ADOPTION AND USE OF PRECISION AGRICULTURE TECHNOLOGIES BY PRACTITIONERS

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ABSTRACT

A survey of farmers was initiated to ascertain the adoption and use of precision agriculture technologies as well as the barriers to and incentives for adoption. Farm-level data were collected via audience response system at the 2009 Alabama Precision Ag and Field Crops Conference. Farmers' adoption or intended adoption of differing levels of precision technology were evaluated ranging from information-intensive yield monitors to embodied-knowledge automated guidance and spray boom-section controls. Results were compared to statistics reported by the USDA Agricultural Resource Management Survey (ARMS) and the annual CropLife/Purdue University Precision Ag Survey where applicable. Approximately 180 Alabama farmers participated in this pilot project which is being replicated across the U.S. to compare adoption and perceptions of precision agriculture.

Keywords: adoption, barriers, incentives, survey, audience response, technology, survey

INTRODUCTION

The adoption and utilization of precision agriculture technologies are presented here and the barriers and incentives to adoption are discussed. Adoption and use statistics are for the U.S. with a focus on Alabama. The barriers and incentives of adopting spatial technologies can best be described based upon how the technology is utilized on what form the technology is applied. Information-intensive technologies include those that provide more information, such as yield monitors, but at the cost of requiring additional ability in management to make practical use of the technology. Information-intensive technology has been readily adopted by some farms and service providers, but not as quickly as embodied-knowledge technologies. The latter include global positioning system (GPS) guidance and automated spray boom controls, requiring less management ability to effectively use the technology. Yield monitors have been used by farmers and researchers for the gamut of crops; however most data on adoption has focused on grains, oilseeds and cotton. Instantaneous yield monitors have been commercially available since the 1990's. Precision agriculture technologies have spread rapidly around the world. In the United States 28% of corn and 22% of soybean areas were harvested in 2005 and 2002, respectively, with a yield monitor (Griffin 2009a) (Table 1).

BACKGROUND

The adoption and use of spatial technologies have been tracked around the world since the 1990s. Griffin and Lowenberg-DeBoer (2005) and Fountas et al. (2003) have reported world-wide adoption of yield monitors. Several studies have examined precision agriculture adoption in the United States (Banerjee et al, 2008; Batte and Arnholt, 2003; Daberkow et al., 2002; Daberkow and McBride, 1998, 2003; Fountas et al., 2003; Griffin et al., 2000; Khanna, 2001, Roberts et al., 2004, 2006). The adoption rates for information-intensive technologies have slowed down in recent years relative to the 1990's (Griffin et al. 2004; Daberkow et al., 2002; Popp et al., 2002). Others studies present possible barriers to adopting precision agriculture technologies (Fountas et al., 2003; Kitchen et al., 2002; Popp et al., 2002; Wiebold, 1998). We build upon the previous literature by addressing adoption of precision agriculture technology in Alabama via audience response system, comparing our results to USDA ARMS and Purdue CropLife survey (Whipker and Akridge, 2009).

DATA AND METHODS

The Alabama Cooperative Extension System (ACES) and cooperating partners hosted the 2009 Precision Agriculture and Field Crops Conference December 8, 2009 at the Wind Creek Hotel in Atmore, Alabama. The conference featured precision agriculture exhibits and vendors, educational sessions and equipment demonstrations. Educational sessions discussed precision agriculture topics including section control technology, economics of precision agriculture, soil fertility applications, and Continuously Operating Reference Stations (CORS) for agriculture. Two hundred thirty-seven participants representing nine states attended the conference. Conference attendees were asked to participate in the Precision Agriculture Technologies Use and Adoption survey via audience response system through an Interactive Presentation on Precision Ag Adoption during the morning educational sessions. The survey contained twenty questions with additional information to define each technology so that respondents had at least basic information common across all respondents.

The overall descriptive statistics from the 2009 Alabama Precision Ag and Field Crops Conference survey is provided next with selected topics being compared to existing results from other sources including farm-level responses from USDA and service providers from the Purdue CropLife Survey. The United States Department of Agriculture – Agricultural Resource Management Survey (USDA ARMS) provides the most detailed information with respect to precision agriculture adoption and use in the U.S. The survey is a collaborative effort by the Economic Research Service (ERS) and the National Agricultural Statistics Service (NASS). Since 1996, the ARMS Survey has provided information on production practices and resource use of America's farmers through face-to-face interviews. Since 1995, CropLife magazine and Purdue University's Center for Food and Agricultural Business surveyed agricultural service providers (Whipker and Akridge, 2009). Several questions asked by the CropLife survey can at least be casually compared to responses from our study. The final portion of this paper describes the sequential adoption of technologies based on the survey.

2009 Alabama Precision Ag and Field Crops Conference

An audience response system from TurningPoint technologies was utilized to collect interactive data. Forty-two farmers responded to the survey, mostly (86%) from Alabama with the remainder from Florida. Half of the respondents farmed between 500 and 1,500 acres. Approximately one-fifth of respondents farmed 1,500 to 3,000 acres and more than 3,000 acres, respectively. Farmer-respondents reported that they produced peanut, cotton, corn, soybean, wheat, and other small grains. Half of the Alabama respondents did no grid soil sampling in 2009 but plan to in the future. While only 28% of Alabama respondents grid soil sampled in 2009, 80% of the Florida respondents did. Only 17% of Alabama respondents zone soil sampled in 2009 while one-third of Florida respondents did. Half of Alabama respondents and one-third of Florida respondents did not zone sampling but intend to within the next two years.

Sixty percent and 40% of Alabama and Florida respondents, respectively, used lightbar guidance in 2009. Twenty-eight percent of Alabama and 60% of Florida respondents do not intend to use lightbars. Those respondents not intending to use lightbars may not have reflected negatively toward the technology but rather can be explained by the 27% of Alabama and 40% of Florida respondents who were using automated guidance in 2009. Half of Alabama and 80% of Florida respondents used RTK in 2009 while only one Alabama respondent used CORS that year. Another type of embodied-knowledge technology is automated swath or shutoff technologies. One-third of Alabama and all Florida respondents used the technology in 2009 and nearly half of Alabama respondents intend to in the future.

Information-intensive technologies such as variable-rate technology were being used by the survey respondents. Nearly 37% of Alabama and 80% of Florida respondents used VRT in 2009 to apply primarily lime (20 to 40%) and fertilizer (20 to 40%). A few farmers stated that they used VRT for seeding and litter applications. The leading information-intensive technology with respect to adoption has been the yield monitor either associated with or without GPS. Respondents were nearly equally separated into the classes of using a yield monitor with a GPS (28%), using a yield monitor without a GPS (26%), not using a yield monitor but intend to (26%), and not intending to use a yield monitor (21%). Sixty percent of Florida respondents intend to use a yield monitor and 20% each use a yield monitor with and without a GPS, respectively (Figure 1).

Once data has been collected from a yield monitor, soil sampling or other site-specific technology, it is usually necessary to use some sort of GIS software to view, store, manage, and analyze the data. Nearly one-forth and four-fifths of Alabama and Florida farmers, respectively, use GIS mapping software in 2009. Nearly 40% of Alabama farmers stated that they do not intend to use GIS.

Most farmers in both states suggested that their best source of precision agriculture information is other farmers. In Alabama, university and Extension was listed as a close second place as the primary source of information. Agricultural consultants and dealers were the primary source of information for less than 15% of farmers. Although only 14% of Alabama farmers stated that they used the internet as the primary source for obtaining precision agriculture information, 72% and 100% of Alabama and Florida respondents use the internet for precision agriculture information although more than 80% of farmers from both states have high speed internet connectivity.

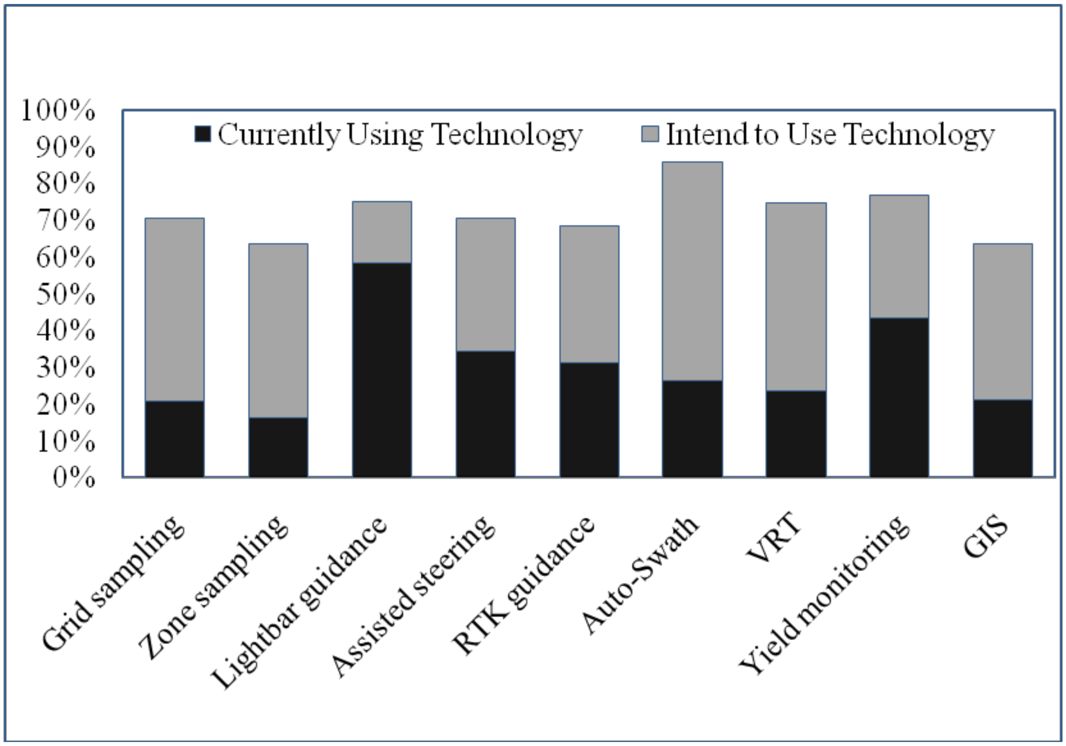

Figure 1. 2010 Alabama Precision Ag Adoption Survey Results.

Yield Monitor Adoption

The respondents from the Alabama survey responded that they had a similar level of yield monitor adoption as the general agricultural population as measured by the USDA ARMS survey. Although the USDA data is only available prior to 2006, anecdotal comparisons can be made with our survey. In the most recent data available, 28% of corn (2005) and 22% of soybean (2002) planted acres were harvested with a combine equipped with a yield monitor (but no GPS), while 26% of Alabama respondents fit this category. The Purdue CropLife Survey suggests that service providers perceive one-fourth of their market area utilizing yield monitors with a GPS and 31% without a GPS. One difference between the surveys was that 28% of our respondents had a yield monitor with a GPS. Possible causes for the differences include the time of the survey, 2005 or earlier for USDA and 2009 for our survey, and the unit of measure (USDA measured as % of planted acres and Purdue CropLife survey measured market area as perceived by service provider respondents while we counted individual farmers rather than acreage farmed). Based on survey responses from the 2009 Alabama Precision Ag and Field Crops Conference, yield monitors were more likely to be adopted by the largest acreage farms.

Table 1. Percent of U.S. planted crop acres on which yield monitor technologies were used [a]

Yield monitor without GPS

	Soybean	Cotton	Peanuts	Winter wheat	Corn
1996	14			2	
1997	10			6	12
1998	15	*		6	12
1999	17	4	*	17	16
2000	21	1		10	18
2001					19
2002	22				
2003		2			
2004			2	10	
2005					28

Yield monitor with GPS

	Soybean	Cotton	Peanuts	Winter wheat	Corn
1996	3			*	
1997	4			1	5
1998	6	*		*	3
1999	6	*		7	6
2000		*		3	6
2001					7
2002	8				
2003		2			
2004			*	2	
2005					

[a] These estimates are revised from previously published estimates based on updated weights from the ARMS.
* = less than 1 percent
Source: Agricultural Resource Management Survey, ERS/NASS, USDA

GPS-enabled Navigation Technologies

The Precision Agricultural Services Dealership Survey Results has been published annually by Whipker and Akridge since 1996. Since 2005, they have reported the estimated market area using GPS guidance; or in other words how service providers perceived farmers using the technology. In 2009, they reported that 41% of market area used lightbar manual guidance, up steady from 22% in 2005. Automated guidance was used on 21% of market area in 2009, up steadily from 4% in 2005. At the service provider level, lightbar guidance had a very high adoption rate, reaching nearly 80% in just 10 years after being commercialized. Automated guidance was used by more than half of service providers in 2009, sharply increasing from 6% in 2004.Results from the 2009 Alabama Precision Ag and Field Crops Conference indicate that farms controlling the most acreage were more likely to adopt automated guidance technologies. About half of our respondents (60% in Alabama and 40% in Florida) used lightbars in 2009; however 27% of Alabama and 40% of Florida respondents used automated guidance. Farms are more likely to use all of one technology than both manual lightbars and automated guidance than service providers who utilize a host of technologies across various types of applicators. At present, midsized farms were more likely to adopt lightbar guidance rather than automated guidance.

Sequential Adoption of Technologies

Most users of lightbar technology do not currently use yield monitors. Only about 6% of respondents use both a lightbar and yield monitor. If a farm used automated guidance, they were likely to have a yield monitor associated with GPS. One-fourth of farmers adopting automated guidance stated that they intend to adopt yield monitor technology within two years. More than half of farmers intending to use automated guidance also intended to use yield monitors within the next two years. Forty-three percent of farms not adopting automated guidance stated that they never intend to adopt yield monitors. Alternatively, given farmers who have adopted yield monitors with GPS, there was no clear adoption for automated guidance; however, for farmers using yield monitors without GPS, they were more likely to state that they never intend to adopt automated guidance. Farmers not using automated guidance were not likely to adopt automated swath controllers. Automated swath controllers were more likely to be adopted by midsized farms than larger farms.

Farmers using yield monitors were more likely to use VRT than to not; however, most of the respondents claimed to not adopt either technology. Farmers who grid soil sampled were more likely to use GPS yield monitors and VRT than farmers who zone soil sampled. Farmers using yield monitors with GPS were more likely to use GIS than farmers who use yield monitors without GPS. Farmers using grid soil sampling were more than twice as likely to use GIS as to not use GIS. Farmers who grid soil sampled were nearly twice as likely to use GIS as farmers who zone sampled.

Farmers' use of the internet was inversely related to their use of GIS. Farmers who either use GIS or intend to use GIS within two years were twice as likely to have high-speed internet as those who never intend to use GIS. Farmers, regardless of their internet use, were most likely to receive their precision agriculture information from university/Extension and other farmers. Regardless of their adoption status regarding yield monitors, farmers received their information from university/Extension. Farmers not intending to use automated guidance relied upon university/Extension more than farmers using automated guidance; however, farmers using lightbar technology relied upon university/Extension for information more than farmers not intending to adopt lightbars.

Farmers using VRT were split on whether land treated with variable rate applications of nutrients was worth more than land treated with uniform applications. Farmers not intending to use VRT were also split equally regarding land value; however farmers intending to adopt VRT within two years were more likely to not perceive farmland treated with variable rates to be worth more money. Compared to farmers using zone sampling, farmers using grid soil sampling were more likely to perceive land receiving variable rates of nutrients to be worth more than with uniform applications.

Farmers' Use of Yield Monitors

Beginning in 2002, the USDA-ARMS survey focused on a single crop and asked eight questions related to how farmers use yield monitor data. Soybean was the crop examined during the first year, cotton was examined in 2003, wheat was examined in 2004, and corn was examined by the 2005 ARMS survey (Table 3).

According to the USDA-ARMS, the leading use of yield monitors has been to monitor crop moisture (Table 3). A likely scenario is that farmers use moisture data to determine if the crop is ready to be harvested or which storage facility to send the particular crop load. Documenting yields is the second most common use of yield monitors and the original intent of the technology. Although these data suggest that yield documentation has not been a primary use of the technology with landowners in negotiations or splitting crop shares, yield documentation in general remains the second greatest use.

Table 3. Use of yield monitor data for selected crops with and without GPS, 2002 – 2005

Crop	Soybean		Cotton		Wheat		Corn	
With GPS?	Yes	No	Yes	No	Yes	No	Yes	No
Monitor crop moisture	68	86	*	*	60	85	91	83
Document yields	50	40	25	41	41	29	51	30
Conduct field experiments	42	23	37	*	14	9	46	28
Tile drainage	32	8	5	3	32	2	31	7
Negotiate new crop lease	9	1	1	3	*	1	5	2
Divide crop production	6	7	7	54	7	8	12	11
Irrigation	4	*	4	8	*	*	4	3
Other uses	7	13	1	19	*	7	7	5

* Less than 1 percent
Source: Agricultural Resource Management Survey, ERS/NASS, USDA
Adapted from Griffin (2009b) using USDA-ARMS data

Yield monitors and other site-specific sensors have allowed farmers to collect many low-cost yield observations. Farmers have used this information to compare crop varieties, tillage treatments, and other inputs or systems. For these four crops, using yield monitors to conduct field experiments ranked in the top four greatest uses. For cotton pickers equipped with GPS, conducting field experiments was the greatest use of the technology.

In areas of the U.S. that rely upon subterranean tile to drain soils, anecdotal evidence has suggested that yield monitors equipped with GPS have helped to quantify the yield reduction due to poor drainage and the potential benefit from drainage improvements. The quantification of yield and profit losses due to poor drainage can be a factor in making land improvements where the farmer owns or leases the land. The ARMS data supports the notion that farmers are using yield monitors with GPS to make tile drainage decisions especially for soybeans, winter wheat, and corn with over 30% of farms utilizing a GPS yield monitor. Irrigation decisions based on yield monitor data has not been a common use of the technology, with less than 10% of farms stating that they have made irrigation decisions based on the technology.

With the exception of cotton, farmers have not used yield monitors in lease negotiations or splitting crop shares. Early in the use of yield monitors, it was expected that leasing arrangements would benefit from the technology; however, from this data and anecdotal evidence, farmland lease arrangements have not been greatly influenced by precision technology especially for negotiating the lease. Farmers producing cotton have made at least some use of the technology for splitting crop shares.

SUMMARY AND CONCLUSIONS

Evidence from the 2009 Alabama Precision Ag and Field Crops Conference indicated that sequential adoption of precision agriculture technologies exist, especially regarding yield monitors and GPS guidance. Also evident was that precision agriculture technologies have been more readily adopted by farms with larger acreage rather than small-acre farms. It was also clear that users of precision agriculture technologies rely upon the university/Extension system for valuable information. The perception of land value as a function of variable or uniform application indicated one incentive to adopt precision agriculture practices.

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