PRECISION AGRICULTURE ADOPTION BY TEXAS COTTON PRODUCERS: TRENDS AND DRIVERS

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Abstract

Increasing demand for agricultural products, declining resource stock, and concerns over environmental pollution are leading to rising emphasis on sustainable agricultural production and efficient use of resources. Precision Agriculture (PA) is an efficient and environmentally friendly technology that aims at improving input use efficiency and reducing potential negative environmental impact of agricultural chemicals by matching input application to crop requirements. However, the technologies are useful to the society only when they are adopted by the end users. Even with all its advantages, the adoption rate of PA technologies was historically low among the Texas cotton producers. Using farm level data from the 2013 Southern Precision farming Survey, this study examines the current adoption levels of PA technology by Texas cotton producers, analyzes some possible factors influencing the adoption decision, and compares the adoption rates from 2009 and 2013 survey. The results indicate that even though 36.60% of the surveyed farmers adopted precision agriculture practice, only 6.87% adopted Variable Rate Technology (VRT). The adoption rate of both PA technologies and VRT is positively associated with adoption of efficient irrigation technologies like center pivot and sub-surface drip irrigation systems. The PA adoption rate was found to be higher among producers with higher irrigated cotton productivity. The PA adoption rate appears to be generally higher for farmers closer to a PA equipment dealer. However, farms more than 40 miles away from the dealership showed a high rate of PA adoption. Most variability data gathering technologies have experienced considerable growth in the adoption rate from 2009 to 2013.

Introduction

Precision Agriculture (PA) is a management strategy that enables the producers to vary input use and cultivation practices to match within-field variability in soil and crop conditions (Srinivasan, 2006). This ensures that the inputs are applied only at the required rates at different parts of the field that may have varying nutrient content and crop requirements. Hence, precision agriculture leads to improved input use efficiency and reduces the potential negative environmental impact resulting from the overuse of agricultural chemicals (Whelan and McBratney, 2000). From an input management perspective, PA helps the producers to make more informed management decisions and the site specific knowledge enables the producers to limit the input use in accordance with the spatial and temporal requirements of the crop (Bongiovanni and Lowenberg-DeBoer, 2004).

The modern technological advances such as Global Positioning Systems (GPS) and Geographical Information System (GIS) have provided a new dimension to the practice of PA. Nowadays, most of the researchers perceive PA as a system with different components such as auto steering technology for tractors, automatic section control for sprayers and planters, geo-referenced soil sampling, several methods of soil variability analysis, and variable rate application of inputs. However, in the classic sense, PA involves collection of within-field variability data, processing of this variability data to assess the extent and distribution of variability, and if needed responding to this variability variable rate application of inputs to match the variability (Blackmore *et al.*, 2003). Common variability detection practices include use of yield monitors, soil maps, geo-referenced soil grid and zone sampling, aerial photos, or satellite imagery to identify the variability in soil fertility, pH of the soil, crop vigor, or moisture stress. Once the variability within the field is detected and analyzed, this information is used to apply inputs like fertilizers, lime, pix or irrigation water in a way that each portion of the field receives the input in required quantities.

The adoption of PA strategies is important not only to increase the profitability and sustainability of the farm, but also to protect the environment as the inputs are not applied in excessive quantities, which limits the potential leaching of the chemicals to water streams. Even with all these potential advantages, the adoption rate of PA practices is low in the United States especially in cotton (Daberkow and McBride, 2000). The lack of awareness of precision agriculture technology among the farmers (Daberkow and McBride, 2003), high cost of the technology, difficulty in proper understanding of the technology, interpretation of the data (Reichardt and Jurgens, 2009), lack of demonstrated evidence of the economic advantages of adoption, and uncertainty in returns from adoption (Khanna, Epouhe, and Hornbaker, 1999) are regarded as major deterrents for PA adoption. PA adoption studies are essential to understand the mechanism of adoption, to evolve efficient extension strategies, and to tide over the bottlenecks in adoption.

This study uses the 2013 Southern Precision Farming Survey to examine the adoption of different precision agriculture practices and its component technologies among the Texas cotton producers. The adoption rates are compared with that reported in the 2009 Southern Precision Farming Survey to analyze changes in adoption rates over time.

Materials and Methods

The data for this analysis are from the 2014 Southern Precision farming Survey (Boyer et al., 2014) and 2009 Southern Precision farming Survey (Mooney et al., 2010). The Southern Precision Farming Survey is an extensive survey supported by Cotton Inc. on adoption of PA practices by cotton producers in the Southern US. The survey covered 12 Southern US cotton producing states in 2009 and 14 states in 2014. The survey provided information on the characteristics of the farmers, their farm, and their farming practices with special references to the different PA practices. The detailed of the states surveyed, survey procedure, sample size, response rate, and overall analysis can be found in Mooney et al. (2010) and Boyer et al. (2014) for 2009 survey and 2013 survey, respectively. Our study used only the Texas portion of the survey to analyze the patterns of PA adoption in Texas.

Results and Discussion

Adoption of Precision Agriculture

The 2014 Southern Precision Farming Survey defined PA as collecting information about within-field variability in yields and crop needs and using that information to manage inputs. A producer will be considered as adopter of PA if he collects information regarding within-field variability regardless of using this data for managing inputs. There was a separate question to understand specifically the adoption rate of Variable Rate Technology (VRT). Out of the 582 respondents, 213 adopted PA (adoption rate of 36.60%), whereas only 40 adopted VRT (adoption rate of 6.87%). This shows that only 18.77% of the PA adopters adopted VRT and majority of the producers did not adopt VRT even after adopting a component technology. This limited adoption among Texas cotton farmers was reported in previous studies and is generally attributed to the low spatial variability in Texas High Plains, which is the most important cotton growing region in Texas (Nair et al., 2011; Nair et al., 2012). The low levels of VRT adoption among PA adopters was also reported by Lowenberg-DeBoer (1999) and Khanna, Epouhe, and Hornbaker (1999).

Irrigation Technology and PA Adoption

Modern irrigation technologies like center pivot and sub-surface drip irrigation have higher irrigation water application efficiency compared to traditional irrigation technologies such as flood and furrow irrigation. Since both PA and the modern irrigation technologies are efficiency enhancing technologies, the adopters of the high efficiency irrigation systems like center pivot and sub-surface drip may have higher PA adoption rate. To analyze the association of adoption of high efficiency irrigation technology and adoption of PA, the producers were grouped into four groups (flood, furrow, center pivot, and sub-surface drip) based on the most efficient irrigation technology adopted by them. A producer will be grouped in sub-surface drip if he has at least 50 acres of cotton under sub-surface drip and the producer with at least 50 acres of center pivot irrigated field will be grouped in center pivot and so on. When a producer has more than one type of irrigation system, the producer will be grouped in to the technology with higher efficiency (sub-surface drip > center pivot > furrow > flood).

The PA and VRT adoption rates of Texas cotton producers with different irrigation systems are provided in Figure 1. It can be observed from Figure 1 that PA adoption rates of producers with high efficiency irrigation systems like center pivot (40.09%) and sub-surface drip (45.53) are almost as twice high as that of producers with low efficiency irrigation systems such as flood (20.00%) and furrow (16.67%). This indicates that the producers using high efficiency irrigation systems are more likely to adopt PA compared to those using low efficiency irrigation systems.

These results are in line with the findings of Nair et al. (2013) that the adoption of efficient irrigation technologies like center pivot and sub-surface drip enhance the likelihood of PA adoption.

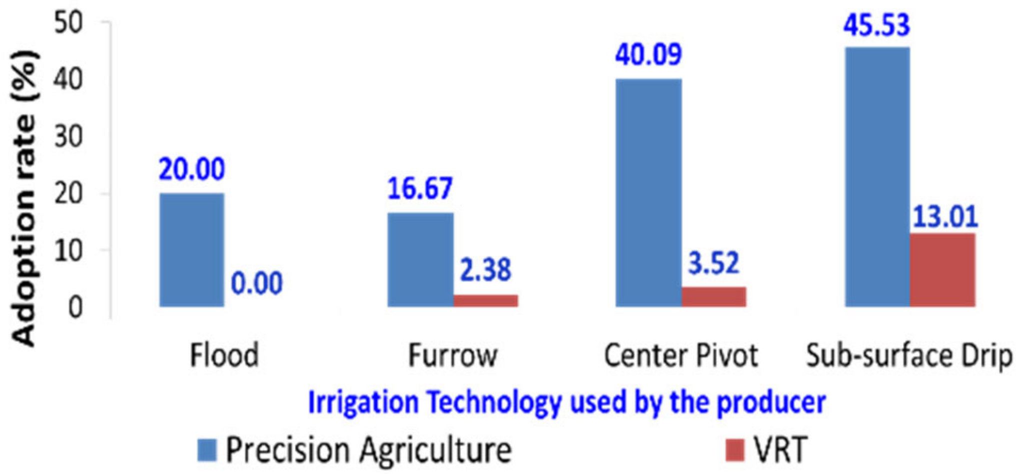

Figure 1. Adoption rates of PA by Texas cotton producers with different irrigation systems.

Cotton Productivity and PA Adoption

Adoption of new farming technologies are mainly driven by the economic advantage obtained from adopting the technology. Hence, the crop productivity can play a major role in the adoption decision by the producer. Moreover, the highly productive farms also can be associated with producers in the forefront of technology and they may be more likely to adopt new technologies like PA. Even though rainfed cotton yield will be more dependent on geographic and soil characteristics, irrigated cotton productivity can reflect the intensity of crop management. The PA and VRT adoption rates for producers having farms with different irrigated cotton productivity (in pounds of lint per acre) ranges are provided in Figure 2. The PA adoption percentage shows a steadily increasing trend with increase in cotton productivity. Only 24.14% of producers with less productive farms (less than 500 lbs./ acre) adopt PA and the adoption rate increases with increase in cotton productivity to 55.00% for producers having highly productive farms (more than 1,500 lbs./ acre). The adoption rate of VRT also shows a generally increasing trend with increase in cotton productivity.

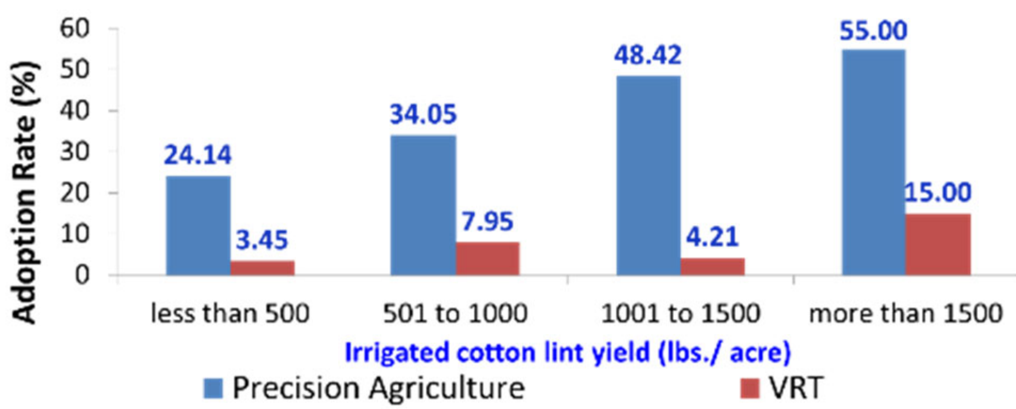

Figure 2. Adoption rates of PA by Texas irrigated cotton producers in different yield ranges.

Distance to PA Equipment Dealer and Adoption

Adoption of precision agriculture can also be influenced by the nearness of the farm to the dealership of precision agriculture equipment. Figure 3 compares the precision agriculture adoption rates of producers grouped by the farm-to-dealership distance. It shows that the adoption rate first decreases with the farm-to-dealership distance, but increases afterwards. The very high adoption rates of both PA and VRT for farms more than 40 miles away from PA equipment dealers observed here may be because of other confounding variables. These faraway farms may be intensively managed larger farms with higher productivity in rural areas and these producers may have shown higher rates of adoption compared to smaller less productive farms closer to the PA dealership.

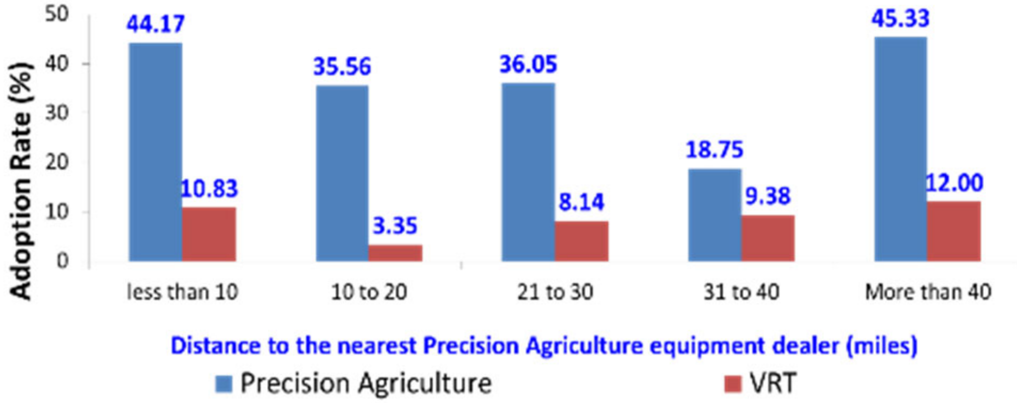

Figure 3. Adoption rates of PA by Texas cotton producers classified by farm-to-dealership distance

Comparison of Adoption Rates from 2009 and 2013 Surveys

Producers can use several technologies to collect information on within-field variability. Yield Monitors (YM), Grid Soil Sampling (GSS), Zone Soil Sampling (ZSS), Aerial Imagery (AI), Satellite Imagery (SI), Soil Survey Maps (SSM), Handheld GPS (HGPS), COTMAN Plant Mapping (COTMAN), Digitized Mapping (DM), and Electrical Conductivity (EC) are the major variability data gathering technologies available to the cotton producers in Texas. Figure 5 compares the adoption rates of these technologies in 2009 and 2013. The adoption rate has increased from 2009 to 2013 for most of the technologies considered. The highest increase is for the adoption of cotton yield monitors, which can be attributed to the fact that many of the modern pickers are sold pre-equipped with cotton yield monitors.

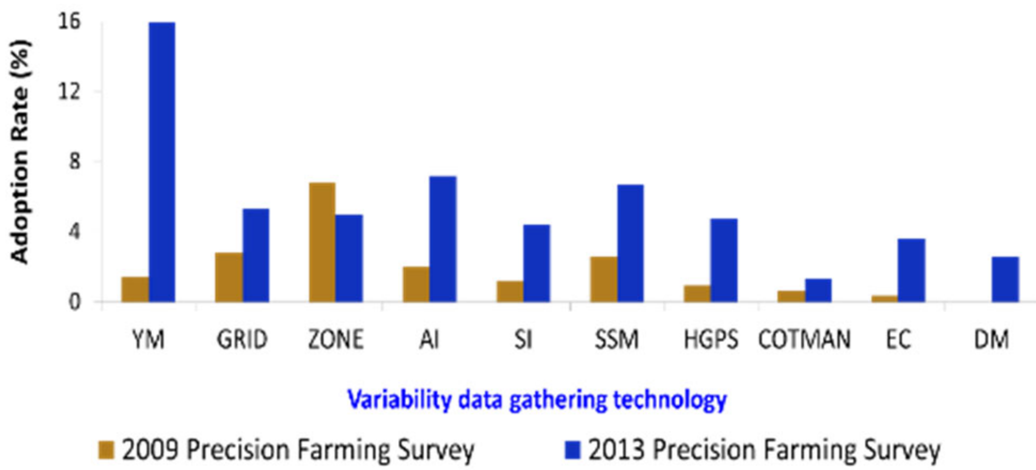

Figure 4. Adoption rates of variability data gathering technologies in 2009 and 2013.

Summary

The 2013 Southern Precision Farming Survey shows that only 6.87% of Texas cotton producers adopted Variable Rate Technology while 36.60% adopted at least one PA technology. The adoption rate was higher for more productive producers, for those using more efficient irrigation technologies, and for those closer to the PA equipment dealer. The adoption rate is higher for most PA technologies in the 2013 survey than in the 2009 survey, but it remains unclear whether or not this is an artifact of the relatively lower number of respondents in the 2013 survey compared to the 2013 survey (n=583 in 2013, n=840 in 2009).

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