REMOTE SENSING AND SOIL MOISTURE MEASUREMENTS IN IRRIGATION MANAGEMENT

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Abstract

Drought conditions and water demands from nonagricultural sources can limit the water available to grow a cotton crop during a given year. In water-limited situations, crop yield is affected by the severity and timing of drought events. The effects of water stress on cotton (DP 555 BG/RR) were studied at various stages of plant growth using soil moisture, plant evapotranspiration, and remote sensing measurements of plant health. In another experiment, the effects of irrigation rate during the growing season were measured with irrigation rates of 160%, 100%, and 50% of normal, as well as an unirrigated treatment. Results from these experiments suggest that plants can recover from short periods of water stress; however, fruit development and retention can be affected by these events.

INTRODUCTION

South Georgia typically receives about 50 inches of precipitation per year, more than twice the amount needed to grow a quality cotton crop. However, the sandy Coastal Plain soils hold only one inch of water per foot. Extra water runs off or leaches through the soil profile, rather than being stored in the soil. This makes stress events possible even during wet years. Irrigation capacity can easily increase yield potential by several hundred pounds during most growing seasons. In addition, soil water availability can influence or even control the production of potential fruiting points and fruit retention. An estimated one-third of the variation in average national yield is associated with the percentage irrigated, because rainfed crops experience droughts of varying severity even during wet years.

The increasing urban demands of water have made the water supply a hot political topic in the southeast, particularly in Alabama, Georgia, and Florida. Despite the above-average precipitation experienced during the summer of 2003, it is likely that water issues will continue to be dominant factors in future cotton production. The establishment of the Stripling Irrigation Research Park in Camilla, Georgia is a conspicuous example of the investment into research to improve irrigation efficiency.

This research attempts to improve the understanding of irrigation management through the following objectives:

1. Define the soil water content vs. plant water stress boundary.
2. Compare these measurements to determine plant reaction to water stress.
3. Determine the long-term effects of short-term water stress.

Materials And Methods

Characteristics of water-stressed cotton were determined in concrete-enclosed plots under a mechanical rainout shelter in Tifton, Georgia. Each plot measured 7 ½ x 7 ½ feet laid out in a randomized block with 6 treatments and 3 replicates of each treatment. Delta Pine 555 BG/RR cotton was grown in three rows spaced three feet apart in a Tift sandy loam soil. The rows, oriented in the east-west direction, were thinned to a population of 3 plants per foot after the stands were established. Mepiquat chloride was applied 7 weeks after planting at a rate of 20 oz. Irrigations were performed at about three day intervals to avoid allowing the soil to dry out at greater depths, and consisted of 0.5” to 1.0” waterings, which remained consistent throughout all watered plots on a given day.

Soil water content at depths of 8, 16, and 24 inches was measured in three replicates of each treatment using buried Watermark sensors (Irrometer Company, Inc., Riverside, CA) and a handheld reader. Leaf water content was measured using a LI-COR 6400 Porometer (LI-COR, Inc., Lincoln, NE). Leaf solute concentration was measured on an upper unshaded leaf from each plot using calibrated leaf-cutter psychrometers (JRD Merrill, Logan, UT). Plant growth was estimated from spectrometer (Apogee Instruments, Logan, UT) canopy reflectance measurements. Sony DSC-717 digital camera (Sony Corp., New York City) measurements of canopy ground cover and plant health were also used to identify the onset of water stress. Measurements were made between 12:30 p.m. and 2:30 p.m. at 3 to 4 day intervals as weather permitted during the season.

Characteristics of water-stressed cotton were determined in field research that was conducted at the Stripling Irrigation Research Park near Camilla, Georgia using a variable-rate center pivot and plots laid out with four water level treatments: 160%, 100% control, 50%, and no irrigation applied. Soil water content, leaf water content, leaf solute concentration, and ground cover measurements were performed in all four replicates of each treatment using the same instrumentation as in the Tifton Rainout shelter experiment. Measurements began 37 days after planting and continued as weather permitted until 85 days after planting. Measurements were made within two hours of solar noon on sunny days.

Results And Discussion

Water stress was detected using soil water content estimates, porometer conductance readings, and overhead imaging techniques during the first two stages of stress. These evidences of stress included more negative tension readings of soil water content, decreases in leaf conductance, and decreases in NDVI. Soil water content for all depths increased over time with water stress, but the Watermark readings at the 20 cm depth showed the quickest response to both drought and water addition, followed by both at the 40 cm depth. The 60 cm depth showed a noticeable lag (several days in some cases).

Reflectance and plant growth measurements showed a tendency of stressed plants to increase growth after irrigation was reinstituted. After the recovery period, the growth habits were similar between stressed and unstressed plots for the remainder of the growing season (Figure 1).

Water stress was detected on the unirrigated plots on day 53 after planting (Figure 2). Rain events between day 54 and day 73 prevented further measurements of the onset of water stress in these plots. However, reflectance and porometer measurements on day 73 showed that growth was similar between the unirrigated treatment and the other treatments. Final yield differences were not statistically significant between any of the treatments, suggesting that early treatment of water stress can help cotton plants recover most or all of their yield potential in the humid Coastal Plain climate of Camilla, Georgia.

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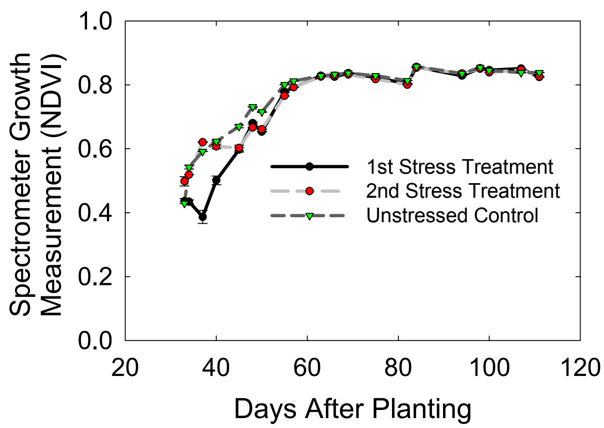

Figure 1. Comparison of the NDVI vegetation index for all treatments in Tifton rainout shelter. The stressed treatments showed a significant decrease in NDVI due to water stress during the time that irrigation was witheld from them.

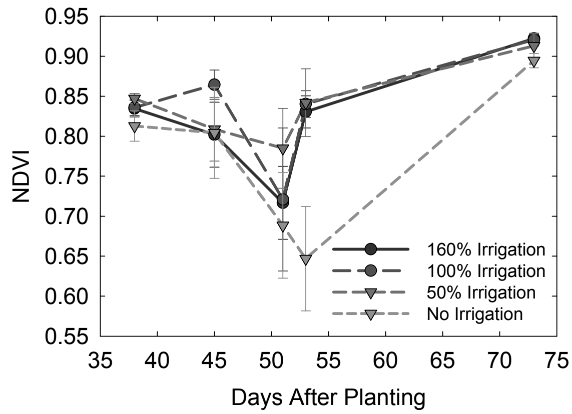

Figure 2. Comparison of NDVI for 4 irrigation treatments at Camilla, Georgia. Water stress was evident in the unirrigated treatment on day 53 by a decrease in NDVI and an increase in the variation between replicates in this treatment.