STATUS OF COTTON PRECISION FARMING IN TWELVE SOUTHERN STATES

Daniel F. Mooney
Roland K. Roberts
Burton C. English
James A. Larson
Dayton M. Lambert
Margarita Velandia
The University of Tennessee
Knoxville, TN
Sherry L. Larkin
University of Florida
Gainesville, FL
Michele C. Marra
Roderick Rejesus
North Carolina State University
Raleigh, NC
Steven W. Martin
Mississippi State University
Stoneville, MS
Kenneth W. Paxton
Ashok Mishra
Louisiana State University
Baton Rouge, LA
Eduardo Segarra
Chenggang Wang
Texas Tech University
Lubbock, TX
Jeanne M. Reeves
Cotton Incorporated
Cary, NC

Abstract

This article presents initial findings from the 2009 Southern Cotton Precision Farming Survey. A mail survey of 13,579 cotton producers in twelve southern U.S. states was conducted from February to March of 2009. States included in the survey were Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, Texas, and Virginia. This article reports adoption figures from that survey for the 12-state region. A total of 1,692 producers provided valid responses for an overall response rate of 12.6%. The distribution of respondents by age and cotton acres planted closely matched figures reported in the 2007 Census of Agriculture. A total of 1,061 (63%) of respondents were classified as precision farming adopters (i.e., they reported having used information gathering technology, applied at least one input at variable rates, or used GPS guidance). Zone and grid soil sampling were the most widely used information gathering technologies, followed by yield monitoring with GPS and soil survey maps. Respondents who undertook variable rate management decisions did so most frequently with fertility/lime inputs. Growth regulators and harvest aids were also commonly applied at variable rates using aerial and satellite imagery. Spraying, planting, and tillage were the most commonly reported field operations for which GPS guidance was used. Findings from this survey are important to research, extension, and industry personnel because results can help focus resources on producers who are most likely to use these technologies and aid in developing effective outreach material.

Introduction

Precision farming technologies are used 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 (Roberts et al., 2006). When used together, these technologies may increase cotton production efficiency, reduce input use, and increase yields and profits. Despite worldwide use, questions regarding the profitability of precision farming

technologies remain. Griffin et al. (2004) summarized current precision farming adoption trends and found that cotton acres had experienced a slower level of adoption compared to other crops such as corn and soybeans.

One reason precision farming technology use in cotton production is more limited is because commercial yield monitors did not become widely available until 2000 (Perry et al. 2001). Because cotton is a high-value agricultural crop of central importance to southern U.S. states, insight into the factors influencing the adoption of cotton precision farming technologies and perceptions about the future of cotton precision farming for both adopters and non-adopters alike would provide important information for cotton producers, university extension officials, and agribusinesses.

The objective of this research was to determine the status of precision farming technology adoption by cotton producers in twelve southern states. A mail survey of cotton producers located in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, Texas and Virginia was conducted in February and March of 2009 to establish the use of precision farming technologies in 2007 and 2008 in these states. This report provides initial adoption figures for the 12-state survey region. The survey is the third in a series of cotton precision farming surveys conducted previously in 2001 and 2005 (Roberts et al., 2002; Roberts et al., 2006). This article presents initial adoption figures from that survey for the 12-state region.

Materials and Methods

A questionnaire was developed to query cotton producers about their attitudes toward and use of precision farming technologies. 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 February 20, 2009, and a reminder post card was sent two weeks later on March 5, 2009. A follow-up mailing to producers not responding to previous inquiries was conducted three weeks later on March 27, 2009. The second mailing included a letter indicating the importance of the survey, the questionnaire, and a postage-paid return envelope. Questionnaire recipients who did not grow cotton during the period 2005 to 2008 were instructed to indicate this fact and return the questionnaire.

A mailing list of 14,089 potential cotton producers for the 2007-2008 marketing year was furnished by the Cotton Board in Memphis, Tennessee (Table 1). Survey questionnaires were mailed to all addresses, of which 306 were returned undeliverable and subsequently dropped from the list. Among responses received, 1,692 were counted as valid, 85 declined participation, and 204 had either retired or did not farm cotton. Assuming those who declined participation and all remaining non-respondents are active cotton producers, the total number of cotton farmers surveyed was 13,579. The survey response rate of 12.5% for the twelve-state region was then calculated as the number of valid responses divided by the number of cotton farmers surveyed.

While slightly fewer cotton farmers were surveyed than are listed in the Census, the distribution of these farmers across states corresponds closely with the distribution of farmers from the Census (Table 1). Over 40% of the cotton producers surveyed were located in Texas. Georgia was the state with the second largest number of cotton farmers surveyed, representing slightly over 15% of the survey sample. Alabama, Arkansas, Mississippi, and North Carolina each represented 5 to 10% of total cotton farmers surveyed, whereas Florida, Louisiana, Missouri, South Carolina, Tennessee, and Virginia each represented less than 5% of total cotton farmers surveyed.

The following statement was given to farmers at the top of the questionnaire: "Precision farming involves collecting site-specific information about within-field variability in yields and crop needs, linking that information to specific locations within a field, and acting on that information to determine and apply appropriate input levels. This may result in varying input levels within each field." This broad definition of precision farming encompasses technologies that may or may not use Global Positioning Systems and Geographical Information Systems.

Table 1. Number of cotton farms surveyed and response rates by farm location

State	2007 Census of Agriculture[a]		Cotton Farmers Surveyed[b]		Number of Useable Surveys Returned[c]	
	N	% of total	N	% of total	N	% response
Alabama	917	5.5	782	5.8	106	13.6
Arkansas	915	5.5	812	6.0	63	7.8
Florida	213	1.3	184	1.4	27	14.7
Georgia	2,577	15.4	2,046	15.1	169	8.3
Louisiana	645	3.9	581	4.3	71	12.2
Mississippi	980	5.9	714	5.3	128	17.9
Missouri	511	3.1	464	3.4	34	7.3
North Carolina	1,308	7.8	1,036	7.6	169	16.3
South Carolina	458	2.7	355	2.6	48	13.5
Tennessee	779	4.7	631	4.6	105	16.6
Texas	7,225	43.2	5,812	42.8	749	12.9
Virginia	196	1.2	162	1.2	23	14.2
12-State Total	16,742	100.0	13,579	100.0	1,692	12.5

[a] US Department of Agriculture (2007). [b]Number of addresses on the 2007-2008 Cotton Board mailing list minus invalid addresses and respondents who did not farm cotton. [c] Respondents who produced cotton at least once during 2005-2008.

Results and Discussion

Results are presented in two sections. The first compares characteristics of the respondents and their farming operations with data from the 2007 Census of Agriculture (US Department of Agriculture, 2007). Precision farming adoption rates for information gathering technologies, variable rate management, and GPS guidance are presented in the second.

Comparison with Census Data

Figure 1 shows the age distribution for cotton farmers who responded to the survey as compared with the age distribution for cotton farmers reported in the 2007 Census of Agriculture (US Department of Agriculture, 2007). The majority of respondents (59%) ranged in age from 45 to 64 years, compared with slightly fewer producers (55%) in these categories as reported in the 2007 Census. Respondents who were 44 years of age or less were a smaller percentage of total producers (17%) than are represented in the 2007 Census (22%) for similar age categories. The proportion of respondents who were 65 years of age or older was about identical to that reported in the 2007 Census for this age category (24%). These findings suggest that survey respondents were concentrated more in the middle age groups than was found in the 2007 Census. However, the overall mean age of 55.8 years for cotton farmers responding to the survey was comparable to the mean age of 55.2 years reported in the 2007 Census.

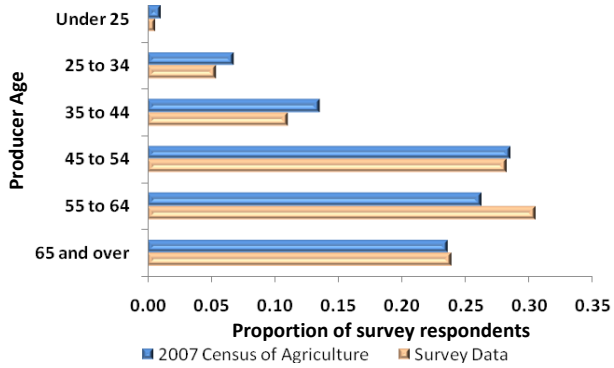

Figure 1. Age distribution of survey respondents.

Figure 2 compares the distribution of cotton acres planted in 2007 and 2008 by farmers who responded to the survey with the distribution of cotton acres harvested in 2007 as reported in the 2007 Census of Agriculture (US Department of Agriculture, 2007). A smaller percentage of cotton producers who grew less than 249 acres of cotton responded to the survey (20% and 21% for 2007 and 2008, respectively) compared with the percentage reported in the 2007 Census (42%) in this category (Figure 2).

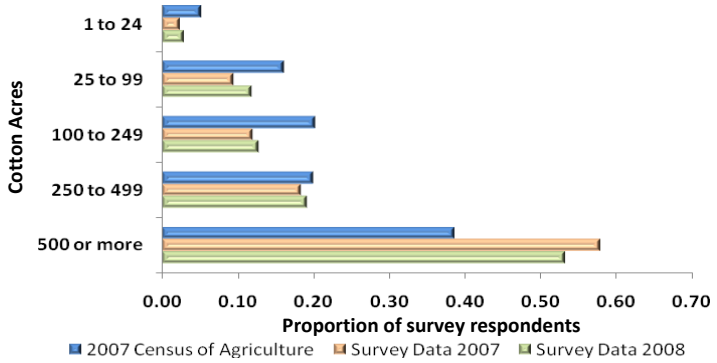

Figure 2. Cotton acreage distribution of survey respondents.

Overall Precision Farming Adoption

Respondents were defined as precision farming adopters if they reported using information gathering technology, variable rate management, or GPS guidance. Table 2 reports precision farming adoption rates for individual states and for the combined 12-state region. Many farmers adopted more than one category of precision farming technology (i.e., some combination of information gathering, variable rate management, and GPS guidance technologies). Adoption rates are therefore reported by individual technology category and by overall adoption status. Overall, 1,061 of the 1,692 respondents from the 12-state region, or 63%, were classified as precision farming adopters. Among the states surveyed, Virginia and Missouri had the highest rate of overall precision farming technology adoption among respondents at 82% and 83%, respectively, whereas Texas had the lowest at 56%.

Table 2. Adoption of precision farming technologies by farm location

State	Number of Survey Responses	Precision Farming Adoption by Technology Category						Overall Precision Farming Adoption [a]	
		Information gathering		Variable Rate Management		GPS Guidance			
		N	%	N	%	N	%	N	%
Alabama	106	40	37.7	27	25.5	42	39.6	64[b]	60.4
Arkansas	63	31	49.2	23	36.5	35	55.6	44	69.8
Florida	27	9	33.3	5	18.5	17	63.0	19	70.4
Georgia	169	74	43.8	48	28.4	73	43.2	104	61.5
Louisiana	71	44	62.0	25	35.2	33	46.5	49	69.0
Mississippi	128	70	54.7	48	37.5	61	47.7	90	70.3
Missouri	34	21	61.8	11	32.4	20	58.8	28	82.4
North Carolina	169	76	45.0	48	28.4	75	44.4	113	66.9
South Carolina	48	28	58.3	19	39.6	21	43.8	33	68.8
Tennessee	105	52	49.5	37	35.2	56	53.3	79	75.2
Texas	749	144	19.2	76	10.1	339	45.3	419	55.9
Virginia	23	10	43.5	6	26.1	15	65.2	19	82.6
12-State Total	1,692	599	35.4	373	22.0	787	46.5	1061	62.7

[a] Overall precision farming adoption includes those producers who used an information gathering technology, who made a variable rate management decision, or who used GPS guidance. [b] The number of precision farming adopters by category may not sum to the overall number of precision farming adopters because some producers adopted technologies from multiple categories.

Sixteen percent of precision farming adopters utilized information gathering technology only, whereas 33% of adopters reported using GPS guidance only. An additional 15% and 16% of precision farming adopters used information gathering technologies in combination with GPS guidance and variable rate management, respectively. The remaining 26% of precision farming adopters reported using information gathering, variable rate management, and GPS guidance technologies in combination with one another (data not shown).

Respondents were asked to indicate if they used one or more of eleven different information gathering technologies, the number of years each technology was used, and the number of acres on which each technology was used in 2007 (Table 3). Among the 478 respondents to this question, grid and zone soil sampling were the two most widely used technologies. Zone soil sampling was used for an average of 13.5 years on an average of over cotton 1100 acres per farm. Grid soil sampling was used only for an average of 6 years on approximately the same acreage per farm. The cotton yield monitor with GPS, soil survey maps, and aerial photography were the next most commonly used information gathering technologies with 15% to 20% of respondents having used them. Least used by adopters (<10% of respondents) were yield monitoring without a GPS, satellite imagery, handheld GPS/PDA, COTMAN plant mapping, digitized mapping, and electrical conductivity.

Table 3. Use of information gathering technologies by cotton farmers

Information Gathering Technology	Number of Adopters		Average Number of Years Used		Number of Acres Per Farm in 2007	
	N	%	N	Years	N	Acres
Yield monitor – with GPS	96	20[a]	90	3.6	72	1830
Yield monitor – no GPS	30	6	28	3.6	21	1289
Soil sampling – grid	220	46	207	6.0	171	1078
Soil sampling – zone	221	46	202	13.5	187	1129
Aerial photos	76	16	73	10.4	58	1346
Satellite images	27	6	26	5.2	23	1112
Soil survey maps	97	20	89	14.7	77	1105
Handheld GPS/PDA	34	7	34	4.2	26	1527
COTMAN plant mapping	17	4	15	5.3	16	832
Digitized mapping	10	2	9	4.1	6	1373
Electrical Conductivity	42	9	40	2.7	34	888
Number of respondents	478		448		418	
Average number of responses per respondent	1.8		1.8		1.7	

[a] The values reported in this column refer to the percent of information gathering technology adopters who used a specific technology (e.g., 96/478 = 20%). They do not reflect overall adoption rates for the cotton farmers surveyed.

Respondents also indicated the specific variable rate management decisions undertaken, and the information gathering technology used to base their decision (Table 4). Among the 207 respondents to this question, the yield monitor with GPS was the most frequently used information gathering technology. Greenseeker units were the least used information gathering technology, yet were used to make more variable rate decisions, on average, than any other technology considered. Yield monitors with GPS, handheld GPS units, and electrical conductivity units were most commonly used to make variable rate fertility or lime management decisions. By contrast, both the Greenseeker and aerial/satellite imagery were used most commonly for the growth regulator, harvest aid, and fertility or lime variable rate management decisions.

Respondents provided information about the GPS guidance systems they have used and indicated the specific field operations for which GPS guidance systems were employed. Among the 768 respondents to this question, 31% reported having used GPS autosteer and 25% reported having used GPS lightbar (data not shown). Table 5 shows for which field operations GPS guidance systems were most used. The 768 respondents to this question reported using GPS guidance systems, on average, for 2.5 different field operations. Adopters used GPS guidance most frequently for the spraying, planting, and tillage field operations. Guidance systems were also used for the cultivating and harvesting operations but by fewer respondents.

Table 4. Variable rate management decisions made by cotton farmers

Variable Rate Decision	Information Gathering Technology Used											
	Handheld GPS Units		Green Seeker		Yield Monitoring with GPS[b]		Aerial or Satellite Imagery		Electrical Conductivity		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Drainage	9	14[a]	2	22	27	28	19	26	9	17	66	22
Fertility or Lime	51	81	4	44	64	65	35	48	43	81	197	67
Seeding	9	14	2	22	32	33	11	15	8	15	62	21
Growth Regulator	12	19	6	67	22	22	35	48	5	9	80	27
Harvest Aids	12	19	4	44	21	21	25	34	2	4	64	22
Fungicide	7	11	1	11	15	15	8	11	1	2	32	11
Herbicide	13	21	2	22	24	24	7	10	3	6	49	17
Insecticide	13	21	3	33	18	18	11	15	4	8	49	17
Irrigation	7	11	3	33	18	18	18	25	5	9	51	17
Number of Respondents	63		9		98		73		53		296	
Average Number of Variable Rate Decisions	2.1		3		2.5		2.3		1.5		2.2	

[a] The values reported in this column refer to the percent of variable rate management adopters who used a specific information gathering technology for their variable rate decision (e.g., 14/63 = 14%). They do not reflect overall variable rate management adoption rates for the cotton farmers surveyed.

Table 5. Use of GPS guidance by field operation

Operation	N	%
Primary tillage	451	59
Planting	483	63
Spraying	610	79
Cultivating	222	29
Harvesting	149	19
Number of respondents	768	
Average number of responses	2.5	

Summary

Cotton producers are continually confronted with information about the rapidly expanding precision farming industry but questions about the profitability of these technologies remain. The objective of this study was to determine the status of precision farming technology adoption by cotton producers in twelve southern states. To complete this objective a mail survey of 13,579 cotton producers in twelve southern U.S. states was conducted in early 2009.

In summary, 1,061 respondents (63%) were classified as precision farming adopters (i.e., they reported having used information gathering technology, applied at least one input at variable rates, or used GPS guidance). Zone and grid soil sampling were the most widely used information gathering technologies, followed by yield monitoring with GPS and soil survey maps. Respondents who undertook variable rate management decisions did so most frequently with fertility/lime inputs. Growth regulators and harvest aids were also commonly applied at variable rates using aerial and satellite imagery. Spraying, planting, and tillage were the most commonly reported field operations for which GPS guidance was used.

The survey reported on here also included questions about adopter use of yield monitors, GPS guidance systems, and precision soil sampling. Adopter and non-adopters also listed their primary information sources, provided their perceptions about the value and future profitability of precision farming technologies, and farm and farm operator characteristics. Future analyses involving this survey data will further investigate these topics.

Cotton producers gather information from university extension and research personnel along with other farmers in making decisions about precision farming. As information becomes increasingly available, cotton producers will have expanded opportunities to make better 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 important information for making adoption decisions. Results can also be used to develop decision aids to help potential precision farming adopters make more informed decisions about adoption, custom hiring, or purchasing these technologies.

Acknowledgements

The authors acknowledge Cotton Incorporated and the land grant universities of the authors for financial support.

Disclaimer

Reference to any specific commercial products or service by trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the authors, their respective land grant universities or Cotton Incorporated.

References

Dillman, D.A. 1978. Mail and telephone surveys, the total design method. John Wiley & Sons, New York.

Griffin, T.W., J. Lowenberg-DeBoer, D.M. Lambert, J. Peone, T. Payne, and S.G. Daberkow. 2004. Adoption, Profitability, and Making Better Use of Precision Farming Data. Staff Paper #04-06. Department of Agricultural Economics, Purdue University.

Perry, C.D., G. Vellidis, N. Wells, and C. Kvien. 2001. "Simultaneous Evaluation of Multiple Commercial Yield Monitors in Georgia," pp. 328-339. In *Proceedings of the Beltwide Cotton Conferences*, Anaheim, CA. January 9-13, 2001. National Cotton Council of America, Memphis, TN.

Roberts, R.K., B.C. English, J.A. Larson, R.L. Cochran, W.R. Goodman, S.L. Larkin, M.C. Marra, S.W. Martin, W.D. Shurley, and J.M. Reeves. 2002. "Precision Farming by Cotton Producers in Six Southern States: Results from the 2001 Southern Precision Farming Survey." Department of Agricultural Economics, Research Series 03-02, Agricultural Experiment Station, University of Tennessee.

Roberts, R.K., B.C. English, J.A. Larson, R. L. Cochran, S.L. Larkin, M.C. Marra, S.W. Martin, K.W. Paxton, W. D. Shurley, W.R. Goodman, J.M. Reeves. 2006. "Use of Precision Farming Technologies by Cotton Farmers in Eleven States" pp. 288-295. In *Proceedings of the Beltwide Cotton Conferences*, San Antonio, TX, January 3-6, 2006. National Cotton Council of America, Memphis, TN.

US Department of Agriculture. 2007. 2007 Census of Agriculture. National Agricultural Statistics Service, Washington, D.C.