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PHYSIOLOGICAL LIMITATIONS TO COTTON PRODUCTION ON THE HIGH PLAINS OF TEXAS

J.J. Burke
Plant Stress and Germplasm Development Unit
USDA-ARS
Lubbock, TX

The High Plains of Texas offers producers diverse weather possibilities at planting. Rainfall shortly after planting may result in soil crusts that form a barrier to seedling emergence. Energy programmed for seedling growth is diverted to the hypocotyl, thereby increasing tissue osmotic pressure that in turn increases turgor pressure to levels required to break through the crust. The diversion of cotyledonary energy to the hypocotyl lowers the available energy for photosynthetic machinery development and narrows the temperature range at which chlorophyll accumulates.

Dramatic shifts in air and soil temperatures shortly after planting can also inhibit seedling establishment. Low temperatures, in combination with rainfall, directly inhiibit root development by reducing enyzme activities, and indirectly reduce growth through seedling invasion by the seedling disease complex. High soil temperatures at the seeding depth may reach 45 to 50C under dryland conditions. Irrigation can reduce soil temperatures to a more favorable range; however, if water is not available then the seedlings must either cope with the elevated temperatures or die.

The effect of water-deficit stress on the expression of cotton's acquired thermotolerance protection system was investigated in germinating cotton seeds water-stressed in either PEG solutions or vermiculite in the laboratory and their ability to induce thermotolerance upon exposure to elevated temperatures was evaluated using a chlorophyll accumulation assay. The results showed reduced seedling growth under water-deficit stress, yet the acquired thermotolerance system was not inhibited. Protein analysis at 5 days after planting showed that developmentally regulated HSP101 and HSP17.6 were present in the cotyledons of water-deficit stressed cotton seedlings, and that they were absent in cotyledons from well-watered seedlings. The presence of these HSPs in the water-deficit stressed seedlings failed to enhance inherent or acquired thermotolerance over well-watered seedlings. These results support the suggested role of developmentally-regulated HSPs in desiccation tolerance in seeds, and suggests that they are unavailable to function in enhancing thermotolerance.

To better understand when thermal stresses are first experienced by plants, techniques to aid in the identification of the optimum temperature were developed. Initial studies used the temperature sensitivity of the apparent Km of enzymes to provide a range of temperatures thought to provide optimum enzyme activity and coined the term 'Thermal Kinetic Window' for this temperature range. Later, the temperature sensitivity of the reappearance of Photosystem II chlorophyll fluorescence following a high light treatment was found to provide data similar to that of the Thermal Kinetic Window, but in a fraction of the time. Laboratory determinations of optimal plant temperatures were linked to continuous canopy temperature measurements in the development of an irrigation control system named the Biologically Identified Optimal Temperature Interactive Console (BIOTIC).

Continuous canopy temperature measurements showed that cotton on the High Plains is exposed to sub-optimal temperatures both seasonally and daily. Canopy temperatures of 20 C are common at night, while canopy temperatures may ramge from 28 C (irrigated) to 40 C (rainfed). Studies comparing cotton responses to a 28/20 C or 28/28 C day/night temperature revealed a feedback control mechanism that reduces photosynthetic activity, even at optimum temperatures, if 20 C night temperatures are experienced by the cotton. Realization of the inhibitory effect of temperatures outside of the optimum range have led us to the development of a Metabolic Fitness assay. This assay showed that *Gossypium hirsutum* grown under high temperatures was unable to cope with a prolonged 38C dark treatment, while *Gossypium barbadense* grown in the same environment showed greater resistance to the 38 C treatment. If grown in cooler environments, the *Gossypium hirsutum* was able to cope with the 38 C stress and the *Gossypium barbadense* was more sensitive to the stress. This assay should prove to be a valuable tool in identifying genetic deversity in temperature sensitivity in cotton germplasm.

To study reproductive heat sensitivity we developed a solid pollen germination media and protocol for pollen germination. The medium comprised 10% (w/v) agarose (pH 7.6), 25% (w/v) sucrose, 0.52 mM KNO3, 3.06 mM MnSO4, 1.66 mM H3BO3, 0.42 mM MgS04.7H20 and 1.0 μM A3 gibberellic acid. The medium is overlayed with a layer of 1.5% agarose prior to use. Optimum pollen germination and rapid tube elongation occurred between 28 C and 31 C under 80% relative humidity. Decreased pollen germination and tube elongation occurred at temperatures above 32 C. Evaluation of pollen, taken at 2 pm from field-grown cotton plants showed that pollen from flowers exposed to direct sunlight had reduced viability compared with pollen from flowers inside the canopy presumably because of internal temperatures 8 C to 10 C above air temperatures, well above the 28 C to 31 C optimum for pollen germination.