Effect of High Night Temperatures on Cotton Gas Exchange and Carbohydrates

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RESEARCH PROBLEM

The unpredictability of cotton yields is a great concern to the cotton industry. The five-year average yield for cotton in the U.S. is 718 lb lint/acre, whereas the theoretical maximum lint yield is 3720 lb lint/acre (Hesketh and Baker, 1969). High temperatures are considered to be one of the main environmental factors contributing to variable yields in cotton. This is apparently due to a negative effect on respiration and carbohydrate accumulation. Yield comparisons between areas with the same day temperatures and different night temperatures have shown that the areas with higher night temperatures have lower yields. In this study it was hypothesized that high night temperatures have a negative effect on cotton photosynthesis and respiration that results in a significant loss of carbohydrates and ultimately in a yield decrease.

BACKGROUND INFORMATION

U.S. cotton production suffers from extreme and unpredictable year-to-year yield variability that has been attributed to genetics, management practices, and unfavorable weather conditions (Robertson, 2001). High temperatures are considered to be the main environmental factor contributing to variable yields (Oosterhuis, 1994), but limited information exists on the effects of high night temperature on cotton growth and yield (Bibi et al., 2006). Although cotton originates from hot climates, the ideal temperature range for its growth is between 20° and 30°C (Reddy et al., 1991) with the optimum being 28°C (Burke et al., 1988). However, at higher temperatures, as often experienced in the U.S. Cotton Belt, plant metabolism and photosynthesis decrease dramatically compromising the reproductive efficiency of the crop.

Additionally, reports in the literature suggest that high night temperatures cause respiration rates to increase resulting in further depletion of carbohydrates and yield reduction (Arevalo, 2005). This suggestion is supported by comparisons of yield and

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temperature regimes in Arkansas and Greece (Oosterhuis, 2000). Greece has comparable production systems, with similar day temperatures but lower night temperatures than Arkansas especially during the boll development period, and produces nearly fifty percent more lint yield per acre than Arkansas.

Most reported studies of the effects of night temperature on growth do not involve solely the night temperature as a contributing factor to yield compromise; i.e. when night temperature increased so did the day temperature, making it impossible to determine the effect of increased night temperature alone. Therefore, the objective of this study was to quantify the immediate effect of high night temperatures on gas exchange and carbohydrate accumulation.

**RESEARCH DESCRIPTION**

Two growth chamber studies were conducted in September and October 2006 at the Altheimer Laboratory, University of Arkansas. The cotton (*Gossypium hirsutum* L.) cultivar DP444BR was planted into 2-L pots containing Sunshine horticulture mix. The growth chambers were set for two 12-h photoperiods with day/night temperatures of 30°C/20°C. Half-strength Hoagland’s nutrient solution was applied daily to maintain adequate nutrients and water content. A completely randomized block with two replications was used.

For the first experiment (September, 2006), three night temperature regimes were imposed (20°C, 25°C, and 28°C) starting at pinhead square with 3-day intervals between each temperature regime. The experiment was repeated under two day temperatures (30°C and 35°C) with the same night temperature regimes. Respiration measurements were taken daily at 10 p.m. on each plant using the fourth main-stem leaf from the terminal with LICOR-6200 infra-red gas analyzer (LICOR Inc., Neb.).

For the second experiment (October, 2006), plants were divided into two groups at pinhead square. One night temperature regime was imposed on the treated group (28°C) for three days, while the control plants remained under the normal temperature regime (30°C/20°C). The antioxidant Glutathione was measured from fresh fourth-position main-stem leaves sampled at 5 a.m. The samples were stored at -80°C prior to being extracted and analyzed with a Biospec-1601 enzyme analyzer using the method of Anderson et al. (1992).

**RESULTS AND DISCUSSION**

The results were unexpectedly variable with no clear trend of the effects of high night temperature on respiration during the night or photosynthesis the following day (data not shown). There appeared to be an increase in photosynthesis with increased day temperature, but no clear effect from increased night temperature. There was also no clear effect on plant carbohydrate status (data not shown). This lack of effect on gas exchange and carbohydrates may have been because of the short duration of the temperature treatment. Arevalo et al. (2005) showed that a stress period greater than two weeks duration is needed to cause a significant effect on yield.
High night temperature was shown to significantly \((a=0.2)\) increase the activity of the antioxidant enzyme glutathione (Fig. 1). This indicates that the plant was experiencing stress and the increased antioxidant levels were to detoxify the plant of excessive, harmful free radicals. However, there was no obvious effect on gas exchange that we hypothesized should have been detrimentally affected by the high night temperature. This study will be repeated with a longer duration of high night temperature, similar to what would be experienced in the field, and thereby hopefully ensure a measurable effect on gas exchange as well as plant stress.

**PRACTICAL APPLICATION**

High night temperature was shown to have a stressful effect on the plant that elicited an increase in antioxidant enzyme activity. However, the short duration of high night temperature had little or no effect on gas exchange and carbohydrates and therefore on expected yield. The study will be repeated with longer periods of high night temperature.

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**LITERATURE CITED**


Fig. 1. The effect of night temperatures of 20°C and 28°C on the antioxidant enzyme glutathione. The plants were grown at 30/20°C (day/night) temperatures until pinhead square, after which the night temperature was increased (20°C and 28°C) for three days at each temperature with the day temperature of 30°C remaining the same. Measurements were taken the next day for each temperature regime.