Precision Agriculture: a Paradigm shift for espousal of Advanced Farming Practices among Progressive Farmers in Punjab –Pakistan

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Abstract. *Precision agriculture provides innovative farm information tools for improved decision making regarding crop growth and yield. Creating awareness for future applications of precision agriculture among progressive farmers in Pakistan was an instrumental force to conduct this study. The purpose was to appraise the awareness level of the respondents for applications of precision agriculture in the field. The objectives such as assessing the awareness level, available information sources, future needs, factors responsible for the applications, the constraints for the implementation of precision agriculture, and farmers' attitude towards current and future agricultural practices were evaluated. Four out of 37 districts were purposively selected. Sample of 150 respondents using systematic sampling with K=10 respondents from the list of 1500 progressive farmers was selected. Average age was 52 years with 20 years farming experience. The respondents were sentient in only four concepts out of 19. Hence, there is a dire need that policy makers should develop supportive policies to create resourceful PA environment for farmers to boost up awareness level and training opportunities. The Factor analysis applied to understand the role of different factors in espousal of precision agriculture. The first factor alone explained 42% variation, and by adding second factor, the explained variation goes up to 71%. So, two factors found enough to achieve the desired level of explained variation in the dataset. By using Varimax factor rotation technique, variables of interest were differentiated. The first component was explained by two variables; training needs and responsible factors for applications of precision agriculture, with maximum loadings of 0.950 and 0.951 respectively and called as "respondents' training needs in the specific concepts" where PA has strong applications. The second principal component called as "demographics of the respondents" since age and experience were highly correlated variables having maximum loadings of 0.903 and 0.926 respectively. The cross tab analysis described that there was no statistical significant association between current and future agricultural practices since* χ^2 *(4) =*

7.048, p = 0.133 that means both practices were independent in usage. However, very weak association observed between the two practices with Phi and Cramer's V value = 0.217.

Keywords: *Espousal, precision farming, progressive farmers, Punjab-Pakistan, training.*

Introduction

The applications of modern technologies are obligatory in performing different tasks almost in every profession for economic growth and development of any country in 21st century. Without applications of technology, the services providing organizations would not meet the requirements of the growing population in near future. Many thinkers and philosophers weave education and innovation and consider as the currencies used in the world of business in present century. Use of technologies is inescapable and instrumental in any field when resources are diminishing at high pace and population influx is a threat for the development of the economies of the world. Countries which are prone to technology adoption are on driving seat in the race of development. Technologies never prove to be economically cost effective at their first use. However, the gradual adoption rate surely brings long term benefits.

The primary purpose should not only be acquiring maximum yield, but to prevent lavish application of agricultural inputs and optimize crop yield by reducing ecological or environmental threats. Generally, these are the steps which likely to provide basic solutions of the complex problems of the society at large and especially in agriculture. Current agricultural practices and crop production do not meet the future food requirements of the growing population of the world. Inputs resources required for high yield crop production in certain geographical areas of the world have already been exploited. Future food security is a challenge for agricultural researchers and scientists. High quality research in agriculture, information technology for decision making, program planning, and trained extension field staff in agriculture are the keys for sustainable agricultural practices.

In one report, the World Bank and the Food and Agriculture Organization of the United Nations (2005) exerted a great emphasis on the idea of agriculture knowledge and information systems. It is a system of institutions that generates, transfers, and utilizes agricultural research, extension, and education. According to this report, investment in agricultural knowledge and information system are increasingly important in addressing the needs of rural people, future food security, and environmental sustainability. Moreover, investing in agricultural knowledge would further develop human resources in this sector. Increasing role of technology and ICT in agriculture has converted farming into profitable industry in many countries of the world. This has made possible in the last few decades because of investment in agricultural knowledge and

use of information and communication technologies. Time has come to introduce new and economically doable technologies for sustainable agricultural development and food security in future. New technologies like precision agriculture would manage ever fast diminishing agricultural resources such as water and excessive use of chemicals and fertilizers on crops. Precision agriculture is a new and changed set of practices as compared to other technologies available in agricultural system.

Precision agricultural technology is a knowledge based farm management system applied successfully in many parts of the world to control variability inside the field. Precision agriculture provides innovative farm information tools for improved decision making regarding crop growth and yield. The significant characteristic of precision agriculture is to work on narrow scale e.g. in the field with individual plants and animals. This has made possible with the help of remotely sensed data available for the applications of precision agriculture. The use of satellite images, remotely sensed data, Geographic Information System, Global Positioning System, Variable Rate Application, and Decision support system are important components to understand the applications of precision agriculture at farm level. The information and communication technology (ICT) and statistical knowledge further bind these components together for precise decision making for the applications of input resources as per desired and requirements of plants.

Experts have emphasized to start precision agriculture in Pakistan for quite some time and have guided the farmers to use precision agriculture, such as tillage, water, agro-chemicals for increasing benefits for the farming community. However, implementing and using of PA is still far away from Pakistani small scale farmers. Many factors are responsible for not espousing PA in the country but the main reason is the lack of awareness among farmers regarding precision agriculture. Precision agriculture even suits to small landholding where the contiguous fields with the same management can be considered a large field and map-based precision agricultural applications have a great scope (Mondal & Basu, 2009).

Precision agriculture as compared to the existing agricultural practices is a combination of well-organized and vibrant practices. With precision agriculture, farmers working efficiency could be improved. Growers are able to perform their activities on large fields and manage them efficiently as compared to the small fields. Definitely, precision agriculture decreases the misapplications of input resources for crops and boost up the yield and arable farm competences. In Pakistan most of the soils are lacking in macro nutrients resembling to nitrogen and potassium, phosphorus, zinc, boron and iron. The majority of the farmers don't have knowledge regarding soils nutrients to their farm lands (Hamid & Ahmad, 2001).

Creating awareness for future applications of precision agriculture among progressive farmers in Pakistan was an instrumental force to conduct this study. Valuable coordination among public sector, private sector and producers is extremely crucial for achieving fruitful results of precision agricultural technologies. Extension field staff's role in implementing any new technology at grassroots level is considered highly significant. Public and private extension services could play their role to facilitate farmers for adoption of PA and it could bring revolution in agricultural production and protection of natural resources in Pakistan.The Primary purpose of the study is to evaluate awareness level of progressive farmers regarding precision agriculture. This study was planned to promote the awareness of precision farming and advanced technologies used in the precision farming among the farmers in the study area.

Shanwad, Patil, and Gowda, (2004) described in their study that millions of years ago; agriculture had begun as a profession when man used agricultural inputs through natural resources to cultivate his land and also to give boost to his agricultural outputs. Thus, an urgent need is to bring innovation in agricultural practices and to produce enough food to meet the growing demands of the population in the present scenario of the world's environment. However, the environmental degradation that has come along with the use of technology in the last few decades has to be reversed and hence the farming could be made sustainable.

There is growing need that farmers in Pakistan must be informed through knowledge transfer regarding recent developments in different type of agricultural advancements and usage of technologies. Doruchowski, Swiechowski, Holownicki, and Godyn (2009) concluded that absolute fruit and vegetable processing methods could be achievable by proper fertilization and careful applications of chemicals in the field. In a sequence, this information, expose the consumers from risk handling, food traceability and precision agriculture in order to get the quality, quantity and high yields from the products with the optimized usage of input resources.

Materials and Methods

Purpose of the study

The study was planned to promote the awareness of precision agriculture and use of advanced technologies in precision farming practices among farmers in study area.

Research objectives of the study

Following objectives were designed to draw necessary conclusions for the researchable idea of the study.

- To describe demographic profiles of the respondents

- To appraise awareness level of the respondents in the specific areas of precision agriculture
- To identify the information sources for acquiring basic awareness of precision agriculture available to respondents
- To identify training needs of respondents required for implementation of precision agriculture among respondents in the study area
- To identify the factors responsible for applications of precision agricultural practices among respondents in the study area
- To identify the potential constraints for implementation of precision agricultural practices as perceived by the respondents
- To identify the attitude of the respondents regarding current and future potential agricultural practices where precision farming technologies could be applied.

Research design

Descriptive and correlational designs were used to summarize the research findings. Correlational research designs measure two or more relevant variables and assess relationship between or among them. The factors responsible for precision agriculture, information sources regarding precision agriculture and training needs of the respondents required for PA practices were studied, described and evaluated during the study.

Population and sample

The study was carried out in Punjab province of Pakistan. The sample was selected from targeted districts of Punjab-Pakistan. Out of 37 districts of Punjab four districts were purposively selected. A sample of size 150 respondents was selected by using systematic sampling technique. A list of 1500 respondents (progressive farmers) from four districts was arranged with the help of extension field staff and desired sample of 150 respondents was selected with the interval of K=10 respondents randomly.

Instrumentation

The interview schedule was used as an instrument for data collection. The opinion of the respondents in the study area was recorded by using Likert-type scale. The face and content validity of the instrument was checked by the panel of experts established from the field of Agricultural Extension and other allied disciplines who were considered as experts of precision agriculture technology. Reliability of the instrument was also checked by computing Cronbach's Alpha value for each section of the interview schedule prepared for the data collection during pilot survey. The detail is given in the following table.

Table-1

S. No.	Instrument's section	Alpha value
1.	Section-3	0.837
2.	Section-4	0.717
3	Section-5	0.737

4	Section-6	0.753

Data collection and analyses

The respondents were interviewed and their opinions regarding precision farming technology were recorded. Data were analyzed using SPSS version 17.0. Descriptive statistics were used to interpret the results, In addition, factor analysis was applied to highlight the significant factors those could be helpful for espousal of precision agriculture among progressive farmers in the country.

Results and Disscussion

Demographic profiles of the respondents, sources of information available to respondents to acquire basic awareness in precision farming, the accessibility to training opportunities for PA, factors responsible for applications of precision agriculture, potential constraints for implementation of PA practices, and attitude of the respondents regarding current and future potential agricultural practices in Punjab-Pakistan were evaluated and discussed.

Demographic profiles

The first objective for demographic profiles of the respondents such as age, education agricultural income, cultivated land and years of experience of the respondents in agricultural practices were assessed and discussed.

Age

The results revealed that average age of the respondents was 52 years. Twenty five percent of the respondents were between the age group of 36 to 45 years. However, the majority of the respondents, 35% were between the ages of 56 to 65 years whereas, almost 5% were between the age group of 66 to 75 years.

Education

According to the results out of 150 respondents, 29 held Secondary School Certificate in technical education, 27 held Higher Secondary School Certificate with computer base studies, and maximum number of respondents i.e. 73 held bachelor degree in agriculture or technical education and remaining 21 respondents were graduated with master degree in agriculture or technical education.

Experience in farming

The results of the study indicated that approximately 59% of the respondents had 20 years or less experience in farming. Almost 26% of the respondents had farming experience between

21-30 years. Moreover, 15% of the respondents had experience over 31 to 50 years. However, results indicated that average experience in farming was 20 years and shows that the respondents had had enough experience in farming and inclined to espouse innovative approaches in farming in the study area.

Farm size in acre

A thresh-hold in this study was 25 acres of agricultural land for a farmer to be included in the list of progressive farmers. In addition, farmer needs to be inclined towards adoption of innovative technology in agriculture. Approximately 57% of the respondents had landholdings between groups from not less than 25 to 46-65 acres. Further, 43% of the respondents were between groups from 66-86 up to 166-185 acres. The average farm size in the study area was observed as of 70 acres.

Awareness level for precision agriculture

The second objective of the study was to identify the awareness level of progressive farmers in precision farming practices. The respondents expressed their awareness level for precision agricultural practices and related technologies on 5-point Likert type scale ranging from not at all aware to extremely aware (1-5). The 19 items such as awareness about PA, remote sensing, geographic information and global positioning systems etc were asked.

The highest mean score was observed as 2.93 for the awareness level of the respondents regarding the "use of precision agriculture in reducing overall environmental threats". The lowest mean was 1.06 for the concept of "precise applications of inputs" (see Table 2).

Table -2

Respondents' Means, Standard Deviations, and Ranks of awareness level in specific areas of PA

Awareness level in PA specific concepts	N	Mean	SD	Rank
Precision agriculture	150	2.00	0.52	6
Advanced farming practices	150	2.07	0.68	5
Global positioning system(GPS)	150	1.40	0.49	11
Geographic information system(GIS)	150	1.33	0.47	12
Remote sensing techniques(RS)	150	1.67	0.59	8
Wireless sensor technology(WST)	150	1.53	0.50	9
Variable rate technology(VRT)	150	1.33	0.47	12
Use of precision agriculture in reducing overall environmental threats	150	2.93	0.44	1
Use of precision agriculture to enhance profit	150	2.73	0.77	2
PA in reducing post harvest losses	150	2.73	0.68	2
Technologies regarding precise application of chemicals(spray)	150	1.73	0.57	7
Technologies regarding precise application of fertilizer	150	1.47	0.50	10
Technologies regarding soil preparation	150	1.33	0.59	12
Technologies regarding soil temperature and humidity	150	1.13	0.34	18

Technologies regarding precise usage of irrigational system	150	1.33	0.47	12	Mean*:1= Not at all aware, 2=somewh
Seed treatment technologies	150	2.27	0.68	4	
Pre and post harvest technologies	150	1.27	0.44	17	
Technologies used for yield monitoring	150	1.33	0.47	12	
Precise applications of inputs	150	1.06	0.25	19	

at aware, 3=moderately aware, 4=highly aware, 5= extremely aware

The mean scores from the results in table-2 showed that respondents' awareness level regarding specific areas of precision agriculture was between "not at all aware to moderately aware". The results also revealed that respondents were barely aware for many advanced technologies used for PA. This provides strong argument for not turning towards precision agricultural practices. Hence, there is a dire need to create awareness among farmers of the area regarding innovative technologies for precision agricultural practices.

Sources of information

According to Abbas, Muhammad, Nabi, and Kashif, (2003) that mass media communication is more effective in dissemination of individual as well as collective information for agricultural innovations among farming communities. The third objective was the sources of information regarding precision agricultural practices available to progressive farmers. The respondents rated the available sources of information for PA on 5-point Likert type scale ranging from none to very high (1-5). The results showed that the minimum mean was about the access of the respondents to the academic institutions regarding PA courses that showed the respondents were least informed about PA from academic institutions as compared to the rest of the sources. The maximum mean was 2.45 which was about the access of the respondents to the print media focusing on precision agriculture. (See table 3). The access to the sources of information on PA ranged from low to moderate on a 5-point Likert type scale. Results depict that print media is the main source of information regarding precision agricultural practices and related technologies among progressive farmers.

Table-3

Means, Standard Deviations, and Ranks for available sources of information to respondents regarding PA

Sources of information	N	Mean	SD	Rank
Academic institutions	150	1.48	0.58	4
Research institutions	150	1.72	0.60	3
Electronic media	150	2.40	0.78	2
Print media	150	2.45	0.87	1

*Mean: 1=None, 2=Little, 3=Moderate, 4=High, 5=Very high

Training needs for precision agriculture

The fourth objective was evaluated for future training needs of the respondents in PA. The respondents were asked to rate the requirement of training opportunities in PA on a 5-point Likert type scale ranging from not needed at all to extremely needed (1-5). The minimum mean score was 4.17 computed for "fertilizer applications" and the maximum mean score was 4.59 calculated for "precise applications of irrigational system" which means that respondents' need of training in these areas were high enough. Moreover, the results from table-4 indicated that respondents' training needs were vary from highly needed to extremely needed in all specific areas of precision agriculture technologies from technical education to remotely sensed data by sensors through geographic information and global positioning systems.

Table-4

Means, Standard Deviations, and Ranks for future training needs of respondents regarding PA

Training needs in specific areas	N	Mean	SD	Rank
Technical education	150	4.32	0.75	6
Advanced farming practices	150	4.22	0.77	12
Soil preparation techniques	150	4.21	0.71	13
Precise spraying applications	150	4.31	0.75	7
Fertilizer applications	150	4.17	0.80	15
Seed rate applications	150	4.30	0.72	8
Farm management practices	150	4.49	0.75	3
Precise usage of irrigational system	150	4.59	0.61	1
Pre harvesting practices	150	4.20	0.70	14
Post harvest practices	150	4.29	0.79	9
Storage practices of fruits and vegetables	150	4.26	0.70	11
Highly proficient and technical computer skills	150	4.27	0.76	10
Usage of global positioning system(GPS)	150	4.36	0.65	5
Usage of geographic information system(GIS)	150	4.37	0.75	4
Information gathering from remotely sensed data(RS)	150	4.55	0.65	2

*Mean: 1=Not needed at all, 2=somewhat needed, 3=moderately needed, 4=highly needed, 5= extremely needed

Factors responsible for applications of precision agriculture

The fifth objective of the study was related to factors responsible for applications of precision agricultural technologies. The respondents described their opinions on five point likert type scales ranging from "not responsible at all" to "extremely responsible" (1-5). The results from table-5 revealed that many progressive farmers opined that underlying factors were highly responsible for the applications of precision agricultural technologies for improved practices in the study area.

The maximum mean score of 4.60 was computed for the factor “multiple benefits by the applications of PA” and minimum mean score was 4.04 computed for the factor “quick decision making capacity to bear risk”. Similarly, remaining items mean ranged from 4.50, 4.46 and 4.42 etc. for precision agriculture promoting food security, sustainable agricultural growth through precision agriculture and technical education respectively provided the reasons for the applications of precision agriculture (see table 5).

Table-5

Means, Standard Deviations, and Ranks of factors responsible for applications of PA

Factors responsible for application of PA	N	Mean	SD	Rank
Limited availability of inputs	150	4.42	0.68	4
Reduced labor work	150	4.16	0.73	14
Water scarcity	150	4.35	0.67	8
Cost effective	150	4.30	0.67	10
Physical access	150	4.20	0.75	12
Quick decision making capacity to bear risk	150	4.04	0.57	15
Sustainable agricultural growth through PA	150	4.46	0.56	3
Multiple benefits by the application of PA	150	4.60	0.50	1
Precision agriculture promoting food security	150	4.50	0.64	2
Management of soil nutrients more precisely	150	4.26	0.69	11
Conservation of arable land to prevent degradation	150	4.18	0 .71	13
Skillful employment generating system	150	4.34	0.64	9
Cultural norms and attitude	150	4.37	0.55	6
Technical education provide the base for PA	150	4.42	0.62	4
Risk management by PA	150	4.36	0.62	7

Mean*: 1=Not responsible at all, 2=somewhat responsible, 3=moderately responsible, 4=highly responsible, 5=extremely responsible

Potential constraints in espousal of precision agriculture

The sixth objective regarding the opinion of farmers for possible constraints regarding implementation of precision agriculture was assessed. Buist et al. (2007) indicated that unfamiliarity, non-applicability, high cost are some of the reasons why seemingly beneficial technologies do not adopted by farmers. Results depict that the lack of technical education regarding implementation of precision agricultural practices was the potential constraint since 60.7% of farmers were not highly proficient in computer skills. Estimated 26% of the respondents considered lack of financial resources as the second potential constraint for implementation of PA practices. Only 4.7% respondents thought that lack of access to desired technology was a major potential constraint in the study area. In addition, 9.3% respondents though that cultural norms and attitude were also potential constraints in the applications of precision agriculture in the study area (see table 6).

Table-6

Potential Constraints for the implementation of precision agriculture as perceived by the progressive farmers

Constraints	Frequency	Percent
Lack of technical education	91	60.7
Lack of access to desired technology	6	4.7
Lack of financial resources	39	26.0
Cultural norms and attitude	14	9.3
Total	150	100.0

Attitude of the respondents regarding agricultural practices

The seventh objective of the study was related to the attitude of the farmers regarding current and future agricultural practices in the study area. In the countries like Pakistan, one way or the other, precision agricultural practices are prevailed. So keeping in view the significance, the association between preferred agricultural practices of the respondents in the present and future scenario was evaluated by using chi-square test of independence.

During the study, hypothesis was designed such as: “there is no significant association between current and future agricultural practices of the respondents”. The results from chi-square test of independence are presented in table-7 below.

Table-7

Current vs. future practices

Current agricultural practices		Future agricultural practices					Total
		Future horticultural practices	Future entomological practices	Future soil practices	Future seed practices	Future irrigational practices	
Traditional practices	Count	23	11	30	31	39	134
	% with current agri practices	17.2%	8.2%	22.4%	23.1%	29.1%	100.0%
	% with future agri practices	79%	84.6%	100.0%	86.6%	90.7%	89.3%
	% of total	15.3%	7.3%	20.0%	20.7%	26.0%	89.3%
Semi-Advanced practices	Count	6	2	0	4	4	16
	With current agri practices	37.5%	12.5	0.0%	25.0%	25.0%	100.0%
	With future agri practices	20.7%	15.4%	0.0%	11.4%	9.3%	10.7%
	% of total	4.0%	1.3%	0.0%	2.7%	2.7%	10.7%

Total	29	13	30	35	43	150

The table-7 shows the trend of current and future agricultural practices among progressive farmers in the study area. However, the results from cross tab analysis described that there is no statistical significant association between the current and future agricultural practices used by the respondents since χ^2 (4) = 7.048, p = 0.133 (See the table-8) and it is concluded that both type of practices are independent and it's up to the choice of the respondents how they adopt either type of practices and they do not depend on the applications of one or the other type.

Table-8

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	*7.048*	*4*	*0.133*
Likelihood Ratio	9.623	4	0.047
Linear-by-Linear Association	1.756	1	0.185
N of Valid Cases	150		

Factor Analysis to describe the data

Lastly, Factor analysis was used to understand the role of different factors in promotion and adaptation of precision agricultural practices among progressive farmers and is extremely important for agricultural development in future. According to the results presented in Table 9 below, the first factor alone explained 42% of the variation, and by adding the second factor, the explained variation goes up to 71%. Therefore two factors found enough to achieve minimum variation in the dataset.

Table-9

Total Variance Explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.842	47.361	47.361	2.549	42.489	42.489
2	1.419	23.652	71.012	1.711	28.523	71.012
3	0.992	16.529	87.541			
4	0.426	7.102	94.643			
5	0.275	4.586	99.229			
6	0.046	0.771	100.000			

Extraction Method: Principal Component Analysis

Varimax factor rotating technique was used to differentiate the variables of interest. Table 10 shows the evidences for the rotated factors. The first component was explained by two variables; training needs of the respondents and responsible factors for applications of precision

agricultural practices, with maximum loadings of 0.950 and 0.951 respectively and can be called as “training needs and factors for applications of precision agriculture”. The second principal component is called as “demographic factors of the respondents” since age and experience are highly correlated variables having maximum loadings of 0.903 for age and 0.926 for experience.

Table-10

Rotated Component Matrix

Factors	Component	
	1	2
Age	0.200	0.903
Farming exp	0.097	0.926
Awareness	-0.106	-0.052
Information sources	-0.826	-0.090
Training needs	0.950	0.113
Responsible factors for applications of PA	0.951	0.123

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Conclusions and Recommendations

Following conclusions were drawn from the results of the study.

Progressive farmers in the Punjab -Pakistan were motivated to be a part of the study. They have basic knowledge of computer operating systems for applications of PA. They believe that change is there, but the pace of the change is slow. The majority of the progressive farmers were not willing to incorporate new material and technologies in their existing agricultural practices. However, due to the overflow of knowledge and technology, it is not possible to stop the change. This perception was highly supported in this study by subjects’ basic knowledge and familiarity with new technology. A similar conclusion was also drawn by Delgado-Hernadez (1998) in his unpublished doctoral dissertation when he pointed out that knowledge and experience influence feelings and opinions towards a given subject. Most of the progressive farmers were between the ages of 56-65 years with average farming experience of 20 years. Their mean scores in competence (knowledge) with precision agriculture application for specific units were “low” to “medium” in the 19 given concepts in the survey.

However, they described themselves as highly competent in basic computer understanding. It is important to note that the subjects described themselves with low-to-medium competency in the given concepts of precision agriculture. The public sector Extension services organizations need to work closely with progressive farmers for development and implementation of precision agriculture technology at grassroots level. Similar results were obtained by Ashraf, Jackson and

Afzal (2012) in their study in which they assessed the in-service educational needs of agricultural officers for adaptation of remote sensing technology for PA in Balochistan Pakistan.

The results show that training opportunities in precision agriculture for the progressive farmers were limited. The respondents had moderate access to technical education. Keeping in view the results, it is highly recommended that the government, academic institutions, and other research organizations must start long term training programs for progressive farmers.

The results indicated that respondents have low-to-high level access to the information for precision agriculture practices via academic and research institutions, electronic and print media. These are few strategies may be used for teaching and learning of this technology and to enhance the competence level of progressive farmers. The institutions play significant role in improving the competence and knowledge level since they provide research-based knowledge in the field. Progressive farmers also described their opinions about the factors responsible for application of precision agricultural practices. It is further concluded that there are certain constraints such as lack of technical education, lack of access to desired technology, lack of financial resources, cultural norms attitude, those create hindrance in the application of precision agriculture in Pakistan. The policy makers need to divert their attention for removing these constraints so that PA may take roots in the country. The results from factor analysis indicated that training and specific factors for applications of PA in the country must be related to the age and experience of the respondents for successful applications of this technology at grass root level.

Recommendations for future of precision agriculture in Pakistan

Implementation of precision agriculture in Pakistan will depend on the fact, that whether policies are accurately implemented or not. There are basic steps to enter into precision agriculture such as;

Initial stage occupies identical crop and soil managing, development of human resources for foundation of precision agriculture, popularization of precision agriculture concepts by communication, mass media, workshop, seminar, etc.

Intermediary stage will go after sampling regions, description of organizational sectors all over the country justification of computer models with zone definite data.

Future stage engage fine grid variety and sensing, function of region precise computer application to replicate the agronomic input situation and accurate sensing and supervision.

Following are few strategies for policy makers to encourage precision farming at farm level.

- Encourage the precision farming technology for committed progressive farmers
- Classification of place or area for encouragement of crop exact natural farming

- Promote study of spatial technologies for espousal of precision agriculture in the country where input resources are diminishing with every passing moment.
- Develop a rule for well-organized transfer of technology to the farmers.

Recommendations for further research

Further research on this topic can be conducted by considering the following issues:

1. Assess the policy measures taken to adopt precision agriculture in the country.
2. Evaluate the crop wise applications of PA to measure the usage of precision agriculture technology.
3. Measure the role of the extension services in transfer of precision agriculture technology at grass root level in the country.

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