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COTTON PRECISION FARMING IN SIX SOUTHEASTERN STATES

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Abstract

Precision farming may increase cotton production efficiency, reduce input use, and increase yields and profits. Thus far, most producers have made only modest investments in precision farming technologies. A need exists to assess producers' experiences with a variety of precision farming technologies and to determine what benefits they have received or expect to receive from using these technologies. The objectives of this study were 1) to determine attitudes toward and current use of precision farming technologies by cotton producers in Alabama, Florida, Georgia, Mississippi, North Carolina, and Tennessee and 2) to examine the willingness of cotton producers in this six-state region to pay for a cotton yield monitoring system. A mail survey of cotton producers was conducted in January and February of 2001 to address these objectives. Most responding cotton producers used computers for farm management decisions, believed precision farming will be profitable in the future, and those producers who had adopted these technologies did so to increase profit. Cotton producers indicated that extension and research personnel at universities, crop consultants, and farm dealers were important sources of information in learning about precision farming. Price was found to affect producers' willingness to pay for a cotton yield monitoring system. Findings from this and other studies that investigate precision farming practices and perceptions are important because they provide needed information for making better decisions about the adoption of these technologies.

Introduction

Preparing seed beds, planting, reducing competition from insects and weeds, applying harvest aids, and harvesting cotton require numerous trips across a field and the purchase of a multitude of inputs. Indeed, the cost of producing cotton is considerably higher than the costs of producing corn, soybeans, or wheat (Gerloff, 2001A and 2001B). Reducing input levels through more efficient input use has long been a goal of cotton producers and researchers alike. Precision farming may increase cotton production efficiency, reduce input use, and increase yields and profits.

Precision farming uses a set of technologies to identify and measure within-field variability and its causes, prescribe site-specific input applications that match varying crop and soil needs, and apply the inputs as prescribed. Thus far, most producers have made only modest investments in precision farming technologies (Lowenberg-DeBoer, 1999).

A review of literature by Lambert and Lowenberg-DeBoer (2000) summarized the profitability of precision farming. Seventy-three percent of the studies they reviewed found precision farming to be profitable. An important determinant of precision farming profitability is crop value. Extensive research has been conducted in low-value grain crops for which yield monitors have been commercialized. The use of precision technology for cotton (a higher-valued crop) is more limited because accurate yield monitors have only recently become commercially available. Because cotton is an important high-value crop in the Southeast, an assessment of the use of precision farming practices, an investigation into the factors that influence adoption of precision farming technologies, and an evaluation of the likelihood that cotton producers will adopt newly developed yield monitoring systems would provide important information for cotton producers and agribusinesses alike.

The future of precision farming in cotton production depends on how producers view this set of technologies and how willing they are to improve current management practices. Swinton and Lowenberg-DeBoer (1998) caution that the early profits of technology adoption will go to those producers with strong technical and managerial skills. A need exists to assess producers' experiences with a variety of precision farming technologies and to determine what benefits they have received or expect to receive from using these technologies. Such an assessment is needed to appraise the present status and future prospects for adoption of precision farming technologies by cotton producers in the Southeast.

Objectives

The objectives of this study were 1) to determine attitudes toward and current use of precision farming technologies by cotton producers in Alabama, Florida, Georgia, Mississippi, North Carolina, and Tennessee and 2) to examine the willingness of cotton producers in this six-state region to pay for a cotton yield monitoring system.

Methods

A mail survey of cotton producers located in Alabama, Florida, Georgia, Mississippi, North Carolina, and Tennessee was conducted in January and February of 2001 to establish the current use of precision farming technologies in these Southeastern states. This paper provides information dealing with results of the survey aggregated over the six-state region.

A questionnaire was developed to query producers about their attitudes toward and use of precision farming technologies. It was pre-tested on two producers in Tennessee and their suggestions were incorporated into the final version. Following Dillman's (1978) general mail survey procedures, the questionnaire, a postage-paid return envelope, and a cover letter explaining the purpose of the survey were sent to each producer. The initial mailing of the questionnaire was on January 16, 2001, and a reminder post card was sent one week later on January 23, 2001. A follow-up mailing to producers not responding to previous inquiries was conducted three weeks later on February 15, 2001. The second mailing included a letter indicating the importance of the survey, the questionnaire, and a postage-paid return envelope.

The list of potential cotton producers, which included a total of 8,411 individuals for the 1999-2000 season, was furnished by the Cotton Board in Memphis, Tennessee (Skorupa, 2000). Of the potential cotton producers, 1,158 were from Alabama, 212 from Florida, 2,990 from Georgia, 1,334 from Mississippi, 1,798 from North Carolina, and 919 from Tennessee. The total number of surveys mailed was reduced to 6,423 by randomly selecting 1,400 potential producers from the Georgia list and 1,400 from the North Carolina list. This reduction lowered the cost of the survey but did not perceptibly reduce the ability to draw inferences about cotton producers in Georgia, North Carolina, or in the six-state region. Of the 6,423 questionnaires mailed, 196 were returned undeliverable and 251 indicated they were not cotton farmers or had retired, giving a total of 5,976 cotton producers who received the questionnaire in the six-state region. A total of 1,131 responses were received from cotton producers, giving a usable response rate was 17%.

In estimating means, standard deviations, and percentages for the six-state region, adjustments were made for Georgia and North Carolina to give them proper weight in the sample. For example, because only 1,400 of the 2,990 potential Georgia cotton producers were surveyed, the number of Georgia responses used to calculate means and percentages for the six-state region was adjusted upward by a factor of 2.14 = 2,990/1,400. The adjustment factor for North Carolina was 1.28 = 1,798/1,400. Implicit in these adjustment factors is the assumption that potential cotton producers who were not surveyed in Georgia and North Carolina would have responded similarly to those who were randomly surveyed from the address lists. For consistency, the adjusted number of responses for the six-state region (1,373 responses) is reported in this paper and the six-state means and percentages are weighted accordingly.

To obtain information about cotton producers' willingness to pay for a yield monitoring system (Objective 2), the mailing list from the Cotton Board was randomly divided into six equal groups with each group given a different purchase price in the willingness to pay questions. Respondents were asked if they would be willing to purchase a cotton yield monitoring system for their existing cotton picker for the stated price. They also were asked if they would be willing to purchase an optional cotton yield monitoring system for the stated price when purchasing a new cotton picker. The stated purchase prices for the six groups were $4,500, $6,000, $7,500, $9,000, $10,500, and $12,000. The list price at the time of the survey was $9,500 for a cotton yield monitoring system that included a monitor, a Global Positioning System (GPS) receiver, sensors on two chutes of a 4-5-row picker, and the ability to estimate lint yield within 4% of actual yields. The price of an additional sensor for a six-row picker was $1,285 (Ag Leader Technology, 2001).

Results

Results are presented in three sections. The first section presents information about the use of precision farming technologies by cotton farmers who have adopted these technologies in the six-state region. Perceptions about the future of precision farming are presented in the second section for all respondents (adopters and non-adopters), along with their willingness to pay for a cotton yield monitoring system. Demographic and farm characteristics are compared for precision farming adopters and non-adopters in the third section.

Adopter Responses about Precision Farming

*Precision Farming Technology Use***.** The numbers of precision farming technology adopters by state were 46 of the 238 respondents for Alabama (19% of respondents), 7 of 50 respondents for Florida (14%), 75 of 301 respondents for Georgia (25%), 65 of 262 respondents for Mississippi (25%), 94 of 370 respondents for North Carolina (25%), and 19 of 152 respondents for Tennessee (19%). For the six-state region, 23% of respondents were precision farming adopters. Almost all responding adopters had used some form of precision farming technology to produce cotton (293 of 316 adopters), while 163 had used it to produce corn, 124 for peanuts, 39 for rice, 138 for soybeans, 57 for tobacco, and 103 for wheat.

The technologies used on cotton by the most farmers were grid soil sampling by 158 farmers for an average of 4.2 years, management zone soil sampling by 121 farmers for 10.3 years, variable rate lime application by 116 farmers for 4.8 years, plant tissue testing by 115 farmers for 6.2 years, soil survey maps by 103 farmers for 11.2 years, and variable rate phosphorous and potassium application by 102 farmers for an average of 5.6 years. Twenty-eight adopting respondents practiced yield monitoring with GPS for an average of 1.7 years.

Decision-Making Value of Technologies. Adopters were asked to rate the decision-making value of precision farming on a scale of 1 (not important) to 5 (very important). Average scores given by adopting respondents were highest for "Improving yields" (4.56), "Maintaining better soil test, financial, and yield records," which received average scores of 4.21, 4.11, and 4.08, respectively, and for "Discovering a need for drainage" (3.94). Precision farming was least important for making decisions about "Quitting farming a portion of a field or an entire field" (2.89) and "Discovering a need for leveling" (3.13). Nevertheless, cotton producers who had adopted precision farming technologies considered them at least moderately important in making farm management decisions.

Factors Influencing Use of Precision Farming Technologies. Precision farming adopters were asked to rate on a scale of 1 (not important) to 5 (very important) four factors that may have influenced their decision to adopt precision farming technologies. Adopters reported that profit was the most important factor prompting their adoption of precision farming (4.54 average score). The fear of being left behind (2.41) and being at the forefront of agricultural technology (3.13), were the least likely to persuade producers to practice precision farming. Environmental benefits received the second highest average score of 3.78, which was considerably lower than the average score received for profit, but still more than moderately important.

Soil Sampling Technologies. Forty-four percent of responding adopters did the majority of their soil sampling within management zones, 27% did grid soil sampling, while only 10% pulled cores from grids within management zones. Nineteen percent of adopters used none of these precision sampling choices.

Forty-four percent of responding adopters collected their own soil samples. Twenty-five percent used a consultant and 31% used a fertilizer or chemical dealer to collect samples. Eighty-four percent of adopters collected cores randomly within a grid or management zone, while only 16% pulled soil cores from around the center point of the grid or management zone. The average management zone size was 18.8 acres. On average, 18.6 soil cores were taken per management zone. The typical grid size for adopters was 5.8 acres. On average, 9.6 soil cores were taken per grid.

Variable Rate Input Application Technologies. Forty-eight percent of responding adopters used variable rate lime application, followed by variable rate phosphorus and potassium application (39% of adopters), variable rate growth regulator application (24% of adopters), and variable rate nitrogen application (23% of adopters). The least used variable rate technologies were variable rate nematicide application (3% of adopters), irrigation (4% of adopters), and manure application (5% of adopters).

Of those responding adopters who used variable rate nitrogen application, 47% reported a decrease in nitrogen use, 24% reported an increase, and 29% reported no change in total nitrogen use. Sixty-four percent of responding adopters reported a decrease in input use, 14% reported an increase in total input use, and 22% reported no change in input use with variable rate phosphorus and potassium application. Seventy-four percent of responding adopters reported a decrease in total lime use when using variable rate application, with only 11% reporting an increase in lime use and 15% reporting no change. Total growth regulator use also decreased with variable rate application for 75% of responding adopters, while 7% experienced an increase and another 16% experienced no change in growth regulator use.

Thirty-seven percent of responding precision farming adopters reported experiencing a 97 lb/acre average increase in lint yield, 9% reported a 166 lb/acre average decrease, and 54% indicated no change in cotton lint yield after variable rate application of inputs. Using these percentages of responding adopters to weight the average yield changes gives an estimated perceived lint yield increase of 21 lb/acre (0.37 x 97 - 0.09 x 166).

Information Sources. Precision farming adopters were asked to rate the importance (1 = not helpful to 5 = very helpful) of different information sources in learning about the precision farming technologies they had used or investigated. The Extension Service and universities (3.86), crop consultants (3.37), and farm dealers (3.10) were the most helpful sources of information, while the news media (1.67), the Internet (1.75), and trade shows (1.79) were the least helpful in learning about precision farming technologies.

Precision Farming Services. Sixty percent of responding precision farming adopters had used off-farm precision farming services. Most of them reported receiving management or technical advice about most of the technologies they had used. Ninety-two percent of responding adopters who had used grid soil sampling reported receiving advice about this technology, while 84% of those who had used management zone soil sampling had received advice. Of those responding adopters who had used variable rate phosphorous and potassium application and variable rated lime application, 90 and 88%, respectively, had received management or technical advice about these technologies. The average cost of advice for grid soil sampling was $3.88/acre and for management zone soil sampling it was $2.00/acre. Advice for yield monitoring with and without GPS cost $5.44 and $350/acre, respectively. Average cost for advice on soil survey maps was $2.50/acre and for variable rate lime application it was $5.00/acre. Except for remote sensing with aerial photography and variable rate herbicide application, most responding adopters indicated that they would purchase the advice again.

Grid soil sampling was the most used precision farming service hired by responding adopters with 100 of 105 responding adopters hiring this service. Variable rate lime application (44 of 48 responding adopters hiring this service) and variable rate phosphorous and potassium application (41 of 45 hiring the service) were the next most hired precision farming services. Management zone soil sampling (22 of 27), plant tissue testing (21 of 25), and yield monitoring with GPS (15 of 23) were other services hired. Per-acre costs of custom hired precision farming services ranged from $9/acre for variable rate defoliant and insecticide applications to $1.74/acre for plant tissue testing. The average costs of custom hiring services for yield monitoring with GPS, grid soil sampling, and management zone soil sampling were $4.88, $5.90, $2.21/acre, respectively, and for variable rate nitrogen, phosphorus and potassium, and lime they were $4.33, $5.89, and $5.09/acre, respectively. Most responding adopter said they would hire these services again.

Changes in Profit and Environmental Quality. Seventy-five percent of responding adopters thought precision farming was profitable on their fields. Thirty-eight percent of responding adopters thought they had experienced an improvement in environmental quality as a result of precision farming. Observed environmental improvements listed by adopters included, “less nitrogen use”, “lower fertilizer rates”, “less fertilizer run-off”, “better drainage”, “leaving out areas that are not profitable”, “better soil texture-tilth”, “more organic matter”, and “less money spent on herbicides”.

Adopter and Non-Adopter Responses about Precision Farming

Future of Precision Farming. Eighty-five percent of adopting cotton producers and 63% of non-adopting cotton producers thought precision farming would be profitable for them to use in the future. For those respondents who believed it would be profitable, 62% of adopters and 52% of non-adopters would prefer to own the precision farming equipment. Respondents were given an opportunity to rate the importance of precision farming for several crops five years in the future. The level of importance ranged from 1 (not important) to 5 (very important). Respondents rated the importance of precision farming five years in the future the highest for cotton (3.6) and the lowest for tobacco (2.7). All crops except tobacco received an average score of 3.0 or better. Except for rice, adopters rated the importance of precision farming five years in the future higher than did non-adopters. For cotton, the average scores for adopters and non-adopters were 3.9 and 3.5, respectively; for corn they were 3.6 and 3.2; for peanuts they were 3.4 and 3.1; for rice they were 3.0 and 3.2; for soybeans they were 3.1 and 2.9; for tobacco they were 2.8 and 2.7; and for wheat they were 3.2 and 3.0, respectively.

Perceived Price of a Cotton Yield Monitoring System. Producers were asked to report their best estimate of the typical purchase price of a cotton yield monitoring system with GPS. The average purchase price given by adopters was $8,776, while the average price given by non-adopters was $1,215 less at $7,561. These average prices were less than the list price of $9,500 that prevailed at the time of the survey for a cotton yield monitoring system that included a monitor, a GPS receiver, and sensors on two chutes of a 4-5-row picker (Ag Leader technology, 2001).

Willingness to Purchase a Cotton Yield Monitoring System. Price appears to affect farmers' willingness to pay for retrofitting a cotton yield monitoring system on an existing 4 or 5-row cotton picker (Table 1). Smaller percentages of respondents were willing to purchase the yield monitoring system and larger percentages were unwilling to purchase the system as the price increased. The percentages of respondents in the "Don't know" and "Don't own a 4-5-row picker" remained about the same as the price increased.

Price also appears to affect farmers' willingness to pay for an optional yield monitoring system when purchasing or leasing a new picker (Table 2). The data show a trend downward in the percentage of farmers who were willing to purchase or lease an optional yield monitoring system as the price increased. An upward trend also exists in the percentage of respondents who were unwilling to purchase or lease the system, but these trends are not as pronounced as in the case of retrofitting a yield monitoring system on an existing picker.

Respondent and Farm Characteristics for Adopters and Non-Adopters

Farm Characteristics. On average, precision farming adopters managed 2,297 acres in 2000 consisting of 1,063 acres owned, 399 acres share rented, and 835 acres cash rented. Compared with adopters, acreage managed by non-adopters was lower at 1,337 acres consisting of 753 acres owned, 239 acres share rented, and 575 acres cash rented.

Precision farming adopters planted an average of 1,133 cotton acres in 1999 with lint yield averaging 790 lbs/acre. Non-adopters planted 663 acres per farm in 1999, nearly half the acres planted by adopters. Cotton lint yield averaged 685 lbs/acre for non-adopters, which was 105 lb/acre less than adopters. On average, planted acreage and yield increased in 2000 for both adopters and non-adopters. Adopters planted 1,175 acres per farm yielding 865 lb/acre, while non-adopters received yields of 749 lb/acre on 699 acres per farm.

Producers provided annual average yields for the most productive one-third, the average, and the least productive one-third of a typical cotton field they farmed. Results suggest that adopters had greater yield variability within a typical cotton field than non-adopters. The difference between mean yields reported by adopters for the most productive one-third and the least productive one-third of a typical cotton field was 559 lb/acre (1148-589 lb/acre), while this difference was 520 lb/acre (1053-533 lb/acre) for non-adopters.

A slightly higher percentage of adopters (37%) reported owning livestock than non-adopters (33%), while 31% of adopters and 22% of non-adopters reported applying manure to their fields.

Respondent Characteristics. The average age of a precision farming adopter was 48 years and varied from 25 to 78 years. Non-adopters averaged 51 years of age, ranging from 21 to 92 years. Precision farming adopters had farmed an average of 25 years, while non-adopters had farmed an average of 28 years. Overwhelming majorities of adopters (97%) and non-adopters (95%) completed high school. Most responding adopters (86%) and non-adopters (74%) owned a computer. Seventy-four percent of adopters used the computer for farm management, compared with 55% of non-adopters.

Precision farming adopters tended to have higher household incomes than non-adopters. For example, fewer adopters had household incomes less than $50,000 (23% of adopters) than non-adopters (28%), while fewer non-adopters had household incomes greater than $200,000 (16% of non-adopters) than adopters (21%). Also, adopters were more dependent on farming as their primary source of income than non-adopters. Farming was the primary source of income for 80% of the responding precision farming adopters, while it was the primary source of income for 76% of the responding non-adopters.

Producers indicated the one statement that best described their farm-planning goal. Fifty-three percent of adopters and 52% of non-adopters stated their farm-planning goal was to "acquire enough farm assets to generate sufficient income for family living." Twenty-five percent of adopters wanted to "expand the size of operation through acquiring additional resources," while 14% of non-adopters had this as their major farm-planning goal. The percentages of adopters and non-adopters who were "thinking about retirement and transfer of farm to the next generation" were 16 and 28%, respectively. Smaller percentages of adopters (5%) and non-adopters (7%) were "considering selling the farm and moving on to a different career."

Conclusions

The objectives of this study were 1) to determine attitudes toward and current use of precision farming technologies by cotton producers in Alabama, Florida, Georgia, Mississippi, North Carolina, and Tennessee and 2) to examine the willingness of cotton producers in this six-state region to pay for a cotton yield monitoring system. Cotton producers are confronted every day with information concerning the rapidly growing precision farming industry. Most responding cotton producers use computers for farm management decisions, believe precision farming will be profitable in the future, and those producers who adopt these technologies do so to increase profit. Cotton producers are listening to extension and research personnel at universities, crop consultants, and farm dealers in making decisions about precision farming. As more information becomes available, cotton producers will have greater opportunities to make more informed decisions about the use of these technologies on their farms. Findings from this and other studies that investigate the current use and future prospects for precision farming technologies are important to cotton producers because they provide the needed information for making better decisions about the adoption of these technologies.

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Table 1. Respondents' willingness to purchase a cotton yield monitoring system with GPS for an existing 4 or 5-row cotton picker at specified dollar amounts.

Purchase price for a yield monitoring system for a 4 or 5-row cotton picker	Number of responses	Yes	No	Don't know	Don't own a 4 or 5-row picker
$4,500					
All	160	16 (10%)[a]	56 (35%)	41 (25%)	47 (30%)
Adopters	38	9 (22%)	10 (26%)	12 (30%)	8 (22%)
Non-adopters	122	7 (6%)	47 (38%)	29 (24%)	39 (32%)
$6,000					
All	203	21 (10%)	89 (44%)	42 (21%)	50 (25%)
Adopters	54	8 (15%)	23 (42%)	12 (22%)	11 (20%)
Non-adopters	149	13 (9%)	67 (45%)	30 (20%)	39 (26%)
$7,500					
All	149	7 (5%)	71 (48%)	31 (21%)	39 (26%)
Adopters	34	5 (16%)	12 (34%)	8 (22%)	9 (28%)
Non-adopters	115	2 (2%)	60 (52%)	24 (21%)	30 (26%)
$9,000					
All	180	14 (8%)	79 (44%)	47 (26%)	41 (23%)
Adopters	38	4 (11%)	14 (38%)	8 (22%)	11 (29%)
Non-adopters	142	10 (7%)	64 (45%)	38 (27%)	30 (21%)
$10,500					
All	154	1 (1%)	86 (56%)	35 (23%)	31 (20%)
Adopters	51	0 (0%)	31 (59%)	7 (14%)	14 (27%)
Non-adopters	102	1 (1%)	56 (54%)	28 (27%)	18 (17%)
$12,000					
All	165	2 (1%)	91 (55%)	29 (18%)	43 (26%)
Adopters	43	1 (2%)	26 (61%)	7 (16%)	9 (20%)
Non-adopters	122	1 (1%)	65 (53%)	22 (18%)	34 (28%)

[a] Numbers in parenthesis indicate the percentage of respondents who gave the associated answer

Table 2. Respondents' willingness to purchase or lease an optional cotton yield monitoring system with GPS for an additional cost when purchasing or leasing a new 4, 5, or 6-row cotton picker.

Purchase price for a yield monitoring system for a 4, 5 or 6-row cotton picker	**Number of responses**	**Yes**	**No**	**Don't know**	**Don't intend to buy or lease a picker**
$4,500					
All	167	24 (14%)[a]	38 (23%)	31 (19%)	75 (45%)
Adopters	37	13 (35%)	4 (11%)	8 (23%)	12 (31%)
Non-adopters	130	11 (8%)	34 (26%)	23 (17%)	63 (48%)
$6,000					
All	219	30 (14%)	56 (26%)	48 (22%)	86 (39%)
Adopters	58	15 (26%)	11 (19%)	13 (23%)	18 (32%)
Non-adopters	162	15 (9%)	45 (28%)	34 (21%)	67 (42%)
$7,500					
All	165	9 (5%)	55 (33%)	39 (23%)	63 (38%)
Adopters	35	7 (19%)	13 (36%)	7 (20%)	9 (25%)
Non-adopters	130	2 (2%)	42 (32%)	31 (24%)	54 (42%)
$9,000					
All	203	18 (9%)	61 (30%)	52 (26%)	71 (35%)
Adopters	48	6 (13%)	13 (27%)	10 (21%)	18 (39%)
Non-adopters	155	12 (7%)	49 (31%)	42 (27%)	53 (34%)
$10,500					
All	176	11 (6%)	65 (37%)	47 (26%)	54 (30%)
Adopters	54	2 (4%)	19 (36%)	16 (30%)	16 (30%)
Non-adopters	123	9 (7%)	46 (38%)	30 (25%)	37 (30%)
$12,000					
All	173	7 (4%)	70 (41%)	39 (22%)	57 (33%)
Adopters	50	5 (11%)	14 (27%)	16 (32%)	15 (30%)
Non-adopters	123	2 (1%)	57 (46%)	23 (18%)	42 (34%)

[a] Numbers in parenthesis indicate the percentage of respondents who gave the associated answer.