2008 Report from Arkansas for NCERA-101

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Impact Nugget:

The University of Arkansas has developed techniques to measure the effects of high temperature stress in cotton flower pistils in controlled environment conditions. These studies have improved our understanding of the effects of high temperature stress on cotton reproductive development in order to explain the yield variability experienced by Arkansas farmers.

New Facilities and Equipment:

Plans have been made and the funds identified to improve and continue replacing the existing controlled environment chambers. We have replaced three of the large walk-in growth chambers and will continue to replace the remaining chambers. Additional equipment was purchased to augment the micro measurements of plant response to elevated temperature. This included equipment o measure the energetic within the pistil, i.e. a multiscan plate reader for carbohydrate and enzyme measurement and a luminometer for adenosine triphosphate (ATP) measurement. In additional micro probes were designed for temperature measurements within the ovary of the flower.

Unique Plant Responses:

High temperature stress caused a decline in the pistil of pollen tube growth, soluble carbohydrates, ATP content, and NADPH oxidase activity, whereas water soluble calcium and glutathione reductase activity increased, and superoxide dismutase activity remained unchanged. In leaves, heat stress decreased photosynthesis, quantum efficiency, and chlorophyll content, but increased stomatal conductance. We concluded that the energy demands of growing pollen tubes cannot be met under heat stress due to decreased source leaf activity, and that a calcium-augmented antioxidant response in heat stressed pistils interferes with enzymatic superoxide production needed for normal pollen tube growth.

Okra-leaf cotton (*Gossypium hirsutum* L.) types have been reputed to produce equal or higher amounts of lint yield than normal-leaf types, while intercepting less or similar amounts of radiation. Growth room and field studies revealed similar single leaf carbon exchange rates and dry matter production between okra-leaf and normal-leaf shapes, but radiation use efficiencies of 1.897 and 2.636 $g \cdot MJ^{-1}$ of intercepted photosynthetically active radiation for the normal- and okra-leaf types, respectively, i.e. differences between the leaf shape isolines were attributed to light interception characteristics.

Accomplishment Summaries:

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. *Gossypium hirsutum* plants were exposed to optimal (30/20°C) or high day temperature (38/20°C) conditions in controlled environment chambers during flowering and analyzed for *in vivo* pollen tube growth, soluble carbohydrates, ATP, calcium, antioxidant enzyme activity, and NADPH oxidase (NOX; EC 1.6.3.1) activity in the pistil, and gas exchange, chlorophyll content, quantum efficiency, and ATP content of the subtending leaf on the day of anthesis. Plants were grown under a 12 hr photoperiod at 500 μmol m^{-2} s^{-1} photosynthetically active radiation and were watered daily with half-strength Hoagland's solution. In the

pistil pollen tube growth, soluble carbohydrates, ATP content, and NOX activity declined significantly, whereas water soluble calcium and glutathione reductase (EC 1.8.1.7) activity increased, and superoxide dismutase (EC 1.15.1.1) activity remained unchanged. In leaves, heat stress decreased photosynthesis, quantum efficiency, and chlorophyll content, but increased stomatal conductance. We concluded that the energy demands of growing pollen tubes cannot be met under heat stress due to decreased source leaf activity, and that a calcium-augmented antioxidant response in heat stressed pistils interferes with enzymatic superoxide production needed for normal pollen tube growth.

Impact Statement:

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. Results support our hypothesis that high temperature stress during reproductive development is a leading cause of decreased cotton yields in Arkansas. These studies have led to ongoing investigations of the use of the anti-ethylene compound 1-methylcyclopropene to ameliorate the detrimental effects of high temperature stress during the early stages of flowering.

Published Written Works:

Refereed Journal Articles:

Arevalo, L.S., Oosterhuis, D.M., Coker, D. and Brown, R.S. 2008. Physiological response of cotton to high night temperature. *Amer. J. Plant Sci. And Biotechnol.* 2:63-68

Bibi, A.B., Oosterhuis, D.M., Gonias, E.D. 2008. Photosynthesis, quantum yield of photosystem II and membrane leakage as affected by high temperatures in cotton genotypes *J. Cotton Science.* 12:150-159.

Bibi, A.B., Oosterhuis, D.M., Gonias, E.D. 2008. Changes in the antioxidant activity of cotton genotypes during high temperature stress. *Life Sciences International Journal* 2:621-627.

Oosterhuis, D.M. and Howard, D.D. 2008. Programmed release nitrogen and potassium fertilizers for cotton production. *Afr. J. Agric. Sci.* 3:68-73.

Symposium Proceeding:

Gonias, E. D., Oosterhuis, D.M. and Bibi, A.C. 2008. Estimating light interception by the cotton crop using a digital imaging technique. pp. 175-177. CD-ROM *Proc. Beltwide Cotton Conferences*. Nashville, TN., Jan 8-11, 2008. National Cotton Council of America, Memphis, TN.

Loka, D.A. and D.M. Oosterhuis. 2008. Effect of high night temperatures on respiration, energy balance and carbohydrates. pp. 142-146. CD-ROM *Proc. Beltwide Cotton Conferences*. Nashville, TN., Jan, Jan 8-11, 2008. National Cotton Council of America, Memphis, TN.

Scientific and Outreach Oral Presentations:

Loka, D. and D.M. Oosterhuis. 2008. Effect of high night temperatures on respiration, energy balance and carbohydrates. Beltwide Cotton Conferences. Nashville, TN. Jan 18-11, 2008.

Gonias, E.D., D.M. Oosterhuis, and A.C. Bibi. 2008. Estimating light interception by the cotton crop using a digital imaging technique. Beltwide Cotton Conferences. Nashville, TN. Jan 18-11, 2008.

Kawakami, E. and Oosterhuis, D.M. 2008. Physiological effects of 1-methylcyclopropene on well-watered and water-stressed cotton plants. Beltwide Cotton Conferences. Nashville, TN. Jan 18-11, 2008.

Oosterhuis, D.M. 2008. Increased proteins, insect mortality and yield of cotton with the plant growth regulator Atonik. International Crop Science Symposium, South Korea, March 2008.