RESULTS FROM A COTTON PRECISION FARMING SURVEY ACROSS FOURTEEN SOUTHERN STATES

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Abstract

This paper reports the findings from the 2013 Southern Cotton Precision Farming Survey. In February 2013, the survey was mailed to over 13,000 cotton producers in fourteen southern states, including: Alabama, Arkansas, Florida, Georgia, Kansas, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. A total of 1,811 cotton producers returned valid responses for a response rate of 13.76%. Georgia, North Carolina, and Texas were the states with the largest numbers of respondents, and Mississippi, North Carolina, and Tennessee were the states with the highest response rates. The largest percentage of respondents was between 55 and 65 years old, and over 60% of the respondents indicated they were over 55 years old. Respondents were defined as precision farming adopters if they indicated using GSP guidance systems, information gathering technologies, variable-rate input management, or automatic section control for planters or sprayers. Approximately 73% of the respondents indicated they were precision farming adopters. GPS guidance was the most adopted technology (66.3%), and variable-rate management was the least adopted technology (25.3%). Among those who adopted variable-rate input management, the most commonly applied variable-rate input was lime, followed by potassium and phosphorous. Map-based technology was more commonly used to apply variable-rate inputs than sensor-based technology. The results from this research will benefit extension, research, and industry personnel by identifying producers who are most likely to adopt precision farming technologies.

Introduction

The definition of precision farming has changed over the years as technologies have evolved from varying fertilizer applications across a field in the mid-1980s to include automatic guidance of tractors and implements along with autonomous machinery (Gebbers and Adamchuk, 2010). Many definitions of precision farming can be found in the literature (McBratney et al., 2005), but generally, precision farming refers to using a wide variety of technologies gather information about with-in field variability of soil and crops characteristics, and using this information to manage inputs (Gebbers and Adamchuk, 2010). Many studies have analyzed the benefits of various precision farming technologies, and overall, the results from these studies show that precision farming can increase cotton production efficiency, reduce input use, and increase yields and profits (Walton et al., 2008).

Despite these benefits, 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. The slower adoption of precision farming technologies in cotton production relative to grain crops might be explained by yield monitors for cotton not being developed until 1997 (Roades et al., 2000) and reliable and accurate cotton yield monitors not becoming available until 2000 (Larson et al., 2005), while yield monitors for combines were introduced in the late 1980s (Griffin et al., 2004). The lack of yield monitors resulted in cotton producers using grid soil sampling and other soil mapping technologies as the first precision farming technologies in cotton production (Walton et al., 2008).

However, since 2001, results from cotton producer surveys suggest an increase in the adoption of precision farming technologies. From the 2001 Southern Cotton Precision Farming Survey, Roberts et al. (2002) found that 23% of cotton producers in six southern states were precision farming adopters. A similar survey was administrated in 2005 and Roberts et al. (2006) reported that 48% of cotton producers in eleven southern states were precision farming adopters. Furthermore, data from a similar 2009 survey found that 63% of the cotton farmers in twelve southern states were classified as precision farming adopters (Mooney et al., 2010).

While adoption of precision farming has not occurred as quickly for cotton compared with other row crops, precision farming adoption for cotton in the southern United States is increasing. Many questions remain about the factors influencing the adoption of precision farming technologies for cotton and about its future importance in cotton production. Since cotton is a high-value agricultural crop, further insight into these questions would provide important information for cotton producers, university Extension officials, and agribusinesses.

This research reports the status of precision farming technology adoption by cotton producers in fourteen southern states. The report summarizes responses to the 2013 Southern Cotton Precision Farming Survey of cotton producers located in Alabama, Arkansas, Florida, Georgia, Kansas, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. The survey was the fourth in a series of cotton precision farming surveys conducted previously in 2001, 2005, and 2009 (Roberts et al., 2002; Roberts et al., 2006; Mooney et al., 2010).

Materials and Methods

A list of cotton producers in the fourteen southern states for the 2011 marketing year was provided by the Cotton Board in Memphis, TN. The list included a total of 13,838 individuals, of which 272 university research and education centers (i.e., experiment stations) and duplicate individual names were removed. In total, there were 13,566 cotton producers surveyed.

Following Dillman’s (1978) mail survey methods, a postcard was first mailed to the list of cotton producers to inform them they would be receiving a mail survey on precision farming technologies in two weeks. On February 1, 2013, the first round of surveys was sent to cotton producers along with a postage-paid return envelope and a cover letter explaining the purpose of the survey. A reminder postcard was mailed a week later on February 8, 2013, and a follow-up questionnaire was sent to non-respondents three weeks later on February 22, 2013. The second mailing included a cover letter reiterating the purpose of the survey, the questionnaire, and a postage-paid return envelope. If recipients of the survey did not grow cotton between 2008 and 2012, they were instructed to return the survey unanswered.

From the mailing list of 13,566 cotton producers, 66 surveys were returned undeliverable due to incorrect addresses, 263 respondents were no longer farming, and 75 declined to participate in the survey. Therefore, the total number of cotton farmers that were surveyed was 13,162. We received a total of 1,811 responses to the survey, giving a response rate of 13.76%.

Table 1 shows the numbers of cotton producers by state found in the 2007 Census of Agriculture (US Department of Agriculture, 2007), the numbers of producers surveyed by state, and the corresponding response rates. Fewer cotton producers were surveyed than were listed in the 2007 Census, but the distribution of producers across the states was similar for the survey and the 2007 Census. Georgia, North Carolina, and Texas were the states with the most cotton producers according to the 2007 Census and the survey list. The survey response rates were highest for Mississippi, North Carolina, and Tennessee cotton producers.

In this survey, we provided respondents with a definition of precision farming that states the following, "*'Precision farming'* involves collecting information about within-field variability in yields and crop needs, and using that information to manage inputs." This broad definition of precision farming encompasses technologies that may use Global Positioning Systems (GPS) and/or Geographical Information Systems (GIS) (Mooney et al., 2010). Respondents were considered precision farming adopters if they indicated using GPS guidance systems, information gathering technologies, variable-rate input management, or automatic section control for planters or sprayers.

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

	2007 Census of Agriculture[a]		Cotton Farmers Surveyed[b]		Number of Usable Surveys Returned[c]	
State	N	% of total	N	% of total	N	% Response
AL	917	5.3%	750	5.7%	129	17.2%
AR	915	5.3%	605	4.6%	43	7.1%
FL	213	1.2%	199	1.5%	28	14.1%
GA	2577	14.9%	2460	18.7%	217	8.8%
KS	110	0.6%	175	1.3%	28	16.0%
LA	645	3.7%	465	3.5%	72	15.5%
MO	511	3.0%	404	3.1%	48	11.9%
MS	980	5.7%	619	4.7%	113	18.3%
NC	1308	7.6%	1313	10.0%	261	19.9%
NM[d]	--	--	1	--	1	--
OK	421	2.4%	291	2.2%	33	11.3%
SC	458	2.7%	542	4.1%	88	16.2%
TN	779	4.5%	568	4.3%	117	20.6%
TX	7225	41.9%	4563	34.7%	597	13.1%
VA	196	1.1%	207	1.6%	36	17.4%
Total	17255	100%	13162	100%	1811	13.76%

[a] US Department of Agriculture (2007). [b]Number of addresses on the 2011-2012 Cotton Board mailing list minus invalid addresses and respondents who did not farm cotton. [c]Respondents who produced cotton at least once during 2008-2012. [d]New Mexico was not included in the list of states surveyed, but a respondent with a Texas mailing address indicated the majority of farm acreage was located in New Mexico.

Results and Discussion

Comparison with Census Data

The age distribution of cotton producers from the 14-state survey was compared with the age distribution reported in the 2007 Census of Agriculture (Figure 1) for the same 14 states. The largest percentage of the survey respondents was between 55 and 65 years old (33.5%), while the largest concentration of producers reported in the 2007 Census was in the age range of 45-55 (28.5%). More than 80% of the survey respondents were 45 years of age or older and 60% of the survey respondents were 55 or older. Cotton producers younger than 45 years of age represented a smaller share of survey respondents (18.9%) than in the 2007 Census (22%). However, the mean age of survey respondents (56.5 years) was similar to the mean age of producers reported in the 2007 Census (55.2 years).

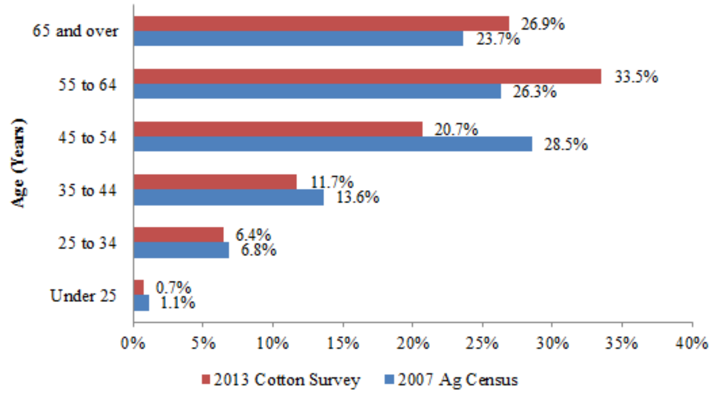

Figure 1. Age distribution of survey respondents and the 2007 Agricultural Census.

Figure 2 shows the distribution of cotton acres planted by survey respondents in 2011 and 2012 compared with the corresponding 2007 Census data for the same 14 states. Relative to the 2007 Census, the percentage of surveyed cotton producers who planted 500 or more acres was greater and the percentage of cotton producers who planted less than 100 acres was smaller. The percentage of surveyed producers who planted between 250 and 500 acres was similar to the percentage found in the 2007 Census.

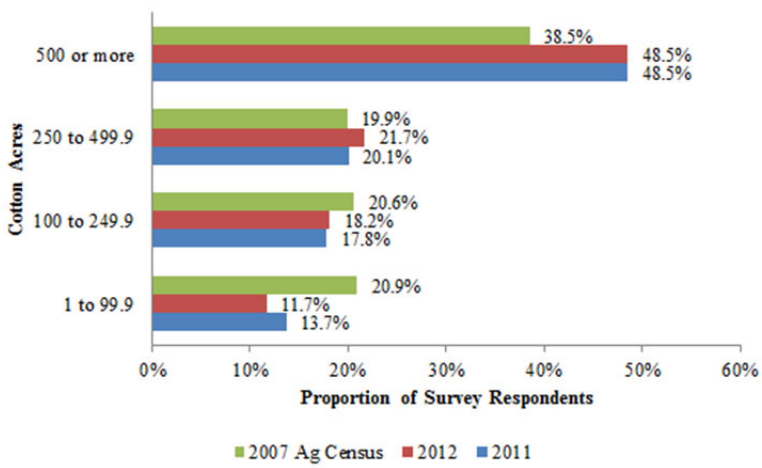

Figure 2. Distribution of cotton acres planted for survey respondents and the 2007 Agricultural Census.

Overall Precision Farming Adoption

Respondents were defined as precision farming adopters if they reported using information gathering technology, variable-rate management, GPS guidance, or automatic section control for planters or sprayers. Table 2 reports precision farming adoption rates by state and technology. A total of 1,329 of the 1,811 (73%) respondents reported the adoption of at least one precision farming technology. Among the states surveyed, Missouri, Kansas, and Arkansas reported the highest adoption rates of precision farming of 91.7%, 89.3% and 88.4%, respectively. The states with the lowest adoption rates were Alabama (62.0%), South Carolina (64.8%), and Virginia (63.9%). Table 2 also shows the adoption of precision farming by technology.

Nearly two-thirds (66.3%) of the responding cotton producers had adopted GPS guidance, followed by information gathering (40.9%), automatic section control for planters or sprayers (29.3%), and variable-rate input management (25.3%). Information gathering technologies were adopted more frequently by cotton producers in Florida (57.1%), Louisiana (65.3%), and Tennessee (57.3%) than in the other states. Cotton producers in Arkansas (46.5%), Missouri (50%), and Tennessee (48.7%) adopted variable-rate management more frequently than the cotton producers in the other states. Interestingly, Kansas (10.7%) cotton producers were the second lowest adopters of variable-rate management by state, but Kansas was the second highest state for overall adoption of precision farming. GPS guidance was adopted by cotton producers in Arkansas (81.4%), Kansas (89.3%), and Missouri (87.5%) more frequently than in the other states. Larger percentages of cotton producers in Kansas (46.4%), Tennessee (52.1%), and Virginia (44.4%) adopted automatic section control for planters or sprayers than cotton producers in the other states.

Table 2. Adoption of precision farming technologies by farm location.

		Precision Farming Adoption by Technology Category[a]									
	Number of Survey Responses	Information Gathering		Variable-Rate Management		GPS Guidance		Automatic Section Control for Planters or Sprayers		Overall Precision Farming Adoption[b]	
State	N	N	%	N	%	N	%	N	%	N	%
AL	129	49	38.0	29	22.5	68	52.7	43	33.3	80	62.0
AR	43	24	55.8	20	46.5	35	81.4	14	32.6	38	88.4
FL	28	16	57.1	13	46.4	20	71.4	5	17.9	24	85.7
GA	217	88	40.6	58	26.7	121	55.8	47	21.7	139	64.1
KS	28	13	46.4	3	10.7	25	89.3	13	46.4	25	89.3
LA	72	47	65.3	33	45.8	57	79.2	18	25.0	61	84.7
MO	48	27	56.3	24	50.0	42	87.5	16	33.3	44	91.7
MS	113	58	51.3	44	38.9	71	62.8	35	31.0	85	75.2
NC	261	121	46.4	77	29.5	157	60.2	82	31.4	185	70.9
NM	1	--	--	--	--	1	--	--	--	1	--
OK	33	11	33.3	6	18.2	24	72.7	12	36.4	24	72.7
SC	88	41	46.6	36	40.9	49	55.7	27	30.7	57	64.8
TN	117	67	57.3	57	48.7	89	76.1	61	52.1	96	82.1
TX	597	162	27.1	50	8.4	418	70.0	141	23.6	446	74.7
VA	36	15	41.7	8	22.2	22	61.1	16	44.4	23	63.9
14-State Total	1811	740	40.9	459	25.3	1200	66.3	531	29.3	1329	73.4

[a]The numbers and percentages of precision farming adopters by category do not sum to the overall number and percentage of precision farming adopters for each state because farmers can adopt more than one category. [b]Overall precision farming adoption includes those who used an information gathering technology (see Table 3 for the technologies), variable-rate management of an input (see Table 4 for the inputs), GPS guidance, or automatic section control for planters or sprayers (see Figure 3 for more detail).

Cotton producers were asked to identify the information gathering technologies they used from a list of many different technologies and the results are presented in Table 3. The information gathering technologies that were adopted the most were grid soil sampling (54.5%) and yield monitor with GPS (49.5%) while the information gathering technologies that were adopted the least were COTMAN plant mapping (4.3%) and digitized mapping (5.4%). The average number of information gathering technologies adopted by a cotton producer that adopts any of these information gathering technologies was 2.5. That is, if a cotton producer adopted information gathering technologies, the producer adopted on average 2.5 of them. The average year the cotton farmer adopted these information gathering technologies is also presented in Table 3. Most of these technologies were adopted beginning in 2005, which could explain why results from the earlier precision farming surveys showed adoption of precision farming increasing from 23% in 2001 to 63% in 2009. Satellite imaging was used on the largest average number of acres per farm, followed by yield monitoring with GPS, and digitized mapping. However, southern cotton producers, who adopted any of the information gathering technologies, used them on more than 1,154 acres on average.

Table 3. Use of information gathering technologies by cotton farmers.

Information Gathering Technology	Number of Adopters[a]		Average Year Farmers Started Using		Average Number of Acres Per Farm	
	N	%	N	Years	N	Acres
Yield monitor - with GPS	366	49.5	348	2007	307	2154
Geo-referenced soil sampling - grid	403	54.5	393	2007	331	1368
Geo-referenced soil sampling - zone	228	30.8	218	2005	188	1875
Aerial photos	213	28.8	206	1996	157	2065
Satellite images	113	15.3	107	2006	85	2921
Soil survey maps	239	32.3	234	1997	178	1915
Handheld GPS/PDA	148	20.0	141	2005	114	1569
COTMAN plant mapping	32	4.3	29	2001	26	1699
Electrical conductivity	83	11.2	83	2008	74	1154
Digitized mapping	40	5.4	39	2007	29	2135
Number of respondents	740					
Average number of technologies per respondent	2.5					

[a] The values reported in this column refer to the percent of information gathering technology adopters who used a specific technology (e.g., 366/740 = 49.5%). They do not reflect overall adoption rates for the cotton farmers surveyed.

Table 4 shows the inputs that cotton producers applied using variable-rate management along with the average year of adoption, number of acres managed and whether they used a map-based or sensor-based technology. Lime (80%), potassium (78.3%), and phosphorus (75.9%) were the most common variable-rate applied inputs by cotton producers who adopted variable-rate input management, followed by nitrogen (40.6%). The average year of adoption by cotton producers was 2007 for all of these inputs. On average, if a cotton producer adopted variable-rate management, the producer variable-rate applied 3.49 inputs. Variable-rate seed management was used on the largest average acreage per farm. Similar to information gathering technologies, cotton produces who have adopted variable-rate management generally farm large acreages using these technologies. Map-based technology was the most common technology used to apply inputs at variable rates.

Table 4. Use of variable-rate management for inputs.

Input	Number of Adopters[a]		Average Year Farmers Started Using		Average Number of Acres Per Farm		Map-Based Technology	Sensor-Based Technology
	N	%	N	Years	N	Acres	N	N
Nitrogen	172	40.6	164	2007	150	1419	97	17
Phosphorous	322	75.9	311	2007	283	1460	201	17
Potassium	332	78.3	324	2007	292	1421	213	18
Lime	339	80.0	329	2007	292	1500	211	17
Seed	76	17.9	72	2006	58	2066	38	7
Growth Regulator	80	18.9	76	2003	59	1184	31	10
Harvest Aid	37	8.7	34	2000	26	1374	15	5
Fungicide	20	4.7	18	1999	13	1304	5	2
Insecticide	34	8.0	34	1998	26	1224	11	5
Herbicide	37	8.7	36	1999	29	1154	11	5
Irrigation	27	6.4	24	2001	19	1043	8	2
Other	4	0.9	2	2007	3	449	1	
Number of respondents	424							
Average number of technologies per respondent	3.49							

[a] The values reported in this column refer to the percent of variable-rate management adopters (e.g., 172/424 = 40.6%). They do not reflect overall variable-rate management adoption rates for the cotton farmers surveyed.

Figure 3 shows the percentage of cotton producers who adopted automatic section control for planters only and automatic section control for sprayers only (and no other precision farming technologies). Results indicate that more cotton producers adopted automatic section control for sprayers only (27%) than adopted automatic section control for planters (13%).

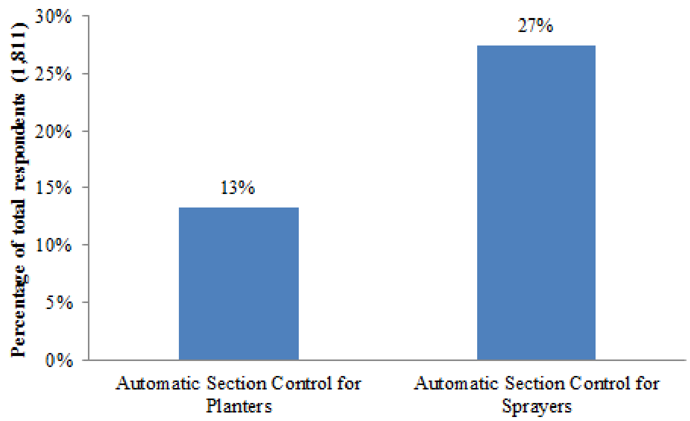

Figure 3. Percentage of respondents who adopted automatic section control for planters or sprayers.

We asked precision farming adopters to rank their reasons for adopting precision farming and the results are reported in Table 5. Cotton producers ranked profit (4.3) as being the most important reason for adopting precision farming, followed by environmental benefits (3.3). Being on the forefront of technology (2.8) was the least important.

Table 5. Rankings of reasons for adopting precision farming.

Reason	Mean[a]	Std. Dev.
Profit	4.3	0.9
Environmental benefits	3.3	1.0
Be at the forefront of technology	2.8	1.3

[a] Importance Rank: 1—Not at all; 2—Somewhat; 3—Moderate; 4—Very; 5—Extremely

Figure 4 shows the primary barriers to using precision farming for adopters and non-adopters. For adopters and non-adopters, the primary barrier was "too expensive" to use, followed by "uncertain benefits." Interestingly, fewer cotton producers perceived "not profitable" as being the primary barrier for adoption relative to most other barriers.

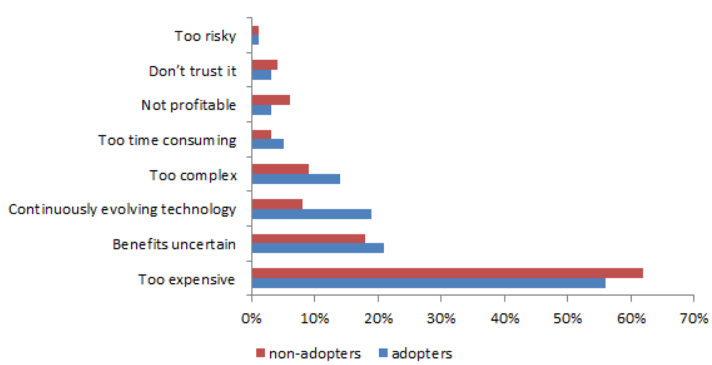

Figure 4. Primary barrier to using precision farming by adopters and non-adopters.

Summary

The objective of this study was to summarize the status of precision farming technology adoption by cotton producers in 14 southern states. A mail survey of cotton producers in the 14 states was conducted in early 2013 to achieve the objective.

Respondents were defined as precision farming adopters if they used GPS guidance, information gathering technologies, variable-rate input application technologies, or automatic section control for sprayers or planters. Overall, 73% of the southern cotton producers indicated they were precision farming adopters. GPS guidance was the most adopted technology, followed by information gathering, automatic section control for sprayers and planters, and variable rate-management. The most common variable-rate applied inputs were lime and potassium, followed by phosphorous and nitrogen. Map-based technology was the most common technology used to apply inputs at variable rates. Profit was the primary reason for adopting precision farming technologies, and the cost of the technologies was the primary barrier to adopting.

Future research using these survey data will investigate many questions such as: the effects of different sources of precision technology information on adoption farmers' perceptions about the environmental benefits of precision technology, and improvement in lint quality from using precision farming, among others. Findings from these studies will build on previous knowledge about precision farming for cotton production, and will be used to develop decision aids to help potential precision farming adopters make more informed decisions about adoption, custom hiring, and/or investing in precision farming equipment.

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Disclaimer

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