# EFFECTS OF DROUGHT STRESS ON GROWTH, DEVELOPMENT AND LEAF PHOTOSYNTHESIS OF FIELD-GROWN COTTON

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## Abstract

Effects of three different levels of soil water deficit on growth, development, lint yield, canopy interceptance of solar radiation and stomatal and non-stomatal limitations to leaf photosynthesis of field-grown cotton were investigated. Cotton (cv. ST474) was planted on June 8, 1999 at the University of Georgia Plant Sciences Farm in Oconee County, GA. Rows were 96.5 cm apart, and seedlings were thinned to a perfect stand of six per m of row after emergence. Irrigation water was applied in 1.5-cm applications using a surface drip tape system with one tape per row. Normal agronomic practices for the region were otherwise followed. The experimental design was a randomized complete block, with four replications and three irrigation treatments. All three treatments were maintained water replete (no observed midday wilting of leaves) until 45 days after planting (DAP). After this date, treatment 1 (control) was maintained water replete, treatment 2 (mild stress) received irrigation half as frequently as treatment 1, and treatment 3 (severe stress) was rainfed only. Each plot consisted of six 18-m rows, and all plant development, growth analysis, canopy interceptance, leaf gas exchange and chlorophyll fluorescence data were collected from the center two rows of each plot.

Destructive harvests for leaf and stem dry matter measurements and determinations of leaf area index (LAI) were taken at 45, 69 and 95 DAP, and final yield was measured 145 DAP. Plant height, number of mainstem nodes and midday canopy interceptance of incident solar radiation were determined on a weekly basis until 95 DAP. Leaf gas exchange measurements were made on sunlit leaves using two LI-6400 Portable Photosynthesis Systems (LiCor, Lincoln NE) on seven dates between the first and third destructive harvests. For all measurements of this type, incident photosynthetic photon flux density (PPFD) was greater than 1400 µmol $m^{-2}$ $s^{-1}$ normal to the leaf surface. On six dates during this same period the relationship between leaf internal $CO_2$ concentration ($C_i$) and net $CO_2$ assimilation rates ($A_N$) was determined for young, fully expanded leaves. For these measurements the LI-6400 systems were equipped with red/blue LED light sources set to provide a PPFD of 1500 µmol $m^{-2}$ $s^{-1}$ at the leaf surface, and $CO_2$ injectors to control leaf chamber $CO_2$ concentration. For each leaf, $A_N$ was measured over a range of $C_i$ and the value of $A_N$ at a $C_i$ of 200 ppm ($A_N$200) was determined by interpolation. Also, on five dates between 38 and 70 DAP, thylakoid electron transport rates of young, fully expanded leaves were determined using a MiniPAM chlorophyll fluorometer (Walz GmbH, Effeltrich, Germany). Curve fitting allowed estimation of the average thylakoid electron transport rate at a PPFD of 250 µmol $m^{-2}$ $s^{-1}$ (ETR250) for each plot on each measuring day.
Plant height, number of mainstem nodes and canopy interceptance were significantly ($p<0.05$) greater for the control than for the two stress treatments by 59 DAP (two weeks after initiating the irrigation treatments), and by 70 DAP each of these parameters was also significantly greater for the mild stress than the severe stress treatment. The control had significantly higher total above ground dry weight and leaf area index, and significantly lower specific leaf weight than the other two treatments at 69 DAP, and all three treatments differed significantly for these parameters by 95 DAP. At 95 DAP, total above ground dry weight was reduced by 36% and 57% relative to the control for the mild and severe stress treatments, respectively. Final lint yield (145 DAP) was 134, 113 and 76 g $m^{-2}$ for the control, mild and severe stress treatments, respectively. No differences in the ratio of lint weight to total seed cotton weight were observed among the treatments.

Leaf gas exchange measurements under ambient PPFD revealed significantly higher $A_N$, $C_i$ and stomatal conductance for the control than the other two treatments on each measuring day except one (79 DAP). On several measuring days, significant differences in gas exchange parameters were also observed between the mild and severe stress treatments. Despite the large differences in stomatal conductance and $C_i$, instantaneous leaf water use efficiency (net $CO_2$ assimilation divided by the transpiration rate) rarely differed between the treatments. This was because higher leaf temperatures created greater leaf to air vapor pressure differences for the drought stressed leaves. At 78 DAP, a rainfall event relieved the water stress in all plots, and no differences in leaf gas exchange parameters were found between the treatments at 79 DAP. This observation suggests that even the severe drought stress treatment had produced no lasting damage to the photosynthetic capacity of young leaves.

On three of the six measuring days, $A_N$200 was significantly greater in the control than in one or both of the other treatments, suggesting that drought stress resulted in non-stomatal limitations to photosynthesis in addition to the large stomatal limitations. The nature of these non-stomatal limitations can not be determined from these data, but the possibility exists that they are related to differences in leaf temperature, since leaves in the drought stressed plots were often significantly warmer than those in the control plots during the $A_N$ / $C_i$ measurements. There was no evidence of any deleterious effect of drought stress at the level of the light

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reactions of photosynthesis. In fact, ETR250 was found to be slightly but significantly higher in severe stress plots than in control plots on each of the three measuring days that followed initiation of the irrigation treatments.