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REMOTE SENSING FOR SITE-SPECIFIC MANAGEMENT OF BIOTIC AND ABIOTIC STRESS IN COTTON

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Abstract

This study evaluated the applicability of remote sensing instrumentation for site-specific management of abiotic and biotic stress on cotton grown under a center pivot. Three different irrigation regimes (100%, 75%, and 50% ETc) were imposed in the cotton field to: 1) monitor canopy temperatures of cotton with infrared thermometers (IRTs) to pinpoint areas of biotic and abiotic stresses, 2) compare aerial infrared photography to IRTs mounted on center pivots to correlate areas of biotic and abiotic stresses, and 3) to relate yield and yield parameters relative to canopy temperatures. Pivot mounted IRTs and IR cameras were able to differentiate water stress between the irrigation regimes. However, only the IR cameras were effectively able to distinguish between biotic (cotton root rot) and abiotic (drought) stresses with the assistance of ground-truthing. Cooler canopy temperatures were reflected in higher lint yields. The 50% ETc regime had significantly higher canopy temperatures, which were reflected in significantly lower lint yields when compared to the 75 and 100% ETc regimes. Deficit irrigation up to 75% ETc had no impact on yield, indicating that for this year water savings were possible without yield depletion. Canopy temperatures were effective in monitoring plant stress during the canopy development.

Introduction

In 1993, the Texas Legislature placed water restrictions on the farming industry by limiting growers to a maximum use of 2 acre-foot of water per year in the Edwards Aquifer Region. Since then, maximization of agricultural production efficiency has become a high priority for numerous studies in the Winter Garden Area of Texas. Recent investigations have proposed Site-Specific Management (SSM) as an alternative to address this problem. SSM involves satellite-based remote sensing technology and mapping systems to detect specific areas suffering from stress within a field (i.e. water, insect, and disease stress). Crop canopy temperature has been found to be an effective indicator of plant water stress (Moran, 1994). Coupled with remote sensing technology, this concept allows collection and analysis of temperature data from crops using infrared thermometers (IRTs). IRTs mounted on irrigation systems or operated from aircraft can detect water stress by recording changes in leaf temperature caused by the alteration of the soil-plant water flow continuum (Hatfield and Pinter, 1993; Michels et al., 1999). Therefore, remote sensing equipment and mapping systems provide an excellent potential for producers to grow crops under high water use efficiency, by treating only the areas where treatment is needed (i.e. irrigation).

Objectives

The overall objectives of this project are as follow: 1) use remote sensing instrumentation for locating areas showing biotic and abiotic stress signs and/or symptoms in a cotton field, 2) evaluate canopy temperature changes in cotton with the use of IRTs, 3) and assess yield and yield parameters relative to the canopy temperatures.

Materials and Methods

The experiment was conducted at the Texas A&M Agricultural Research and Extension Center in Uvalde, Texas. Cotton variety Stoneville 4892B/Round-up Ready was planted in a circle at 50,000 ppa on 40-inch row spacing and grown under a center-pivot LESA (Low Elevation Sprinkler Application) irrigation system. Furrow dikes were placed between beds to increase water capture and minimize run-off. The soil type is a Knippa clay soil (fine-silty, mixed, hyperthermic Aridic Calciustolls) with a pH of 8.1. Three irrigation regimes (100%ETc, 75%ETc, and 50% ETc) were replicated twice in a randomized block design. A 90-degree wedge was divided equally into six 15-degree regimes, which were maintained at the above mentioned (ETc) values. Thirty Exergen (Irt/c.01-T80F/27C) infrared thermometers (IRTs) were mounted at approximately 15- foot spacing along the pivot length to scan the canopy temperature as the pivot moved. The IRTs recorded canopy temperatures every 10 seconds, and average temperature values every 60 seconds, on a 21X Campbell Scientific datalogger. In addition, canopy temperature differences were determined among treatments using a helicopter equipped with a Mikron 7200 LWIR (Long Wave-length Infrared) infrared camera with infrared band of 8-14 microns. Physiological parameters (i.e., leaf water and osmotic potential) were taken from leaves to determine the level of stress imposed by the different irrigation regimes and the presence of disease. Temperature data were statistically analyzed by ANOVA and separated by Fisher's LSD at α= 0.05. Aerial infrared temperature readings were analyzed by using the program Mikroscan 2.6.

Results and Discussion

Environmental conditions for the 2002 cotton season are shown in Fig. 1. The minimum and maximum temperatures were normal for the area, but excessive rainfall in the month of July prevented the imposition of differential irrigation regimes. Significant differences in canopy temperature were detected in all three irrigation regimes, with a linear increase in canopy temperature resulting from a decrease in plant water availability (Fig. 2). Extreme temperatures detected early in crop development were related to the detection of bare soil and moisture availability in the soil by the IRTs. Pivot mounted IRTs were effective in detecting crop canopy temperature differences between the 3 irrigation regimes (Fig. 3 and 4). Early in the season there were significant differences between all three irrigation regimes; however, at the end of the growing season no significant differences were found between the 100 and 75% ETc regimes, These results are also best explained by yield differences. No significant differences in lint yield were found between the 75% and 100% ETc regimes. Yield from the 50% regime were significantly less than the 75 and 100% ETc regimes. This yield reduction is associated with increased canopy temperatures of this regime. Yields were 1160 lb/acre, 1420 lb/acre, and 1600 lb/acre for the 50%, 75%, and 100% ETc treatments, respectively (Fig. 5). Abiotic and biotic stress can be differentiated better by the Mikron 7200 than the pivot mounted IRTs because of its increased image scanning resolution. The IR camera was able to detect distinct canopy temperature differences between all 3 irrigation regimes. Biotic stress (root rot) was detected by using the camera before symptoms could be detected visually. Pivot mounted IRTs and IR cameras were able to differentiate water stress between the irrigation regimes, but only IR cameras were able to distinguish between abiotic and biotic stress. There was an excellent correlation between canopy temperature and lint yield. Deficit irrigation up to 75% ETc had no impact on yield, indicating that water savings are possible without yield depletion. Also, canopy temperature can be an excellent tool to monitor plant stress.

References

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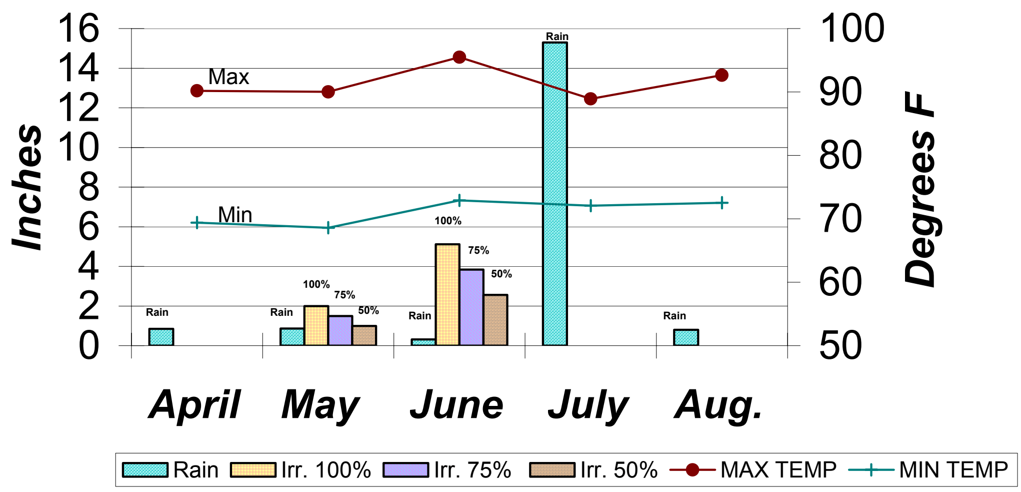

Figure 1. Weather conditions and irrigation regimes for the cotton 2002 season.

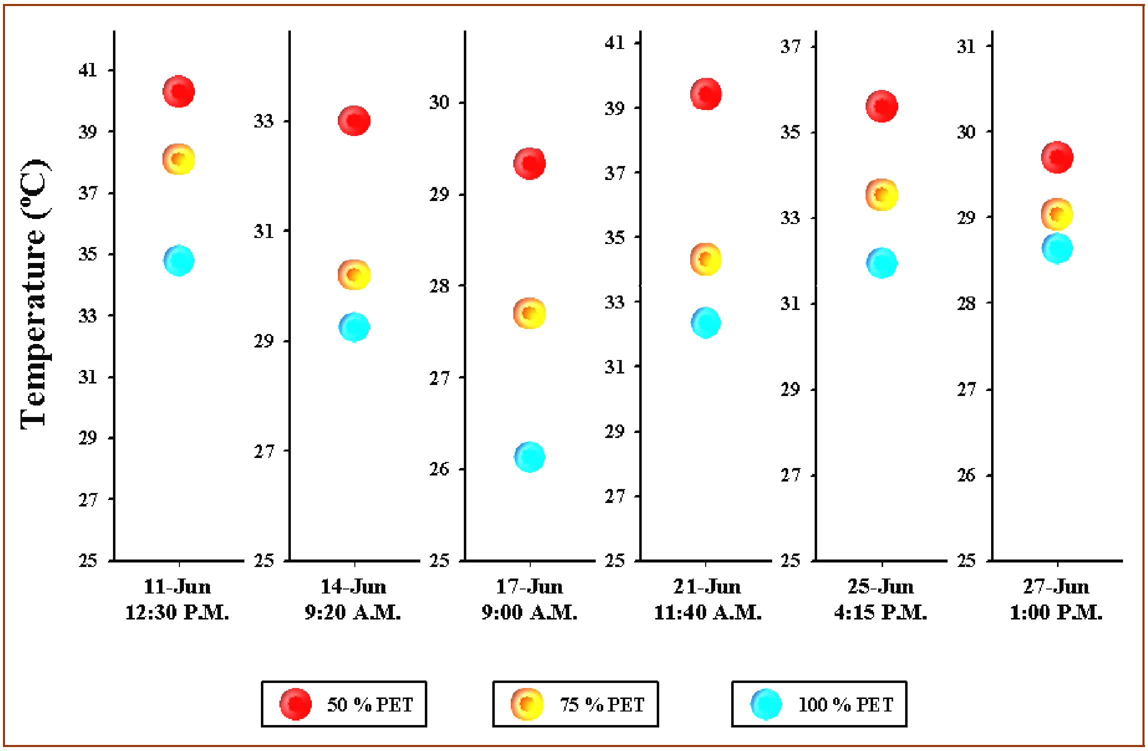

Figure 2. Pivot mounted IRTs showing bi-weekly cotton canopy temperatures.

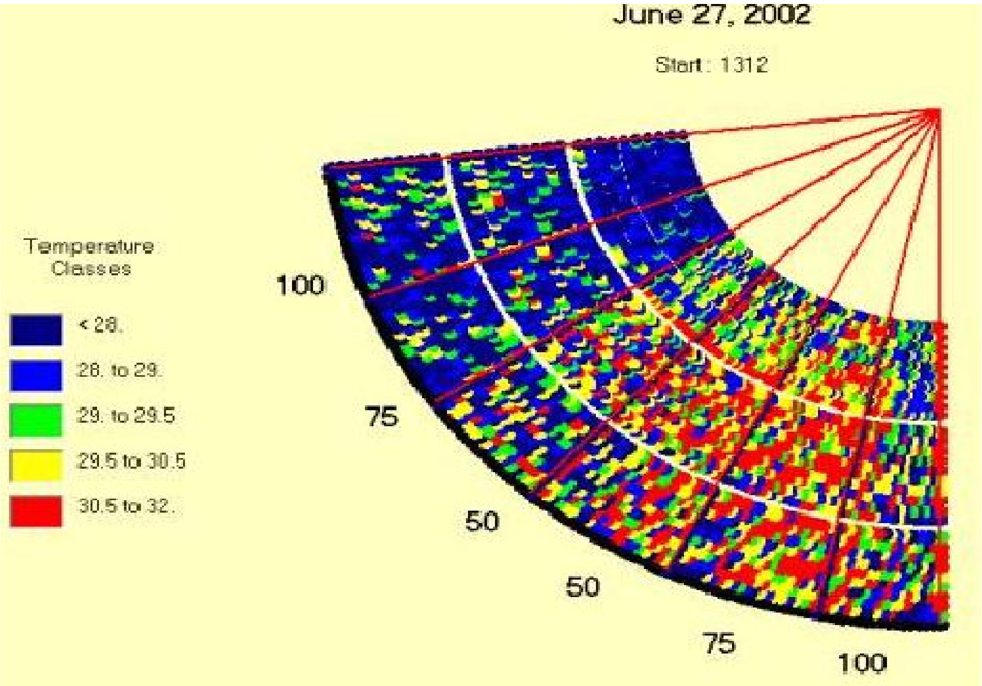

Figure 3. Pivot mounted IRTs early in the season showed significant differences in all three irrigation regimes.

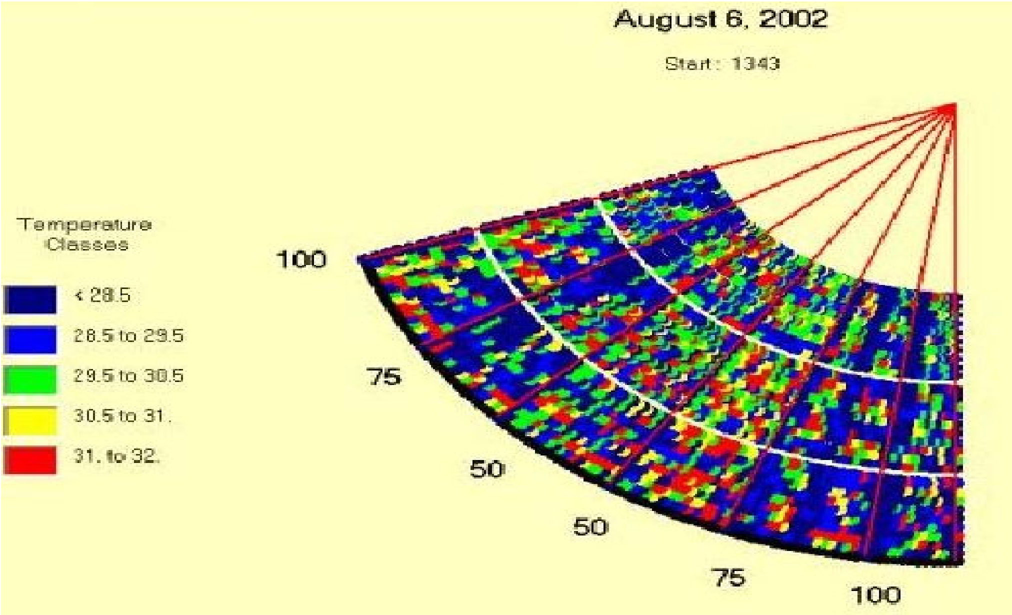

Figure 4. Late season cotton canopy temperatures showed significant differences in the 50% ETc regimes.

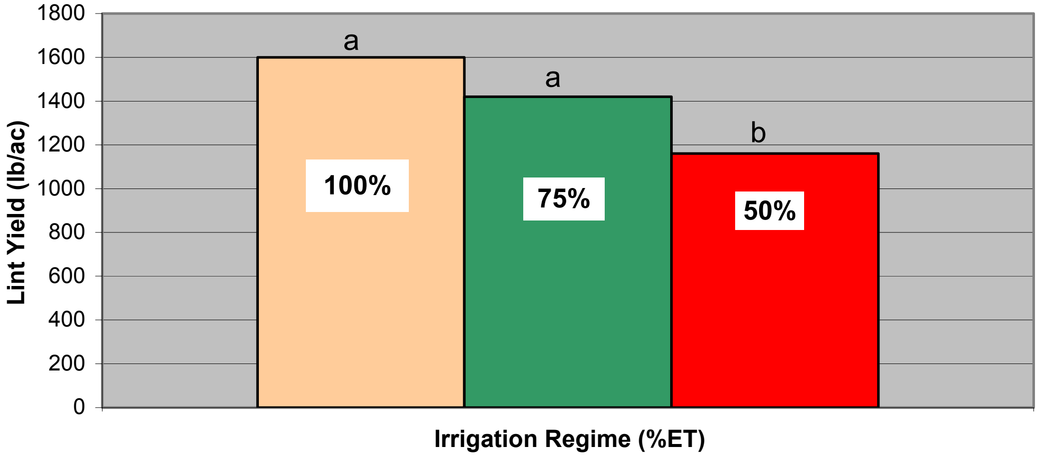

Figure 5. Lint yield comparison for different irrigation regimes.