Economic Analysis of Remote Sensing Technology UseD to Determine Mepiquat Chloride Application On Cotton under Variable Rate Irrigation

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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 fresh crop plant mass. Water 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, which affects 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, 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. Bednarz *et al.* {, 2002 #32} 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, 2006 #89}, 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 #70}. 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. 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 has been recognized as a useful cotton growth regulator since the late 1970s {Kerby, 1985 #293}, due to its control of cotton height. Although some plants have a low response to mepiquat chloride, cotton is highly responsive to its action {Rademacher, 2000 #300}. Mepiquat chloride has been shown to decrease the number of 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}. These effects may improve lint quality and impact yield as they inhibit excessive vegetative growth.

Because both irrigation and mepiquat chloride 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 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 costs of these chemical applications were consistent across all plots; therefore, they were not included in the economic analysis.

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. Application costs for these two irrigations were consistent across all plots and were not included in the economic analysis.

Irrigation treatments were started on May 25, 2007, and continued until July 24, 2007, to a total of seven irrigation dates. The irrigation treatments consisted of a 100% irrigation treatment, a 75% irrigation treatment, a 50% irrigation treatment, and a non-irrigated 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. 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 per application for a total of $49/acre. There were no irrigation application costs associated with the non-irrigated plots.

The split plot consisted of four mepiquat chloride treatments: a non-applied control (No Pix), a mepiquat chloride regime based on a single aerial image prior to the first mepiquat chloride application (Single RS Pix), a mepiquat chloride regime based on aerial images collected prior to each mepiquat chloride application (Multiple RS Pix), and a standard mepiquat chloride application based on standard practice (Standard Pix). Mepiquat chloride was applied on June 22 and July 6, 2007. Each treatment was replicated four times for a total of 64 plots.

Mepiquat chloride application costs included the cost of the chemical at $0.26/oz and its physical application (fuel, labor and machinery operation costs) for either one or two trips across the field as determined by the aerial imagery. Total mepiquat chloride application costs ranged from $0.00/acre to $10.35/acre.

Other costs based on yield included ginning, storage, and warehouse costs minus a credit for cottonseed. The November 2007 southeast cottonseed price of $140 per ton was used.

Price was based on several quality factors: leaf, staple, strength and uniformity. We assumed that all of the plots were color 41. The southeast base price of $0.6158/lb was used for the base. Prices ranged from a low of $0.5983/lb to a high of $0.6413/lb.

Results and Discussion

The treatment programs had various impacts on yield (Table 1). As expected, the 100% irrigated plots yielded significantly higher than the variable rate-irrigated and non-irrigated plots. Furthermore, the Standard Pix plots yielded significantly less than the No Pix control plots.

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

PGR Rate	Irrigation Rate			
	0% [y]	50% [y]	75% [y,z]	100% [z]
No Pix [a]	1,249 ± 60	1,313 ± 142	1,409 ± 117	1,381 ± 58
Single RS Pix [a,b]	1,248 ± 130	1,314 ± 57	1,238 ± 85	1,335 ± 93
Multiple RS Pix [a,b]	1,217± 73	1,396 ± 270	1,253 ± 12	1,270 ± 148
Standard Pix [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 α = 0.05

Taking yield into consideration, average total costs by treatment (Table 2) ranged from a low of $0.026/lb for the non-irrigated, No Pix plots to a high of $0.072/lb for the 50 and 75%-irrigated, Standard Pix plots. All non-irrigated plots had significantly lower total costs than the irrigated plots. The Single RS Pix and Multiple RS Pix had average total costs that were significantly higher than the No Pix plots, but significantly lower than the Standard Pix plots.

Table 2. Average Total Cost by Treatment ($/lb)

PGR Rate	Irrigation Rate			
	0% [y]	50% [z]	75% [z]	100% [z]
No Pix [a]	$0.026 ± 0.0034	$0.065 ± 0.0041	$0.062 ± 0.0042	$0.063 ± 0.0036
Single RS Pix [b]	$0.027 ± 0.0045	$0.065 ± 0.0052	$0.070 ± 0.0041	$0.071 ± 0.0037
Multiple RS Pix [b]	$0.028 ± 0.0028	$0.068 ± 0.0031	$0.071 ± 0.0048	$0.069 ± 0.0032
Standard Pix [c]	$0.033 ± 0.0006	$0.072 ± 0.0026	$0.072 ± 0.0044	$0.070 ± 0.0011

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

Average prices, based on quality and uniformity, are located in Table 3. Average prices ranged from $0.617/lb for the 100% irrigated, No Pix plots to $0.633/lb for the 75% irrigated, Single RS Pix plots. However, there were no significant differences between the average prices for all plots.

Table 3. Average Price Based on Premium/Discount for Quality by Treatment ($/lb)

PGR Rate	Irrigation Rate			
	0% [y]	50% [y]	75% [y]	100% [y]
No Pix [a]	$0.629 ± 0.009	$0.629 ± 0.005	$0.627 ± 0.006	$0.617 ± 0.015
Single RS Pix [a]	$0.620 ± 0.011	$0.631 ± 0.004	$0.633 ± 0.006	$0.627 ± 0.007
Multiple RS Pix [a]	$0.627 ± 0.012	$0.627 ± 0.011	$0.627 ± 0.004	$0.631 ± 0.010
Standard Pix [a]	$0.627 ± 0.008	$0.627 ± 0.005	$0.625 ± 0.008	$0.624 ± 0.007

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

The average net returns per pound of lint yield are located in Table 4. The non-irrigated plots had significantly higher net returns per pound of lint yield than the irrigated plots by $0.039/lb on average. The No Pix plots also had significantly higher net returns per pound of lint yield than the Standard Pix plots by $0.007/lb on average. The Single RS Pix and Multiple RS Pix had net returns that fell between the Standard Pix and No Pix. Even though these values were not statistically significant, there may be a slight savings through the use of remote sensing-based mepiquat chloride application compared to the standard application.

Table 4. Average Net Returns to Irrigation and Mepiquat Chloride Application by Treatment ($/lb)

PGR Rate	Irrigation Rate			
	0% [y]	50% [z]	75% [z]	100% [z]
No Pix [a]	$0.603 ± 0.0059	$0.564 ± 0.0084	$0.563 ± 0.0044	$0.554 ± 0.0153
Single RS Pix [a,b]	$0.593 ± 0.0145	$0.555 ± 0.0071	$0.559 ± 0.0110	$0.562 ± 0.0098
Multiple RS Pix [a,b]	$0.599 ± 0.0138	$0.563 ± 0.0036	$0.566 ± 0.0084	$0.555 ± 0.0053
Standard Pix [b]	$0.594 ± 0.0078	$0.553 ± 0.0079	$0.555 ± 0.0069	$0.554 ± 0.0063

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

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 pound of lint yield. The No Pix (triangles) at 100% irrigation created the most risk and the lowest net return. The Single RS Pix (diamonds) and Multiple RS Pix (circles) at zero irrigation were also risky; however they generated higher net returns than the No Pix at 100% irrigation. The Standard Pix (squares) appeared to have the least risk, but also had the lowest net returns on average. The non-irrigated, or 0% Irr, plots appeared to have the highest net returns, however there was more variability, or risk, associated with these plots than those that received irrigation. The plots that received 75% irrigation had the least variability, or risk, but also had lower net returns.

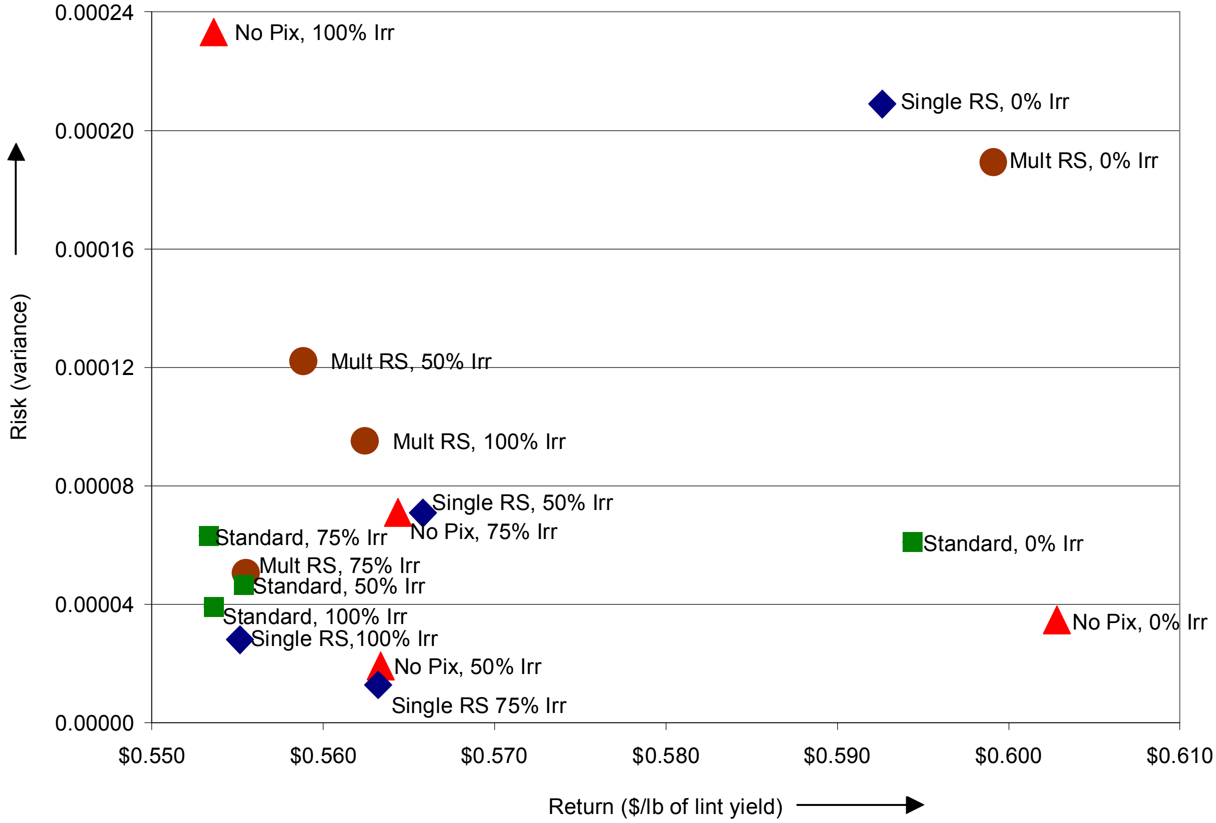

Figure 1. Risk-Return by Treatment

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