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COTTON PRECISION FARMING IN TENNESSEE

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Abstract

Precision farming may increase cotton production efficiency, reduce input use, and increase yields and profits. Thus far, most producers in Tennessee 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 Tennessee cotton producers and 2) to examine the willingness of cotton producers to pay for a cotton yield monitoring system. A mail survey of cotton producers in Tennessee was conducted in January and February of 2001 as part of a six-state survey to address these objectives. Most responding Tennessee 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. 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).

The future of precision farming in cotton production depends on how producers view this set of technologies and how willing they are to change current management practices. 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 future prospects for adoption of precision farming technologies by cotton producers in Tennessee.

Objectives

The objectives of this study were 1) to determine attitudes toward and current use of precision farming technologies by Tennessee cotton producers and 2) to examine the willingness of Tennessee cotton producers 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 Tennessee portion of the survey.

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 919 individuals for the 1999-2000 season, was furnished by the Cotton Board in Memphis, Tennessee (Skorupa, 2000). Of the 919 questionnaires mailed, 30 were returned undeliverable and 50 indicated they were not cotton farmers or had retired, giving a total of 839 potntial cotton producers in Tennessee. Of those potential cotton producers, 152 individuals provided data. Assuming the non-respondents were active cotton producers, the usable response rate was 18%.

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 6-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 Tennessee. 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. Responses indicated that 29 0f 152 of respondents (19%) had adopted some form of precision farming technology. Almost all responding adopters (27 farmers) had used some form of precision farming technology to produce cotton, while 15 had used it to produce corn, 19 to produce soybeans, and 13 to produce wheat.

The technologies used on cotton by the most farmers were grid soil sampling by 14 farmers for an average of 7 years, soil survey maps by 11 farmers for 13 years, variable rate growth regulator application by 10 farmers for 11 years, and variable rate nitrogen application by 9 farmers for an average of 13 years. Only one farmer used yield monitoring with GPS and one used yield monitoring without GPS. Variable rate phosphorous and potassium application was used on cotton by 8 farmers for an average of 10 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" (4.75), "Maintaining better soil test, yield, and financial records", which received average scores of 4.58, 4.50, and 4.46, respectively, and for "Discovering a need for drainage" (4.14). Precision farming was least important for making decisions about "Quit farming a portion of a field or an entire field" (3.04) and "Discovering a need for leveling" (3.08). Nevertheless, cotton producers who had adopted precision farming technologies considered these technologies at least moderately important by scoring their value in making management decisions an average of three or better.

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 (4.59 average score). The fear of being left behind (2.51) and being at the forefront of agricultural technology (3.10) were the least likely to persuade producers to practice precision farming. Environmental benefits received the second highest average score of 3.86, which was considerably lower than the average score received for profit, but still more than moderately important.

Soil Sampling Technologies. Forty-two percent of responding adopters did the majority of their soil sampling within management zones, 19% did grid soil sampling, while only 8% pulled cores from grids within management zones. Thirty-one percent of adopters used none of these precision sampling choices.

Fifty-four percent of responding adopters collected their own soil samples. Forty-two percent used a fertilizer or chemical dealer to collect samples, while only 4% used a consultant. Ninety percent of adopters pulled soil cores from around the center point of the grid or management zone, while only 10% of adopters collected cores randomly within a grid or management zone. The average management zone size was 13 acres. On average, eight soil cores were taken per management zone. The typical grid size for adopters was 6 acres. On average, 7 soil cores were taken per grid.

Variable Rate Input Application Technologies. Twenty-six percent of responding adopters used variable rate lime application, followed by variable rate nitrogen application (25%), variable rate phosphorous and potassium application (24%), and variable rate growth regulator application (24%). No responding adopter had used variable rate technology for manure application, nematicide application, or irrigation.

Of those responding adopters who used variable rate nitrogen application, 25% reported a decrease in nitrogen use, 25% reported an increase, and 50% reported no change in total nitrogen use. Twenty-nine percent of responding adopters reported a decrease in input use, 29% reported an increase in total input use, and 43% reported no change in input use with variable rate phosphorous and potassium application. Eighty-six percent of responding adopters reported a decrease in total lime use when using variable rate application, with only 14% reporting an increase in lime use and no responding adopters reporting no change. Total growth regulator use also decreased with variable rate application for 43% of responding adopters, while 29% experienced an increase and another 29% experienced no change in growth regulator use.

Thirty-two percent of the 19 responding adopters experienced an increase in cotton lint yield, 11% reported a decrease, and 58% indicated no change in lint yield. Adopters were given an opportunity to indicate the magnitude of the yield change. Responses to this question were insufficient in number to report.

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. Extension/universities (3.50), farm dealers (3.24), the crop consultants (3.06), and other farmers (2.90) were the most helpful sources of information, while the news media (2.24), the Internet (2.07), and trade shows (1.98) were the least helpful in learning about precision farming technologies.

Precision Farming Services. Fifty-three 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 percent of responding adopters who had used grid soil sampling reported receiving advice about this technology, while 80% 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, 80 and 83%, respectively, had received management or technical advice about these technologies. The average cost of advice for grid soil sampling was $3.44/acre and for management zone soil sampling it was $1.00/acre. Advice for yield monitoring with and without GPS cost $2.50 and $3.50/acre, respectively. Average cost for advice on soil survey maps was $1.25/acre and for variable rate lime application it was $1.67/acre. Almost all responding adopters indicated that they would purchase the advice again.

Grid soil sampling was the most used precision farming service hired with 90% of those who had adopted this technology hiring this service. All but one of six adopters of variable rate phosphorous and potassium application had custom hired this service and all but one of eight adopters of variable rate lime application had hired custom this service. The average costs of custom hiring the services were $4.11/acre for grid soil sampling, $4.00/acre for variable rate phosphorous and potassium application, and $4.17/acre for variable rate lime application. All responding farmers indicated they would purchase the services again.

Changes in Profit and Environmental Quality. Seventy percent of responding adopters thought precision farming was profitable on their fields. Thirty-one percent of 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 64% 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, 61% of adopters and 58% 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). Average scores for all respondents were 3.58 for cotton, 3.45 for corn, 2.96 for soybeans, and 3.17 for wheat. Adopters consistently rated the importance of precision farming five years in the future higher than non-adopters. For cotton production, the average scores for adopters and non-adopters were 3.93 and 3.48, respectively; for corn production they were 3.60 and 3.40; for soybean production they were 3.12 and 2.92; and for wheat production they were 3.32 and 3.12, 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 $7,200, while the average price given by non-adopters was $343 less at $6,857. 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" showed little trend 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 2,336 acres in 2000 consisting of 624 acres owned, 975 acres share rented, and 737 acres cash rented. Compared with adopters, acreage managed by non-adopters was lower at 1,569 acres consisting of 624 acres owned, 589 acres share rented, and 356 acres cash rented.

Precision farming adopters planted an average of 1,087 cotton acres in 1999 with lint yield averaging 553 lb/acre. Non-adopters planted 599 acres per farm in 1999, nearly half the acres planted by adopters. Cotton lint yield averaged 526 lb/acre for non-adopters, which was 27 lb/acre less than adopters. On average, planted acreage and yield increased in 2000 for both adopters and non-adopters. Adopters planted 1,202 acres per farm yielding 652 lb/acre, while non-adopters received yields of 615 lb/acre on 638 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 382 lb/acre (870-488 lb/acre), while this difference was 357 lb/acre (801-444 lb/acre) for non-adopters.

A slightly higher percentage of adopters (36%) reported owning livestock than non-adopters (33%). Only 8% of responding cotton producers applied manure to their fields and none of them was an adopter of precision farming technologies.

Respondent Characteristics. The average age of a precision farming adopter was 47 years and varied from 29 to 63 years. Non-adopters averaged 50 years of age, ranging from 24 to 82 years. Precision farming adopters had farmed an average of 26 years, while non-adopters had farmed an average of 28 years. Overwhelming majorities of adopters (97%) and non-adopters (95%) completed high school. Respondents who had completed high school averaged two years of college for both adopters and non-adopters. Most responding adopters (83%) and non-adopters (72%) owned a computer. Seventy-five 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 (38%), while fewer non-adopters had household incomes greater than $200,000 (13% of non-adopters) than adopters (28%). Also, adopters were more dependent on farming as their primary source of income than non-adopters. Farming was the primary source of income for 89% of the responding precision farming adopters, while it was the primary source of income for 65% of the responding non-adopters.

Producers indicated the one statement that best described their farm-planning goal. Sixty-one percent of adopters and 50% 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 10% 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 14% and 27%, respectively. Smaller percentages of adopters (0%) and non-adopters (13%) were "considering selling the farm and moving on to a different career."

Conclusions

The objectives of this research were 1) to determine attitudes toward and current use of precision farming technologies by Tennessee cotton producers and 2) to examine the willingness of Tennessee cotton producers 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.

Acknowledgments

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References

Ag Leader Technology. 2001. 2001 list prices. 2202 South Riverside Drive, Ames, IA 50010.

Dillman, D.A. 1978. Mail and telephone surveys: The total design method. Wiley, New York.

Lowenberg-DeBoer, J. 1999. Risk management potential of precision farming technologies. *J. Agric. Appl. Econ.* 31:275-285.

Skorupa, B. 2000. Cotton Board, 871 Ridgeway Loop, Ste. 100, Memphis, TN 38120-4019.

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	16	3 (19%)[b]	5 (31%)	5 (31%)	3 (19%)
Adopters	4	2 (50%)	0	2 (50%)	0
Non-adopters	12	1 (8%)	5 (42%)	3 (25%)	3 (25%)
$6,000					
All	21	5 (24%)	11 (52%)	3 (14%)	2 (10%)
Adopters	6	2 (33%)	4 (67%)	0	0
Non-adopters	15	3 (20%)	7 (47%)	3 (20%)	2 (13%)
$7,500					
All	22	2 (9%)	11 (50%)	3 (14%)	6 (27%)
Adopters	3	1 (33%)	1 (33%)	1 (33%)	0
Non-adopters	19	1 (5%)	10 (53%)	2 (11%)	6 (32%)
$9,000					
All	19	1 (5%)	7 (37%)	5 (26%)	6 (32%)
Adopters	5	1 (20%)	1 (20%)	1 (20%)	2 (40%)
Non-adopters	14	0	6 (43%)	4 (29%)	4 (29%)
$10,500					
All	17	0	13 (76%)	4 (24%)	0
Adopters	3	0	3 (100%)	0	0
Non-adopters	14	0	10 (71%)	4 (29%)	0
$12,000					
All	22	2 (9%)	13 (59%)	4 (18%)	3 (14%)
Adopters	5	0	4 (80%)	1 (20%)	0
Non-adopters	17	2 (12%)	9 (53%)	3 (18%)	3 (18%)

[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	18	4 (22%)[b]	4 (22%)	2 (11%)	8 (44%)
Adopters	4	3 (75%)	0	1 (25%)	0
Non-adopters	14	1 (7%)	4 (29%)	1 (7%)	8 (57%)
$6,000					
All	23	7 (30%)	8 (35%)	4 (17%)	4 (17%)
Adopters	6	2 (33%)	3 (50%)	0	1 (17%)
Non-adopters	17	5 (29%)	5 (29%)	4 (24%)	3 (18%)
$7,500					
All	23	0	4 (17%)	5 (22%)	14 (61%)
Adopters	3	0	0	1 (33%)	2 (67%)
Non-adopters	20	0	4 (20%)	4 (20%)	12 (60%)
$9,000					
All	21	4 (19%)	3 (14%)	4 (19%)	10 (48%)
Adopters	5	2 (40%)	0	0	3 (60%)
Non-adopters	16	2 (12%)	3 (19%)	4 (25%)	7 (44%)
$10,500					
All	20	1 (5%)	11 (55%)	4 (20%)	4 (20%)
Adopters	3	0	1 (33%)	2 (67%)	0
Non-adopters	17	1 (6%)	10 (59%)	2 (12%)	4 (24%)
$12,000					
All	26	3 (12%)	6 (23%)	8 (30%)	9 (35%)
Adopters	5	1 (20%)	2 (40%)	1 (20%)	1 (20%)
Non-adopters	21	2 (10%)	4 (19%)	7 (33%)	8 (38%)

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