



Water Management: Precision Irrigation Scheduling and Site Drought Characterization

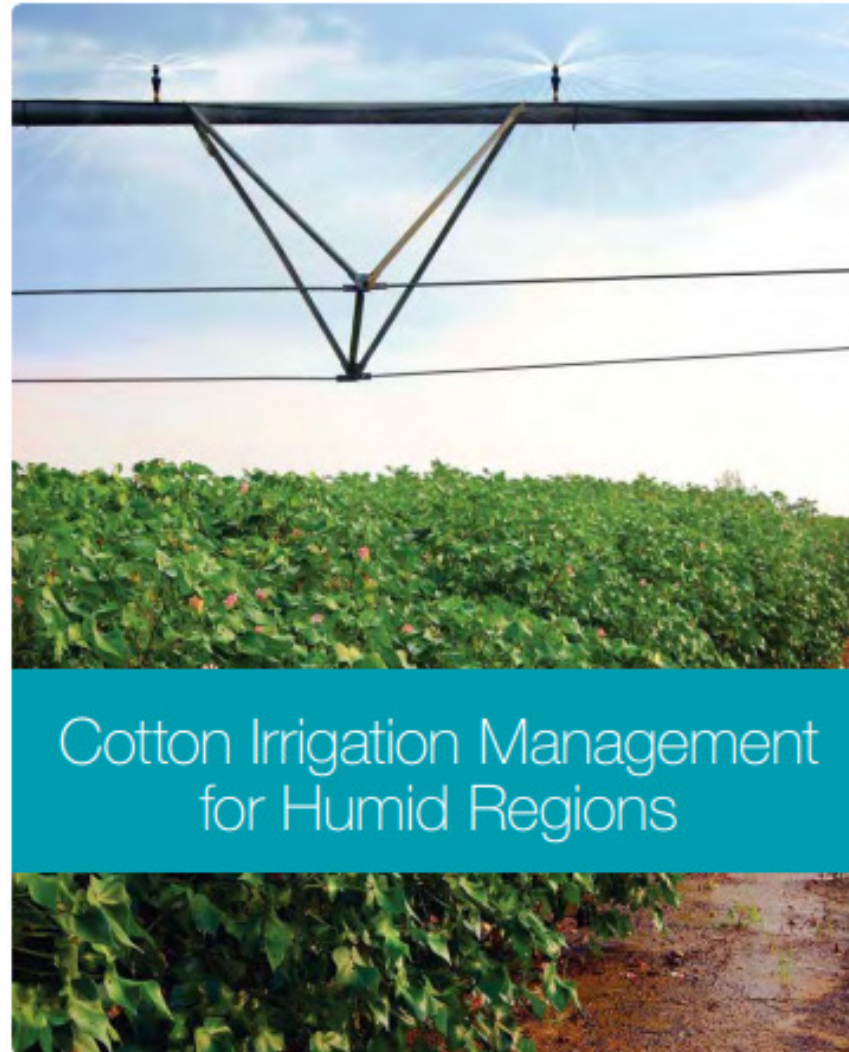
Tyson B. Raper

Cotton and Small Grains Specialist
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





Cotton Irrigation Management for Humid Regions

Introduction

Plant Physiological Response to Water Deficit The Onset of Water Stress

Process Affected (in order)

Cell growth (division & enlargement)

Proteins

Enzymes affected (e.g for N)

Hormones (Absciscic acid)

Stomatal closure

Photosynthesis decreased

Sugar concentration decreased

= YIELD REDUCTION

Increasing severity of stress

By the time wilting occurs,
the stomates have closed
and photosynthesis and
yield have been affected





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):

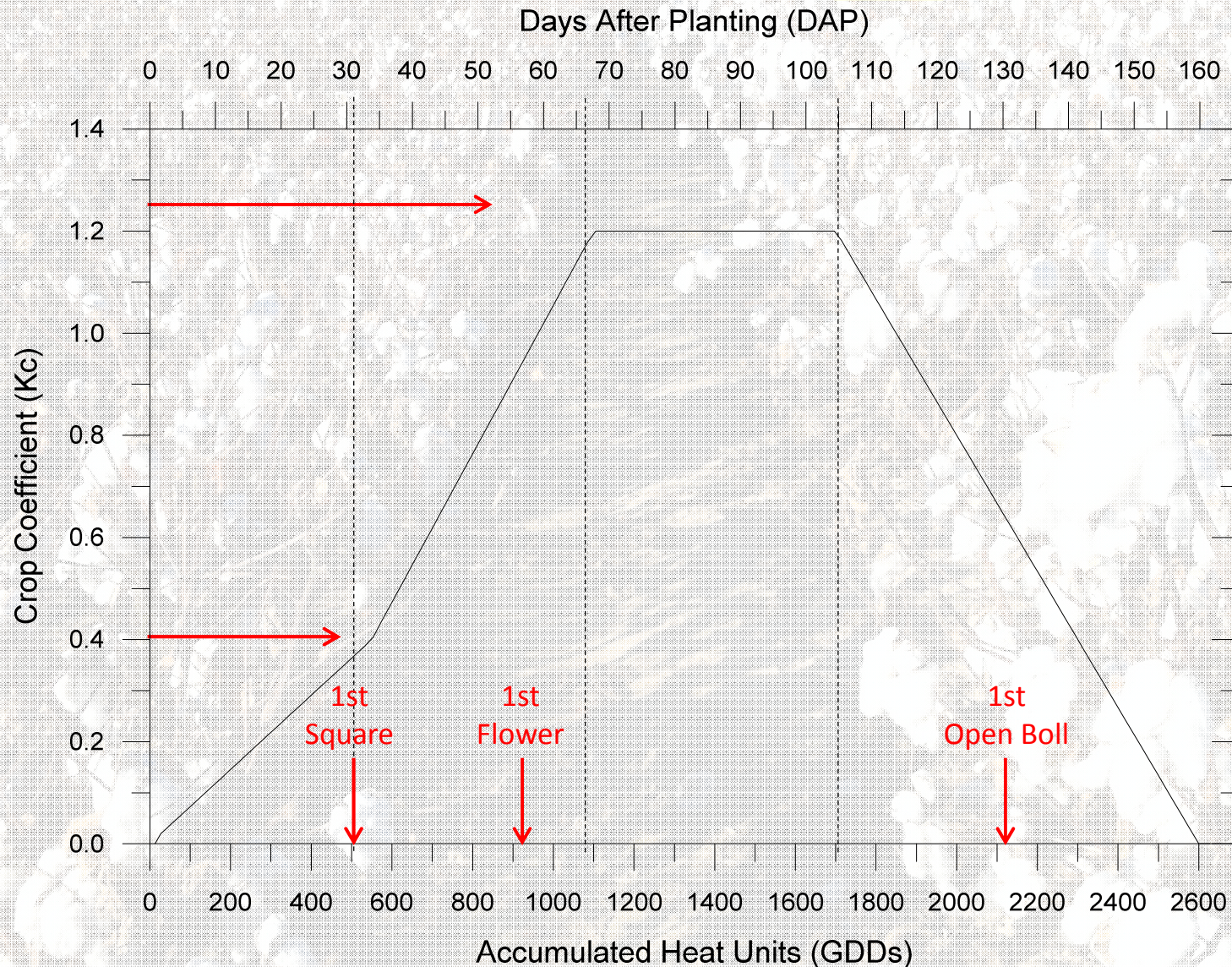
$$ET_c = ET_o \times K_c$$

- Where:

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

Determining the Kc Curve

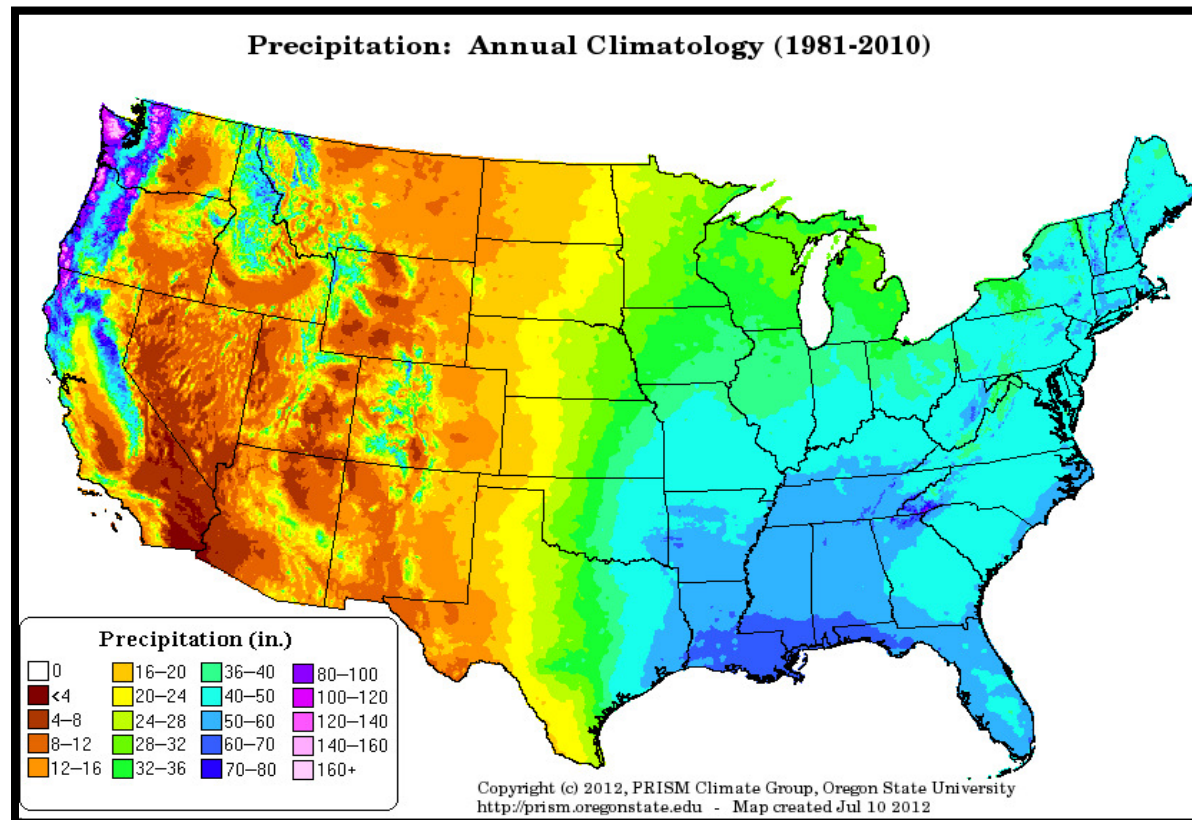
$$ET_c = ET_o \times Kc$$



Environmental Demand

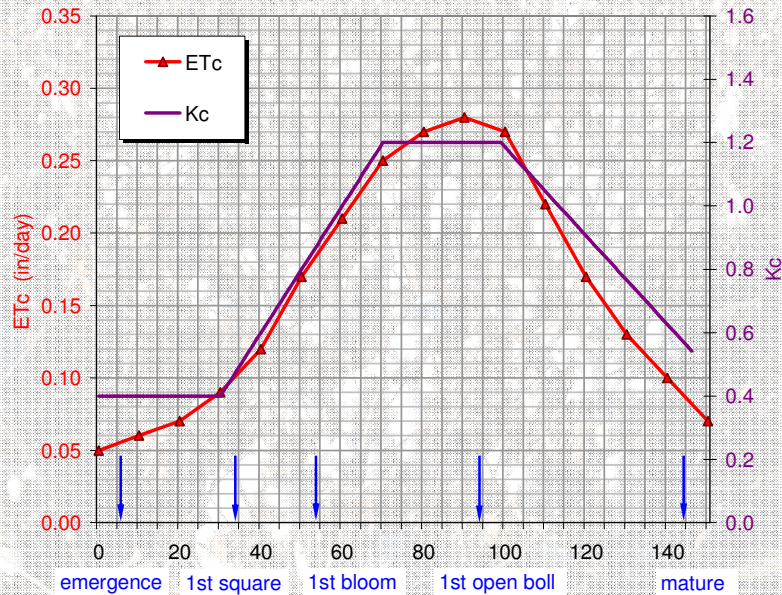
$$ET_c = ET_o \times K_c$$

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

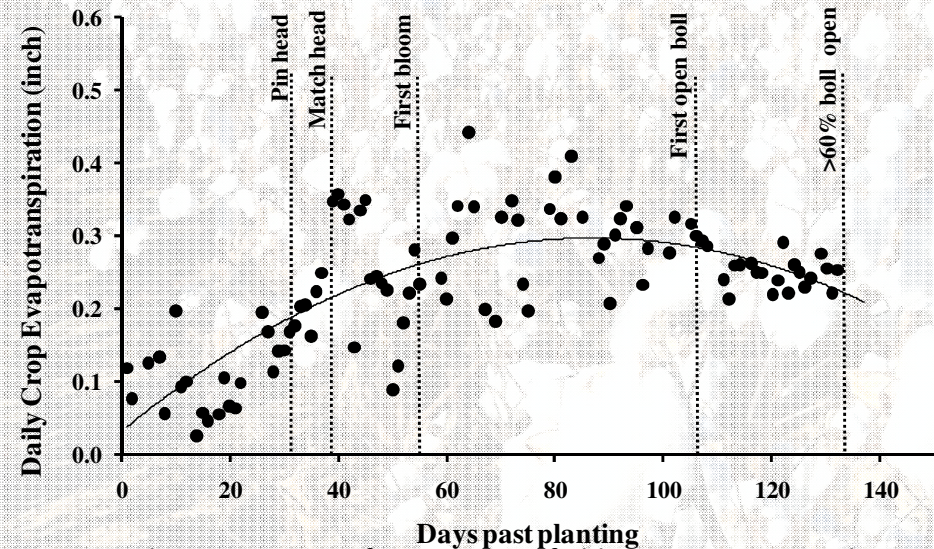
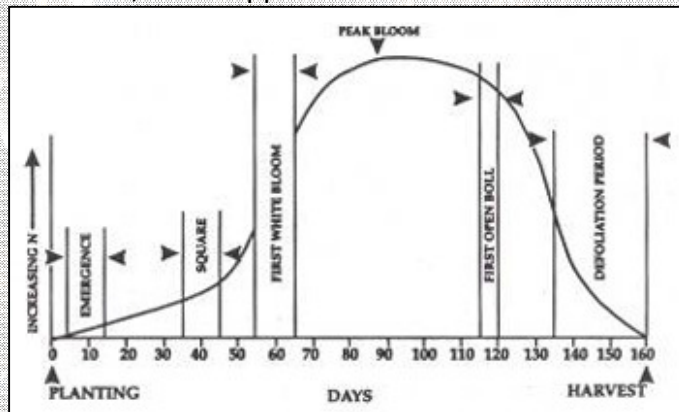


Determining the Kc Curve

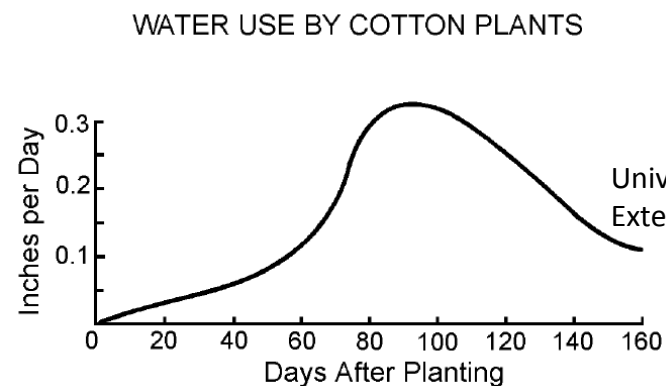
$$ET_c = ET_o \times K_c$$



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

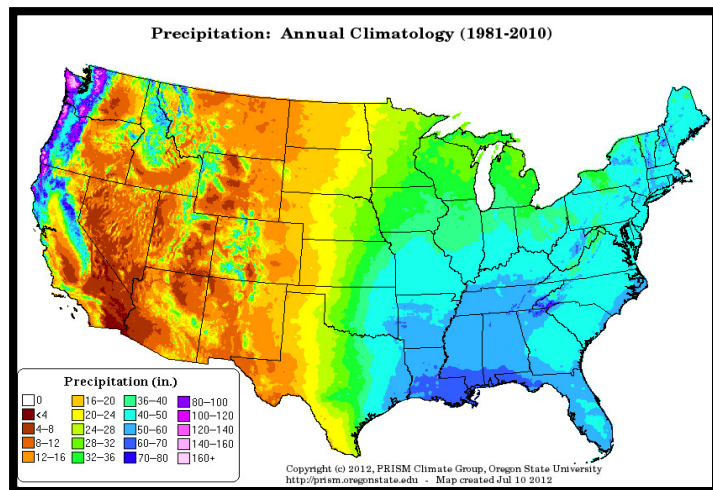


Measured crop water use from a cotton field in Louisiana over the growing season.

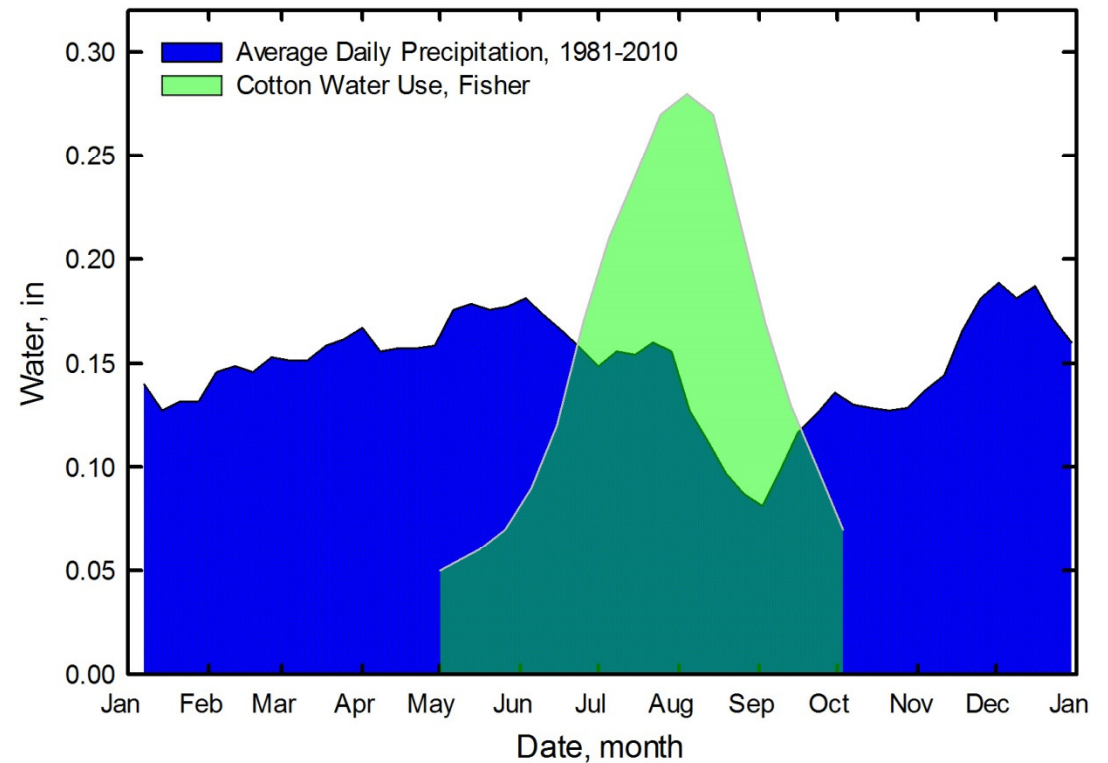


Introduction

- Discrepancy between rainfall pattern and crop demand



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



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.



The screenshot shows the AGWEB website interface. At the top, there are navigation links for various agricultural topics: AGWEB, FARM JOURNAL, Legacy Project, Top Producer, Dairy, Beef Today, Profit Farmer, and AGDA. Below these is a date bar for March 3, 2014, and a row of links: Home, Tools, Events, Blogs, Discussions, and Sign Up. A main navigation bar includes News, Weather, Markets, Crops, Livestock, Business, and a partially visible 'La' link. Below the navigation bar is a social media sharing section with links for Facebook, Twitter, a general Share button, Email, and Print. The main article headline is 'Drought Means No U.S. Water Delivery for California Farmers', dated February 22, 2014, by Bloomberg. The article text states that farmers in California's Central Valley will not receive the water they requested due to a drought. A photograph of a large splash of water is visible on the left side of the article. The right side of the screenshot shows a partial view of a sidebar with a 'MO' heading and a list of links.

AGWEB FARM JOURNAL Legacy Project Top Producer Dairy Beef Today Profit Farmer AGDA

Mar 3, 2014 Home Tools Events Blogs Discussions Sign Up

AGWEB POWERED BY FARM JOURNAL News Weather Markets Crops Livestock Business La

Facebook Twitter Share Email Print (1 Comment)

Drought Means No U.S. Water Delivery for California Farmers

FEBRUARY 22, 2014
By: Bloomberg



Farmers in California's Central Valley, the world's most productive agricultural region, will get none of the water they requested this year from a federally controlled system because of the drought gripping the state.

Feb. 21 -- Farmers in California's Central Valley, the world's most productive agricultural region, will get none of the water they

Cotton Inc Water Strategy

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:

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}

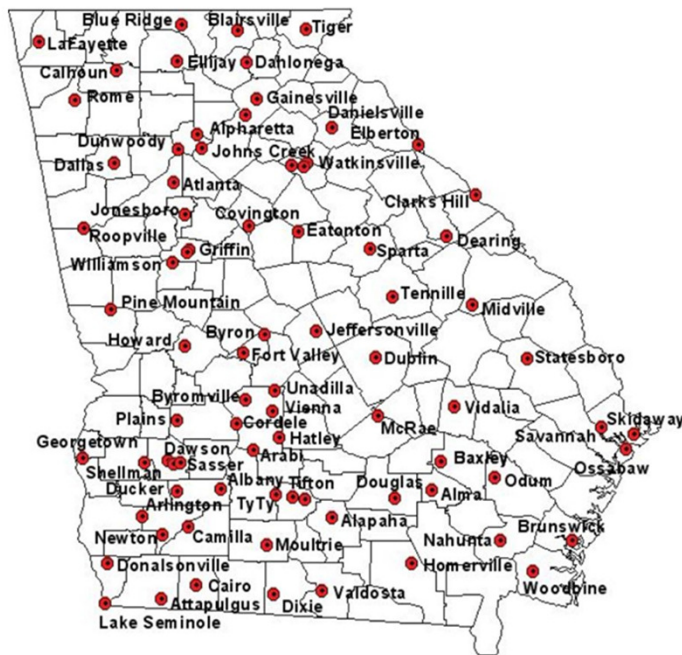


Cotton App

GAEMN - Georgia Automated Environmental Monitoring Network



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

FAWN - Florida Automated Weather Network



Florida Automated Weather Network

[HOME](#)
[DATA ACCESS](#)
[TOOLS](#)
[CLIMATE](#)
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Hey! Looks like your browser is out of date. Why not update to the latest version? [Click Update](#)

Freeze Alert Txt Service

Latent Observations

Graphic Weather Data

FAWN Data Hotline

NWS Forecast

FAWN TEXT ALERT SYSTEM

Save \$1000's On Watering Costs

[LEARN MORE](#)

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!

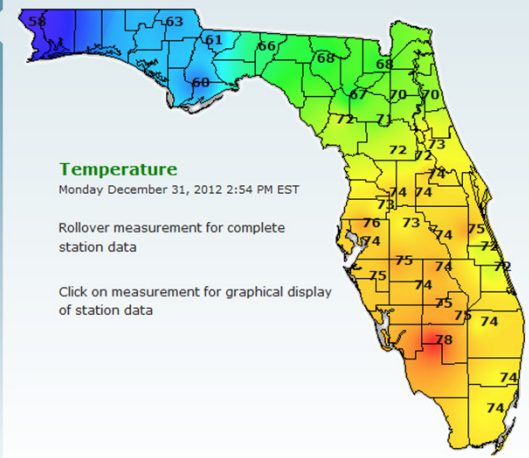
Temperature

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



In-season water status

Instrumentation capable of giving insight into drought stress:

- Atmometer
 - Mini-weather station
 - Capable of providing a reference ET (ET_o)
 - 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_c

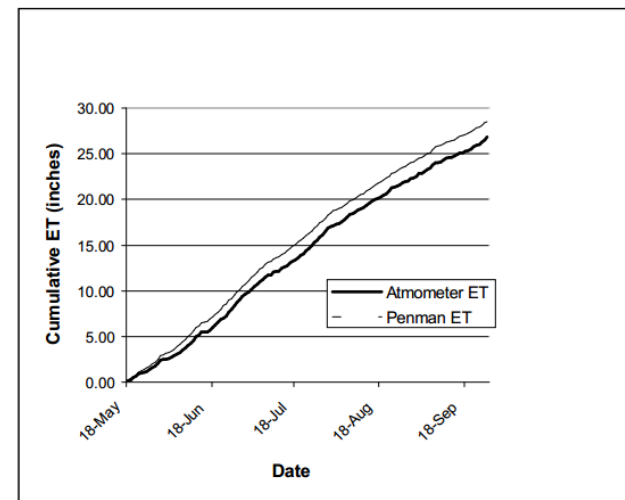
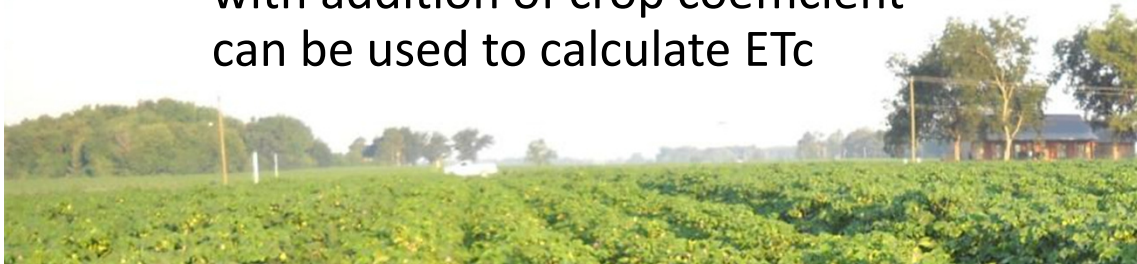


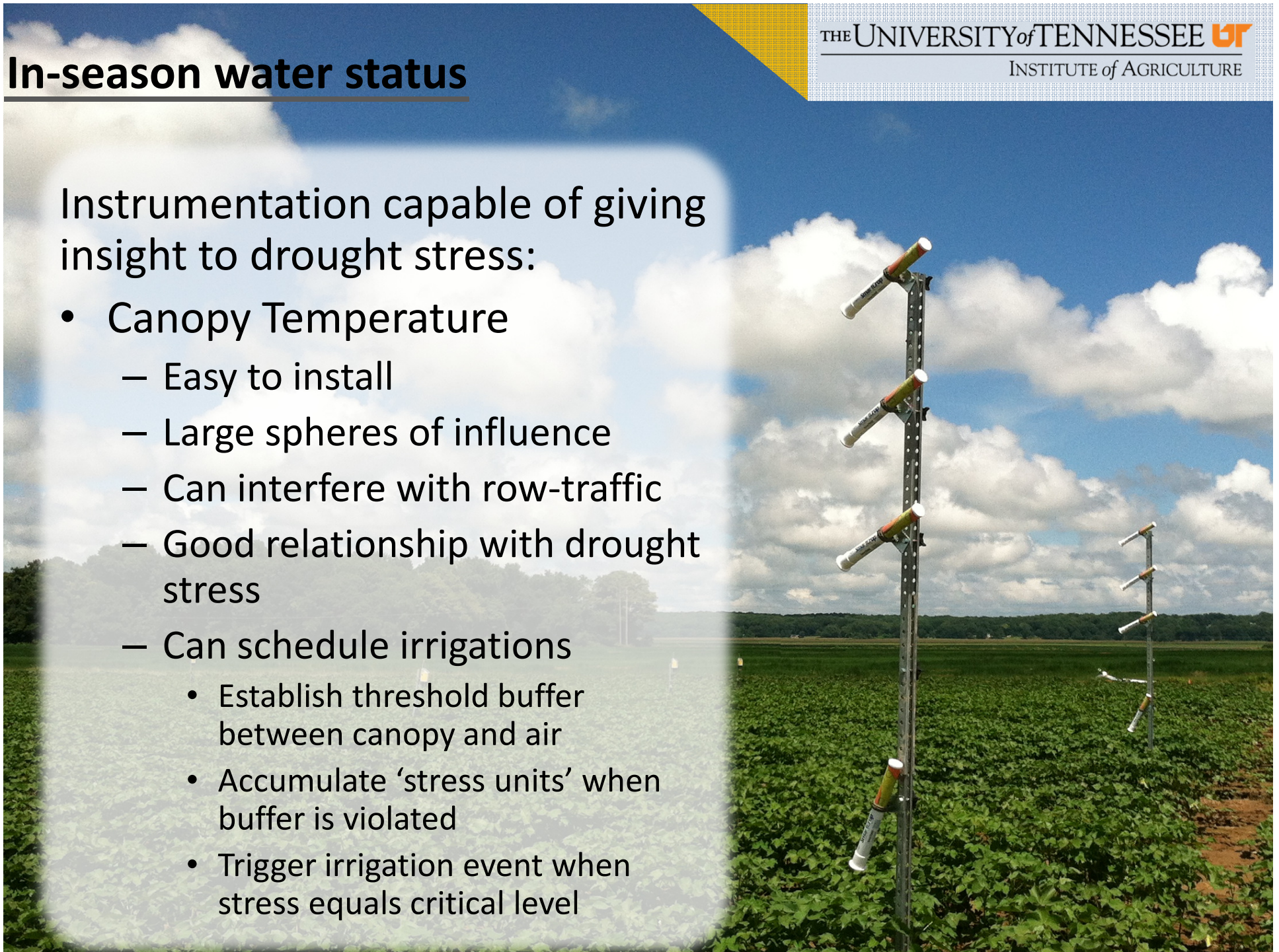
Figure 1: Comparison of Atmometer ET to Penman ET. Source: Bausch and Altenhofen.



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

AgroFresh Invinsa Trigger, Timing Trial

FAYETTEVILLE, AR
26 August 2013

WINGSCAPES™

5 MINUTES

TL CAM

AUG.26,13

03:30 PM



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:

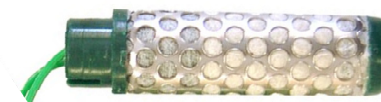
- Canopy Temperature
- Soil Moisture
 - What type of sensor should I use?
 - What does the reading mean?
 - How many do I need to install?
 - What depths?
 - Are readings similar from sensor to sensor?



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

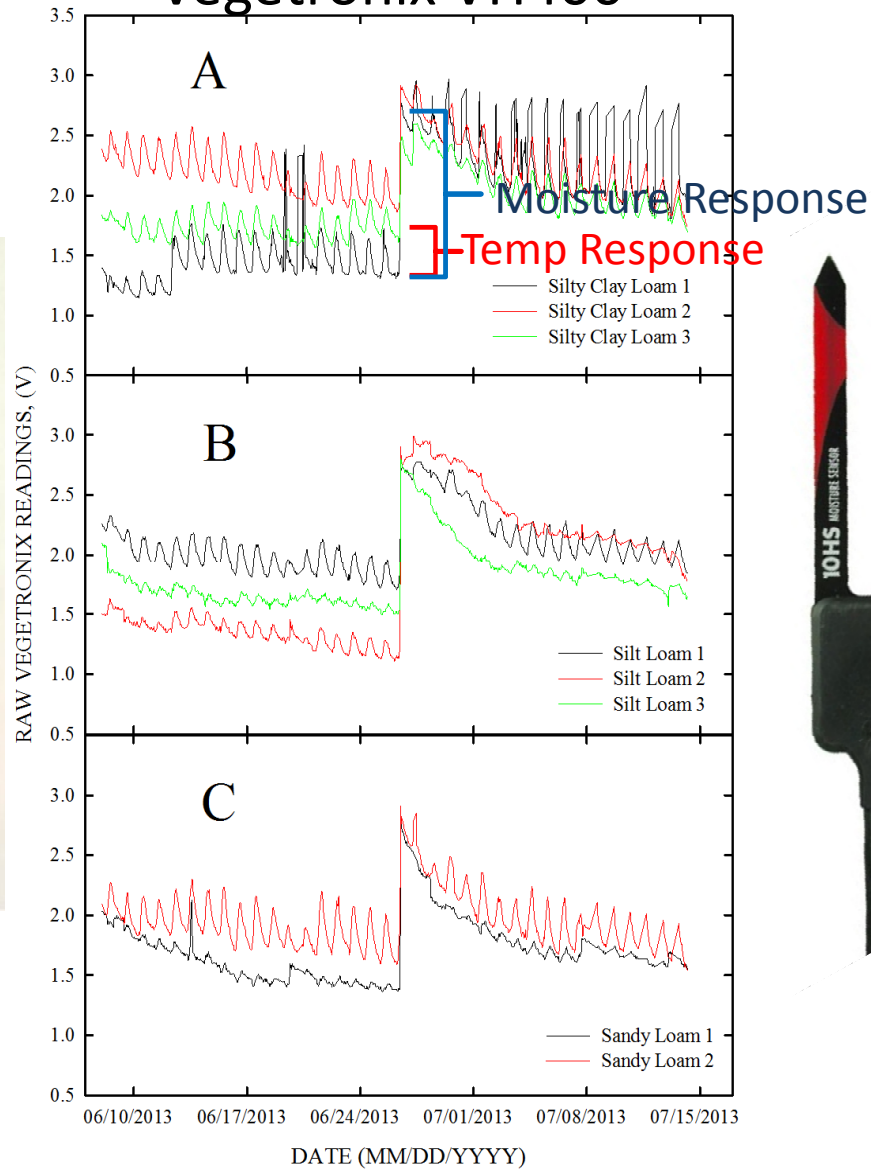
THE UNIVERSITY of TENNESSEE 
INSTITUTE of AGRICULTURE



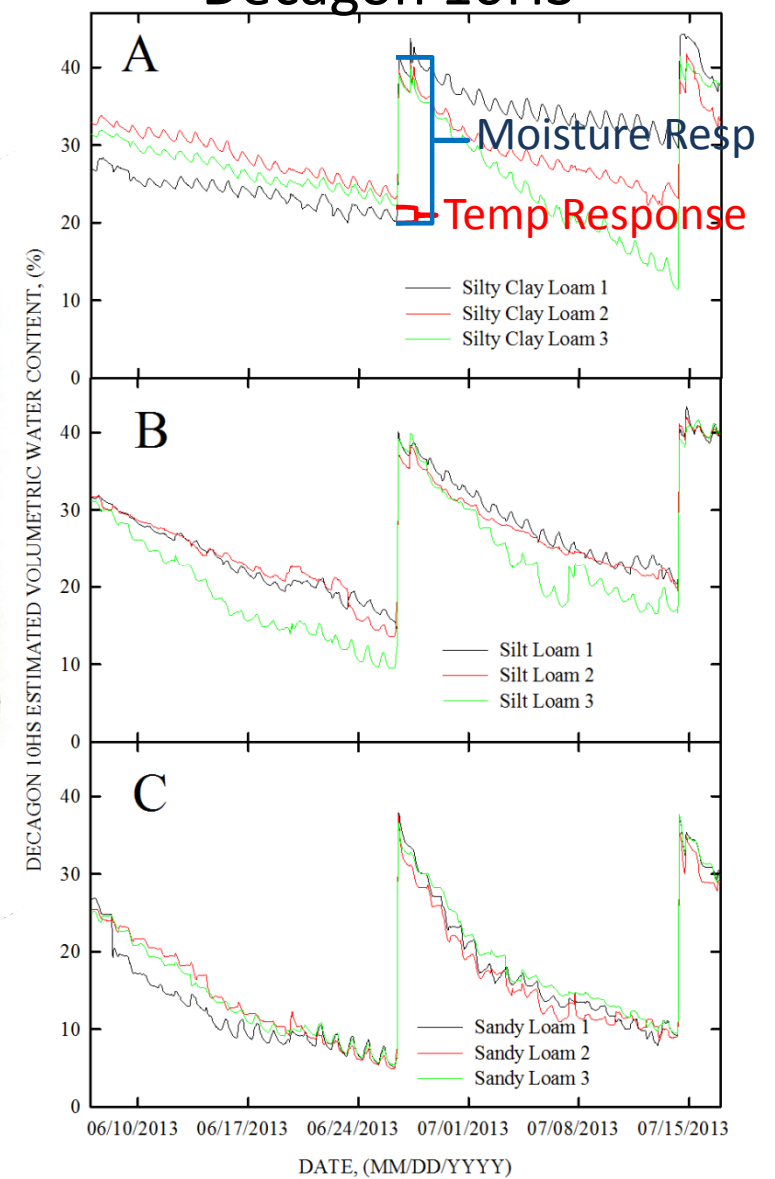
Sensor Response over Time



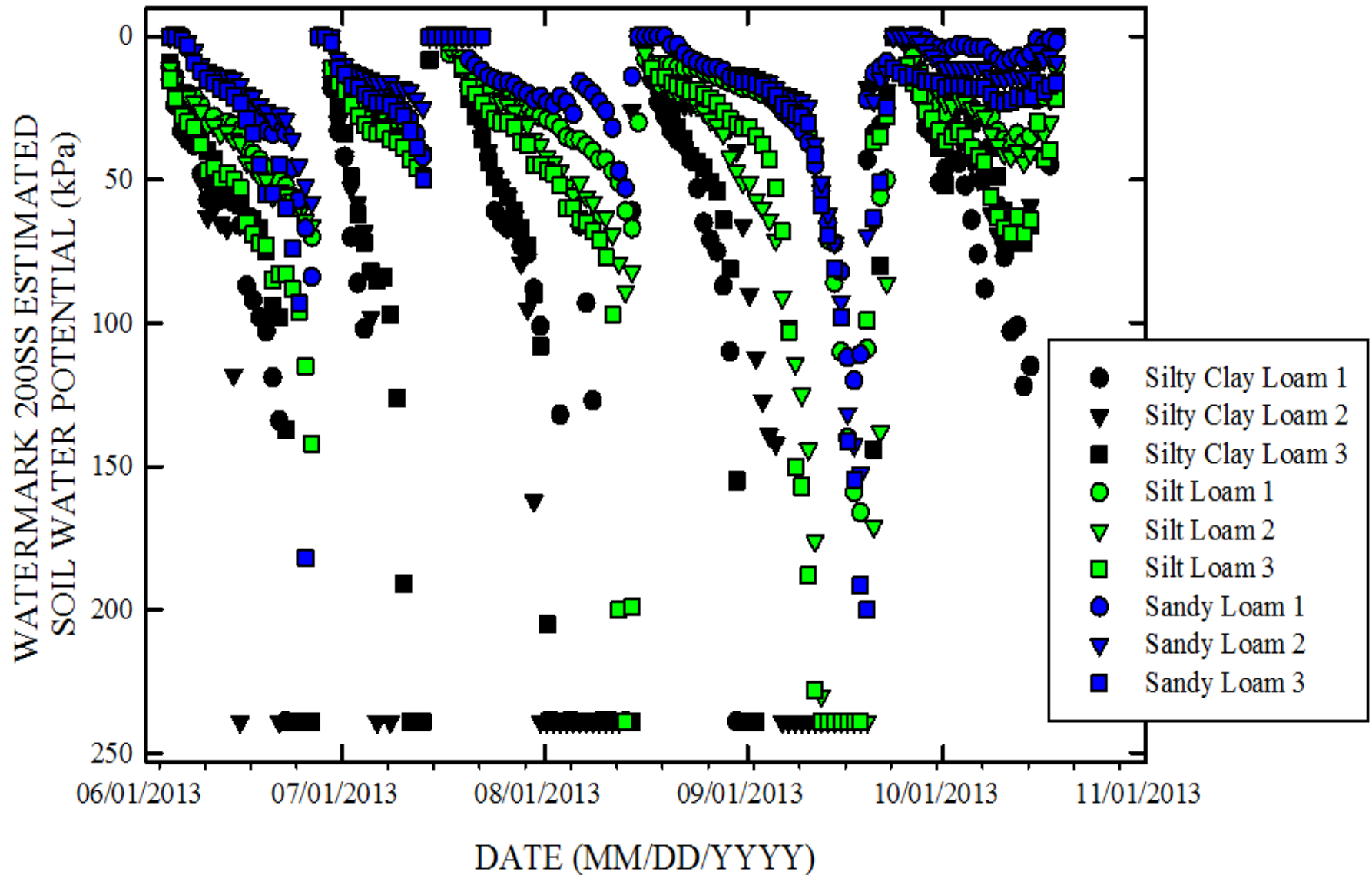
Vegetronix VH400



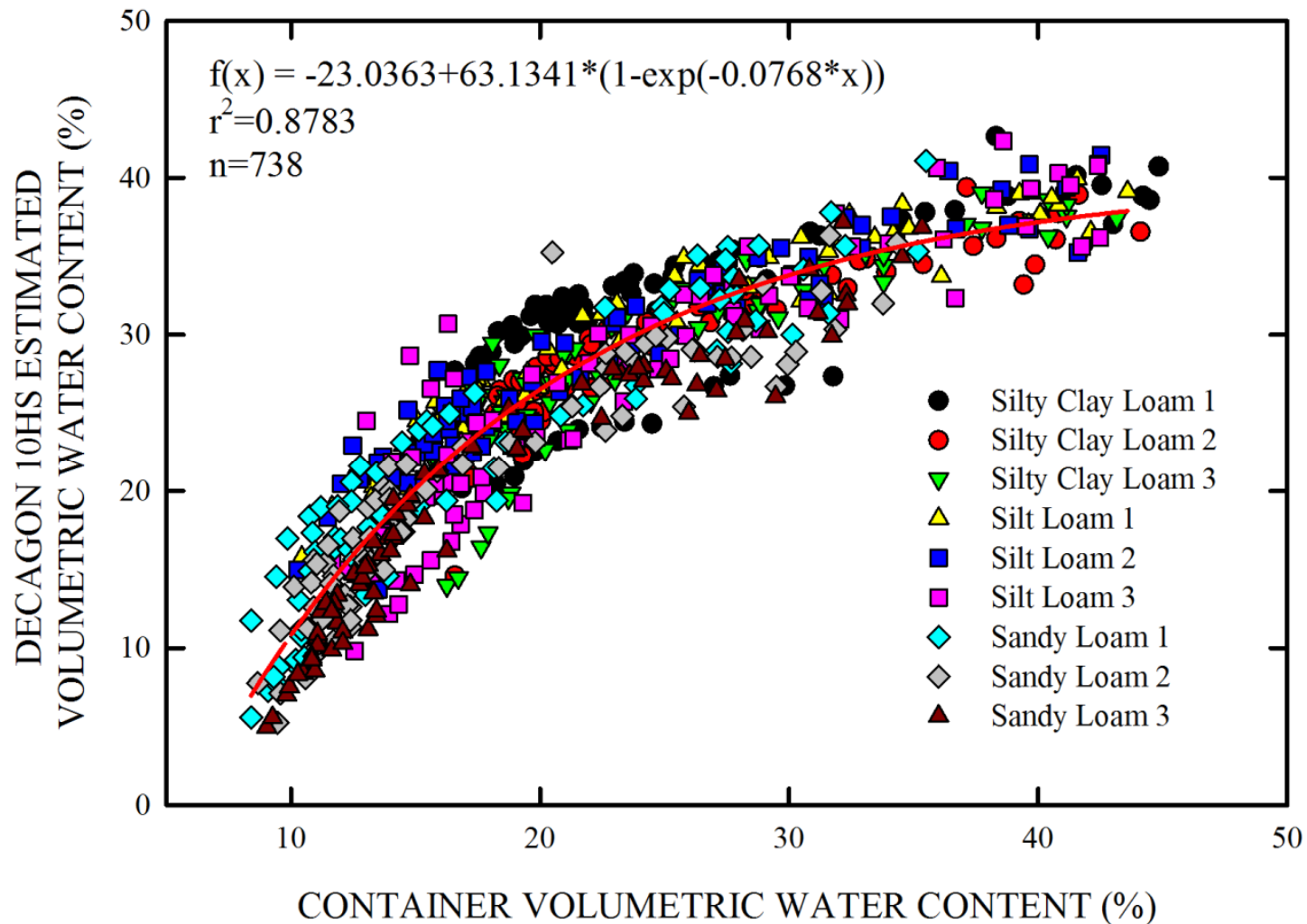
Decagon 10HS



Sensor Response over Time



Sensor Response to VWC



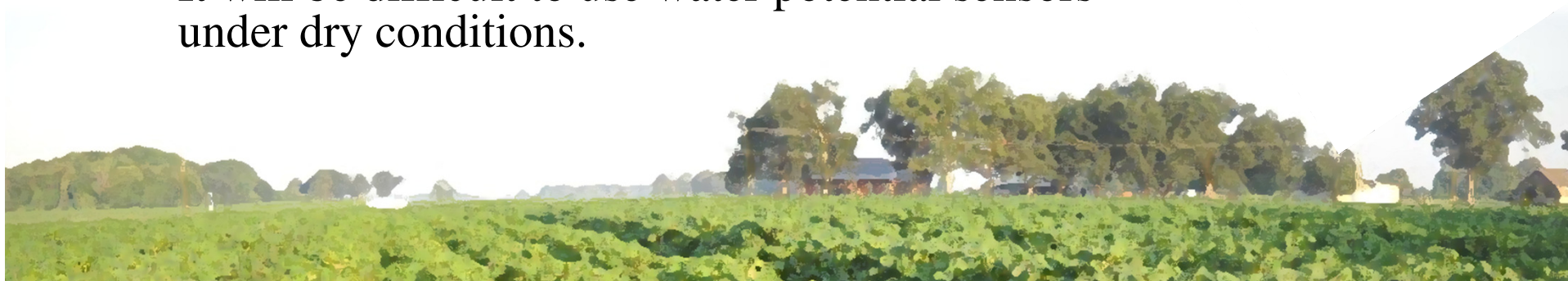
In-season water status

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 to 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
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Cotton Incorporated's Water Strategy



Maximize Rainfall Capture



Optimize Irrigation Water



Increase Plant Water Use Efficiency



Evaluate with Credible Metrics



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

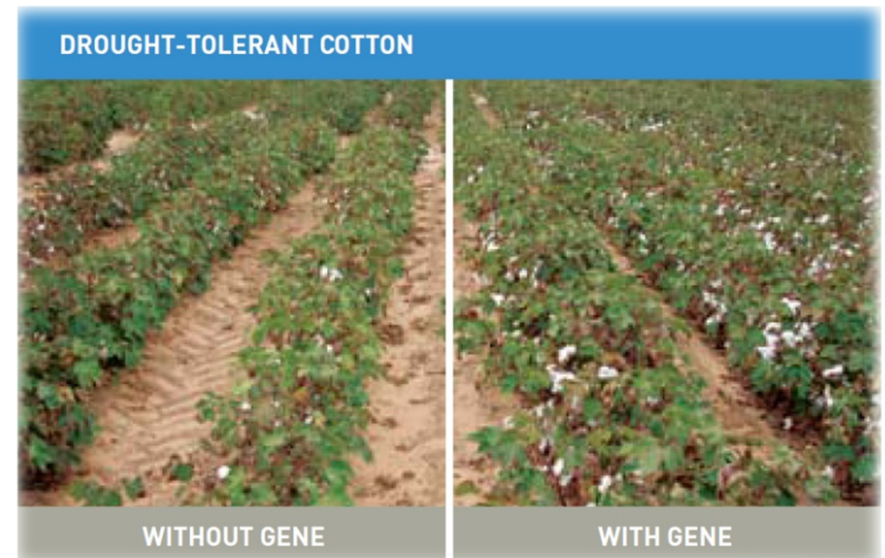
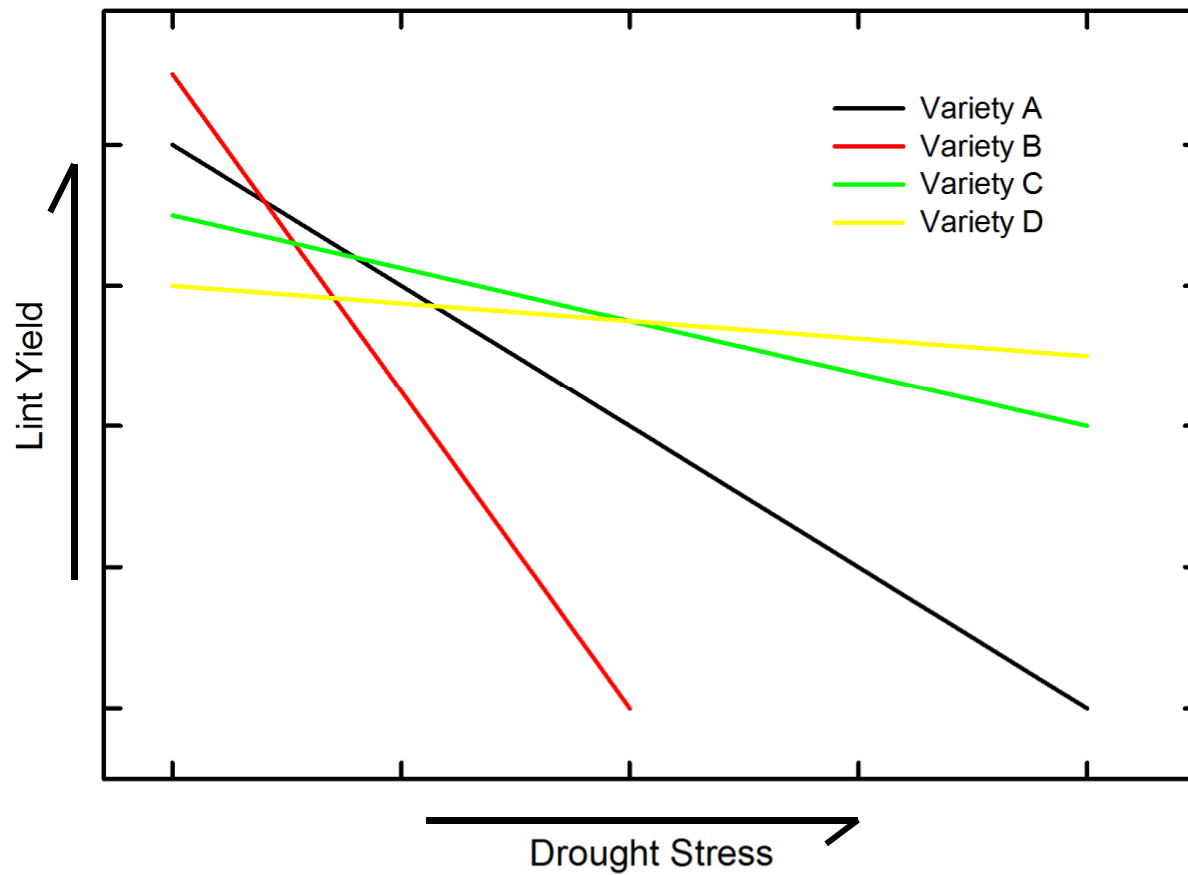


Image Courtesy: BASF/Monsanto



Increasing System WUE



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Cotton
Incorporated



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ALABAMA AGRICULTURAL
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EXTENSION**

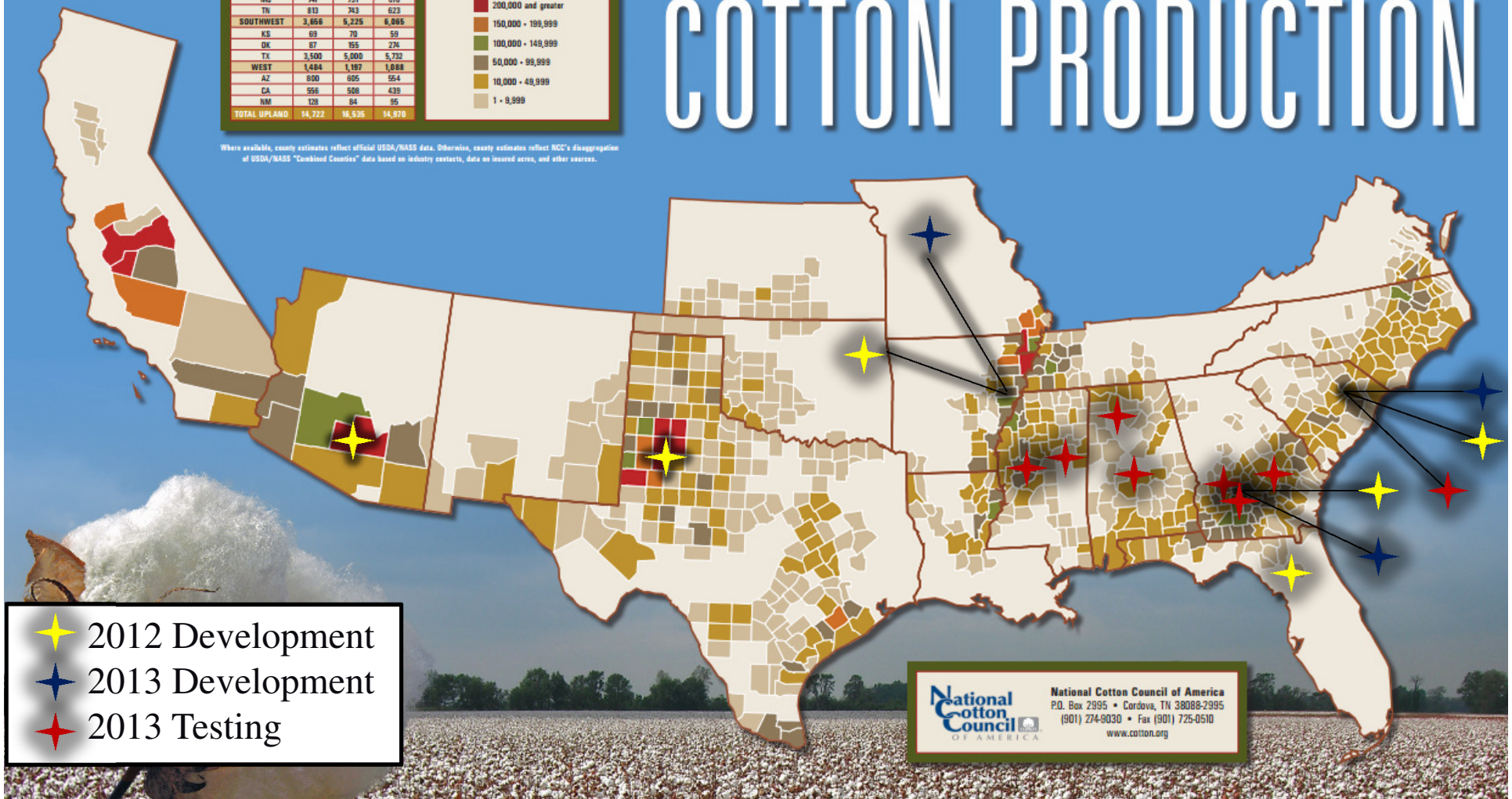
CLEMSON
EXTENSION



2012 UNITED STATES COTTON PRODUCTION

CROP	2011	2012	Average 07-11	CROP	2011	2012	Average 07-11
UPLAND				ELS			
SE	5,840	5,871	3,868	AZ	20	7	7
AL	685	745	479	CA	785	753	561
FL	183	200	137	NM	6	5	5
GA	2,465	2,910	1,967	TX	40	15	34
NC	1,026	1,225	856	ALL COTTON	15,573	17,315	15,577
SC	519	553	302				
VA	162	199	126				
MID-SOUTH				2012 UNITED STATES COTTON PRODUCTION			
AR	1,277	1,297	1,299	1000 (4804L Bales)			
LA	511	478	455		200,000 and greater		
MS	1,200	953	893		150,000 - 199,999		
MO	741	731	678		100,000 - 149,999		
TN	813	743	623		50,000 - 99,999		
SOUTHWEST					10,000 - 49,999		
KS	69	70	59		1 - 9,999		
OK	87	155	274				
TX	3,500	5,000	5,732				
WEST							
AZ	890	685	554				
CA	558	508	439				
NM	128	84	95				
TOTAL UPLAND	14,722	16,535	14,970				

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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P.O. Box 2995 • Cordova, TN 38008-2995
(901) 274-9030 • Fax (901) 725-0510
www.cotton.org



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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