COTTON IRRIGATION TIMING USING REMOTE SENSING

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Abstract

Cotton irrigation scheduling methods tend to be underutilized because they are expensive or time consuming to institute on large acreages. With the introduction of variable rate irrigation systems, remote sensing offers a relatively low-cost method to "scout" large acreages and water accordingly. We examined overhead imagery as a method for irrigation scheduling. Images were collected with visible and near-infrared cameras suspended from a tethered blimp, and remote sensing-based irrigation was compared with watermark-triggered irrigation. The experiment consisted of four irrigation treatments: a control treatment with irrigation triggered by watermark sensors; a remote sensing treatment where irrigation was triggered at the first identified changes in crop growth; a remote sensing treatment where irrigation was triggered three days after the first identified changes in crop growth; and a non-irrigated treatment. We determined that scheduling based on remote sensing can produce yields comparable with scheduling based on watermark readings.

Introduction

The sandy Coastal Plain soils hold only one inch of water per foot of depth, and extra water runs off or leaches through the soil profile. Because the water does not remain in the soil, cotton can experience water stress 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 control the growth habits of plants, both during stress events and during recovery from stress (Ball et al., 1994). It can also affect the number and position of bolls a cotton plant sets, as well as the retention of these bolls.

The increasing urban water demands have made the water supply a hot political topic in Georgia, Alabama, and Florida. It is likely that water issues will continue to be dominant factors in future cotton production. Efficient irrigation techniques that result in high cotton yields will allow cotton producers to maximize their yield potential for a given water supply.

Remote sensing can act as both a potential production tool and a method for large-scale verification of research on cotton growth characteristics (Plant et al., 2000). Full-season crop monitoring techniques can help cotton growers produce a quality crop and make management decisions for following years. However, for remote sensing to be effective for in-season management decisions, it must provide a quick, accurate method for identifying crop growth characteristics and detecting stress events. Current remote sensing platforms include satellites, airplanes, and ground-based platforms. Of these, airplanes offer promise as a fairly flexible method for obtaining imagery.

Our research objectives for this project were as follows:

1. Define the soil water content vs. plant water stress boundary using measurements of soil water status and plant health (including plant reflectance).
2. Compare these measurements to determine plant reaction to water stress.
3. Determine the long-term effects of short-term water stress. These effects may be identified as changes in cotton yield and quality due to changes in boll production.
4. Compare growth and yield of cotton scheduled for irrigation based on aerial photography with cotton scheduled for irrigation using soil moisture triggers.

Materials and Methods

The research was conducted at the Stripling Irrigation Research Park in Camilla, Georgia on a field planted with Delta & Pineland 555 BG/RR at a rate of 3.5 plants per foot and irrigated with a variable-rate center pivot. Watermark sensors were buried at depths of 8, 16, and 24 inches in each plot, and the design was a 4 x 4 Latin square with the following treatments:

1. Irrigation based on watermark triggers of -40 cbars at 8 inches and -50 cbars at 16 and 24 inches;
2. Irrigation based on detection of water deficit using aerial imagery;
3. Irrigation three days after detection of water deficit using aerial imagery to simulate a remote sensing program that cannot make flyovers when the stress is first detectable; and
4. Dryland plots with irrigation applied only at the beginning of the season to aid emergence.

Aerial imagery was collected using a 15-foot long tethered blimp and a two-camera remote system. The camera system consisted of two Nikon 4300 digital cameras, one of which was modified to be near-infrared sensitive, an electronic shutter, and a radio control system that allowed remote firing of the cameras simultaneously. The blimp was flown over the plots at a height of about 300 feet, and images were collected 2-3 times per week on average.

Normalized difference vegetation indices (NDVI) were calculated based on plant color and scene color compared to reference regions of each image with known reflectance.

The timing of irrigation scheduling regimes based on soil water content and plant reflectance were compared with each other, as well as the overall yield and quality obtained with each scheduling regime. This comparison helped us examine the usefulness of field-scale crop health estimates in precision agriculture.

Statistical analyses included a comparison of both in-season growth differences and final yield differences between treatments.

Results

Ground cover estimates and NDVI correlated closely throughout the growing season, as shown in Figure 1. Both ground cover and NDVI decreased as plant water status decreased, allowing the identification of water stress using these methods. Figure 2 shows ground cover changes by treatment during the 2004 growing season. The decreases in crop growth on July 6 and July 13 triggered irrigation for the plots irrigated based on the aerial imagery. The watermark trigger treatment was also watered on July 6, although most of the plots had not reached the watermark trigger on that date (Figure 3). Upon watering, the delayed irrigation treatment (aerial – 3 days) showed recovery during the season until the end of measurements, at which time it was nearly the same as the watermark trigger and aerial regimes. The dryland treatment showed consistently lower ground cover throughout the data collection period. Another notable result was that although all of the irrigated treatments maintained moderate soil water status, the aerial and aerial – 3 days treatments were significantly drier at the 16 and 24 inch depths than was the watermark trigger treatment (Figure 3).

The aerial treatment and aerial - 3 days treatments used 0.6 and 1.2 inches less irrigation respectively than the watermark trigger treatment (Figure 4). However, yields were not significantly different between any of the irrigated treatments, as shown in Figure 5, based on ANOVA at a 0.05 confidence level and Tukey's pairwise analysis.

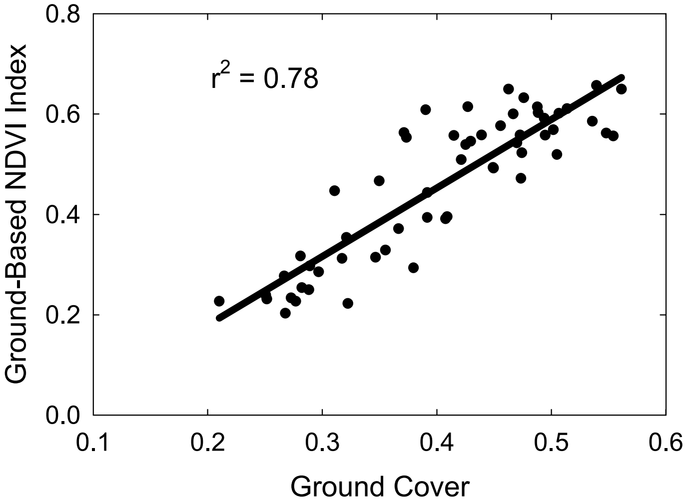

Figure 1. Correlation of ground cover with ground-based NDVI index.

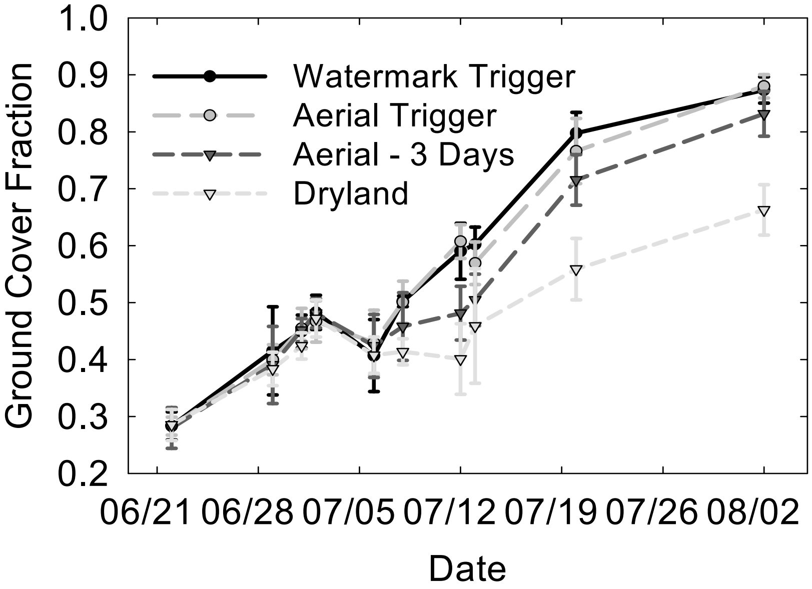

Figure 2. Ground cover of the four irrigation treatments during 2004.

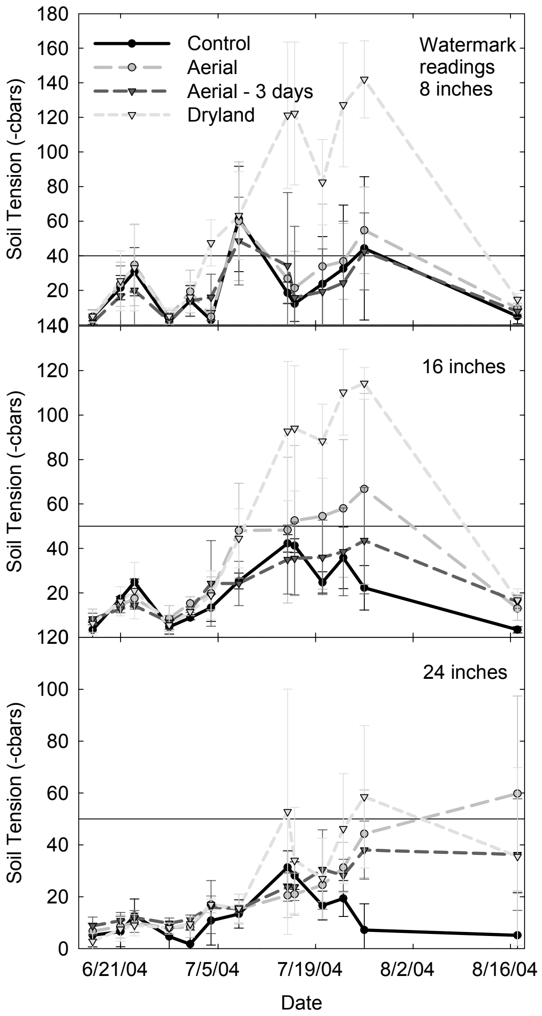

Figure 3. Watermark readings during 2004. Horizontal lines represent watermark trigger at each depth.

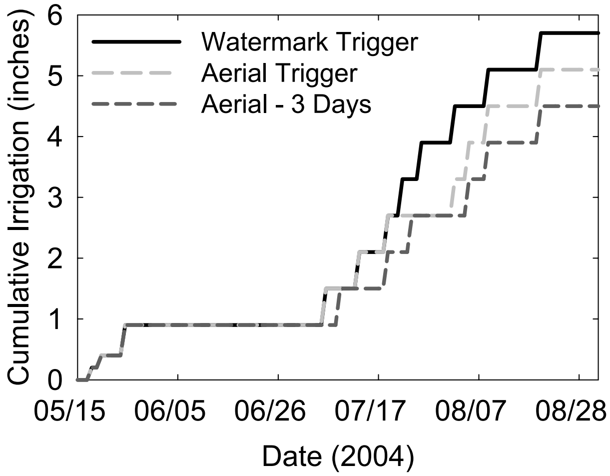

Figure 4. Cumulative irrigation for each of the irrigation treatments.

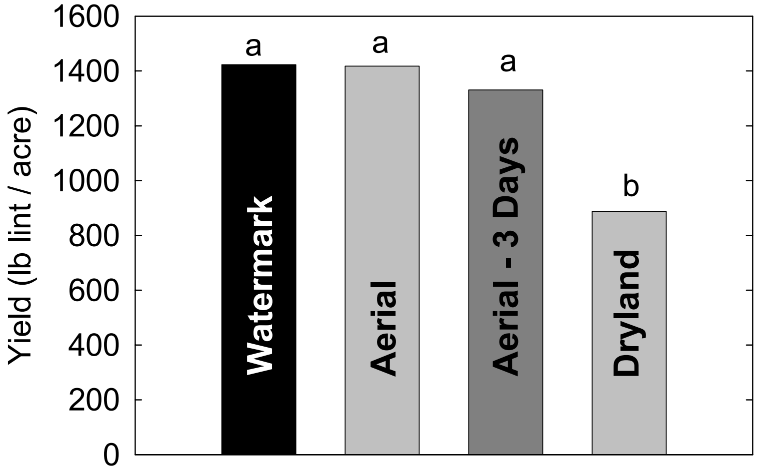

Figure 5. Final yield of all treatments for 2004.

Acknowledgments

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