PRECISION AGRICULTURE USE IN SELECTED AGRICULTURAL REGIONS IN BRAZIL

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ABSTRACT

Investment in technology brought Brazil to the position among the top agricultural producers in the world. Brazilian agricultural production has increased drastically as a result of productivity growth instead expansion in area. In this scenario the use of Precision Agriculture (PA) in the farm management, considering the spatial variability for maximizing economic return and minimizing the risk of damage to the environment can be decisive. However, the adoption of PA by Brazilian producers iss occurring at a slower rate than the production increasing. Understanding the factors that influence the adoption of PA can be decisive to devise strategies that will enable it dissemination by Brazilian agribusiness. This paper provides a brief overview of selected agricultural regions in Brazil and the main features of the farms surveyed, summarizing the main results of the survey and examining particular features of the precision agriculture adoption and use in Brazil. The survey was conducted through applying a questionnaire to 301 land owners and managers in the Brazilian localities of traditional agriculture region as: Cascavel,PR; Não me Toque, RS, Patos de Minas, MG e Rio Verde, GO and the latest agriculture frontier as Balsas, MA; Bom Jesus, PI; Campo Verde, MT; Luís Eduardo Magalhães, BA; Maracaju, MS. The results indicated that the profile of the owners and property managers who adopt the PA is young, educated, more likely to use technology and informatics and cultivate large land areas. The average time of PA technologies use is 4 years. The properties in which the PA is being used tend to be higher than the traditional ones, indicating that the larger production scales favor the adoption of PA technologies. The main agricultural products cultivated with PA tools are soybeans and corn, followed by wheat and beans. The properties that use PA have equipment, but are underused. The most common equipment in the farms is the navigation systems like light bar and auto guidance, and variable rate for both fertilizer and seed. The main activities in which PA is use are in the supplying of soil amendments/fertilizer and harvest. Most of the PA activity is performed by a third party using farmer's or rental equipment. The soil sampling grid used ranges from one samples for each 3 to 5 ha. The main sources of information producers have been consultants, courses and training programs, and agricultural fairs and exhibitions. There is a perception that the PA adoption can increase productivity, economic returns, and product quality and reduce the negative environmental impact.

Keywords: adoption factors, PA tools, farmers.

Introduction

Investment in technology brought Brazil to the position among the top agricultural producers in the world. Brazilian agricultural production has increased drastically as a result of productivity growth instead expansion in area (Contini and Martha Jr., 2010). In this scenario the use of Precision Agriculture (PA) in the farm management, considering the spatial variability for maximizing economic return and minimizing the risk of damage to the environment can be decisive.

However, in Brazil are scarce studies on the adoption of PA technologies and the factors that influence its adoption. The analysis conducted by Griffin & Lowenberg-DeBoer (2005) suggested that the PA adoption in Brazil was occurring at a slow and unequally way. Among the factors that contributed to the delay in the PA technology adoption were the relatively low land prices, low cost of workforce, low usage of IT in farms and the high cost of imported high-tech equipment. Other studies carried out in Brazil on the PA adoption were from Silva et al. (2011) for the sugar and ethanol industries in the State of São Paulo, Borghi et al. (2011) showing an approach to the Tocantins State and Anselmi (2012) to Rio Grande do Sul State.

Understanding the factors that influence the adoption of PA can be decisive to devise strategies that will enable it dissemination by Brazilian agribusiness. Tey & Brindal (2012) reviewed several articles on the adoption of the PA and raised 34 factors related to this decision. These factors can be grouped into seven groups of factors: socio-economic, agro-ecological, institutional, informational, farmer perception, behavioral and technological. Understanding the factors that influence the adoption of PA can be decisive to address strategies that will improve PA implementation in Brazilian agriculture.

This paper provides a brief overview of selected agricultural regions in Brazil and the main features of the farms surveyed, summarizing the main results of the survey and examining particular features of the precision agriculture adoption and use in Brazil.

Material & Methods

A survey was conducted between September 10th November 13th 2012, during the "Seminars on Precision Agriculture", promoted by the National Rural Education Service - SENAR in the Brazilian localities of traditional agriculture region as: Cascavel, PR; Não me Toque, RS, Patos de Minas, MG e Rio Verde, GO and the latest agriculture frontier as Balsas, MA; Bom Jesus, PI; Campo Verde, MT; Luís Eduardo Magalhães, BA; and Maracaju, MS.

Seminar participants were farmers, extension agents, consultants, employees of agricultural companies, teachers and students. From the responses collected, 301 questionnaires completed by farmers and farm manager were selected.

Questions were addressed to characterize farmer (age, gender, education, income), the farm property (location, area, land ownership, lease, soil texture, relief), and the production system adopted (crops, soil conservation and cultural practices). Then questions were presented on the technologies use (computer, mobile, internet access) and PA use (tools and equipment, activities, activities implementation, sources of information, and soil sampling grid and frequency). There were also questions about the farmers' subjective perception on the use of PA in their region (adoption rate and expected

growth) and the effects of using PA on productivity, profitability, cost, product quality and environment.
The answers were tabulated and their evaluation allowed to sketching the farmers and farmers managers profiles that have used the PA in the main agricultural regions of Brazil.

Results and Discussion

Table 1 shows the characteristics of farmers and farm managers (age, gender, education, income), farm (area, soil texture, relief), and the production system adopted (soil conservation practices and cultural practices) and also the technologies use (computer, mobile, internet access). Regarding gender, over 80% of the respondents were men. The education level of the respondents indicated that more than 42% had a university degree.
The age and education level are drivers for the new technology adoption and there were some differences in the characterization of the farmers and farms managers to adopt the conventional system or PA. Average age of who used the conventional system was 39.3 years, while those who adopted the PA were 35.5 years (Table 1). The results obtained by Roberts et al. (2004) had indicated a lower probability of adoption of PA by older farmers.There were also some differences regarding use of the technologies, with the trend of PA adopters had higher educational levels, since there were a higher percentage of respondents with graduate degree who use PA (19%) than those using conventional systems (11%). And also there were a higher percentage of farmers with education limited to elementary/middle or high school using conventional systems. Anselmi (2012) observed the same trend of higher education among adopters in South region of Brazil. Daberkow & McBride (2003) had already indicated that younger farmers tended to have higher levels of education and this interfered positively in the adoption of PA.
Farms where PA have being used tend to be larger properties. The influence of the farm size in the adoption of PA was also observed by Daberkow & McBride (2003). These results confirm the observations of Griffin & Lowenberg-DeBoer (2005) that larger scales of production tend to favor the adoption of PA technologies. No influence on soil texture or relief was observed. Farms using PA also use more no-tillage system and crop rotation, indicating greater environmental suitability of these farms.
Results indicated that the profile of the owners and property managers who adopt the PA is young, educated, more likely to use technology and informatics and cultivate large land areas. The properties in which the PA is being used tend to be higher than the traditional ones, indicating that the larger production scales favor the adoption of PA technologies.
Computers using in the management of the farm is the first step towards the adoption of PA, since the computer is an integral part of this process (Roberts et al. 2004). The survey indicated (Table 1) significant differences between the properties using the conventional system and using the PA. Among those who take PA, 74% use computer management while only 47% for those who did not adopt the technologies. This difference was already also been observed by Daberkow & McBride (1998). However, these values are larger than the 14% observed in the survey on the use of computers in farms in the São Paulo State (Pino & Francis, 2002) and are close to the values reported for the U.S. and Argentina (Griffin & Lowenberg-DeBoer, 2005). Data show that 68% of

farms that use PA usually access the web for farm purposes, whereas 46% of the conventional farmers do it.

Table 1. Characteristics of farmers and farm managers (age, gender, education, income), farm (area, soil texture, relief), and the production system adopted (soil conservation practices and cultural practices) and also the technologies use (computer, mobile, internet access) in the farms that adopt conventional and PA systems.

a) Farmers

	N	Age	Gender		Education				Income (minimum wage*)		
			Female	Male	Elem/ middle	High school	Under graduate	Graduate	< 5	5 a 10	> 10
Conventional	141	39.3	11.3	83.0	11.3	31.9	41.8	11.3	29.1	34.0	24.8
PA	160	35.5	8.8	81.3	9.4	26.9	43.1	18.8	17.5	31.3	38.8

b) Farms and agricultural systems

	Area (ha)	Soil texture			Relief				No-till	Crop rotation
		Sandy	Loam	Clay	Plane	Slightly undulating	Undulating	sloping		
Conventional	977	9.2	43.3	45.4	24.8	52.5	19.9	3.5	69.5	33.3
PA	2357	14.4	46.3	38.8	27.5	58.1	16.3	3.1	89.4	51.3

c) Technology access

	Computers to farm management	Laptop in the field	Internet access	Mobile	Smartphone
Conventional	46.8	19.9	46.1	90.1	27.7
PA	73.8	37.5	67.5	90.0	46.3

* Minimum wage in Brazil = 724 BRL (US$ 315) per month, paid 13 times a year.

Soil chemical analysis is the tool used to know the soil fertility and make appropriate lime and fertilizer recommendation. The results in Figure 1A confirm this, indicating that soil analysis is a common practice among respondents, as 83 and 93% respectively of the farms under conventional and PA system perform the soil testing. Regarding to sampling frequency there is a trend of annual or 2 years interval for both systems (Figure 1B).

Sampling grid is the key tool to evaluate the soil attributes spatial variability and to establish a lime and fertilizer based on variable rate (VRT) technology. Most of the group that uses PA (72%) performs georefered soil sampling (Figure 1C). Sampling grid size is related to the accuracy and cost of the sampling. In general, most of the respondents (Figure 1D) reported using grids of 3 to 4 ha (24%) and 5 ha (26%). These larger grids may not be efficient to indicate the variation in chemical and physical properties of soils in these areas (McBratney et al., 2005).

Figure 2A shows that the main agricultural products cultivated with PA tools are soybeans and corn, followed by wheat and beans. The average time of PA technologies use is 4 years (Figure 2B).

Originally, in Brazil the PA technologies were restricted to the use of yield monitors to generate yield maps. However the navigation systems on the farm

had expanded their uses. Data also showed that the farms that use PA have equipment, but they are underused. The survey (Figure 2C) indicated that the navigation systems (light bars and auto guidance) are in 42 and 37% of farms. Silva et al. (2011) indicated that 39% of sugarcane crops in São Paulo State adopt auto navigation systems. Gebbers & Adamchuk (2010) reported that this is the tool most widely adopted PA. Other equipment in the farms are the VRT for both lime/fertilizer (38%)and seed (49%).

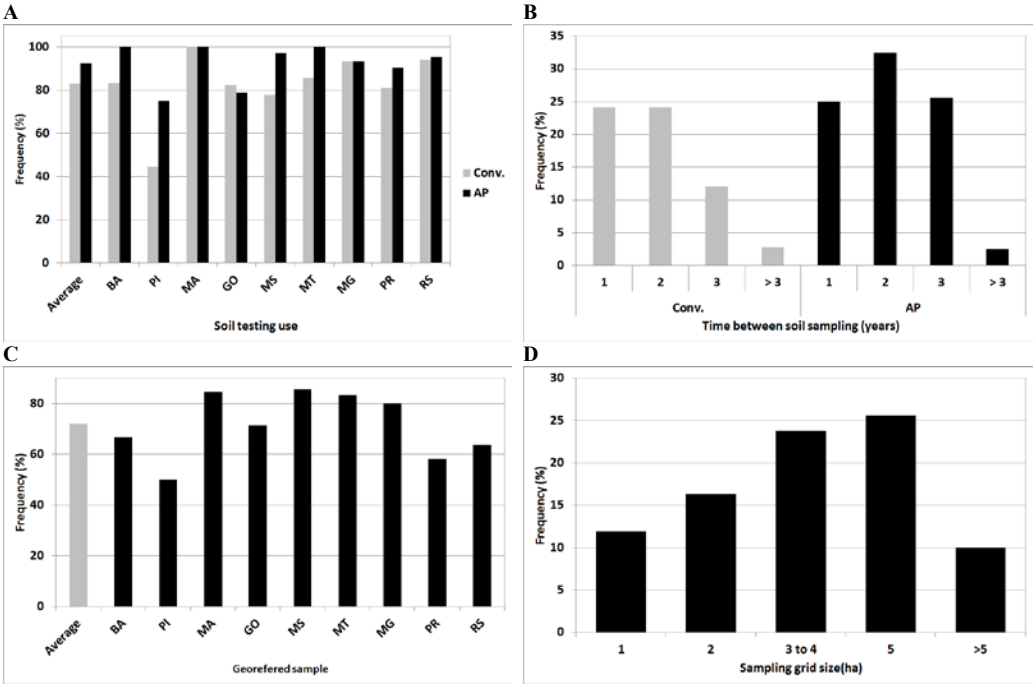

Figure 1. Soil testing use (A), period between soil sampling (B) in the farms that adopt conventional and PA systems; georefered soil samples use (C) sampling grid size (D) in the farms that adopt PA.

The main activities in which PA is use are in the supplying of soil amendments/fertilizer and harvest (Figure 2D). However the combines with yield monitors are present in only 19% of the farms. Pesticides spraying (fungicides, insecticides and herbicides) and foliar fertilizers with PA technologies are performed just in 28% of the farms. Precision irrigation is still in the development phase, as shown by the low adoption numbers (3.8%).
Thirty three percent of the farms perform yield monitoring, despite the low percentage of farms with harvest monitors. Most of the PA activity is performed by a third party using farmer's or rental equipment (Figure 2E).
The main sources of information producers have been consultants, courses and training programs, and agricultural fairs and exhibitions (Figure 2F).
There is a perception that the PA adoption can increase productivity, economic returns, and product quality and reduce the negative environmental impact.
The perception of the respondents were optimistic about the PA become a reality in the major agricultural regions of Brazil, since 84 and 96% confirm the statement (Figure 3A). The differences arise when questioned the time the PA will effectively be a reality for the region, since 51% of those who adopt PA this is already a reality, and 48% of those who do not adopt, PA will be a reality only in 5 years (Figure 3B).

Profitability is the major concern of agricultural enterprises, which is a result of productivity and costs. Between farmers and managers who adopt PA, 94% indicate that PA technologies can increase yield, while 85 % of those who use conventional systems agree with this statement (Figure 3C). Regarding the percentage of yield increasing, most PA adopters claim that the increasing can be from 6 to 10% (25 %) and between 11 to 20% (36 %). Those who do not adopt PA estimate the increasing between 6 to 10%. The majority (93 and 95 %) of those who take the PA confirm that these technologies lead to cost reduction and increase economic returns. For those farmers who do not use PA just 77 and 76% agree with this statement. Griffin & LowenDeBoer (2005) reviewed several studies and indicated that in 68% of analyzed systems PA were more profitable than conventional systems. Tey & Brindal (2012) affirm that the probability of PA adoption will be higher with higher profit for the producer.

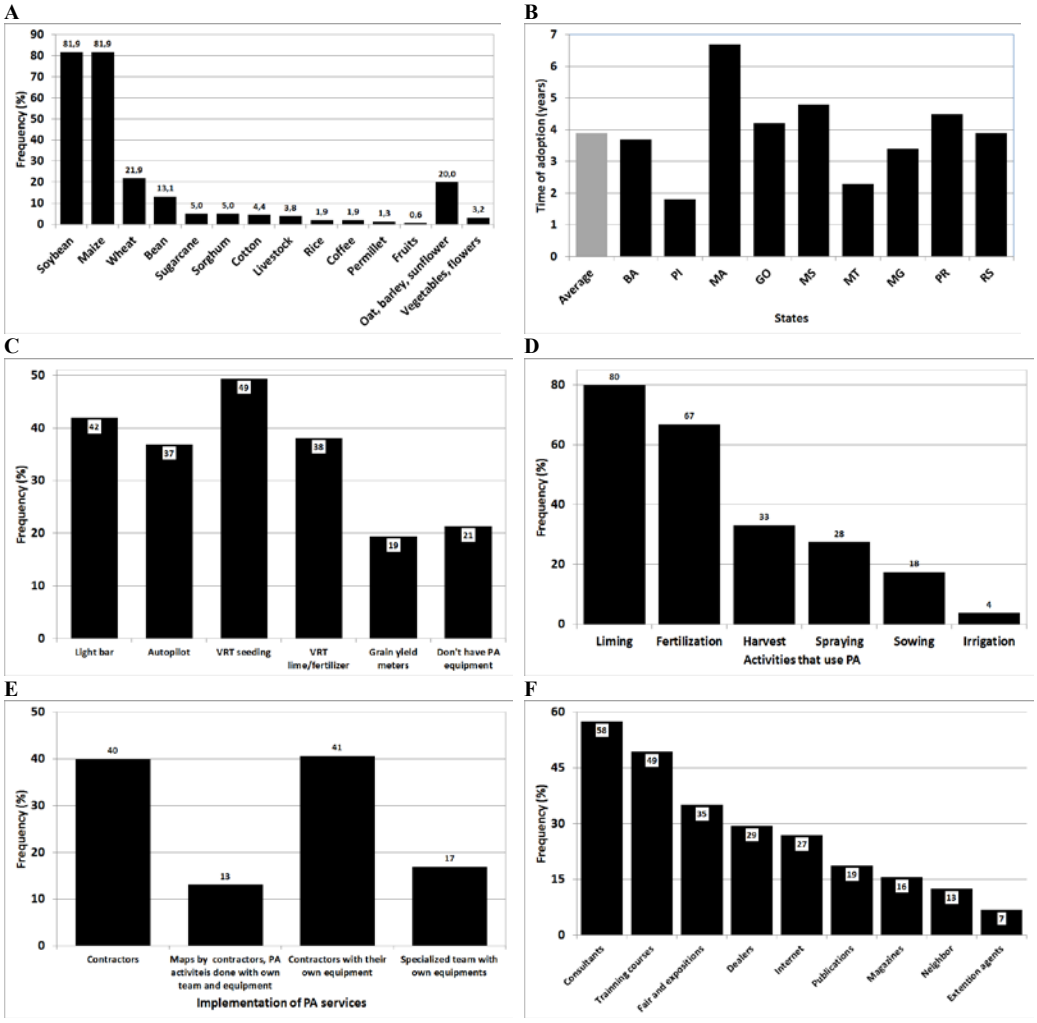

Figure 2. Main crops (A), adoption time (B), equipment (C) and activities in which the PA is used (D) implementation of PA services (E) and information sources (F) in the farms that adopt PA.

In the survey, respondents were asked to further evaluate the use of the PA on the final product quality and reducing environmental impact. The differences between users and nonusers of PA was also perceived, but less markedly.

Almost all PA adopters (95 and 94%) confirm that there is improvement of product quality and reducing the environmental impact using PA, while the other group these values were around 88 and 89% (Figure 3F). This trend confirms the beneficial effects of PA to the environment, which had been described by Lowenberg-DeBoer & Bongiovani (2004) and Stoorvogel & Bouma (2005). In a recent study carried out in Brazil, Silva et a. (2011) showed the same trend in the biofuels industry in the São Paulo State. The study showed that PA technologies were useful for management improvement, increasing yield, reducing cost, reducing environmental impact and improving quality of sugarcane.

The results of this study showed the increasing adoption of PA among farmers of major Brazilian agricultural regions. And also highlighted the need for further research on PA technologies and promote the PA technologies extension.

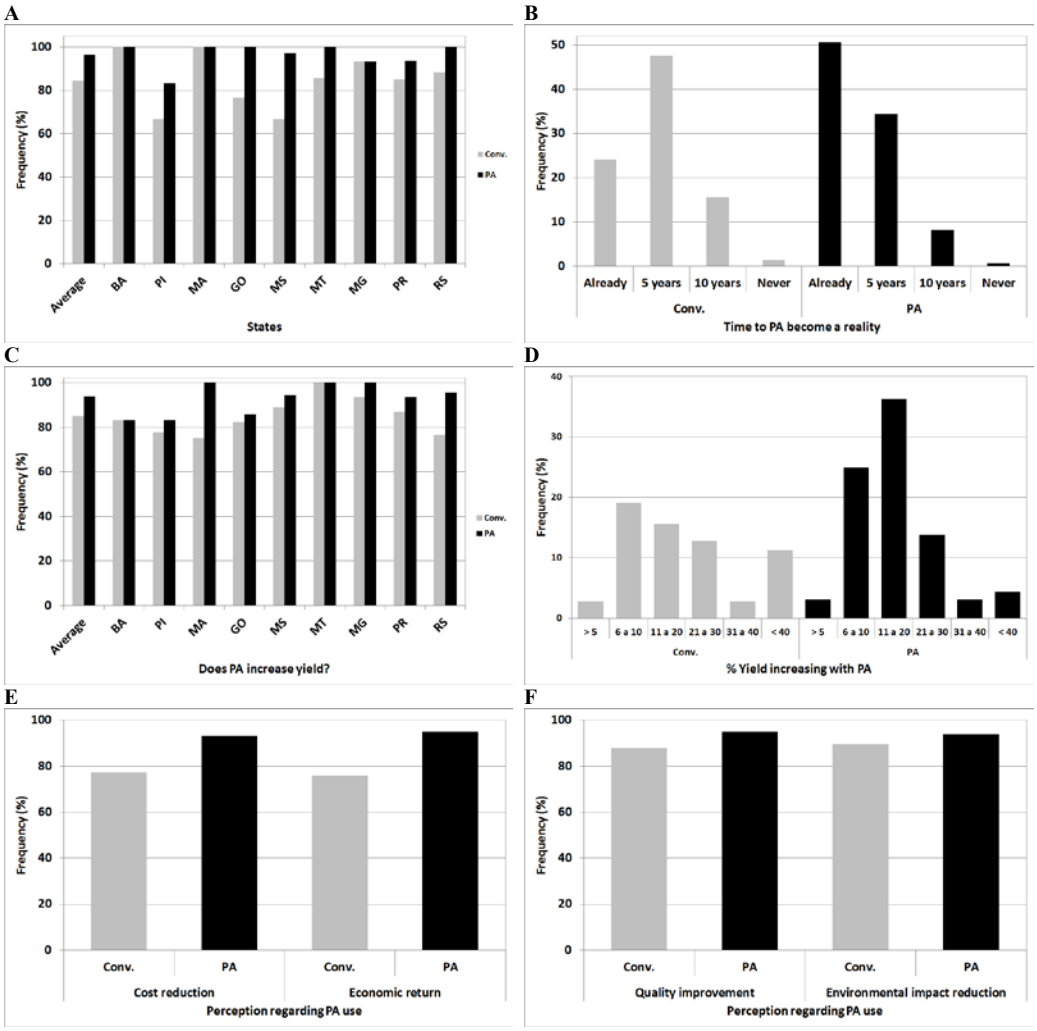

Figure 3. Perception regarding PA to be a reality in the region (A), estimative of PA adoption (B), PA effects in yield (C, D), cost and economic return (E), product quality improvement and environment impact reduction (F) in the farms that adopt conventional and PA systems.

Conclusions

The results indicated that the profile of the owners and property managers who adopt the PA is young, educated, more likely to use technology and informatics and cultivate large land areas. The average time of PA technologies use is 4 years. The properties in which the PA is being used tend to be higher than the traditional ones, indicating that the larger production scales favor the adoption of PA technologies. The main agricultural products cultivated with PA tools are soybeans and corn, followed by wheat and beans. The properties that use PA have equipment, but are underused. The most common equipment in the farms is the navigation systems like light bar and auto guidance, and variable rate for both fertilizer and seed. The main activities in which PA is use are in the supplying of soil amendments/fertilizer and harvest. Most of the PA activity is performed by a third party using farmer's or rental equipment. The soil sampling grid used ranges from one samples for each 3 to 5 ha. The main sources of information producers have been consultants, courses and training programs, and agricultural fairs and exhibitions. There is a perception that the PA adoption can increase productivity, economic returns, and product quality and reduce the negative environmental impact.

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