*Agronomy Research* **14**(4), 1307–1320, 2016

# Awareness and adoption of precision agriculture in the Cukurova region of Turkey

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**Abstract.** Adoption of precision agriculture (PA) technologies has an increasing trend in developed countries. However, it is not well known in developing countries including Turkey. No study was reported on the awareness of PA in Turkey before. The objectives of this study were to assess the awareness of PA in the Cukurova region of Turkey using an interview survey study and also to briefly inform each survey participant about these technologies. The study was conducted with 164 participants that were agricultural engineers, farm equipment dealers and farmers. 90.2% of all participants reported that they followed new trends in agriculture. However, 51.8% of all participants indicated that they did not hear the term 'PA' before. Only 29.3% of the participants who heard the term 'PA' knew its concept. Internet was the most important means to gather information on new technologies. Most three well-known technologies by all participants were satellite positioning (GPS) (81.7%), geographical information systems (GIS) (69.5%) and remote sensing (61.0%) as the least known two ones were variable rate application (33.5%) and soil sampling and mapping (34.8%). In addition, a training brochure was handed out to each participant and the PA technologies were explained. 97.6% of the participants expressed that these technologies would be somehow beneficial for agriculture in Turkey. 88.4% of the participants wanted to get more detailed training on these technologies. Also, information on recent developments in the adoption of PA technologies is included in the paper.

**Key words:** Precision agriculture (PA), awareness, adoption, survey, Cukurova Region, Turkey.

## INTRODUCTION

Agriculture is a crucial sector in Turkey producing a wide range of agricultural products including grains, pulses, fruits, vegetables and livestock and providing employment to nearly 23% of the total in 2012 (Berk, 2013). The cultivated area is very large (24.5 million ha); however, the average farm size is only 5.9 ha which is well below than EU and US averages (174 and 180 da respectively) (Berk, 2013). Farms in Turkey are mostly specialized in field crop production (25.7%), mixed crop and livestock production (21.8%) and fruit and vineyards (19.8%) (Berk, 2013).

Technological developments in agricultural sector yield better management practices resulting in more precision in agricultural operations from planting to harvesting to reduce inputs, increase profits and protect environment (Ess & Morgan, 2003; Rains & Thomas, 2009; Keskin & Görücü Keskin, 2012). The term precision agriculture (PA) or precision farming comprise these improved management technologies such as soil sensing and mapping, yield mapping, satellite-based

positioning, remote sensing, geographical information systems (GIS), variable rate application and automatic steering (Ess & Morgan, 2003; Rains & Thomas, 2009).

Awareness and adoption rate of PA technologies are affected by many factors including personality and family structure of the farmer, education level, characteristics of the farms, farm size, affordability and profitability of equipment, characteristics of the technologies such as complexity and compatibility, legal affairs, social interaction (fairs, exhibition and field days) and properties of the institutions offering support on these technologies (Daberkow & McBride, 2003; Pawlak, 2003; Edwards-Jones, 2006; Kutter et al., 2011; Paudel et al., 2011; Robertson et al. 2012; Keskin, 2013).

The adoption of PA is in an increasing trend in developed countries particularly in the US. Isgin et al. (2008) reported that 36% of farmers surveyed in Ohio reported that they use at least one PA technology. Norwood & Fulton (2009) stated that 54% of the farmers adopted one or more technologies and most common ones were yield monitoring and automatic steering (32%) in the US. Whipker & Akridge (2009) reported that 85% of agricultural dealers in the US use at least one PA technology in their operations. Paudel et al. (2011) reported that about one-third of the cotton farmers (34%) in twelve states in the US adopted PA technologies. Schimmelpfennig & Ebel (2011) indicated that yield monitoring was used on over 40% of US grain crop acres as GPS maps and variable-rate technologies were used on 24% and 16% of corn acres, respectively in 2005 and on 17% and 12% of soybean acres in 2006 in US Corn Belt region, but nationally the adoption rates for variable-rate technologies were 12% for corn and 8% for soybeans. Erickson & Widmar (2015) carried out a survey study with 261 crop input dealers across the US and reported that the most popular three technologies were GPS guidance with auto control/autosteer (83%), GPS-enabled sprayer section control (74%) and GPS guidance with manual control (63%) and stated that 82% of the dealers offered PA services to their customers. According to a report by the USDA (2015a), about 25% of peanut farms adopted GPS soil map technology and over 40% used auto steering systems while variable rate fertilizer application had a higher adoption rate in peanut production at over 20% of farms than for many other crops in the US in 2013 (USDA, 2015a). In another report by the USDA (2015b), about 60% of rice farms adopted yield monitoring technology and about 55% used auto guidance systems in the US in 2013 (USDA, 2015b).

Similar trends can be seen in other developed or developing countries. Bongiovanni & Lowenberg-DeBoer (2005) indicated that yield monitors, positioning systems (GPS), auto guidance and satellite images are increasingly used in Argentina which was reported to be the second country after the US with number of yield monitors (1200) and fifth country with yield monitor density of 51 monitors per million hectares (after the US, Denmark, Sweden and Great Britain). It was reported that, in South Africa, in the year of 2005, the number of yield monitors was increased to more than 600, the number of variable rate controlled lime application to 244, the number of manual guidance systems to 200 and the number of auto guidance systems to 60 (Helm, 2005). Reichardt et al. (2009) interviewed with farmers at agricultural exhibitions in Germany and reported that a large number of farmers did not know what PA meant and stated that between 6.6% and 11.0% of them used PA, mainly data collection techniques such as GPS based area measurement and soil sampling rather than variable rate application. In Germany, Finland and Denmark, 36% of the survey respondent farmers had previous experiences in PA but 28% of them had difficulties due to ‘language problems’ between different

equipment and software (Bligaard, 2013). Robertson et al. (2012) indicated that the variable rate technology adoption in 2008–2009 has increased significantly to 20% nationally in Australia. Leonard (2014) reported that 80% of the grain growers in Australia use automatic guidance. In China, tractor auto guidance was the most accepted technology and about 25% of the farmland was managed using PA in Heilongjiang Province (Verma, 2015). In Sweden, nitrogen sensors are used in about 20% of wheat fields primarily for nitrogen fertilizer application (Söderström, 2013). Silva et al. (2011) carried out a survey study on sugar and ethanol companies in the Sao Paulo state of Brasil reporting that 58% of the domestic companies and 38% of the foreign capital companies adopt PA stating the most preferred technologies as satellite imaging (76%), auto pilot guidance (39%), geo-referenced soil sampling (31%) and variable rate fertilizing and liming (29%).

PA is not recognized well in most of the developing countries including Turkey. No study was reported on the awareness level of PA in Turkey before. Therefore, the two objectives of this study were to:

- assess the awareness level of PA technologies in Cukurova region of Turkey using a face-to-face survey;
- briefly inform each survey participant about PA technologies at the end of the survey questionnaire.

## MATERIALS AND METHODS

### Study area

The study was conducted in the Cukurova region of Turkey including four provinces (Hatay, Osmaniye, Adana and Mersin) based on interview questionnaire. Cukurova region is located on the mid-south of Turkey (Fig. 1) and is one of the important agricultural areas in Turkey. The total area of the region is 38,509 km$^2$ as the area of cropping land is 1,091,000 ha with 421,000 ha irrigated and it accounts for 5% of the total cultivation area of Turkey (Akcaoz & Ozkan, 2005). Most important crops include cereals, cotton, corn, soybean, peanut, sunflower, olives, citrus, vegetables, fruits and medicinal and aromatic plants. The region has a typical Mediterranean climate having warm and rainy winters and hot, humid and dry summers. Farmers in this region tend to use new agricultural practices and cultivars in their production as the use of agricultural inputs has risen very rapidly and yields of crops such as wheat, cotton and maize are in an increasing trend (Akcaoz & Ozkan, 2005).


**Figure 1.** The study area, Cukurova region, is located on the mid-south of Turkey.

**Survey questionnaire and training brochure**

The survey questionnaire consisted of five pages and included questions in five categories:

1) Personal information (age, gender, education level, work experience, etc),
2) General information (job related questions),
3) General questions on PA (basic concepts),
4) Detailed questions on PA (technologies),
5) Questions after short training (possible adaption of PA).

In addition, a four-page training brochure was prepared along with the questionnaire (Fig. 2). A copy of the brochure was given to each participant after the survey and PA technologies were explained in a short face-to-face training session (about 5 to 10 minutes for each participant).

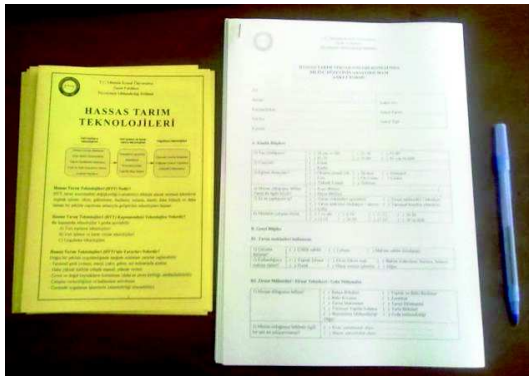


**Figure 2.** Training brochure (left) and questionnaire (right) used in the study.

**Target people**

Questionnaire study was conducted with 164 participants. The participants were agricultural engineers, farm equipment dealers and farmers. Majority of the participants were agricultural engineers working for the government institutions. In the study, the graduates from the departments of agricultural machinery, irrigation and agricultural structures, biosystems engineering, field crops, horticulture, soil science, crop protection, animal science and agricultural economics were considered as agricultural engineers in compliance with the technical terminology in Turkey even if it is not same in some developed countries.

**Statistical analysis**

Statistical data were analyzed in SPSS statistics software (v 17.0).

## RESULTS AND DISCUSSION

**Characteristics of the participants**

The study was conducted with 164 participants using interview survey method. The participants were agricultural engineers, farm equipment dealers and farmers. The number of participants in each group is presented in Table 1. Personal characteristics of the participants including age, gender, education level and work experience were also

studied (Table 2). Majority of the participants were in the age group of 31–40 (33.5%) followed by 41–50 (26.2%). 80.5% of the participants were male while 19.5% were female. It was observed that majority of the participants had a bachelor's degree (51.8%). Regarding the work experience, 18.9% of the participants had an experience of less than five years as 18.3% of them had an experience of 16–20 years (Table 2).

**Table 1.** Number of participants in each group

| Participant group | Number | Ratio |
|---|---|---|
| Agricultural engineers | 103 | 62.8% |
| Farm equipment dealers | 22 | 13.4% |
| Farmers | 39 | 23.8% |
| Total | 164 | 100% |

**Table 2.** Personal characteristics of all participants

| Property | Value | Number | Ratio |
|---|---|---|---|
| Age | < 20 | 0 | 0% |
| | 21–30 | 34 | 20.7% |
| | 31–40 | 55 | 33.5% |
| | 41–50 | 43 | 26.2% |
| | 51–60 | 26 | 15.9% |
| | > 61 | 6 | 3.7% |
| Gender | Male | 132 | 80.5% |
| | Female | 32 | 19.5% |
| Education level | Elementary school | 20 | 12.2% |
| | Middle school | 7 | 4.3% |
| | High school | 14 | 8.5% |
| | Associate's degree | 16 | 9.8% |
| | Bachelor's degree | 85 | 51.8% |
| | Master's degree | 15 | 9.1% |
| | Doctorate degree | 7 | 4.3% |
| Work experience (years) | < 5 | 31 | 18.9% |
| | 6–10 | 22 | 13.4% |
| | 11–15 | 21 | 12.8% |
| | 16–20 | 30 | 18.3% |
| | 21–25 | 11 | 6.7% |
| | 26–30 | 23 | 14.0% |
| | 31–35 | 11 | 6.7% |
| | > 36 | 15 | 9.1% |

Agricultural engineers constituted the biggest group (62.8%). They play a crucial role as a consultant to inform and promote new agricultural technologies including PA (Kutter et al., 2011). Therefore, we included them as one of the participant groups in the study. Most of the agricultural engineers were employed by government institutions mainly the Ministry of Food, Agriculture and Livestock. In the study, the graduates from the departments of agricultural machinery, irrigation and agricultural structures, biosystems engineering, field crops, horticulture, soil science, crop protection, animal science and agricultural economics were considered as agricultural engineers in compliance with the technical terminology in Turkey even if it is not same in some developed countries. The majority of the agricultural engineers participated were the

graduate of the field crops major (22.3%) followed by the horticulture major (17.5%) and the crop protection major (14.6%) (Table 3).

**Table 3.** Majors of the agricultural engineers participated in the study

| Graduation by Major | Number | Ratio |
|---|---|---|
| Agricultural machinery | 9 | 8.7% |
| Agricultural structures and irrigation | 9 | 8.7% |
| Biosystems engineering | 2 | 1.9% |
| Field crops | 23 | 22.3% |
| Horticulture | 18 | 17.5% |
| Soil science | 8 | 7.8% |
| Crop protection | 15 | 14.6% |
| Animal science | 6 | 5.8% |
| Agricultural economics | 5 | 4.9% |
| Other | 8 | 7.8% |
| Total | 103 | 100% |

In the subsequent sections of the interview, three general questions about PA were asked to each participant (Table 4).

Firstly, the participants were asked if they follow new trends in agriculture. Overall, 90.2% of them gave a positive answer. When we look at the participant groups, 87.4% of the agricultural engineers, all of the farm machinery dealers (100%) and 92.3% of the farmers told that they followed the new trends in agriculture. It was observed that agricultural engineers followed new trends in agriculture with a lower percentage compared to the farm machinery dealers and the farmers. Most of the remaining participants that answered 'no' to this question told that they are not able to follow the innovations in agriculture due to very busy work tasks.

Secondly, overall, only 51.8% of the participants reported that they heard the term 'PA' before (Table 4). Regarding the participant groups, 52.4% of the agricultural engineers, 77.3% of the farm machinery dealers and 35.9% of the farmers told that they heard the term 'PA' before. This showed that dealers and agricultural engineers have a significantly higher awareness compared to the farmers.

**Table 4.** Percentage of the positive answers to the general questions

| | All Participants | Agricultural Engineers | Machinery Dealers | Farmers |
|---|---|---|---|---|
| Question | Yes | Yes | Yes | Yes |
| 1) Do you follow new trends in agriculture? | 90.2% | 87.4% | 100.0% | 92.3% |
| 2) Have you heard the term 'PA' before? | 51.8% | 52.4% | 77.3% | 35.9% |
| 3) Do you know what 'precision agriculture' is? | 29.3%; | 25.2% | 59.1% | 23.1% |

Finally, 29.3% of all participants who heard the term 'PA' before replied that they knew the meaning and concept of the PA (Table 4). Concerning the participant groups, 25.2% of the agricultural engineers, 59.1% of the farm machinery dealers and 23.1% of the farmers told that they knew the meaning and concept of the PA. Again, farm

machinery dealers and agricultural engineers have a significantly higher knowledge level compared to the farmers. It could be stipulated that dealers and agricultural engineers were not able to transfer their knowledge of PA to the farmers well. Also, it was observed that dealers were the most aware of PA compared to the other two participant groups (agricultural engineers and farmers).

In the further sections of the questionnaire, two more questions related to the source of information on PA were directed to the participants that are aware of PA (Table 5). Firstly, most two common information sources were internet (25.6%) and TV (17.7%) for the participants who heard the term 'PA' before. Secondly, 17.1% and 12.8% of the participants who know what 'PA' is replied that they got the information from the training activities and the internet, respectively (Table 5). This revealed that internet was the most important means to gather information about new agricultural technologies. Also, training is crucial to increase the awareness on PA. In general, agricultural engineers and farm machinery dealers had the opportunity to get training on new technologies including PA.

**Table 5.** Answers to the questions on the source of information on PA

| Question | Source | Ratio |
|---|---|---|
| 1) If you have heard the term 'PA' before, what was the source of information? | Radio | 0.6% |
| | **TV** | **17.7%** |
| | Newspaper | 1.8% |
| | Magazine | 9.8% |
| | **Internet** | **25.6%** |
| | Fair | 14.6% |
| | Congress | 5.5% |
| | Colleague | 12.2% |
| | Training/Other | 14.6% |
| 2) If you know what 'PA' is, what was the source of information? | Radio | 0.6% |
| | TV | 6.1% |
| | Newspaper | 1.8% |
| | Magazine | 5.5% |
| | **Internet** | **12.8%** |
| | Fair | 6.7% |
| | Congress | 4.9% |
| | Colleague | 7.3% |
| | **Training/Other** | **17.1%** |

Further sections covered seven PA technologies including yield monitoring and mapping, soil sampling and mapping, satellite-based positioning (GPS), remote sensing, geographical information systems (GIS), assisted and automatic steering and variable rate application (Table 6). For all participants, the most three well-known PA technologies were satellite-based positioning (GPS) (81.7%), remote sensing (69.5%) and geographical information systems (GIS) (61.0%). In reference to the participant groups, the most three well-known PA technologies by the agricultural engineers were positioning (GPS) (87.4%), geographical information systems (GIS) (77.7%) and remote sensing (75.7%). Farm machinery dealers were mostly aware of automatic steering (95.5%), positioning (GPS) (90.9%) and remote sensing (72.7%) while the most three

known technologies by the farmers were positioning (GPS) (61.5%), remote sensing (51.3%) and automatic steering (38.5%).

Overall, the least known technologies were variable rate application (33.5%) and soil sampling and mapping (34.8%) for all participants (Table 6). On the other hand, regarding the participants groups, the least known technologies were automatic steering (28.2%) by the agricultural engineers, geographical information systems (GIS) (40.9%) by the dealers and yield monitoring and mapping (20.5%) by the farmers.

**Table 6.** Percentage of the positive answers to the questions on PA technologies

| | All Participants | Agricultural Engineers | Machinery Dealers | Farmers |
|---|---|---|---|---|
| Question | Yes | Yes | Yes | Yes |
| Do you have knowledge on: | | | | |
| 1) yield monitoring and mapping technologies? | 40.9% | 44.7% | 59.1% | 20.5% |
| 2) soil mapping technologies? | 34.8% | 36.9% | 45.5% | 23.1% |
| 3) satellite positioning technologies (GPS)? | **81.7%** | **87.4%** | 90.9% | **61.5%** |
| 4) remote sensing technologies? | 69.5% | 75.7% | 72.7% | 51.3% |
| 5) geographical info systems (GIS)? | 61.0% | 77.7% | 40.9% | 28.2% |
| 6) assisted and automatic steering technologies? | 39.6% | 28.2% | **95.5%** | 38.5% |
| 7) variable rate application technologies? | 33.5% | 29.1% | 63.6% | 28.2% |

It was observed that most of the agricultural engineers in both private and public sectors use GPS receivers and satellite remote sensing primarily to identify fields and calculate area. Farmers are also aware of GPS receivers since it is intensively used in field area calculation. They are also aware of remote sensing since agricultural government agencies determine the total and average yield of a farmer's field and arrange agricultural price support payments based on the yield data from satellite remote sensing technologies.

Another question directed to the farmers in the interview was 'Do you currently use any of the seven PA technologies?'. 23.0% of them answered that they use satellite-based positioning technologies (GPS) and only 5% use automatic steering (Table 7). None of the farmers use soil mapping, remote sensing and variable rate application technologies.

In the last section of the survey, a four-page training brochure (Fig. 2) was handed out to each participant and the PA concept and seven PA technologies were explained. This brief training process took about five to ten minutes.

**Table 7.** Percentage of the positive answers by farmers (n = 39) to the question 'Do you currently use PA technologies?'

| Precision agriculture (PA) technologies | Yes |
|---|---|
| Do you currently use: | |
| 1) yield monitoring and mapping technologies? | 2.5% |
| 2) soil mapping technologies? | 0.0% |
| 3) satellite-based positioning technologies (GPS)? | **23.0%** |
| 4) remote sensing technologies? | 0.0% |
| 5) geographical information systems (GIS)? | 2.5% |
| 6) assisted and automatic steering technologies? | 5.0% |
| 7) variable rate application technologies? | 0.0% |

Five more questions were directed to each participant after the short training, (Table 8). First, 97.6% of all participants told that the information given in the short training was valuable for them. Secondly, 97.6% of all participants expressed that these technologies would somehow be beneficial for agricultural sector in Turkey. When asked 'Which technology will be more beneficial', 68.4% of participants answered that all technologies could be useful as 15.8% of them answered that variable rate application could be most beneficial. Thirdly, concerning the question 'does the Ministry of Food, Agriculture and Livestock offers grants and/or subsidy for these technologies?', 89.0% of all participants gave a negative answer or they did not have any information on this matter. In fact, the Ministry of Food, Agriculture and Livestock offered 50% grant for only yield monitoring systems in the year of 2014. This information was shared with each participant at the end of the survey. It was determined that unfortunately the Ministry would not continue to support these technologies in the near future including the year of 2015. In the fourth question the participants were asked 'Would you want to acquire more detailed training on PA?' and 88.4% of all participants were willing to get more detailed training. Finally, the farmers were asked if they want to use these technologies and 89.7% of them were positive (Table 8). Farmers who answered 'no' for this question told that high investment cost and small field size would be an important barrier to adopt PA technologies. On the other hand, 2.6% of them replied that they wanted to test the equipment first before using. When asked 'Which technology will be more beneficial?' to the farmers, 62.9% of participants answered that all technologies will be useful as 22.9% and 8.6% favored variable rate application and automatic steering as most beneficial, respectively. Farmers wanted to use the variable rate application due to the high cost of the agricultural inputs particularly chemical fertilizers.

**Table 8.** Answers to the questions after short training on PA (n = 164)

| Question | Yes | No |
|---|---|---|
| 1) Is the information given in the short training valuable for you? | 97.6% | 2.4% |
| 2) Would these technologies be beneficial for agriculture in Turkey? | 97.6% | 2.4% |
| 3) Does the Ministry of Food, Agriculture and Livestockoffers grants and/or subsidy for these technologies? | 11.0% | 89.0% |
| 4) Would you want to acquire more detailed trainingon PA technologies? | 88.4% | 11.6% |
| 5) Would you want to use these technologies? | 89.7% | 10.3% |

**Statistical data analysis**

Statistical analysis was conducted using *Chi-square test* for the awareness level of all participants and participant groups (agricultural engineers, farm equipment dealers and farmers). The awareness level was based on the answers to two general questions on PA 'Have you heard the term PA before?' and 'Do you know what PA is?'.

For all participants, no statistically significant relationship were found between the awareness level of PA and age, gender, education level and work experience ($p > 0.05$). However, a significant relation was found between the awareness level of the three participant groups, agricultural engineers, farm equipment dealers and farmers ($p < 0.05$). Farm equipment dealers had higher awareness percentage (77.3%) than the agricultural engineers (52.4%) and farmers (35.9%) (Table 4).

Regarding the agricultural engineers, no significant relationship was found between the awareness level and age, gender and work experience ($p > 0.05$). On the other hand, a significant relation was found between the awareness level and education level (BS, MS, PhD) and major graduated ($p < 0.05$).

In reference to the dealers, no significant relationship was found between the awareness level and age, gender, major graduated (related to agriculture or not) and work experience ($p > 0.05$). Conversely, significant relations existed between the awareness level and employing an engineer, education level and training ($p < 0.05$).

Concerning the farmers, no relationship was found between the awareness level and age, gender, education level, experience and training ($p > 0.05$). On the other hand, a significant difference was found between the awareness level and farm field size and participation in agricultural fairs ($p < 0.05$). It was found out that participation in exhibitions has an importance to increase the awareness of PA. Some other researchers also indicated that social aspects including communication, co-operation, professional literature, exhibitions, fairs and field days have major importance to increase the awareness of new technologies including PA (Kutter et al., 2011).

**Barriers in the adoption of PA technologies**

In the study, farmers were also asked if they want to use PA technologies and 89.7% of them were positive (Table 8). We found a significant relationship between the willingness to use PA technologies and two factors being farm field size and high investment cost ($p < 0.05$).

Firstly, a significant relationship existed between field size and the willingness to use 'PA' such that the farmers with bigger field size want to use these technologies (Fig. 3). In Turkey, the average farm size is only 5.9 ha and is well below than EU and the US averages (17.4 and 18.0 ha, respectively) (Berk, 2013). Projects are carried out by state agencies in Turkey for land consolidation to increase average field size. Also, small farms (< 2 ha) are being replaced by large farms as a result of globalization and multinational corporations gaining control over markets (Berk, 2013). Farmers with small field area do not have sufficient incomes to invest in expensive technologies. Small farm size is also reported by other researchers to be a significant barrier (Gandonou et al., 2001; Pawlak, 2003; Bongiovanni & Lowenberg-DeBoer, 2005; Whipker & Akridge, 2009; Paudel at al., 2011). Lending of PA equipment to other farmers through multi-farm machinery use programs (Pawlak, 2003) may be a cure for this problem. We observed that some farmers having automatic steering use it to serve other farmers mainly in ridge tillage in cotton and corn cultivation in the study area.

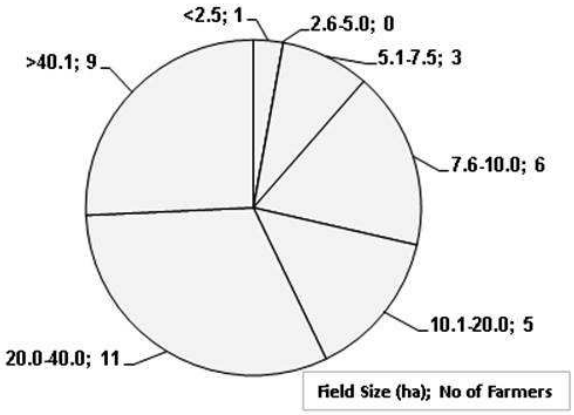


**Figure 3.** Relation of farm field size and willingness to use 'PA'.

Secondly, another barrier that prevents the adoption of PA was reported by the farmers to be the high investment cost. When asked 'Would you want to use these technologies?', 10.3% of the farmers answered 'no' (Table 8) telling that high investment requirement (as well as small field size) would be an important barrier to prevent the adoption. High cost of equipment was also reported by other researchers to be significant constraint preventing farmers to adopt PA (Gandonou et al., 2001; Pawlak, 2003; Bongiovanni & Lowenberg-DeBoer, 2005; Whipker & Akridge, 2009; Paudel et al., 2011). A solution would be to utilize farm equipment grant programs for PA equipment. The Ministry of Food, Agriculture and Livestock in Turkey offered 50% grant for yield monitoring systems in the year of 2014; however, it was learned that the Ministry will not continue to utilize such supports for the year of 2015.

**Current status in precision agriculture adoption**

Current status and recent developments in the adoption of PA technologies in the study area and nationwide are explained below:

Yield monitoring and mapping: This technology is not utilized well in the Cukurova region. However, it was found out that an international company (New Holland) planned to install yield monitors on about 500 combine harvesters countrywide in recent years. The Ministry of Food, Agriculture and Livestock offered 50% grant for only yield monitoring systems in the year of 2014. However, we learned that the Ministry will not continue to utilize such supports for the year of 2015.

Soil sampling and mapping: Precision soil sampling and mapping based on soil type or grid is not utilized well in the study area as well. Classical soil sampling is applied based on a condition for a farmer to receive agricultural price support from the state agencies. On the other hand, soil type or grid soil sampling and mapping is used for research purposes.

Satellite-based positioning (GPS): It was observed that most of the agricultural engineers in both private and public sectors use GPS receivers primarily to identify fields and calculate area. Also, most of the farmers are aware of GPS receivers since it is intensely used in field area calculation.

Satellite remote sensing: It is used primarily to identify the fields, calculate area and predict yield by the agricultural engineers employed by the Ministry of Food, Agriculture and Livestock. Farmers are also aware of remote sensing since government agencies determines the total and average yield on a farmer's field and arranges agricultural price support payments based on the yield data from this technology. However, it is common to see conflict between the farmer and the state agencies in determining the precise average yield. In this manner, a combine harvester with a yield monitor will be more accurate to determine the average and total yield and also generate a yield map to study the variability. The Ministry along with a state university and some government agencies develop an integrated decision support system for good agricultural practices and PA under the acronym of TARBIL by combining satellite remote sensing data and meteorological data from 1,200 countrywide ground stations (Altilar, 2014). The system is used for such purposes including prediction of seasonal and early harvest crop yield, reduction of chemical usage, early warning for possible crop damage and field based mobile data to subscribers (Altilar, 2014).

Geographical information systems (GIS): It was observed that most of the agricultural engineers particularly in public sectors know and use GIS primarily to calculate field area and predict yield. Also, it is used for land consolidation applications governed by the state agencies.

Assisted and automatic steering: The utilization of this technology is in an increasing trend in the study area in recent years. It was found out that an international company (mainly Topcon) sold about 60 auto steering systems in recent years in the study area. Auto steering service providers establish their own reference station networks for positioning correction. Some farmers who have automatic steering use them to serve other farmers mainly in ridge tillage in cotton and corn cultivation.

Variable rate application: This technology is not utilized well in the study area. Most farmers are aware of variability in their field and some of them manage field variability manually rather than sophisticated variable rate technology. Also, it is used for research and demonstration purposes.

## CONCLUSIONS

The conclusions of the study were as follow:

- 90.2% of all participants reported that they followed new trends in agriculture. Only 51.8% of all participants reported that they did not hear the term 'PA' before. Only 29.3% of the participants who heard the term 'PA' before replied that they knew the meaning and concept of the PA. Internet was the most important means to gather information about new agricultural technologies including PA.
- The most three known PA technologies by all participants were satellite positioning (GPS) (81.7%), geographical information systems (GIS) (69.5%) and remote sensing (61.0%). Most of the agricultural engineers in both private and public sectors use GPS receivers and satellite remote sensing primarily to identify fields and calculate area. The least known technologies by all participants were variable rate application (33.5%) and soil sampling and mapping (34.8%).
- 97.6% of all participants told that the information given in short training was valuable for them. Also, 97.6% of the participants expressed that these technologies

would be somehow beneficial for agricultural sector in Turkey. 88.4% of the participants were willing to get more detailed training on these technologies.

– 89.7% of the farmers told that they could use PA technologies. However two important barriers preventing the adoption were reported being farm field size and high investment cost.
– It was found out that the adoption of yield monitoring and auto guidance systems is in an increasing trend.

ACKNOWLEDGEMENTS. The authors thank the Scientific Research Project Office (BAP) of Mustafa Kemal University for their financial support for the study (Project No: 12240). Also, they acknowledge the survey participants, related government agencies and agricultural organizations for their cooperation during the study.

## REFERENCES

Akcaoz, H. & Ozkan, B. 2005. Determining risk sources and strategies among farmers of contrasting risk awareness: A case study for Cukurova region of Turkey. *Journal of Arid Environments* **62**, 661–675.

Altilar, D.T. 2014. Integrated Agricultural Monitoring and Information System (AGRIMONIS - TARBiL). Workshop on Agricultural Trade and Food Security in the Euro-Med Area. 26 September 2014. Antalya, 35 pp. (In Turkey)

Berk, A. 2013. Processor driven integration of small-scale farmers into value chains in Turkey. Agrarian Structures Initiative. Food and Agriculture Organization (FAO).

Bligaard, J. 2013. Identified user requirements for precision farming in Germany, Finland and Denmark. Project Report, 12 pp.

Bongiovanni, R. & Lowenberg-DeBoer, J. 2005. Precision agriculture in Argentina. *3 Simposio Internacional de Agricultura de Precisao*. 16–18 August 2005. Sete Lagoas, MG (In Brasil).

Daberkow, S. & McBride, W. 2003. Farm and operator characteristics affecting the awareness and adoption of precision agriculture technologies in the US. *Precision Agriculture* **4**, 163–177.

Edwards-Jones, G. 2006. Modelling farmer decision-making: Concepts, progress and challenges. *Animal Science* **82**, 783–790.

Erickson, B. & Widmar, D.A. 2015. Precision agricultural services dealership survey results. Purdue University. West Lafayette, Indiana, USA, 37 pp.

Ess, D. & Morgan, M. 2003. *The Precision-Farming Guide for Agriculturists*. Deere & Company, Moline, Illinois, 138 pp.

Gandonou, J.M., Stombaugh, T.S., Dillon, C.R. & Shearer, S.A. 2001. Precision Agriculture: A Break-Even Acreage Analysis. *2001 ASAE Annual International Meeting*. Paper No. 01-1029. ASAE, St. Joseph, Michigan (In USA).

Helm, C. 2005. Precision Farming in South Africa. FarmTech 2006 Proceedings. pp 76-80.

Isgin, T., Bilgic, A., Forster, L. & Batte, M.T. 2008. Using count data models to determine the factors affecting farmers' quantity decisions of precision farming technology adoption. *Computers and Electronics in Agriculture* **6**, 231–242.

Keskin, M. 2013. Factors Affecting the Adoption of Precision Agriculture Technologies and the Usage Rate of These Technologies in the World. *Journal of Agricultural Machinery Science (Tarim Makinalari Bilimi Dergisi)* **9**, 263–272. (in Turkish).

Keskin, M. & Görücü Keskin, S. 2012. *Precision Agriculture Technologies*. Mustafa Kemal University. Publication No: 35. Antakya, Hatay, Turkey, 212 pp. (in Turkish).

Kutter, T., Tiemann, S., Siebert, R. & Fountas, S. 2011. The role of communication and co-operation in the adoption of precision farming. *Precision Agriculture* **12**, 2–17.
Leonard, E. 2014. Precision Ag Down Under. www.precisionag.com/guidance/precision-ag-down-under.
Norwood, S. & Fulton, J. 2009. GPS/GIS Applications for Farming Systems. *Alabama Farmers Federation Commodity Organizational Meeting*. 5 February 2009 (In USA).
Paudel, K., Pandit, M., Mishra, A. & Segarra, E. 2011. Why Don't Farmers Adopt Precision Farming Technologies in Cotton Production? *2011 AAEA & NAREA Joint Annual Meeting*. 24-26 July 2011, Pittsburgh, PA (In USA).
Pawlak, J. 2003. Precision agriculture - economic aspects. In J.V.Stafford & A.Werner (eds): *Precision Agriculture*. pp. 527–531. Wageningen Academic Publishers.
Rains, C.R. & Thomas, D.L. 2009. Precision Farming: An Introduction. The University of Georgia. Bulletin 1186. Rev. March 2009, 12 pp.
Reichardt, M., Jurgens, C., Kloble, U., Huter, J. & Moser, K. 2009. Dissemination of precision farming in Germany: acceptance, adoption, obstacles, knowledge transfer and training activities. *Precision Agriculture* **10**, 525–545.
Robertson, M.J., Llewellyn, R.S., Mandel, R., Lawes, R., Bramley, R.G.V., Swift, L., Metz, N. & O'Callaghan, C. 2012. Adoption of variable rate fertiliser application in the Australian grains industry: Status, issues and prospects. *Precision Agriculture* **13**, 181–199.
Schimmelpfennig, D. & Ebel, R. 2011. On the Doorstep of the Information Age Recent Adoption of Precision Agriculture. *Economic Information Bulletin No 80*. Economic Research Service, United States Department of Agriculture (USDA), 31 pp.
Silva, C.B., Moraes, M.A.F. & Molin, J.P. 2011. Adoption and use of precision agriculture technologies in the sugarcane industry of Sao Paulo state, Brazil. *Precision Agriculture* **12**, 67–81.
Söderström, M. 2013. Country Report - Sweden. The International Society of Precision Agriculture (ISPA) Report. May 2013, pp 4–5.
USDA. 2015a. Agricultural Resource Management Survey: US Peanut Industry. United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) Highlights. No 2015-1, 4 pp.
USDA. 2015b. Agricultural Resource Management Survey: US Rice Industry. United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) Highlights. No 2015-2, 4 pp.
Verma, L. 2015. China Pursues Precision Agriculture on a Grand Scale. *Resource Magazine*. July/August 2015 **22**, 18–19.
Whipker, L.D. & Akridge, J.T. 2009. Precision Agriculture Services Dealership Survey Results. Purdue University. West Lafayette, Indiana, USA, 64 pp.