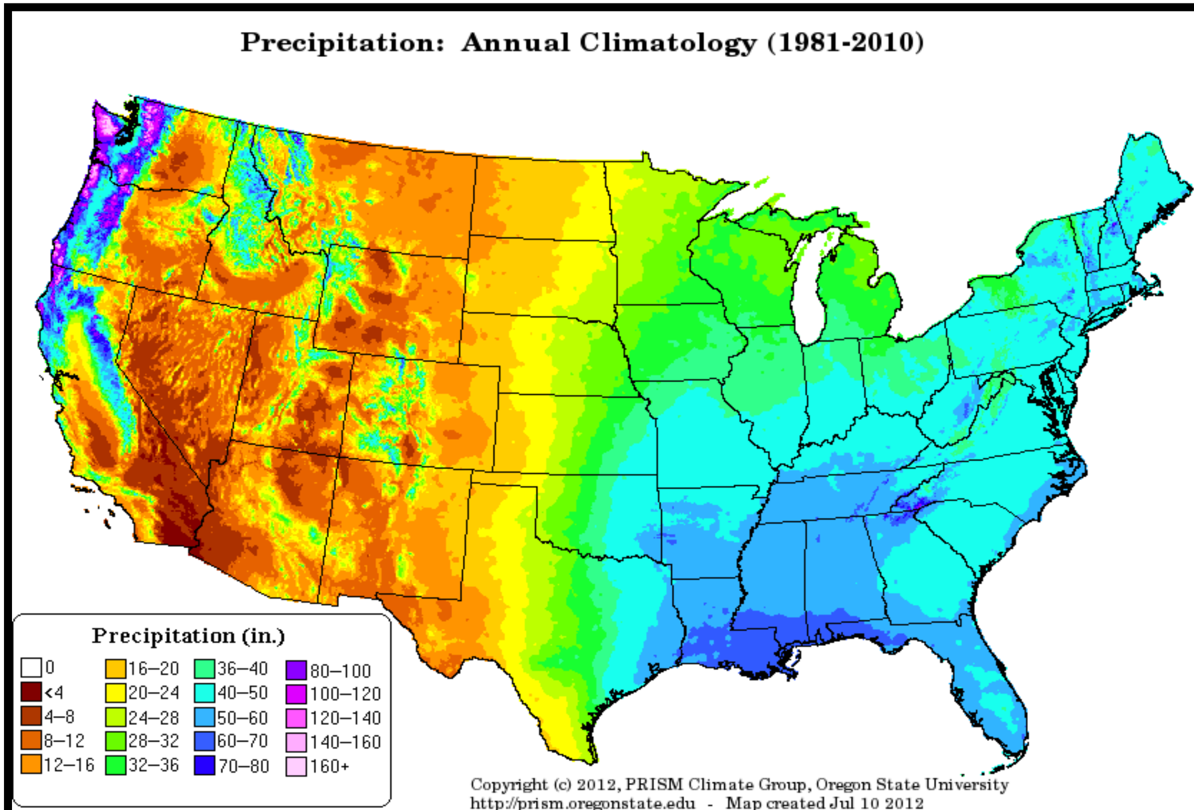


Environmental Demand

$$ET_c = ETo \times Kc$$

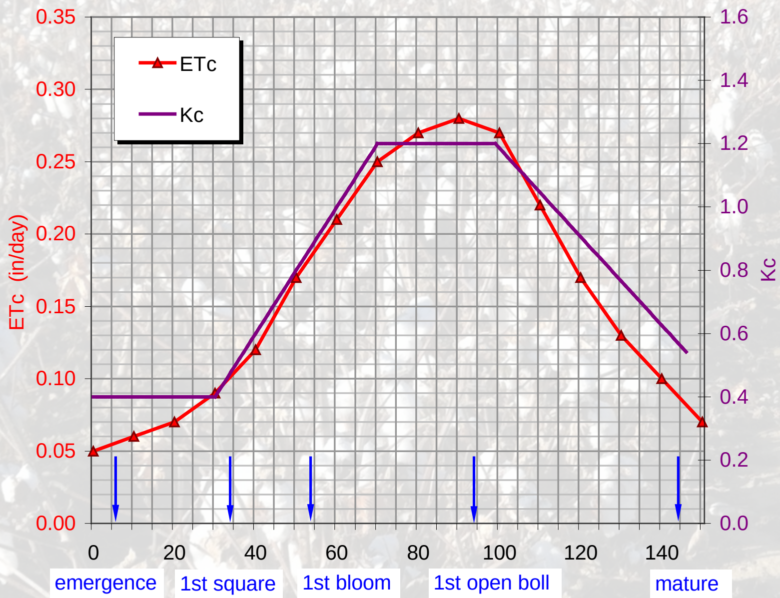
– 40 -50 in. per year in dry, hot environments

– 20-30 in. per year in humid, moderate environments

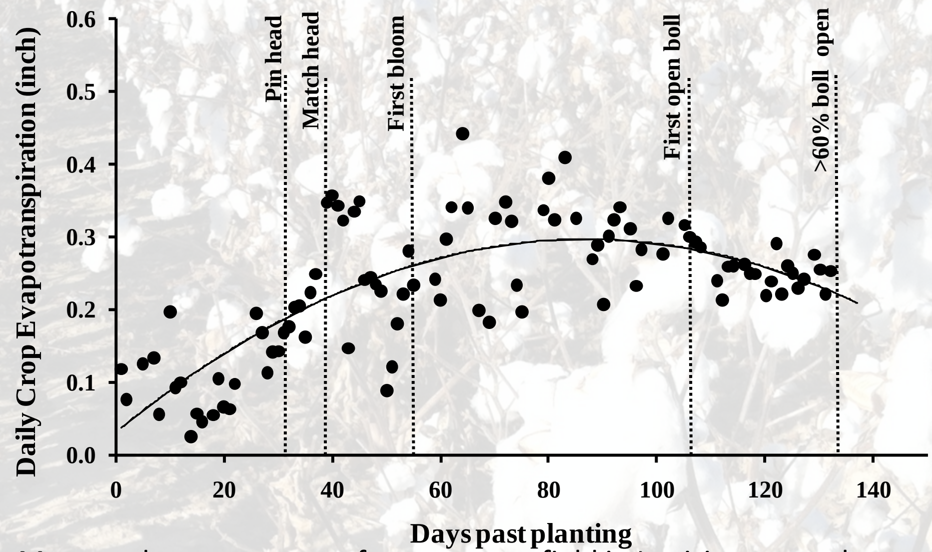


Determining the Kc Curve

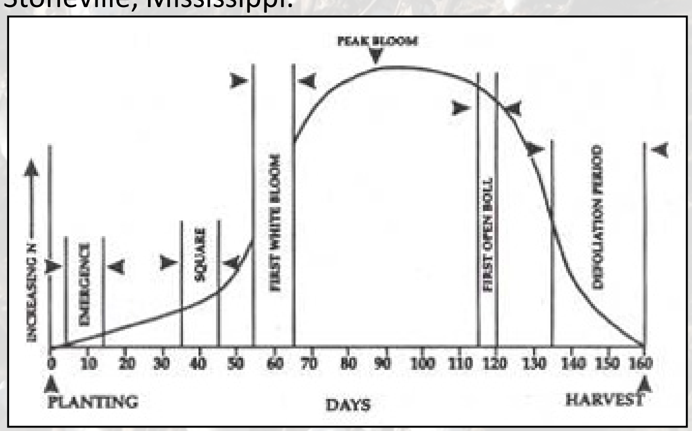
$$ET_c = ETo \times Kc$$

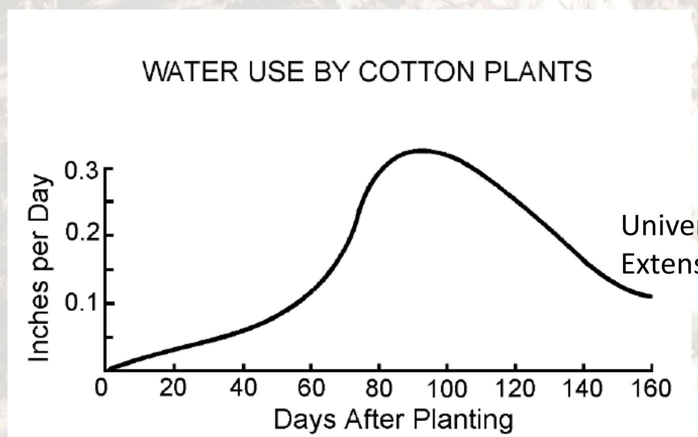


Water use and crop coefficient function for cotton in Stoneville, Mississippi.



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

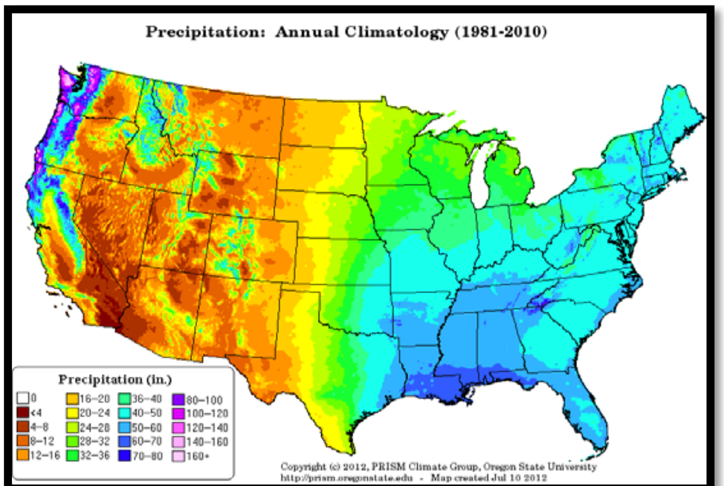


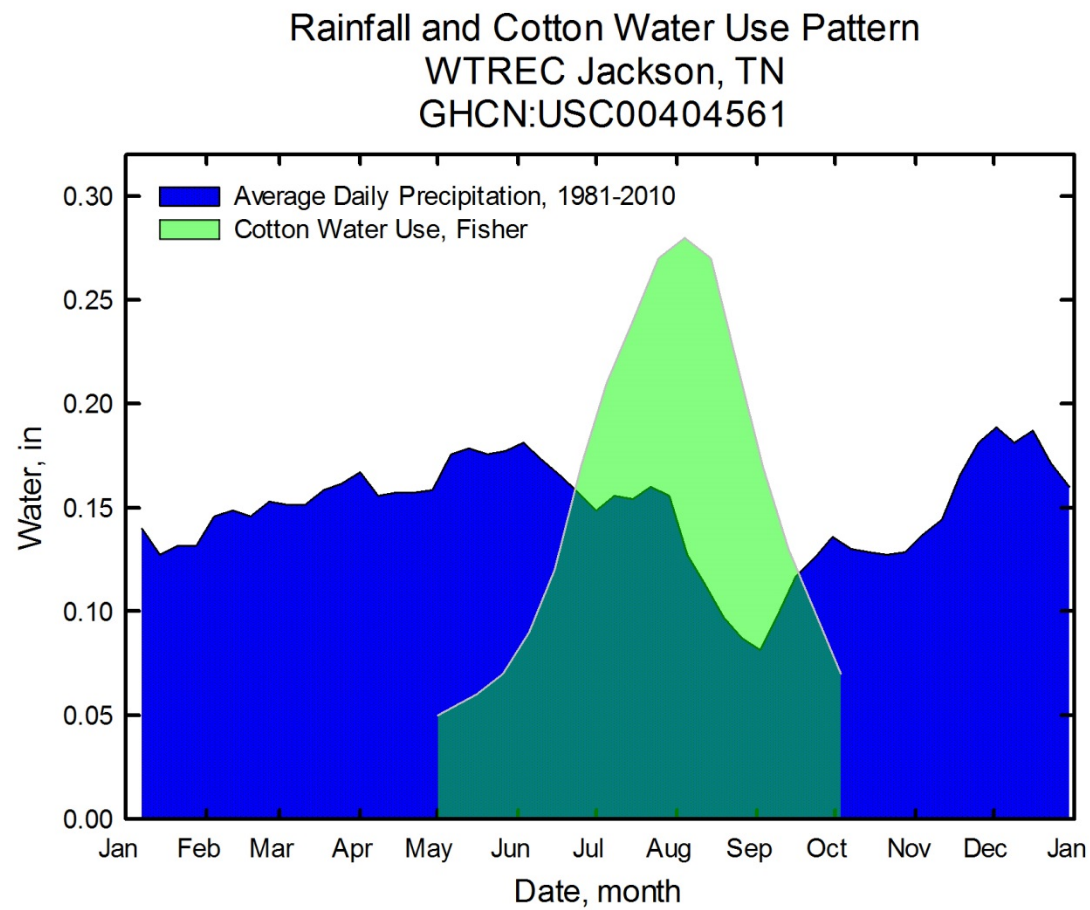


University of Georgia Extension publication.

Introduction

- Discrepancy between rainfall pattern and crop demand





Effective Rainfall

Benefits to Irrigating

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 as a Resource

- Recent emphasis placed on water use efficiency in the humid Mid-South and Southeast. In part due to:
  - Increasing conflicts over water in the arid Mid-West and Western United States
    - Glieck et al. (2003)
  - Unsustainable depletion of multiple Mississippi Delta Aquifers
    - USGS (2005)
    - Scott et al. (1998)
  - Supreme Court Case between GA and FL. Issues with Flint River Basin in GA. Suspension of new wells in this Basin.

Cotton Inc Water Strategy

Water Use Efficiency

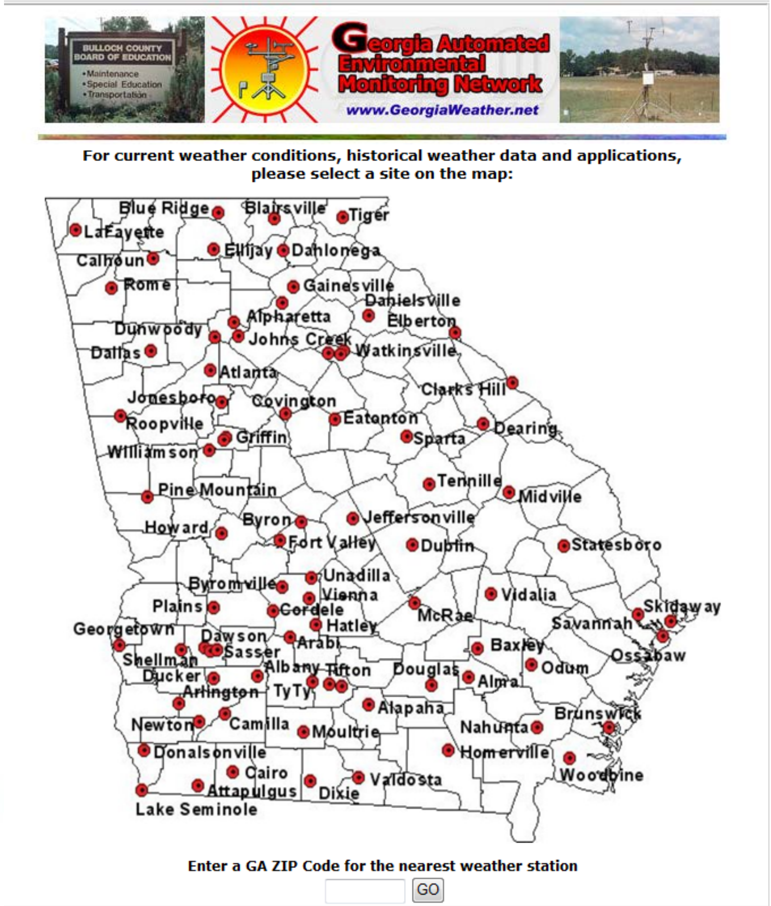
- Approaches to increase WUE in the Mid-South and Southeast:
  2. Better Irrigation Scheduling
     - Checkbook, time-interval methods currently used
       - » May not take into account water use of crop and/or atmospheric demand
       - » Use of some in-season measurement could increase WUE
  3. Selection/placement of more drought tolerant varieties
     - Could increase WUE of dryland and irrigated acres
       - less frequent, fewer events

Cotton App

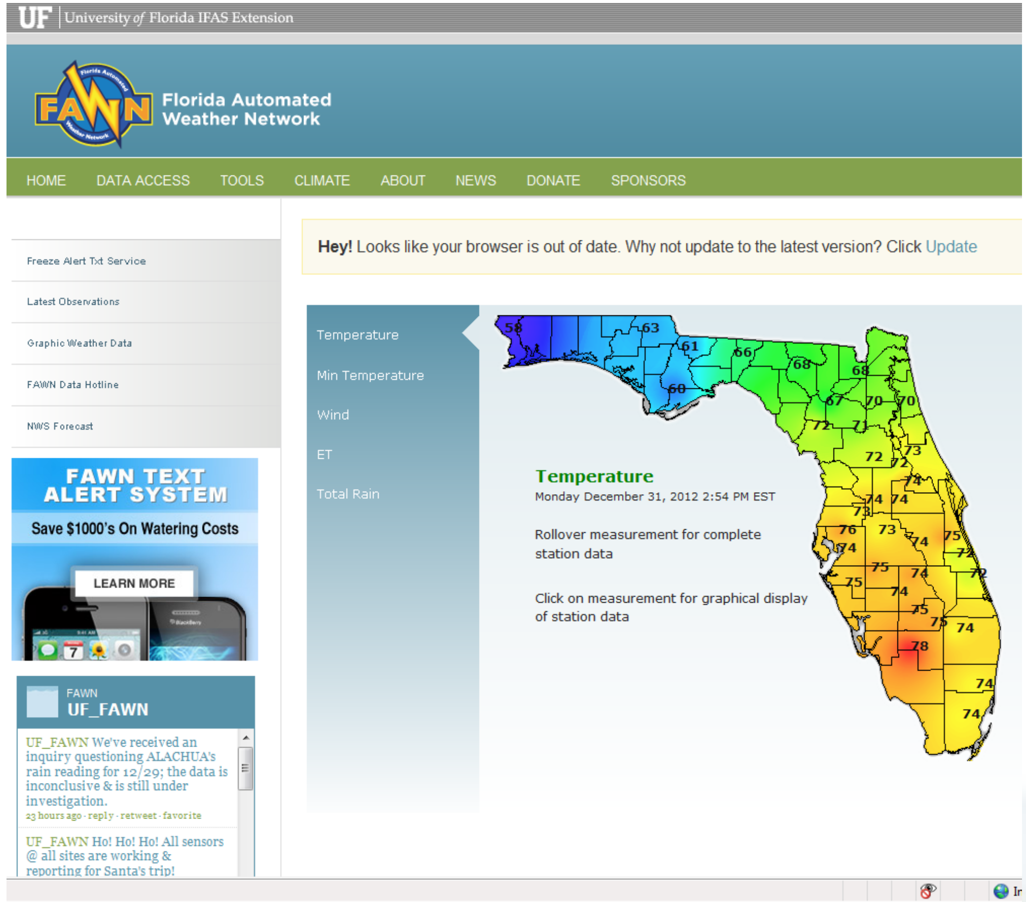
- Does not recommend irrigation amounts
- Advises user of Root Zone Water Deficient in terms of inches and % total
- Maximum Recommended Deficit is 50%
- Provides weekly (Monday-Sunday) estimated ET_{Cc}

Cotton App

GAEMN - Georgia Automated Environmental Monitoring Network



FAWN - Florida Automated Weather Network



In-season water status

Instrumentation capable of giving insight into drought stress:

- Atmometer
  - Mini-weather station
  - Capable of providing a reference ET (ETo)
  - 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 ETc

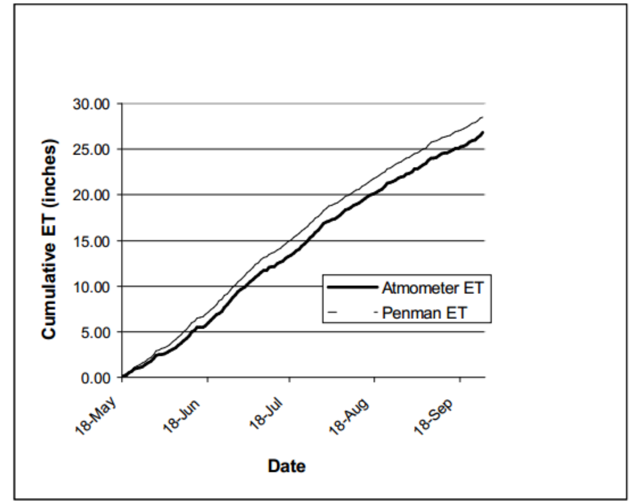


Figure 1: Comparison of Atmometer ET to Penman ET. Source: Bausch and Altenhofen.

In-season water status

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
  - Can schedule irrigations
    - Establish threshold buffer between canopy and air
    - Accumulate 'stress units' when buffer is violated
    - Trigger irrigation event when stress equals critical level

In-season water status

In-season water status

Instrumentation capable of giving insight to drought stress:

- Canopy Temperature
- Soil Moisture
  - Difficult to install
  - Very small sphere of influence
    - Requires fairly large deployments to accurately characterize status
    - Can interfere with row-traffic
  - Good relationship with soil moisture, plant water status
  - Gives insight into water availability even under cloudy conditions

In-season water status

Instrumentation capable of giving insight to drought stress:

- Canopy Temperature
- 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?

In-season water status

Many low-cost soil moisture sensors have been introduced into the market recently. These include:

- Decagon EC-5, 10HS, 5TE (Decagon Devices, Inc., Pullman, WA)
  - Dielectric Permittivity, capacitance-based sensor
  - Estimates volumetric water content

- Vegetronix VH400 (Vegetronix, Inc., Riverton, UT)
  - Dielectric Permittivity, capacitance-based sensor
  - Estimates volumetric water content

- Watermark 200SS (Irrometer Company, Inc., Riverside, CA)
  - Solid-state, resistance block sensor
  - Estimates water potential of soil from 0-200 cb

In-season water status

Sensor Response over Time

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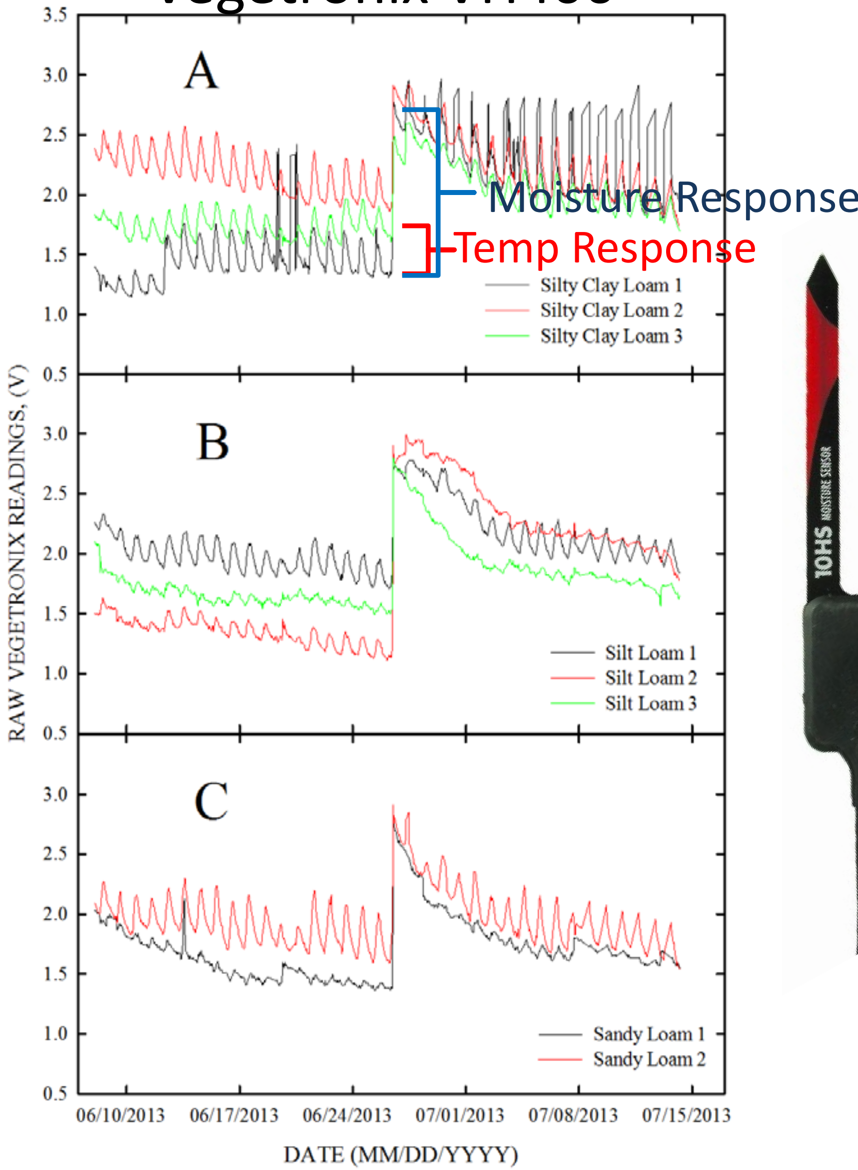
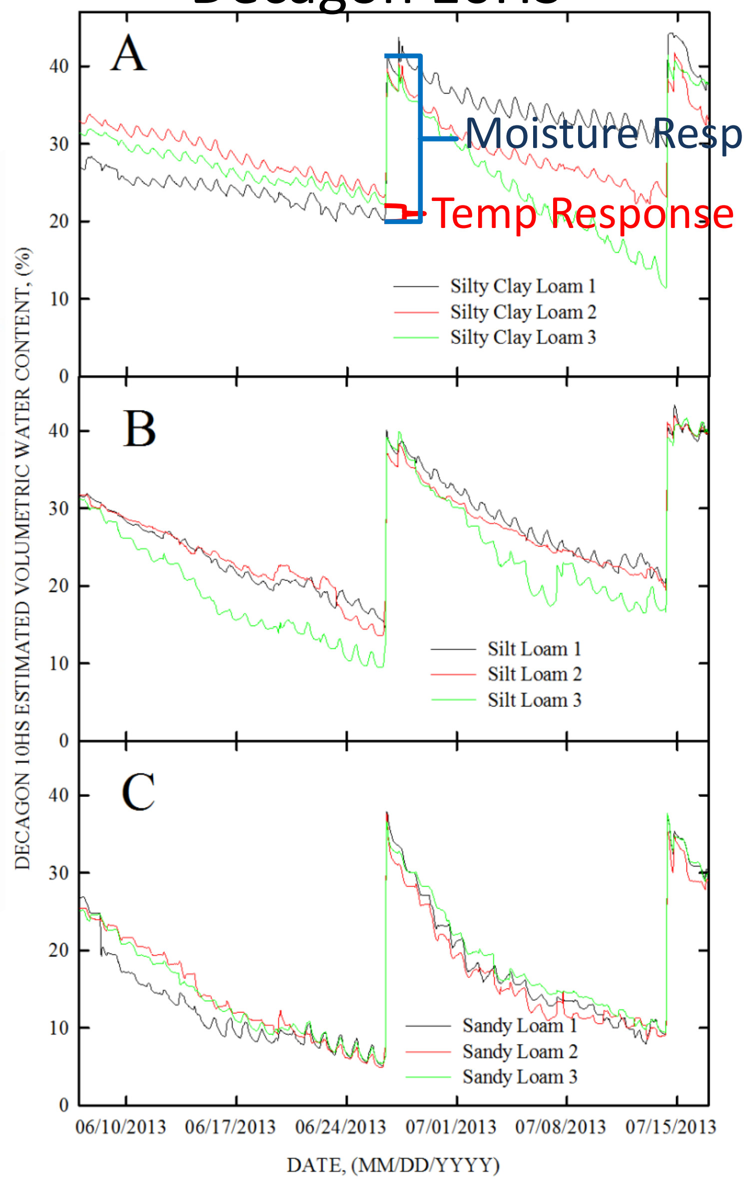
Vegetronix VH400



Decagon 10HS



Sensor Response over Time

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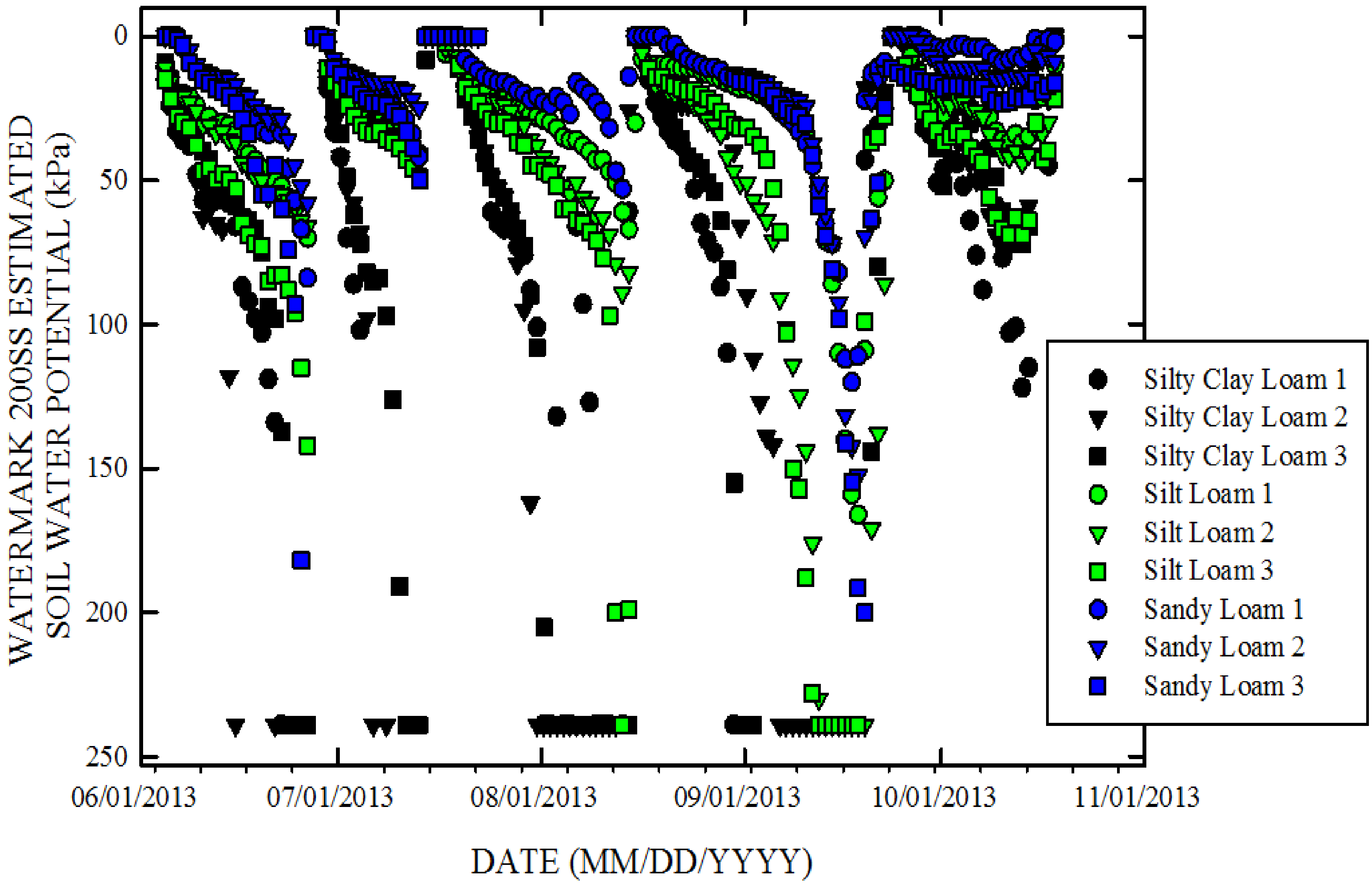
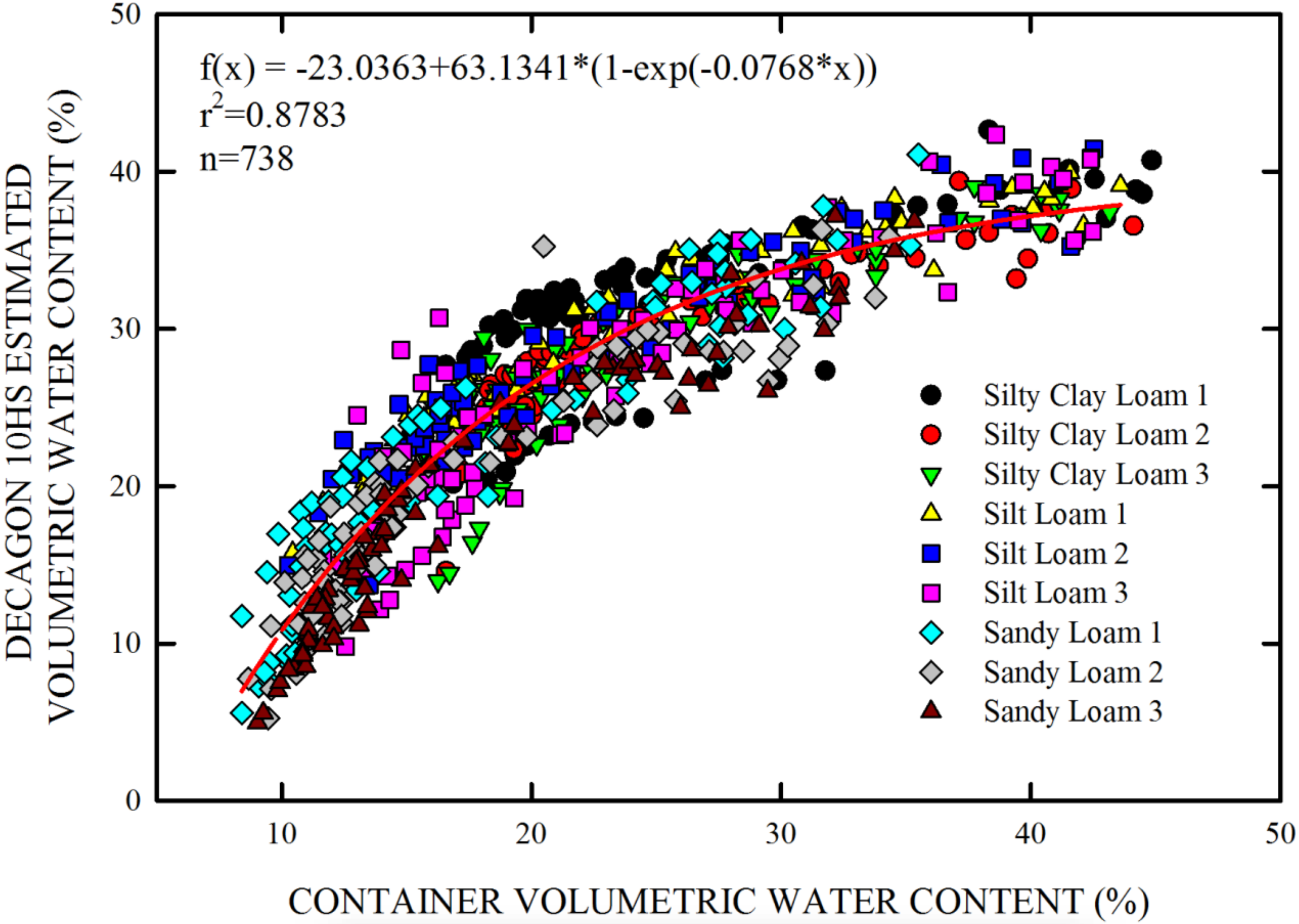


Sensor Response to VWC



In-season water status

Preliminary data suggests VWC sensors are:

- Precise
  - readings have the same meaning throughout the growing season
- Accurate? Not exactly . . .
  - Need to improve here!
  - Readings may not mean the same from location t location, will require deployment-by-deployment calibration

It will be difficult to use water potential sensors under dry conditions.

Water Use Efficiency

- Approaches to increase WUE in the Mid-South and Southeast:

  2. Better Irrigation Scheduling
     – Checkbook, time-interval methods currently used
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  3. Selection/Placement of more drought tolerant varieties
     - Could increase WUE of dryland and irrigated acres
       – less frequent, fewer events

Increasing System WUE

- Currently characterized by dryland variety trials
  - Difficult to combine yield response across sites, seasons
- Rapid varietal turnover
  - Bollgard I to II, III coming 2015/2016- Bollguard IV in development
  - New drought tolerant genes in near future?
  - Producers need robust, rapid drought tolerance information
    - Not possible without accurate measure of in-field drought status

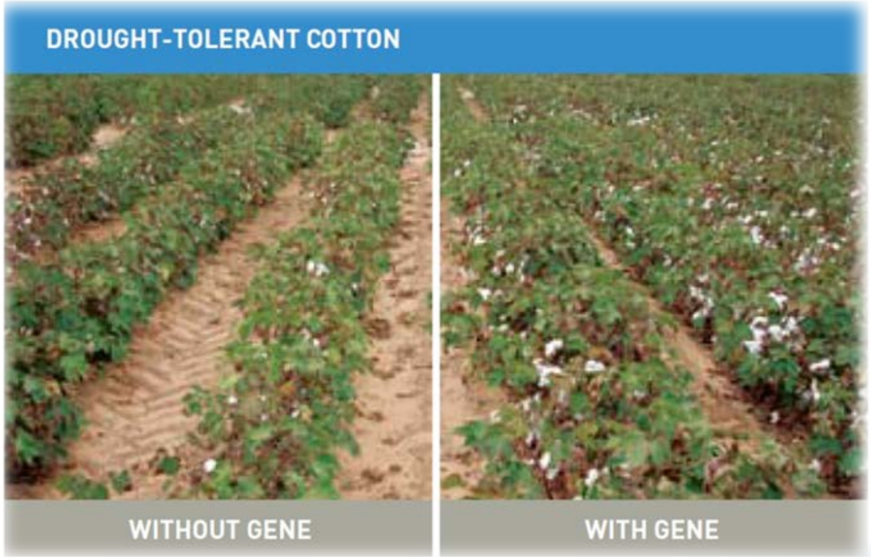
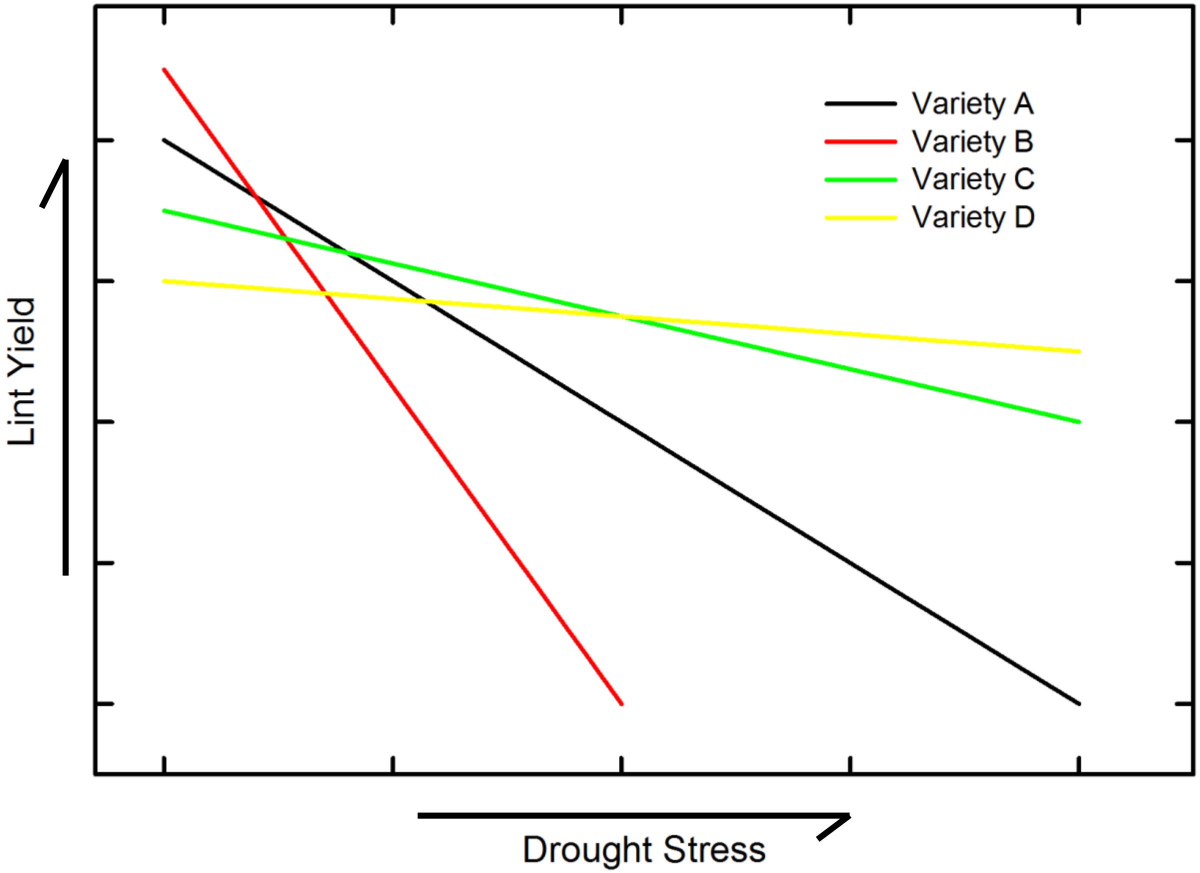


Image Courtesy: BASF/Monsanto

Increasing System WUE



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2012 UNITED STATES COTTON PRODUCTION

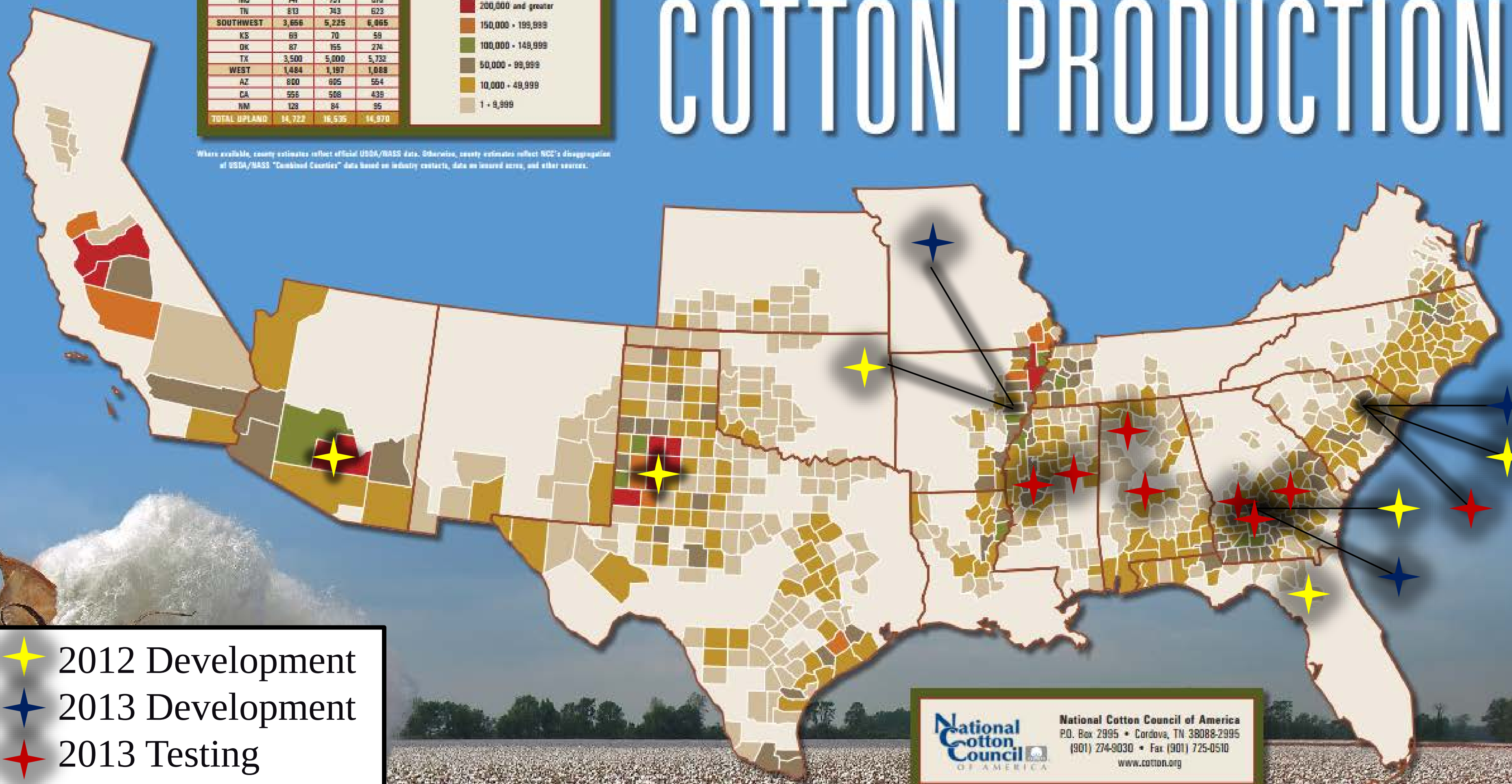
CROP	2011	2012	Average 07-11
UPLAND			
SOUTHEAST	5,040	5,871	3,868
AL	685	745	479
FL	183	200	137
GA	2,465	2,910	1,967
NC	1,026	1,225	856
SC	519	593	302
VA	162	198	128
MID-SOUTH	4,542	4,242	3,949
AR	1,277	1,297	1,299
LA	511	478	455
MS	1,200	993	893
MO	741	731	678
TN	813	743	623
SOUTHWEST	3,656	5,225	6,065
KS	69	70	59
OK	87	155	274
TX	3,500	5,000	5,732
WEST	1,484	1,197	1,088
AZ	800	605	554
CA	556	508	439
NM	128	84	95
TOTAL UPLAND	14,722	16,535	14,970

CROP	2011	2012	Average 07-11
ELS	851	780	608
AZ	20	7	7
CA	785	753	561
NM	6	5	5
TX	40	15	34
ALL COTTON	15,573	17,315	15,577

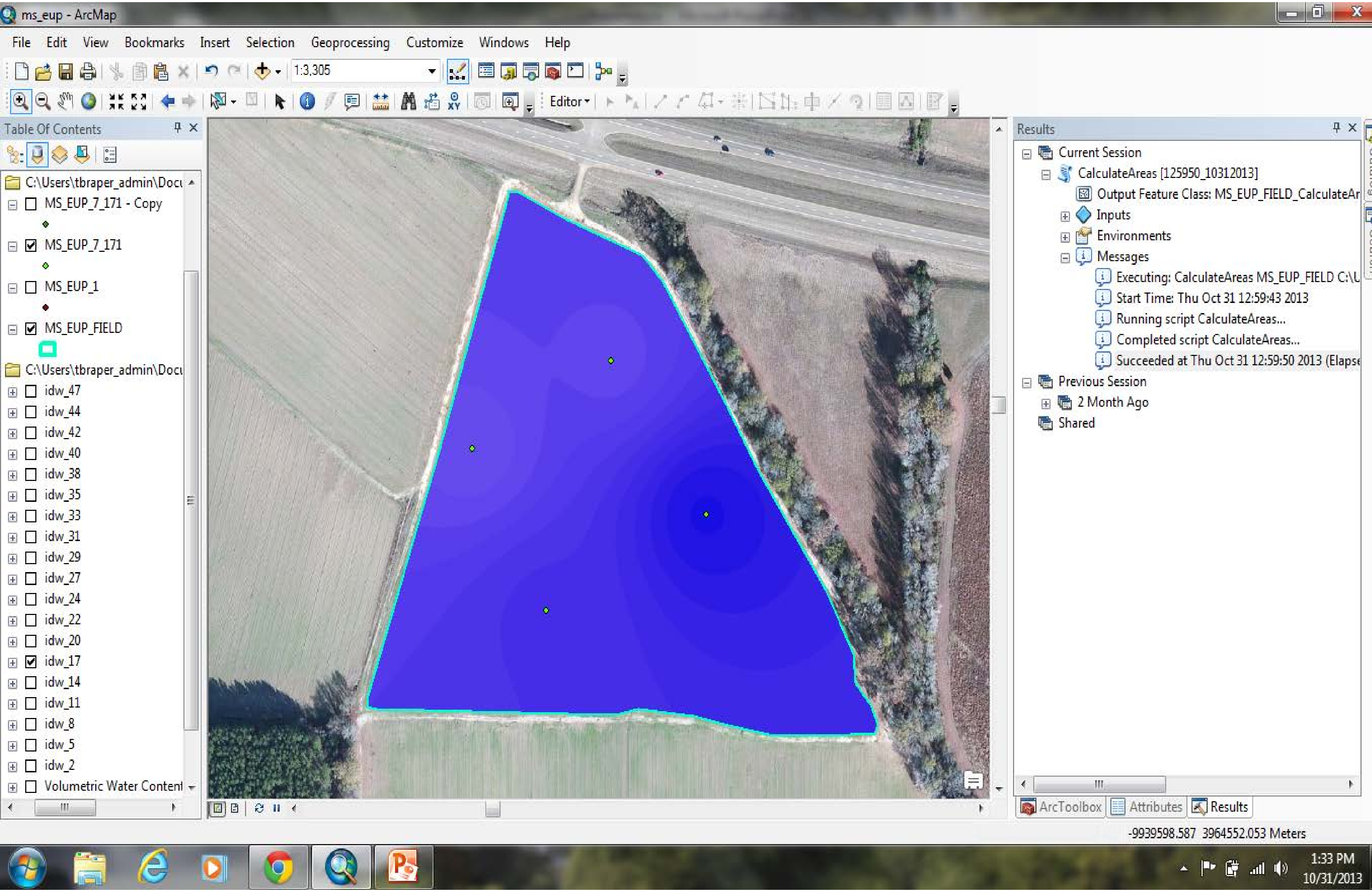
2012 UNITED STATES COTTON PRODUCTION
1000 (480-Lb. Bales)

- 200,000 and greater
- 150,000 - 199,999
- 100,000 - 149,999
- 50,000 - 99,999
- 10,000 - 49,999
- 1 - 9,999

Where available, county estimates reflect official USDA/NASS data. Otherwise, county estimates reflect NCC's disaggregation of USDA/NASS "Combined Counties" data based on industry contacts, data on insured acres, and other sources.



2012 Development
2013 Development
2013 Testing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Wrapping Up

- 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 with many of these instruments
  - These can help us understand when to start, how long we can wait between events, and when to terminate-
    - Ultimately, increasing water use efficiency and reduce economic risks associated with production

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