2011 Report from Arkansas for NCERA-101

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Impact Nugget:

Research has continued at the University of Arkansas to study the effects of high temperature and drought stress on reproductive development in cotton in controlled environment conditions. These studies have shown the extreme sensitivity of pollen tube growth to high temperature, and the manner in which the cotton flower is buffered from water deficit compared to the adjacent leaves. These results have helped explained the yield losses and yield variability experienced by Arkansas farmers.

New Facilities and Equipment:

We have modified and refined an enhanced thermoelectric cooler/heater to augment our micro measurements of plant response to elevated temperature and water stress. The equipment has an actinic LED light source and built-in PAR sensor, to allow for stable and continuous illumination of the leaf surface during temperature changes from 0 to 40^0C for measurement of fluorescence. Plans and funding for a new medium sized CONVIRON controlled environment chamber have been finalized to supplement the existing set of twelve chambers.

Unique Plant Responses:

High temperature stress: resulted in a decrease in soluble carbohydrates and ATP in the flower pistil, which resulted in decreased pollen tube growth and fewer ovules being fertilized. Water soluble calcium and glutathione reductase activity increased. A calcium-augmented antioxidant response in heat-stressed pistils interferes with enzymatic superoxide production needed for normal pollen tube growth. Maintaining a sufficient antioxidant enzyme pool prior to heat stress is an innate mechanism for coping with rapid leaf temperature increases that commonly occur under field conditions.

Water deficit stress: decreased photosynthesis and respiration in the leaves, with a concomitant decrease in leaf water potential, whereas the pistil water potential remained unaffected. Water stress also increased carbohydrate levels in the pistil and raised antioxidant levels.

Accomplishment Summaries:

In our earlier studies, we investigated the hypothesis that *in vivo* pollen tube growth would be affected by heat stress-induced changes in energy reserves and calcium-mediated oxidative status in the pistil. The conclusion was that the energy demands of growing pollen tubes cannot be met under heat stress due to decreased source leaf activity, and a calcium-augmented antioxidant response in heat-stressed pistils that interferes with enzymatic superoxide production needed for normal pollen tube growth.

Comparing the physiological and biochemical responses of a thermosensitive cultivar (ST4554B2RF) from the US Cotton Belt and thermotolerant cultivar (VH260) from Pakistan, we concluded that maintaining a sufficient antioxidant enzyme pool prior to heat stress is an innate mechanism for coping with rapid leaf temperature increases that commonly occur under field conditions.

A diurnal study of pollen tube growth in the cotton pistil was conducted. Microclimate measurements included photosynthetically active radiation, relative humidity, and air temperature. Pistil measurements included surface temperature, pollen germination, and pollen tube growth through the style, fertilization efficiency, fertilized ovule number, and total number of ovules per ovary. Subtending leaf measurements included leaf temperature, photosynthesis, and stomatal conductance. Results showed that under high temperatures the first measureable pollen tube growth through the style was observed earlier in the day (1200 h) than under cooler conditions (1500 h). Also, high temperature resulted in slower pollen tube growth through the style (2.05 mm h-1) relative to cooler conditions (3.35 mm h-1). We concluded that diurnal pollen tube growth is exceptionally sensitive to high temperature.

Impact Statement:

In cotton (*Gossypium hirsutum* L.), the growth of pollen tubes through the style has been shown to be especially sensitive to elevated temperatures, but not apparently to water stress. Under elevated temperatures the energy demands of growing pollen tubes cannot be met under heat stress due to decreased source leaf photosynthetic activity. Under water deficit, the cotton pistil seems to be well buffered compared to leaves adjacent in the canopy. There is an increase in antioxidants in the pistil under stress, which helps the ameliorate deleterious effects of the stress. The findings will facilitate the development of methods of ameliorating heat stress for yield stabilization.

Published Written Works:

<u>Refereed Journal Articles</u>:

Harris, P., D.E. Longer, D.M., Oosterhuis, and D. Loka. 2011. Comparison of growth medium for container grown plants. *Discovery Journal* 12:19-25.

Gonias, E., D.M., Oosterhuis, and A.C. Bibi. 2010. Light interception and radiation use efficiency of okra and normal leaf cotton isolines. *J Agric Sci. 72:217-222*

Loka, D., D.M. Oosterhuis, and G. Ritchie. 2011. Water stress in cotton. pp. 37-72. *In* D.M. Oosterhuis (ed.) Stress Physiology in Cotton. Publ. Cotton Foundation, Memphis, TN.

Oosterhuis, D.M., and J.L. Snider. 2011. High temperature stress on floral development and yield of cotton. pp. 1-24. *In* D.M. Oosterhuis (ed.) Stress Physiology in Cotton. Publ. Cotton Foundation, Memphis, TN.

Oosterhuis, D.M. (Ed.) 2011. Stress Physiology in Cotton (book). Publ. Cotton Foundation, Memphis, TN. ISBN 978-0-939809-07-3

Pettigrew, W.T. and D.M. Oosterhuis. 2011. Cotton adaptation to climate change. NCA Gov. publ. DC.

Snider, J.L., D.M. Oosterhuis, and E.M. Kawakami. 2011. Diurnal pollen tube growth is slowed by high temperature in field-grown *Gossypium hirsutum* pistils. *J. Plant Physiol.* 168:441-448.

Snider, J.L., D.M. OosterhuiS, and E.M. kawakami. 2011. Mechanisms of reproductive thermotolerance in *Gossypium hirsutum*: the effect of cultivar and exogenous calcium application. *J Agron & Crop Science.* 197:228-236.

Snider, J.L., and D.M. Oosterhuis. 2011. How does timing, duration, and severity of heat stress influence pollen-pistil interactions in angiosperms? Chapter. *Plant Signaling & Behavior.* pp. 930-933. Landes BioScience

Snider, J.L., D.M. Oosterhuis, D.A. Loka, and E.M. Kawakami. 2011. High temperature limits *in vivo* pollen tube growth rates by altering diurnal carbohydrate balance in field-grown *Gossypium hirsutum* pistils. *J. Plant Physiology* 168:1168-1175.

Symposium Proceedings:

Loka, D. and D.M. Oosterhuis. 2011. The effect of water-deficit stress on the biochemistry of the cotton flower. CD-ROM *Proc. Beltwide Cotton Conferences*. Atlanta, GA, Jan 4-7, 2011. National Cotton Council of America, Memphis, TN.

Loka, D. and D.M. Oosterhuis. 2011. Effect of 1-MCP on the cotton flower under water-deficit. . CD-ROM *Proc. Beltwide Cotton Conferences*. Atlanta, GA, Jan 4-7, 2011. National Cotton Council of America, Memphis, TN.

Loka, D. and D.M. Oosterhuis. 2011. Effect of 1-Methylcyclopropene on the cotton flower under water-deficit. pp. 66-69. In: D.M. Oosterhuis (Ed.) Summaries of Arkansas Cotton Research 2010. Univ. Arkansas Agric. Exp. Sta., *Research Series* 589.

Snider, J.L., D.M. Oosterhuis, and E.M. Kawakami. 2011. Gnotypic thermotolerance is associated with elevated pre-stress antioxidant enzyme activity in cotton leaves and pistils.. CD-ROM *Proc. Beltwide Cotton Conferences*. Atlanta, GA, Jan 4-7, 2011. National Cotton Council of America, Memphis, TN.

Scientific and Outreach Oral Presentations:

Oosterhuis, D.M. 2011. Should we be worried about higher temperatures in crop production? *Proc. 14th Annual Conservation Systems Cotton and Rice Conference.* Baton Rouge, LA. Feb 1-2, 2011. pp. 8-111.

Oosterhuis, D.M., E.M. Kawakami, J.L. Snider, and J. Phillips. 2011. 1-MCP effects on antioxidant activity and gene expression of ACC-synthase and ACC-Oxidase in cotton flowers. CD-ROM *Proc. Beltwide Cotton Conferences*. Atlanta, GA, Jan 4-7, 2011. National Cotton Council of America, Memphis, TN.