COTTON IRRIGATION AND MEPIQUAT CHLORIDE MANAGEMENT USING REMOTE SENSING

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Introduction

Water is the most common environmental factor that limits crop productivity. Water is the primary component of actively growing crop plants, ranging from 70-90% of the crop plant fresh mass, and is essential to nutrient transport, chemical reactions, cell enlargement, transpiration, and most other plant processes. All plants are affected by soil moisture deficit. Moisture deficit inhibits cellular growth, changes enzyme concentrations, and eventually affects respiration, photosynthesis, and assimilate translocation, changing plant growth and development (Gardner et al. 1984). Water depletion affects cotton grown throughout the United States, particularly non-irrigated cotton. The costs of water application and the competitive demands for water further enhance the attractiveness of water-efficient cotton in production settings.

Cotton is an indeterminate crop with a fruiting habit that allows vegetative growth to continue above the fruiting branches after reproductive growth has been initiated. Left unchecked, cotton can exhibit rank growth (Cathey and Luckett 1980). This excess vegetative growth can cause fruit shed, difficulty in picking the cotton, boll rot, increased insect and disease pressure, decreased lint quality, and potentially impact yield (Nichols et al. 2003).

Mepiquat chloride (1,1-dimethylpiperidinium chloride) has been recognized as a useful cotton growth regulator since the late 1970s (Kerby 1985), due to its control of cotton height. Mepiquat chloride is an ammonium-containing compound that blocks the early steps of gibberellic acid (GA) metabolism, decreasing production of GA and resulting in shorter cotton.

Because both irrigation and mepiquat chloride application have associated application costs, the benefits of these amendments might be increased by imagery-based application. Not only may input costs be mitigated with more oversight over water and chemical application, but yield and quality may also be positively affected. Our objectives were to compare four levels of irrigation with multiple rates of mepiquat chloride application and compare the growth habits, yield, and quality of cotton under these regimes.

Materials and Methods

This study was a split plot experiment conducted on a variable rate center pivot at the Stripling Irrigation Research Park in Camilla, Georgia. The pivot is designed to allow variable application of water in a randomized complete block design, so irrigation was the main plot. DP161B2RF cotton was planned at a rate of three plants per foot with 36 inch row spacing on May 20, 2009. All pesticide and herbicide applications were based on University of Georgia extension guidelines. Nitrogen was applied in a split application, with 20 lb N applied on April 28 in the form of 3-9-18, and follow-up applications of 45 lb each were made on June 17 and June 24, 2009. The irrigation component of this study formed the main plot. One irrigation was applied prior to planting, at a rate of 0.3 inches to all plots. Irrigation treatments were begun on June 26, 2009, and the last irrigation was conducted on July 23, 2009. The irrigation treatments consisted of a 100% irrigation treatment, a 75% irrigation treatment, a 50% irrigation treatment, and a nonirrigated control. Irrigation scheduling and rates were based on the 100% irrigation treatment. In the 100% irrigation treatment, watermark sensors were placed at depths of 8, 16, and 24 inches. Irrigation was commenced when watermark sensors measured -40 centibar soil tension.

The split plot consisted of four mepiquat treatments: a nonapplied control, a mepiquat regime based on a single aerial image prior to the first mepiquat application, a mepiquat regime based on aerial images collected prior to each mepiquat chloride (MC) application, and a standard MC application based on standard practice. Mepiquat chloride was applied on June 22 and July 6, 2007. Each treatment was replicated four times for a total of 64 plots. Measurements included NDVI using a GreenSeeker spectrometer, green/red ratio using images from the aerial blimp, and in-the-field measurements of plant height, nodes, and nodes above first square or uppermost white flower. At the end of the season, subsamples were cut out of each plot and analyzed using box mapping. Plots were harvested with a two-row picker with a bagging attachment, and individual bags were ginned at the University of Georgia Microgin in Tifton. Fiber samples were sent to the Macon classing office and analyzed using HVI.

Results and Discussion

Plant height was related to irrigation rate, with the full irrigation rate yielding the tallest plants, followed by the 75% irrigation, 50% irrigation, and dryland treatments (Figure 6). The 0 mepiquat application resulted in taller plants than the treated plots, but none of the treated plots showed a significant difference in crop height on any of the sampling dates. This matched the results from the previous two years of this study. In all three study years, the “no MC” treatments were consistently taller than the other mepiquat chloride treatments. The intermediate mepiquat chloride treatments resulted in virtually identical two remote sensing treatments were similar in height to each other and taller than the standard mepiquat treatment at the lower levels of irrigation, but were not different in the full irrigation treatment. The remote sensing mepiquat chloride rates were similar to the standard rate at both the 75% and 100% irrigation rate. Nodes above first square (NAFS) and nodes above white flower (NAWF) measurements give estimates of crop maturity. First bloom occurred at 50 days after planting, but the measurements are combined, since the first squares become the first white flowers. Irrigation rate had the most impact on these ratings in 2009, as shown in Figure 2. The full irrigation plots had delayed maturity compared to the two intermediate irrigation treatments, and the dryland treatment had the lowest NAFS and NAWF throughout the season.

NDVI and Green:Red Ratio

NDVI and Green:Red ratio are both vegetation indices that estimate crop growth. As with the height and maturity measurements, these indices showed increased vegetative growth for the full irrigation treatment compared to the other irrigation treatments (Figure 2). The Green:Red ratio showed more pronounced differences between the full irrigation and the other two irrigated treatments than the NDVI. One potential reason for this difference is that the NDVI was measured near the ground using a GreenSeeker, and they tended to reach a maximum measurement early in the growing season. The Green:Red ratio was sensitive to higher ground cover fractions. The NDVI measurements did not indicate any differences between MC treatments on any dates, and the Green:Red ratio only indicated significant differences on one date, in which the untreated plots had significantly higher Green:Red values, indicating more vegetative growth (Figure 2).

Box Mapping, Yield, and Quality

Box mapping data are still being analyzed, but preliminary data is shown in Table 2. Table 2 shows the gains and losses of lint yield based on differences in boll mass during mapping by fruiting zone, compared to the fully irrigated treatment. There were no significant differences ($P<0.05$) for the MC treatments, so the data is not shown. Zone 1 is nodes 5-8, zone 2 is nodes 9-12, zone 3 is nodes 13-17, and zone 4 is nodes 18 and above. The 75%, 50%, and dryland treatments all had higher yields at the lower three zones than the fully irrigated treatment, but lower yields at zone 4. This suggests significantly higher early boll retention, and may explain at leas part of the increased height and vegetative growth of the full irrigation treatment compared to the other treatments. This phenomenon has been observed in other studies we have conducted. The final yield and quality of the plots are shown in Table 2. DP161 does not have the yield capabilities of DP555, which was the original variety planned for this study. Therefore, some of the decreases in yield probably would not have been observed with 555, since it tends to compensate well for loss of early fruiting sites on the plant. However, DP161 has impressive fiber quality parameters, as shown in Table 3. The highest yielding plots were the 50% and 75% irrigation treatments, suggesting that even a little over-watering can have a large impact on yield.

Acknowledgments

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References

Anonymous (2006) Camilla 3 SE, Georgia (091500): Period of record monthly climate summary. Southeast Regional Climate Center

Bednarz CW, Hook JE, Yager R, Cromer S, Cook D, Griner I (2002) Cotton crop water use and irrigation scheduling. In: Culpepper AS (ed) 2002 Georgia Cotton Research-Extension Report, pp 61-64

Cathey GW, Luckett K (1980) Some effects of growth regulator chemicals on cotton earliness, yield, and quality. Proc Beltwide Cotton Prod Res Conf. Natl. Cotton Council Am., St. Louis, MO, p 35

Cook DR, Kennedy CW (2000) Early flower bud loss and mepiquat chloride effects on cotton yield distribution. Crop Sci 40:1678-1684

Gardner FP, Pearce RB, Mitchell RL (1984) Physiology of crop plants, 1st edn. Iowa State Press

Harrison K (2005) Irrigation Survey, 2005. The University of Georgia College of Agricultural and Environmental Sciences Cooperative Extension Service

Kerby TA (1985) Cotton response to mepiquat chloride. Agron J 77:515-518

Kerby TA, K.D. Hake, Keely M (1986) Cotton fruiting modification with mepiquat chloride. Agron J 78:907-912

Nichols SP, Snipes CE, Jones MA (2003) Evaluation of row spacing and mepiquat chloride on cotton. Journal of Cotton Science 7:148-155

Rademacher W (2000) GROWTH RETARDANTS: Effects on Gibberellin Biosynthesis and Other Metabolic Pathways. Annual Review of Plant Physiology & Plant Molecular Biology 51:501

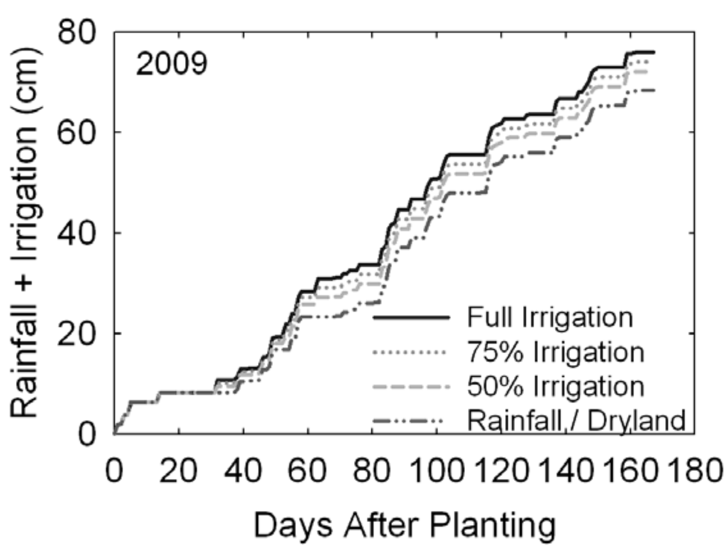

Figure 5. Cumulative rainfall and irrigation amounts for 2009.

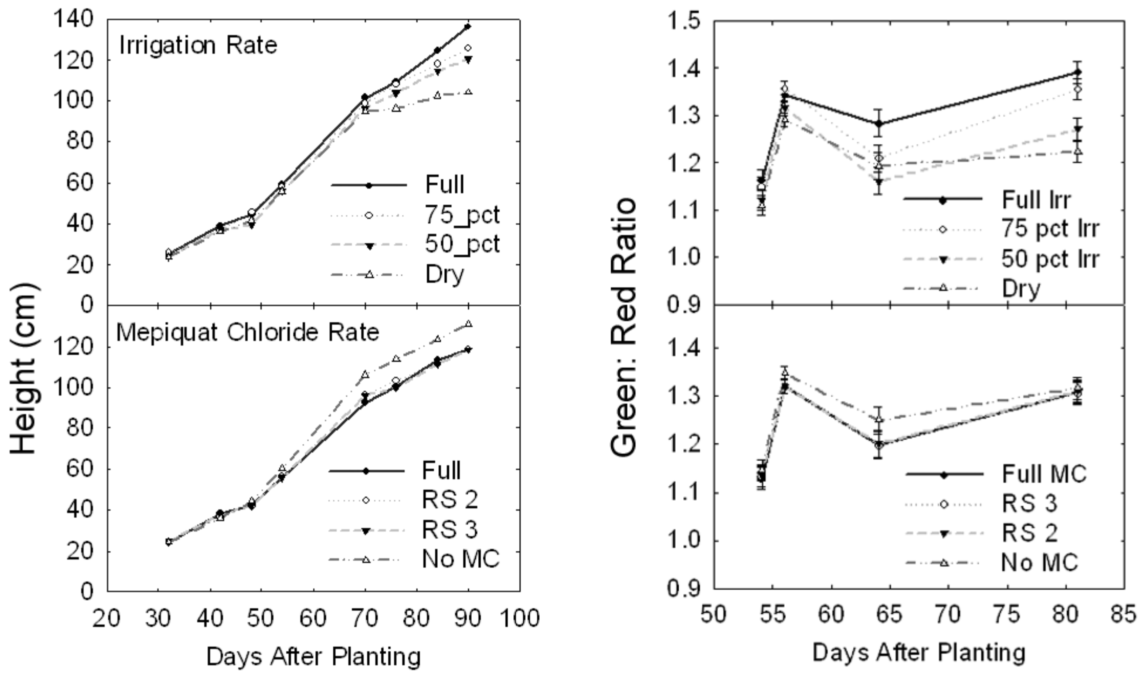

Figure 6. Height and Green:Red ratio by irrigation and mepiquat chloride treatment in 2009.

Table 2. Yield and quality of all irrigation and mepiquat chloride treatments in 2009.

Irr	Pix	Micronaire	Strength	Length	Uniformity	Yield (lb/acre)	Staple
Full	Full	3.69±0.16 fgh[a]	31.89±0.41 de	1.204±0.009 ab	83.48±0.36 abcd	905±68 de	38.6±0.3 ab
Full	RS 3	3.56±0.19 gh	32.83±0.48 abcd	1.201±0.010 ab	82.56±0.42 cd	906±68 de	38.4±0.4 ab
Full	RS 2	3.79±0.16 efgh	31.44±0.41 e	1.201±0.009 b	82.76±0.36 bcd	999±68 cd	38.3±0.3 b
Full	No MC	3.54±0.16 h	31.92±0.41 cde	1.201±0.009 b	82.56±0.36 d	809±68 e	38.3±0.3 b
75_pct	Full	4.04±0.16 cdef	33.37±0.41 a	1.219±0.009 ab	83.63±0.36 ab	1033±68 cd	38.8±0.3 ab
75_pct	RS 3	4.04±0.16 cdef	32.17±0.41 bcde	1.211±0.009 ab	83.61±0.36 ab	1057±68 bcd	38.8±0.3 ab
75_pct	RS 2	4.01±0.16 defg	33.02±0.41 ab	1.211±0.009 ab	83.41±0.36 abcd	1131±68 abc	38.6±0.3 ab
75_pct	No MC	4.09±0.16 bcdef	32.49±0.41 abcde	1.214±0.009 ab	83.41±0.36 abcd	1086±68 abc	39.1±0.3 ab
50_pct	Full	4.04±0.16 cdef	32.49±0.41 abcde	1.219±0.009 ab	83.78±0.36 a	1238±68 a	38.8±0.3 ab
50_pct	RS 3	4.16±0.16 bcde	33.04±0.41 ab	1.219±0.009 ab	83.46±0.36 abcd	1237±68 a	39.1±0.3 ab
50_pct	RS 2	4.11±0.16 bcde	32.54±0.41 abcd	1.224±0.009 ab	83.93±0.36 a	1209±68 ab	39.3±0.3 a
50_pct	No MC	4.14±0.16 bcde	32.44±0.41 abcde	1.211±0.009 ab	83.36±0.36 abcd	1238±68 a	38.8±0.3 ab
Dry	Full	4.59±0.16 a	32.54±0.41 abcd	1.226±0.009 a	83.71±0.36 ab	1118±68 abc	39.3±0.3 a
Dry	RS 3	4.44±0.16 abc	32.67±0.41 abcd	1.211±0.009 ab	83.36±0.36 abcd	1030±68 cd	38.8±0.3 ab
Dry	RS 2	4.34±0.16 abcd	32.97±0.41 abc	1.206±0.009 ab	83.11±0.36 abcd	1048±68 bcd	38.6±0.3 ab
Dry	No MC	4.46±0.16 ab	33.04±0.41 ab	1.209±0.009 ab	83.56±0.36 abc	1059±68 bcd	38.6±0.3 ab

[a]Letters in columns indicate significant differences between treatments.