ECONOMICS OF REMOTE SENSING TECHNOLOGY USED TO DETERMINE MEPIQUAT CHLORIDE APPLICATION ON COTTON UNDER VARIABLE RATE IRRIGATION: RESULTS OF A TWO-YEAR STUDY

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Abstract

Irrigation and plant growth regulators such as mepiquat chloride (MC) affect cotton growth, height, and development. Irrigation increases crop height and delays maturity, while the addition of MC decreases crop height and hastens maturity. Irrigation and MC application both increase cotton management costs. We examined the effects of varied irrigation and MC application based on remote sensing to test the effects of precision MC application on crop yield and net returns to irrigation and MC application. Cotton was grown under a variable rate irrigation center pivot system at the Stripling Irrigation Research Park in Camilla, Georgia during crop years 2007 and 2008. There were four levels of irrigation and four replicates. Subplots within each irrigation plot had four levels of MC application. One level was a standard application, the second and third levels were based on varying degrees of oversight using aerial imagery throughout the season, and the fourth level was a non MC applied regime. Revenues were determined by yield and based on the southeast base price. Costs were based on irrigation application, MC amount and ginning, storage and warehouse expenses. There was no significant difference in total costs in 2007. However in 2008, the plots where remote sensing technology was used, cost significantly less (an average \$3.89/acre across all levels of irrigation) than the plots that received the standard application amount. In 2007 the 100%-irrigated plots had significantly higher net returns per acre than the non-irrigated plots by \$49.75/acre averaged across all MC treatments. In 2007 the non MC plots returned significantly higher net returns per acre (an average \$58.50/acre across all levels of irrigation) than those treated with the standard application of MC. The net returns for the plots where remote sensing technology was utilized fell between those of the standard and non-MC plots in 2007 and 2008, but they were not statistically different from either. Although there was a cost savings in 2008, it did not significantly impact net revenue. There was no significant difference in net revenues in 2008. Future analysis on the impact of quality (premiums and discounts) will be conducted pending the data.

Introduction

Water is the most common environmental factor that limits crop productivity. 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 experienced moderate to exceptional drought during 2007 and 2008 (Svoboda 2007, Tinker 2008). Agricultural use accounts for a significant portion of water consumption in the United States, even in less arid regions of the country such as Alabama, Georgia, and South Carolina. Bednarz *et al.* (2002) stated that cotton grown in South Georgia requires about 18.1 inches of water for maximum yields. Although South Georgia receives about 23.6 inches of water during the average growing season (Anonymous 2008), periodic dry periods often cause crop water stress, which can be resolved by irrigation. In Georgia, an estimated 617,750 acres of cotton are irrigated (Harrison 2005). This means that about 16.8 million gallons of water are required to apply one inch of irrigation water to all of the irrigated cotton in Georgia alone. Technology that decreases crop water use can have a major impact on available water resources.

Cotton is an indeterminate crop 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 rank, or excess vegetative growth, can cause fruit shed, difficulty in picking, boll rot, increased insect and disease pressure, decreased lint quality and potentially impact yield (Nichols et al. 2003). Mepiquat chloride (MC) has been recognized as a useful cotton growth regulator since the late 1970s (Kerby 1985), due to its control of cotton height. Although some plants have a low response to MC, cotton is highly responsive to its action (Rademacher 2000). MC has been shown to decrease the number of nodes and reproductive branches, decrease internode length, increase maturity rate, and decrease boll rot (Nichols et al. 2003). The effects on maturity and the number of reproductive branches have also been linked to the enhanced retention of early buds and bolls (Cook and Kennedy 2000; Kerby et al. 1986). These effects may improve lint quality and impact yield as they inhibit excessive vegetative growth.

Because both irrigation and MC application have associated application costs, the benefits of these amendments might be increased by imagery-based application through remote sensing technology.

Data and Methods

This study was a split plot experiment conducted under a variable rate center pivot at The University of Georgia Stripling Irrigation Research Park in Camilla, Georgia. The pivot is designed to allow variable application of water in a randomized complete block design. DP555 cotton was planted. All fertilizer, pesticide and herbicide applications were based on The University of Georgia Extension guidelines. The costs of these chemical applications were consistent across all plots; therefore, they were not included in the economic analysis.

The irrigation treatments consisted of a 100% irrigation treatment, a 75% irrigation treatment, a 50% irrigation treatment, and a non-irrigated treatment. 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. Because all plots were under a variable rate pivot, the costs of the irrigated plots were the same. The irrigation application costs for the irrigated plots were calculated at $7.25 per application. In 2007 there were seven irrigation applications for a total cost of $50.75/acre. In 2008 there were four irrigation applications for a total cost of $29.00/acre.

The split plot consisted of four MC treatments: a non-applied regime (No MC), a regime based on a single aerial image prior to the first MC application (Single RS MC), a regime based on aerial images collected prior to each MC application (Multiple RS MC), and a standard application based on standard practice (Standard MC). Mepiquat chloride was applied twice in 2007 and three times in 2008. Each treatment was replicated four times for a total of 64 plots. Mepiquat chloride application costs included the cost of the chemical at $0.23/oz. Application costs (fuel, labor and machinery operation costs) were assumed constant across all regimes because of the use of variable rate spray technology. Total MC application costs ranged from $0.00/acre to $9.38/acre.

Other costs based on yield included ginning, storage, and warehouse costs minus a credit for cottonseed. An average of the November 2007 and November 2008 southeast cottonseed price was used ($164/ton).

Revenue was based on yield using the average base price for the southeast for 2007 and 2008. The base price in 2007 was $0.6158/lb. In 2008 the base price was $0.5491/lb including the loan deficiency payment. This resulted in an average price of $0.5825/lb.

Results and Discussion

The treatment programs had various impacts on yield (Tables 1 & 2). In 2007, the 100% irrigated plots yielded significantly higher than the variable rate-irrigated and non-irrigated plots. Furthermore, the Standard MC plots yielded significantly less than the No MC plots. There were no significant differences in yield in 2008.

Table 1. Average Yield by Treatment, 2007 (lb/ac)

MC Rate	Irrigation Rate			
	0% [y]	50% [y]	75% [y,z]	100% [z]
No MC [a]	1,249 ± 60	1,313 ± 142	1,409 ± 117	1,381 ± 58
Single RS MC [a,b]	1,217± 73	1,396 ± 270	1,253 ± 12	1,270 ± 148
Multiple RS MC [a,b]	1,248 ± 130	1,314 ± 57	1,238 ± 85	1,335 ± 93
Standard MC [b]	1,201 ± 80	1,230 ± 95	1,224 ± 93	1,301 ± 81

[a,b,y,z] Means with the same letter are not significantly different at $\alpha = 0.05$

Table 2. Average Yield by Treatment, 2008 (lb/ac)

MC Rate	Irrigation Rate			
	0% [y]	50% [y]	75% [y]	100% [y]
No MC [a]	1,039 ± 114	990 ± 202	943 ± 76	1,109 ± 84
Single RS MC [a]	980 ± 80	1,009 ± 168	987 ± 134	1,064 ± 160
Multiple RS MC [a]	981± 117	1,101 ± 136	982 ± 120	996 ± 162
Standard MC [a]	1,085 ± 100	1,028 ± 124	987 ± 121	970 ± 250

[a,b,y,z] Means with the same letter are not significantly different at α = 0.05

Average total costs by treatment (Tables 3 & 4) ranged from a low of $75.40/acre for the non-irrigated, No MC plots to a high of $81.17/acre for the 100%-irrigated, Standard MC plots in 2007. In 2008, costs ranged from a low of $39.60 for the non-irrigated, Single RS MC plots to a high of $47.04 for the 75%-irrigated, Standard MC plots. There was no significant difference in costs in 2007. However in 2008 across all levels of irrigation, the Standard MC regime cost significantly higher than the other regimes at an average of $4.15/acre more than the Multiple RS MC plots, $3.63/acre more than the Single RS MC plots and $4.89/acre more than the No MC plots. This indicates a potential cost savings to using remote sensing technology to determine the amount of MC to apply.

Table 3. Average Total Cost by Treatment, 2007 ($/acre)

MC Rate	Irrigation Rate			
	0% [y]	50% [y]	75% [y]	100% [y]
No MC [a]	$75.40 ± 5.22	$79.10 ± 3.64	$80.65 ± 2.62	$80.84 ± 5.45
Single RS MC [a]	$76.10 ± 5.01	$80.11 ± 8.48	$78.82 ± 5.49	$80.94 ± 8.05
Multiple RS MC [a]	$77.41 ± 5.01	$80.20 ± 1.24	$79.08 ± 4.13	$81.49 ± 2.52
Standard MC [a]	$79.63 ± 2.55	$78.96 ± 4.28	$78.63 ± 1.49	$81.17 ± 4.41

[a,b,y,z] Means with the same letter are not significantly different at α = 0.05

Table 4. Average Total Cost by Treatment, 2008 ($/acre)

MC Rate	Irrigation Rate			
	0% [y]	50% [y]	75% [y]	100% [y]
No MC [a]	$40.37 ± 1.93	$40.42 ± 5.74	$41.06 ± 0.75	$43.45 ± 4.19
Single RS MC [a]	$39.60 ± 4.51	$42.29 ± 4.55	$44.41 ± 1.27	$44.06 ± 3.40
Multiple RS MC [a]	$40.40 ± 4.77	$43.14 ± 6.69	$42.36 ± 2.23	$42.36 ± 4.62
Standard MC [b]	$44.33 ± 2.34	$46.47 ± 1.28	$47.04 ±1.70	$47.03 ± 3.45

[a,b,y,z] Means with the same letter are not significantly different at α = 0.05

The average net returns per acre are located in Tables 5 and 6. In 2007 the 100%-irrigated plots had significantly higher net returns per acre than the non-irrigated plots by an average $49.75/acre. The No MC plots also had significantly higher net returns per acre than the Standard MC plots by an average $58.50/acre. The Single RS MC and Multiple RS MC had net returns that fell between the Standard MC and No MC plots buy these values were not statistically different. There were no statistical differences in net returns per acre in 2008.

Table 5. Average Net Returns to Irrigation and Mepiquat Chloride Application by Treatment, 2007 ($/acre)

MC Rate	Irrigation Rate			
	0% [y]	50% [yz]	75% [yz]	100% [z]
No MC [a]	$652 ± 31	$686 ± 79	$740 ± 67	$723 ± 32
Single RS MC [a,b]	$633 ± 39	$733 ± 149	$651 ± 11	$659 ± 79
Multiple RS MC [a,b]	$650 ± 71	$685 ± 34	$642 ± 49	$696 ± 54
Standard MC [b]	$620 ± 44	$637 ± 52	$634 ± 53	$676 ± 43

[a,b,y,z] Means with the same letter are not significantly different at α = 0.05

Table 6. Average Net Returns to Irrigation and Mepiquat Chloride Application by Treatment, 2008 ($/acre)

MC Rate	Irrigation Rate			
	0% [y]	50% [y]	75% [y]	100% [y]
No MC [a]	$565 ± 68	$536 ± 112	$508 ± 44	$603 ± 47
Single RS MC [a]	$531 ± 45	$545 ± 94	$530 ± 78	$576 ± 92
Multiple RS MC [a]	$531 ± 68	$598 ± 74	$529 ± 68	$538 ± 92
Standard MC [a]	$588 ± 57	$552 ± 72	$528 ± 69	$521 ± 142

[a,b,y,z] Means with the same letter are not significantly different at α = 0.05

The following risk-return plot (Figure 1) shows where each treatment regime was located dependent upon the variance, or risk, of the treatment program and the estimated net returns per acre across both years. Comparing irrigation levels, the non-irrigated plots created the least risk and the lowest returns. The partially-irrigated plots (50% and 75%) increased net returns per acre over the non-irrigated plots but also increased risk. The 100% irrigated plots had moderate risk, but higher net returns per acre. Comparing the MC regimes, the No MC (circles) regimes created low to moderate risk and low to moderate returns, except for the No MC regime at 50% irrigation which created the highest risk for a moderate return. The Standard MC (squares) appeared to have the least risk, but also had the lowest net returns on average. The Single RS MC (triangles) appeared to have higher net returns and moderate risk. The Multiple RS MC (diamonds) reduced risk compared to the Single RS MC and No MC regimes.

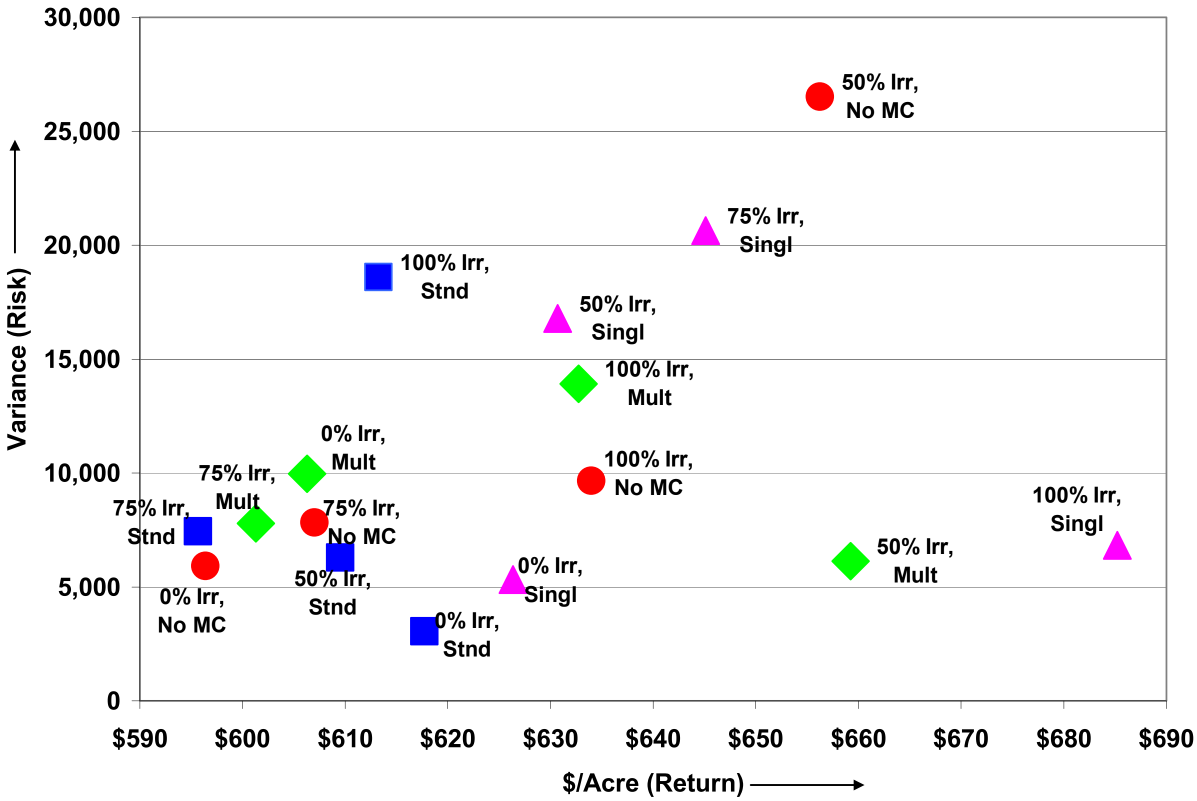

Figure 1. Risk-Return by Treatment

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