COMPARATIVE ANALYSIS ON PRECISION FARMING TECHNOLOGIES IN SELECTED CROPS OF NORTH EASTERN KARNATAKA

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CERTIFICATE

This is to certify that the thesis entitled **"COMPARATIVE ANALYSIS ON PRECISION FARMING TECHNOLOGIES IN SELECTED CROPS OF NORTH EASTERN KARNATAKA"** submitted by **Mr. SHITU ADENIPEKUN GABRIEL** in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL EXTENSION EDUCATION,** to the University of Agricultural Sciences, Raichur, is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

Place: Raichur
Date: June, 2014

(G. N. MARADDI)
CHAIRMAN

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3. ______________________
(M. B. PATIL)

Affectionately dedicated
To
My JEWEL

(ADEMIJU MAYOWA VICTORIA)
maydevickycolossus

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To God be The Glory…GreaT Things he hath done….

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JUNE, 2014 ***(SHITU ADENIPEKUN GABRIEL)***

CONTENTS

LIST OF ABBREVIATIONS

CIAE	–	Central Institute of Agricultural Engineering
CISH	–	*Central Institute for Subtropical Horticulture*
Fig.	–	Figures
g	–	Gram
GDP	–	Gross Domestic Product
GIS	–	Geographical Information System
GPS	–	Global Positioning System
ha	–	Hectare
IARI	–	Indian Agricultural Research Institute
ICAR	–	Indian Council of Agricultural Research
kg	–	Kilo gram
>	–	Greater than
<	–	Less than
M	–	Means
IIT	–	Indian Institute of Technology
n	–	Sample size
NP	–	Non-participant farmers
P	–	Participant farmers
q	–	Quintal
/	–	per
%	–	per cent
PA	–	Precision Agriculture
PFT	–	Precision farming technologies
PF	–	Precision Farming

PFDCs	–	Precision Farming Development Centres
PGS	–	Post Graduate Studies
Rs.	–	Rupees
SD	–	Standard deviation
SAUs	–	State Agricultural Universities
UAS	–	University of Agricultural Sciences
UASR	–	University of Agricultural Sciences, Raichur
U.S.A	–	United States of America

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Introduction

I. INTRODUCTION

Agriculture is the main stake of Indian economy as it remains the principal source of livelihood for more than 58 per cent of the population though its contribution to the national GDP has declined to 13.7 per cent. The decline was as a result of high growth experienced in industries and services sectors in the recent years (Anonymous, 2013). It accounts for about 10 per cent of the total export earnings and provides raw material to a large number of industries. It is also serves as a means of achieving food security for the vast growing population. However, adoption of several interventions to increase agricultural productivity to meet the ever growing demand for agricultural products has resulted over the years in indiscriminate utilization of resources. These have posed a threat to future of Indian agriculture on a sustainable basis. India has experienced considerable changes in the crop mix, yield and production since the inception of the green revolution. Kumar and Mittal (2006) asserted that the green revolution phase displayed a high yield growth per unit of input. The first post-green revolution phase (from late-1960s to mid-1980s) was marked by the continued growth in returns from land through the intensification in use of chemical inputs and machine labour. The second post-green revolution phase (beginning the mid-1980s) was characterized by high input-use and decelerating productivity growth.

The focus on enhancing the productivity during the green revolution coupled with total disregard of proper management of inputs without considering the ecological impacts has resulted in environmental degradation (Singh, 2010). Agricultural fields are managed on field basis and on recommendation of the research project not considering the differences in spatial and temporal variability of the soil. A farmer goes for simply blanket application of input such as fertilizer, irrigation facilities and labour which do not produce a desirable crop yield. The only alternative is to enhance productivity on sustainable basis from the limited natural resources at the disposal, without any adverse effect is by maximizing the resource input use efficiency (Singh, 2010). Precision agriculture, however answers the clarion call by its focus on effective resource utilization through the management of spatial and temporal variability of the soil and the ecosystem. It is defined as the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for the purpose of improving crop performance and environmental quality (Pierce and Nowak, 1999). It is thoughtfulness of in-field variations in soil fertility and crop conditions and matching the agricultural inputs like seed, fertilizer, irrigation, insecticide, pesticide, etc. in order to optimize the input or maximizing the crop yield from a given quantum of input (Mishra *et al*., 2003).

Dated back to history, Precision agriculture (PA) was initiated in the early to mid 1980s in United States where researchers varied lime inputs in crop fields at the University of Minnesota. The grid sampling practices also appear for the first time during this time which led to the generation of first input recommendation maps for fertilizers and pH corrections. The advent of GPS in 1990 became a plus to the propagation of precision farming. In 1993, yield monitors allowed the fine-scale monitoring and mapping of yield variation within fields. By late 1990's, a zonal management approach had become a real option for management. Advances in Global Navigation Satellite System (GNSS) technology in 1999 opened door for machinery guidance, auto-steering and controlled-traffic farming. Precision Agriculture has become a worldwide technology integrating the application of information technology with agricultural sciences towards the management of variability for optimum crop production at low cost input (Pierce and Nowak, 1999).

Precision agriculture is not just the injection of new technologies but it is rather an information revolution, made possible by new technologies that result in a higher level, a more precise farm management system (Robert, 1999). The concept behind precision agriculture started from farmers inquisitive about variation in their field. The interest to know why variation exist and ways to manage it led to active responsibility at farmers' end in assessing variation in their field as well as managing the variation for the purpose of evaluating the outcomes over space and time. This was common conventional farmer's practice in the 19th century. However, the demand for food at a large scale to feed the ever growing population led to large scale uniform average agricultural practices which resulted into less accuracy and efficiency in assessing variation at the farmers' end and therefore holistic knowledge about variability becomes difficult and tedious. Also, the aftermath of post green revolution which led to high input use, blanket application of fertilizers, high cost of inputs, decelerating in productivity growth, inability to achieve potential yield, change in consumer preference, environmental hazards, as well as global warming and climate change effect on agriculture demands farmers to be on the lookout for up scaling way of farming to maximize the limited resources on a sustainable basis.

Moreover, specific profitability of any technologies over the years has been identified as the underline drive for such technology adoption. Precision agriculture (PA) is one of such innovative way of farming through application of technology which has gained a reputable ground in the developed countries as well as developing ones due to its economic and environmental profitability. Batte and Arnholt, (2003) in their studies on the adoption of precision farming (PF) and its use in Ohio, USA reported that profitability was the biggest motivating factor in using precision agriculture tools. Benefits such as on-farm experimentation, improved information to support decisions, risk reduction potential, resource use efficiency, reduction in cost of production, saving inputs, precision pest and stress management, conservative farm management as well as environmental sustainability as been reported by several literature as reasons for using precision agriculture technologies (Snyder, 1996, Bongiovanni and Lowenberg-DeBoer, 1998, Patil, 2009, Yu *et al.,* 2000).

Globally, adoption level of precision farming technologies was estimated based on the yield monitor adopted. Whipker and Akridge,(2009) reported that USA recorded the largest yield monitor adoption with 80.66 per cent of the total worldwide yield monitor adoption estimates followed by Germany with 11.43 per cent and Argentina with estimated record of 2.68 per cent. Continent wise, it was reported that European yield monitor estimates was 14.17 per cent on a 426 million acres, followed by Latin America with 3.0 per cent on 29 million acres while there was no record for Asian and Africa as it was recently introduced to the two continents. However, India as a nation has taken series of innovative steps towards adopting precision farming technology. The initiative of establishing Precision Farming Development Centres (PFDCs) was a sure way to promote precision farming and plasticulture applications for hi-tech horticulture. Presently, there are 22 centre in India located in State Agricultural Universities (SAUs), ICAR Institutes such as IARI, New Delhi, CIAE, Bhopal, CISH, Lucknow and IIT, Kharagpur.

The technology has also been currently implemented in Karnataka state under the RKVY founded project on Precision farming in selected crops since 2011. The project was implemented through the three State Agricultural Universities in the state with UAS, Raichur as the leading centre to guide the other two Universities (UAS, Dharwad and UAS, Bangalore) in the project activities. Farmers' participatory approach was adopted to execute the project at the farmers' fields of Raichur, Gulbarga and Koppal districts, covering equivalent of 100 acres each in cotton, pigeon pea and paddy crops respectively, that represent major crops of the North-Eastern Karnataka zone, along with on-farm research demonstration plots (5.00 acres in each crop) at research stations (04) of UAS, Raichur (Patil *et al.* 2013).

The need for adoption of precision farming (PF) in country like India cannot be over emphasized considering the new trend of challenges facing the nation's agricultural sector in the recent time. The increasing need to produce more from less available resources, the decline in agricultural growth rate, high cost of inputs, scarcity of farm labours, indiscriminate use of fertilizer and pesticides, as well as demand for quality produce are the pending need for adopting precise way of farming to optimize the limited resources.

From this background, this investigation was planned and conducted with the following specific objectives

Objectives

1. To study the socio-economic characteristics of the participant and non-participant farmers
2. To study the farmers perception towards precision farming technologies in selected crops
3. To assess the knowledge level of participant farmers about precision farming technologies in selected crops
4. To analyze the resource utilization pattern in precision farming in comparison with conventional farmers' practice
5. To elicit the factors responsible for plan to use precision farming technology

6. To assess the constraints faced by participant and non-participant famers in adoption of precision farming technologies

Significance of the study

As progress in life cannot be achieved without adequate evaluation, assessment of knowledge and farmers' perception of precision farming technologies is of paramount issue. Tireless effort of scientist and research will amount to waste of time and resources when proper and long term adoption is not achieved at the farmers' end. The study therefore unravel the determinants of plan to use precision farming technologies as well as shedding more light into the constraints faced by the farmers in adopting the technologies. Perception and knowledge of farmers in addition to resource use efficiency of precision farming in comparison with the conventional farmers' practices was also evaluated for making policies as well as future planning. The rationale behind taking up this study is to evaluate the precision farming (PF) technologies (PFT) and see to its profitability and suitability to developing countries agricultural scenario. Also, as there is a gap in literature about knowledge and perception of precision farming technologies, the findings of the study will help to bridge the gap and also assist the policy makers and field functionaries to be more effective in the process of transfer of technology.

Farmers opinions on precision farming technologies was the basis for this study as information was collected directly from farmers to evaluate the technologies from their point of view. The data generated may be helpful to the various research and developmental organizations in understanding the perception and knowledge of farmers about precision farming technologies and problems expressed by the farmers.

Limitation of the study

During the course of the study, the researcher encountered the problem of language barrier which demands for local interpreter to interpret the schedule to the farmers. Data collection activities were therefore tedious and consume more time. Also, the characteristics of social investigation which include bias in respondents' response cannot be rule out in the study as data collected was exclusively based on the opinion of the participant and non-participant farmers.

Review of Literature

II. REVIEW OF LITERATURE

An exhaustive review of literature is necessary for proper understanding and gaining insight in to the research study at hand. The review of literature was undertaken keeping in view the variables considered for the study. Sourcing for adequate research studies exclusively relating knowledge and perception of precision farming with respect to famers' socio-economic characteristics in India was a bit difficult as the concept is a new area of research where few literature over time exist. Hence, studies conducted at the international scene together with related local studies were reviewed covering all aspects of the investigation comprehensively under the following headings;

2.1 Socio-economic characteristics of the participant and non participant farmers

2.2 Farmers perception towards precision farming technologies in selected crops

2.3 Knowledge level of participants farmers about precision farming technologies in selected crops

2.4 Resource utilization pattern in precision farming in comparison with conventional farmers practice in selected crops

2.5 Factors responsible for plan to use precision farming technology

2.6 Constraints faced by participant and non-participant famers in adoption of precision farming technologies

2.1 Socio-economic characteristics of the participant and non participant farmers

2.1.1Age

Roberts *et al.,* (2001) reported from the farming survey on cotton producer in southern states of U.S.A. that the mean age was 48 years and majority of respondents (59 %) ranged in age from 35 to 54 years, thirty per cent of the respondents were 34 years of age or less while respondents who were 65 years of age or older were smaller percentage of all respondents (11 %). The non adopter mean age was reported to be 51 years.

Hudson and Hite (2002) conducted a study on *adoption of precision agriculture* technology in Mississippi: Preliminary results from a producer and reported that the average age of respondents is 50.42 with standard deviation of 11.56.

Sain (2008) conducted a study on socio-economic and technological constraints in adoption of SRI in Chhattisgarh, Madhya Pradesh, Uttarakhand, Punjab, Tripura, and Andhra Pradesh and reported that majority (64 %) of the SRI farmers were of medium age (33-53 years) followed by 24 per cent of the farmers belonged to old age group (more than 53 years) and 12 per cent of farmers were in young age group (less than 33 years).

Florian Diekmann and Marvin T. Batte (2010) conducted a study on adoption and use of precision farming technology in Ohio State of U.S.A. and reported that the average age of respondents was 54.0 years, 2.8 per cent of the respondents are younger farmers of aged less than 35, while 29.4 per cent of the respondents are aged 65.

Paudel *et al.,* (2011) investigated into factors responsible for why farmers do not adopt profitable precision farming technology in southern states of U.S.A. They reported that average age of the respondents is 53.8 years.

Paxton *et al.,* (2011) reported in their study on intensity of precision agriculture technology adoption by cotton producers in southern states of U.S that the average age of the respondents is 49 years.

D'antoni *et al.,* (2012) reported in their study on farmer's perception of precision technology, the case of auto seer adoption by cotton farmers in southern states of U.S.A. It was revealed that average age of farm operator is 56 years and is negatively associated with the probability of adoption of auto steer and light bar technology.

2.1.2 Education

Karpagam (2000) conducted a study in Tamil Nadu state and found that majority of the respondents had educational level up to high school (29.17 %) followed by middle school (19.17 %) and only 1.77 per cent of the respondents were post graduate.

Shakuntala and Chaman (2000) in their study on socio-economic characteristics of rural families in Bangalore rural district of Karnataka state revealed that, 33.33 per cent of the family heads had education up to high school followed by middle school (22.17 %) and illiterates (18.67 %).

Sevier and Lee (2003) in separate studies on adoption trends and attitudes towards precision agriculture in Florida citrus: preliminary results from a citrus producer survey revealed that 16.2 per cent of the respondent had high school education or below, 22.9 per cent had some college education, 42.2 per cent were college graduate, while 15.5 per cent were graduate or had a professional degree.

Sevier and Lee (2004) in their study on "Precision agriculture in citrus: A probit model analysis for technology adoption in Florida states of U.S.A and it was deduced that younger farmers may be more educated as well as ready to adopt technology but may be short changed by expensive cost of the technology.

Sevier and Lee (2005) examine the precision farming adoption by Florida citrus producers using probit model analysis and affirmed that the majority of the respondents (82 %) had college education, high school education (16 %) while three per cent respondents didn't attempt the question.

Banerjee *et al.,* (2008) in their study on a binary logit Estimation of factors affecting adoption of GPS guidance systems by cotton producers of mid-south and southeastern states of U.S.A. and found out that the average years of formal education of respondents is 14.26 years and it was not significant to farmers decision to adopt GPS guidance system.

Mohammad Jalal-Ud-Din (2011) conducted a study in three viallges of Mardan district of Pakistan on socio-economic problems of small farmers in adopting new agricultural technology. He reported that 46.16 % of the sample respondents had primary education, while 38.46 % of the total respondents got education up to secondary level. Similarly, 15.38 % of the sample respondents were recorded in the category above secondary level.

2.1.3 Land holding

Nagaraja (2002) conducted study on knowledge of improved cultivation practices of sugarcane and their extent of adoption by farmers in Bhadra command area in Davanagere district, Karnataka and found that, majority of the respondents belonged to medium land holding (48.75 %) followed by semi medium land holding category (30.00 %).

Sridhar (2002) conducted a study on watershed programme in Pavagad taluk of Tumkur district in Karnataka, that majority of the respondents (30.00 %) had medium land holding while least number of respondents (2.00 %) was found to be having big size land holding.

Sunilkumar (2004) conducted a study on farmers knowledge and adoption of production and post harvest technology in Tomato crop of Belgaum district in Karnataka and reported that 40.00 per cent of the respondents had big lands, nearly an equal per cent of the respondents belonged to medium (25.83 %) and small land holding (24.16 %) categories followed by 10.00 per cent of them belonged to marginal land holding category.

Ahmad *et al.*, (2007) in their studies on water saving technologies: myths and realities revealed in Pakistan's rice-wheat systems reported that the average farm size is 17 ha. Twenty five per cent of the respondents have less than 5 ha, 30.95 % had between 5-10 ha while 44.05 % had greater 10 ha. Adopter farmers were reported having slightly higher farm size than non-adopters.

Walton et al (2010) conducted a study in the southern states of U.S.A. on "Factors influencing farmer adoption of portable computers for site-specific management: a case study for cotton production and they reported that the average acreage of land of holding of adopter and non adopter is 1,447.74 and 736.75 respectively with positive significant to adoption of portable computer for site-specific management.

Velandia *et al.,* (2011) studied factors influencing cotton farmers' perceptions about the importance of information sources in precision farming decisions in twelve southern states of U.S.A. They revealed that average farm size of cotton farmers owned in addition to rented acres is 1314.82 acres.

2.1.4 Farming experience

Jorge Fernandez-Cornejo *et al.,* (2001) in their study on decomposing the size effect on the adoption of innovations: Agro-biotechnology and precision agriculture a study conducted in U.S.A. reported that the average years of farming experience of the respondents is 23.5 years.

Chandra (2001) conducted a study on rate of adoption and consequences of hybrid Paddy in Cauveri command area and revealed that nearly 50.00 per cent of hybrid Paddy growers had low education followed by medium (28.7 %) and high (25.4 %) education level.

Kiran (2003) in a study on technological gap and constraints in adoption of recommended practices of mango growers reported that nearly half (49.00 %) of the respondents had medium experience in mango cultivation, while remaining 26.00 per cent and 25.00 per cent of the respondents had low and high experience in the mango cultivation respectively. On an average the respondents had 19.28 years of experience in mango cultivation.

Sevier and Lee (2005) conducted a study on precision farming adoption by Florida citrus producers using probit model analysis and reported that the average year of farming experience of the respondents is 31.4 years.

Thiranjangowda (2005) conducted a study on knowledge and adoption level of soil and water conservation practices by farmers in north Karnataka and observed that, 40.62 per cent of the respondents belonged to high experience category while, 35.93 per cent and 23.45 per of the respondents belonged to medium and low experience category respectively.

Raghavendra (2007) conducted a study on management practices of pineapple growers in Karnataka reported that the majority (70.00 %) of the respondents belonged to medium experience category (6.25-18.65), while 17.50 per cent of respondents had low experience (<6.24years) and 12.5 per cent had (>18.66 years) high farming experience.

Paudel *et al.,* (2011) investigated into why farmers don’t adopt precision farming technologies in cotton production. They reported that the average years of experience of cotton farmers in southern states of U.S.A. were 31.5 years.

Paxton *et al.,* (2011) reported in their study on intensity of precision agriculture technology adoption by cotton producers in southern states of U.S.A that the average year of farming experience of respondents is 25.81 years with standard deviation of 11.44.

2.1.5 Attitude

Sevier and Lee (2003) in separate studies on adoption trends and attitudes towards precision Agriculture in Florida citrus: preliminary results from a citrus producer survey revealed that approximately twenty per cent of the respondents were in the top two adoption attitude categories.

Adrian *et al.,* (2005) reported in their investigations into producer's perceptions and attitudes toward precision agriculture technologies in southeastern United States that average mean of perceived attitude of confidence of producer is 9.55 while S.D is 2.32.

Meti (2008) conducted a study on technology reach, perception, knowledge, adoption and attitude towards agriculture technology by small and marginal farmers in Tungabhadra command area and reported that majority (56.67 %) of farmers had favourable attitude towards improved agricultural practices whereas 23.75 per cent of farmers were observed to possess less favourable attitude, while 19.58 per cent had most favourable attitude towards improved agricultural practices.

Abdullah *et al.,* (2012) conducted a study on attitude, knowledge and competency towards precision agricultural practice among paddy farmers in Malaysia and they reported that the average mean of the farmer's attitude is 5.60, with a standard deviation of 1.01 which indicates that the attitude of farmers in this study was at a good level.

Kumar and Sankarakumar (2012) examined impact of information and communication technology in Agriculture – perception of the farmers in Ramanathapuram district of Taminadu and reported that out of the 300 farmers, 192 (64.00 %) have a positive attitude, while 132 (44.00 %) have a negative attitude towards the statement "ICT application in agriculture is a cheap sources of information to the farmers"

2.1.6 Annual Income

Martin and cooke (2002) in their study on precision farming practices and perception of Mississipi cotton producer revealed that the eighty three per cent of the survey respondents reported farming as their source of income.

Vedamurthy (2002) in his study on arecanut growers of Shimoga district in Karnataka noticed that 48.66 per cent of the respondents belonged to high income category, while 34.00 per cent and 17.34 per cent were noticed in medium and low income category, respectively.

Nagesh (2006) in a study on entrepreneurial behavior of pomegranate growers in Bagalkot district of Karnataka reported that nearly three fourth of the respondents (73.33 %) were in medium income group followed by high and low income groups with18.33 and8.33 per cent respectively.

Paudel *et al.,* (2011) investigates into why farmers don't adopt precision farming technologies in cotton production and reported that 72 per cent of the household's income was generated from cotton production.

Velandia *et al.,* (2011) studied factors influencing cotton farmers' perceptions about the importance of information sources in precision farming decisions in twelve southern states of U.S and they reported that the per cent of income from farming of the respondents is 0.7441

Thompson (2012) evaluates adoption of information technologies and subsequent changes in input use in cotton production in Tennessee, U.S and reported that sixty eight per cent of farmer's household's income were generated from farming operations on average.

2.1.7 Risk orientation

Verma (1993) conducted a study on differential impact of milk co-operative societies in upper Gangetic plains of Karnal and found that majority (64.00 % and 50.67 %) of the member and nonmember dairy farmers had medium orientation towards admitting risk. There were 20.67 per cent members and 16.00 per cent non-members who had high-risk preference ability as against 14.87 per cent members and 33.33 per cent non-members who had low risk preference ability.

Meeran and Jayaseelan (1999) studied socio-personal, socio-economic and socio-psychological profile of shrimp farmers and reported that high-risk orientation (72.00 %) among shrimp farmers followed by medium (26.00 %) and low (20.00 %) risk orientation.

Vijaykumar (2001) conducted a study on entrepreneurial behavior of floriculture farmers in Ranga Reddy district of Andhra Pradesh and indicated that majority (33.34 %) of the respondents fell under low risk taking ability, followed by 35 per cent and 26.66 per cent of them were in the categories of medium and high level of risk taking ability, respectively.

Bhagyalaxmi *et al.*, (2003) in their study on profile of rural women micro entrepreneurs revealed that majority of the respondents (75.56 %) had medium risk orientation followed by low (15.56 %) and high (13.33 %) risk orientation categories.

Suresh (2004) conducted study on entrepreneurial behaviour of milk producers in Andhra Pradesh indicated that majority of respondents had medium level of risk taking ability followed by low and high level at the rate of 62.02, 24.58 and 13.34 per cent, respectively.

Chandramouli (2005) in his study on entrepreneurial behaviour of farmers in Raichur district of Karnataka revealed that 40.83 per cent of the respondents had low risk taking ability, followed by high (35.00 %) and medium (24.17 %) risk taking ability, respectively.

Kharatmol (2006) in his study revealed that more than one third of the trained respondents (43.33 %) and 41.66 per cent of untrained respondents belonged to medium risk orientation category, whereas 28.33 per cent of trained and 26.33 per cent of untrained respondents belonged to high level of risk orientation category respectively while, 28.33 per cent of trained and 31.67 per cent of untrained respondents belonged to low level of risk orientation categories.

2.1.8 Management orientation

Kumar (1998) conducted study on knowledge, adoption and economic performance of banana growers in Bangalore district of Karnataka observed that 43.0 per cent of the banana growers had medium management orientation followed by 30.0 and 27.0 per cent of them had high and low management orientation, respectively.

Hanchinal (1999) conducted study on privatization of extension service attitude and performance of farmers and extension personal in Haveri district of Karnataka observed that percentage of the respondents were grouped into low (34.58 %), medium (32.92 %) and high (32.50 %) management orientation categories.

Vijayakumar and Narayanagouda (1999) in their study on rose flowers in Bangalore district of Karnataka found that 14 per cent of the growers had obtained the lowest management orientation scores ranging between 36 to 45 while 28 per cent of the farmers had obtained management orientation scores between 46 to 55. A majority (54 %) of the farmers received management orientation scores varying from 56 to 65 and only 4 per cent of the growers were received highest management orientation scores varying from 66 to 75.

Gaikwad and Gunjal (2000) revealed that medium level management orientation of the beneficiaries from KVKs Thane and Jalgone was found more than 73 per cent. Whereas, low management orientation of the beneficiaries was found in KVK Wardha and Aurangabad.

2.1.9 Deferred gratification

Raghupathi (1994) examined agricultural modernization among farmers in upper Krishna project area of Karnataka and observed that 52.00 per cent farmers of command area had medium level (8-12 score) of deferred gratification, whereas 26.00 per cent were in low (4-8) and 22.00 per cent found in high (12-16) deferred gratification.

Palaniswamy and Sriram (2001) in their study on modernization characteristics of sugarcane growers reported that 72.11 per cent of respondents belonged to medium level of deferred gratification category, while 19.05, 8.84 per cent of respondents belonged to high and low level of deferred gratification category, respectively.

Krishnamurthy *et al.,* (2006) in their study on knowledge level of farmers about recommended cultivation practices of vanilla crop in Shimoga districts in Karnataka reported that deferred gratification of the farmers is not significant to their knowledge level.

Parvathamma (2012) assessed the impact of sujala watershed project on socio-economic status of women beneficiaries in Chitradurga district of Karnataka and reported that the respondents has medium to high deferred gratification level 37 per cent to 44 per cent medium and high respectively.

2.1.10 Achievement motivation

Chandra Paul (1998) conducted study on entrepreneurial behaviour of vegetable growers in Hyderabad revealed that 52.50 per cent of respondents had medium achievement motivation followed by more or less equal percentage of 22.50 and 25.00 per cent of respondents in low and high achievement motivation categories, respectively.

Prakash Joy (2000) in his study on Production constraints of pineapple cultivation in Jhoubal district of Manipur revealed that majority (37.50 %) of the respondents had medium level of achievement motivation followed by high (32.50 %) and low (30.00 %) achievement motivation.

Palaniswami and Sriram (2001) observed in their study on modernization characteristics of sugarcane growers that, 72.11 per cent of respondents belonged to medium level of achievement motivation category, while 14.28 and 13.61 per cent of respondents belonged to high and low level of achievement motivation category respectively.

Vijay Kumar (2001) conducted study on entrepreneurial behaviour of floriculture farmers in Hyderabad reported that 44.16 per cent of respondents had medium achievement motivation followed by 28.34 and 27.50 per cent of respondents in low and high achievement motivation, respectively.

Hemanthkumar (2002) study on attitude, knowledge and adoption of recommended practices by oriental tobacco farmers in Chittoor district of A.P. showed that 61.17 per cent of the oriental tobacco farmers had medium achievement motivation followed by high (20.00 %) and low (15.83 %) achievement motivation.

2.1.11 Extension contact

Angadi (1999) in his study on knowledge, adoption and marketing pattern of pomegranate growers in Karnataka found that majority of the respondents 65.62 per cent had contact with Agricultural Assistant whenever there was a problem, while 62.50 per cent of the respondents had no contact with Assistant Agricultural Officer. Only 13.12 per cent had contact with scientists whenever there was a problem.

Ramanna *et al.,* (2000) revealed that 70 per cent of the respondents had medium level extension agency contact and 30 per cent of the respondents had high level extension agency contact.

Dhamodaran and Vasantha Kumar (2001) in their study on relationship between registered sugarcane growers and their extent of adoption of improved sugarcane cultivation practices revealed that more than half of the respondents (52.50 %) had low level of extension agency contact, followed by 47.50 per cent of the respondents who had medium level of extension agency contact.

Nagesh (2006) in his study on entrepreneurial behavior of pomegranate growers in Bagalkot district of Karnataka and reported that more than half of the respondents (54.16 %) belonged to medium extension contact category, whereas, 28.33 and 17.50 per cent of respondents belonged to high and low extension contact categories, respectively.

Agwu *et al.,* (2008) conducted a study on adoption of improved agricultural technologies disseminated via radio farmer programme by farmers in Enugu State, Nigeria and reported that 70.4 of the respondents has no contact with extension agents in a year while 18.5 of the respondents reported that they had 1 to 3 contact with extension agents in a year.

Okunlola *et al.,* (2011) studied adoption of new technologies by fish farmers in Akure, Ondo state, Nigeria and revealed that 18 per cent of the respondents reported contact with extension services.

2.1.12 Extension participation

Angadi (1999) in his study on pomegranate growers in Bagalkot district of Karnataka reported that, majority of the respondents had not participated in various extension activities (98.76 per cent), group meetings (75.23 per cent) and training programmes (72.50 per cent). Only 43.75 and 38.13 per cent of the respondents participated regularly in 'method demonstration' and 'Krishimela' respectively.

Mamatha and Hiremath (2000) conducted a study on farm women participation in socio-economic organization and extension activities in Tumkur district of Karnataka reported that, small, medium and artisian category of farm women participated in trainings, demonstrations and other extension activities in various levels ranging from 4.5 to 17.5 per cent.

Raghavendra (2004) conducted study on knowledge and adoption level of post-harvest technology by red gram cultivators in Gulbarga district and found that, 24.66 per cent of the respondents were participated regularly in agricultural exhibitions, demonstrations (22.67 %) conducted in their villages.

Atul (2008) in his study on constraints analysis of grape exporting farmers of Maharashtra state reported that, majority (70 %) of the respondents were from medium extension participation category, followed by low (19 %) and high extension categories (11 %) categories.

2.1.13 Mass media utilization

Moulasab (2004) conducted a study on mango growers of North Karnataka and found that, 74.17 per cent of the respondents were subscribers of television followed by 32.50 and 6.67 per cent of the respondents possess farm magazines and news papers, respectively. Among these, 43.33 per cent of the respondents are occasional viewers of television.

Suresh (2004) in his study entrepreneurial behaviour of milk producers in Chittoor district of Andhra Pradesh reported that, 64.17 per cent of respondents were exposed to mass media to a moderate extent followed by 21.25 per cent to low extent and 14.58 per cent to high extent.

Nagadev and Venkataramaiah (2007) while studying the characteristics of integrated pest management (IPM) trained dry paddy farmers in Maharashtra state revealed that majority (74.00 %) of respondents had medium mass media utilization, followed by low (16.00 %) and high (10.00 %) respectively.

Agwu *et al.,* (2008) conducted a study on adoption of improved agricultural technologies disseminated via radio farmer programme by farmers in Enugu State, Nigeria and reported that 74.8 per cent of the respondents affirmed that radio is useful as a source of information.

Hinge (2009) conducted study on diffusion and adoption of wine grape production technology in Maharashtra and reported that higher proportion of the wine grapes growers (38.75 %) had medium mass media participation and nearly one third of them (32.50 %) belonged to low mass media participation category whereas, 28.75 per cent of them belonged to high mass media participation category.

Pawar Prakash (2010) conducted a study on the use of communication media for the adoption of vetiver grass plantation technology in Watershed management programme in Maharashtra and reported that group media were used in great extent (92.78 %) followed by interpersonal media (88.00 %) and mass media including print material (82.00 %) and electronic media (65.33 %).

Okunlola *et al.,* (2011) in their study on adoption of new technologies by fish farmers in Akure, Ondo state, Nigeria reported that 32 per cent of the respondents got their information from published materials such as practice booklets and bulletins, 22.00 per cent through television programme, while 20.00 per cent got information from radio.

Nwankwo and Orji (2013) conducted a study in Nigeria on Assessment of mass media contributions to agricultural technology adoption in Owerri Agricultural Zone of Imo State and reported that mass media methods most available and most utilized were radio and television sets. While 50 respondents (83.33 %) had access to radio, 40 respondents (66.67 %) utilized the technology obtained through it. Forty five (75.00 %) respondents had access to television and forty (66.67 %) utilized the technology obtained through it. The least accessed and least utilized method was the internet. While only seven respondents accessed internet services, only four respondents utilized the technology so obtained through it. The low level of participation in the use of internet services may be connected with its high technology requirements and high cost in Nigeria.

2.1.14 Use of computer for farm management

Martin and Cooke (2002) in their study on precision farming practices and perception of Mississipi cotton producer revealed that majorities of adopters (83.00 %) and non-adopters (81.00 %) owned a computer while Eighty per cent of adopters used the computer for farm management, compared with 58% of non adopters.

USDA (2003) The United States Department of Agriculture reported that 48% of U.S. farms have Internet access (United States Department of Agriculture National Agricultural Statistics Service, 2003). Fifty-four per cent of farms were found to own computers. In the leading cotton-producing states, an average of 52.70 per cent of farms had computer access.

Banerjee *et al.* (2008) in their study on a binary logit estimation of factors affecting adoption of GPS guidance systems by cotton producers of mid-south and southeastern states of USA found out that 56.42 per cent and 43.57 per cent of the cotton producers reported yes and no to use of computer for farm management respectively.

Walton *et al.* (2010) conducted a study in the southern states of U.S.A on “Factors influencing farmer adoption of portable computers for site-specific management: A case study for cotton production”. It was reported that fifty nine per cent of the respondents had used computers in farm management.

Shyam Nair (2011) conducted a study on adoption of variability detection and variable rate application technologies by cotton farmers in Southern United States and reported that younger, more educated farmers who use computers for farming operations are more likely to adopt VRT when they choose soil based or both soil and plant based VDT. They further affirms that computer use for farming operations have significant impact on the adoption of VRT for farmers adopting soil based VDT and both soil and plant based VDT at 10 per cent alpha level.

Sofia Kotsiri *et al.,* (2011) studied farmers perceptions about spatial yield variability and precision farming technology adoption: An empirical study of cotton production in 12 Southeastern States of U.S.A. and reported that younger farmers, who use computer for farm management will more likely use the precision farming bundle by 0.2

2.1.15 Scientific orientation

Birajdar Somasekhar (1999) in his study reported that nearly three-fourth of the grape growers (74.38 %) belonged to medium category of scientific orientation followed by low category (20.00 %) and high category (5.62 %) categories.

Sriram and Palaniswamy (2000) observed in their study on modernization characteristics of sugarcane growers that, 70.75 per cent of respondents belonged to medium level of scientific orientation category, whereas 17.01 and 12.24 per cent of respondents belonged to high and low level of scientific orientation category, respectively.

Maraddi (2006) in his study on analysis of sustainable cultivation practices followed by sugarcane growers in Karnataka reported that incidence of medium level of scientific orientation was seen with 46.11 per cent of farmers followed by low scientific orientation with 35.56 per cent of farmers and only 18.33 per cent of famers had high scientific orientation.

Raghavendra (2010) in his study in Bijapur district of Karnataka on impact front line demonstration of sunflower on farmer’s knowledge and adoption found that majority (40.00 %) of demonstration farmers belonged to medium scientific orientation category, while 31.67 and 28.33 per cent respondents belonged to low and high scientific orientation category, respectively. But 58.33, 35.00 and 6.67 per cent of other farmers belongs to low, medium and high scientific orientation category.

2.1.16 Innovative behaviour

Bhagyalaxmi *et al.,* (2003) in their study on profile of rural women micro entrepreneurs observed that majority (69.44 %) of the respondents had medium innovativeness followed by 15.56 and 15.00 per cent of respondents having high and low innovativeness, respectively.

Suresh (2004) conducted study on entrepreneurial behaviour of milk producers in Andhra Pradesh indicated that the milk producers in the district had medium, high and low innovativeness in the order of 55.00, 24.58 and 20.42 per cent, respectively.

2.2 Farmers perception towards precision farming technologies in selected crops

Adesina and Zinnah (1993) conducted a study in Sierra Leone to test the hypothesis that farmer perceptions of technology specific characteristics significantly condition technology adoption decisions using tobit model and reported that farmer perceptions of the technology-specific attributes of the varieties are the major factors determining adoption and use intensities.

Napier *et al.,* (2000) studied Adoption of precision farming within three mid-west watersheds in Ohio, Iowa, and Minnesota. They found that farmers who perceived that they would receive returns on conservation investments and that conservation information was important in farm management decision-making were more likely to adopt precision agriculture.

Adrian *et al.,* (2005) reported in their investigations into producer's perceptions and attitudes toward precision agriculture technologies in southeastern United States that perception of net benefit positively influenced decision to adopt while perception of usefulness positively influenced perception of net benefit.

Kotsiri *et al.,* (2011) conducted a study on farmer's perception about spatial yield variability and precision farming technology adoption in 12 southern states of U.S.A. using two stage econometric approaches. The results shows that yield perception has more spatially heterogeneous and future profitability, however important of precision farming will enhance precision farming adoption.

D’antoni *et al.,* (2012) investigates farmers’ perception of precision technology: the case of auto seer adoption by cotton farmers in southeastern United States and reported that perceived future importance of precision agriculture was found to be significant and positively related to the auto steer adoption.

2.3 Knowledge level of Red gram farmers about precision farming technologies

Patil and Shanwad (2004) in their paper on relevance of precision farming to indian agriculture, emphasized compliance in the adoption of new level of management proficiency on the farm increases knowledge level of the precision farming technology by the farmers.

Reichardt *et al.,* (2006) conducted a survey to monitor the adoption of precision farming in Germany and reported that higher percentage of young farmers has a zero knowledge level about precision farming.

Anonymous (2009) reported in their paper on precision farming technology at Madurai that knowledge level of the farmers regarding precision farming in vegetables and banana has improved. This was possible through the proper guidance of KVK scientists, their demonstration and constant follow up.

Anonymous (2013) in their paper on farmer education enables precision farming of dairy operations illustrated with the aid of casual loop diagram indicating the role of farmer educations plans to strength the efficacy of precision farming technology adopted by dairy cattle farmers that farmer’s knowledge level about precision farming is induced by farmer’s education background as a result of farmers investment in technology education.

Abdullah *et al.,* (2012) conducted a study on attitude, knowledge and competency towards precision agricultural practice among paddy farmers in Malaysia and they reported farmers knowledge level about precision farming as high (SD= 0.84 & M= 5.51) while competence level is comparably low (SD= 0.85 & M = 5.47).

2.4 Resource utilization pattern in precision farming in comparison with conventional farmers’ practice

Man (2000) studied comparison of productivity level under conventional whole-field farming and precision farming technology in Lamesa, Texas and reported that precision farming practices can not only improve the productivity of production, *i.e.,* nitrogen use efficiency, but can also help to build up nitrogen residual in the soil at the end of cotton growing season and can aid in improving the distribution of nitrogen residual levels across locations in the field.

Islam *et al.,* (2007) conducted impact assessment of farmer participatory experiment in west Bengal and reported that adoption of leaf colour chart for nitrogen use efficiency in rice saved N by 25 kg /ha (19.40 %), with the highest saving of 31.4 kg /ha (21.00 %) in the boro season. Adoption of LCC resulted in 50, 60 and 90 kg additional paddy per ha in the prekharif, kharif and boro seasons, respectively. LCC adoption also reduced insecticide applications by 50%. Economic benefit of LCC adoption estimated at Rs. 1107 (US$ 27.0) /ha in boro followed by Rs. 808 (US$ 19.7) /ha in kharif and Rs. 778 (US$ 19.0) /ha in pre-kharif season.

Maheswari *et al.,* (2008) investigates into the productivity differences between precision and non precision farming of tomato in Tamil Nadu. The study revealed that among various inputs contributing to the productivity difference in precision farming, labour, plant protection chemicals, phosphorus and potassium contributed positively, whereas seed and manure, water and nitrogen contributed negatively.

2.5 Factors responsible for adoption of precision farming technology

Wiebold *et al.,* (1998) on examining the barriers that prevent or inhibit increased adoption of precision agriculture in soybeans using producer focus groups in North central of U.S.A. They identify the factors as costs of technology adoption, training programs and resources, data quality control, consumer guide for precision agriculture, environmental factors as well as need for new technology development.

Wiebold, *et al.,* (1999) studied factors determining barriers to adoption and research needs of precision agriculture in the north central soybean research program in Missouri using focus groups. It was reported that factors such as start-up cost, lack of expertise time, inadequate training resources, operator age, as well as farm size are to be obstacles to adoption of precision farming.

Batte and Van Buren (1999) conducted a study on precision farming: Factors influencing profitability in Ohio and found that farm size and economies of scale played a role in producers’ decisions to adopt precision agriculture.

Daberkow and McBride (2003) conducted a nationwide survey of 8,400 producers in U.S.A. and reported that almost 70 per cent of the respondents were unaware of precision agriculture technology and therefore concluded that awareness, farm size, computer literacy, full time farming status, farm type as well as location of the farm are the factors that determine adoption of precision farming.

Sevier and Lee (2005) examine the precision farming adoption by Florida citrus producers using probit model analysis. Probit model was employed since the dependent variable is dichotomous in nature. The empirical results revealed that age of the farmers was negatively significant to probability of adoption while moderate and maximum spatial variability was positively significant.

Walton *et al.,* (2010) conducted a study on factors influencing farmer adoption of portable computers for site-specific management: A case study for cotton production using logit model in twelve southern states of U.S.A. They reported that farm size is a significant factor influencing the adoption of soil grid sampling.

Paudel *et al.,* (2011) investigated into factors responsible for why farmers do not adopt profitable precision farming technology in southern states of U.S.A. They observed that cost, time constraint, satisfaction with the current practice and other as reasons for not adopting precision farming technology while factors such as manure application on field, more formal education, larger farm size, participation in conservation easement or agricultural easement generally decreases the probability of non-adoption of precision agriculture in cotton production The model used for the study was multinomial logit regression (MNL) model which gives opportunity for choice of dichotomous variables.

Paxton *et al.,* (2011) reported in their study on intensity of precision agriculture technology adoption by cotton producers in southern states of U.S.A. that factors such as within-field yield variability resulted in higher intensity of adoption while younger age and better education were significantly correlated.

Pandit *et al.,* (2012) conducted a study on adoption and non adoption of precision farming technologies by cotton farmers in twelve southern states of U.S.A. and reported that formal education, farm size, and number of precision farming meeting attend by farmers have positive effect on adoption of precision farming technologies as well as probability of adopting precision farming technologies for profit reasons increases with spatial yield variability.

2.6 Constraints faced by participant and non-participant famers in adoption of precision farming technologies.

Vedamurthy (2002) while studying the management of areca gardens and marketing pattern preferred by the arecanut growers of Shimoga district in Karnataka observed that the main constraints faced by the arecanut growers were price fluctuation, non-availability of labour, lack of finance and lack of knowledge.

Maraddi *et al.*, (2004) conducted a study on constraints in adoption of cotton production technologies in Malaprabha Command area of Karnataka and reported that many of the constraints were related to economic (75.00 %) and technical guidance (71.66 %) as compared to other categories of constraints related to input (67.58%), production (60.00 %) and marketing (57.77 %).

Thiranjangowda (2005) in his study on cultivation and marketing pattern of selected cut flowers in balgaum District reported that high investment in poly house (75.00 %), problem of pest and diseases (65.00 %), high cost of fertilizers (45.00 %) and high cost of plant protection chemicals (17.50 %) are the main constraints towards gerbera flower cultivation.

Ramakrishna, (2012) conducted a study on impact analysis of demonstration of transplanting method of Redgram cultivation in Bidar district of Karnataka and reported that majority of demonstration farmers expressed constraint such as low price to their product (78.33 %) while majority of non-demonstration farmers (81.67 %) expressed constraints like high cost of cultivation practices.

Methodology

III. METHODOLOGY

This chapter reveals the methodology adopted for this study. This includes the characteristics of the study area, procedures for data collection as well as tools and techniques employed for data analysis are hereby explained under the following headings.

3.1 Research design

3.2 Locale of the study

3.3 Description of the study area

3.4 Selection of the district

3.5 Selection of the talukas and villages

3.6 Selection of the respondents

3.7 Variables for the study

3.8 Operationalization and measurement of variables

3.9 Data collection instrument

3.10 Statistical tools used in the study

3.1 Research design

The Ex post facto research design was used for the purpose of this study. The rationale for this was because the phenomenon has already occurred under project mode and researcher does not have direct control over the independent variables.

3.2 Locale of the study

The study was conducted in Karnataka state with focus on the North Eastern region of the state comprising six district namely Bidar, Gulbarga, Raichur, Koppal, Bellary and Yadgir district.

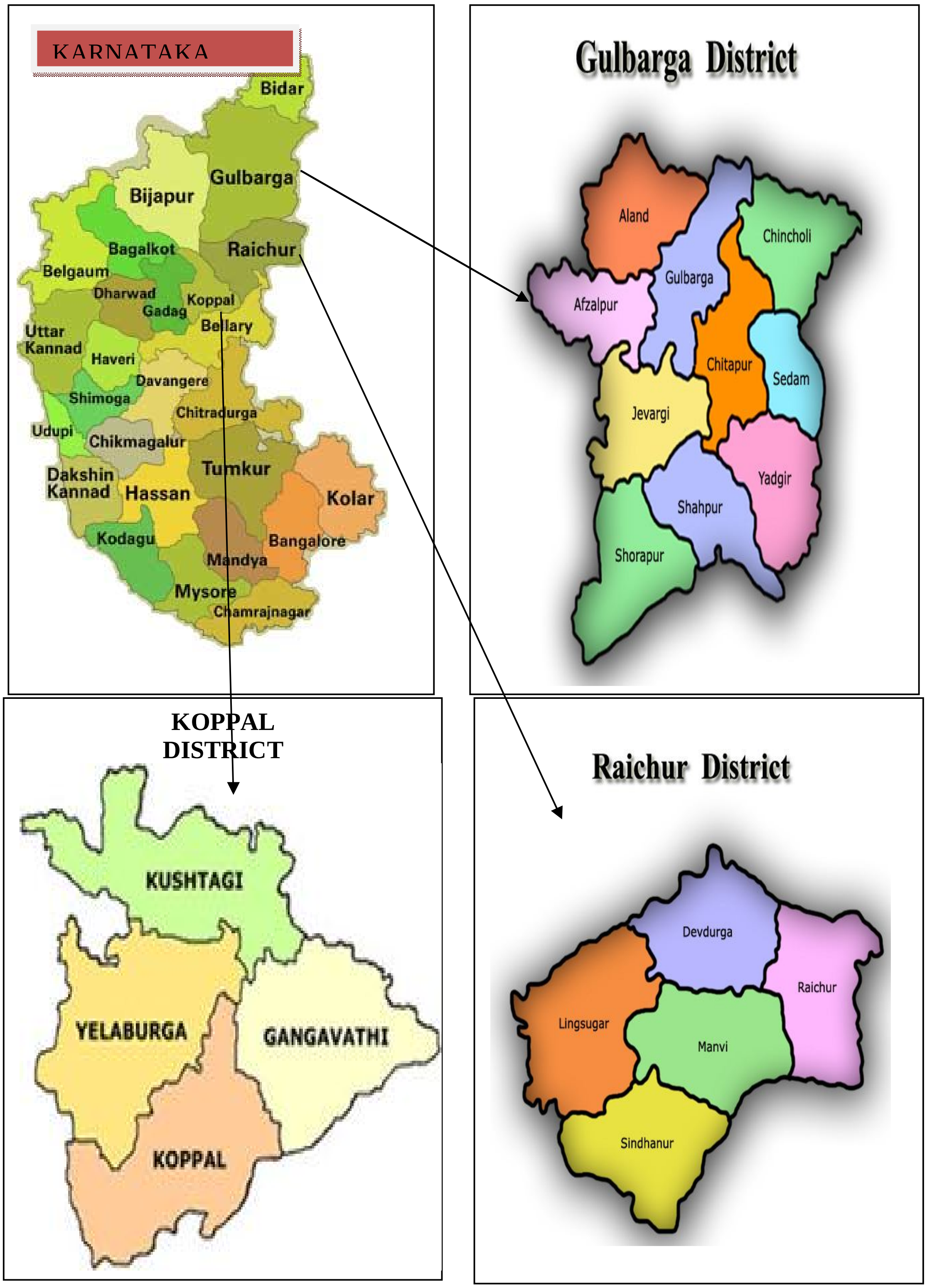

KARNATAKA
Bidar
Gulbarga
Bijapur
Bagalkot
Raichur
Belgaum
Dharwad
Gadag
Koppal
Bellary
Uttar Kannad
Haveri
Davangere
Shimoga
Chitradurga
Udupi
Chikmagalur
Tumkur
Dakshin Kannad
Hassan
Kolar
Kodagu
Bangalore
Mandya
Mysore
Chamrajnagar
Gulbarga District
Aland
Chincholi
Gulbarga
Afzalpur
Chitapur
Sedam
Jevargi
Yadgir
Shahpur
Shorapur
KOPPAL DISTRICT
KUSHTAGI
YELABURGA
GANGAVATHI
KOPPAL
Raichur District
Devdurga
Raichur
Lingsugar
Manvi
Sindhanur

Fig. 1. Map showing the study area

3.3 Description of the study area

3.3.1 Physiography

Karnataka state is located within 11°30' North and 18°30' North latitudes and 74° East and 78°30' East longitude. It is situated on a tableland where the Western and Eastern Ghat ranges converge into the Nilgiri hill complex in the western part of the Deccan peninsular region of India. The State is bounded by Maharastra and Goa States in the north and northwest, by the Arabian Sea in the west, by Kerala and Tamil Nadu States in the south and by the States of Andhra Pradesh in the east. Karnataka extends to about 750 km from north to south and about 400 km from east to west. According to 2001 population census, the state was regarded as the eighth largest state in India with a total population of about 5.27 crores.

3.3.2 Climate

Karnataka is a warm climatic state with mean temperature ranges from 21.50^0C to 31.70^0C, the minimum and maximum temperature ranges from 24^0C to 42^0C respectively which is favourable to crop cultivation. The North eastern region of Karnataka is categorized as part of the north interior Karnataka three meteorological zones.

3.3.3 Rainfall

The southwest monsoon which starts in the first week of June and continues till September accounts for almost 80 % of the rainfall that the state receives. The annual rainfall across the state ranges from low 50 cm to copious 350 cm. The districts of Bijapur, Raichur, Bellary and Southern half of Gulbarga experience the lowest rainfall ranging from 50 to 60 cm.

3.4 Selection of the districts

The three districts namely Raichur, Koppal and Gulbarga district of North Eastern Karnataka were purposively selected based on the criterion of the implementation of precision farming project by University of Agricultural Sciences, Raichur in the selected crops, cotton, paddy and pigeon pea respectively.

3.5 Selection of the taluks and villages

The taluk and villages selection was made on the criterion of the implementation of precision farming project in the study area which was based on the crop ecosystem of the region. The four villages selected are Marichethal**,** Jangamarakal gudi**,** Chinamgera, Ingalagi and Chowdapur all from Raichur, Koppal and Gulbarga districts respectively.

3.6 Selection of the respondents

Precision farming participant farmers in the three selected crops and non-participant farmers of the same selected crops in the district were selected for the study using simple random sampling technique. Simple random sampling was used to select randomly 35 participants and 35 non participants in the selected crops. The total sample size constitutes the 70 respondents for the study.

The details of selection of district, villages and respondents are given below;

Sampling Details						
District	Raichur (Cotton)		Koppal (Paddy)		Gulbarga (Pigeon pea)	
Taluks	Raichur		Gangavathi		Gulbarga	
Villages	Marichetal		Jangamrakal/gudi		Chinamgera/Ingalagi/ Chowdapur	
Number of respondents	7 participant	7 Non-participant	17 participant	17 Non-participant	11 participant	11 Non-participant
35 participant				35 non-participant		
70 respondents						

3.7 Variables for the study

3.7.1 Dependent variables

The following variables were considered based on the objectives of the study.

1. Knowledge
2. Perception

3.7.2 Independent variables

The following variables were selected for the study based on the literature reviewed and discussion with the scientists of the University of Agricultural Sciences, Raichur and scientists working on the precision farming project. These are;

1. Age
2. Education
3. Land holding
4. Farming experience
5. Attitude
6. Annual income
7. Risk orientation
8. Management orientation
9. Deferred gratification
10. Achievement motivation
11. Extension contact
12. Extension participation
13. Mass media utilisation
14. Use of computer for farm management

15. Scientific orientation

16. Innovative behavior

3.8 Operationalization and measurement of variables

The variables selected for the study along with their empirical measurements are presented here under.

Sl. No.	Variables	Measurement tool
	Dependent variables	
1	Knowledge level	Knowledge index tool developed for the study
2	Perception	Schedule developed for the study
	Independent variables	
1	Age	Procedure followed by Daberkow & McBride (1998)
2	Education	Procedure followed by Maheswari *et al,*. (2008)
3	Size of land holding	Government of Karnataka (1992-93), procedure followed by Mangala (2008)
4	Farming experience	Procedure followed by Kenneth Paxton (2011)
5	Attitude	Scale developed by Singh and Singh (1973)
6	Annual income	Procedure followed by Government of India, 1992 and as followed by Deepak (2003).
7	Risk orientation	Procedure followed by Nagaraja (1989).
8	Management orientation	Procedure followed by Samanta (1977)
9	Deferred gratification	Scale developed by Supe (1969)

10	Achievement motivation	Procedure followed by Singh (1978) with slight modification
11	Extension contact	Procedure followed by Maheswari *et al.,* (2008)
12	Extension participation	Procedure followed by Jeremy M. D'Antonia, (2012)
13	Mass media utilization	Procedure followed by Binkadakatti (2008)
14	Use of computer for farm management	Procedure followed by Walton *et al.*, (2012)
15	Scientific orientation	Procedure followed by Supe (1969), with slight modifications made and used by Nagaraj (1989).
16	Innovative behavior	Scale developed by Moulik's (1965) with slight modification

3.8.1 Dependent variables

3.8.1.1 Knowledge

Knowledge in this study is defined as information understood & retained by the respondent. Knowledge index tool was developed with questions as regards to precision farming practices. Questions and answers were carefully framed mainly on the basis of precision farming practices in the selected crops given by the precision farming project scientist of University of Agricultural Sciences, Raichur. The knowledge items were converted into questions with objective questions, Yes / No type, open end questions wherever felt appropriate were also included. Totally 25 questions were formed. The knowledge index tool developed was administered to the respondents. Quantification of the knowledge item answers were made by giving one score and zero score for correct and incorrect answers, respectively. The score of the entire individual item were summed to get the knowledge score of respondents. The maximum score that one could get was 25 and minimum was zero.

The knowledge index was computed using the following formula,

KI = n/ N

Where, KI = knowledge index,   n = total score for correct answer

N= Maximum obtainable score

Based on the knowledge index score, the respondents were classified into three categories namely, low, medium and high, using mean and standard deviation as a measure of check.

Sl. No.	Category	Range
1	Low	Less than (Mean - 0.425 SD)
2	Medium	In between (Mean ± 0.425 SD)
3	High	More than (Mean + 0.425 SD)

3.8.1.2 Perception

This is farmers' perception about the precision farming technology attributes. Slight modification was made to the procedure employed by Adrian *et al.* 2005 following Rogers, 1983. Perceived benefit statements on precision farming technology was created with slight modifications while perceived usefulness and ease of use statements was created based on measurement scale developed by Davis 1989 with modifications. The perception was measured using likert scale on a 5- point scale continuum ranging from "strongly agree, agree, undecided, disagree and strongly disagree". With the scores of 5, 4, 3, 2 and 1 for positive statements and 1, 2, 3, 4 and 5 for negative statements, respectively. Based on the total score obtained, the perception was categorized into less favourable, medium favourable and more favourable perception based on the mean and standard deviation as a medium of check.

Sl. No.	Category	Range
1	Less favourable	Less than (Mean - 0.425 SD)
2	Favourable	In between (Mean ± 0.425 SD)

3	More favourable	More than (Mean + 0.425 SD)

3.8.2 Independent variables:

3.8.2.1 Age

This was defined as number of years of the respondents at the time of investigation. The age of the respondents was recorded as mentioned by them in completed years. The respondents were categorized in to three age groups based on the procedure followed by Daberkow & McBride, (1998).

Sl.	Category	Age (in years)
1	Young	Less than 35
2	Middle	Between 36 to 55
3	Old	Above 55 years

3.8.2.2 Education

Education was operationalized as the number of years of formal education the person has undergone. For each year of schooling, a score of one was given. The respondents were grouped into different categories as following the procedure followed by Maheswari *et al.* (2008).

Sl. No.	Category	Education
1	Illiterate	Cannot read and write
2	Primary school	1 to 4th standard
3	Middle school	5 to 7th standard
4	High school	8 to 10th standard
5	Pre-university	11 to 12th standard
6	Graduate	Above 12th standard

3.8.2.3 Land holding

The operationalization of land holding of the respondents was done by considering the size of the land owned and cultivated by the respondents. The land holdings of the respondents were of different kinds namely wet, dry and garden. Hence, they were converted into standard acres, according to Karnataka land reforms act 38 of 1966; one acre of garden/wetland was equated to three acres of dry land. The same procedure was followed in the study to calculate the total land holding of the farmer. The Government of Karnataka (1992-93) has prescribed norms for the categorization of landholdings and the procedure as followed by Mangala (2008) was made use.

Sl. No.	Category	Land holding
1	Marginal farmers	Up to 1ha
2	Small farmers	1 to 2 ha
3	Medium farmers	2 to 4 ha
4	Big farmers	Above 4 ha

3.8.2.4 Farming experience

It refers to total number of years of farming experience of the farmers in completed years at the time of investigation. They were categorized into low, medium and high following the procedure of Kenneth Paxton (2011).

Sl. No.	Category	Farming experience (years)
1	Low	(up to 8 years)
2	Medium	(9-16 years)

3	High	(17 and above)

3.8.2.5 Attitude

It refers to the degree of positive and negative feelings of the respondents towards the precision farming technologies. The scale developed by Singh and Singh (1973) was employed to quantify the variable with slight modification to precision farming concept. The scale included 6 positive and 6 negative statements. The responses were obtained on five point continuum namely "strongly agree, agree, undecided, disagree and strongly disagree". The scores of 5, 4, 3, 2 and 1 were given to positive statements and the scoring was reversed for negative statements. The scale was modified to 4 positive statements and 1 negative statement to assess the attitude of respondents about precision farming technologies. The summation of the score obtained by each of the respondents indicates his score of attitude towards precision farming technologies. The respondents were grouped into the three categories based on total attitude scores using mean and standard deviation as a check.

3.8.2.6 Annual income

It was defined as the total income earned by the respondents from agriculture and allied enterprises and expressed in rupees. Based on this, the respondents were grouped into four categories as per the norms suggested by Ministry of Rural Development, Government of India, 1992 and as followed by Deepak (2003).

Sl. No.	Category	Income (Rs. / annum)
1	Low income group	Up to Rs. 17,000
2	Semi-medium income group	Rs. 17,001 – 34,000
3	Medium income group	Rs. 34,001 – 51,000
4	High income group	Above Rs. 51,001

3.8.2.7 Risk orientation

It was operationalized as the degree to which a farmer is oriented towards risk and uncertainty in agriculture and has the courage to face the various risks involved in agricultural aspects. The scale for measuring risk orientation of farmers developed by Nagaraja (1989) was used in this study with slight modification. The scale contained six statements. The fifth statement was negatively and all other were positively statement. In case of positive statements a score of two was assigned for the positive response (agree) and one score for negative (disagree) response. This was reversed in the case of negative statements. The scores were added to get total score of the respondents. Minimum and maximum score one can get is 6 and 12, respectively. The respondents were grouped into the three categories based on total risk orientation scores using mean and standard deviation as a check.

Sl. No.	Category	Range
1	Low	Less than (Mean – 0.425 SD)
2	Medium	Between (Mean ± 0.425 SD)
3	High	More than (Mean + 0.425 SD)

3.8.2.8. Management orientation

The scale developed by Samanta (1977) was employed to understand the management orientation of the respondents. The scale consists of 18 statements each for planning, production and marketing aspects. In each group, positive and negative statements were mixed retaining more or less a psychological order of statements. The mean scores of the management orientation of the respondents were used for all purpose of grouping the respondents into low, medium and high management orientation.

3.8.2.9 Deferred gratification

This was operationalized as defined deferred gratification as the postponement of immediate satisfaction in anticipation of future rewards. This variable was quantified by using the scale developed by Raghupati (1994)**.** The statements numbered 2, 3, and 4 were negatively keyed and all others were positively keyed. In case of positive statements, a score of 3, 2 and 1 as assigned for agree, undecided and disagree respectively. This was reversed in case of negative statements. The score obtained on each statement were summated and total scores of respondents were obtained on deferred gratification.

3.8.2.10 Achievement orientation

This was operationalized as degree to excel regardless of social rewards. Achievement motivation scale developed by Reddy (1976) was employed for the study with slight modification. The statements numbered 2, and 5 were negatively keyed and all others were positively keyed. In case of positive statements, a score of 3, 2 and 1 as assigned for agree, undecided and disagree respectively. This was reversed in case of negative statements. The score obtained on each statement were summated and total scores of respondents were obtained and categorized into low, medium and high using mean and standard medium as a check.

3.8.2.11 Extension contact

It was operationalized as the awareness of the respondents about various extension agencies and their frequency of contact with them to acquire information or seek advice related to farming. This variable was quantified by adopting the procedure followed by Maheswari *et al.* (2008) with slight modification. The score for individual respondents extension contact was the summation of the scores for all the extension personnel contacted by him. The higher score reveals higher contacts with extension personnel by the respondent. Then respondents were categorized into 3 categories as low, medium and high based on mean and standard deviation.

3.7.2.12 Extension participation

Extension participation refers to the extent of participation of farmers in different extension activities conducted during the last one year prior to the time of interview. Training programmes, demonstrations, field days, field visits, group meetings, agricultural exhibitions, krishimela and educational tours were the activities included for the study. Extent of participation was ascertained as regular, occasional and never with a scores of 2, 1 and 0 respectively, as followed by Jeremy M. D’Antonia, 2012 with light modification.

3.8.2.13 Mass media utilization

It refers to the exposure and utilization of the respondents to different mass communication media and involvement in the related activities such as listening to radio, viewing TV and reading news papers and farm magazines. Mass media possession was measured on two point continuum such as, possessed/subscribed and not possessed/not subscribed. Extent of utilization, however, was measured on five point continuum i.e., everyday, once in a week, once in a month and not at. The scores of 4, 3, 2, 1 and 0 were assigned for everyday, once in a week, once in a month and not at all respectively.

3.8.2.14 Use of computer for farm management

This was defined as the Possession and utilization of computer for farm management. Dichotomous variable of Yes =1 and No = 0 for possess and not possess. Degree of usage was quantified on a three point continuum i.e., regularly, occasionally, never. The scores of 2, 1 and 0 were assigned for regularly, occasionally and never respectively and the scores obtained were categorized into 3 categories as low, medium and high based on mean and standard deviation as a check following procedure of Walton *et al.,* (2012).

3.8.2.15 Scientific orientation

It is defined as the degree to which a farmer is oriented to the use of scientific methods in agriculture. The variable was quantified by using the scientific orientation scale of Supe (1969), with slight modifications made by Nagaraj (1989). A score of 3, 2 and 1 was assigned for agree, undecided and disagree respectively. This was reversed in case of negative statements. The score obtained on each statement were summated and total scores of respondents were obtained and categorized into low, medium and high using mean and standard medium as a check.

3.8.2.16 Innovative behaviour

This refers to the behaviour pattern of an individual who has interest and desire to seek changes in farming techniques and ready to introduce such changes into his operations when considered as practical and feasible. The “Self rating innovation proneness scale” developed by Moulik’s (1965) was used with slight modification to quantify the innovative behavior of the respondents. The modified scale consist of 5 statements with 2, 3, 5 are negative and others are positive. A score of 3, 2 and 1 was assigned for agree, undecided and disagree respectively. This was reversed in case of negative statements. The score obtained on each statement were summated and total scores of respondents were obtained and categorized into low, medium and high using mean and standard medium as a check.

3.8.3 Resource utilization pattern in precision farming in comparison with conventional farmers' practice

This was operationalized as amount of resources used per hectare for the cropping season following Maheswari *et al.*, (2008) procedure with slight modification.

SEED = Seed rate in g/ ha

MANURE = Manures in tonnes/ ha

LABOUR = Total labour in human days / ha

PPC = Total plant protection chemicals in g/ ha

N = Total nitrogen in kg/ ha

P = Total phosphorus in kg/ ha

K = Total Potassium in kg/ ha

Micro Nutrients = kg/ ha

3.9 Data collection instrument

A well structured interview schedule was prepared based on the objective of the study and exhaustive review of literature. Consultation was also made with the University scientist and precision farming project scientist. The interview schedule was pre-tested which led to the adequate modification of the instrument. The data was collected by personal interview with the help of field enumerators to translate the information for the farmers considering the challenge of language barrier between the researcher and the farmers (Plate 1, 2, 3 and 4).

Plate 1: Researcher driving tractor mounted with Laser land leveling at precision farm plot during precision agriculture practical class at UASR

Plate 2: Researcher with farmers during data collection at Mariechetal village, Raichur district

Plate 3: Researcher interviewing participant farmers during data collection at J. K. Gudi, Ganganvathi, Koppal district

Plate 4: Researcher during precision farming paddy harvesting and data collection in J. K. Gudi, Gangavathi, koppal district

3.10 Statistical tools used in the study

The following statistical tools were employed in analyzing the data collected from the farmers. The data thus collected for the purpose of the study were quantified, categorized and tabulated. The following statistical tools were made use of in the study to analyze the data.

Mean:

The arithmetic mean is the sum of the scores divided by their number. This measure was used to categorize the dependent and independent variables into low, medium and high categories.

Frequency:

This measure was used to know the distribution pattern of respondents, variable wise and to categorize the constraints perceived by the farmers in the selected crops.

Percentage:

This measure was used for simple comparisons and to analyze the socio-economic characteristics of the respondents.

Standard deviation:

This measure was used to categorize the dependent and independent variables into low, medium and high categories.

T test:

T-test was used to analyze the resource utilization pattern of the participant farmers in comparison with conventional farmer’s practice.

Regression:

Logistic regression model was used to analyze the factors responsible for future adoption. Logistic regression is a type of probabilistic statistical classification model that used to predict a binary response from a binary predictor used for predicting the outcome of a categorical dependent variable based on one or more predictor variables (features). It deals with situations in which the observed outcome for a dependent variable is dichotomous *i.e.*, having only two possible answers (Yes/No). The general logistic model is stated below;

$$\text{logit}(\mathrm{E}[Y_i \mid x_{1,i}, \ldots, x_{m,i}]) = \text{logit}(p_i) = \ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 x_{1,i} + \cdots + \beta_m x_{m,i}$$

$$Y_i = \begin{cases} 1 & \text{if } Y_i^* > 0 \text{ i.e. } -\varepsilon < \boldsymbol{\beta} \cdot \mathbf{X}_i, \\ 0 & \text{otherwise.} \end{cases}$$

P_i = probability function

X_i = nxk matrix of explanatory variable

β_i = k x 1 vector of parameter to be estimated

Therefore, the probability of choice of future adoption of precision farming technologies is a function of the vector of unknown parameters.

The specified future adoption of precision farming technologies for the study is as follows.

$Y = \beta o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \ldots.. \beta X_n + E_i$

Where,

Y = choice of future adoption of precision farming technologies

(dependent Variables, adopt = 1 and not adopt = 0)

X_1……. X_n are independent variables (socio-economic characteristics)

X_1 = Education (years)

X_2 = Land holdings

X_3 = Farming experience (years)

X_4 = Yield (kg/ ha)

X_5 = Extension participation

X_6 = Extension contact

X_7 = Risk orientation

X_8 = Scientific orientation

β = Coefficient

Ei = error term

Results

IV. RESULTS

The results of the investigation are presented in the chapter under the following headings;

4.1 Socio-economic characteristics of the participant and non participant farmers

4.2 Farmers perception towards precision farming technologies in selected crops

4.3 Knowledge level of participants farmers about precision farming technologies in selected crops

4.4 Resource utilization pattern in precision farming in comparison with conventional farmers’ practice in selected crops

4.5 Factors responsible for plan to use precision farming technology

4.6 Constraints faced by participant and non-participant famers in plan to use precision farming technologies

4.1 Socio-economic characteristics of the participant and non participant farmers

4.1.1 Age

The data presented in Table 1 indicated that 71.43, 20.00 and 8.57 per cent of the participant farmers are in middle age, old age and young age category respectively, while 65.72 per cent of the non-participant farmers are in middle age.

4.1.2 Education

It can be observed from Table 1 that, 5.71, 5.71, 48.57 and14.29 per cent of the participant farmers had education up to middle school, high school, pre-university and degree and above respectively while, 25.72 per cent of them were illiterates. In the same vein, 14.29, 17.14, 25.71 and 2.86 per cent of the non-participant farmers had education up to middle school, high school, pre-university and degree and above respectively while, 40.00 per cent of them were illiterates.

4.1.3 Land holding

The data in the Table 1 revealed that, 22.86, 20.00, 25.71, and 41.43per cent of the participant farmers are marginal farmers, small farmers, medium farmers and big farmers respectively, while 31.43. 54.29. 5.71 and 8.57 per cent of the non-participant are marginal farmers, small farmers, medium farmers and big farmers respectively.

4.1.4 Farming experience

Table 5 revealed that more than half of the participant and non-participant farmers belonged to high category of farming experience. Among participant farmers, 57.14 per cent belonged to high farming experience category (17 years above) followed by 40.00 per cent in medium farming experience category (9-16 years), and only 2.86 per cent belonged to low farming experience category(< 8 years). Also, 60.00, 34.29 and 5.71 per cent of the non-participant belonged to high, medium and low farming experience category respectively. Since other farmers also might be convinced by the progressive farmers about the advantages of cultivating the crops and this might be reason that farmer bearing more experience in cultivation of crops.

4.1.5 Attitude

It was revealed from Table 1 that, 68.57 per cent of the participant farmers belonged to most favourable attitude category followed 31.43 per cent in least favourable attitude category.

4.1.6 Annual income

The data presented in Table 1 indicated that, 42.86 per cent of the participant farmers belonged to high income group (> Rs. 51000) followed by 25.71 per cent in medium income (Rs. 34000-51000) group, 17.14 per cent semi medium group (Rs.17000-34000) and only 14.28 per cent belonged to low annual income category (< Rs.17000), while that 17.14 per cent of the participant farmers belonged to high income group (> Rs. 51000) followed by 22.86 per cent in medium income (Rs. 34000-51000) group, 25.71 per cent semi medium group (Rs.17000- 34000) and only 34.28 per cent belonged to low annual income category (< Rs.17000) the maximum annual income being Rs. 4.5 lakh and the minimum being Rs.10000.

4.1.7 Risk orientation

Table 1 revealed the level of risk orientation of the participant and non-participant farmers. It was observed that more than sixty per cent (68.57 %) of the participant famers had high risk orientation while 31.43 per cent had low risk orientation. Also, about half of the non-participant (45.71 %) had medium risk orientation, 31.43 per cent had low risk orientation while 22.85 per cent of the non-participant farmers had high risk orientation.

4.1.8 Management orientation

From Table 1, it was observed that, 55.00 per cent of the participant farmers had medium management orientation while 22.50 per cent each of them had low and high level of management orientation. In the same vein, 42.50, 29.02 and 28.3 per cent of the non-participant farmers had low, medium and high level of management orientation respectively.

4.1.9 Deferred gratification

The data presented in Table 1 depicted deferred gratification level of the participant and non-participant farmers. From the Table, 45.71, 34.29, 20.00 per cent of the participant farmers had high, medium and low level of deferred gratification respectively, while 40.00, 34.29 and 25.71 per cent of the non-participant farmers had low, high and medium of deferred gratification respectively.

4.1.10 Achievement motivation

The data presented in the Table 1 revealed that, majority (74.29 %) of the participant farmers were in high achievement category, while 25.71 per cent of had low level achievement motivation. Also, 42.86, 22.85 and 34.29 per cent of the non-participant farmers had low, medium and high level of achievement motivation respectively.

4.1.11 Use of computer for farm management

Table 1 revealed that none (0.00 %) of the participant and non participant farmers possessed and used computer for farm management.

Table 1: Distribution of respondents according to their personal, socio-economic and psychological characteristics

n = 70

Sl. No.	Characteristics	Category	Participant $n_1 = 35$ F	Participant $n_1 = 35$ %	Non-participant $n_2 = 35$ F	Non-participant $n_2 = 35$ %
1	Age	Young (< 35 years)	3	8.57	6	17.14
		Middle age (36-55 years)	25	71.43	23	65.72
		Old (> 55 years)	7	20.00	6	17.14
2	Education level	Illiterate (cannot read & write)	9	25.72	14	40.00
		Primary (1-4th standard)	0	0.00	0	0.00
		Middle school (5-7th standard)	2	5.71	5	14.29
		High school (8-10th standard)	2	5.71	6	17.14
		Pre-university (11-12th standard)	17	48.57	9	25.71
		Degree and above (> 12 standard)	5	14.29	1	2.86
3	Land holding	Marginal farmers (up to 1 ha)	8	22.86	11	31.43
		Small farmers (1 to 2 ha)	7	20.0	19	54.29
		Medium farmers (2 to 4 ha)	9	25.71	2	5.71
		Big farmers (>4 ha)	11	41.43	3	8.57
4	Farming experience	Low (up to 8 years)	1	2.86	2	5.71
		Medium (9-16 years)	14	40.00	12	34.29
		High (17 and above)	20	57.14	21	60.00
5	Attitude	**Category**	**Participant $n_1 = 35$ F**	**%**		
		Least favourable (Mean - 0.425*SD)	11	31.43		
		Favourable (Mean ± 0.425*SD)	0	0.00		
		Most favourable (Mean + 0.425*SD)	24	68.57		
		$Mean_1 = 14.7$, $SD_1 = 2.23$				

F = Frequency, % = Percentage

Cont…

Sl. No	Characteristics	Category	Participant $n_1 = 35$		Non-participant $n_2 = 35$	
6	Annual income (Rs.)	Low (Up to Rs. 17,000)	5	14.28	12	34.28
		Semi medium (Rs. 17,000-Rs 34,000)	6	17.14	9	25.71
		Medium (Rs 34,000- Rs. 51,000)	9	25.71	8	22.86
		High (>Rs. 51,000)	15	42.86	6	17.14
		Maximum income	45000			
		Minimum income	10000			
7	Ecosystem	Irrigated	28	80	24	68.57
		Dryland	7	20	11	41.43
		Rainfed	0	0	0	0.00
8	Cropping intensity	Single crop	35	100	35	100
		Double crop	0	0.00	0	0.00
		Triple crop	0	0.00	0	0.00
10	Risk orientation	Low (Mean - 0.425*SD)	11	31.43	11	31.43
		Medium (Mean ± 0.425*SD)	0	0.00	16	45.71
		High (Mean + 0.425*SD)	24	68.57	8	22.85
		$Mean_1 = 11.2$, $SD_1 = 1.23$; $Mean_2 = 8.02$, $SD_2 = 1.12$				

F = Frequency, % = Percentage

Cont…

Sl. No	Characteristics	Category	Participant $n_1 = 35$		Non-participant $n_2 = 35$	
		Low (Mean - 0.425*SD)	7	20.0	14	40

11	Deferred gratification	Medium (Mean ± 0.425*SD)	12	34.29	9	25.71
		High (Mean + 0.425*SD)	16	45.71	12	34.29
		$Mean_1$ = 17.65, SD_1 = 0.76; $Mean_2$ = 9.77, SD_2 = 1.73				
12	Achievement motivation	Low (Mean - 0.425*SD)	9	25.71	15	42.86
		Medium (Mean ± 0.425*SD)	0	0.00	8	22.85
		High (Mean + 0.425*SD)	26	74.29	12	34.29
		$Mean_1$ = 14.7, SD_1 = 2.23; $Mean_2$ = 11.45, SD_2 = 2.61				
13	Possession and use of computer for farm management	Possessed	0	0.00	0	0.00
		Not possessed	35	100	35	100
		Use for farm management	0	0.00	0	0.00
		Not use for farm management	35	100	35	100
14	Scientific orientation	Low (Mean - 0.425*SD)	6	17.14	9	25.71
		Medium (Mean ± 0.425*SD)	0	0.00	19	54.29
		High (Mean + 0.425*SD)	29	82.86	7	20.0
		$Mean_1$ = 17.65, SD_1 = 0.76; $Mean_2$ = 13.4, SD_2 = 2.3				
15	Innovative behaviour	Low (Mean - 0.425*SD)	10	28.57	20	57.14
		Medium (Mean ± 0.425*SD)	0	0.00	4	11.43
		High (Mean + 0.425*SD)	25	71.43	11	31.43
		$Mean_1$ = 14.5, SD_1 = 0.81; $Mean_2$ = 8.77, SD_2 = 3.20				

F = Frequency
% = Percentage

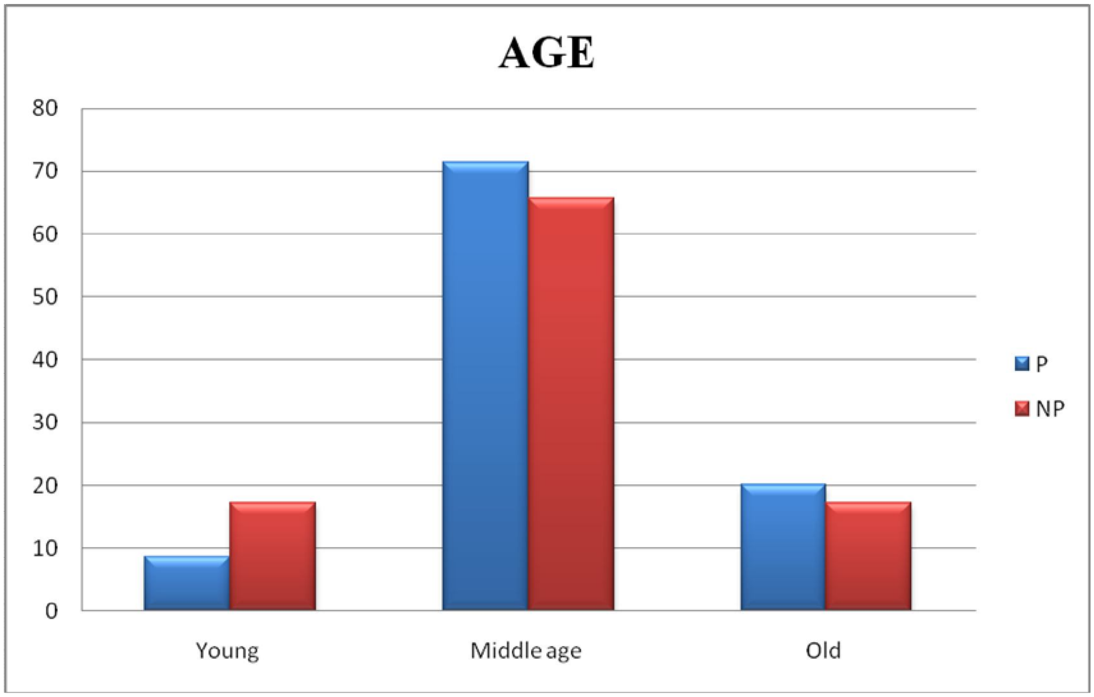


Fig. 2. Distribution of respondents according to their Age

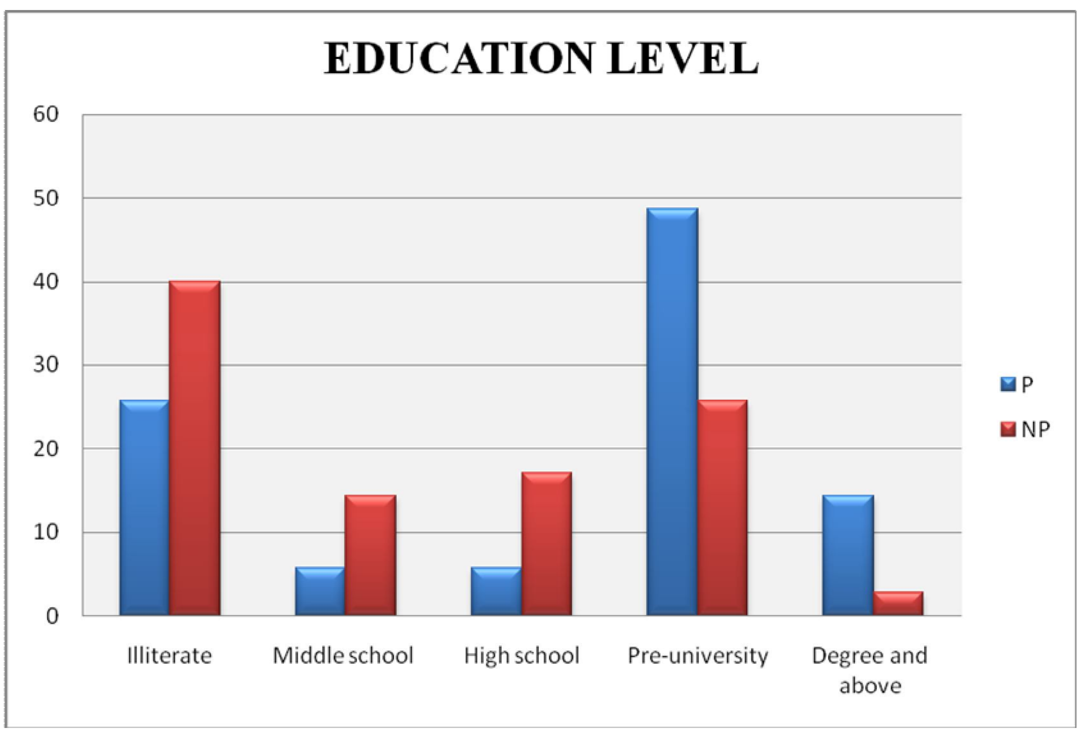


Fig. 3. Distribution of respondents according to their Education level

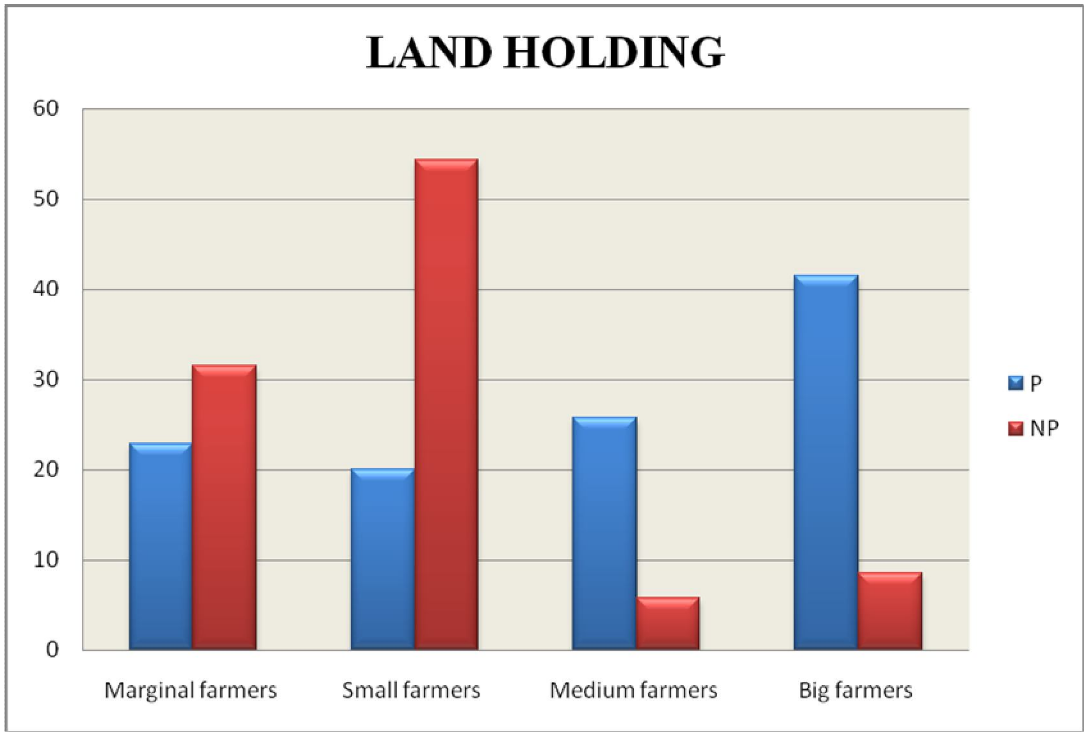


Fig. 4. Distribution of respondents according to their Land holdings

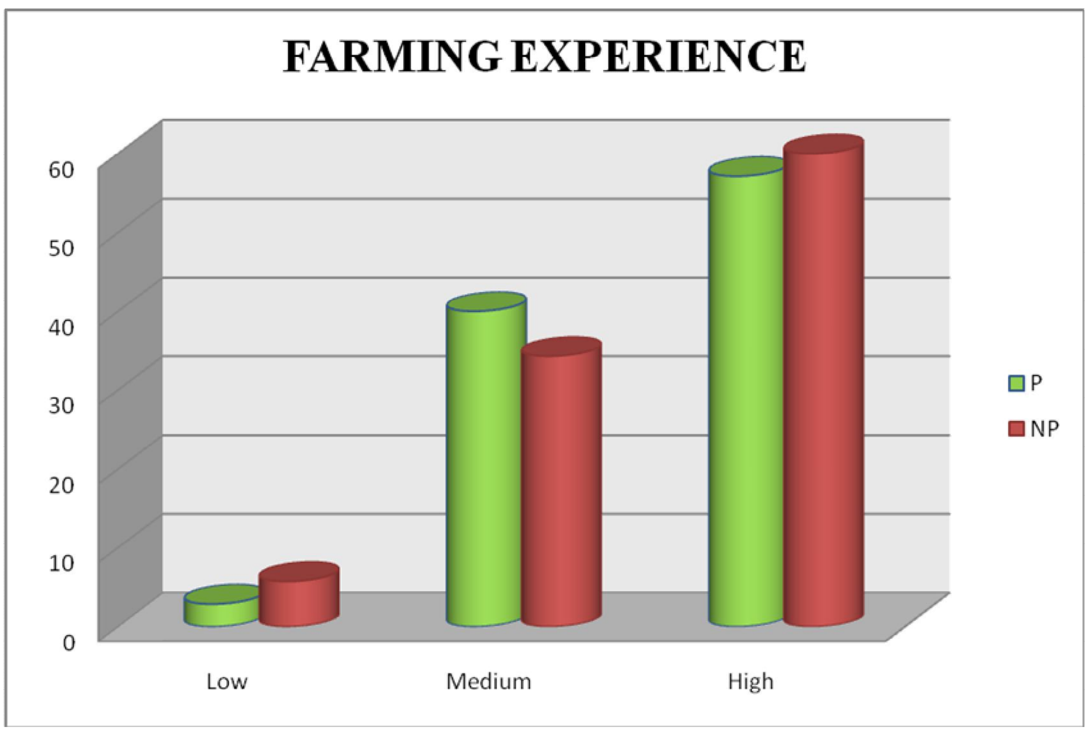


Fig. 5. Distribution of respondents according to their Farming experience

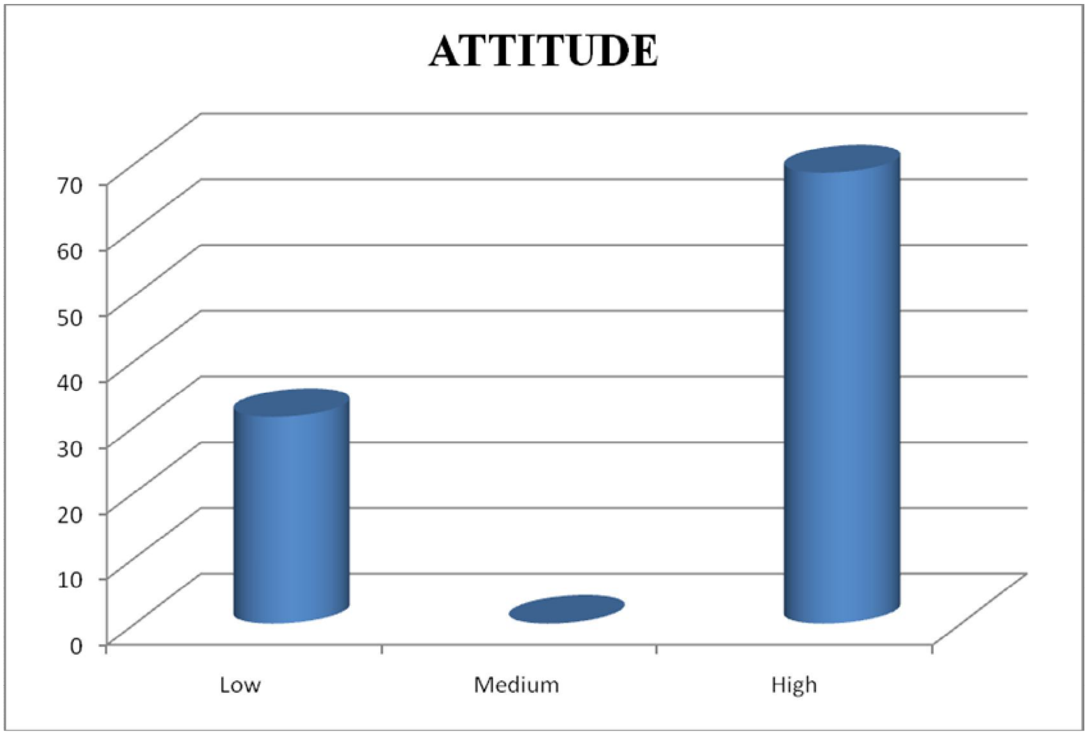


Fig. 6. Distribution of respondents according to their Attitudes towards precision farming technologies

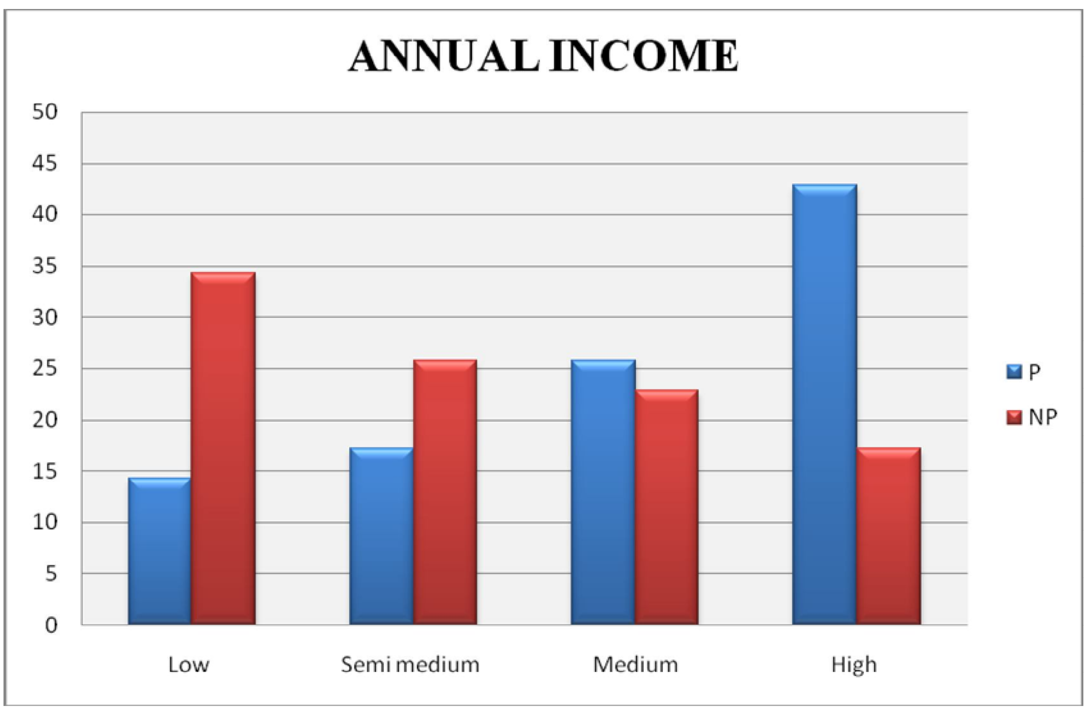


Fig.7. Distribution of respondents according to their Annual income

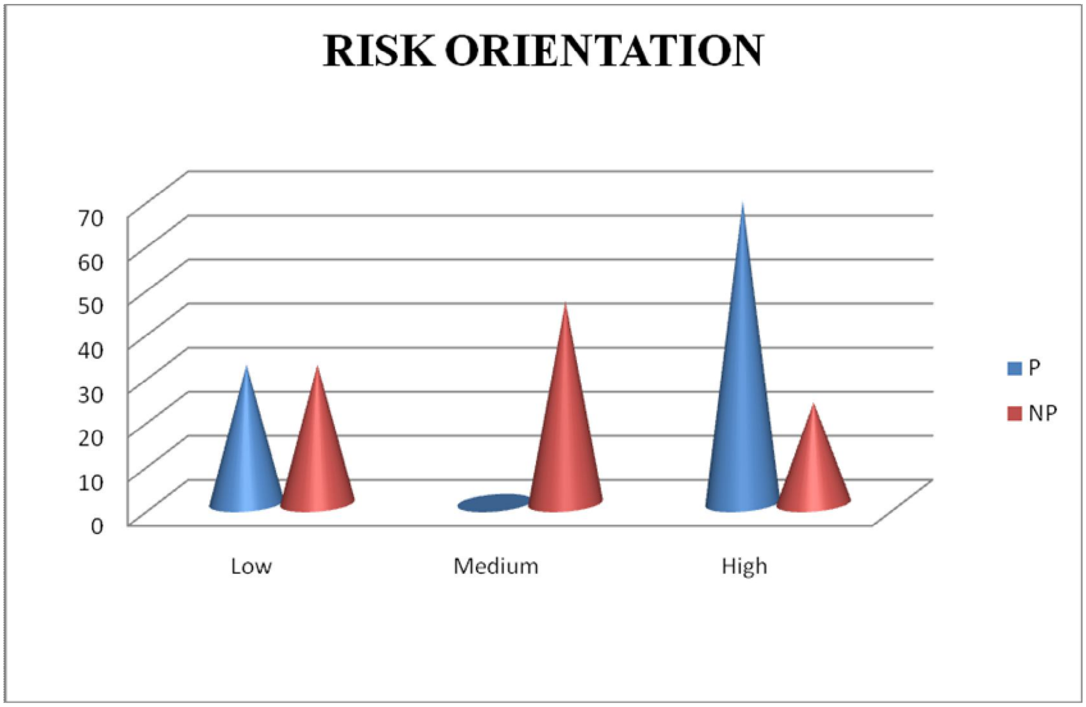


Fig. 8. Distribution of respondents according to their Risk orientation

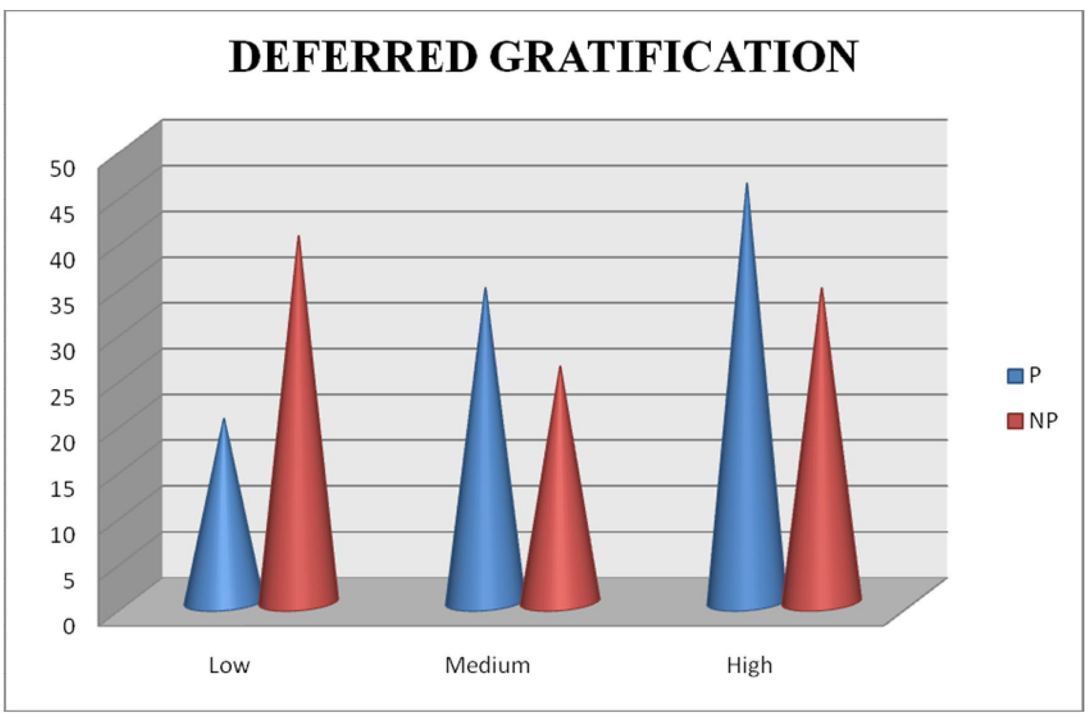


Fig. 9. Distribution of respondents according to their deferred gratification

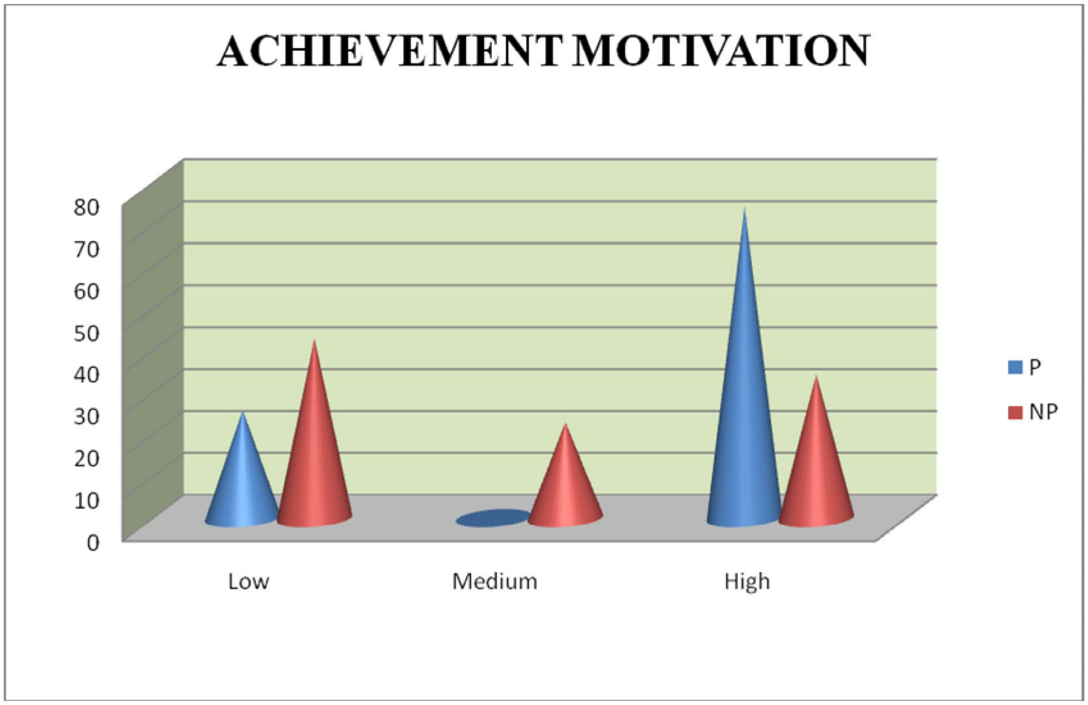


Fig. 10. Distribution of respondents according to their Achievement motivation

4.1.12 Scientific orientation

The data presented in the Table 1 revealed that, majority (81.86 %) of the participant famers were in high scientific orientation category followed by 17 per cent in low scientific orientation category, while 54.29, 25.71 and 20.00per cent of the non-participant were in medium, low and high scientific orientation levels, respectively.

4.1.13 Innovative behaviour

From Table 1, it was observed that that, more than seventy per cent (71.43 %) of the participant famers had high innovative behaviour followed by 28.57 per cent are in low innovative behaviour category, while 57.14, 31.43 and 11.43 per cent of the non-participant were in low high and medium innovative behavior levels, respectively.

4.1.14 Extension contact

Table 2 revealed the distribution of the respondents according to their extension contact. It was observed from the table that 60.00 and 40 per cent of the participant farmers had high and low level of extension contact respectively while 68.57, 25.71 and 5.71 per cent of the non-participant farmers had low, high and medium level of extension contact respectively.

Furthermore from Table 3, the percentage of the respondents contact with the government agency extension personnel was revealed thus, both participant and non-participant farmers contacted only Agricultural officer, Assistant Director of Agriculture and scientist of University of Agricultural Sciences, Raichur (UASR).

It was observed that 48.57 and 51.43 per cent of the participant farmers contacted Agricultural officer once in a week and once in a fortnight respectively. In the same vein, 14.29, 77.14 and 6.61 per cent of the non-participant farmers reported that they contacted Agricultural officer once in a week and once in a fortnight respectively while 6.61 had no contact at all. Also, 2.86 per cent of the participant farmers and non-participant farmers reported to have contact with Assistant Director of Agriculture once in a week while 97.14 per cent had no contact.

It was further observed that 97.14 had contact with Scientist of UASR once in a week while 2.86 per cent had contact once in a fortnight. However, 2.86, 40.00 per cent of the non-participant had contact with scientist of UASR once in a week and once in a fortnight respectively while 57.14 per cent had no contact.

Table 2: Distribution of respondents according to their Extension contact

n = 70

Sl. No.	Category	Participant $n_1 = 35$		Non- Participant $n_2 = 35$	
		Frequency	Percentage	Frequency	Percentage
1	Low (Mean - 0.425*SD)	14	40.0	24	68.57
2	Medium (Mean ± 0.425*SD)	0	0.00	2	5.71
3	High (Mean + 0.425*SD)	21	60.0	9	25.71

$Mean_1$= 3.7 **SD_1**= 0.66; **$Mean_2$**= 1.77 **SD_2**= 1.31

Table 3: Extension contact of the respondents

n = 70

Sl. No.	Extension officers	Frequency of contact											
		Once in a week				Once in a fortnight				Never			
		Participants n_1 =35		Non-participants n_2 =35		Participants n_1 =35		Non-participants n_2 =35		Participants n_1 =35		Non-participants n_2=35	
		F	%	F	%	F	%	F	%	F	%	F	%
1	Agricultural Assistant	0	0	0	0	0	0	0	0	0	0	0	0
2	Asst. Agricultural officers	0	0	0	0	0	0	0	0	0	0	0	0
3	Agricultural Officer	17	48.57	5	14.29	18	51.43	27	77.14	0	0	3	6.61
4	Asst. Director of Agriculture	1	2.86	1	2.86	0	0	0	0	34	97.14	34	97.14
5	Scientists of UAS	34	97.14	1	2.86	1	2.86	14	40	0	0	20	57.14
6	Private agency Extension officer	0	0	0	0	0	0	0	0	0	0	0	0
7	NGOs Extension officer	0	0	0	0	0	0	0	0	0	0	0	0

F = Frequency   % = Percentage

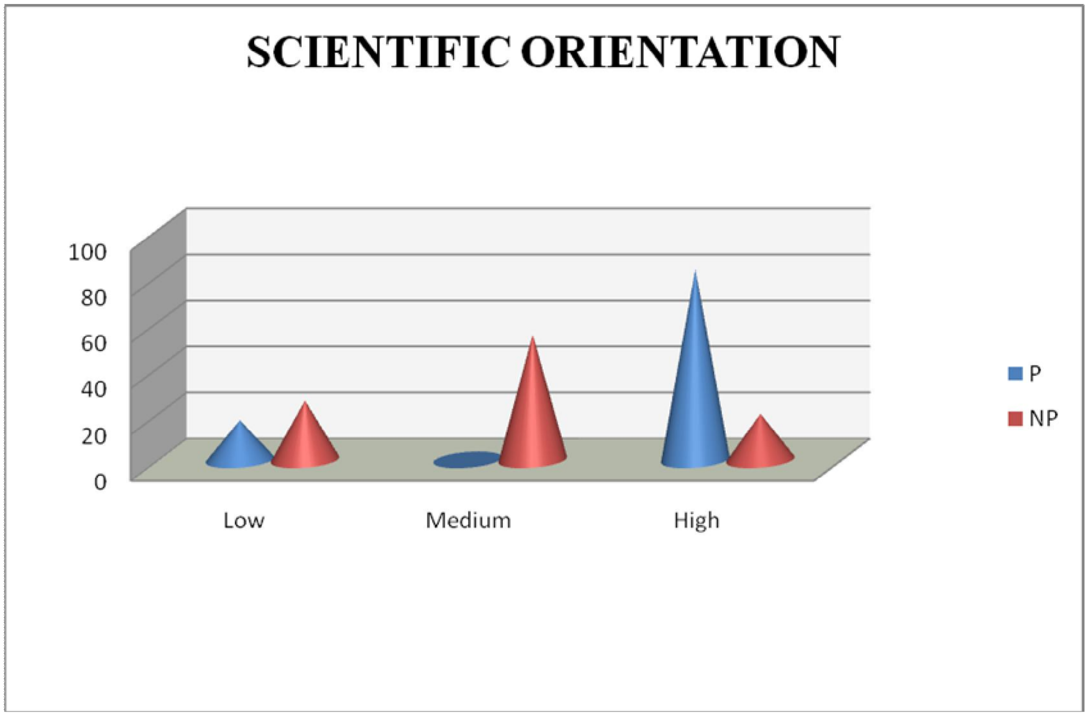


Fig. 11. Distribution of respondents according to their Scientific orientation

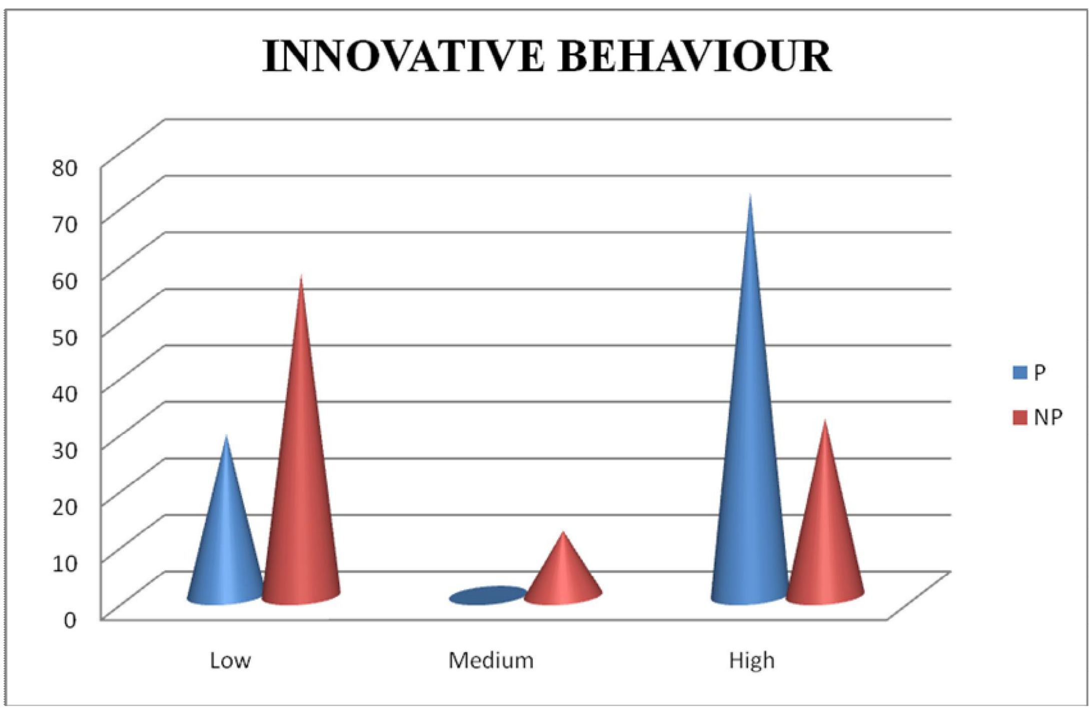


Fig. 12. Distribution of respondents according to their Innovative behaviour

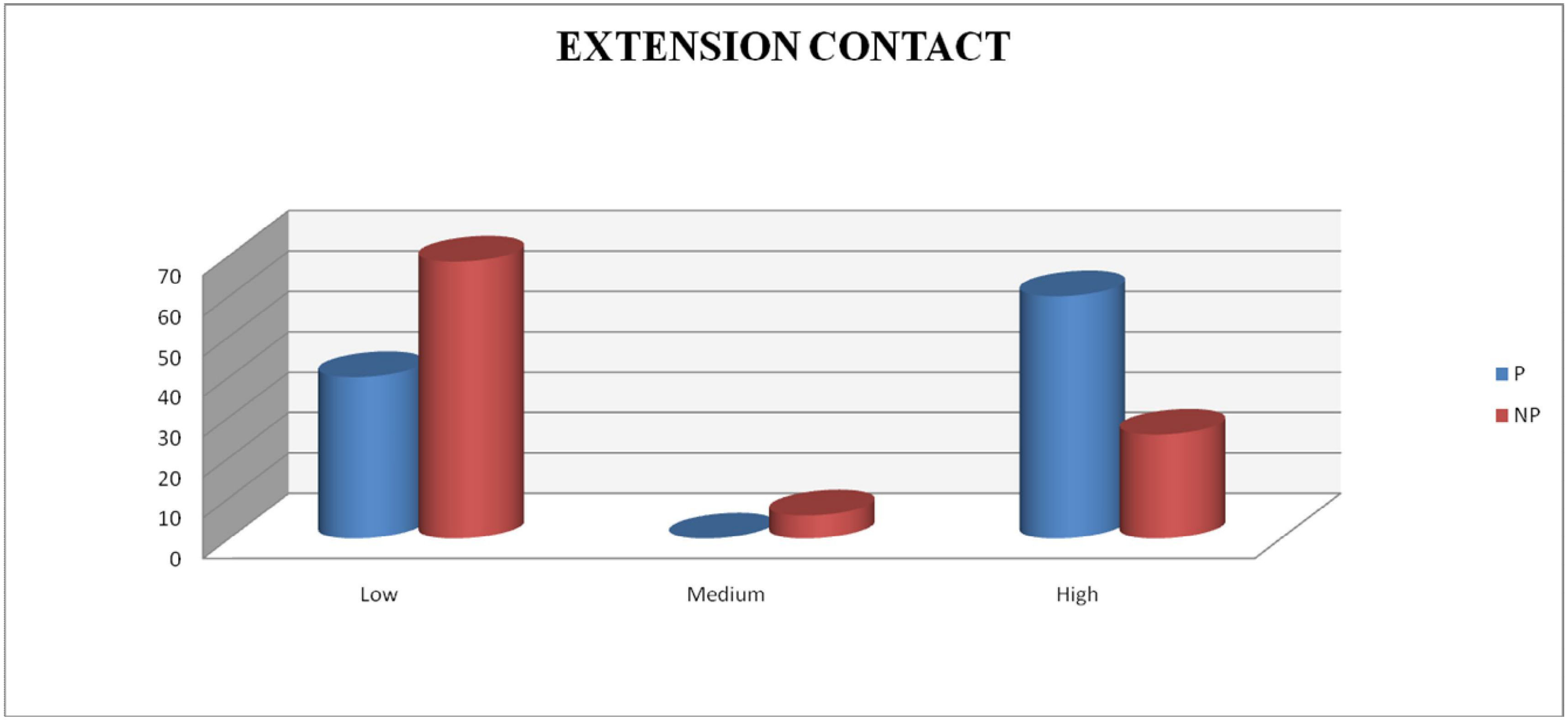


Fig. 13. Distribution of respondents according to their Extension contact

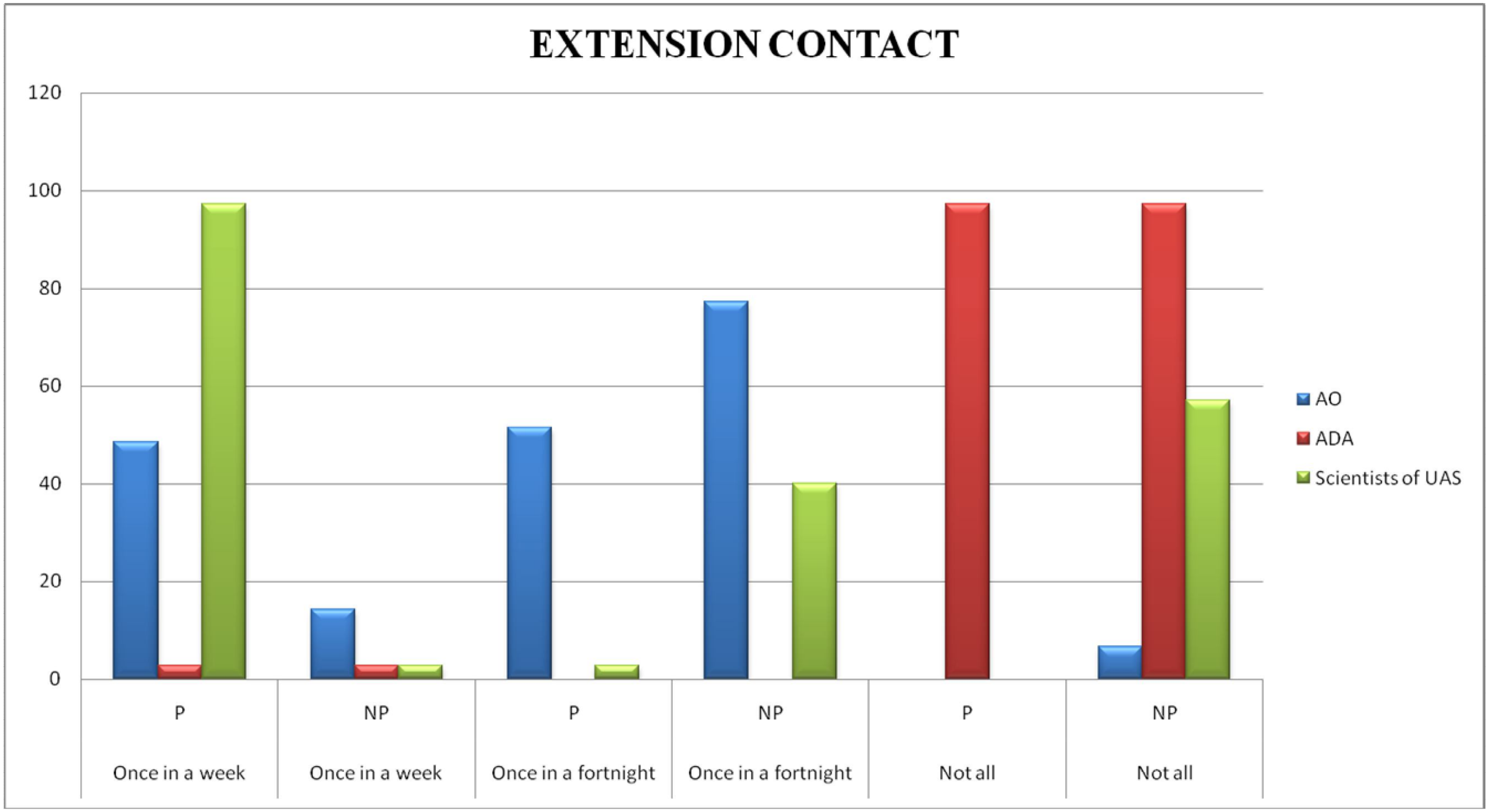


Fig.14. Extension contact of the respondents

4.1.15 Extension participation

The data presented in Table 4 revealed that, 45.71, 31.43, and 22.85 per cent of the participant had high, low and medium level of extension participation respectively while 54.29 22.86, and 22.86 of the non-participant had medium, low and high level of extension participation respectively. Furthermore, Table 5 revealed that cent per cent (100 %) of the participant farmers had attended training programme, field visit, group meetings and Krishi mela while 91.43 per cent of non-participant attended Agricultural exhibitions and krishi mela. Also, 82.85 per cent of the participant farmers attended demonstrations and field days while 2.85 per cent attended Educational tours. In the same vein, 85.71, 82.85, 77.14, 60.00, 51.43 per cent of the non-participant farmers attended training programmes, demonstrations, field days, field visit, and group meeting respectively, while none of them attended educational tours.

Furthermore, extent of participation of the participant and non-participant farmers were observed in Table 5 based on their participation regularly, occasionally or never participated. It was revealed that participant farmers participated regularly in training programme (82.85 %), demonstrations (51.43 %), field days (60.00 %), field visit (82.85 %), group meetings (60.00 %), agricultural exhibitions (71.43 %), krishi mela (100 %) and educational tours (2.95 %) while non-participant farmers participated regularly in training programmes (14.29 %), demonstrations (20.00 %), field days (14.29 %) field visit (11.42 %), group meetings (11.42 %), agricultural exhibitions (91.43 %), krishi mela (91.43 %) and none participated regularly in educational tours (0.00 %).

Also, occasionally participation of participant farmers was observed as *viz.*, training programme (22.50 %), demonstrations (31.43 %), field days (22.85 %), field visit (17.14 %), group meetings (40.00 %), agricultural exhibitions (11.43 %), while none participated occasionally in krishi mela (0.00 %) and educational tours (0.00 %). Also, the observation of non-participant farmers revealed the percentage of occasional participation in training programmes (71.43 %), demonstrations (62.86 %), field days (62.86 %) field visit (48.57 %), group meetings (40.00 %) and none participated occasionally in agricultural exhibitions (0.00 %), krishi mela (0.00 %) educational tours (0.00 %).

However, the percentage of participant farmers that never participated in extension activities was revealed *viz.*, training programme (0.00 %), demonstrations (17.14 %), field days (17.14 %), field visit (0.00 %), group meetings (0.00 %), agricultural exhibitions (17.14 %), krishi mela (0.00 %) and educational tours (97.14 %). Also, the percentage of non-participant farmers that never participated in extension activities was revealed *viz.*, training programme (14.29 %), demonstrations (17.14 %), field days (22.86 %), field visit (40.00 %), group meetings (48.57 %), agricultural exhibitions (8.57 %), krishi mela (0.00 %) and educational tours (100 %).

Table 4: Distribution of respondents according to their Extension participation

n = 70

Sl. No.	Category	Participant $n_1 = 35$		Non- Participant $n_2 = 35$	
		Frequency	Percentage	Frequency	Percentage
1	Low (Mean - 0.425*SD)	11	31.43	8	22.86
2	Medium (Mean ±.425*SD)	8	22.85	19	54.29
3	High (Mean + 0.425*SD)	16	45.71	8	22.86

$Mean_1$= 11.5 **SD_1**= 2.87; **$Mean_2$**= 8.28 **SD_2**=3.25

Table 5: Extension participation of the respondents

n =70

Sl. No.	Extension activities	Attended				Extent of participation											
						Regular				occasional				Never			
		P		NP		P		NP		P		NP		P		NP	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	Training Programme	35	100	30	85.71	29	82.85	5	14.29	6	22.50	25	71.43	0	0	5	14.29
2	Demonstratio ns	29	82.85	29	82.85	18	51.43	7	20.0	11	31.43	22	62.86	6	17.14	6	17.14
3	Field days	29	82.85	27	77.14	21	60.0	5	14.29	8	22.85	22	62.86	6	17.14	8	22.86
4	Field Visit	35	100	21	60.0	29	82.85	4	11.42	6	17.14	17	48.57	0	0.0	14	40.0
5	Group Meetings	35	100	18	51.43	21	60.0	4	11.42	14	40.0	14	40.0	0	0.0	17	48.57
6	Agricultural Exhibitions	29	82.85	32	91.43	25	71.43	32	91.43	4	11.43	0	0.0	6	17.14	3	8.57
7	Krish Mela	35	100	32	91.43	35	100	32	91.43	0	0.0	0	0.0	0	0.0	0	0.0
8	Educational Tours	1	2.85	0	0.0	1	2.95	0	0.0	0	0.0	0.0	0.0	34	97.14	35	100

F = Frequency % = Percentage P = Participants (n_1=35) NP = Non-participants (n_2 = 35)

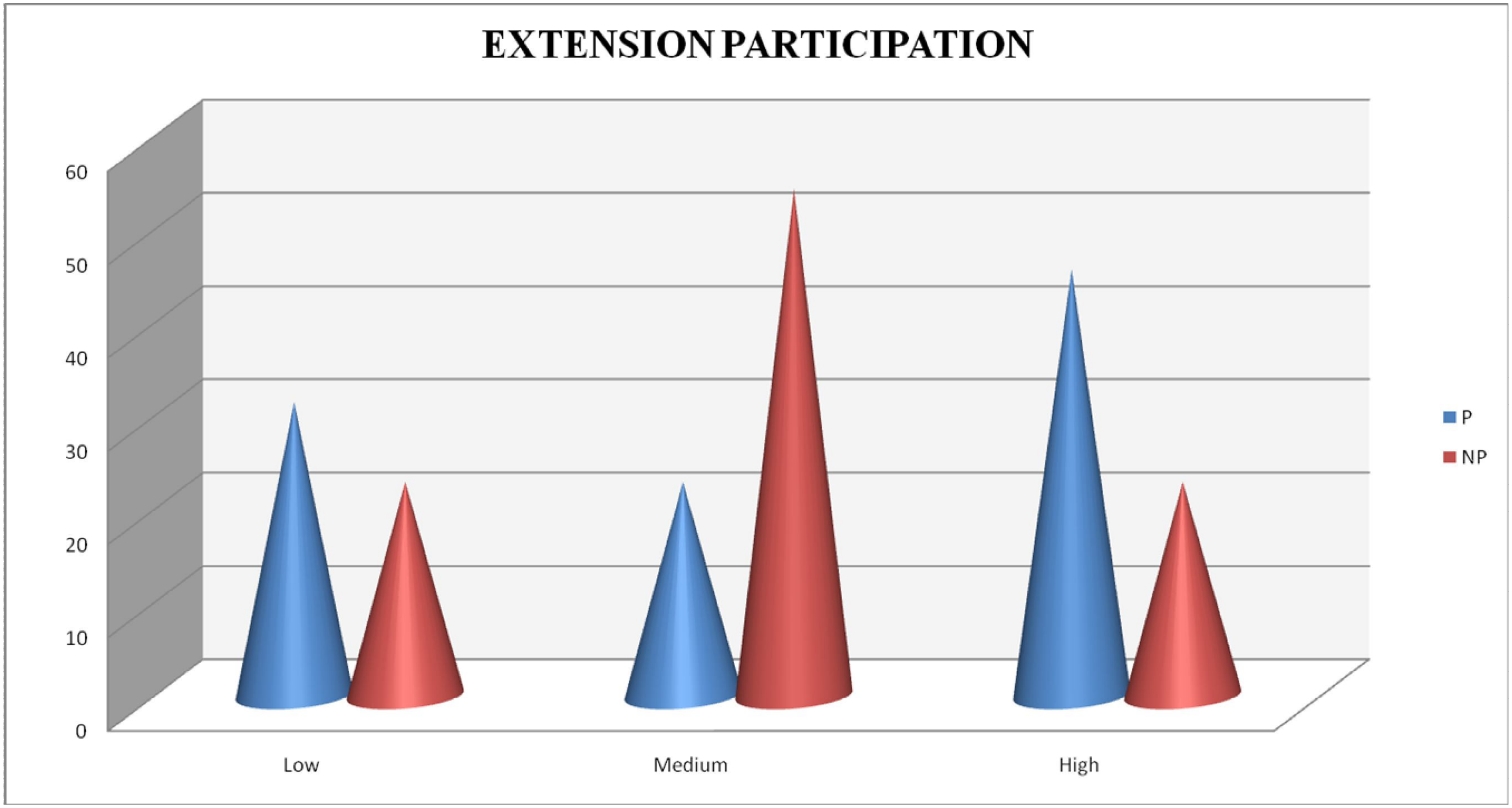


Fig. 15. Distribution of respondents according to their Extension participation

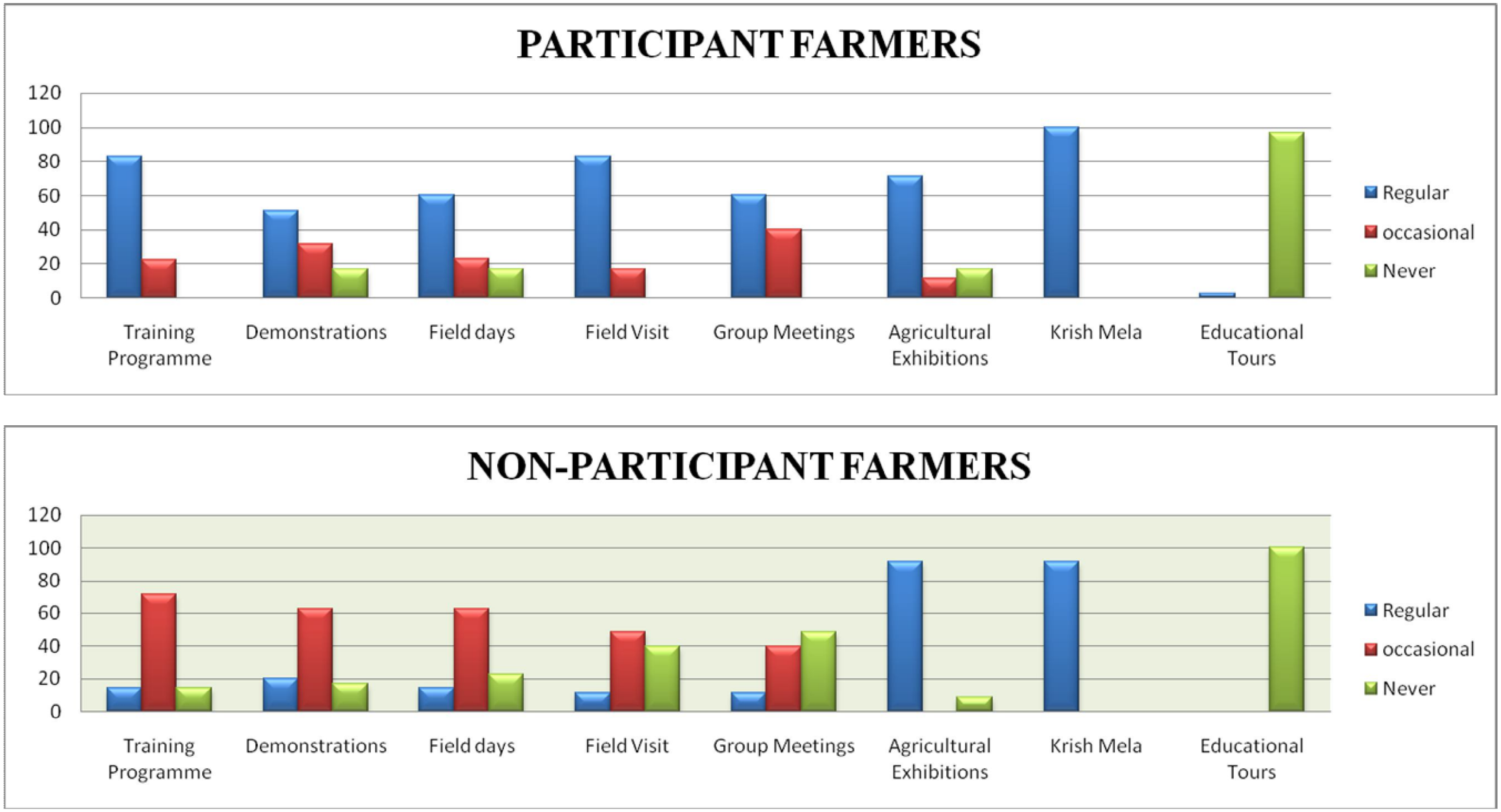


Fig. 16. Extension participation of the respondents

4.1.16 Mass media utilization

The data in Table 6 depicts the mass media utilization by the respondents. It was observed that, 74.29, 17.14 and 8.57 per cent of participant farmers had medium, high and low level of mass media utilization respectively. In the same vein, 48.57, 31.43, and 20.00 per cent of the non-participant farmers had medium, low and high level of mass media utilization respectively.

From Table 7, it was observed that Radio was possessed by 48.57 per cent of the participant farmers, whereas 17.14 and 28.57 per cent of them listened to radio everyday; 31.42 and 20.00 per cent listened once in a week while 51.42 and 51.42 per cent never listened to agricultural and general programmes respectively. In the same vein, it was observed that 28.57 per cent of non-participant farmers possessed radio whereas 25.74 and 28.57 per cent of them listened to radio everyday; 5.70 and 5.70 per cent listened once in a week while 68.57 and 65.71 per cent never listened to agricultural and general programmes respectively.

Also, the Table 7 revealed that, 94.28 per cent of participant farmers possessed Television whereas 65.71 and 94.28 per cent of them watched everyday; 28.57 and 0.00 per cent watched once in a week while 20.00 and 20.00 per cent never watched agricultural and general programmes respectively. In the same vein, it was observed that 80.00 per cent of non-participant farmers possessed television whereas 74.29 and 74.30 per cent of them watched everyday; 5.70 and 5.70 per cent watched once in a week while 20.00 and 20.00 per cent never watched agricultural and general programmes respectively.

Furthermore, the Table 7 revealed that, 17.14 per cent of participant farmers subscribed for News paper whereas 57.14 and 77.14 per cent of them read it every day, 34.29 and 22.85 per cent read it once in a week while 8.57 and 8.57 per cent never read it for agricultural and general programmes respectively. In the same vein, it was observed that 62.85 per cent of non-participant farmers subscribed for News paper whereas 14.28 and 28.57 per cent of them reads it every day; 2.86 and 22.85 per cent reads it once in a week while 83.00 and 37.10 per cent never read it for agricultural and general programmes respectively.

Table 6: Distribution of respondents according to their mass media utilization

n = 70

Sl. No.	**Category**	**Participant $n_1 = 35$**		**Non- Participant $n_2 = 35$**	
		Frequency	**Percentage**	**Frequency**	**Percentage**
1	Low (Mean - 0.425*SD)	3	8.57	11	31.43
2	Medium (Mean ±.425*SD)	26	74.29	17	48.57
3	High (Mean + 0.425*SD)	6	17.14	7	20.0

$Mean_1$=8.97 **SD_1**= 2.62; $Mean_2$=7.05 **SD_2**= 3.04

Table 7: Mass media utilization by the respondents

n = 70

Sl. No.	Mass media	Possessed /subscribed				Extent of use																			
						Everyday				Once in a week				Once in a fortnight				Once in a month				Never			
		P		NP		P		NP		P		NP		P		NP		P		NP		P		NP	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	Radio	17	48.6	10	28.6																				
	Agriculture					6	17.1	9	25.7	11	31.4	2	5.7	0	0.0	0	0.0	0.0	0.0	0	0.0	18	51.4	24	68.6
	General					10	28.6	10	28.6	7	20.0	2	5.7	0	0.0	0	0.0	0.0	0.0	0	0.0	18	51.4	23	65.7
2	Television	33	94.3	28	80.0																				
	Agriculture					23	65.7	26	74.3	10	28.6	2	5.7	0	0.0	0	0.0	0.0	0.0	0	0.0	2	5.7	7	20.0
	General					33	94.3	26	74.3	0	0	2	5.7	0	0.0	0	0.0	0.0	0.0	0	0.0	2	5.7	7	20.0
3	Newspaper	32	91.4	22	62.9																				
	Agriculture					20	57.1	5	14.3	12	34.3	1	2.9	1	2.9	1	2.9	0.0	0.0	0	0.0	3	8.6	29	82.9
	General					27	77.1	10	28.6	8	22.9	8	22.9	4	11.4	4	11.4	0.0	0.0	0	0.0	3	8.6	13	37.1
4	Magazine	6	17.1	0	0.0																				
	Agriculture					0	0.0	0	0.0	1	2.9	0	0.0	5	14.3	0	0.0	0.0	0.0	0	0.0	29	82.9	35	100
	General					0	0.0	0	0	0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0	0.0	29	82.9	35	100

F = Frequency % = Percentage P = Participants (n_1=35) NP = Non-participants (n_2 = 35)

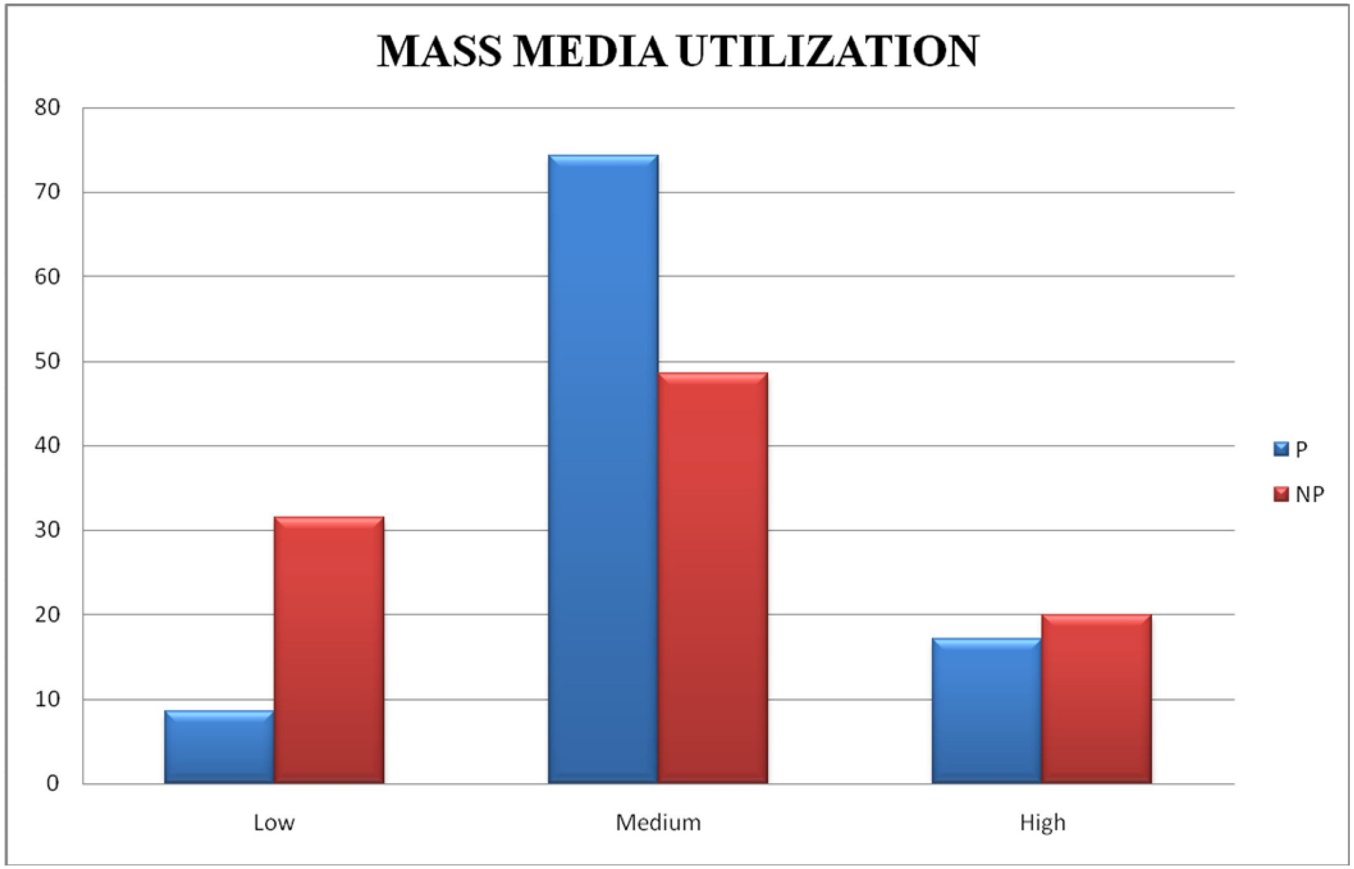
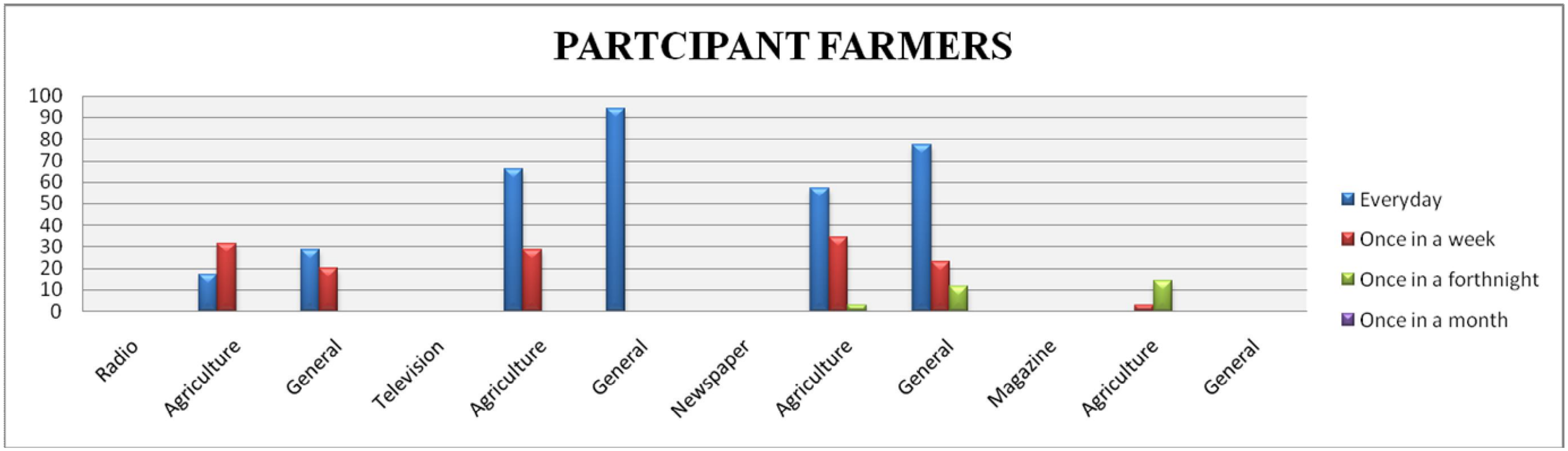


Fig. 17. Distribution of respondents according to their mass media utilization



PARTCIPANT FARMERS
100
90
80
70
60
50
40
30
20
10
0
Radio
Agriculture
General
Television
Agriculture
General
Newspaper
Agriculture
General
Magazine
Agriculture
General
Everyday
Once in a week
Once in a forthnight
Once in a month

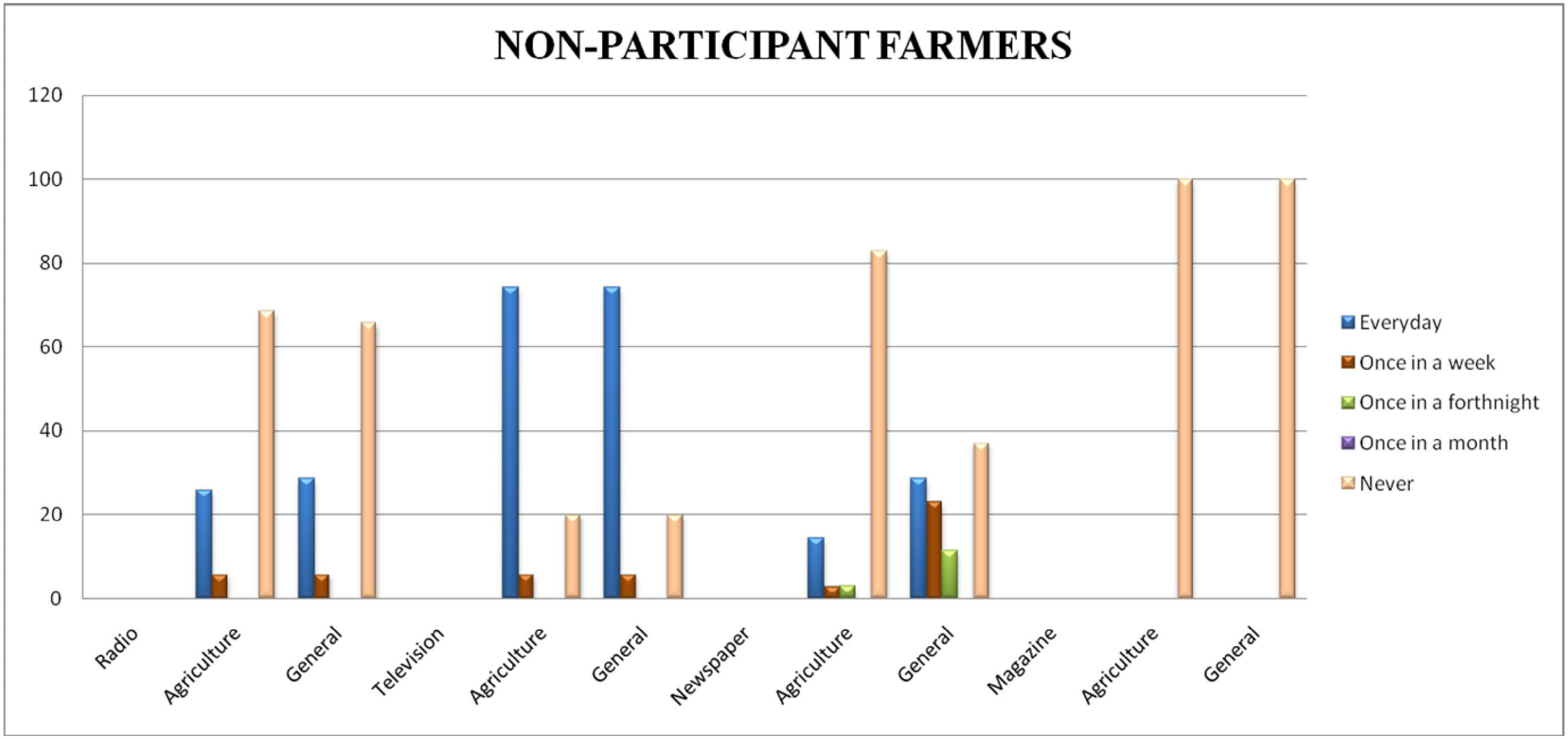


Fig.18. Mass media utilization of the respondents

However, 17.14 per cent of the participant famers subscribed for Magazine whereas 2.85 and 14.80 per cent of them reads it once in a week and once in a fortnight meanwhile 82.86 per cent of them never read it for agricultural and general programmes respectively. However it was observed that none of the participant (100 %) never subscribed or read magazine for agricultural and general programmes respectively.

4.1.17 Usage of precision farming technologies

Table 8 revealed the precision farming technologies already used by the participant farmers. The cent per cent of the participant farmers (100 %) reported that they have already used Grid Soil sampling, Global Positioning System (GPS), Geographic Information System (GIS), Variable Rate Applicators/ Techniques and crop sensors while none (0.00 %) of the participant farmers had used remote sensing and yield monitor.

4.1.18 Participation of respondents in precision farming activities

From Table 9, it was observed that cent per cent of the participant farmers had participated in deciding the grid, formation of grid size using GPS, soil sampling, variable rate application of fertilizer as well as harvesting in grids while 34.29 and 20.00 per cent participated in observation of crop characteristics and GIS map interpretation. However, none of the participant farmers (100 %) had participated in soil analysis and GIS mapping.

4.1.19 Future plan to use precision farming

It was evident from Table 10 that cent per cent of the participant farmers (100 %) plan to use all precision farming technologies in future. It was also observed that 34.29, 20.00, 5.71, 14.29, 14.29 and 17.14 per cent reported to plan to use Grid Soil sampling, Global Positioning System (GPS), Geographic Information System (GIS), Variable Rate Applicators/ Techniques, yield monitor and crop sensors respectively, while cent per cent was not planning to use remote sensing.

Table 8: Distribution of respondents according usage of precision farming technologies

n_1 =35

Sl. No.	Technologies	Frequency	Percentage
1	Grid soil sampling	35	100
2	Global positioning system (GPS)	35	100
3	Geographic information system (GIS)	35	100
4	Variable rate applicators/ techniques	35	100
5	Yield monitors	0	0
6	Remote sensing	0	0
7	Crop sensors	35	100

Table 9: Distribution of respondents according to their participation in Precision farming activities

n_1 =35

Sl. No.	Activities	Frequency	Percentage
1	Deciding the grid size	35	100
2	Formation of grid size using GPS	35	100
3	Soil sampling	35	100
4	Soil analysis	0	0.0
5	Observation of crop characteristics	12	34.29
6	GIS mapping	0	0.0
7	GIS map interpretation	7	20.0
8	Variable rate application of fertilizers	35	100
9	Harvesting according to grids	35	100

Table 10: Distribution of respondents according to plan to use precision farming technologies

n = 70

Sl. No.	Technologies	Plan to use	Participant n_1 =35		Non – Participant n_2 =35	
			F	%	F	%
1	Grid soil sampling	Yes	35	100	12	34.29
		No	0	0.00	23	65.71
2	Global positioning system (GPS)	Yes	35	100	7	20.00
		No	0	0.00	28	80.00
3	Geographic information system (GIS)	Yes	35	100	2	5.71
		No	0	0.00	33	94.29
4	Variable rate applicators/ techniques	Yes	35	100	5	14.29
		No	0	0.00	30	85.71
5	Yield monitors	Yes	35	100	5	14.29
		No	0	0.00	30	85.71
6	Remote sensing	Yes	35	100	0	0.00
		No	0	0.00	35	100
7	Crop sensors	Yes	35	100	6	17.14
		No	0	0.00	29	82.86

F = Frequency, % = Percentage

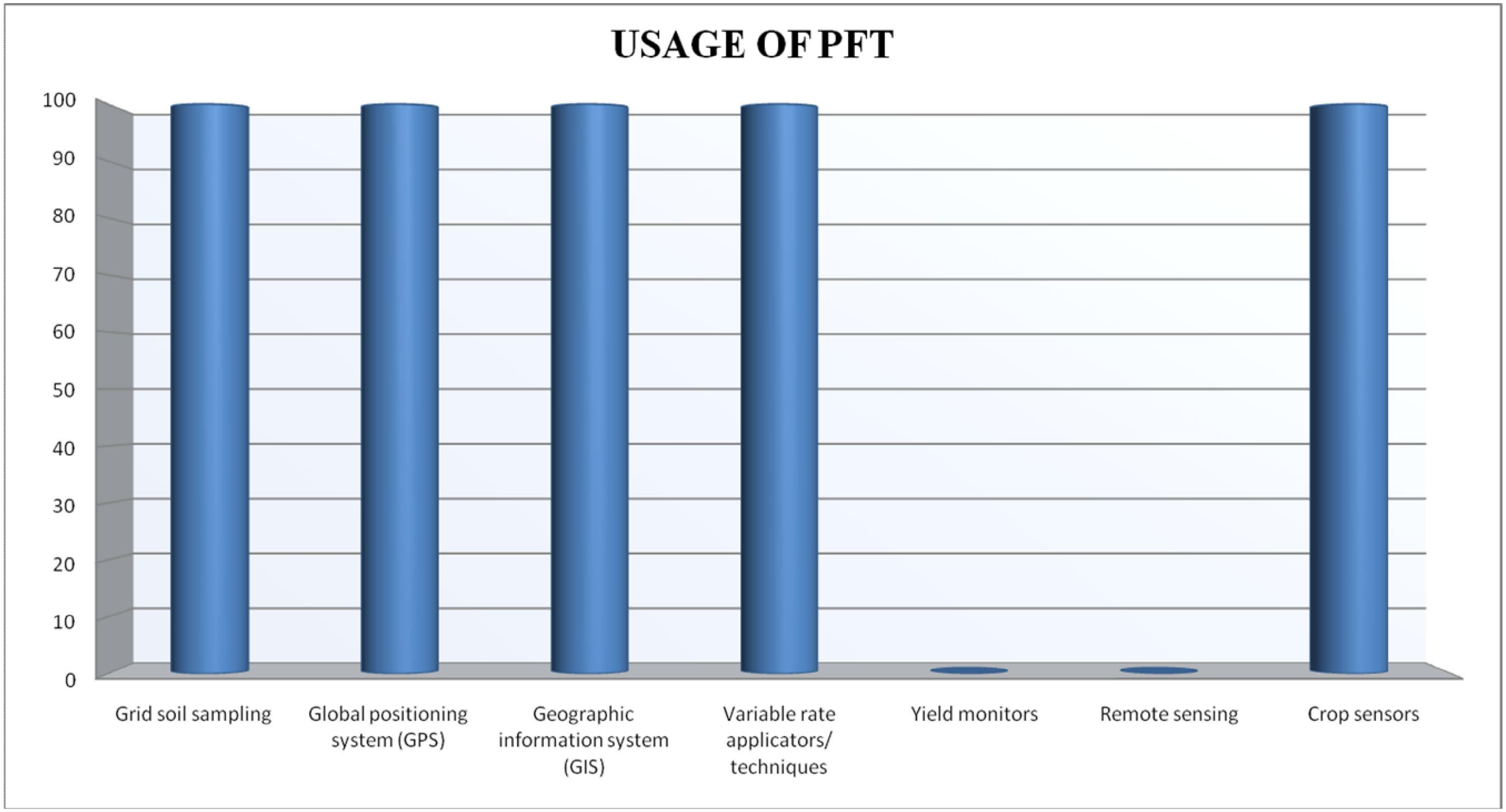


Fig. 19. Distribution of respondents according usage of precision farming technologies

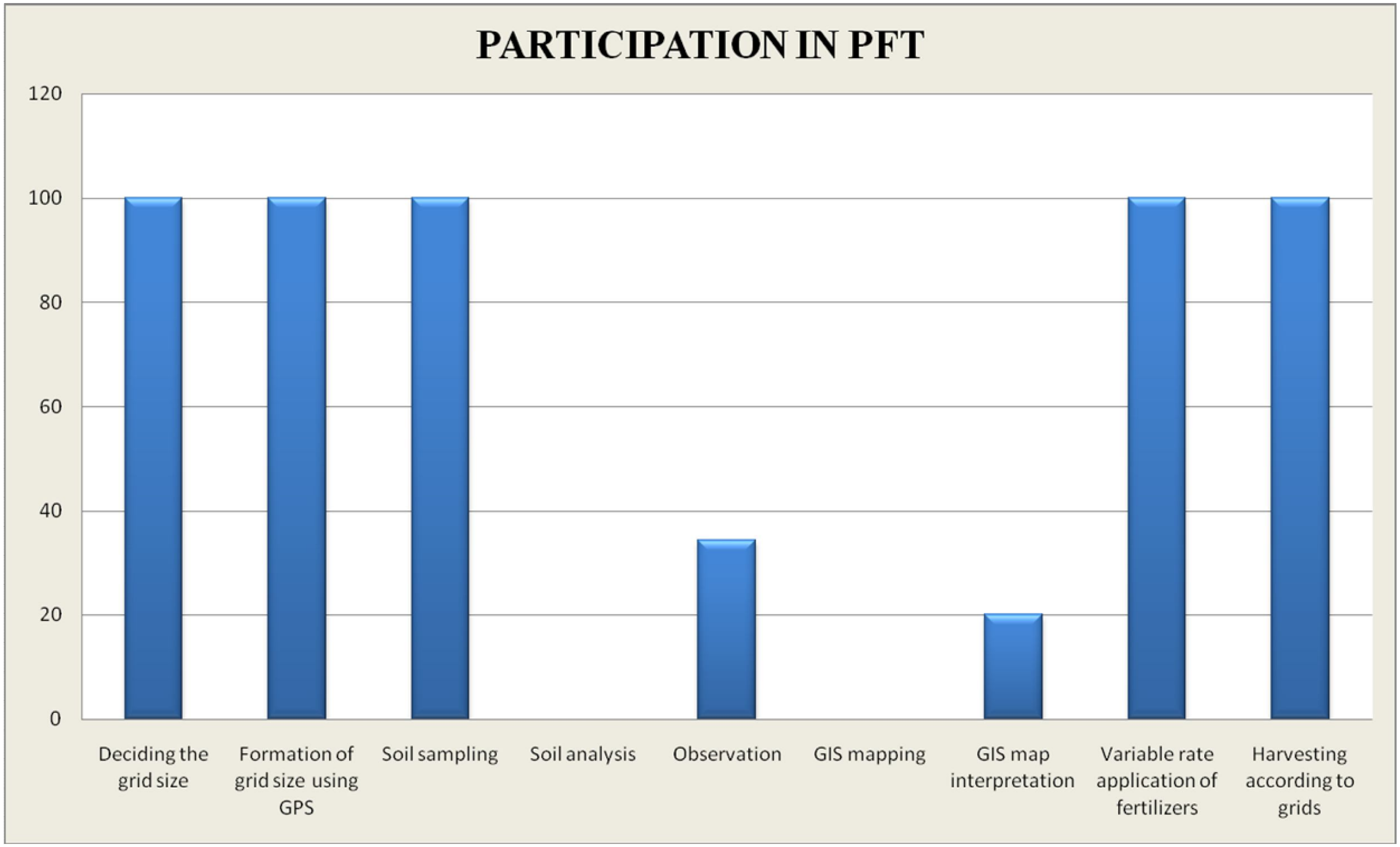


Fig. 20. Distribution of respondents according to their participation in precision farming technologies

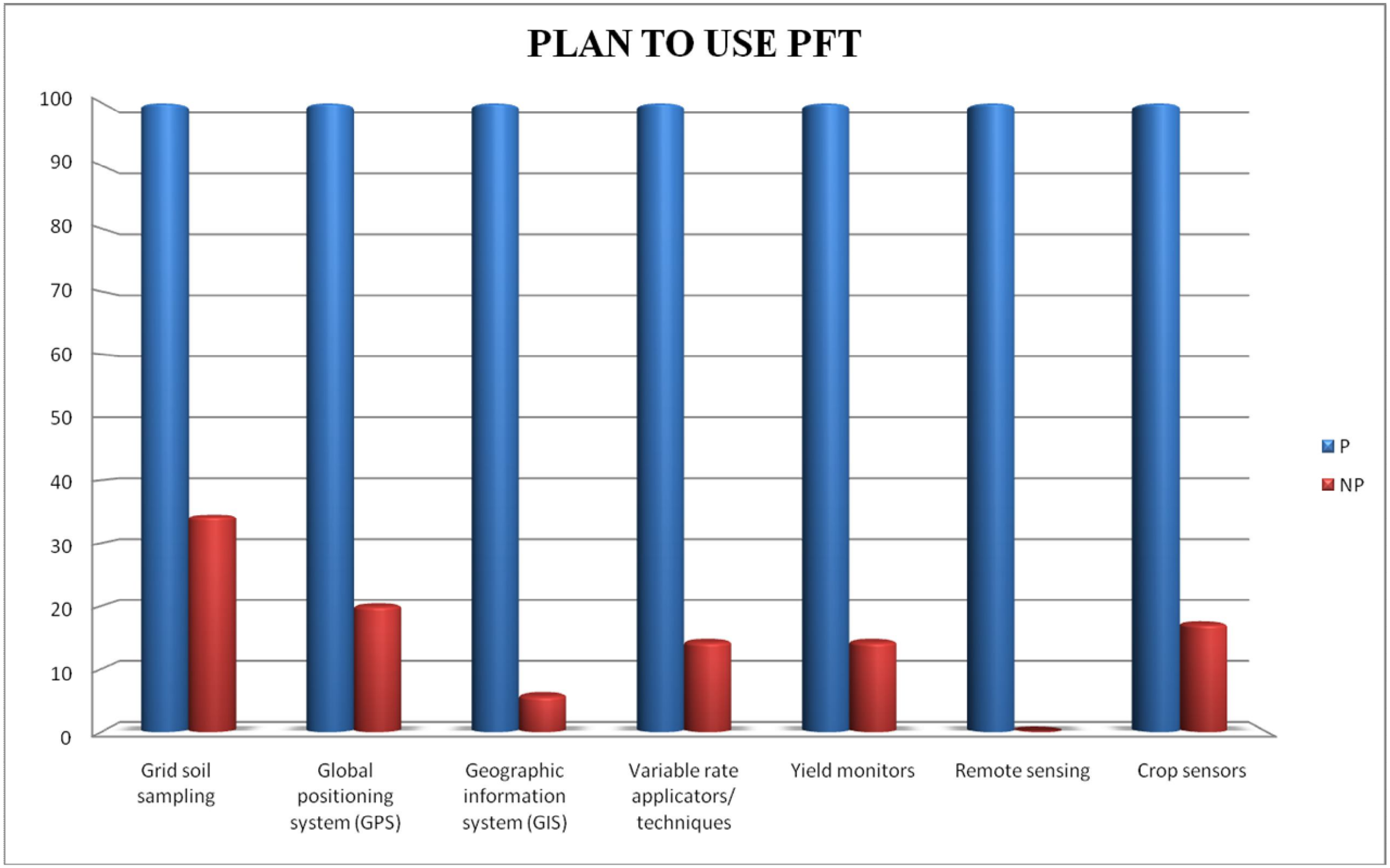


Fig. 21. Distribution of respondents according to their participation and plan to use precision farming technologies

4.2 Farmers perception towards precision farming technologies in selected crops

4.2.1 Overall perception of participant farmers towards precision farming technologies

It was observed from the data in Table 11 that 40.00 per cent had more favourable perception about precision farming technology while 31.43 per cent of the participant farmers had medium favourable perception and 28.57 per cent had less favourable perception. The mean perception score of the respondents was 78.79.

4.2.2 Statement wise perception of the respondents about precision farming technologies

An appraisal of Table 12 revealed that individual farmers had perception about precision farming technologies based on their personal opinion of the technologies. It was evident from the perception of benefits of precision farming technologies that 82.86 per cent of the respondents strongly agree that precision farming will increase the yield while 17.14 agrees with the statement. The reason for this high level of agreement to the perception might be from their increase in yield experienced by the farmers as seen is believing. In the same vein, 80.00 per cent strongly agree that precision farming technologies can save input such has fertilizers while 17.14 per cent were undecided followed by 2.85 per cent which agrees with the statement. Also, cent per cent of the respondents strongly agrees that precision farming can minimize the cost of cultivation.

On perceived usefulness of precision farming technologies, 71.43 and 28.57 per cent strongly agree and agree respectively that precision farming technologies will be useful for them. Also, 62.86 per cent of the respondents agree that precision farming technologies will provide relative information for decision making on their farm while 37.14 per cent were undecided. However, more than half (57.14 %) of the respondents agrees that precision farming technologies will reduce environmental hazards and soil health problem caused by blanket use of resources while 42.86 per cent disagrees with the perception.

Furthermore from the table, it was reported by cent per cent of the respondents that they are strongly agree to the perception of ease of use of precision farming technologies. This was followed by 80.00 per cent which strongly agree that it will be easy to learn how to use precision farming technologies while 17.14 and 2.86 per cent agrees and undecided respectively on ease of learning of precision farming technologies. Also, 85.71 per cent of the respondents agree that they would be able to remember how to perform task using precision farming technologies while 14.29 per cent strongly agree.

On the barriers to plans to use precision farming technologies, cent per cent of the respondents strongly agree that Precision farming technologies requires sophisticated equipments while about half of the respondents strongly disagree that Precision farming technologies are more suited to educated farmers followed by 25.71 per cent who agrees with the perception and 17.14 per cent disagree. Also, perception that Precision farming technologies demands more labour was agreed to by about half (51.43 %) of the respondents while 48.57 per cent strongly agrees.

Table 11: Overall perception level of the respondents about precision farming technologies

n = 35

Sl. No.	Category	Frequency	Percentage
1	Less favourable (Mean - 0.425*SD)	10	28.57
2	Medium favourable (Mean ±.425*SD)	11	31.43
3	More favourable (Mean + 0.425*SD)	14	40.00

Mean=78.79 **SD**=12.38

Table 12: Distribution of the respondents according to their statement wise perception about precision farming technologies

n = 35

Sl. No.	Perception Statements	SA	A	U	D	SD
1	**Benefits of precision farming technologies**					
	Precision farming technologies increase the yields	29 (82.86)	6 (17.14)	0 (0.00)	0 (0.00)	0 (0.00)
	Precision farming technologies saves input such as fertilizers	28 (80.00)	1 (2.85)	6 (17.14)	0 (0.00)	0 (0.00)
	Precision farming technologies minimized the cost of cultivation	35 (100)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
2	**Usefulness of precision farming technologies**					
	Precision farming technologies is useful for me	25 (71.43)	10 (28.57)	0 (0.00)	0 (0.00)	0 (0.00)
	Precision farming technologies provides relative information for decision making	0 (0.00)	22 (62.86)	13 (37.14)	0 (0.00)	0 (0.00)
	PFT reduces environmental hazards and soil health problem caused by blanket use of resources	0 (0.00)	20 (57.14)	0 (0.00)	15 (42.86)	0 (0.00)
3	**Ease of use of precision farming technologies**					
	Precision farming technologies is easy to use	35 (100)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
	It is easy to learn how to use precision farming technologies	28 (80.00)	6 (17.14)	1 (2.86)	0 (0.00)	0 (0.00)
	I am able to remember how to perform task using precision farming technologies	5 (14.29)	30 (85.71)	0 (0.00)	0 (0.00)	0 (0.00)
4	**Barriers to plans to use precision farming technologies**					
	Precision farming technologies requires sophisticated equipments	35 (100)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
	Precision farming technologies are more suited to educated farmers	0 (0.00)	9 (25.71)	0 (0.00)	6 (17.14)	20 (57.14)
	Precision farming technologies demands more labour	17 (48.57)	18 (51.43)	0 (0.00)	0 (0.00)	0 (0.00)

Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D), Strongly disagree (SA)

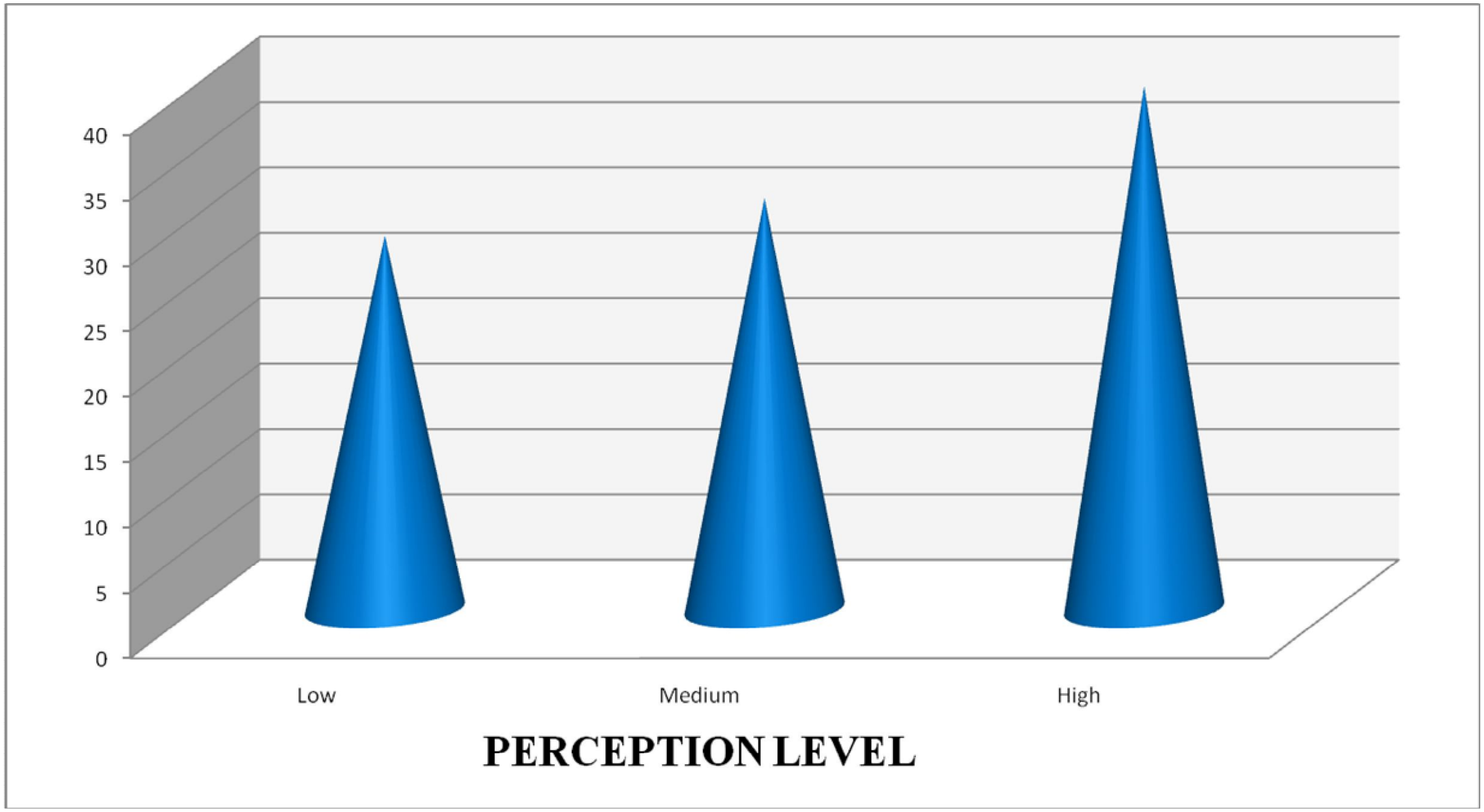


Fig 22. Overall perception level of the respondents about precision farming technologies

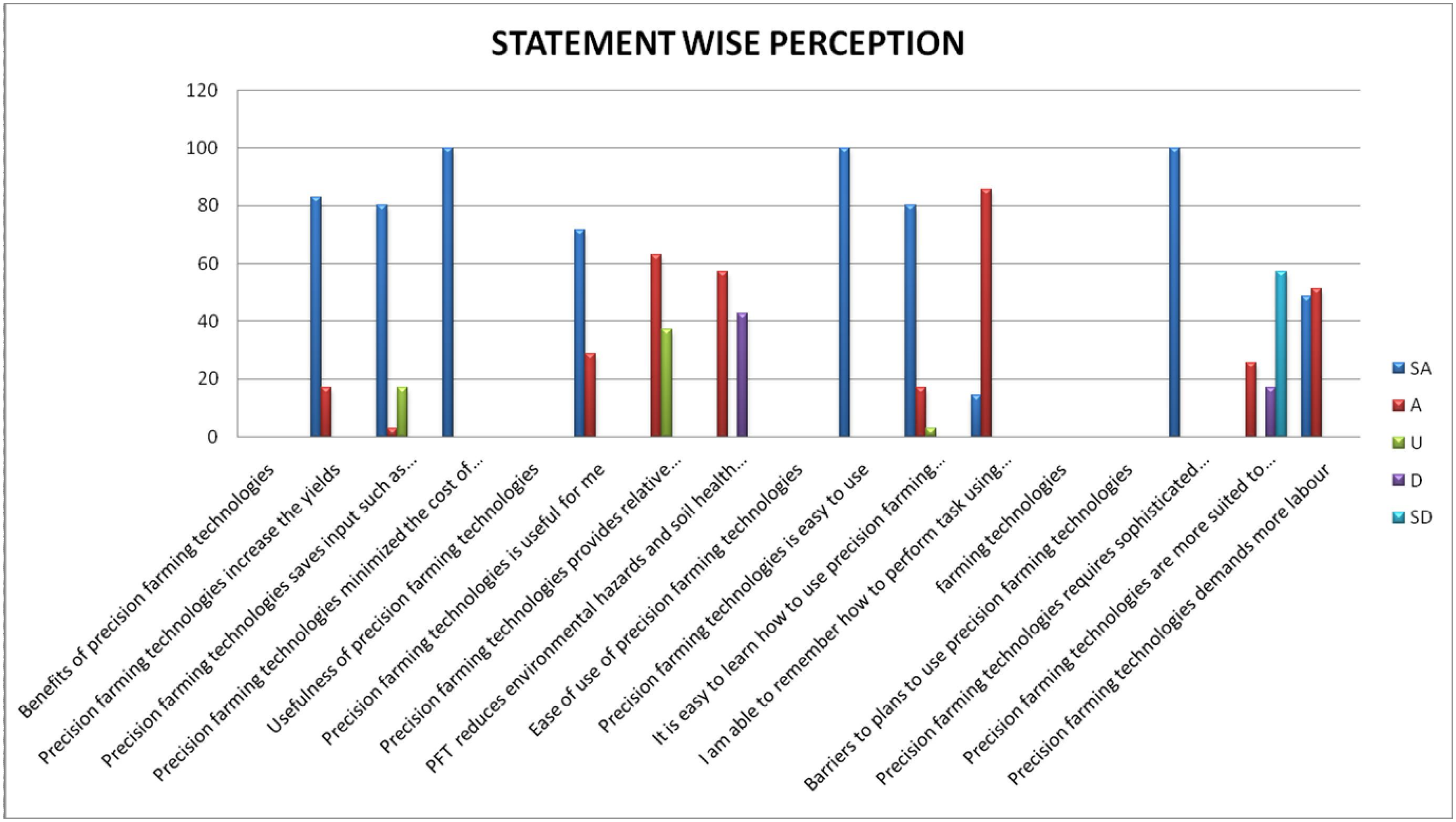


Fig. 23. Distribution of the respondents according to their statement wise perception about precision farming technologies

4.3 Knowledge level of participant farmers about precision farming technologies in selected crops

4.3.1 Overall knowledge level of participant farmers towards precision farming technologies

Table 13 revealed the knowledge level of the participant farmers about precision farming technology. It was evident that 45.71 per cent were in medium knowledge level category followed by 28.57 and 22.86 per cent in the high and low level of knowledge about precision farming technology respectively.

4.3.2 Component wise knowledge level of the respondents about precision farming technologies

From Table 14, it was evident that cent percent had a understanding about precision farming technologies while 94.28 per cent had understanding of the farming technologies components. Also, 45.71 per cent of the respondents had understanding of the variability types in their field. Also about the knowledge of soil sampling technique, cent per cent had knowledge about seasonal sampling while 34.28 per cent had knowledge about grid sampling and management zone. Furthermore, 97.14 per cent of the respondent had knowledge about soil sampling depth, grid area for sampling (100 %) and soil analysis parameter (25.71 %). On the knowledge of variable application of input, cent per cent (100%) had knowledge about STRC variable application of fertilizer and pest and diseases variation across grids while 54.28 per cent had knowledge and followed plant protection measures accordingly. Also about knowledge of sensors and its application, 82.86 per cent had knowledge about uses of green seeker. Also, 57.14 per cent of the respondents were able to identify sensors correctly while 45.71 per cent had knowledge of the procedures to take readings with ceptometer.

4.4 Resource utilization pattern in precision farming in comparison with conventional farmers' practice in selected crops

4.4.1 Resource utilization pattern in precision farming in comparison with conventional farmers' practice in cotton crops

It was evident from Table 15 that, the average mean of seed rate used by the participant and non-participant famers are 1685.5g/ ha and 1848.2g/ ha respectively. Also

Table 13: Overall knowledge level of the respondents about precision farming technologies

n = 35

Sl. No.	Category	Frequency	Percentage
1	Low (Mean - 0.425*SD)	8	22.86
2	Medium (Mean ±.425*SD)	16	45.71
3	High (Mean + 0.425*SD)	10	28.57

Mean=19.2 **SD**= 3.31

Table 14: Component wise knowledge level of the respondents about precision farming technologies

n = 35

Sl. No.	Particulars	Knowledge level	
		Frequency	**Percentage**
1	**Introduction to precision farming practices**		
	Farmers understanding of precision farming	35	100
	Types of variability (Spatial and temporal)	16	45.71
	Precision farming technologies components	33	94.28
2	**Soil sampling technique**		
	Seasons sampling	35	100
	Grid soil sampling and Management zone	12	34.28
	Soil sampling depth (0-20cm)	34	97.14
	Grid area for sampling (50x50 m)	35	100
	Soil analysis parameters	9	25.71
3	**Variable rate application of input**		
	STRC variable application of fertilizer	35	100
	Plant protection measures	19	54.28
	Knowledge of pest and disease variation across grids	35	100
4	**Sensors and their applications**		
	Identification of sensors	20	57.14
	Reading procedures on ceptometer	16	45.71
	Use of Green seeker	29	82.86

Table 15: Comparison of resource utilization pattern in precision and conventional farming in cotton

n=14

Sl. No.	Resource utilization	Participant ($n_1 = 7$)	Non-participant ($n_2 = 7$)	t
1	Seed Rate (g/ ha)	1687.50	1848.20	1 NS
2	Manures (t/ ha)	7.14	0.00	2.83*
3	Labour (Human days / ha)	101.38	64.78	4.71**
4	Plant protection Chemical (g/ ha)	3602.50	8065.47	8.15**
5	Nitrogen (kg/ ha)	316.06	211.31	3.61**
6	Phosphorus (Kg/ ha)	476.53	211.31	5.38**
7	Potassium (kg/ ha)	538.24	80.36	14.48**
8	Bio fertilizer (g/ ha)	4682.53	1059.52	6.52**
9	Micro Nutrients (g/ ha)	2500.00	0.00	**NS**

** Coefficient significant at 1% level of significance

* Coefficient significant at 5% level of significance

Table 16: Comparison of resource utilization pattern in precision and conventional farming in Pigeon pea

n = 22

Sl. No.	Resource utilization	Participant ($n_1 = 11$)	Non-participant ($n_2 = 11$)	t
1	Seed Rate (g/ ha)	12500.00	12500.00	NS
2	Manures (t/ ha)	3.00	1.95	2.44*
3	Labour (Human days/ ha)	130.00	115.00	NS
4	Plant protection Chemical (g/ ha)	4200.00	5162.72	26.33**
5	Nitrogen (kg/ ha)	1.86	79.54	4.93**
6	Phosphorus (Kg/ ha)	86.98	90.91	0.28 NS
7	Potassium (kg/ ha)	49.63	125.00	25.33**
8	Herbicides	4075.00	5081.36	30.71**

** Coefficient significant at 1% level of significance

* Coefficient significant at 5% level of significance

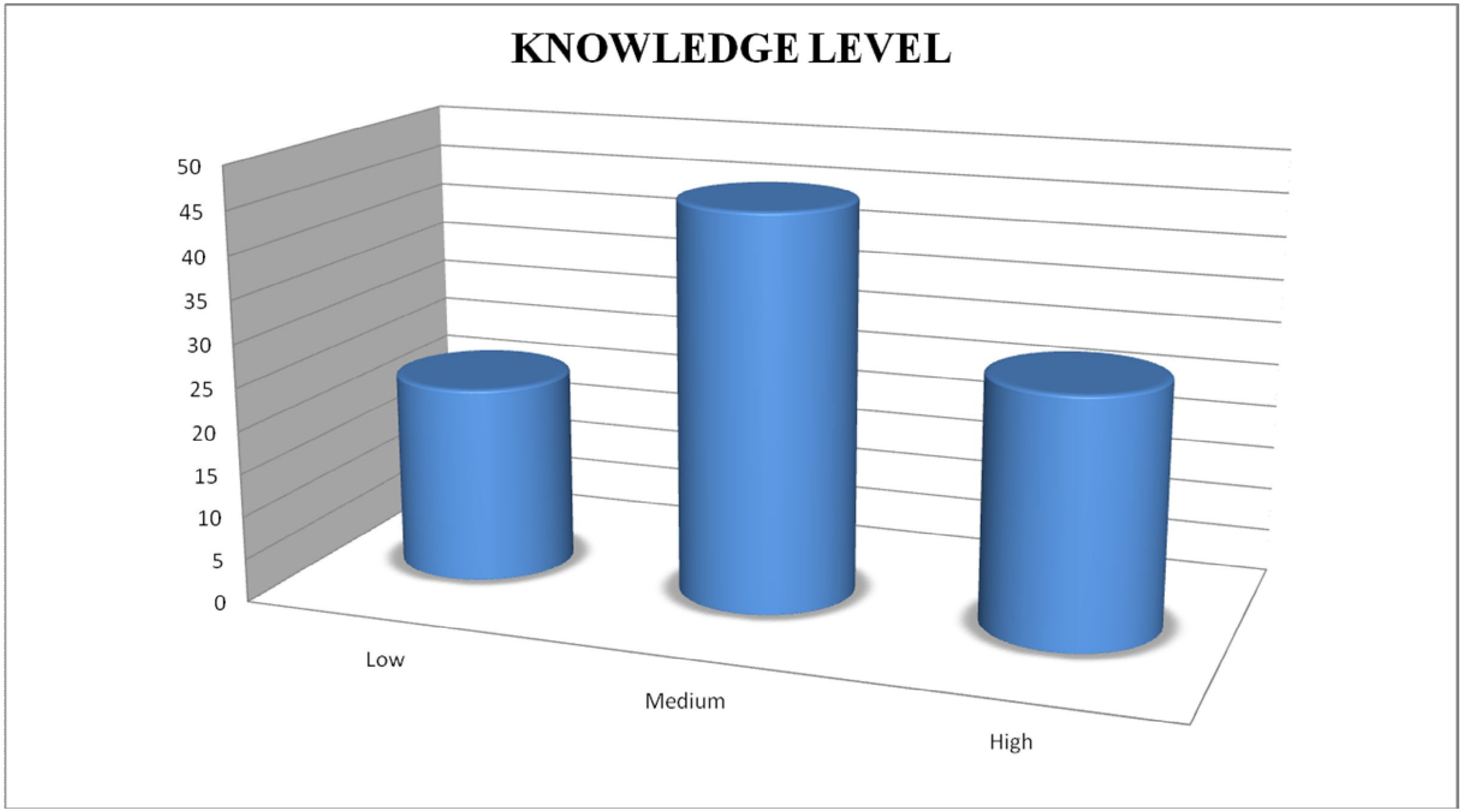


Fig 24. Overall knowledge level of the respondents about precision farming technologies

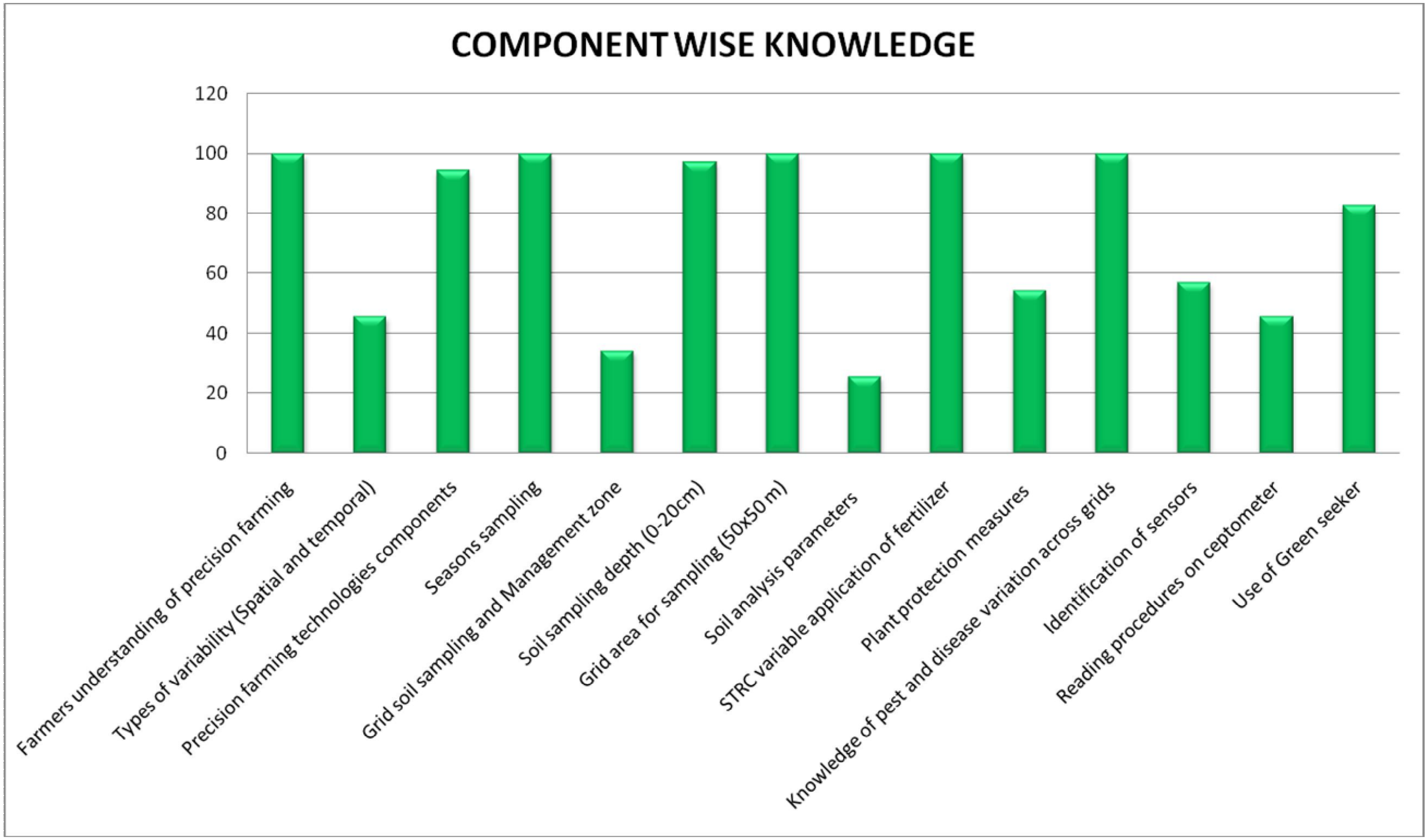


Fig. 25. Component wise knowledge level of the respondents about precision farming technologies

the average mean of manures used by the participant farmers is 7.14 tonnes/ ha while the non-participant farmers reported that they did not apply manures to their cotton field. Also the average mean of labour employed the participant and non-participant famers during the cotton production period were reported as 101.38 human days/ ha and 64.78 human days/ ha respectively. It was also observed that the average mean of plant protection chemicals used by the participant and non-participant cotton farmers was 3602g/ha and 8065.47g/ ha respectively.

Furthermore, the Table 15 shows the fertilizer utilization of the participant and non-participant cotton farmers. The average mean of Nitrogen fertilizer applied by the participant and non-participant cotton farmers was 316.06kg/ ha and 211.31kg/ ha respectively. It was revealed that the average Phosphorus fertilizer applied by the participant and non-participant cotton farmers was 476.53kg/ ha and 211.31 respectively. Also, the average mean of Potassium fertilizer applied by the participant and non-participant cotton farmers was 538.24kg/ ha and 80.36kg/ ha respectively. Also, the average mean of bio-fertilizer applied by the participant and non-participant cotton farmers was reported as 4682.53g/ ha and 1059.52g/ ha. It was also revealed that the average micro-nutrients applied by the participant cotton farmers was 2500g/ ha while the non-participant cotton farmers reported none. Moreover, the t-test statistics results of compared means revealed that labour, plant protection chemicals, Nitrogen fertilizer, Phosphorus fertilizer potassium fertilizer and bio-fertilizer were significant at 1 per cent while seed rate was non-significant and micro nutrient was not statistically testable as the standard deviation was zero.

4.4.2 Resource utilization pattern in precision farming in comparison with conventional farmers' practice in pigeon pea crop

It was observed from Table 16 that, participant and non-participant had same average mean of seed rate used (12,500g/ ha). Also the average mean of manures used by the participant farmers is 3.0 tonnes/ ha while the non-participant cotton farmers was 1.95 tonnes/ ha. Also the average mean of labour employed the participant and non-participant famers during the pigeon pea production period was reported as 130 human days /ha and 115 human days /ha respectively. It was also observed that the average mean of plant protection chemicals used by the participant and non-participant pigeon pea farmers was 4200g/ha and 5162.72/ha respectively.

The average mean of Nitrogen fertilizer applied by the participant and non-participant pigeon pea farmers was 1.86kg/ ha and 79.54kg/ ha respectively. It was revealed that the average Phosphorus fertilizer applied by the participant and non-participant pigeon pea farmers was 86.98kg/ ha and 90.91kg/ ha respectively. Also, the average mean of Potassium fertilizer applied by the participant and non-participant pigeon pea farmers was 49.63kg/ ha and 125kg/ ha respectively. The t-test statistics results of compared means revealed that plant protection chemicals, Nitrogen fertilizer, potassium fertilizer and herbicides were significant at 1 per cent while manure was significant at 5 per cent and Phosphorus was non-significant. Seed rate and labour were not statistically testable as the standard deviation was zero.

4.4.3 Resource utilization pattern in precision farming in comparison with conventional farmers' practice in paddy crop

It was evident from Table 17 that the, average mean of seed rate for participant and non-participant paddy farmers were 72941g /ha and 73823.53g/ ha. Also the average mean of manures used by the participant farmers is 30.35tonnes/ha while the non-participant paddy farmers was 27.94 tonnes/ ha. The average mean of labour employed the participant and non-participant famers during the paddy production period were reported as 123.5 human days /ha and 118 human days /ha respectively. It was also observed that the average mean of plant protection chemicals used by the participant and non-participant paddy farmers was 6618.94g/ ha and 10220.56g/ ha respectively.

Furthermore, it was revealed in Table 17 that average mean of Nitrogen fertilizer applied by the participant and non-participant paddy farmers was 289.01kg/ ha and 378.64kg/ ha respectively. It was revealed that the average Phosphorus fertilizer applied by the participant and non-participant farmers was 93.81kg/ ha and 298.53kg/ ha respectively. Also, the average mean of Potassium fertilizer applied by the participant and non-participant farmers was 97.95kg/ ha and 360.29kg/ ha respectively. Also, the average mean of machines used by the participant and non-participant paddy farmers was reported as 12,250 Rs./ ha and 12,250 Rs./ ha. The t-test statistics results of compared means revealed that plant protection chemicals, Nitrogen fertilizer, Phosphorus fertilizer and potassium fertilizer were significant at 1 per cent while seed rate and manure were non-significant. Labour and machines were not statistically testable as the standard deviation was zero.

4.4.4 Yield comparison of precision farming with conventional farmers' practice in selected crops

Table 18 reveals the yield comparison of precision farming and convectional farmer practices in selected crop. It was clear that the yield in precision farming is more compare to convectional farmers practice. The average mean of yield for participant farmers in pigeon pea, cotton and paddy were 12.86kg/ ha, 34.64kg/ ha and 97.08kg/ ha respectively while non-participant farmers recorded 9.42kg/ ha, 32.98kg/ ha and 80.34kg/ ha respectively. The t-test statistic reveals that yield of pigeon pea and paddy is significant at 1 per cent while that of cotton is non-significant.

4.5 Factors responsible for future plan to use precision farming technology

Table 19 revealed the result of logistic regression to determine the factors responsible for future plan to use precision farming technology by the respondents. It was observed that, level of extension contact as well as respondents' scientific orientation were positively significant at 10 per cent to the likelihood of future plan to use precision farming technologies with estimates of 0.85 and 0.43 respectively while farmer's years of experience was negatively significant at 5 per cent with estimates of 0.2. Also, explanatory variable such as years of formal education, level of extension participation and risk orientation were statistically positive but not significant to the likelihood of future plan to use precision farming technologies with estimates of 0.13, 0.20 and 0.11 respectively. However, explanatory variables such as size of land holding and yield were statistically negative but not significant to the likelihood of future plan to use precision farming technologies with estimates of 0.05 and 0.09 respectively.

4.6 Constraints by participant and non-participant famers in plan to use precision farming technologies.

Table 20 revealed the constraints faced by participant and non-participant famers in plan to use precision farming technologies. The major production constraints encountered by the participant farmers were high rate of wages for labourers, shortage of labours and high cost of inputs as these was reported by the entire participant farmers (100 %). The other production constrains reported were uneconomic land holding for plan to use precision farming technologies (62.85 %), low supply of electricity (54.29 %), lack of water availability and pumping efficiency (51.43 %), lack of technical skill to follow precision farming recommendations (42.85 %), non availability of input in time

(37.14%), lack of advisory services for precision farming technologies (28.57 %) and land leveling problem (28.57 %). In the same vein, the entire non-participant farmers (100 %) reported that production constraints encountered by them were high rate of wages for labourers, shortage of labours, high cost of inputs, uneconomic land holding for plan to use precision farming technologies, lack of technical skill to follow precision farming recommendations and lack of advisory services for precision farming technologies follow by low supply of electricity (48.57 %), lack of water availability and pumping efficiency (48.57 %), non availability of input in time (97.14 %) and land leveling problem (37.14 %).

Furthermore, the Table 20 also presented the financial constraints faced by the participant and non-participant farmers. It was reported that 60 per cent of the participant faced financial constraints such as lengthy procedures of loan sanctions in bank, too much documentation, no easy access to credit and lower support from financial institutions while shortage of own capital and high rate interest was reported as 71.43 and 45.71 per cent respectively. However, cent per cent of the non-participant farmers reported that they faced all financial constraints above. Also, the marketing constraints such as inadequate market demands for output, low remunerative price for produce, high transportation cost, price fluctuation and lack of marketing intelligence were reported by all participant farmers (100 %) while all the non-participant farmers (100 %) reported high transportation cost, price fluctuation and lack of marketing intelligence further with inadequate market demands for output and low remunerative price for produce which were reported by 97.14 per cent of the non-participant farmers. Also, the participant farmers reported management constraints such as time consumption of precision farming (100 %), inadequate training and demonstration (20.00 %) and poor research extension farmer linkage (14.29 %) while 97.14, 100and 100 per cent of the non-participant reported time consumption of precision farming, inadequate training and demonstration and poor research extension farmer linkage respectively.

Table 17: Comparison of resource utilization pattern in precision and conventional farming in Paddy

n = 34

Sl. No.	Resource utilization	Participant (n_1 = 17)	Non-participant (n_2 = 17)	t
1	Seed Rate (g/ ha)	72941.18	73823.53	0.66 NS
2	Manures (t/ ha)	30.35	27.94	1.32 NS
3	Labour (Human days / ha)	123.50	118.50	NS
4	Plant protection Chemical (g/ ha)	6618.94	10220.65	5.34**
5	Nitrogen (kg/ ha)	239.01	378.64	4.02**
6	Phosphorus (Kg/ ha)	93.81	298.53	4.50**
7	Potassium (kg/ ha)	97.59	360.29	8.14**
8	Machines (Rs.)	12250.00	12250.00	NS

** Coefficient significant at 1% level of significance

* Coefficient significant at 5% level of significance

Table 18: Comparison of yield level in precision and conventional farming in selected crops

n = 70

Sl. No.	Crop	Participant (n_1) q/ha	Non-participant (n_2) q/ha	t
1.	Pigeon pea	12.86	9.42	3.41**
2.	Cotton	34.64	32.98	0.626 NS
3.	Paddy	97.08	80.34	7.21**

** Coefficient significant at 1% level of significance

* Coefficient significant at 5% level of significance

Table 19: Factors responsible for plan to use precision farming technology

n= 70

Sl. No.	Explanatory variables	Estimates	S.E.	Wald	Sig.
1	**AGE***	**0.155804**	**0.092488**	**2.837837**	**0.092068**
2	EDU	0.130854	0.096903	1.823467	0.176901 NS
3	**FME** **	**-0.20324**	**0.100566**	**4.084166**	**0.043287**
4	SLH	-0.05782	0.219985	0.069083	0.792677 NS
5	YLD	-0.00972	0.018304	0.282083	0.595339 NS
6	**LEX** *	**0.852061**	**0.451778**	**3.557056**	**0.059293**
7	LEP	0.012243	0.238627	0.002632	0.959081 NS
8	ROR	0.11885	0.458219	0.067274	0.795347 NS
9	**SCO** *	**0.431458**	**0.249845**	**2.982193**	**0.084185**

*** Coefficient significant at 1% level of significance

** Coefficient significant at 5% level of significance

* Coefficient significant at 10 % level of significance
Log likelihood = 49.45
Constant = -11.66

Table 20: Constraints faced by participant and non–participant farmers

n= 70

Sl. No.	Particulars	Participant n_1 =35		Non – participant n_2 =35	
		F	%	F	%
	Production constraints				
1.	Non availability of input in time	13	37.14	34	97.14
2.	High rate of wages for labourers	35	100	35	100
3.	Shortage of labours	35	100	35	100
4.	High cost of inputs	35	100	35	100
5.	Low supply of electricity	19	54.29	17	48.57
6.	Inadequate land holdings for adoption of precision farming technology	22	62.85	35	100
7.	Lack of technical skill to follow precision farming recommendations	15	42.85	35	100
8.	Lack of knowledge about Precision farming technologies	10	28.57	35	100
9.	Lack of water availability and pumping efficiency	18	51.43	17	48.57
10.	Land leveling problem	10	28.57	13	37.14
	Financial Constraints				
1.	Shortage of own fund	25	71.43	35	100
2.	Lengthy process of loan sanctions in bank	21	60	35	100
3.	Too much documentation	21	60	35	100
4.	No easy access to credit	21	60	35	100
5.	High interest rates	16	45.71	35	100
6.	Low support by financial institutions	21	60	35	100
	Marketing Constraints				
1.	Inadequate market demands for output	35	100	34	97.14
2.	Low remunerative Price for produce	35	100	34	97.14
3.	High transportation cost	35	100	35	100

4.	Price fluctuation	35	100	35	100
5.	Lack of marketing information	35	100	35	100
	Management Constraints				
1.	Time consumption of Precision farming	35	100	34	97.14
2.	Inadequate training and demonstration	7	20	35	100
3.	Poor Research-Extension -Farmer linkage	5	14.29	35	100

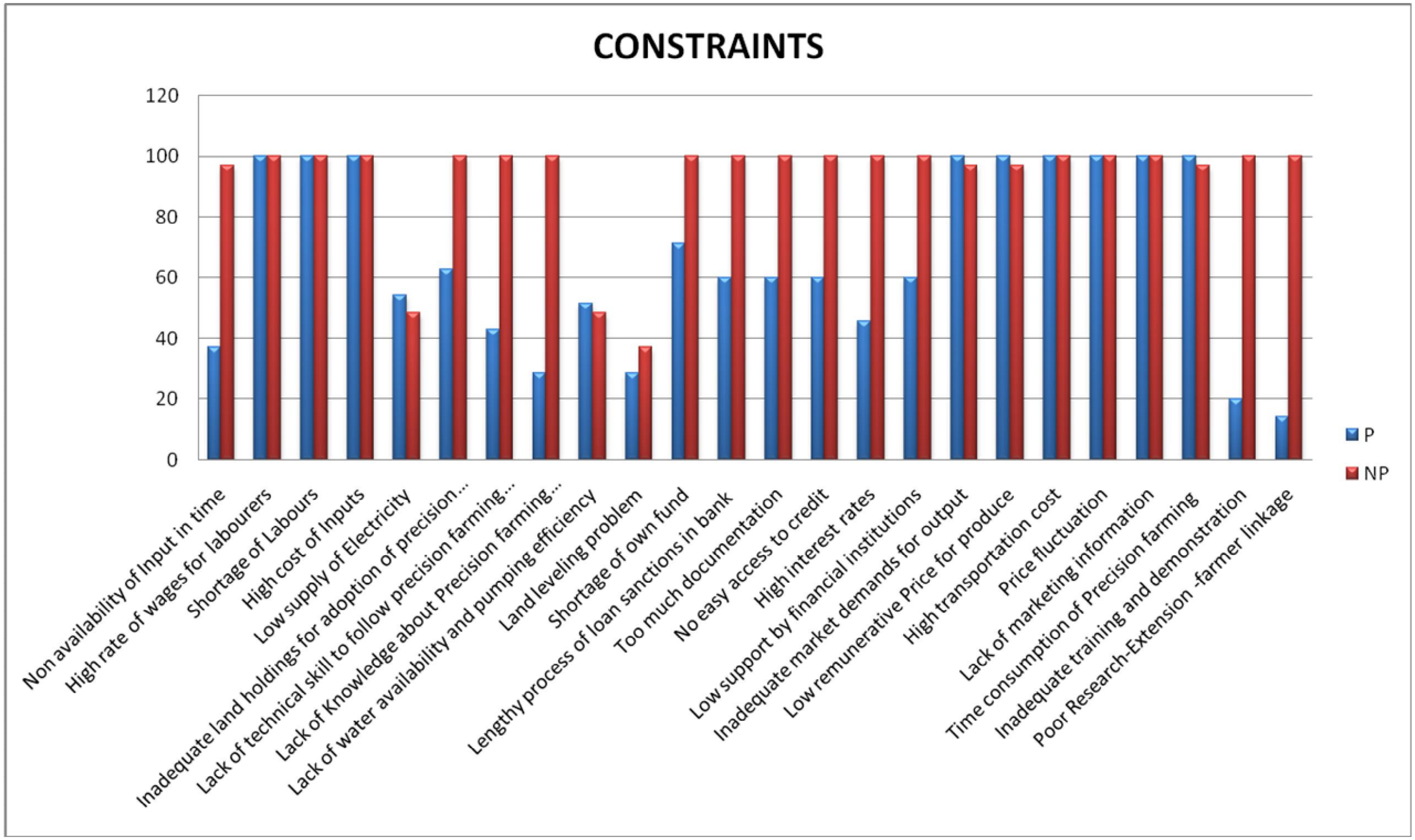


Fig. 26. Constraints faced by participant and non–participant farmers

Discussion

V. DISCUSSION

The results of the investigation were discussed in this chapter under the following headings.

5.1 Socio-economic characteristics of the participant and non participant farmers

5.2 Farmers perception towards precision farming technologies in selected crops

5.3 Knowledge level of participants farmers about precision farming technologies in selected crops

5.4 Resource utilization pattern in precision farming in comparison with conventional farmers' practice in selected crops

5.5 Factors responsible for plan to use precision farming technology

5.6 Constraints faced by participant and non-participant famers in adoption of precision farming technologies

5.1 Socio-economic characteristics of the participant and non participant farmers

5.1.1 Age

It was evident from results in Table 1 that, majority (71.43 %) of the participant farmers are in middle age while 65.72 per cent of the non-participant farmers are also in middle age category. This revealed that the majority of the participant and non-participant farmers are still in their active age. This is in line with the findings of Angadi (1999), Sain (2008) and Robert *et al.*, (2001) where they reported in separate studies that the majority of the farmers were in active middle age.

5.1.2 Education

Results in Table 1 also revealed the educational status of the respondents. It can be observed from table that barely half (48.57 %) of the participant had education up to pre- university education. Same scenario was observed in the non-participant farmers as 25.71 per cent had up to pre university education. The reasons for this might be the encouragement for formal education in the study area. This is in support with Sevier and Lee (2003) report on education status of the citrus producer in their study.

5.1.3 Land holding

It was evident from results in the Table 1 that, barely half (41.43 %) of the participant farmers are big farmers while 22.86, 20.00 and 25.71 per cent of the participant are marginal farmers, small farmers and medium farmers respectively. Also, more than half (54.29 %) of the non-participant farmers are small farmers. These results conform to the report of Ahmad *et al.*, (2007) as they revealed the typical landholding situation of developing countries. However, the results were contrary to the report of Walton *et al.*, (2010) and Velandia *et al.*, (2011) studies conducted in USA. It was reported that average size of landholding was 525.93 hectares.

5.1.4 Farming experience

Results in Table 1 revealed that, more than half (57.14 %) and (60.00 %) of the participant and non-participant farmers belonged to high category of farming experience respectively. The reason might be that the study area is the major crop ecosystem for the selected crops, cotton, pigeon pea as well as paddy and most of these farmers were getting benefits from these crops in the study area. Also many of these farmers were recognized as progressive farmers and may be aware of benefits in precision farming technologies. The result is in agreement with the report of Paudel *et al.*, (2011) in their research studies in U.S.A.

5.1.5 Attitude

It was revealed from Table 1 that, 68.57 per cent of the participant farmers belonged to most favourable attitude category towards precision farming technologies. It was observed that majority with most favourable attitude might be as a result of their full participation in the project as they undergone training and fully participated in extension activities on precision farming practice. The result is in line with observation of Sevier and Lee (2003).

5.1.6 Annual income

It was evident from results in Table 1 that, 42.86 per cent of the participant farmers belonged to high income group (> Rs. 51000) while 34.28 per cent belonged to low annual income category (< Rs.17000) the maximum annual income being Rs. 4.5 lakh and the minimum being Rs.10000. The possible reason for high annual income of the respondents it could be contributed to their land holding, cropping pattern and subsidiary occupation. These results were in line with the results of Raghavendra (2007).

5.1.7 Risk orientation

Table 1 also revealed the psychological characteristics of the respondents as the level of risk orientation of the participant farmers observed was high (68.57%). The reason for this may be that the individual farmers had critical and cautious in understanding different aspects of technology and also the tendency to take more risk may based on their income level, land holding and other resources. On the other hand, barely half of the non-participant (45.71%) had medium risk orientation. The high risk orientation of the participant farmers might also be the reasons for their participation in precision farming technology. Similar result was reported by Meeran and Jayaseelan (1999).

5.1.8 Management orientation

It was observed from Table 1 that, 55.00 per cent of the participant farmers had medium management orientation while 22.50 per cent each of them had low and high level of management orientation. Also, in the same vein, 42.50 per cent of the non-participant farmers had low level of management orientation. This is in agreement with the report of Sakharkar (1995).

5.1.9 Deferred gratification

The data presented in Table 1 show that, barely half percent (45.71%) of the participant farmers were in high category level of deferred gratification, while the non-participant had medium to high level of deferred gratification. The high level of deferred gratification of the participant may also be the reason for participating in the precision farming technologies among others. The result is similar to the work of Parvathamma (2012) in chitradurga district of Karnataka state.

5.1.10 Achievement motivation

The result presented in the Table 1 revealed that, majority (74.29 %) of the participant farmers were in high achievement category, while 42.86, per cent of the non-participant farmers had low level of achievement orientation respectively. The participant level of motivation which is high may be the reason for participating in the precision farming technologies. The result of the participant is a bit contrary to the earlier work reported by Palaniswami and Sriram (2001) that high percentage (72.11 %) belongs to medium category of achievement motivation whereas is in conformity to the result of the non-participant farmers in the study area. The reason for this may be that the participant farmers are also among the progressive farmers in the study area.

5.1.11 Use of computer for farm management

Results in Table 1 shows that, none of the participant and non participant farmers possessed and used computer for farm management. The reason may be that Indian farmers are not yet exposed to the utilization of computer for farm management purposes unlike the USA counterpart. This was contrary to the report of Martin and Cooke (2002) and Walton *et al.,* (2010), both studies conducted in USA.

5.1.12 Scientific orientation

The data presented in the Table 1 revealed that, majority (81.86 %) of the participant famers were in high scientific orientation category, while 54.29 per cent of the non-participant were in medium scientific orientation level. Scientific orientation is the orientation of farmer to adopt new technologies in a scientific way. The results is slightly different from the earlier report of Sriram and Palaniswamy (2001) and Nagaraja (2002) as they reported high percentage are in medium category of scientific orientation. The high level of scientific orientation of the participants may be the reason for participation in the precision farming project.

5.1.13 Innovative behaviour

From Table 1, it was observed that majority (71.43 %) of the participant famers are in high innovative behaviour category, while 57.14 per cent of the non-participant were in low innovative behavior category. The reason for this might be that the participant farmers are progressive farmers and are interested in trying new technologies which might also be their rationale for participating in precision farming project. The result is slightly different from the observation of Bhagyalaxmi *et al.*, as the reported high percentage of the respondents in medium category of innovativeness.

5.1.14 Extension contact

From Table 2, it was observed that, majority (60.00 %) of the participant farmers had high extension contact, while majority (68.57 %) of the non-participant farmers had low level of extension contact. The possible reasons for this situation may be as a result of extension activities in the study area especially the activities of the scientist of University of Agricultural Sciences, Raichur in the precision farming project as it was further observed that 97.14 per cent of the participant had contact with Scientist of UASR once in a week. The result is similar to the repot of Angadi (1999).

5.1.15 Extension participation

The data presented in Table 4 revealed that, about half (45.71 %) per cent of the participant had high level of extension participation while 54.29 per cent of the non-participant had medium level of extension participation. Furthermore, Table 5 revealed that all participant farmers (100 %) attended training programme, field visit, group meetings and Krish mela while 91.43 per cent of non-participant attended Agricultural exhibitions and krish mela. Agriculture exhibition is conducted every year at fixed month that enables the farmers' to plan their activities and participate in it. Demonstrations are usually laid in farmer's field and many of them might have participated in it. The above findings were in accordance with the findings of study conducted by Angadi (1999).

5.1.16 Mass media utilization

Table 6 revealed the mass media utilization of the respondents. It was observed that larger percentage (74.29) of the participants had medium level of mass media utilization whereas 48.57 per cent of the non-participant had medium level of mass media utilization respectively. The results shows that the participant utilized more the available mass media sources than non-participant and this may be the reasons behind their awareness and participation in precision farming technology project and also rationale behind their interest in participating in the project. It was also observed that television was highly possessed by the respondents (94.28 % of the participant and 80.00 % of the non-participant) compared to the other media sources. The reason could be that most of the agriculture programs are telecasted in the morning hours and the farmers could spend time to watch TV after completing all the field works in the evening hours.

However, it was observed that there was low subscription for farm magazine as 17.14 per cent of the participant famers subscribed while none (100 %) of the non-participant subscribed for farm magazine. The reason for this may be clearly seen from the result of the television subscribed for as the respondents may be satisfied with the information available from television media source. The result is in conformity with Nagadev and Venkataramaiah (2007).

5.1.17 Usage of Precision farming technologies

Table 8 revealed the precision farming technologies already used by the participant farmers. The cent per cent of the participant farmers (100 %) reported that they have already used Grid Soil sampling, Global Positioning System (GPS), Geographic Information System (GIS), Variable Rate Applicators/ Techniques and crop sensors. The reasons for this might be the influence of their good perception about precision farming technologies as the perception level shows that they had a medium to high level of perception. Furthermore, the results of perception of ease of use of precision farming technologies revealed that cent per cent (100 %) of the participant farmers strongly agreed that precision farming technologies is easy to use. This may be the reason for their good level of usage of the technologies. This is in conformity with the studies of Adrian *et al.* (2005). However, it was observed that none of the participant farmers had used remote sensing and yield monitor. The reason for this might be the high cost of purchasing yield monitor and its unavailability in India market. Participant farmers expressed the need for the government to come to their aid by making the components available and accessible to them at low cost or subsidized rate so as to maximize the full potential of precision farming technologies.

5.1.18 Participation of respondents in precision farming activities

Results in Table 9 revealed the participation of respondents in precision farming activities. It was observed that cent per cent of the participant farmers had participated in deciding the grid, formation of grid size using GPS, soil sampling, variable rate application of fertilizer as well as grids harvesting. This might be as a result of encouragement received from the scientist of University of Agricultural Sciences, Raichur through regular contact with the participant farmers in the precision farming project. During the project implementation, demonstrations and training were conducted in the farmer’s field to motivate and encourage the farmers to put it to practice what they did themselves on their respective fields. Also the good involvement of the farmers in the project can be link to the approach adopted for the implementation of the project. Participatory approach was adopted and it can be seen as the underline factor for their good involvement which in turns resulted into a better yield and input savings than the experience of non-participant farmer especially in pigeon pea and paddy crop.

Also, it was observed that 34.29 per cent had participated in observation of crop characteristics and 20.00 per cent had participated in GIS map interpretation. The reason for low participation in the two activities might be that the activities are taking up by the field technician in the project for generating data base information about the farmer's field and thus not require the full participation of the farmers. Another reason may also be that the farmers are not interested in too much data collection as data accumulation can be boring and looks unproductive and waste of time. This revealed the underline factors why the participant farmers had low level of knowledge in the utilization of the components that has do with field data base generation. However, the participant farmers need to be motivated to participate in this activities also so as to build up their capacity and confident needed in undertaken the activities in the future without the assistance of the field technicians.

5.1.19 Future plan to use precision farming technologies

The results in Table 10 revealed the future plan of the participant and non-participant to use precision farming technologies. It was observed that, cent per cent of the participant farmers (100 %) plan to use all precision farming technologies in future. The reason for this might be the increase in yield achieved especially in pigeon pea and paddy which may be a source of encouragement to plan to use precision farming technologies in future. The perceived benefit of the precision farming technologies which was attested to by the majority of the farmers as they strongly agree with the perception of benefit might be the reason for good response in plan to use precision farming technologies in future. This is similar to work of Adrian *et al.* (2005) and Kotsiri *et al.*, (2011) in their studies on effect of perception of benefit on the adoption of precision farming technologies. Also, participant farmers' level of knowledge which was observed as medium category (Table 14) might also be another reason for cent per cent plan to use precision farming technologies in the future. This was also reported by Abdullah *et al.* (2012).

On the other hand, it was also observed that 34.29 per cent of the non-participant had planned to use Grid Soil sampling. The reason for this might be the low level of awareness of precision farming technologies in the study area which calls for effective dissemination of information about precision farming technologies by the extension agents in the study area.

5.2 Farmers perception towards precision farming technologies in selected crops

5.2.1 Overall perception of participant farmers towards precision farming technologies

The result in Table 11 revealed that 40.00 per cent of the participant farmers had more favourable perception about precision farming technology. This may be the reason for their moderate knowledge about precision farming technologies and also may be responsible for their plans to adopt precision farming technologies in the future. This is in conformity with the report of Adesina and Zinnah (1993) and D'antoni *et al.*, (2012). It can also be concluded at this juncture that farmers individual perception of the precision farming technologies might be the reason behind the good response of the participant about plan to use precision farming technologies in the future as literature over the years reveals that farmers' perception of technologies influenced the adoption of such technologies (Napier *et al.*, 2000, Adrian *et al.*, 2005 and Kotsiri *et al.*, 2011).

5.2.2 Statement wise perception of the respondents about precision farming technologies

Table 12 reveals the perception of the individual respondents about precision farming technologies. It was evident from the perception of benefits of precision farming technologies that more than three quarter of the respondents (82.86 %) strongly agree that precision farming increases their yield while 17.14 agrees with the statement. In the same vein, 80.00 per cent strongly agree that precision farming technologies saves input such has fertilizers while 17.14 per cent were undecided. The undecided category might be the participant that experienced not much difference in yield in their field. This was observed during the data collection especially in cotton crop.

Also, perceived usefulness of precision farming technologies revealed that about seventy percent (71.43 %) of the respondents strongly agree that precision farming technologies was useful for them. Also, more than half of the respondents (62.86 %) agreed that precision farming technologies provides relative information for decision making on their farm while 37.14 per cent were undecided. This can best understand as the participant farmers' activities and farming practices has been greatly influenced by participating in the precision farming project.

However, more than half (57.14 %) of the respondents agrees that precision farming technologies will reduce environmental hazards and soil health problem caused by blanket use of resources while 42.86 per cent disagrees with the perception. The reason for this might be that impact of precision farming adoption on environment cannot be observed within short time. This may be the reason for their moderate perception about the statement. Also, perceived ease of use of precision farming technologies was observed as cent per cent of the respondents strongly agrees that precision farming technologies will be easy to use, followed by 80.00 per cent which strongly agree that it will be easy to learn how to use precision farming technologies while 17.14 per cent agrees on the ease of learning of precision farming technologies. Also, 85.71 per cent of the respondents agree that they would be able to remember how to perform task using precision farming technologies while 14.29 per cent strongly agree. The reason for this might be the fact that precision farming is not really an injection of new idea but application of technologies in assessing agriculture variability. Also, it may be due to the fact that the complex part of the technology utilization which is process of generating field data base information was undertaken by the field technicians and the scientist. On the barriers to plans to use precision farming technologies, cent per cent of the respondents strongly agree that Precision farming technologies requires sophisticated equipments. This is true as equipment like yield monitor, variable rate applicator etc are sophisticated in nature and may takes time for farmers to lean perfectly about its utilization.

Interestingly, about half of the respondents strongly disagree that precision farming technologies are more suited to educated farmers followed by 25.71 per cent who agrees with the perception and 17.14 per cent disagree. The reason for this might be the fact that farmers with moderate years of formal education as well as the illiterate ones participated in the project. This is contrary to the general opinion that education influences the favourable adoption of technologies (Paudel *et al.,* 2011 and Paxton *et al.,* 2011). Also, perception that precision farming technologies demands more labour was agreed to by about half (51.43 %) of the respondents while 48.57 per cent strongly agrees. The reason for this might be the need for some activities such as grid soil sampling, variable rate application of fertilizers and grid harvesting demands much labour. The result is similar to the report of Maheswari *et al.,* (2008).

5.3 Knowledge level of participant farmers about precision farming technologies in selected crops

5.3.1 Overall knowledge level of participant farmers towards precision farming technologies

The results in Table 13 revealed that the knowledge level of participant farmers about precision farming technology was moderate as it was evident that about half (45.71 %) of the respondents are in medium level of knowledge category about precision farming technology. The reason for this may be that the project is just a new innovation in agricultural farming system and acquiring quality knowledge may takes some times to be achieved. This was better than the outcome of investigation of Reichardt *et al.,* (2006) in Germany which reported that young farmers have zero knowledge about precision farming technologies.

5.3.2 Component wise knowledge level of the respondents about individual precision farming technologies

Results presented in Table 14 revealed that, cent per cent of the respondents had understanding about precision farming technologies while majority (94.28 %) had understanding of the precision farming technologies components. The reason for high level of knowledge in general understanding of precision farming technologies might be as a result of up to date seminars and training conducted for the farmers about the technologies. Also, the participant had regular contact with the scientist of the University working in the project and this may be a plus to their knowledge about the general meaning of precision farming technologies.

The knowledge level of respondents in soil sampling technique shows that, cent per cent had knowledge about seasonal sampling. This shows their commitment to the activities especially the grid soil sampling as the farmers' reported a high participation level in grid soil sampling techniques (Table 9). This also reveals the impact of the approach adopted for the implementation of the project as it gives the farmers opportunity to participate fully and do it themselves which in turn improves their knowledge in such activities. This was also further confirmed as majority of the respondents (97.14 %) had knowledge about soil sampling depth and grid area for sampling (100 %).

On the knowledge of variable application of input, cent per cent (100 %) had knowledge about STRC variable application of fertilizer and pest and diseases variation across grids. The reason for this might be the fact that this was the major focus of the farmers to save input as well as to achieve a potential yield thereby they took their time to learn to do it well. Also, barely half of the respondents (54.28 %) had knowledge and followed plant protection measures accordingly. The reason for this might be some of the farmers also practice their conventional farmers practice when it comes to plant protection as they applied some chemicals which were not actually recommended by the precision farming team. Also about knowledge of sensors and its application, 82.86 per cent had knowledge about uses of green seeker. Also, 57.14 per cent of the respondents were able to identify sensors correctly while 45.71 per cent had knowledge of the procedures to take readings with ceptometer. The reason for this might be the fact that majorly, observation with sensors are done by the field technicians for generation of field data base information.

5.4 Resource utilization pattern in precision farming in comparison with conventional farmers' practice in selected crops

5.4.1 Resource utilization pattern in precision farming in comparison with conventional farmers' practice in cotton crop

The result of the t-test statistics of compared means in cotton presented in Table 15 revealed that, participant farmers used more input compare to non-participant farmers especially in Nitrogen fertilizer (316.06kg/ ha and 211.31kg/ ha), Phosphorus fertilizer (476.53kg/ ha and 211.31kg/ ha) and potassium fertilizer (538.24kg/ ha and 80.36kg/ ha) as they were significant at 1 per cent level respectively. However, the participant saved input in plant protection chemicals (3602g/ ha and 8065.47g/ ha) which was also statistically significant at 1 % level. There are no differences in seed utilizations of the participant and non-participant farmers while participant farmers used slightly more labours (101.38 human days/ ha) compared to the non-participant (64.78 human days/ ha) though it was not significant. The reason for this was the activities in precision farming practices such as grid soil sampling and harvesting according to grids which demands more labour compare to conventional farmer's practice. The results of fertilizer utilization is slight contrary to the report of Man (2000) when he studied comparison of productivity level under conventional whole-field farming and precision farming technology in Lamesa, Texas. This might due to the fact that the land used by farmers for cultivation of cotton in the study area are already exhausted in nutrients due to blanket application of resources over time which may take some time to recover under precision farming technology practices.

5.4.2 Resource utilization pattern in precision farming in comparison with conventional farmers' practice in pigeon pea crop

Results presented in Table 16 revealed the t-test statistics of compared means in pigeon pea crop. It was observed that participant farmers saved more input compare to non-participant farmers especially in plant protection chemicals (4200g/ ha and 5162.72/ ha), Nitrogen fertilizer (1.86kg/ha and 79.54kg/ ha) and potassium fertilizer (49.63kg/ ha and 125kg/ha) as they were significant at 1 per cent level respectively as well as Phosphorus fertilizer (86.98kg/ ha and 90.91kg/ ha) which was however not statistically significant. Also the average mean of Manures used by the participant farmers is 3.0 tonnes/ ha while the non-participant cotton farmers was 1.96 tonnes/ ha while the average mean of labour employed by the participant and non-participant famers during the pigeon pea production period was reported as 130 human days /ha and 115 human days / ha respectively though they were not statistically testable as the standard deviation was zero. The result was in conformity with the report of the report of Man (2000).

5.4.3 Resource utilization pattern in precision farming in comparison with conventional farmers' practice in paddy crop

It was evident from Table 17 that, participant farmers saved more input compare to non-participant farmers as observed result from the t-test statistics of compared means shows that plant protection chemicals (6618.94g/ ha and 10220.56g/ ha), Nitrogen fertilizer (289.01kg/ ha and 378.64kg/ ha), Phosphorus fertilizer (93.81kg/ ha and 298.53kg/ ha) and potassium fertilizer (97.95kg/ ha and 360.29kg/ ha) were statistically significant at 1 per cent for participant and non-participant respectively. The average mean of labour employed the participant and non-participant famers during the paddy production period were reported as 123.5 human days /ha and 118 human days /ha respectively which was not statistically significant. The reasons for more labours in precision paddy is due to that fact that activities such as grid soil sampling require more labour compare to conventional famers practices. The result is similar to the report of Islam et al. (2007).

5.4.4 Yield comparison of precision farming with conventional farmers' practice in selected crops

It was evident from the result presented in Table 18 that yield in precision farming is more compare to conventional farmers practice. The average mean of yield for participant farmers in pigeon pea, cotton and paddy were 12.86kg/ ha, 36.64kg/ ha and 97.08kg/ ha respectively while non-participant farmers recorded 9.32kg/ ha, 32.98kg/ ha and 80.34kg/ ha respectively. The t-test statistic reveals that yield of pigeon pea and paddy is significant at 1 per cent while that of cotton is non-significant. The reason for none significant of cotton may be due to the fact that indiscriminate used of the resources over time in the study area has led to imbalance of the soil nutrients in the region. This was also evident in fertilizer utilization in the crop. This was in line with the report of Islam *et al.,* (2007).

5.5 Factors responsible for future adoption of precision farming technology

The results in Table 19 revealed logistic regression analysis to determine the factors responsible for future adoption of precision farming technology by the respondents. It was observed that level of extension contact as well as respondents' scientific orientation were positively significant at 10 per cent to the likelihood of future adoption of precision farming technologies with estimates of 0.85 and 0.43 respectively. The higher level of extension contact and scientific orientation of the respondents implies that it has a positive influence on the future adoption of precision farming. The reasons for this might be that higher level of extension contact will improve the understanding of the respondents to the benefit of precision farming technology. Also farmer with high scientific orientation may want to try a new technology unlike those with lower level of scientific orientation. This was similar to report of Shyam Nair *et al.,* (2011) and Pandit *et al.,* (2012).

Also, explanatory variable such as years of formal education, level of extension participation, risk orientation, deferred gratification as well as achievement motivation were statistically positive but not significant to the likelihood of future adoption of precision farming technologies. The reason for this might be that participants with higher level of extension participation will have more information about improved technologies such as precision farming and which will in turn influence their future adoption positively. However, farmer's years of farming experience were negatively significant at 5 % with estimates of 0.2. The reason for this may be that farmers with less years of farming experience which are middle age, more educated progressive farmers may have more likelihood to adopt precision farming technologies in future. This was in conformity with the report of Shyam Nair *et al.,* (2011).

Also, explanatory variables such as size of land holding and yield were statistically negative but not significant to the likelihood of future adoption of precision farming technologies with estimates of 0.05 and 0.09 respectively. The reason for this might be that the farmers with fewer yields in their conventional farmer's practices may likely want to try new improved technologies to boost their yield thereby leading to likelihood of future adoption. Also negative sign for size of land holding implies that farmers with less land holding may also likely to adopt precision farming technologies in future and this reveals the typical scenario of farm size holdings in developing countries unlike the developed countries. The result was contrary to the report of Paudel *et al.,* (2011) and Wiebold, *et al.,* (1999).

5.6 Constraints faced by participant and non-participant farmers in adoption of precision farming technologies

Table 20 revealed the constraints faced as expressed by participant and non-participant famers in adoption of precision farming technologies. The major production constraints encountered by the participant farmers were high rate of wages for labourers, shortage of labours and high cost of inputs as it was reported by the entire participant farmers (100%). The reason for this might be non availability of labour due to rural urban migration in the study area which resulted into high cost of labour.

The other production constrains reported were uneconomic land holding for adoption of precision farming technologies (62.85 %). The reason for this is clearly known as the fragmentation of land holding which is characteristic of the developing countries land holdings. Also low supply of electricity (54.29 %), lack of water availability and pumping efficiency (51.43 %). This challenge might be because the study area especially for cotton (Mariechatal) is at the tail end of dam so they have limited access to water for irrigation.

Also the participant farmers reported management constraints such as time consumption of precision farming (100 %), inadequate training and demonstration (20 %) and poor research extension farmer linkage (14.29 %) while 97.14, 100 and 100 per cent of the non-participant reported time consumption of precision farming, inadequate training and demonstration and poor research extension farmer linkage respectively. Lack of technical skill to follow precision farming recommendations was also reported by 42.85 per cent of the participant. This shows the need of extension agency to be a partner in precision farming project so as to convey the message down to the grass root.

Furthermore, the Table 20 presented the financial constraints faced by the participant and non-participant farmers. It was reported that 60 per cent of the participant faced financial constraints such as lengthy process of loan sanctions in bank, too much documentation, no easy access to credit and lower support from financial institutions while shortage of own capital and high rate interest was reported as 71.43 and 45.71 per cent respectively. However, the entire non-participant farmers reported that they faced all financial constraints above.

Further the study also revealed the marketing constraints such as inadequate market demands for output, low remunerative price for produce, high transportation cost, price fluctuation and lack of marketing intelligence were reported by all participant farmers (100 %) while all the non-participant farmers (100 %) reported high transportation cost, price fluctuation and lack of marketing intelligence further with inadequate market demands for output and low remunerative price for produce which were reported by 97.14 per cent of the non-participant farmers. This shows the reason for more involvement of extension agents in linking the farmers to market to have a remunerative profit for their produce.

Summary and Conclusions

VI. SUMMARY AND CONCLUSIONS

Developing nations of the world over the years have witnessed a paradigm shift in the content of agricultural development. This includes among others technological change at all level of agricultural production in meeting the challenge of food availability on sustainable basis for the alarming growing population. The same situation was the experience of Indian agriculture as it undergone a rapid transformation in the past few decades which catapults the nation from net importing country to food sufficient and exporting country. However, the post green revolution phase which was characterized with focus on accelerating productivity through high input use and high yielding crop varieties has resulted in series of soil health and environmental problems coupled with decline in productivity growth at the expense of increase in production cost. First half of 2000s witnessed a decelerated growth of 2.3 per cent in the agricultural sector which improved slightly to reach 2.6 per cent in 2008-09 and dropped to 1.8 per cent in 2012-13.

With this current scenario, precision farming can however help to maintain the national agricultural growth by its focus on efficient resource utilization through the management of spatial and temporal variability of the soil and the ecosystem. It is not generally a new type of farming system but system of matching the agricultural inputs like seed, fertilizer, irrigation, insecticide, pesticide, etc. in order to optimize the input or maximizing the crop yield from a given resources at a given time. The present study was undertaken to compare the precision farming technologies in the selected crop of North Eastern region of Karnataka and to study the perception and knowledge of the participant farmers as well as the comparison of resource utilization of precision farming technologies with conventional farmer’s practices.

The study was undertaken with the following specific objectives;

1. To study the socio-economic characteristics of the participant and non-participant farmers
2. To study the farmers perception towards precision farming technologies in selected crops

3. To assess the knowledge level of participant farmers about precision farming technologies in the selected crops
4. To analyze the resource utilization pattern in precision farming in comparison with conventional farmers' practice
5. Factors responsible for plan to use precision farming technology
6. Constraints by participant and non-participant famers in adoption of precision farming technologies

Methodology

The study was undertaken during the year 2013-2014 in district namely Raichur, Koppal and Gulbarga districts of North Eastern Karnataka which was purposively selected based on the criterion of the implementation of precision farming project by University of Agricultural Sciences, Raichur in the selected crops, Cotton, Paddy and Pigeon pea respectively. Four villages were selected based on the crop ecosystem of the region. Precision farming participant farmers in the three selected crops and non-participant farmers of the same selected crops in the district was selected for the study using simple random sampling technique to constitute a sample size of 35 participants and 35 non participants in the selected crops. The total sample size constitutes the 70 respondents for the study.

Based on the objectives of the study an interview schedule was prepared. The information was elucidated from respondents with the help of structured schedule. The interview schedule was pre-tested in non sample area for its practicability and relevancy. Based on the experience gained, the interview schedule was modified wherever necessary. The final schedule was used to collect the information from the respondents by personally interviewing through the assitantance of field enumerators and the data was analyzed by using suitable statistical measures.

Major findings

1. It is evident that 71.43 and 65.72 per cent of the participant and non-participant farmers were in middle age category respectively

2. In respect of formal education, barely half (48.57 %) of the participant had education up to pre- university education while 25.71 per cent of the non-participant farmers had education up to pre university education.
3. It was reported that 41.43 % of the participant farmers are big farmers while 22.86, 20.00 and 25.71 per cent of the participant are marginal farmers, small farmers and medium farmers respectively. Also, more than half (54.29 %) of the non-participant farmers are small farmers.
4. More than half (57.14 %) and (60.00 %) of the participant and non-participant farmers belonged to high category of farming experience respectively.
5. About half of the participant (55.00 %) had medium management orientation.
6. Barely half per cent (45.71 %) of the participant farmers were in high category level of deferred gratification.
7. Larger per cent (74.29 %) of the participant farmers were in high achievement category.
8. It was observed that 60.00 and 40 per cent of the participant farmers had high and low level of extension contact respectively while 68.57, 5.71 and 25.71 per cent of the non-participant farmers had low, medium and high level of extension contact respectively.
9. As per extension participation, 31.43, 22.85, and 45.71 per cent of the participant had low, medium and high level of extension participation respectively while 22.86, 54.29 and 22.86 of the non-participant had low, medium and high level of extension participation respectively.
10. It was observed that larger percentage (74.29 %) of the participants had medium level of mass media utilization.
11. None of the participant and non participant farmers possessed and used computer for farm management.
12. More than seventy per cent (71.43 %) of the participant famers had high innovative behaviour followed by 28.57 per cent are in low innovative behaviour category.

13. Cent per cent of the participant famers were aware of all precision faming technologies except remote sensing of which majority (77.14 %) of the respondents reported to be aware of remote sensing.

14. About one quarter (34.29 %) of non-participant farmers was aware of grid soil sampling.

15. Cent per cent of the participant had used Grid Soil sampling, Global Positioning System (GPS), Geographic Information System (GIS), Variable Rate Applicators/ Techniques and crop sensors while none of the participant farmers (0.00 %) had used remote sensing and yield monitor.

16. Cent per cent of the participant farmers had participated in deciding the grid, formation of grid size using GPS, soil sampling, variable rate application of fertilizer as well as grids harvesting.

17. Cent per cent of the participant plan to use precision farming technologies in the future.

18. It was evident that 40.00 per cent of the participant had high level of perception about precision farming technology.

19. Perception of benefits of precision farming technologies shows that more than three quarter of the respondents (82.86 %) strongly agree that precision farming will increase the yield while 80.00 per cent strongly agree that precision farming technologies can save input such has fertilizers.

20. Perceived ease of use of precision farming technologies revealed that cent per cent of the respondents strongly agrees that precision farming technologies will be easy to use, while 80.00 and 85.71 per cent strongly agree that it will be easy to learn how to use precision farming technologies and agree that they would be able to remember how to perform task using precision farming technologies respectively.

21. On the perception of barriers to precision farming technologies, about half (51.43 %) of the respondents perception agrees that precision farming demands more labour.

22. Knowledge level of participant farmers about precision farming technology was moderate as it was evident that 45.71 per cent of the participant farmers had medium level of knowledge about precision farming technology respectively.

23. Cent per cent of the respondents had understanding about precision farming technologies while majority (94.28 %) had understanding of the precision farming technologies components.

24. Cent per cent had knowledge about seasonal sampling while majority of the respondents (97.14 %) had knowledge about soil sampling depth and grid area for sampling (100 %).

25. Cent per cent (100 %) had knowledge about STRC variable application of fertilizer and pest and diseases variation across grids.

26. About half (57.14 %) of the respondents were able to identify sensors correctly while 45.71 per cent had knowledge of the procedures to take readings with ceptometer.

27. Participant farmers in cotton crop used more input compare to non-participant farmers especially in NPK fertilizer.

28. It was observed that participant farmers in pigeon pea saved more input compare to non-participant farmers especially in plant protection chemicals (4200g/ ha and 5162.72/ ha), Nitrogen fertilizer (1.86kg/ ha and 79.54kg/ ha) and potassium fertilizer (49.63kg/ ha and 125kg/ ha) as they were significant at 1 % level respectively as well as Phosphorus fertilizer.

29. Also, participant farmers in paddy saved more input compare to non-participant farmers as it was observed from the t-test statistics of compared means result.

30. Yield in precision farming is more compared to convectional farmer's practice.

31. Farmer's years of farming experience was negatively significant at 5 per cent level of probability

32. More than sixty per cent (62.85 %) reported uneconomic land holding for adoption of precision farming technologies.

33. About half per cent (51.43 %) reported lack of water availability and pumping efficiency

34. Cent per cent of the participant farmers reported management constraints such as time consumption of precision farming.

35. Lack of technical skill to follow precision farming recommendations was also reported by 42.85 per cent of the participant.

36. It was reported that 60 per cent of the participant faced financial constraints such as lengthy process of loan sanctions in bank, too much documentation, no easy access to credit and lower support from financial institutions.

37. Cent per cent of the participant farmers reported marketing constraints such as inadequate market demands for output, low remunerative price for produce, high transportation cost, price fluctuation and lack of marketing intelligence.

38. Inadequate market demands for output and low remunerative price for produce which were reported by 97.14 percent of the non-participant farmers.

Implications of the study

The current study brought out certain important findings which have got direct bearing on those involved in technology transfer and policy making. They are detailed below;

1. Majority of the non-participant farmers in the study area were not aware of precision farming technologies which gives more scope for the relevance of extension agents and department of agriculture to do more in disseminating the information to farmers.
2. Since precision farming has proved to be beneficial especially by increased in yield and saving of input in the selected crops except cotton, it can be recommended for the policy makers to increase the crop coverage of precision farming technologies and practices to other crops of the region.
3. About half of the respondents strongly disagree with the perception of barriers to precision farming technologies that the technologies are more suited to educated farmers. This gives a new trend of scope for developing nations to adopt precision farming as farmers with no or little education background can utilize the technologies.
4. Majority of the respondents belonged to medium level of knowledge regarding precision farming technologies. This indicates a vast scope for the developmental departments to intervene and improve the knowledge level of farmers about precision farming technologies.

5. About half of the participant had low level of knowledge about sensors and their applications and this shows the need for extension functionaries to build up the capacity of the farmers so as to upscale their confidence in utilizing the technologies with little or no assistance from the field technicians.
6. Lack of irrigation water was problem which is especially in case of tail end farmers, High cost of input, lack of technical skill to follow precision farming technologies were problems expressed by the farmers that need intervention of researchers and extension agents.

Suggestions for the future study

- ❖ An impact assessment studies can be conducted on the precision farming project using before and after the project approach to measure the contribution of precision farming to the livelihoods of the participant farmers.

- ❖ A study could be planned to assess the effect of precise system of farming in mitigating climate change through the adoption of precision farming technologies towards sustainable agricultural development.

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Appendices

COMPARATIVE ANALYSIS OF PRECISION FARMING TECHNOLOGIES IN SELECTED CROPS

INTERVIEW SCHEDULE (PARTICIPANT FARMERS)

Respondent no: **Date:**

Part-A

I. General Information

1. Name of the farmer: ________________ 2. Station: ______ 3.Village:____________

4. Name of the taluk: ________________ 5. Name of the district: ____________

II. Personal and Socio-economic Characteristics

1. Age: ____years 2. Education: _______years

3. Farming experience: ________ years

4. Size of the land holding (ha): _______ 5. Annual income: Rs___________/-

Sl. No.	Ecosystem	Areas (Acres)	Crop Yield (q/acres)
1	Irrigated		
2	Dry land		
3	Rainfed		
	Total		

Sl. No.	Particular	Amount (/-)
1	Agriculture	
2	Subsidiary	
3	Others	
	Total	

6. Cropping Intensity

Sl. No.	Type	Area	Crops Grown		
			Kharif	Rabi	Summer
1	Single cropped area				
2	Double cropped area				
3	Triple cropped area				

7. Mass media utilization

Sl. No.	Mass Media Sources	Subscriber/ Poss	Programmes	Frequency of Use				
				Every day	Once in a week	Once in fort night	Once in a month	Not at all

		esesd						
1	Radio		i)Agriculture Programmes					
			ii)General Programmes					
2	Television		i)Agriculture Programmes					
			ii)General Programmes					
3	News Paper		i)Agriculture Programmes					
			ii)General Programmes					
4	Farm Magazine		i)Agriculture Programmes					
			ii)General Programmes					
5	Others (Specify)		i)Agriculture Programmes					
			ii)General Programmes					

8. Extension Contact

Sl. No.	Extension Worker	Frequency of contact in a Month			
		Everyday	Once in a week	Once in fortnight	Not all
1	Agricultural Assistant				
2	Agricultural Assistant Officer				
3	Agricultural Officer				
4	Assistant Director of Agriculture				
5	Agril. University SMS				
6	Private Agency Extension Officer				
7	NGO Extension Officer				
8	Others (specify)				

9. Extension Participation

Sl. No.	Extension Activities	Frequency of Participation in a Month		
		Regular	occasional	Never
1	Training Programme			
2	Demonstrations			
3	Field days			

4	Field Visit			
5	Group Meetings			
6	Agricultural Exhibitions			
7	Krish Mela			
8	Educational Tours			

10. Risk Orientation

Please indicate your degree of agreement or disagreement to the following statements

Sl. No.	Statements	Agree	Disagree
1	A farmer should grow large number of crops to avoid greater risk involved in growing one or two crop		
2	A farmer should rather take more of a change in making a big profit than to be content with small but less risky profits		
3	A farmer who is willing to take greater risks than average farmers usually have better financial condition		
4	It is good for a farmer to take risk when he knows his chances of success is high		
5	It is better for a farmer not to try new farming methods unless most other farmers have used them with success		
6	Trying an entirely new method in farming by a farmer involves risk, but it worth it		

11. Achievement Motivation

Please indicate your degree of agreement or disagreement to the following statements

Sl. No.	Statements	Agree	Undecided	Disagree
1	Work should come first even if one cannot get proper rest in order to achieve his goals			

2	It is better to be content with whatever little on has than to be always struggling for more			
3	No matter what I have don I always want to do more			
4	I would like to try hard at something which is really difficult even if it proves that I cannot do it			
5	The way things a now a days discourage one to work hard			
6	One should succeed in occupation even if one has to neglect his family			

12. Scientific Orientation

Please indicate your degree of agreement or disagreement to the following statements

Sl. No.	Statements	Agree	Undecided	Disagree
1	Improved Practices gives better yield than old practices			
2	The way farmer's fore farmers practiced Agriculture is still the best way even today			
3	Even a farmer with lots of experience should use improved practices			
4	Though it takes a lot of time to for a famer to learn improved production practices, it is worth of efforts			
5	A good farmer experiments with new ideas in farming			
6	Traditional methods of farming have to be changed in order to raise the level of a farmers			

13. Deferred Gratification

Please indicate your opinion against the following statements

Sl. No.	Statements	Agree	Undecided	Disagree
1	A farmer should not postpone his desire rather fulfill it with savings			
2	Today that we are is more important than tomorrow what we would be			

3	Invest when a farmer has money and no investment when he does not have money is a best way of farming			
4	Saving often invite troubles theft and robbing are very common now a days			
5	A farmer should be like an ant than green hopper (spindrifts) to save the money for future farming			

14. Innovative Behaviour

Please indicate your opinion against the following statements

Sl No.	Statements	Agree	Undecided	Disagree
1	I am very much interested in adopting new practices that are helpful in conserving input, soil and water			
2	Since am not sure of success of new practices, I will like to wait till others adopt it			
3	Since new farming practices are not profitable, am not interested in any of them			
4	I try to keep myself inform about improved farming practices and to adopt it as earlier as possible			
5	Improved farming system are not easily adoptable so I don't adopt them			

15. Attitude towards precision farming technologies

Sl/No.	**Statements**	**SA**	**A**	**UD**	**DA**	**SDA**
1	The use of precision farming technologies is the easiest way to increase the crop yield					
2	The use of precision farming technologies improved the quality of crops, which fetch more prices in the market					
3	The use of precision farming technologies is less profitable in relation to the cost involved.					
4	The yield of crops is very much increased by the use of precision farming technologies					

5	The use of precision farming technologies is essential for better crop yields.					

SA: Strongly agree, A: Agree, UD: Undecided, DA: Disagree, SDA: Strongly Disagree

16. Management orientation

Please indicate your agreement or disagreement about each of the following statements

Sl. No.	**Statement**	**Response category**		
		Agree	**Undecided**	**Dis-agree**
I.	**Planning**			
1.	Each year one should think afresh about the crop to be cultivated in each type of land			
2.	It is not necessary to make prior decisions about the variety of crop to the cultivated in the land			
3.	The amount of agricultural input like seed, organic manures etc. needed for raising a crop should be assessed before cultivation			
4.	It is not necessary to think a least of the cost involved in raising a crop			
5.	One need not consult an agricultural expert for crop planning			
6.	It is possible to increase the yield through farm production plan			
II.	**Production**			
7.	Timely sowing of crops ensures good yield			
8.	Determining nutrient analysis by soil testing saves no money			
9.	One should use as much as fertilizer as he likes			
10.	Seed (Set) rate should be given as recommended by specialists			
11.	For timely harvest one should analyze the maturity of crop			
12.	With high water rate one should use as much irrigation water as available			

III.	**Market**			
13.	Market news is not useful to farmer			
14.	A farmer can get good price by grading his produce			
15.	One should sell his produce at the nearest mandi irrespective of price			
16.	One should purchase the inputs from shop where his other relative purchase			
17.	One should sell his produce through middlemen			

17. Precision Farming Technologies Used

Kindly select which of these technologies you already used on your field and which you plan to use in the future

Sl. No.	Technologies	Already Used	Plan to use in future
		Yes / NO	Yes / No
1	Grid Soil sampling		
2	Global Positioning System (GPS)		
3	Geographic Information System (GIS)		
4	Variable Rate Applicators/ Techniques		
5	Yield Monitors		
6	Remote Sensing		
7	Crop sensors		

16. What are the factors that motivate you to participate in this project?

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Part B

FARMERS' KNOWLEDGE LEVEL TEST STATEMENTS ON PRECISION FARMING TECHNOLOGIES

(I) GENERAL QUESTION

(1) What do you understand by precision farming in your own words?...

(2) Which of the following is not a precision farming technology?
(a) GPS (b) Grid soil sampling (c) Harrow (d) Don't know

(3) Precision farming can also be known as …………………
(a) Site specific crop management (b) Sustainable Agriculture (c) cultivation (d) Don't know

(4) Which of this is not part of the 5 R's of Precision Farming?
(a) Right Input (b) Right time (c) Right milling (d) Don't know

(5) ………… and ……….. are the two type of variability in Agricultural fields.
(a) Planting and Temporal (b) Spatial and Temporal (c) Cropping and field (d) Spatial and Cropping

(6) The recommended spacing for the crop you cultivated under precision farming is
(a) 90 x 60cm (b) 45 x 30cm (c) 90x 30cm (d) Don't know

(7) The recommended dosage for fertilizer for crop you cultivated is …………………………..

(II) SOIL SAMPLING TECHNIQUE

(1) Are you going to do soil sampling in all the season of the year?
(a) Yes (b) No (c) Undecided (d) Don't Know

(2) Grid based soil sampling is also the same as Management Zone (MZ)? True / false

(3) How many grids were formed in your farm?

- Area under precision = Crop cultivated under precision =
- Grid size = Number of grids =

(4) Which of the following is reliable and popularly used to define Management Zone (MZ)

(a) Soil Electrical conductivity (Soil EC) (b) Texture (c) Fertility (d) Soil Topography

(5) The appropriate depth for soil surface samples is……

(a) 0-10cm (b) 0-20cm (c) 0-30cm (d) 0- 50cm

(6) The Grid area for sampling is …...

(a) 100 X 100m (b) 50 X 50 m (c) 50 X 100m (d) don't know

(7) The following are the various parameters that can be processed from soil samples except …….

(a) (NPK) (b) Soil organic carbon (OC) (c) pH (d) water (H_20)

(III) VARIBLE RATE APPLICATION OF INPUTS

(1) Based on soil sample results, have you applied variable rate of fertilizer?

(a) Yes (b) No (c) Undecided (d) Don't Know

(2) Which nutrient you have reduced in your field according to variable rate application?

(a) N (b) P (c) K (d) water (e) Don't know

(3) Which nutrient you have increased in your field according to variable rate application?

(a) N (b) P (c) K (d) water (e) Don't know

(4) Have you observed variation in pest and disease problem across grids?

(b) Yes (b) No (c) Not at all (d) Don't Know

(5) Have you followed plant protection measures accordingly?

(c) Yes (b) No (c) Undecided (d) Don't Know

(6) How do you come to know variation in pest and diseases across grids?

(a) Scientist (b) self experience (c) Field workers (d) Others (specify)

(7) How many observations are required for your crop?

(a) 2 (b) 4 (c) 5 (d) 1

(IV) SENSORS AND THEIR APPLICATIONS

(1) Which one of the following is not a crop sensor?

(a) SPAD (b) Ceptometer (c) Green Seeker (d) GPS

(2) Ceptometer is used to measure ………

(a) Water (b) Chlorophyll (c) Leaf Area Index (LAI) (d) Don't know

(3) The light intensity on ceptometer when taking reading should be more than …………….

(a) 1000 (b) 500 (c) 5000 (d) Don't know

(4) The recommended time for taking readings with ceptometer is between ……….

(a)7am – 10am (b) 11am – 3pm (c) 4pm – 6pm (d) Don't know

(5) Before taking readings with ceptometer, the bubble should be where?

(a) Center of the circle (b) side of the circle (c) not in the circle (d) Don't know

(6) The readings on which label is taking as the Leaf Area Index (LAI) when using ceptometer?

(a) L (b) T (c) Fb) (d) don't know

(7) Weed mapping can be done by?

(a) Throwing 1m stick in the grid randomly and take weed count from $1m^2$ of the stick

(b) Throwing 2m stick in the grid randomly and take weed count from $2m^2$ of the stick

(c) Normal random counting from the field (d) Don't Know

(8) After harvesting, the next observation is to measure ………. From the field

(a) Total dry matter (b) Chlorophyll remains (c)Plant height (d) Don't know

(9) Green seeker is used to measure …………

(a) NDVI (b) ND (c) Leaf Area Index (LAI) (d) Don't know

(10) Green seeker should be place at …..inches above plant canopy when taking readings

(a) 100 (b) 48 (c) 150 (d) Don't know

LEVEL OF PARTICIPATION IN PRECISION FARMING TECHNOLOGY

Below are the activities in precision farming, please indicate the one you participated or not

Sl. No.	Activities	Yes/No
1.	Deciding the grid size	
2.	Formation of grid size using GPS	
3.	Soil Sampling	
4.	Soil analysis	
5.	Observation of crop characteristics (eg. Crop height, leaf area index etc)	
6.	GIS mapping	
7.	GIS map interpretation	
8.	Variable rate application of fertilizers	
9.	Harvesting according to grids	
	Others (specify)	

Part – C

RESOURCES UTILIZATION PATTERN

Sl No.	Resources	Amount used /cropping season
1.	Seed Rate (g/ha)	
2.	Manures (t/ha)	
3.	Labour (Human days /ha)	
4.	Plant protection Chemical (g/ha)	
5.	Irrigation (ha/cm)	
6.	Nitrogen (kg/ha)	
7.	Phosphorus (Kg/ha)	
8.	Potassium (kg/ha)	
9.	Others (specify)	

SUGGESTIONS

Please indicate your suggestions for adoption of Precision farming technology.

1. ____
2. ____
3. ____
4. ____
5. ____.

Part –D

PERCEPTION OF PRECISION FARMING TECHNOLOGIES

Below are set of statements which represent perception of precision farming technologies. Please, state the degree of your response by ticking one of the following Strongly Agree (SA) Agree (A), Undecided (UD) Disagree (DA) and Strongly Disagree (SD) about each statement.

Sl No.	Statements	SA	A	U	DA	SD
1.	Precision farming technologies will be useful for me					
2.	Precision farming technologies improve the resource use efficiency					

3.	Precision Agriculture tools will improve my farm system					
4.	It will be easy to learn how to use precision farming technologies					
5.	Precision farming technologies will be easy to use					
6.	I will be able to remember how to perform task using precision farming technologies					
7.	Precision farming technologies are clear and understandable					
8.	Precision farming technologies can increase the yields					
9.	Precision farming technologies can increase marginal returns					
10.	Precision farming technologies will provide relative information for decision making					
11.	Precision farming technologies can minimized the cost of cultivation					
12.	Precision farming technologies will reduce environmental hazards caused by blanket use of resources					
13.	Precision farming technologies will minimized soil problems					
14.	Precision farming technologies will be more profitable in future					
15.	Sustainable Agriculture can be achieved through Precision farming					
16.	Precision farming technologies requires sophisticated equipments					
17.	Precision farming technologies are more suited to educated farmers					
18.	Precision farming technologies demands more labour					
19.	Precision farming technologies helps in applying inputs in a more scientific way					
20.	Adoption of precision farming technologies will empower me as a farm manager					

Part-E

PERCEIVED CONSTRAINTS TO PRECISION FARMING

Possible constraints faced in this project, kindly tick Yes/No based on your perception of the constraints to you.

Sl No.	**Perceived constraints**	**Extent of Problem**			**Suggestions for Improvement**
		Always	**sometimes**	**Not a problem**	
	Production constraints				
1.	Non availability of Input in time				
2.	High rate of wages for labourers				
3.	Shortage of Labours				
4.	High cost of Inputs				
5.	Low supply of Electricity				
6.	Inadequate land holdings for adoption of precision farming technology				
7.	Lack of technical skill to follow precision farming recommendations				
8.	Lack of Knowledge about Precision farming technologies				
9.	Lack of water availability and pumping efficiency				
10.	Land leveling problem				
	Financial Constraints	**Always**	**sometimes**	**Not a problem**	**Suggestions for Improvement**
1.	Shortage of own fund				
2.	Lengthy process of loan sanctions in bank				

3.	Too much documentation				
4.	No easy access to credit				
5.	High interest rates				
6.	Low support by financial institutions				
	Marketing Constraints	**Always**	**sometimes**	**Not a problem**	**Suggestions for Improvement**
1.	Inadequate market demands for output				
2.	Low remunerative Price for produce				
3.	High transportation cost				
4.	Price fluctuation				
5.	Lack of marketing information				
	Management Constraints				
1.	Time consumption of Precision farming				
2.	Inadequate training and demonstration				
3.	Poor Research-Extension -farmer linkage				

COMPARATIVE ANALYSIS OF PRECISION FARMING TECHNOLOGIES IN SELECTED CROPS

INTERVIEW SCHEDULE (NON PARTICIPANTS FARMERS)

Respondent no: **Date:**

Part-A

I. General Information

1. Name of the farmer: ________________ 2. Station: ______
3.Village:____________

4. Name of the taluk: ________________ 5. Name of the district: ____________

II. Personal and Socio-economic Characteristics

1. Age: ____years 2. Education: _______years

3. Farming experience: ________ years

4. Size of the land holding (ha): _______ 5. Annual income:
Rs___________/-

Sl. No.	Ecosystem	Areas (Acres)	Crop Yield (q/acres)
1	Irrigated		
2	Dry land		
3	Rainfed		
	Total		

Sl. No.	Particular	Amount (/-)
1	Agriculture	
2	Subsidiary	
3	Others	
	Total	

6. Cropping Intensity

Sl. No.	Type	Area	Crops Grown		
			Kharif	Rabi	Summer
1	Single cropped area				
2	Double cropped area				
3	Triple cropped area				

7. Mass media utilization

Sl. No.	Mass Media Sources	Subscriber/ Possesesd	Programmes	Frequency of Use				
				Every day	Once in a week	Once in fort night	Once in a month	Not at all
1	Radio		i)Agriculture Programmes					

			ii)General Programmes					
2	Television		i)Agriculture Programmes					
			ii)General Programmes					
3	News Paper		i)Agriculture Programmes					
			ii)General Programmes					
4	Farm Magazine		i)Agriculture Programmes					
			ii)General Programmes					
5	Others (Specify)		i)Agriculture Programmes					
			ii)General Programmes					

8. Extension Contact

Sl. No.	Extension Worker	Frequency of contact in a Month			
		Everyday	Once in a week	Once in fortnight	Not all
1	Agricultural Assistant				
2	Agricultural Assistant Officer				
3	Agricultural Officer				
4	Assistant Director of Agriculture				
5	Agril. University SMS				
6	Private Agency Extension Officer				
7	NGO Extension Officer				
8	Others (specify)				

9. Extension Participation

Sl. No.	Extension Activities	Frequency of Participation in a Month		
		Regular	occasional	Never
1	Training Programme			
2	Demonstrations			
3	Field days			
4	Field Visit			
5	Group Meetings			
6	Agricultural Exhibitions			

7	Krish Mela			
8	Educational Tours			

10. Risk Orientation

Please indicate your degree of agreement or disagreement to the following statements

Sl. No.	Statements	Agree	Disagree
1	A farmer should grow large number of crops to avoid greater risk involved in growing one or two crop		
2	A farmer should rather take more of a change in making a big profit than to be content with small but less risky profits		
3	A farmer who is willing to take greater risks than average farmers usually have better financial condition		
4	It is good for a farmer to take risk when he knows his chances of success is high		
5	It is better for a farmer not to try new farming methods unless most other farmers have used them with success		
6	Trying an entirely new method in farming by a farmer involves risk, but it worth it		

11. Achievement Motivation

Please indicate your degree of agreement or disagreement to the following statements

Sl. No.	Statements	Agree	Undecided	Disagree
1	Work should come first even if one cannot get proper rest in order to achieve his goals			
2	It is better to be content with whatever little on has than to be always struggling for more			
3	No matter what I have don I always want to do more			
4	I would like to try hard at something which is really			

	difficult even if it proves that I cannot do it			
5	The way things a now a days discourage one to work hard			
6	One should succeed in occupation even if one has to neglect his family			

12. Scientific Orientation

Please indicate your degree of agreement or disagreement to the following statements

Sl. No.	Statements	Agree	Undecided	Disagree
1	Improved Practices gives better yield than old practices			
2	The way farmer's fore farmers practiced Agriculture is still the best way even today			
3	Even a farmer with lots of experience should use improved practices			
4	Though it takes a lot of time to for a famer to learn improved production practices, it is worth of efforts			
5	A good farmer experiments with new ideas in farming			
6	Traditional methods of farming have to be changed in order to raise the level of a farmers			

13. Deferred Gratification

Please indicate your opinion against the following statements

Sl. No.	Statements	Agree	Undecided	Disagree
1	A farmer should not postpone his desire rather fulfill it with savings			
2	Today that we are is more important than tomorrow what we would be			
3	Invest when a farmer has money and no investment when he does not have money is a best way of farming			
4	Saving often invite troubles theft and robbing are very common now a days			

5	A farmer should be like an ant than green hopper (spindrifts) to save the money for future farming			

14. Innovative Behaviour

Please indicate your opinion against the following statements

Sl No.	Statements	Agree	Undecided	Disagree
1	I am very much interested in adopting new practices that are helpful in conserving input, soil and water			
2	Since am not sure of success of new practices, I will like to wait till others adopt it			
3	Since new farming practices are not profitable, am not interested in any of them			
4	I try to keep myself inform about improved farming practices and to adopt it as earlier as possible			
5	Improved farming system are not easily adoptable so I don't adopt them			

16. Management orientation

Please indicate your agreement or disagreement about each of the following statements

Sl. No.	**Statement**	**Response category**		
		Agree	**Undecided**	**Dis-agree**
I.	**Planning**			
1.	Each year one should think afresh about the crop to be cultivated in each type of land			
2.	It is not necessary to make prior decisions about the variety of crop to the cultivated in the land			
3.	The amount of agricultural input like seed, organic manures etc. needed for raising a crop should be assessed before cultivation			
4.	It is not necessary to think a least of the cost involved in raising a crop			
5.	One need not consult an agricultural expert for crop planning			

6.	It is possible to increase the yield through farm production plan			
II.	**Production**			
7.	Timely sowing of crops ensures good yield			
8.	Determining nutrient analysis by soil testing saves no money			
9.	One should use as much as fertilizer as he likes			
10.	Seed (Set) rate should be given as recommended by specialists			
11.	For timely harvest one should analyze the maturity of crop			
12.	With high water rate one should use as much irrigation water as available			
III.	**Market**			
13.	Market news is not useful to farmer			
14.	A farmer can get good price by grading his produce			
15.	One should sell his produce at the nearest mandi irrespective of price			
16.	One should purchase the inputs from shop where his other relative purchase			
17.	One should sell his produce through middlemen			

Part – C

RESOURCES UTILIZATION PATTERN

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4.	Plant protection Chemical (g/ha)	

5.	Irrigation (ha/cm)	
6.	Nitrogen (kg/ha)	
7.	Phosphorus (Kg/ha)	
8.	Potassium (kg/ha)	
9.	Others (specify)	

Part-E

PERCEIVED CONSTRAINTS TO PRECISION FARMING

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	pumping efficiency				
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ABSTRACT

COMPARATIVE ANALYSIS ON PRECISION FARMING TECHNOLOGIES IN SELECTED CROPS OF NORTH EASTERN KARNATAKA

SHITU ADENIPEKUN GABRIEL **2014** **DR. G. N. MARADDI**

Major Advisor

ABSTRACT

The present study was undertaken to compare precision farming technologies in selected crops of North Eastern Karnataka, India. The study was conducted during the year 2013-2014 in three districts of North Eastern Karnataka. A random sampling technique was used to select 35 precision farming participant farmers and 35 non-participant farmers of the same selected crops making a total sample size of 70 respondents for the study. Data collection was done through the use of a well structure interview schedule. Data was analyzed using descriptive statistics such as mean, frequency distribution, percentage as well as standard deviation. Inferential statistics such as t-test of comparing means and Logistic regression model was used to analyze the resource utilization pattern and factors responsible for future adoption respectively.

The results showed that 71.43 and 65.72 per cent of the participant and non-participant farmers were in middle age category respectively. Also, barely half (48.57 %) of the participant had education up to pre- university education while 25.71 per cent of the non-participant farmers had education up to pre university education. The result of t-test of comparing means revealed that participant farmers in pigeon pea and paddy saved more input compare to non-participant farmers especially in plant protection chemicals, Nitrogen fertilizer as well as potassium fertilizer as they were significant at 1 % level. However, inputs such as seeds, manures and labours were not significant. The result of Logistic regression model showed that level of extension contact as well as respondents' scientific orientation were positively significant at 10 per cent to the likelihood of future adoption of precision farming technologies.