EFFECTS OF VARYING IRRIGATION AND MEPIQUAT CHLORIDE APPLICATION ON COTTON HEIGHT, UNIFORMITY, YIELD, AND QUALITY

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Abstract

Irrigation and plant growth regulators (PGRs) affect cotton growth, height, and development. Irrigation increases crop height and slows maturity, while the addition of PGRs, such as mepiquat chloride, decreases crop height and increases maturity. Irrigation and PGR application both increase cotton management costs. We examined the effects of varied irrigation and mepiquat chloride application based on remote sensing to test the effects of precision mepiquat chloride application on input costs, crop uniformity, and crop yield and quality. Cotton was grown under a variable rate irrigation system at the Stripling Irrigation Research Park in Camilla, Georgia with four levels of irrigation and four replicates. Subplots within each irrigation plot had four levels of mepiquat chloride application. One was a full application, the second and third were based on varying levels of oversight based on aerial images during the season, and the fourth was a control treatment with no mepiquat chloride applied. Plant height and maturity were measured prior to each mepiquat chloride application, and crop yield and quality were measured at the end. The results suggest effects of varied application of both irrigation and mepiquat chloride application.

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, 1984 #46}.

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. For instance, much of the Southeast is currently experiencing moderate to severe drought (Figure 1), and agricultural use accounts for a significant portion of water consumption in the United States, even in normally relatively wet regions of the country such as Alabama, Georgia, and South Carolina (Figure 2). Bednarz *et al.* {, 2002 #32} stated that cotton grown in South Georgia requires about 460 mm of water for maximum yields. Although South Georgia receives about 600 mm of water during the average growing season {Anonymous, 2006 #89}, periodic dry periods often cause crop water stress, which can be resolved by irrigation. In Georgia, an estimated 250,000 hectares of cotton are irrigated {Harrison, 2005 #70}. This means that about 1.8 billion liters of water are required to apply one cm of irrigation water to all of the irrigated cotton in Georgia alone. Other states are even more dependent on irrigation than Georgia. Technology that decreases crop water use can have a major impact on available water resources.

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, 1980 #299}. 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, 2003 #298}.

Mepiquat chloride (1,1-dimethylpiperidinium chloride) has been recognized as a useful cotton growth regulator since the late 1970s {Kerby, 1985 #293}, 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. Although some plants have a low response to mepiquat chloride, cotton is highly responsive to MC application {Rademacher, 2000 #300}. Mepiquat chloride has been shown to decrease the number of sympodial nodes and reproductive branches, decrease internode length, increase maturity rate, and decrease boll rot {Nichols, 2003 #298}. The effects on maturity and the number of reproductive branches have also been linked to the enhanced retention of early buds and bolls {Cook, 2000 #296; Kerby, 1986 #294}.

Because both irrigation and mepiquat chloride application have associated application costs, the benefits of these amendments might be increased by imagery-based application.

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. DP 555 cotton was planted at a rate of three plants per foot with 36 inch row spacing on May 10, 2007. All pesticide and herbicide applications were based on University of Georgia extension guidelines. 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. An additional 1.1 inches of irrigation were applied to all plots within the first week after planting to facilitate emergence. Irrigation treatments were begun on May 25, 2007, and continued until July 24, 2007. 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 application, and a standard mepiquat chloride 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.

Results and Discussion

Unsurprisingly, the control treatments with no mepiquat chloride added were consistently taller than the other treatments (Figure 1). The 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.

Plant height during the growing season was lowest for the nonirrigated treatment at 54 DAP, and trended lower than the same mepiquat chloride rates at different irrigation rates at day 82 (Table 1). However, by day 144 (harvest), the nonirrigated treatments were the tallest of any irrigation treatment (Figure 1). Similarly, mepiquat chloride treatments based on remote sensing data were similar in height to the standard mepiquat chloride treatment at 54 and 82 days after planting, but were higher at harvest at the 50% and 75% irrigation rate treatments.

Yield, staple, uniformity, and strength varied by irrigation and PGR (Table 2). In the no-Pix treatment, the irrigated treatments had significantly higher yield than the non-irrigated treatment. This trend was evident in most of the pix treatments, with the exception of the 75% irrigated treatment with pix based on multiple remote sensing measurements.

Figure 2 shows the relative yield distribution of the cotton plants with each irrigation and PGR treatment. The treatments with lower PGR rates showed the highest level of lint yield above node 16, as shown in Figure 2. The nonirrigated treatments also showed higher levels of yield above node 16, likely due to the late rainfall and the compensation of the crop to increase yield.

Acknowledgments

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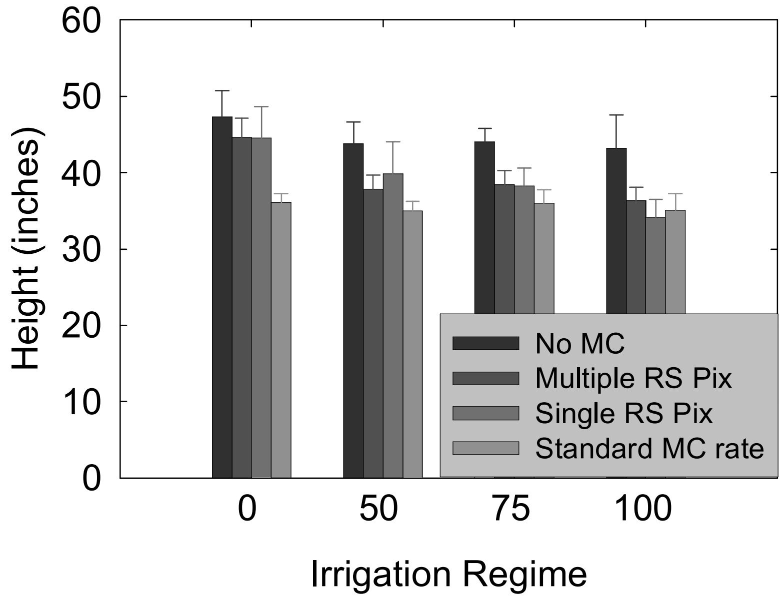

Figure 4. Final plant height of all treatments. Error bars represent standard error of the mean (n=4).

Table 1. Plant height during the growing season for all treatments.

		Irrigation			
DAP	PGR	Dry	50%	75%	100%
		Height (inches)			
54	No MC	17.85 ± 0.84	21.25 ± 0.92	21.8 ± 1.32	22.15 ± 0.78
	Multiple RS Pix	17.55 ± 0.58	18.95 ± 0.91	19.85 ± 1.2	20 ± 0.56
	Single RS Pix	18.3 ± 1.03	19.75 ± 1.06	19.95 ± 0.89	20.3 ± 1.01
	Standard	15.7 ± 0.68	17.95 ± 0.69	19 ± 1.09	19.45 ± 0.58
82	No MC	37.75 ± 0.95	40.4 ± 1.02	40 ± 1.38	38.7 ± 0.96
	Multiple RS Pix	37.3 ± 0.99	34.75 ± 1.09	34.45 ± 1.22	32.05 ± 1.18
	Single RS Pix	37.45 ± 2.12	34.45 ± 1.42	35.45 ± 1.02	31.9 ± 1.74
	Standard	31.3 ± 0.92	32.25 ± 1.95	30.75 ± 1.77	31.1 ± 0.88
144	No MC	47.3 ± 3.46	43.75 ± 2.9	44 ± 1.75	43.2 ± 4.34
	Multiple RS Pix	44.6 ± 2.48	37.85 ± 1.79	38.45 ± 1.79	36.35 ± 1.72
	Single RS Pix	44.5 ± 4.11	39.84 ± 4.16	38.25 ± 2.33	34.15 ± 2.31
	Standard	36.1 ± 1.18	34.95 ± 1.25	36 ± 1.73	35.05 ± 2.21

Table 2. Yield, staple, strength, and uniformity of all treatments. Errors represent standard error of the mean (n = 4).

		Irrigation			
PGR	Data	0	50	75	100
No Pix	Yield (kg/ha)	1402 ± 39	1474 ± 92	1582 ± 76	1550 ± 38
	Staple	34.5 ± 0.3	34.8 ± 0.6	34.5 ± 0.3	34.3 ± 0.6
	Strength	31.5 ± 1.9	29 ± 0.6	28.9 ± 0.8	30.1 ± 1.7
	Uniformity	0.805 ± 0.006	0.803 ± 0.0033	0.807 ± 0.0029	0.806 ± 0.0018
Multiple RS Pix	Yield (kg/ha)	1401 ± 84	1476 ± 37	1390 ± 55	1499 ± 60
	Staple	34.5 ± 0.7	34.5 ± 0.3	34.8 ± 0.6	35.5 ± 0.3
	Strength	32 ± 1.1	31.2 ± 2.2	28.5 ± 0.6	30.6 ± 0.9
	Uniformity	0.803 ± 0.0014	0.804 ± 0.0028	0.804 ± 0.001	0.808 ± 0.0016
Single RS Pix	Yield (kg/ha)	1366 ± 48	1567 ± 175	1406 ± 8	1426 ± 96
	Staple	34.5 ± 0.7	34.8 ± 0.3	36 ± 0.8	35 ± 0.5
	Strength	28.3 ± 1.1	31 ± 1.8	29.5 ± 1	31.5 ± 0.9
	Uniformity	0.81 ± 0.004	0.804 ± 0.0051	0.811 ± 0.0071	0.81 ± 0.0052
Standard Pix	Yield (kg/ha)	1349 ± 52	1381 ± 62	1374 ± 60	1460 ± 53
	Staple	34.8 ± 0.3	34.5 ± 0.3	35.3 ± 0.3	34.5 ± 0.3
	Strength	30.2 ± 1.4	29.3 ± 1.6	30.1 ± 1.4	30.7 ± 1.6
	Uniformity	0.803 ± 0.0021	0.808 ± 0.0038	0.809 ± 0.0026	0.807 ± 0.0019

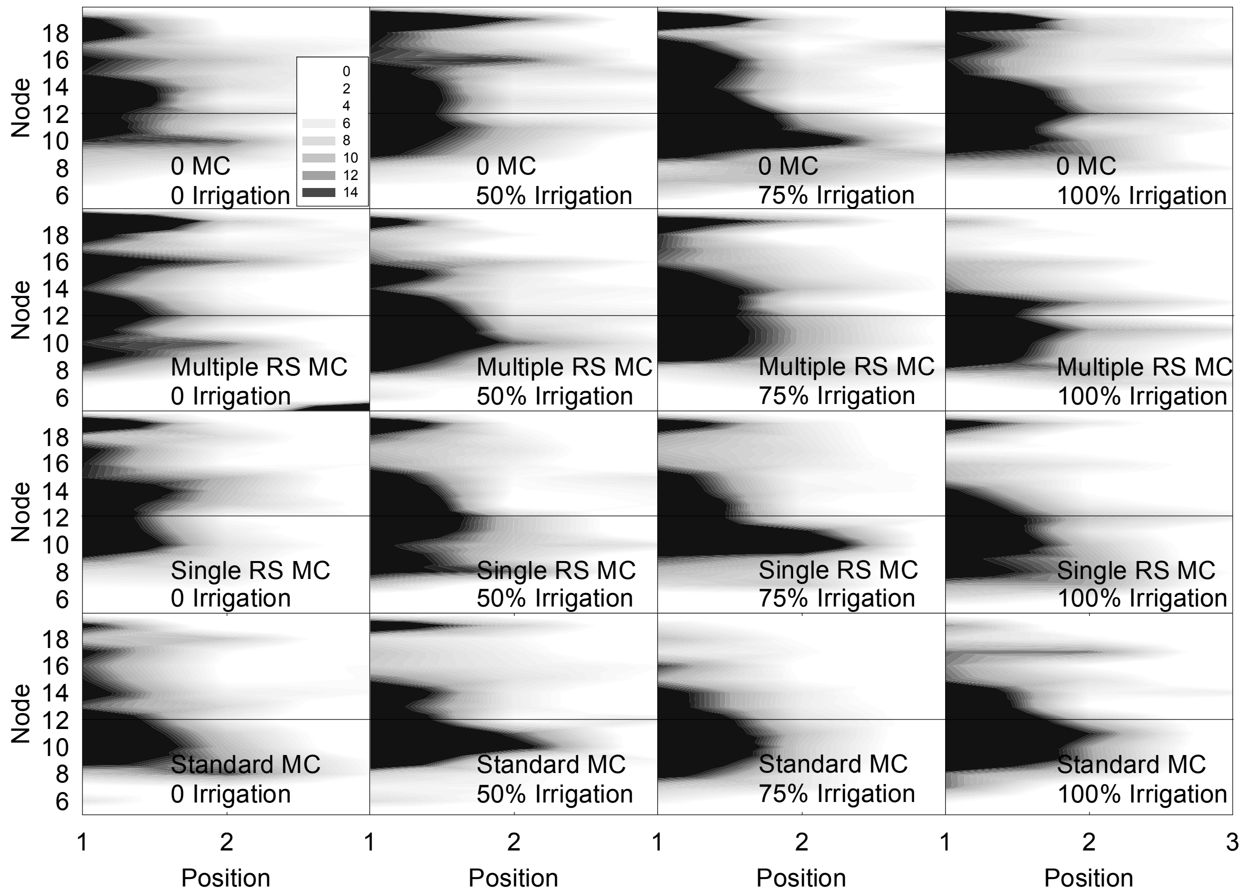

Figure 5. Yield distribution of all treatments. The darker regions of each graph represent regions of the plant with the highest yield.

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