Michael Gore[1], Andrew French[1], Pedro Andrade-Sanchez[2], Michael Salvucci[1], Kelly Thorp[1], Doug Hunsaker[1], Elizabete Carmo-Silva[1], and Jeffrey White[1]

High-Throughput Phenotyping the Physiological Responses of Cotton to a Hot, Arid Environment

[1]USDA-ARS, Arid-Land Agricultural Research Center, Maricopa, AZ, [2]Department of Agricultural and Biosystems Engineering, Maricopa Agricultural Research Center, University of Arizona, Maricopa, AZ

SUMMARY

In the past century, high yielding cotton has been adapted to the irrigated agricultural areas of central and western Arizona. Despite progress, it will be perhaps a greater challenge to further increase the yield of cotton in this period of global climate change and diminishing fresh water supplies. Genetic improvement of cotton via modern plant breeding is the most sustainable and economical approach to address these eminent problems. However, the development of superior heat tolerant and water-use efficient cotton cultivars has been slowed by a limited knowledge of the physiological processes that relate to improved productivity under supra-optimal temperatures and water deficit. This project is striving to enhance our understanding of which physiological traits are important for higher yield in Arizona. To accomplish this, we are studying the genetic basis of physiological stress responses and productivity in Upland (*Gossypium hirsutum*) and Pima (*Gossypium barbadense*) cotton grown under well-watered (heat stress) and water-limited conditions (heat and drought stresses). We present results from a statistical genetic analysis of phenotypic data that were predominantly collected with tractor-based and hand-held senor technologies.

Pima and Upland Cotton Germplasm

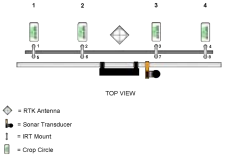
4 reps of 24 historical Pima cotton varieties for Well-Watered and Water-Limited treatments

2 reps of TM1xNM24016 RIL population with varietal checks for Well-Watered and Water-Limited treatments

Irrigation Monitoring and Scheduling

Soil neutron probes throughout the field allowed the periodic measurement of soil water content. This in combination with timed drip irrigation and a modified FAO-56 Crop ET model permitted the maintenance of a constant and consistent water stress (~70% depletion) throughout flowering and boll set.

Tractor-based Plant Phenotyping

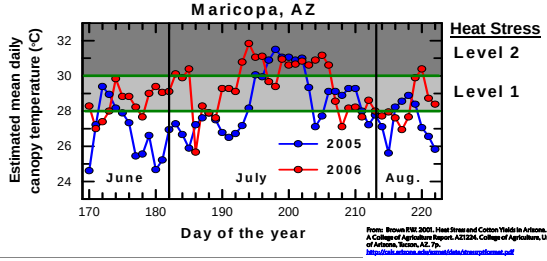


- Sonar transducers to measure plant height
- Infrared temperature sensors (IRTs) to measure canopy temperature
- Crop Circle sensors to measure spectral wavelengths to calculate vegetation indices such as Normalized Difference Vegetation Index (NDVI)

This work was funded in part by Cotton Incorporated and by the USDA-ARS

Why use Maricopa, AZ as a location to evaluate cotton stress?

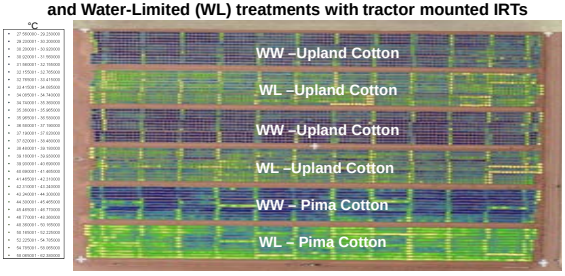
High Tm at peak flowering and limited annual rainfall (19.9 cm)



From: Brown PW. 2001. Heat Stress and Cotton Yields in Arizona. Cotton: A College of Agriculture Report. AZ1224. College of Agriculture, University of Arizona, Tucson, AZ. 7p. http://ag.arizona.edu/pubs/crops/az1224.pdf

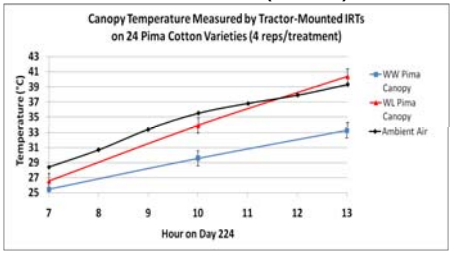
Maricopa, AZ has highly favorable weather conditions for year round remote sensing

Detection of differential cotton canopy Tm between Well-Watered (WW) and Water-Limited (WL) treatments with tractor mounted IRTs



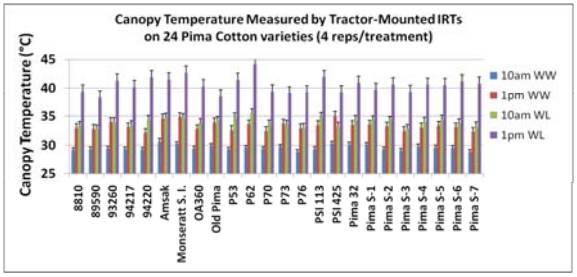
Day 224 at 1 pm – Ambient Air Tm of 39.3°C

Significant Treatment (*P*<0.0001), Time (*P*<0.0001), and Time*Treatment interaction (*P*<0.0001) effects

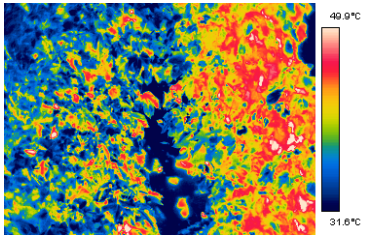


Mixed Model Analysis of Repeated Measures

Significant Variety effect for canopy temperature at 10am WW (*P*<0.05) and 1pm WL (*P*<0.005)

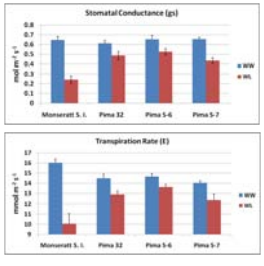


Thermal imaging detects variation for canopy Tm between Pima cotton plants under heat and drought stress



94217 (1pm WL) **Pima S-2 (1pm WL)**

Drought conditions reduce gs and E, which leads to higher canopy temperatures in Pima cotton plants



Gas exchange measurements taken with a LI-Cor 6400

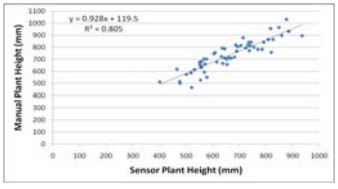
Monserratt S.I. plant under heat and drought stress

FUTURE WORK

-Multivariate QTL analysis of highly correlated spectral data collected by Crop Circle or other instruments

-Time-related QTL analysis of weekly plant height data collected with sonar transducers

Man vs. Machine



Technical assistance provided by M. Conley, G. Coyle, C. Fanger, J. Gilley, K. Harbour, B. Luckett, S. Maneely, D. Simer, N. Taylor, and K. Thacker