Adoption of Precision Agriculture Technology in Mississippi: Preliminary Results from a Producer Survey

Darren Hudson and Diane Hite

Department of Agricultural Economics
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Mississippi State University

Abstract: *Precision application technology has been an important topic in agriculture in recent years. This technology has the promise to improve farm management through improved information and control over in-field variability of soil characteristics and productivity. Despite this apparent promise, recent studies have shown that adoption has been low. However, little is known about the adoption of this technology in Mississippi or the reasons for or against adoption as seen through the eyes of the producer. This survey was designed to collect basic information on producer perceptions about precision agriculture technology and to assess potential reasons for or against adoption.*

Keywords: *precision agriculture, site-specific management, surveys, Mississippi*

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Site specific management (SSM) refers to a management technique that allows the collection of in-field data on yield, nutrient content, and soil quality that is spatially referenced, and uses that information with computer-controlled equipment to more precisely apply inputs (Khanna, Epouhe, and Hornbaker; Yule et al.; Blackmore). More precise input application leads to improved input uptake, which potentially leads to increased input productivity (more efficient use/reduced costs per unit of production) and yields. SSM includes newer technologies such as global positioning systems (GPS), variable rate technologies (VRT) (often referred to collectively as precision application technologies), and yield mapping, as well as older technologies such as soil sampling and pest scouting.

In general, producers are seeking technologies that will reduce costs and/or increase yields, ultimately leading to increased profits. However, results on increased profitability have been mixed. Carr et al. found no significant difference in returns to SSM strategies as compared to homogeneous field applications on wheat and barley in Montana, but did find that accurate fertility information could lead to increased returns in some cases. Morris and Blackmore found long payback periods were necessary for precision application technology on British farms. Swinton and Lowenberg-DeBoer found that SSM was generally not profitable on wheat, sometimes profitable on corn, and profitable on sugar beets. Finally, Sawyer surveyed the early literature on SSM outcomes and also found profitability results to have been generally mixed. Given uncertain impacts on profitability, the question becomes "why should the producer adopt SSM techniques and technologies?"

One possible alternative motivation for adoption is the potential environmental impacts associated with SSM. Several studies suggest that SSM has the potential to reduce chemical runoff and leaching through improved matching of chemical application with crop needs (Hite, Hudson, and Intarapapong; Office of Technology Assessment; Fuglie and Bosch; Khanna and Zilberman; Oriade et al.; Schnitkey and Hopkins). Assuming that these environmental impacts are tenable, they create a positive externality by reducing pollution that accrues to the public, but provide no added incentive for producers to adopt SSM.

There is currently little information about the adoption of SSM technologies in Mississippi, and consequently, little idea about the underlying factors affecting adoption of these technologies. The purpose of this study was to collect primary data on current adoption and producer perceptions about SSM technologies and to use that information to generate conclusions about the prospects for SSM technologies in Mississippi.

Survey Design

A questionnaire was designed to elicit basic information about producer and farm characteristics such as age, education, income, soil characteristics, production regions, etc. Producers were asked about their current use of SSM technologies and their primary sources of information about SSM. Producers were also asked about the primary factors that would be necessary to induce them to adopt SSM technologies.

The questionnaire was mailed to a random sample of 780 row crop producers in Mississippi by the Mississippi Agricultural Statistics Service during the summer of 2000. The sample was limited to farmers with more than 250 acres because previous research has shown that SSM technologies are cost prohibitive on smaller farms (Morris and Blackmore). Telephone follow-up was used to mitigate non-response bias. A total of 557 responses were returned, representing a 71.4% response rate. Some questions had no responses from some respondents. All available data were analyzed for each question, leading to different sample sizes for different questions.

Survey Results

Basic Data

Table 1 shows the descriptive statistics for some of the basic data collected in the survey. The average farm size (ACRES) was 2,832 acres, with an average gross farm income (INCOME) of $747,229. The average age (AGE) of the respondent was 50.42 years, and 42.79% of the respondents had a high school diploma or less (HS), 44.71% had some college or a college degree (COLL), and the remaining 12.5% had a graduate or professional degree. The average off-farm income (OFF) was $41,436, suggesting that off-farm income as a percentage of gross farm income averaged 10.92%. Of those differentiating between owned and rented acres, farmers owned (POWN) 46.47% of acres farmed.

Soil Characteristics and Production Regions

Table 2 shows the production regions of the respondents. Approximately 70% of the respondents were from the Delta, which is not surprising given that the Delta is the predominant agricultural production region in Mississippi. The rest of the production regions are about equally represented with the exception of the Lower Coastal Plain, which had only two respondents.

Soil quality is likely an important factor in the adoption of SSM technologies. Data were collected on the predominant soil classification of the respondent's farm (Table 3). Soil classification is divided into Class I-IV (there are higher classifications, but those are not considered suitable for cultivation), with Class I being the highest quality soils. Nearly half of the respondents reported having Class I soils, suggesting higher soil quality and fewer problems with soil characteristics than with lower soil classes. Nearly half reported having Class II soils, which are of generally good quality but with some slope and drainage problems.

Producers were also asked to rate their in-field variability of soil characteristics (Table 4). Results suggest that about one quarter of producers believe they have a high degree of in-field variability, while a clear majority believe they have moderate variability. Because SSM is designed to assist in management and control of in-field variability, these results suggest that SSM has a large target audience.

SSM Awareness and Use

Approximately 82% (n = 499) of the respondents reported familiarity with the term “precision agriculture” or are currently using SSM/precision agriculture technologies. Of those reporting familiarity, trade publications were their primary source of information about precision agriculture (Table 5). The Extension Service was ranked as the second most important source of information, on average.

Another important element is the current use of SSM technologies by Mississippi producers (Table 6). Soil sampling/testing is, by far, the most widely used SSM technology. This is partly explained by the length of time that soil sampling has been available to producers and partly explained by its simplicity in use. More advanced technologies such as GPS guidance and variable rate applications are much less prevalent, which is consistent with studies in the Upper Midwest (Khanna, Epouhe, and Hornbaker). Further, of the 376 responding to the use question, only 47% of the respondents use the available technologies in combination, which reinforces the notion that

SSM technologies are adopted sequentially rather than as one complete package.

Producers were also asked what factors were most important for their adoption of SSM technologies. Table 7 shows the proportion of respondents citing each reason as their most important factor for adoption. Logically, profit motives are the leading factors likely to influence adoption. As cited earlier, profitability of SSM is mixed, which is a legitimate concern for producers. The second and third factors in Table 7 may be labeled as management information motives, which comprise over one quarter of the responses together. This suggests that while profits are most important, better information for decision-making (which is likely to lead to higher profits) is the second most important factor determining potential adoption. Reducing yield variability and improving environmental monitoring appear to be less important. However, if environmental regulations become more stringent, environmental monitoring may become a more important motivation for adoption.

Producer Perceptions

Producers were asked their perceptions about several issues relating to SSM/precision agriculture technologies (Table 8). A clear majority of producers believe that the costs of SSM technologies outweigh the potential benefits. This is consistent with previous empirical research on the profitability of SSM and suggests that producers are well aware of uncertainties regarding profit potential. This result also does not bode well for potential SSM adoption unless profitability of SSM technologies is improved and/or awareness of potential benefits is enhanced.

Few strong opinions were expressed on the question of SSM technology complexity, although slightly more respondents thought the technology too complex than not. This suggests that there is room for improved education on use of the technology. As many of these technologies are relatively new and not widely used, perceptions about excessive complexity will certainly change with time. Nevertheless, perceptions of complexity may dampen adoption.

The majority of respondents believed sufficient service support for SSM technologies is currently available. However, few producers actually reported using these technologies. As use grows, there will be increased demands on current service specialists, and ultimately there will be increased demand for their services. If this happens, there will be a need for increases in the number of specialists if satisfaction is to remain high.

Satisfaction with the Extension Service with regards to precision agriculture appears to be high as well. Again, with few users, it has been relatively easy for the Extension Service to interact and provide information to their constituency. However, if use grows, this will create pressure to provide more information to a broader range of producers, which may put pressure on the Extension Service to handle the growing demand. This suggests that proper planning is needed at this point to prepare for any increase in use of SSM technologies by producers.

The majority of respondents felt that SSM technologies did not integrate well with current equipment. This is a challenge to developers of SSM technologies to create equipment that can be easily integrated with current equipment used by producers. Likewise, a majority of producers felt that SSM technologies did not integrate well with current farming practices. This suggests that the challenge to SSM manufacturers is two-fold. New technologies must integrate well with existing equipment and current farming techniques to achieve widespread adoption.

Comparisons Between Adoption Groups

It is important to examine differences between those producers who may wish to adopt SSM technologies compared to those who do not. This comparison should provide some information to businesses and policy makers about what factors are likely to influence adoption. Producers in this survey were provided a hypothetical package of SSM equipment at different prices and asked if they would be willing to purchase that package (see Hudson and Hite for a full discussion of the pricing portion of this survey and implications for government and businesses). The sample was then divided into those willing and those not willing to purchase the SSM technology.

The means of selected variables for these two groups and results of t-tests for differences in those means are presented in Table 9. It is apparent from this analysis that there is a significant difference in farm size between adopters and non-adopters. Adopters tend to have larger farms, which is not surprising because there are likely economies of size associated with SSM technologies. That is, there is a sizeable fixed cost investment in the technology. Thus, larger farms can spread this fixed cost over a greater number of acres, thereby lowering the average fixed cost of the investment.

The VARIAB variable represents the self-assessed in-field variability provided by the producers as described in Table 4 (a value of 1 is associated with low variability and a value of 3 is associated with high variability). This analysis suggests that there is no real difference between adopters and non-adopters with regard to their in-field variability. This is admittedly a gross measure of in-field variability, and a finer measure of in-field variability may yield statistically different results.

The EARLY variable represents those producers that classified themselves as early-adopters (that is, respondents said that they were either always first or usually the first person in their area to adopt new technologies or techniques). As one might expect, early adopters were much more prevalent in the group that has adopted SSM, with 62% of the SSM adopters classified as early adopters compared to 44% in the non-adoption group.

There did not appear to be a significant difference in age between adopters and non-adopters. However, gross farm income was significantly different between groups. Income is related to farm size and reinforces the findings for ACRES. The size of off-farm income relative to gross farm income (POFF) was significantly lower in the adopter groups as compared to the non-adopters. Off-farm income is a measure of diversification, which suggests that farms that have diversified income are less likely to be attracted to SSM technologies. Alternatively, higher off-farm income relative to gross farm income increases the opportunity cost of learning new techniques and technologies. Thus, farms with higher off-farm income are less likely to adopt SSM technologies.

Education appears to be significantly different between adopters and non-adopters. Specifically, the adoption group has a significantly lower proportion of respondents with a high school diploma or less. This suggests that higher education is related to willingness to adopt SSM technologies. Finally, ownership appears to be related to willingness to adopt. That is, farmers responding that they were willing to adopt owned a significantly higher proportion of their farmed acres than those not willing to adopt. Perhaps ownership induces stewardship by producers. Alternatively, perhaps ownership increases risk aversion. The nature of this relationship need further examination.

Conclusions

This study points to some general conclusions regarding SSM/precision agriculture technologies in Mississippi. First, current use of

SSM technologies is low, with the exception of soil sampling/testing. This appears to be consistent with other parts of the country. Generally speaking, the more advanced technologies of GPS and variable rate application have achieved less that 20% adoption. Part of this low adoption likely is related to the newness of the technology and the rapid changes in technology that have taken place in recent years. However, it is likely that the largest contributor to low adoption rates is uncertainty about profitability and the belief of producers that the costs of the technology outweigh the potential benefits. This uncertainty (and the related perceptions about costs and benefits) must be addressed if widespread adoption is to take place.

Awareness of SSM technologies is relatively high, and trade publications and the Extension Service appear to be doing an adequate job of promoting awareness though educational programs. There appears to be some room for practical training in the use of SSM as reflected through producer perceptions about SSM complexity.

A primary challenge appears to be perceptions on the ability to integrate SSM technologies with current equipment and farming practices and perceptions on profit impacts. One should not underestimate the power of the perceptions on ease of integration. Even if SSM technologies were profitable, the probability of adoption would be much lower if the technologies did not integrate within a producer’s current farming practices.

Thus, careful attention should be paid to potential integration problems in the developmental phases of these technologies and services.

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Table 1. Descriptive Statistics of Selected Data.

Variable	Number of Obs.	Mean or Proportion	Standard Deviation
ACRES	416	2,832.14	2,216.93
INCOME	397	$747,229.22	$483,377.55
AGE	413	50.42	11.56
HS	416	0.4279	0.4954
COLL	416	0.4471	0.4978
OFF	376	$41,436.17	$42,883.55
POWN	293	0.4647	0.3369

Table 2. Production Regions of Respondents.

Production Region	Proportion
Upper Delta	45.74
Lower Delta	23.76
Upper Brown Loam	8.71
Lower Brown Loam	3.76
Upper Coastal Plain	2.38
Lower Coastal Plain	0.40
Black Belt	6.73
Don’t Know	8.51
n = 505	

Table 3. Predominant Soil Classification of Respondent's Farm.

Soil Classification	Proportion
Class I (Have few limitations. Deep, well drained, nearly level).	45.78
Class II (Gentle slopes, moderate erosion hazards, inadequate soil depth, less than ideal soil structure and workability, slightly to moderate alkaline or saline conditions and somewhat restricted drainage).	45.19
Class III (Moderately steep slopes, high erosion hazards, very slow water permeability, shallow depth and restricted root zone, low water-holding capacity, low fertility, moderate alkalinity/salinity, and unstable soil structure).	6.88
Class IV (Steep slopes, severe erosion susceptibility, severe past erosion, shallow soils, low water-holding capacity, poor drainage and severe alkalinity/salinity).	0.59
Don't Know	1.57
n = 509	

Table 4. Self-Assessed Variability of In-Field Soil Characteristics.

In-Field Variability	Proportion
High Variability (for example, more than three different soil types, significant slope, many “low spots,” and/or significant variation in soil chemistry)	26.60
Moderate Variability (for example, 2-3 soil types, some slope, a few “low spots,” and/or some variation in soil chemistry)	62.33
Low Variability (for example, 1 soil type, little slope, no “low spots,” and or very little variation in soil chemistry)	10.10
Don’t Know	0.97
n = 515	

Table 5. Primary Sources of Information About SSM/Precision Agriculture Technologies and Techniques.

Source of Information	Proportion Saying Source is Most Important[a]
Trade Publications	48.44
University Extension Service	25.78
Other Farmers	10.94
Manufacturers	7.81
Newspaper/Television/Radio	7.03
n = 384	

[a] Numbers may not sum to 100% due to rounding.

Table 6. Current Use of SSM/Precision Agriculture Technologies in Mississippi.

SSM/Precision Agriculture Technology	Proportion
Soil Sampling	54
GPS Guidance	20
Yield Monitor/Mapping	16
Variable Rate Fertilizer	16
Variable Rate Insecticides	15
Variable Rate Seeding	12
Weed Mapping	8
n = 376	

Table 7. Factors Cited As Most Important for Producer Adoption of SSM/Precision Agriculture Technologies.

Factor	Proportion Saying Factor is Most Important for Adoption[a]
It should reduce cost and/or increase profits.	59.59
It should provide a better understanding of relationships between input use and yield.	15.00
It should provide a better understanding of field characteristics.	12.19
It should reduce yield variability within the field.	7.53
It should provide for better monitoring/management of environmental impacts of chemical use.	5.72
n = 340	

[a] Numbers may not sum to 100% due to rounding.

Table 8. Producer Perceptions about SSM/Precision Agriculture Technologies.

Statement	Percent Responding					
	SA[a]	A	N	D	SD	DK
The cost of the technology is too high relative to the potential benefits. (n = 502)	35.66	38.25	11.55	8.17	1.79	4.58
The process and equipment are too complex to use. (n = 501)	11.98	28.34	22.36	26.75	6.59	3.99
There are a sufficient number of consultants and prescription writers to service my needs. (n = 500)	13.00	41.00	17.00	16.40	6.40	6.20
The University Extension Service provides me with adequate assistance with precision agriculture questions. (n = 502)	13.94	42.03	21.51	12.75	4.58	5.18
There is a lack of satellite resolution/accuracy to make effective decisions. (n = 502)	5.58	17.53	28.29	22.91	7.37	18.33
The precision agriculture technology does not integrate well with existing equipment. (n = 501)	12.18	40.12	17.56	15.97	5.39	8.78
The precision agriculture technology does not integrate well with existing farming techniques. (n = 501)	7.98	33.93	18.36	22.94	7.58	9.18

[a] SA = strongly agree, A = agree, N = neutral, D = disagree, SD = strongly disagree, DK = don't know.

Table 9. Comparison of Means Between Respondents Saying They Will or Will Not Adopt SSM/Precision Agriculture Technologies.

		Mean or Proportion	
Variable	No. Obs.	Yes[a]	No
ACRES	416	3,214.8[*b]	2,680.6
VARIAB	416	2.21	2.14
EARLY	416	0.62[**]	0.44
AGE	413	51.07	50.16
INCOME	397	$845,495[*]	$709,091
POFF	374	0.08[*]	0.12
HS	416	0.36[**]	0.46
POWN	293	0.53[*]	0.44

[a] Those responding "Yes" to their decision to purchase SSM package at stated price level; and those responding "No" at their price level.

[b] Statistical test based on unequal variances because an F-test suggested that two groups exhibited different variances.

[*] Means or proportions statistically different at the 0.05 level.
[**] Means or proportions statistically different at the 0.10 level.