ECONOMIC IMPACT OF BENGALGRAM TECHNOLOGIES DEVELOPED BY UAS, RAICHUR IN NEK REGION

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CERTIFICATE

This is to certify that the thesis entitled **"ECONOMIC IMPACT OF BENGALGRAM TECHNOLOGIES DEVELOPED BY UAS, RAICHUR IN NEK REGION"** submitted by **Ms. BRUNDA S.,** for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ECONOMICS,** College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, is a record of research work done by her during the period of her 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.

RAICHUR
August, 2018

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(S.B. GOUDAPPA)

AFFECTIONATELY DEDICATED

TO

MY BELOVED PARENTS

SHIVARAMAIAH. K.

BHAGYAMMA

AND

MY LOVELY SISTERS

NAYANA. S.

VIDYASHREE. S.

CONTENTS

LIST OF ABBREVIATIONS USED

Abbreviation		Expansion
et al.	:	And others
/	:	Per
°C	:	Degree celcius
viz.,	:	Namely
B-C ratio	:	Benefit- Cost ratio
Fig.	:	Figure
Ha	:	Hectare/s
Hrs	:	Hours/s
K_2O	:	Potassium
Kg	:	Kilogram/s
i.e.,	:	That is
etc.	:	Etcetera
`₹	:	Rupees
$	:	Dollar
Kg/ha	:	Kilogram/s per hectare
q/ha	:	Quintal/s per hectare
`₹/q	:	Rupees per quintal
%	:	Per cent
&	:	And

@	:	At the rate
N	:	Sample size
N	:	Nitrogen
No.	:	Number
$P_2 O_5$	:	Phosphorous
PPC	:	Plant protection chemicals
FYM	:	Farm yard manure
RD	:	Recommended dose
Q	:	Quintal/s
SD	:	Standard deviation
$\bar{X}$		Mean
=	:	Equal to
POM	:	Proportional odds model
CI	:	Composite Index
PCA	:	Principal Component Analysis
NEK	:	North-Eastern Karnataka
Mt	:	Million tonnes
Mha	:	Million hecatres
UASR	:	University of Agricultural Sciences,Raichur

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Introduction

I. INTRODUCTION

The agricultural sector has been recognized as a key for spurring growth, overcoming poverty and enhancing food security. Around 60-70 per cent of population depends upon agriculture and allied sectors in India and currently it contributes to 16-17 per cent of the GDP (MoF, 2018). Agriculture is often characterized by low use of modern technology and low productivity. Improving the productivity, profitability and sustainability of small holder farming is the main pathway to reduce poverty. Achieving agriculture productivity growth will not be possible without developing and disseminating cost effective yield increasing technologies because it is no longer possible to meet the needs of growing population by expanding area under cultivation. Agricultural research and technological improvements are therefore crucial to increase agricultural productivity and thereby reducing poverty and meeting demands for food without irreversible degradation of natural resource base.

Major objectives of breeding and releasing high yielding varieties are to reduce hunger, malnutrition, poverty and increase the income of poor people living in rural areas. Major benefits from improved agricultural technologies are to reduce poverty directly by raising income of farm households, indirectly by raising employment, wage rates of functionally landless labourers and by lowering the price of food staples (Afsaw *et al.* 2012).

Ensuring a stable and healthful food supply for the world's growing population has become increasingly important, particularly in the face of climate change. Despite expected increase in food production in developing countries, the number of people at risk of hunger is predicted to grow, especially in the world's poorest regions. Calls to address the problem have become insistent; underscoring that political will for action exists, at least at the global level. As a starting point for further research and discussion among policy makers, development practitioners and researchers, these brief points to some of the complex factors related to adopting technologies that can address these challenges has been choosen.

Technical innovations and improved farming practices that increase agricultural production and productivity while enhancing climate resilience exist. These include drought tolerant seed varieties, drip irrigation, the precision application of fertilizers and agrochemicals as well as practices such as integrated pest management, conservation farming, improved watershed and soil management among others. However, getting these technologies into the hands of the farmers who will benefit most from them is not straightforward. Although technology is not a panacea, it is key to addressing the food production side of the food security equation. Increasing food production simply by using more land, water, seeds, fertilizer, and pesticides will not achieve the significant improvements in productivity necessary to advance the economic well-being of the food insecure countries. Equally important, the “more” approach is limited by the scarcity of resources and contributes to greenhouse gas emissions, deforestation and other environmental ills. Hence, widespread use of advanced technologies and practices is critical to intensifying production in an environmentally sustainable manner (Weisenfeld and Wetterberg, 2015).

Productivity increase in agriculture can reduce poverty by increasing farmers’ income, reducing food prices and thereby enhancing increments in consumption. Consistent with this argument, the Department for International Development (2003) estimated that one per cent increase in agricultural productivity reduces the percentage of poor people living on less than 1$ a day by between 0.6 and 2 per cent and no any other economic activity generates the same benefit for the poor. It is also of considerable significance that when agricultural production increases through the use of improved varieties of crops in a given area, farmers and their communities derive added socio-economic benefit. Such activities can increase the value of locally produced crops, generate local employment, stimulate local cashflow through processing, marketing and related activities can bring about improvement in socio-economic status and the quality of life.

Agricultural growth is seen as a best strategy for achieving food security because of the fact that agriculture is central to livelihood of more than half of world’s population. Growth in agricultural production can reduce food insecurity by increasing the amount of food available for consumption. This is particularly important for rural consumers whose food entitlement is mainly based on own production.

New agricultural technologies and improved practices play a key role in increasing agriculture production and hence improving national food security in developing countries. Whereas, successful adoption of improved technologies could stimulate overall economic growth through inter sector linkages while conserving natural resources. However, several research findings have pointed the fact that the use of new agricultural technology such as high yielding varieties that kick-started the Green Revolution in Asia, could lead to significant increase in agricultural productivity in Africa and stimulate the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy (Awotide *et al.* 2012).

Bengalgram (*cicer ariatinum* L.), is an important legume in India belonged to family fabaceae. It is also known as gram, chickpea, and *chana* and commonly called as *daals.* It is originated from Western Asia (Turkey). In India, major types of bengalgram cultivated are *viz., desi* and *kabuli* in the ratio of 3:1 and it is rich source of protein. The seed contains 21.10 per cent protein, 61.50 per cent carbohydrates and 4.5 per cent fats. Besides, it contains iron, calcium and niacin in sufficient quantity. It is very good for milking animals as it is a good source of energy and protein. Raw bengalgrams have a lower *trypsin* and *chymotrypsin* inhibitor content than peas, common beans, and soybeans. This leads to higher nutrition values and fewer digestive problems in non-ruminants. The tender leaves used as vegetables. Flour is used in preparing different products. The malic acid and oxalic acid present in bengalgram plant are used in medicine preparation. Germinated bengalgrams are rich in essential amino acids such as lysine, isoleucine, tryptophan and total aromatic amino acids.

Bengalgram is the third most important pulse crop after dry bean and peas, produced in the world. It accounts for 20 per cent of the world pulses production and its global importance has increased considerably during the past three decades. The number of bengalgram growing countries has increased from 36 to 52 and importing countries from 30 to 150 during 1981 to 2011. Bengalgram reached a record high global area of 13.3 million ha (mha) and production of 11.75 million tonnes (mt) during 2011. In 2013, the area of bengalgram cultivation increased to 13.5 mha but production remained at 13.mt (FAOSTAT 2015). During 2013, 89.20 per cent of the bengalgram area and 84.47 per cent of production was in Asia, 3.57 per cent and 4.05 per cent in Africa, 4.24 per cent and 6.22 per cent in Oceania, 2.44 per cent and 4.55 per cent in America and 0.55 per cent and 0.71 per cent in Europe (FAOSTAT 2015). The major bengalgram producing countries, which contributed to about 90 per cent of the global bengalgram production during 2013, include India (67.4%), Australia (6.21%), Pakistan (5.73%), Turkey (3.86%), Myanmar (3.74%), and Iran (2.25%), which could be evidenced from Table 1.1

Table 1.1 Global ranking in area, production and productivity of bengalgram in major countries

Rank	Country	Area (lakh ha)		Country	Production (lakh tonnes)		Country	Yield (kg/ha)
		Area	% to world		Prodn	% to world		
1	India	96.00	70.90	India	88.32	67.41	Isreal	6120
2	Pakistahan	9.92	7.33	Australia	8.13	6.21	Yemen	2974
3	Australia	5.73	4.24	Pakisthan	7.51	5.73	Canada	2353
4	Iran	5.50	4.06	Turkey	5.06	3.86	Egypt	2136
5	Turkey	4.23	3.13	Mynmar	4.90	3.74	Ethiopia	2041
6	Mynmar	3.35	2.47	Iran	2.95	2.25	Mexico	1817
7	Ethiopia	1.22	0.90	Ethiopia	2.49	1.90	Cyprus	1533
8	Mexico	1.15	0.85	Mexixo	2.09	1.60	Myanmar	1463
9	Syrian Arab	0.84	0.62	Canada	1.69	1.29	Australia	1418
10	Canada	0.72	0.53	Yemen	0.58	0.44	Turkey	1195
11	-	-	-	-	-	-	India	920
	World	135.40		World	131.02		World	968

Source: FAO statistics -2013

India is the largest producer and consumer of bengalgram followed by Pakistan, Turkey and Iran. It producers around 6-8 mt and contributes around 70 per cent of the total world production. It accounts for two-third of the world’s bengalgram production. It imports around 3-4 lakh tonnes of bengalgram annually from Canada, Australia, Iran, and Myanmar.

Madhya Pradesh is the single largest producer in the country, accounting for over 40 per cent of total production. Rajasthan, Maharashtra, Uttar Pradesh and Andhra Pradesh contributed about 14 per cent, 10 per cent, 9 per cent and 7 per cent, respectively. On the other hand, the share of Andhra Pradesh and Karnataka has been consistently raising during the past 10 years. Further, states like Jharkhand and Chhattisgarh are expanding their area and production of bengalgram crop. During 2012-13, the highest production of bengalgram (3551 thousand tonnes) was recorded in Madhya Pradesh with productivity of 435 kg/ha.

In Karnataka, bengalgram is grown in 9.26 lakh hectares with production of 7.03 lakh tonnes and productivity of 799 kg/ha. Major bengalgram growing districts in Karnataka are Belagavi, Bidar, Vijayapur, Dharwad, Gadag, Kalaburagi, Haveri, Koppal and Raichur.

Bengalgram is major pulse crop in North-Eastern Karnataka (NEK) region as region contributes to 55.29 per cent to total bengalgram production of the state. More technologies relevant to production, protection have been developed by the University of Agricultural Sciences, Raichur (UASR). There is a wide scope to study the impact of the technologies developed by UASR in bengalgram. Hence, the present study has been taken up with the following specific objectives,

Objectives

1. To estimate the spread of bengalgram technologies developed by UASR
2. To study the socio-economic features of bengalgram growers in the study area
3. To study the economic impact of bengalgram technologies developed by UASR

4. To determine the factors influencing the adoption of bengalgram technologies developed by UASR

5. To assess the constraints faced by the farmers in adoption of bengalgram technologies developed by UASR

Hypotheses

1. The bengalgram technologies developed by UASR are widespread.

2. Socio-economic features of farmers are positively related with adoption of technologies.

3. Adoption of technologies have positive impact on productivity, marketable surplus, household income and consumption expenditure.

4. Constraints faced by the farmers are less in adoption of technologies.

Special features of Investigation

The remarkable productivity growth in the agricultural sector of the World mainly comes from the technological improvement. It is proved from the Asian and some Latin countries that the green revolution is able to increase the productivity of the farmers very significantly. Adoption of agricultural technologies can boost production and productivity of crops. Similarly, bengalgram crop production and productivity is enhanced by different improved technologies. Improved technologies were developed by researchers in different time. Kalaburagi and Raichur districts have best suitable land for bengalgram production. However, the adoption of technologies in the farmers seems very sluggish. Farmers' are not always adopting the newly introduced technologies that came to them from any extension organization immediately. They try to evaluate according to its match with their social environment and economic importance. So, knowing drivers and levels of improved bengalgram technologies adoption by farmers have a paramount importance for the researchers to develop agricultural technologies and for the agricultural extension to make scale out and promote more which suits to the current setting conditions of farmers. Decision makers too will benefit from the research output since they require micro level information to formulate and revise strategies concerning agricultural research and extension.

Thus, the present study is a modest attempt to examine the economic impact of bengalgram technologies developed by UAS, Raichur, factors influencing the farmers and also constraints faced by farmers in adopting technologies. Finally, the findings of the study will contribute for technology generators, extension agents, input suppliers and other organization working in agricultural sector to improve their service for the bengalgram production. The findings of this study will enable agricultural researchers, higher education institutions and peoples working on agricultural development to redirect their research focus based on the real situation and demand of farmers. An understanding of the processes leading to the adoption of new technologies by farmers would help in planning and successful implementation of research and extension programs.

Presentation of the study

The study has been presented in seven chapters. Chapter-I, provides a brief introduction along with specific objectives. Chapter-II deals with the review of the relevant past studies conducted by the researchers earlier. Chapter-III gives an overview of the study area, sampling procedure, the nature and source of data, analytical tools employed for evaluating the objectives and various concepts used in the study. The results of the study have been presented in tables and a variety of graphs in Chapter-I. A critical discussion of the results obtained has been presented in Chapter-V. A brief summary of main findings of the study along with policies emerged have been presented in the Chapter-VI. Chapter-VII includes the list of books, journals, research papers and reports referred for the study.

Review of Literature

II. REVIEW OF LITERATURE

Review of past research studies is necessary for proper understanding and gaining insight into the research study and identifying the conceptual and methodological issues relevant to the study. The review of literature was undertaken keeping in view the the objectives of the study. This enabled the researcher to collect relevant information, analyze and interpret with meaningful conclusion. Keeping in view of objectives of the study, reviews are presented in this chapter under the following sub headings

2.1 Spread of different crop technologies

2.2 Socio-economic features of adopters of crop technologies

2.3 Economic impact of crop technologies

2.4 Factors influencing the adoption of crop technologies

2.5 Constraints faced by the farmers in adoption of crop technologies

2.1 Spread of different crop technologies

Shiyani *et al*.(2002) conducted a study on adoption of improved chickpea varieties and assess their impact on-farm benefits in some remote and backward tribal villages in Gujarat, India. Where, few newly developed varieties were introduced by non-government organization. The study found that adoption of improved chickpea varieties was gradually increasing by replacing a prominent local variety.

Soni (2002) reported that only 22 per cent of the total farms adopted 75-100 per cent of the recommended gram production technologies. While, 46 per cent farms adopted between 0-25 per cent, 20 per cent farms between 25-50 per cent and 12 per cent of farms adopted between 50-75 per cent of recommended technologies. The overall adoption gap was 52.90 per cent. The maximum gap was occurred in adoption of plant production measures (70.80%). The use of chemical fertilizer as a common practice in improved method of cultivation but the adoption gap in fertilizer application was more than 50 per cent. Majority of the farms (46%) were practiced traditional method followed by intermediate practices (32%) and improved method (22%).

Chatterjee *et al.*(2003) reported that majority (91%) of chickpea growers have completely adopted recommended field preparation practices, improved varieties, sowing time, seed rate, sowing methods and time of harvesting. Whereas, 53-63.6 per cent have partially adopted seed treatment, balanced dose of fertilizers, insect control and irrigation management. About 85 per cent of the respondents have not adopted soil testing and weed management practices.

Thoke and Gunjal (2010) in their study on adoption behavior of farmers in chickpea production technology in Nashik district of Maharashtra found that complete adoption of recommended technologies can be found in case of ploughing, sowing by drilling method, first weeding, control of pod borer by chemical means, harvesting at proper maturity and threshing. The practices which were adopted by majority of farmers were cultivating chickpea on proper soil type, 2-3 harrowing, sowing improved varieties *viz..,*Vishal, maintaining the proper seed rate to maintain appropriate plant population, recommended spacing, depth of sowing, seed treatment with thirum, seed treatment with rhizobium, sowing at proper time *i.e.,* during 15th October to 15th November, application of nitrogen, application of phosphorus, hoeing, thinning, providing irrigation to the crop at 50 per cent flowering stage and 50 per cent pod filling stage and average yield (55.35% and 66.07 % for irrigated condition and late sowing, respectively). The practices, which were partially adopted by the respondent farmers were FYM application, appropriate seed rate, phosphorus application. The practices which were not adopted by farmers were dibbling method of sowing, Virat variety, Dig Vijay variety, use of trichoderma for wilt control and 2nd weeding.

Dwivedi *et al.* (2011) carried out a study on adoption of improved production technology of pigeon pea in Ghazipur district of Uttar Pradesh. Study revealed that 52 per cent of the total respondents were found to be in the medium adoption group, whereas 33 per cent respondents were reported to be in the low adoption group and only 15 per cent respondents were in the high adoption group. It was also found that the majority of the famers adopted scientific recommendations about improved varieties, time of sowing, manual and chemical weed management, while seed treatment and plant protection measures were not adopted by majority of the farmers due to lack of knowledge, high cost involved in purchasing agro-chemicals, use of sprayers in standing long duration crop for control of pod fly and pod borer.

Saritha and Pushpa (2012) conducted a study on extent of knowledge and adoption level of farmers about improved technologies in cashew based dry land farming system. They reported that most of the respondents had medium level of adoption about recommended cashew cultivation practices. Nearly half of the respondents adopted manuring, propagation, stem and root borer management and tea mosquito bug management. It could be observed from the above findings that the low level adoption was found in the technologies *viz.*, preparation of field, recommended pit size, shoot caterpillar management and pink disease management.

Islam *et al.* (2013) conducted a study on adoption of BARI mung varieties and results showed that there was 51 per cent adoption can be found in case of BARI Mung-5 variety. The level of adoption in case of seed rate, use of urea, MoP, ploughing, sowing time, weeding and insecticides use were found to be high. On an average, about 59 per cent of farmers ploughed their land three times, 65 per cent of the farmers sown seeds during the month of february, 76 per cent of the farmers used pesticides and 69 per cent of the farmers not weeded their land.

Beena *et al.* (2014) studied the extent of adoption of recommended practices in pulses through FLD and showed that level of adoption of improved production technology practices on pulses crop was medium. The maximum adoption level was reported in practices like selection of high yielding varieties (90%) this was followed by the practices like time of harvesting (80%), use of culture (78.33%), control of insect/pest (76.67%), disease management (75%), precaution before storage (73.33%), application of fertilizers (68.33%), seed treatment (66.67%), selection of land (58.33%), crop rotation (53.33%), time of sowing/seed rate (50 %), land preparation (46.67%), depth of sowing/spacing (41%) and weed management 40%), respectively, while practices like irrigation management(38.33%) and sowing method (36.67%) were having less adoption level by the respondents.

Haque *et al*. (2014) investigated on adoption of mung bean technologies and technical efficiency of mung bean (*Vigna radiata*) farmers in selected areas. The results of the study showed that BARI Mung-3, 4 and 5 were the varieties highly adopted by the farmers. Technologies, such as ploughing, weeding and seed rate occupied higher level of adoption. Sowing time and insect-pest control were medium level and irrigation was lower level adoption. In case of chemical fertilizer, urea secured higher level of adoption followed by TSP and MoP.

Maraddi *et al*.(2014) examined extent of adoption of improved technologies by groundnut farmers and constraints analysis in Raichur district of Karnataka and reported that more than half of the respondents (55%) belongs to full adopter category followed by varieties (45%), seed rate (23.33%), spacing (23%), land preparation (20%), whereas, lesser percentage of respondents noticing in full adopter category in disease management (2.50%), organic manure (3.33%), and seed treatment with bio-agents. More than half of respondents identified in partial adopter category in almost all selected technologies except pest (23.33%) and disease management (20.83%). In no adoption category, more than half of the respondents were not following improved technologies in disease management.

Dhayal and Mehta (2015) in their study on knowledge and adoption of green gram production technology by farmers in Chhotaudaipur district of Gujarat. Authors found that adoption level of farmers was very high (above 75%) in case of time of sowing with 76.00 MPS. Farmers had good amount of adoption level (above 50%) regarding high yielding varieties, irrigation management, field preparations, seed rate and spacing, harvesting, threshing and storage and seed treatment. Other practices like weed management and fertilizer application adoption level was observed with less than 50 per cent and least adoption were found in plant protection practices. The overall extent of adoption level for green gram production technology by the farmers was about 53.00 per cent. About 10.00 per cent, 51 per cent and 39 per cent farmers were come under the category of high, medium and low adopters, respectively.

Umrathiya *et al*. (2015) reported adoption of improved chickpea varieties in Indore district of M.P and revealed that higher number of “chickpea variety JG-412 growers” (50.00%) adopted improved chickpea technologies to medium level followed by higher number of “chickpea variety JG-16 growers” (43.34%) adopted to medium level, higher number of “chickpea variety JG-130 growers” (43.33%) adopted to medium level and higher number of “chickpea variety Dollar (local) growers”(46.66 %) adopted to medium level. In nut shell, the higher number of chickpea growers (45.83 %) adopted overall technologies in chickpea cultivation by medium level.

Patel *et al.* (2016) studied an extent of adoption of *kharif* groundnut production technology in Banaskantha district in North Gujarat and revealed that among the different recommended *kharif* groundnut production technologies, 96.22 per cent and 85.55 per cent mean score was recorded for tillage and inter cultivation and ranked first and second respectively in adoption of groundnut production technologies. The practices *viz.,* irrigation (73.33%), harvesting (66%), fertilizers (64.11%), sowing (61%), improved varieties (54.66%) and weed control (52.61%) were obtained mean score and ranked third, fourth, fifth, sixth and seventh respectively adopted by majority of the farmers. Whereas, the practices *viz.,* plant protection (49%), marketing (46.53%), seed treatment (43.03%), gap filling (37.66%) and intercropping (3.44%) got the mean score less than 50 per cent.

Choudhary *et al*. (2017) carried out a study on adoption of mung bean production technology by the farmers in Jaipur district of Rajasthan. It was found that majority of the farmers (70 %) were in the medium adoption group, while 20.83 per cent of farmers were in low adoption group and only 9.17 per cent of farmers were in the high adoption group of mung bean cultivation and also found that the farmers had adopted practice "Spacing" to the higher extent with MPS 71.25. The practice "Storage" was found to be least adopted by the farmers with MPS 36.25. The study revealed that the majority of farmers had adopted practice "Spacing" to the higher extent and practice "Storage" was found to be least adopted by the farmers.

Singh *et al.* (2017) studied on adoption of blackgram production technology by the farmers in Mirzapur district of Uttar Pradesh and reported that majority of (82.5%) of the respondents had medium level of adoption of the cultivation practices while 9.17 per cent of the low and 8.33 per cent of high level adoption of recommended cultivation practices. Full adoption of technologies can be found in case of soil and its preparation, recommended planting material, right time of sowing and recommended cultural practices. In case of spacing 50.83 percent respondents adopted recommended spacing. In case of recommended manure and fertilizer application, 79.16 percent of the respondent had adopted FYM application while 66.66 per cent respondent had adopted the recommended chemical fertilizer application, 80.84 percent respondents had adopted recommended water management practices and 73.33 percent of the respondent had adopted the recommended control measures of disease and insect pest.

The above studies highlighted the extent of adoption of technologies in the crops like chick pea, redgram/pigeon pea, mung bean and cashew, etc. These studies have classified respondents into different categories into low, medium and high adopters and full adopters v/s partial adopters etc. in order to understand the extent of adoption of crop technologies in the farming community.

2.2 Socio-economic features of adopters of crop technologies

Thoke and Gunjal (2010) reported that majority of the respondents (77.67%) belonged to middle age group (*i.e.*between 26 to 45 years). Majority of respondents (51.79%) had undergone some formal education. Majority of the respondents (50 %) had land holding in between 4.01 to 7.00 acre. Majority of the respondents (54.46 %) had farming experience in between 9 years to 17 years. Majority of respondents (47.32 %) were found in medium social participation category. Majority of the respondents (67.86%) were having the annual income in between ₹ 75,551 to ₹ 1, 50,765. Majority of the farmers (60.72 per cent) were having their land at 2-3 places.

Singh *et al*. (2013) in their study on adoption of modern agricultural technologies in Bihar and reported that average age of respondent was 44 years and there was no much variation in respondent’s age belonging to different categories of farm households. In marginal and small farm categories, more than two-thirds of respondents belonged to younger age group (20-40 years) whereas about 44 per cent respondents of large farm size group belonged to younger age group (20-40 years). Analysis of educational information revealed that about 90 per cent of respondent farmers were literate with the higher rate of literacy on small farm households and the least on medium farm households. But about 81.25 per cent of respondents of large farm category were educated above secondary level, indicating higher level of education in family members of large category of farm households in study villages. Agriculture was the main occupation of households in study area.

Maraddi *et al.* (2014) in their study reported that 37.50 per cent of the groundnut farmers were educated upto primary school followed by 31.66 per cent were illiterate , middle school (24.16%), secondary school (4.16%) and collegiate (2.50%). With respect to farming experience, it was observed that about fifty percent possessed low experience followed by medium experience (31.67%) and high experience (19.17%) category. About half the (48.33%) groundnut growers belonged to Semi-medium farmers followed by Small farmers (23.33%), Medium farmers (13.33%), Marginal farmers (10%) and big farmers (5%). Regarding risk orientation of the groundnut farmers low level of risk orientation was noticed in 45 per cent farmers, while medium risk orientation was in the case of 35 percent followed by high risk orientation (20%) category. Nearly half of the respondents possessed lower level of scientific orientation (50.83%) followed by medium (36.67%) and high (12.50%) scientific orientation category. The nature of extension contact revealed that, Assistant Agriculture Officer was known to 76.67 per cent of respondents, around 32 per cent of the respondents were found to contact AAO whenever problem arises followed by once in a year (20%) and once in a month (9.17%). Among 23.33 per cent of the respondents who were aware of ADA very meager per cent of respondents were being contacted with Assistant Director Agriculture. About 74 per cent respondents were known to other extension agencies like private Agril. inputs, dealers, Private consultancy, NGOs, *etc*, of which 31.67 per cent of respondents contacted once in year followed once in month (26.67%).

Raghav and Sen (2014) studied socio-economic status of farmers and their perception about technology and revealed that average age of respondents ranged from 48.55 years (large farmers) to 58.10 years (marginal farmers) where as, their average land holding varied from 0.58 hectares (marginal farmers) to 13.20 hectares (large farmers). More than 20 per cent of farmers in each category were illiterate on each farm size, except large one. Proportion of farmers having primary education varied from 15 per cent (small farm size) to 30 per cent (large and semi-medium farm size) furthermore, 20 per cent of farmers in each category except semi-medium (30 %) had an education upto secondary level. On an average, 12 per cent sample farmers were educated up to intermediate level. About 58 per cent families of sample farmers were nuclear ones and only 42 per cent are living in joint family system and majority of marginal and small farmers follow nuclear family system, where as the majority semi-medium, medium and large farmers still live in a joint family system. About 27 per cent families belong to general category, 15 per cent comes under other backward class and 58 per cent belongs to SC/ST category. Most of large and medium size farmers belong from general category, where as most of marginal and small farmers to SC/ST category.

Dhayal and Mehta (2015) in their study on adoption of greengram production technology and reported that the majority of farmers belonged to the middle age group *i.e.,* between 30-54 years. It was further found that 63 per cent farmers belonged to the up to secondary category of educational level. The majority of farmers were having more than 2 ha land followed by small farmers and marginal farmers in the study sample. It was also found that 88 per cent farmers belonged to have more ₹ 24000 income per annum. The 30 per cent of farmers were no member of any organization followed by member of one organization (45%) and office bearer of organization (25%).

Meera *et al.* (2015) undertaken a study to assess the socio-economic features of chickpea growers in Bihar and reported that the majority of female workers were engaged in household works but a substantial proportion was also engaged in agriculture. Each and every household had owned 100 per cent of mobile ownership followed by ownership of two wheeler and television set. Fellow farmer among all sources was given top priority whereas, for disease management fellow farmers followed by extension staff and input dealers were the major sources of information.

Siddayya *et al.* (2016) in their study on adoption pattern of improved pigeon pea varieties in Kalaburagi district and revealed that about 50 per cent of illiterates were non-adopters of improved varieties of pigeon pea, where as only 30 per cent of illiterate were adopters, 30 per cent of adopters were having education level up to intermediate and degree level as against only five per cent in case of non-adopters. The farmers with an age group of above 45 years were found to be more in case of adopters (39.5%) than non-adopters (32.5%) in case of adopters, about 35 per cent of their income was from cultivation of crop, whereas the same was about 41 per cent in case of non-adopters. Interestingly, about 43 per cent of the incomes of non-adopters were from livestock.

Singha *et al.* (2016) studied socio-economic profile of the common adopters of improved practices of crops and livestock enterprises and majority of respondents in adopted villages had belonged to middle age category (47.70%) with age category of 36-50 years, 40 per cent of them were with low and medium education level each who had formal education up to middle school and high school, 60.77 per cent belonged to Scheduled Caste/Schedule Tribe (SC/ST), single family type (63.08%). As many as 69.23 per cent respondents in adopted villages belonged to medium family size (5 to 9 members) and most of them (82.31%) had farming as primary occupation for income and livelihood security with average annual income ranging from ₹ 50,000.00 - ₹ 100000.00 (45.38%). While majority of them (43.07%) were big farmers with operational land holding size of above 3 hectare and possessed farming experience more than 20 years (43.10%). Agriculture along with livestock and fisheries were the primary type of farming activities as reported by majority of 45.38 per cent respondents.

Thinde *et al.(*2017) studied socio-economic characteristics of wheat growers regarding adoption of improved wheat production technology in Kanpur Dehat district, Uttar Pradesh and revealed that 43.33 per cent of the wheat grower farmers had middle age (31-45 years) and 89.33 per cent had literate among 28.66 per cent of farmers who primary level. Among the sample about 42.66 per cent of wheat growers were marginal farmers with size of land holding <1 hectare. As far as social participation is concerned about 65.33 per cent of farmers were the member of one organization. The annual income of wheat growers revealed that about 42.66 per cent were found in the high income category ranging from ₹ 45,000 to ₹ 60,000. The study revealed that 74.66 per cent of wheat growers had medium level of economic motivation followed followed by scientific orientation and risk orientation had 69.33 per cent and 65.33 per cent respectively.

The above studies indicated that the majority of sample farmers who adopted different crop technologies were belonged to middle age group. They had good formal education and studied up to high school level. Farming is main occupation of the majority of the farmers. They had sizeable portion of land holding this showed that there was positive relation between landholding and adoption of technology. And also they had income ranged between ₹ 50000 to ₹ 150000. The sample farmers were also member of some faith based organization and also had extension contact with AO, AAO and ADA this encouraged them to adopt new farm technologies.

2.3 Economic impact of crop technologies

Ramakrishna *et al.* (2005) studied increased chickpea yield and economic benefits by improved crop production technology in *rainfed* areas of Kurnool district of Andhra Pradesh and reported that the improved production technology gave higher grain yield and recorded a mean yield of 2.09 t ha-1 which was 53 per cent higher than that obtained with farmers' practice yields of 1.37 t ha-1. The additional cost of US$56 ha-1 incurred in the improved technology as compared to farmers practice was mainly due to balanced fertilization (micro-nutrients and additional N and P), additional seed cost, seed treatment, IPM and one additional intercultivation. However, the improved technology resulted in increased mean income of US$190 with a benefit- cost ratio of 2.9.

Ogunsumi *et al.* (2007) carried out a study on economic impact assessment for improved soybean varieties in Southwest Nigeria and found that real adoption cost for the improved varieties ranged between ₦ 66 in 1975 and ₦ 45,000 in 1999. The real social returns from the improved soybean varieties ranged between ₦ 230,791 in 1982 and ₦ 1, 360 mio. in 1999, while the net real social gain was between ₦ 1,366,575 mio. in 1979 and ₦ 332 mio. in 1999. From the stream of the net gains, an internal rate of return (IRR) of 38 per cent was estimated for the investment that produced the technology. The payoff to investment that produced soybean varieties of 38 per cent can be said to be attractive because the return is above the prevailing interest rate during the same period.

Awotide *et al.(*2012) undertaken a study on impact of improved agricultural technology adoption on sustainable rice productivity and rural farmers' welfare in Nigeria and it was found that the consumption expenditure of the adopters (₦ 9877.71) was higher than that of the non-adopters (₦ 9588.92). The incidence of poverty was however higher among the non-adopters (51%) than the adopters (46%). The adopters had an increase of 267.12 kg/ha in rice productivity and the adoption of improved rice varieties significantly increase rice productivity by 358.89 kg/ha.

Macharia *et al.*(2012) conducted a study on the potential economic and poverty impact of improved chickpea varieties and found that adopters of technologies of chickpea had got total benefit of US$ 111 million for 30 years. Consumers are estimated to get 39 per cent of the benefit and producers 61 percent of benefit. The benefit-cost ratio was estimated at 5:1 and an internal rate of return of 55 percent, indicating that the investment is profitable. The generated benefit is expected to lift more than 0.7 million people (both producers and consumers) out of poverty.

Rajiv *et al.* (2013) studied impact of improved technologies on productivity and profitability of pulses, oilseeds and wheat at farmer's fields in in Uttar Pradesh and results revealed that improved techniques increased seed yield over farmer's practices by the margins of 6.93 q/ha or 107.9 per cent in pigeon pea, 10.77 q/ha or 113.8 per cent in chickpea, 8.79 q/ha or 71.5 per cent in field pea, 6.22 q/ha or 75.2 per cent in lentil, 1.57 q/ha or 135.3 per cent in sesame, 7.35 q/ha or 89.0 per cent in mustard, 15.81 q/ha or

60.1 per cent in wheat (T. aestivum) and 17.63 q/ha or 81.0 per cent in wheat (T. durum). Net profit due to improved techniques increased maximum of ₹ 20665/ha in chickpea followed by ₹ 16734/ha in pigeonpea. Lowest of ₹ 3462/ha net profit was increased in sesame.

Mohamed and Abdalla (2014) undertaken a study on impact assessment of improved wheat production package in Sudan and the results of the partial budgeting analysis revealed that the average total costs for adopters was higher than that of non-adopters by 11 per cent and the marginal rate of return (MRR) was about 529 per cent. The adopters of wheat technological package was gained higher yield of about 970 kg/Fed as compared to non-adopters. The net return (benefit) (NR) for adopters was about 39521.9 SD/Fed, while the net return (benefits) for non-adopters was approximately 33390.6 SD/Fed.

Singh *et al.* (2016) carried out study on impact assessment of pigeon pea variety NA-2 through FLDs in Ghazipur district of Eastern Uttar Pradesh and revealed that the improved technology (NA-2 variety) recorded higher yield of 18.06 q/ha over farmers practice (local check) 12.14 q/ha. The improved technology gave higher gross return (₹ 49313 /ha), net return (₹ 32293 /ha) with higher benefit-cost ratio (2.97) as compared to farmer's practices.

Tesfaye *et al*. (2016) carried out a study on impact of improved wheat technology adoption on productivity and income in Ethiopia and it was found that improved wheat variety adoption on an average increased wheat productivity of adopters by 1.1 t ha^{-1} than the non- adopters and average income of adopters was 35 to 50 per cent greater than non-adopters.

Teggelli *et al.*(2016) undertaken a study on improvement in productivity of the pigeon pea through innovative production technology and found that on an average the highest yield achieved by adopting improved production technology was 27.26 q/ ha over farmer's practices was 19.54 q/ha. The increase in the yield was 39.35 per cent over farmer practices. The average technological gap, extension gap and technological index were noticed 27.74 per cent, 7.72 per cent and 50.44 per cent respectively. The economics of average of ₹ 96,697 per ha was recorded net profit under recommended practices while it was ₹65076 per ha under farmer practices. Benefit-cost ratio was 4.74 under demonstration, while it was 3.85 under farmer practices.

Vinayak *et al.*(2016) studied impact of improved farm technology on pulses production in Karnataka and found that the total growth in bengalgram output was 14.86 per cent higher under A3P famers than that of Non-A3P farmers. The increase in output was further decomposed into different sources of change i.e. adoption of A3P and use of inputs. The A3P technology adopted farmers contributed to the ex-tent of 22 per cent increase in bengalgram output, while the contribution of change in input use level was negative (-7%). Among various inputs, seeds (0.23 %), human labour (1.49 %), plant protection chemicals (1.51 %), and fertilizer (0.13 %) contributed positively, whereas, land (-3.60 %), bullock labour (-4.42 %) and farm yard manure (-2.34 %) contributed negatively to the increased total bengalgram output.

Bharthiya *et al.* (2017) in their study on comparative yield gaps, economic impact and constraint analysis in front line demonstrations of soybean and black soybean in Uttarakhand hills and revealed that the improved production technologies under FLD produced on an average 44.98 per cent and 81.18 per cent more yield of soybean and black soybean, respectively as compared to local cultivars and existing traditional practices. Average technology gap for black soybean (1.58 q/ha) was lower than soybean (7.87 q/ha) at farmer's field. Improved black soybean cultivars (₹ 50,042) exhibited more profitability with benefit-cost ratio of 1.0 than local cultivars of black soybean (₹ 20,742) with benefit cost ratio 0.40.

The above studies compared the economic impact of crop production technologies over farmer practices and also among adopters and non- adopters. All these studies showed increase in net profits due to higher yields crops. The above studies also highlighted the increase in total cost due to adoption of improved practices such as recommended seed rate, seed treatment, balanced fertilization and IPM *etc.* Further, the increase in benefit- cost ratio and IRR was due to adoption of improved practices, thus there was reduction in poverty among adopters as compared to non- adopters.

2.4 Factors influencing the adoption of crop technologies

Nkonya *et al* .(1997) analysed factors affecting adoption of improved maize seed and fertilizer in Northern Tanzania indicated that farm size, education and frequency of visits by extension agents significantly and positively influenced maize seed adoption. whereas the influence of farmers' age, family labour and yield variability was not significant in improved maize seed adoption.

Admasu (2009) in his study carried out to determine factors influencing adoption of triticale in Farta wereda of Amhara region using logistic regression model, maximum likelihood estimation procedure, traced that distance to market center, access to leased-in land, perception about superiority of yield of triticale, livestock holding, off/non-farm income and input price were found to influence farmers adoption decision of Triticale.

Simtowe *et al.(*2010) carried out a study on determinants of agricultural technology adoption: The case of improved groundnut varieties in Malawi and revealed that education, membership in faith based organization, number of year of residence in village, number of years of experience in groundnut farming had positive and significant effect on adoption of groundnut technologies whereas, access to agricultural extension, access to market, gender of the household head, contact with NGO and extension workers, were not significant on adoption of groundnut technologies.

Singh (2011) investigated factors influencing the adoption of mung bean production technology in Arid Zone of Rajasthan and found that occupation, landholding, irrigation facilities, economic motivation were positively and significantly related to adoption of mung bean production technology where as, age, education, caste, type of family, size of family, farming experience, annual income, extension contact, scientific motivation and risk orientation were not significantly related to adoption of mung bean production technology

Simtowe *et al*. (2011) conducted a study on determinants of agricultural technology adoption: the case of improved pigeon pea varieties in Tanzania and reported that the distance to agricultural office, the land holding size and the ownership of livestock have a significant effect on the adoption of improved pigeonpea varieties whereas, access to markets (distance to the main market), education, age, gender of the head of household and size of the household were not significant in adoption of improved pigeon pea varieties.

Egge *et al*. (2012) undertaken a study on factors affecting the adoption of improved sorghum varieties in Awbare district of Somali Regional State, Ethiopia and found that access to credit (68.7%), contact with extension agent (35.5%), use of mass media viz., radio (37.8%), large farm size, livestock ownership and access to information were major factors in influencing adoption of improved varieties of sorghum

Kassa *et al.* (2014) in their study on adoption of hybrid and chemical fertilizer and factors that affect the adoption decision has been identified using probit model and the marginal effect using OLS estimates. The result showed that gender, land ownership, irrigation use, access to credit, contact with extension agent, participation in off farm business activity have positive and significant relation with the adoption decision of chemical fertilizer; while, plot distance from the home stead, distance to the nearest market and TLU (Tropical Livestock Unit) has an inhibiting role in adoption decision.

Hagos and Zemedu (2015) conducted a study to analyze factors affecting adoption of rice improved varieties in Fogera district of Ethiopia. The results indicated that house hold size, education, farming experience of household head, off -farm income, contact with different institutions (governmental, NGOs and private) were positively and significantly related with adoption of improved rice varieties where as access to village market, access to main market and the distance to access agricultural extension office were negatively and significantly affect the adoption of improved rice varieties. .

Behera and Satapathy (2017) reported factors affecting adoption of pulse technology in Odisha and revealed that pulse growers were found in all age groups, most of them have primary education with illiterates up to 16.67 per cent were devoid of capacity building training belong to all social classes and were not members of any formal organizations. There was difference between marginal and small farmers with regard to social contact higher being with small farmers, limited farmers have irrigation facilities, about 40 per cent use electricity and few have modern agricultural equipments.

Diro *et al.* (2017) studied factors affecting adoption and degree of adoption of soybean in Ilu-Ababora Zone; Southwestern Ethiopia and found that distance to cooperatives and consumption of soya food at home had negative and significant impact on the proportion of land allocated to soybean production. Whereas, farm size and attendance on training of soybean production had positive and significant impact on the proportion of land allocated to soybean production.

It was evident from the above studies that land holding was significantly and positively influencing the adoption of technologies. Logistic regression model and probit model were used to determine the factors influencing adoption of technologies. Some of studies showed that, education and extension contact and farming experience have positive and significant influence in the adoption of technologies. The factors which considered in adoption of technologies were age, education, extension contact, years of experience in farming, off-farm income, and distance to agriculture office, membership in faith based organization and off farm income.

2.5 Constraints faced by the farmers in adoption of crop technologies

Singh *et al*. (2002) observed incidence of gram pod borer and cut worm was one of the most important constraints in decreasing the yield of chickpea crop followed by untimely rainfall, high cost of pesticides, lack of knowledge regarding improved technology, inadequate irrigation facilities and more risk in adopting improved technology.

Singh *et al* (2007) reported constraints in pigeon pea cultivation in Lucknow district of Central Uttar Pradesh and indicated that incidence of pests and diseases (97.52%), non-availability of quality material (96.23%), non-availability of sulphur-based phosphatic fertilizer for balanced nutrition (94.35%), non-availability of appropriate plant protection chemicals (91.45%), infestation of weeds (59.47%), lack of proper knowledge about seed treatment(53.62%), non-availability of inputs in time (49.32%), non- adoption of proper crop rotation (41.62%) and lack of knowledge about scientific crop production (40.44%) were reported major constraints by farmers.

Singh and Varshney (2010) undertaken a study on adoption level and constraints in rice production technology at Jabalpur district of Madhya Pradesh and reported that non-availability of suitable high yielding varieties (63.33%), occurrence of heavy weed infestation (51%), heavy pest and disease incidence (40%), high cost of labour (72.50%), high cost of inputs (60.00%), lack of regulated market (44.17%), lack of conviction in new technology (35.00%), non-availability of desired technology(30.83%), the lack of extension activities at village level(59.17%) and lack of proper communication system (30.00%) were major constraints faced by the farmers.

Shashikant *et al.(*2011) carried out a study in Kalaburgi district of Karnataka state of India to find out the constraints in raising productivity and marketing of redgram by the farmers and indicated that high incidence of pest and diseases (rank I), followed by inadequate availability of labour (rank II) in red gram cultivation were the major problems expressed by farmers in raising red gram productivity. High cost of pesticide, inadequate availability of fertilizers and quality seeds, low output price during post-harvest period, high output price fluctuation, damage due to natural calamities and non-availability of quality pesticides were the common constraints faced by the farmers. With respect to constraints related to marketing of the produce, the results revealed that inadequate transportation facility, high market fees and charges, high transportation cost, lack of storage facilities were ranked I, II, III, and IV respectively as the important constraints faced by the farmers.

Chandra (2012) carried out a study in Sundarban area of West Bengal state to record the constraints responsible for the non-adoption of mung bean production technology. The constraints were recorded under five broad categories *viz.*, knowledge and information, technical, socio-economic, infrastructural and managerial. Financial limitations, harvesting and disposal troubles, non-availability of rhizobium inoculum, small holdings, lack of timely availability of inputs, marketing of output, lack of timely assured irrigation, high cost of inputs, security of crops, risk and uncertainty were the major constraints found in the adoption of recommended practices by the farmers cultivating moong bean in Sundarban.

Singh *et al.* (2012) carried out a study on constraints in adoption of soybean production technology in Berhampur district of Madhya Pradesh and revealed that lack of education (67.72%) and lack of knowledge (54.05%) were the major constraints. Problem of non-availability of credit at proper time and non-availability of proper amount in credit were important socioeconomic constraints. The study also indicated that the lack of social participation and lack of risk bearing capacity were major socio-psychological constraint. As far as the communicational constraints were concerned, lack of information at proper amount was found a major constraint followed by lack of information in proper time and non-availability of information media. It was observed about 91.72 per cent respondents reported the lack of irrigation facility as the major constrain

Chodavadia *et al.* (2013) in their study on constraints and suggestions in adopting groundnut-pigeon pea relay cropping system in Saurashtra region of Gujarat. It was observed that the most important constraints were not getting remunerative price of crops (Rank I), high price of improved seeds (Rank II), lack of irrigation facility (Rank III), high price of chemical fertilizers (Rank IV), non-availability of finance in time (Rank V), high price of weedicides and high price of fungicides/pesticides (Rank VI), labour requirement is more in groundnut-pigeon pea relay cropping system (Rank VII), non-availability of extension worker in villages as per time schedule (Rank VIII), due to the adoption of recommended sowing distance, there is difficulty in inter-culturing (Rank IX) and unawareness about the recommendations of pesticides and fungicides (Rank X)

Kerketta *et al*. (2015) studied constraints faced by chickpea growers in adoption of integrated pest management practices and found that. non availability of bio-agents (91.66%), followed by non-availability of inputs at a time (90%), lack of proper training conduct for IPM practices by extension agent or agencies (80.83%), lack of knowledge about use of inputs at proper time (71.66%), lack of media advertisement (70%), lack of technical knowledge of IPM practices (66.66%), non-availability of resistant varieties (62.50%), high cost of inputs (50%), lack of knowledge about appropriate selection and dose of insecticide and weedicide (41.16%) as important constraints faced by farmers.

Singh *et al.* (2015) reported constraints faced by the farmers in chick pea cultivation in Baldevgarh Block of Tikamgarh District and found that improved seeds and fertilizers are costly, inadequate credit facilities for purchasing necessary inputs, improved seeds are not available sufficiently, Low market price of chickpea, Lack of knowledge about proper place of marketing, Lack of cooperative marketing organization, Lack of knowledge on location specific improved varieties of chickpea, Lack of knowledge about seed treatment, Lack of demonstration and training, Problem of insect, pest and disease, chickpea crops get damaged due to unfavorable weather conditions as major constraints faced by chickpea growers.

Garima *et al.* (2016) investigated the constraints faced by the farmers and their remedies in technological adoption of rice–wheat cropping system in Eastern Uttar Pradesh and reported that the major social constraints faced by the farmers were lack of remunerative price for their produce due to more involvement of intermediaries, lack of community interaction between scientist and progressive farmers, lack of risk orientation in farming community and lack of contact with information sources by farmers. Economic constraints faced by majority of farmers were more incidences of pest and diseases damage the crops was ranked 1st (94%) followed by lack of availability of manures and fertilizers in market at required times (81.5%), non-availability of quality seeds when required (52%), tractor on hire is hardly available at the time in the village (48%), duplicate fertilizers sold to the farmers damage the crops adversely affect the yield (26%), and risk due to erratic monsoon (18%).

Kumari and Singh (2016) studied on production and marketing of chickpea in Bihar: problems and prospects for the farmers. It was reported that the major constraints faced by the farmers were moisture stress, lack of knowledge about high yielding varieties., inadequate supply of seeds of improved varieties, slow seed replacement rate, insufficient and unbalanced use of fertilizers, poor and zero management of salt affected soils, inadequate supply and poor adoption of quality bio fertilizers based on efficient strains of Rhizobium and PSB, Poor adoption of IPM and IDM and Post-harvest problems faced by the farmers were enormous losses in pulse grains due to faulty storage practices and processing, poor and undeveloped infrastructural facilities like covered threshing floor, road, godown etc. Disruption of drainage system leading to water logging, lack of awareness of developed technologies, fluctuating prices of pulses, heavy infestation of weeds, severe crop damage due to attack of disease and insects *etc.*, were other constraints faced by the farmers.

Raviya *et al*. (2016) studied the constraints in adoption of groundnut production technologies in Junagadh district of Gujarat state and reported that failure of crop due to heavy rainfall (89.16%), timely non-availability of fertilizers (85%), weight and quality loss during storage and transportation (80 %), inadequate storage facilities (75%), lack of marketing infrastructure facilities (71.66%), fluctuation of groundnut price in the market (66.67%) were major constraints faced by groundnut growers in recommended groundnut production technology.

Singh *et al*. (2017) carried out study on constraints and adoption of blackgram production technology by the farmers in Mirzapur district of Uttar Pradesh and revealed that lack of technical guidance (93.33%), not existing of the market (92.5%), lack of marketing facilities (91.66%), non-availability of skilled labour (90.83%), monopoly of merchant in the market (51.66%) and lack of financial support (43.33%) were constraints faced by the farmers in adoption of black gram technologies.

Soujanya and Kumari (2017) examined constraints faced by the farmers in adoption of integrated crop management in chilli crop in Telangana and found that labour scarcity for farm operations, power cut, requirement of more labour for production of quality chilli and more expenditure towards plant protection chemicals were major constraints ranked first, second, third and fourth with mean scores of 71.03, 70.17, 63.17 and 59.40 respectively by ICM farmers.

The above studies indicated that high cost of inputs, occurrence of pest and diseases, high cost of labour, non-availability of skilled labour, less remunerative price for produce, high price fluctuation of output, non-availability of fertilizers at a time, non-availability of bio fertilizers, failure of crop due to natural calamities were the major constraints faced by the farmers.

Methodology

III. METHODOLOGY

This chapter reveals the methodology adopted for the study. To analyze various objectives of the study, appropriate methodology describing sampling design, data collection tools and techniques employed for data analysis are explained under the following headings.

3.1 Locale of the study

3.2 Description of the study area

3.3 Sampling procedure

3.4 Nature and sources of data

3.5 Analytical tools employed

3.6 Definition of terms and concepts

3.1 Locale of the study

The study was conducted in Karnataka state with a focus on the North Eastern Karnataka region. However, the study area confined to two districts of North Eastern Karnataka *viz.*, Kalaburagi and Raichur districts as area under bengalgram is relatively higher in two districts of the region. (Fig.3.1). North-Eastern Karnataka region contributes about 55.29 per cent to bengalgram production of the State. The major bengalgram growing districts in Karnataka are Raichur, Kalaburagi, Koppal, Ballari, Yadgir, Bidar, Dharwad and Belagavi.

3.2 Description of the study area

The study area mainly covers two districts *viz.*, Kalaburagi and Raichur districts coming under North-Eastern dry zone

North-eastern dry zone includes Devadurga, Manvi, and Raichur taluks of Raichur district, all taluks of Kalaburagi district except Aland and Chincholi and Shahapur, Shorapur and Yadgir taluks of Yadgir district. It has total area of 17.65 lakh hectares. Out of this, 13.27 lakh hectares is under cultivation. Area under irrigation of the North-eastern dry zone was 1.56 lakh hectares which include 11.9 per cent of the total area under cultivation during 2016-17. For this, 80 per cent of the source of irrigation is by canals. It gets average rainfall of 710 mm. Since major areas of this zone get heavy rains during September and October months, major crops in these areas were cultivated during post monsoon season. The temperature of 43˚c to 44˚c during the months of April and May is the special feature of this zone. Major area of the zone has got black soil. Light red soil is also seen at Shorapur, Yadgir, Devadurga, Manvi, and Raichur districts.

3.2.1 Description of Kalaburagi district

Kalaburagi district lies in the northern part of Karnataka between $16^0$11' –$17^0$45' N. latitudes and $76^0$03' - $77^0$30' E. longitudes, with a geographical area of 16,174 sq. km. The district is bounded by Bidar district in the north, Bijapur district in west, Raichur district in south and Andhra Pradesh in the east.

As per 2011 census, the population of the district was 25,66,326 (Male: 13, 01,756 Female:12, 64,571). The district has a population density of 233 inhabitants per square km. Its population growth rate over the decade from 2001 to 2011 was 17.94 per cent. Kalaburagi is the district headquarters comprises of seven taluks *viz.,* Aland, Afzalpur, Kalaburagi, Chincholi, Chittapur, Sedam, and Jewargi. There are 32 hoblis, 264 grama panchyaths, 32 nada offices, seven TMCs and one CMC. The rural population constituted 67.44 per cent of total population and sex ratio was 971 females per 1000 males. The normal rainfall is 820mm. The major occupation of the district is agriculture and nearly 75 per cent of population living in rural areas is dependent on agriculture. Therefore, agriculture is the main contributor (55%) to district income and other sectors contribute for 45 per cent of total district income.

The important crops grown in district are bajra, tur, sugarcane, groundnut, sunflower, sesame, castor bean, blackgram, jowar, wheat, cotton, bengalgram, and linseed.

3.2.2 Description of Raichur district

Raichur district lies between 15˚09' to 16˚34′ North latitude and 75˚46′ to 77˚35 ' East longitude in between two major rivers, viz., the Krishna and the Tungabhadra. The general slope of the district is from the north-west towards the south-east, its average height above the Mean Sea-Level being just 1,311 feet. The district is bounded on the north by the district of Kalaburagi, on the west by the districts of Vijayapur and Dharwad, on the east by the district of Mahboobnagar of Andhra Pradesh, and on the south by the districts of Kurnool, also of Andhra Pradesh and Ballari. It is known as “Rice Bowl” of India situated in the eastern part of Karnataka covering five talukas i.e. Devadurga, Lingasugur, Manvi, Raichur and Sindhanur.

It has max temperature of 45^0C and min temperature of 18^0 C. Geographical area of district is 8386 sq.km, average rainfall of 681 mm. Raichur is the district head quarter. District had a population of 1,924,773 (As per 2011 census), population density of 228 inhabitants per sq.km. and sex ratio of 992 per 1000 males. Literacy rate is 60.46 per cent. There are 37 hoblis, 180 grama panchayaths, 37 nada offices, two CMCs and five TMCs in the district.

Major source of irrigation is through canals, tube wells, tanks and wells. Net area sown is 53,98,33 hectare as per 2015-16. Major crops grown in district are paddy, jowar, bajra, vegetables, pulse crops such as redgram and bengalgram, other millets and castor *etc.*

3.3 Sampling procedure

3.3.1 Selection of the districts

The two districts *viz.,* Kalaburagi and Raichur districts of North-Eastern Karnataka were purposively selected as area under bengalgram is relatively higher in two districts of the region. NEK region contributes about 55.29 per cent to bengalgram production of the State.

3.1.2 Selection of the taluks and villages

The taluks in Kalaburagi district were selected in consultation with KVK, Kalaburagi and the taluks in Raichur district were selected based on the highest area in bengalgram production. The villages in both districts were selected in consultation with Agriculture officer (AO) of respective taluks. Seleced taluks and vaillages were detailed in Table 3.2.

Multistage purposive sampling technique was used for selection of sample farmers. In the first stage, Raichur and Kalaburagi districts were selected based on bengalgram production potential and the technology interventions. In the second stage, two taluks *viz.*, Sedam and Chittapur were selected from Kalaburagi district and two taluks *viz.*, Manvi and Lingasugur were selected from Raichur district using same criterion, accordingly four taluks were selected in consultation with KVK and AEEC of the University of Agricultural Sciences, Raichur to get the required number of sample farmers. In third stage, three villages from each of the chosen taluk were selected. Finally, 10 sample farmers were selected from each village. Thus, in total, 120 sample farmers were selected from 12 villages of 4 taluks in 2 districts. It is detailed in Table 3.1.

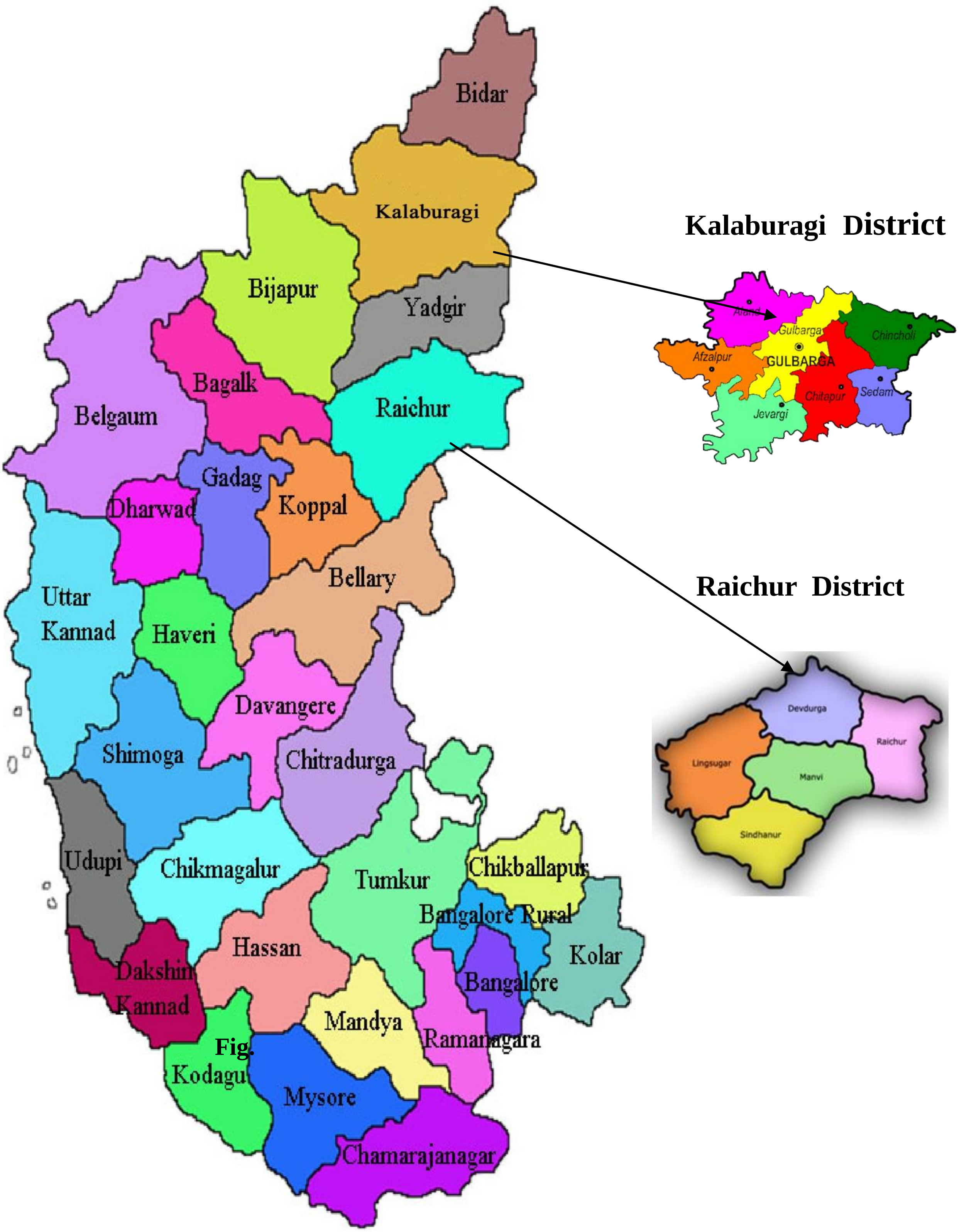
Table 3.1 Distribution of sample farmers

Sl. No.	Districts	Taluks	Villages	No. of sample farmers
1.	Kalaburagi	Sedam	Adki	10
			Mudhol	10
			Battgera	10
		Chittapur	Gundgurthi	10
			Tengli	10
			Dandothi	10
2.	Raichur	Manvi	Kurdi	10
			Harvi	10
			Kallur	10
		Lingasugur	Kuppigudda	10
			Gudadanal	10
			Sarjapur	10
Total				120

3.4 Nature and sources of data

For evaluating the objectives of the study, primary data relating to economics of crop production were obtained from the sample farmers using the pre-tested schedule. The sample farmers were personally interviewed to ensure accuracy ceteris paribus memory lapses. Data related to cropping pattern, landholdings, asset position, family size, educational level were obtained. Details regarding input use and output obtained were collected. Further, the data on the quantity of produce sold, prices of inputs and output was obtained from the sample farmers. The opinions about technologies developed by UASR and adopted by the farmers and the problems faced by the farmers in adoption of those technologies were recorded. Further secondary data was collected from DES Bengaluru, Agricultural Research Stations, KVKs, seed unit of UAS, Raichur and other input supplying agencies in public sector.

Karnataka State



3.1 Map showing study area

3.5 Analytical tools employed

For the purpose of fulfilling the specific objectives of the study, the data collected were subjected to following analytical techniques.

3.5.1 Simple tabular presentation

3.5.2 Descriptive statistics

3.5.3 Composite Index

3.5.4 Partial budgeting technique

3.5.5 Multi ordinal logistic regression analysis

3.5.6 Garrett ranking technique

3.5.1 Tabular presentation

Tabular presentation was employed to study the general characteristics of sample farmers, the extent of awareness and factors influencing on adoption of bengalgram technologies, cost and returns and profits of bengalgram technologies. The data were summarized with the aid of statistical tools like percentage, averages etc. to draw meaningful inferences.

3.5.2 Descriptive statistcs

The sample farmers who adopted technologies were scored with one and those who do not have adopted the technologies scored as zero. In such a manner, the adoption score for all recommended technologies for an individual farmer was worked out. Then calculated the number of technologies adopted by each sample farmer. The mean and standard deviation are worked out for total number of technologies adopted by all the sample farmers. Then classification of the farmers into low, medium and high adopters using following formula.

$$\leq \bar{X} SD*0.425 = \text{Low level of adoption}$$

$$\bar{X} \pm SD*0.425 = \text{Medium level of adoption}$$

$\geq \bar{X}+SD*0.425$ = High level of adoption

3.5.3 Composite Index

The components of technology recommended by the University of Agricultural Sciences, Raichur (UASR) for bengalgram crop in terms of adoption scores (X1 ..... Xn) were utilized for developing composite index of technology adopted. A composite index is a single numerical value representing the net adoption of all components of technologies whose values lies between 0 and 1 (Nimbalkar *et.al*.).

The Principle Component Analysis (PCA) approach was used for developing composite index. A set of K^{th} components explaining 100 per cent of total variation of all components of recommended technologies were considered. Correlation matrix where row represents variables and columns represents eigen vectors from which weight (wi) or coefficients of components of technology is determined as,

$$Wi = \sum Mi/Mi$$

Where,

Wi = Weight or coefficient of component of technology

Mi = Maximum element in i^{th} row

ΣMi = Sum of maximum element in i^{th} row

The required linear function for deriving composite index was,

$$Si = W1X1 + W2X2 + ... + WnXn$$

Where,

Si = Composite index score

Xi's = Adoption scores for individual component of technology

This provides adoption index (of all components of technologies) for each cultivator. The composite index obtained in the process lie in between 0 and 1. The composite score of farmers was classified as low level adoption (below 60 per cent) medium level (61-80 per cent) and high level of adoption (above 81 per cent).

3.5.3 Partial Budgeting technique

The partial budget is one of the basic tools in all farm management decision making. Partial budgeting is an excellent managerial tool to help evaluate the financial considerations caused by changes in a business.

In order to compare the costs and returns of varietal technologies and different level of adopters partial budgeting technique was employed. This will reflect difference in quantitative aspects among different level of adopters of bengalgram technologies. A partial budget model was constructed by considering all revenue and expenses that would change with an alteration to the farm operation. The model of the following form was used.

Sl.No	Debit	₹/ha	Credit	₹/ha
	A. Increse in costs		C. Decrese in costs	
1				
2				
3				
	B. Decrease in returns		D. Increase in returns	
1				
2				
Total (A+B)			Total (C+D)	
Net gain /loss =[(C+D)-(A+B)]				

3.5.4 Multi ordinal logistic regression analysis

3.5.4.1. Factors influencing the adoption of bengalgram technologies

In functional analysis, it would be essential to choose appropriate form of production function with consideration of data to be analyzed and objective to be achieved. With this perspective, in order to analyze the factors influencing adoption of technologies Multi ordinal logistic regression type of production function was fitted to determine which factors have more influence on adoption of bengalgram technologies developed by UASR.

Special type of multivariate analysis is best suited for ordinal data when several factors are taken into account. There are various approaches, such as the use of mixed models or another class of models, probit for example, but the ordinal logistic regression models have been widely publicized in the statistical literature. It is used when the dependent variable is ordinal in nature.

Ordinal logistic regression model is sometimes referred to as the constrained cumulative logit model originally proposed by Walker and Duncan (1967) and later called proportional odds model by (McCullagh, 1980; Ananth and Kleinbaum, 1997; Agresti, 2007; Hosmer and Lemeshow, 2000). Many quality of life scales are ordinal, "statistical methods such as ordinal regression models have been reviewed on a number of times", said (Lall et al., 2002).

In this study, since response variable (level of adoption of technology) is categorized into low, medium and high and independent variables taken in this study were also ordinal in nature. Hence, multi ordinal logistic regression was best fitted to analyze the data on factors influencing adoption of technologies of bengalgram.

Among different models of ordinal logistic regression, (POM) proportional odds model is best fitted to analyze the data on factors influencing adoption of technologies since the response variable adoption of technology is continuous variable and chi-square test of proportional odds assumption was found non-significant at 5 per cent level of significance indicating the data satisfy the proportional odds assumption.

The following form of production function was used to determine factors 3influencing adoption of bengalgram technologies among different level of adopters.

The model is:

$$\eta_j(X)=\ln\left[\frac{P_r(Y\leq j/x_1, x_2, \ldots\ldots x_p)}{P_r(Y>j/x_1, x_2, \ldots\ldots x_p)}\right]=\gamma_j+\beta_1 x_1+\ldots+\beta_p x_p+u$$

Where:

Y = Adoption of bengalgram technology

X $(x_1, x_2, \ldots\ldots\ldots x_p)$ = Vector of explainatory variable

γ_0 = threshold or intercept

$\beta_1, \beta_2, \beta_3, \beta_4$, and β_5 = Logit coefficients

$X_{1,1}$ = Age of household head (years)

$X_{2,2}$ = Education of household head

$X_{3,3}$ = Farming experience (years)

$X_{4,4}$ = Landholding (ha)

$X_{5,5}$ = Extension contact

u = random variable

3.2 Description of variables in model

	Variables	**Description**
Y	Dependent variable	Level of adoption of technology. Which is categorized in to low =1, medium=2

		and high=3. It is ordinal in nature.
$X_{1,1}$	Age of household head	Age of house hold head measured in years. It is categorized into young age=1, middle age=2 and old age=3. It is ordinal in nature.
$X_{2,2}$	Education of household head	It is ordinal in nature. It is categorized into illiterate=0, primary=1, high school=2, college level =3 and above college level =4.
$X_{3,3}$	Farming experience	It is measured in years. It is subdivided into low=1, medium=2 and high level of farming experience. It is a ordinal in nature.
$X_{4,4}$	Land holding	It is measured in hectare. It is categorized into marginal=1, small=2, medium=3 and large=.4. It is ordinal in nature.
$X_{5,5}$	Extension contact	It is ordinal in nature. It is sub devided into not at all=0,once in month=1,once in a fort night=2 and once in a week=3

Statistics for goodness-of-fit for ordinal regression models are:

1. Chi-square statistic $x^2 = \sum_i^N r_i^2 = \frac{(o_i - e_i^2)}{e_i}$

Where, $r_i = \frac{o_i - e_i}{\sqrt{e_i}}$ the Pearson chi-squared residuals;

a_i and ei are the observed and expected frequencies for $i = 1 \ldots\ldots\ldots N$;

N is J times the number of distinct covariate patterns;

2. Deviance $D = 2[(1(bmax) - 1(b)]$

Where $1(b)$ the maximum values of the log-likelihood are function for the fitted model and $(bmax)$ is the maximum values of the log-likelihood function for the maximal model;

3. Likelihood ratio chi-square statistic $C = 2[l(b) - l(bmin)]$,

Where $(bmin)$ is the maximum value of the log-likelihood function for the minimal model;

4. Pseudo $R^2 = \frac{l(b_{min}) - l(b)}{l(b_{min})}$

If the model fits well then both x^2 and D are asymptotically, the distribution 2 $\chi^2(n - p)$, where, p is the number of parameters estimated. C has the asymptotic distribution $\chi^2 [p - (J - 1)$

3.5.5 Garrett's ranking technique

The constraints faced by the sample farmers during adoption of bengalgram technologies were ranked by using Garrett's ranking technique. As per this method, respondents were asked constraints that they were faced in adoption of bengalgram technologies. Depending upon extent of constraints faced by them rankings were assigned separately to each constraint. Likewise, ranks were assigned to different frequency of various factors/parameters. The results of such rankings were converted into score value by using following formula.

$$\text{Per cent position} = \frac{100 * (R_{ij} - 0.5)}{N_j}$$

Where,

R_{ij} = Rank given for the i^{th} factor by j^{th} respondent.

N_j = Number of factors ranked by the j^{th} respondent.

The per cent position of each rank was converted to scores by referring to tables given by Garret and Woodworth (1969). Then for each factor, the scores of individual respondents were summed up and divided by the total number of respondents for whom scores were gathered. The mean scores for all the factors were ranked.

3.6 Definitions of terms and concepts used

3.7 Variable costs

The variable costs included cost on seeds, organic manures, bio fertilizers, chemical fertilizers, plant protection chemicals and wages of human labour, bullock labour and machine labour.

Human labour

The human labour includes labour put forth by men and women for taking up different cultivation operations. Human labour was estimated in terms of eight hours of work per day. Men labour was measured in terms of man days. Women days were converted into man days on the basis of wage differentials between men and women labour.

Machine labour

The machine labour included the use of tractor, combined harvester, sprayer, etc. to carry out various operations in bengalgram. The cost of machine labour in hours was calculated for different farm operations.

Farm yard manure (FYM)

FYM is the traditional organic manure and is most readily available to the farmers. It is produced by decomposing locally available agricultural wastes, dung and urine. The quantity of FYM used was measured in terms of tonnes and the cost was computed considering the actual price paid by the farmers.

Chemical fertilizers

These are the synthetic fertilizers, includes urea, DAP, superphosphate and complex fertilizers, etc. used for supply of nutrients in crop production. The cost of chemical fertilizers was based on the actual price paid by the sample farmers including cost of transportation.

Plant protection chemicals (PPCs)

Plant protection chemicals include different insecticides, fungicides and herbicides used in controlling bengalgram pests, diseases and weeds. The cost of plant protection chemicals calculated based on the actual price paid by the farmers towards these chemicals.

Interest on working capital

The working capital consisted of the expenditure on labour, seeds, organic manures, fertilizers, herbicides and pesticides. The interest on working capital was calculated at 7.5 per cent per annum (the rate at which nationalized bank provide short term loans).

Interest rate on fixed capital

The fixed capital consists of expenditure incurred on purchase of land, machinery and equipments used on farm *etc.* The interest rate on fixed capital is calculated at 9 per cent per annum (the rate at which nationalized banks provide long term loans)

Fixed costs

These include depreciation on farm implements and machinery, land revenue, rental value of land and interest on fixed capital.

Depreciation

Depreciation on each capital equipment and machinery owned by the farmers was calculated by the straight line method by using the following formula.

$$\text{Annual depreciation} = \frac{\text{Purchase value} - \text{Junk value}}{\text{Economic life of the asset}}$$

The charges on account of minor repairs of implements and machinery during the year were added to the depreciation charges. It was apportioned on the basis of area of land allocated for bengalgram during the year.

Land rent

Land rent is the consideration for the using leased- in land which was paid in the form of money.

Total cost of cultivation

Cost of cultivation included variable costs and fixed costs. Variable costs included the cost of human labour, bullock labour, machine labour, seeds, farmyard manure, plant protection chemicals and interest on working capital. Fixed costs comprised depreciation, land revenue, rental value of land and interest on fixed capital.

Gross return

The gross returns was computed by multiplying the quantity of main product and by product obtained with respective prices received

Net returns

Net returns were computed by deducting the total costs incurred from the gross returns obtained.

Returns per rupee investment

Returns per rupee of expenditure were obtained by dividing gross returns by the total cost of cultivation.

Cropping intensity

It is the ratio of gross cropped area to the net sown area

Man day

Refers to eight hours of work turned out by an adult male in a day.

Adoption

Adoption is a decission to make full use of an innovation as a best course of action available.

Low adopters

The sample farmers who adopted the recommended technologies ≤ 5 out of nine technologies are classified as low adopters.

Medium adopters

The sample farmers who adopted the recommended technologies between five and seven are classified as medium adopters.

High adopters

The sample farmers who adopted the recommended technologies ≥ 7 are classified as high adopters.

Results

IV. RESULTS

The study was conducted in two districts of NEK region. The necessary data were collected from sample farmers through pre tested and well-structured schedule and analysed through appropriate techniques. The results of the analysis are presented under the following headings.

4.1 Spread of bengalgram technologies developed by UASR

4.1.1 Spread of GBM-2 variety in Kalaburagi district of NEK region

4.1.2 Spread of GBM-2 variety in Raichur district of NEK region

4.1.3 Spread of GBM-2 variety in other districts of NEK region

4.1.4 Spread of GBM-2 variety in other parts of Karnataka and India

4.1.5 Distribution of bengalgram growers according to their adoption level of bengalgram technologies

4.1.6 Extent of adoption of improved technologies by bengalgram growers

4.1.7 Distribution of bengalgram growers on the basis of composite index (CI)

4.2 Distribution of sample farmers according to their socio-economic characteristics

4.2.1 Socio-economic characteristics of sample farmers

4.2.2 Socio-economic characteristics of different level of adopters of bengalgram varieties

4.3 Cropping pattern followed by sample farmers in the study area

4.4 Input use pattern in bengalgram cultivation

4.4.1 Usage of inputs against recommended practices among different level of adopters of GBM-2 variety

4.4.2 Usage of inputs against recommended practices among different level of adopters of JG-11 variety

4.8 Factors influencing adoption of bengalgram technologies developed by UASR

4.8.1 Different tests for selection of appropriate model (Multi ordinal logistic regression)

4.8.2 Estimates of multi ordinal proportional odds model for adoption of bengalgram technology

4.9 Marketing practices followed by bengalgram growers

4.10 Constraints faced in adoption of bengalgram technologies developed by UASR

4.1 Spread of bengalgram technologies developed by UASR

There were about 14 technologies developed by UASR related to production, protection and varietal technologies. Among the varietal technologies, GBM-2 variety is a new variety developed by UAS, Raichur and released for commercial cultivation in the year 2014-15. This variety has special characteristics of erect branches. This makes most suitable for mechanical harvesting. The present study assesses how far this technology spread within and across the state. Hence, the spread of GBM-2 variety of bengalgram developed by UASR is presented separately for study districts, other districts of the NEK region and other parts of the state and neighboring states in the following sections.

4.1.1 Spread of GBM-2 variety in Kalaburagi district of NEK region

The spread of GBM-2 variety in different taluks of Kalaburagi district from 2014-15 to 2017-18 is presented in Table 4.1 and Fig.4.1. During 2014-15, the spread of GBM-2 variety was observed in all the taluks of Kalaburagi district. The highest area under this variety was observed in Chittapur (107.50 acres) followed by Afzalpur (97 acres) and Sedam (62.75 acres) taluks. The lowest area was observed in Jewargi taluk (4.75 acres). There has been a decreasing trend in area under this variety from 2014- 15 to 2017-18. The highest area (402 acres) in Kalaburagi district under this variety was observed during 2014-15 and the lowest area (128.50 acres) was observed during 2017-18. There was increase in per cent of bengalgram area under this variety from 2014-15 (0.746%) to 2015-16 (1.241%) and further it decned (0.08%) in 2016-17 and again increased in 2017-18 (0.21%). The highest per cent of bengalgram area (1.24%) was observed in 2015-16 and the lowest per cent of bengalgram area was observed in 2016-17 (0.08%).

Table 4.1 Spread of GBM-2 variety in Kalaburagi district of NEK region

Sl. No.	Taluks	2014-15		2015-16		2016-17		2017-18		Aggregate	
		Area (acres)	Per cent*	Area (acres)	Per cent	Area (acres)	Per cent	Area (acres)	Per cent	Area (acres)	Per cent
1	Chittapur	107.50	0.300	78.50	0.661	27.00	0.038	46.00	0.064	259.00	1.063
2	Afzalpur	97.00	0.120	75.00	0.219	6.00	0.013	-	-	161.75	0.352
3	Sedam	62.75	0.120	55.25	0.144	3.00	0.004	50.75	0.111	171.75	0.379
4	Aland	62.50	0.095	46.00	0.119	15.00	0.017	12.00	0.013	135.50	0.244
5	Chincholi	43.75	0.053	41.00	0.098	-	-	-	-	84.75	0.151
6	Kalaburagi	23.75	0.051	-	-	6.00	0.010	19.75	0.028	49.50	0.089
7	Jewargi	4.75	0.007	-	-	3.00	0.006	-	-	7.75	0.013
Total		**402.00**	**0.746**	**299.50**	**1.241**	**60.00**	**0.088**	**128.50**	**0.216**	**870.00**	**2.291**

Source: ARS, Kalaburagi, Seed Unit, UAS, Raichur

* Per cent to total bengalgram area in respective taluks during respective yea

Note: Lateral spread from farmers to farmers is not taken into account

Chittapur taluk was leading in cultivating this variety among different taluks of Kalaburagi during study period. The total spread of this variety was about 870 acres with 2.29 per cent of bengalgram area from 2014-15 to 2017-18 in Kalaburagi distcrict.

4.1.2 Spread of GBM-2 variety in Raichur district of NEK region

The spread of GBM-2 variety in five taluks of Raichur district from 2014-15 to 2017-18 is presented in Table 4.2 and Fig.4.1. The highest area was observed in Devadurga taluk (22 acres) and lowest area was observed in Lingasugur taluk (1acre) and no other taluks of the district have cultivated this variety during 2014-15. In terms of per cent to bengalgram area, Devadurga taluk ranked top (0.05%) followed by Lingasugur taluk (0.003%) in 2014-15. During, 2015-16, Sindhanur taluk had highest area (10 acres) with highest per cent of bengalgram area (0.029%) followed by Lingasugur taluk (3.7 acres). The least area under this variety was observed in Manvi taluk (3.25 acres) during the same period. The area under this variety has been increased from 2014-15 to 2016-17 from 23 acres to 451.81acres and per cent of bengalgram area under this variety also has been increased from 0.054 per cent to 3.27 per cent during same period. The area and per cent under this variety has been decreased during 2017-18 compared to 2016-17. Among all the taluks of Raichur district, per cent share of bengalgram area as well as area under this variety was the highest in Sindhanur taluk during 2015-16 to 2017-18. In total, this variety was spread to 608.87 acres from 2014-15 to 2017-18 in Raichur district.

4.1.3 Spread of GBM-2 variety in other districts of NEK region

Table 4.3 and Fig.4.2 presents the spread of GBM-2 variety in other districts of NEK region. In 2014-15, the highest area under this variety was observed in Yelburga taluk of Koppal district and the lowest area during the same period was observed in Shorapur taluk of Yadgir district. During 2015-16, the highest area (130 acres) under this variety was observed in Yelburga taluk of Koppal district followed by Shahapur taluk of Yadgir (52.65 acres) and the lowest area (7.5 acres) was observed in Shorapur taluk of Yadgir district. In 2016-17, Basavakalyan of Bidar district topped in area under this variety followed by Bhalki taluk of Bidar district (10acres) and lowest area (1acre each) under this variety was observed in both Gangavathi taluk of Koppal district and Shahapur taluk of Yadgir district. In 2017-18, Hagaribommanahalli taluk of Ballari district had the highest area (25 acres) under this variety followed by Bhalki taluk of

Table 4.2 Spread of GBM-2 variety in Raichur district of NEK region

Sl. No.	Taluks	2014-15		2015-16		2016-17		2017-18		Aggregate	
		Area (acres)	Per cent*	Area (acres)	Per cent	Area (acres)	Per cent	Area (acres)	Per cent	Area (acres)	Per cent
1	Lingasugur	1.00	0.003	3.70	0.027	15.00	0.005	-	-	19.70	0.035
2	Sindhanur	-	-	10.00	0.029	150.00	2.012	71	0.208	231.00	2.249
3	Manvi	-	-	3.25	0.005	140.50	0.876	26	0.029	169.75	0.91
4	Raichur	-	-	8.05	0.009	146.37	0.379	12	0.014	166.42	0.402
5	Devadurga	22.00	0.051	-						22.00	0.051
Total		**23.00**	**0.054**	**25.00**	**0.070**	**451.87**	**3.270**	**109**	**0.251**	**608.87**	**3.645**

Source: Seed Unit, UAS, Raichur

*Per cent to total bengalgram area in respective taluks during respective year

Note: Lateral spread from farmers to farmers is not taken into accou

Table 4.3 Spread of GBM-2 variety in other districts of NEK region

Sl. No.	District	Taluk	2014-15	2015-16	2016-17	2017-18	Aggregate
			Area (acres)	Area (acres)	Area (acres)	Area (acres)	Area (acres)
1	Yadgir	Shahapur	1.00	52.65	1.00	-	54.65
		Shorapur	-	7.50	5.00	-	12.50
		Yadgir	-	37.00	1.20	-	38.20
2	Koppal	Yelburga	20.00	130.00	5.00	-	155.00
		Gangavathi	-	-	1.00	-	1.00
3	Bidar	Bhalki	-	-	10.00	11.25	21.25
		Basavakalyan	-	-	17.00	6.75	23.75
		Bidar	-	-	-	11.00	11.00
4	Ballari	Ballari	-	-	-	6.00	6.00
		Hagaribommanahalli	-	-	-	25.00	25.00
Total			**21.00**	**227.15**	**40.20**	**60.00**	**348.35**

Source: ARS, Kalaburagi, Seed Unit, UAS, Raichur, ARS B'Gudi, and KVK, Bidar

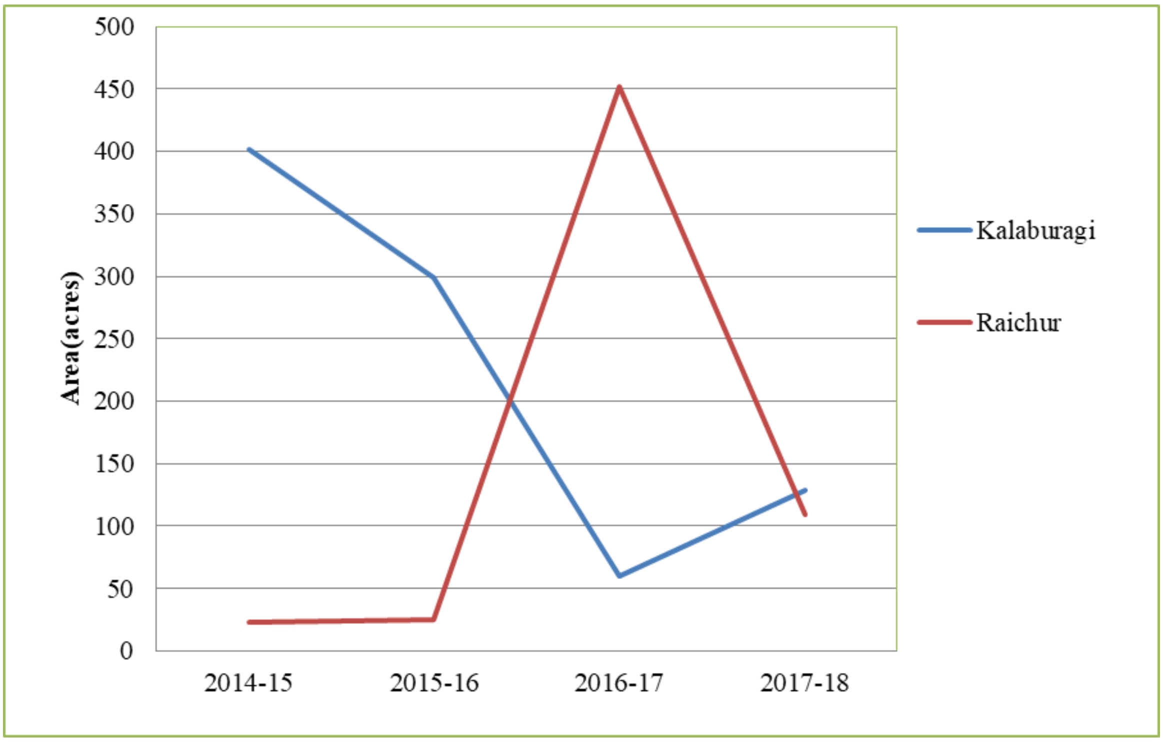


Fig. 4.1 Spread of GBM-2 varietyin Kalaburagiand Raichurdistricts

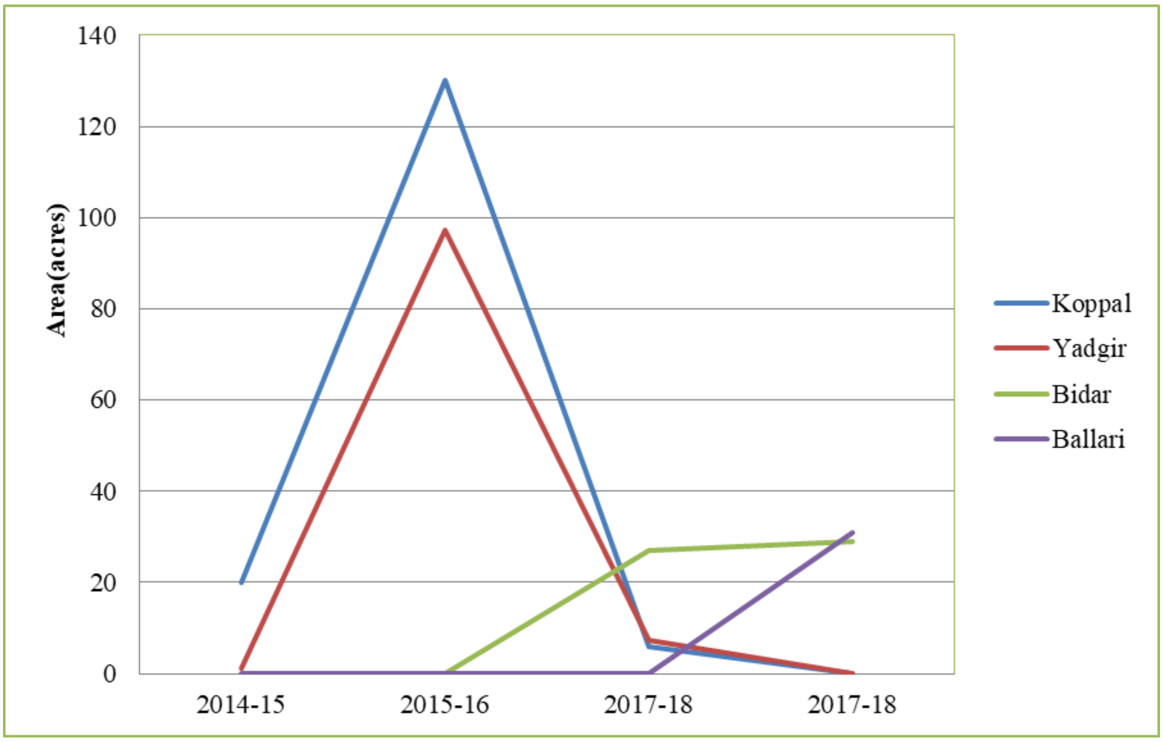


Fig. 4.2 Spread of GBM-2 variety in other districts of NEK region

Bidar district and the least area (6 acres) was observed in Ballari taluk of Ballari district. There was an increasing trend in area under this variety during 2014-15 to 2015-16 and declined in area during 2016-17 and further it increased to 60 acres in 2017-18. The highest area under this variety (227.15 acres) was observed during 2015-16. The total spread of this variety was about 348.35 acres from 2014-15 to 2017-18 in other districts of NEK region.

4.1.4 Spread of GBM-2 variety in other parts of Karnataka and India

The spread of GBM-2 variety in other parts of Karnataka State and India during 2014-15 to 2017- 18 is presented in Table 4.4, Fig.4.3 and Fig.4.4. In 2014- 15, this variety was spread to Gadag and Belagavi districts of Karnataka and Kolhapur and Kurnool districts of Maharashtra and Andhra Pradesh, respectively. Total area under this variety was about 16.10 acres in 2014-15. The highest area (6 acres) under this variety was observed in Ron taluk of Gadag district followed by Kagal taluk (5acres) of Kolhapur district. Lowest area (0.10 acres) under this variety was observed in Bailhongal taluk of Belagavi district. Area under this variety was about six acres in other than Karnataka state which was observed in Kolhapur and Kurnool districts of Maharashtra and Andra pradesh respectively. In 2015-16, this variety was spread to Gadag, Vijayapura, Dharwad and Haveri districts of Karnataka and Ananthapur district of Andhra Pradesh. Total area under this variety was about 464.50 acres in 2015-16. The highest area (170 acres) was observed in Vijayapura taluk of Vijayapura district followed by Mundargi taluk (95 acres) of Gadag district. The least area (5acres each) was observed in Indi taluk of Vijayapura and Ranibennur taluk of Haveri district. During 2016-17, this variety was spread to Vijayapura, Gadag, Haveri and Bagalkot districts of Karnataka state only. Total area under this variety was 37.25 acres. The highest area (12 acres) was observed in Muddebihal taluk of Vijayapura followed by Gadag taluk. The lowest area (2 acres each) under this variety was observed both in Hunagund taluk of Bagalkot district and Sindagi taluk of Vijayapura district. In 2017- 18, this variety was spread to Gadag, Bagalkot and Chitradurga districts of Karnataka, Guntakal taluk of Andhra Pradesh and Ahmednagar district of Maharashtra. Total area under this variety was about 21 acres in this period. More area (10rt acres) under this variety was observed in Ahmedanagar district of Maharashtra and least area was observed in Hiriyur taluk of Chitradurga (1 acres). There has been an increasing trend in area under this variety from 2014-15 to 2015-16. Further

Table 4.4 Spread of GBM-2 bengalgram variety in other parts of Karnataka and India

State	District	Taluk	2014-15	2015-16	2016-17	2017-18	Aggregate
			Area (acres)	Area (acres)	Area (acres)	Area (acres)	Area (acres)
Karnataka	Gadag	Ron	6.00	60.00	-	-	66.00
		Mundargi	-	95.00	-	-	95.00
		Gadag	-	50.00	11.25	3.00	64.25
	Belagavi	Khanapur	2.00	-	-	-	2.00
		Saudatti	2.00	-	-	-	2.00
		Bailahongal	0.10	-	-	-	0.10
	Vijayapura	Vijayapura	-	172.50	-	-	172.50
		Muddebihal	-	23.00	12.00	-	35.00
		Sindagi	-	-	2.00	-	2.00
		Indi	-	5.00	-	-	5.00
	Dharwad	Navsalgund	-	30.00	-	-	30.00
	Haveri	Ranibennur	-	5.00	10.00	-	15.00

	Bagalkot	Bagalkot	-	-	-	6.00	6.00
		Hunagund	-	-	2.00	-	2.00
	Chitradurga	Hiriyur	-	-	-	1.00	1.00
Andhra Pradesh Pradesh	Ananthapur	Garaladinne	-	24.00	-	-	24.00
		Guntakal	-	-	-	1.00	1.00
	Kurnool	-	1.00	-	-	-	1.00
Maharashtra	Kolhapur	Kagal	5.00	-	-	-	5.00
	Ahmednagar	-	-	-	-	10.00	10.00
Total			16.10	464.50	37.25	21.00	538.85

Source: ARS, Kalaburagi, Seed Unit, UAS, Raichur, ARS, B'Gudi and KVK, Bidar

Note: Lateral spread from farmers to farmers is not taken into account

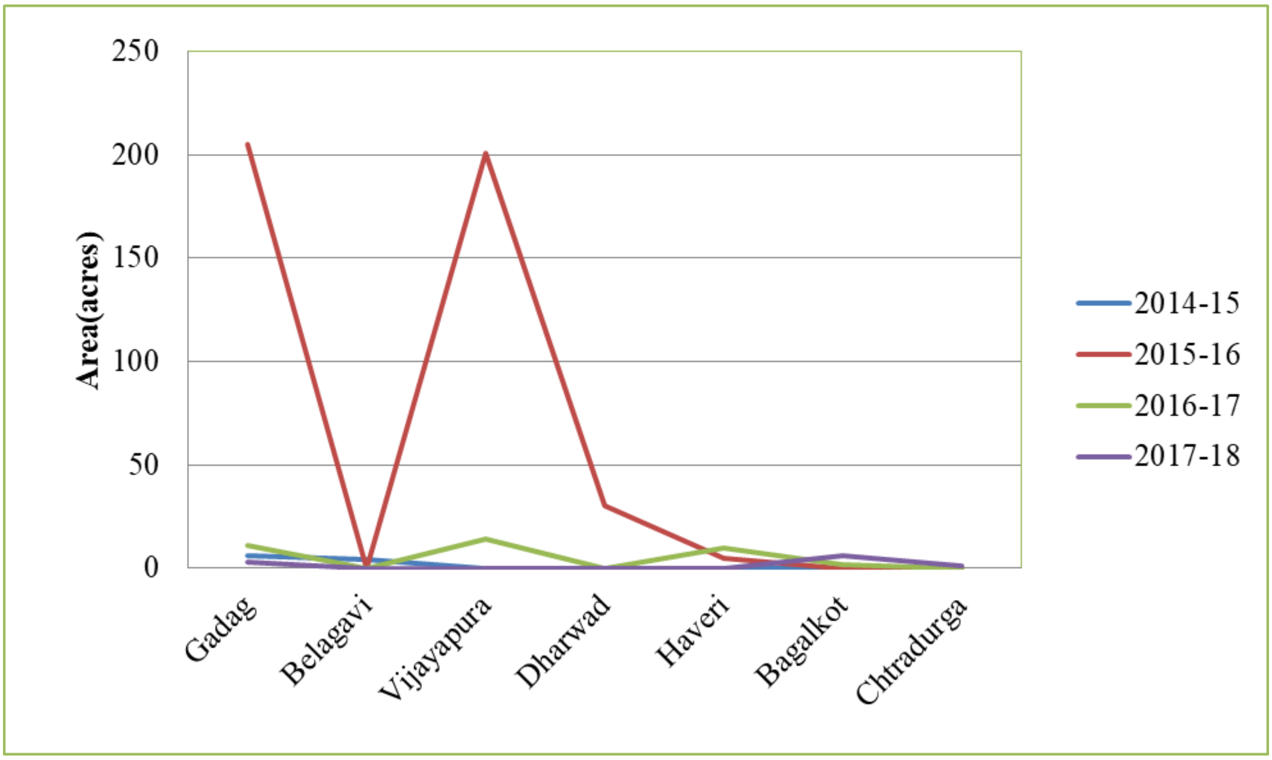


Fig. 4.3 Spread of GBM-2 variety in other parts of Karnataka

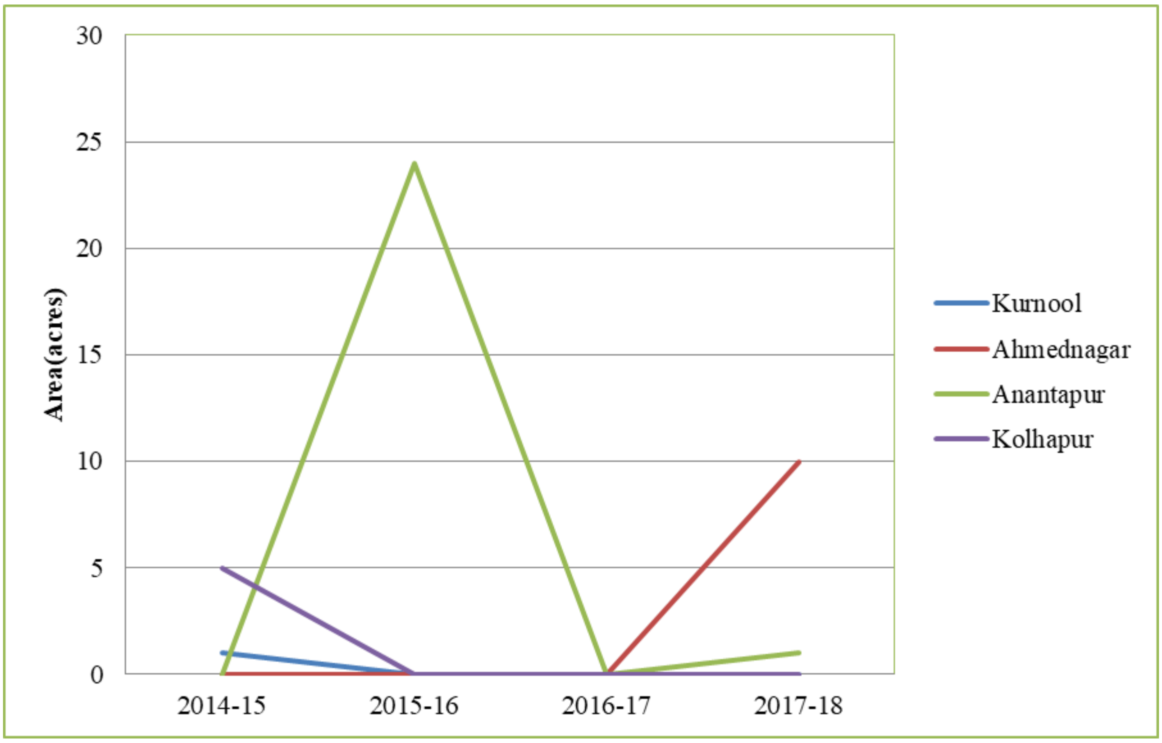


Fig. 4.4 Spread of GBM-2 variety in other than Karnataka State

there was decrease in area from 2016-17 to 2017-18. The highest area (464.50 acres) under this variety was observed in 2015-16. This variety was spread to 538.85 acres in other parts of Karnataka and across the States.

4.1.5 Distribution of bengalgram growers according to their adoption level of bengal gram technologies

There were about 14 technologies developed by UAS, Raichur with respect to production, protection and varietal technologies in bengalgram cultivation. Out of 14 technologies, only nine technologies were adopted by sample farmers. GBM-2 (released variety), JG-11 and Annigeri-1 varieties (adopted varieties) were come under varietal technologies. Whereas, sowing time, recommended fertilizer application, seed rate, seed treatement, nipping, intercultivation, use of growth promoters and seed hardening were major practices developed by UASR with respect to production. While, use of bird perches, soil application of FYM with neem seed cake and trichoderma, pest management and disease management were major practices developed by UASR with respect to protection. The details on extent of adoption of 11 technologies are presented in Table 4.6.

The data pertaining to the overall adoption level of the respondents is given in Table 4.5. The findings revealed that the highest percentage (41.66%) of bengalgram growers had medium level of adoption of various recommended practices while, 32.50 per cent respondents had low level of adoption. However, 25.83 per cent of bengalgram growers had high level of adoption. Out of 120 sample farmers, 39 were under low adopter category, 50 were under medium adopter category and 31 were under high adopter category.**4.1.6 Extent of adoption of improved technologies by bengalgram growers**

The data pertaining to the practice wise adoption of improved technologies of bengalgram cultivation is presented in Table 4.6 and Fig.4.5 revealed that the practices adopted by all the respondent farmers were sowing time (100%) and nipping (100%). It is also evident from table that the higher per cent of adoption of most of improved technologies of bengalgram could be seen in high adopter categories followed by medium and low adopter categories. With respect to varietal technologies, majority of the sample farmers were adopted JG-11 variety and per cent of adoption of JG-11 was highest in

Table 4.5 Distribution of bengalgram growers according to their adoption level of bengalgram technologies

n=120

Sl. No.	Level of adoption	No. of sample farmers	Per cent
1	Low (mean-0.425*SD)	39	32. 50
2	Medium (mean±0.425*SD)	50	41.66
3	High (mean+0.425*SD)	31	25.83
	Total	120	100.00

Table 4.6 Extent of adoption of improved technologies by bengalgram growers

Sl. No.	Technologies	Extent of adoption					
		Low (n=39)	Per* cent	Medium (n=50)	Per cent	High (n=31	Per cent
I	**Varietal technologies**						
1	GBM-2	2	5.12	4	8.00	6	19.35
2	Annigeri-1	17	43.58	9	18.00	5	16.12
3	JG-11	20	51.28	37	74.00	20	64.51
II	**Production technologies**						
1	Sowing time	39	100.00	50	100.00	31	100.00
2	Recommended fertilizer application	11	28.20	41	82.00	26	83.87
3	Seed rate	16	41.00	39	78.00	28	90.32
4	Seed treatement	-	-	15	30.00	23	74.19
5	Nipping	39	100.00	50	100.00	31	100.00
6	Intercultivation	21	53.84	44	88.00	28	90.32
III	**Protection technologies**						
1	Insect pest management	15	19.73	34	44.73	27	87.09
2	Disease management	1	2.22	21	46.66	23	74.19

Note: *Per cent to respective totals.

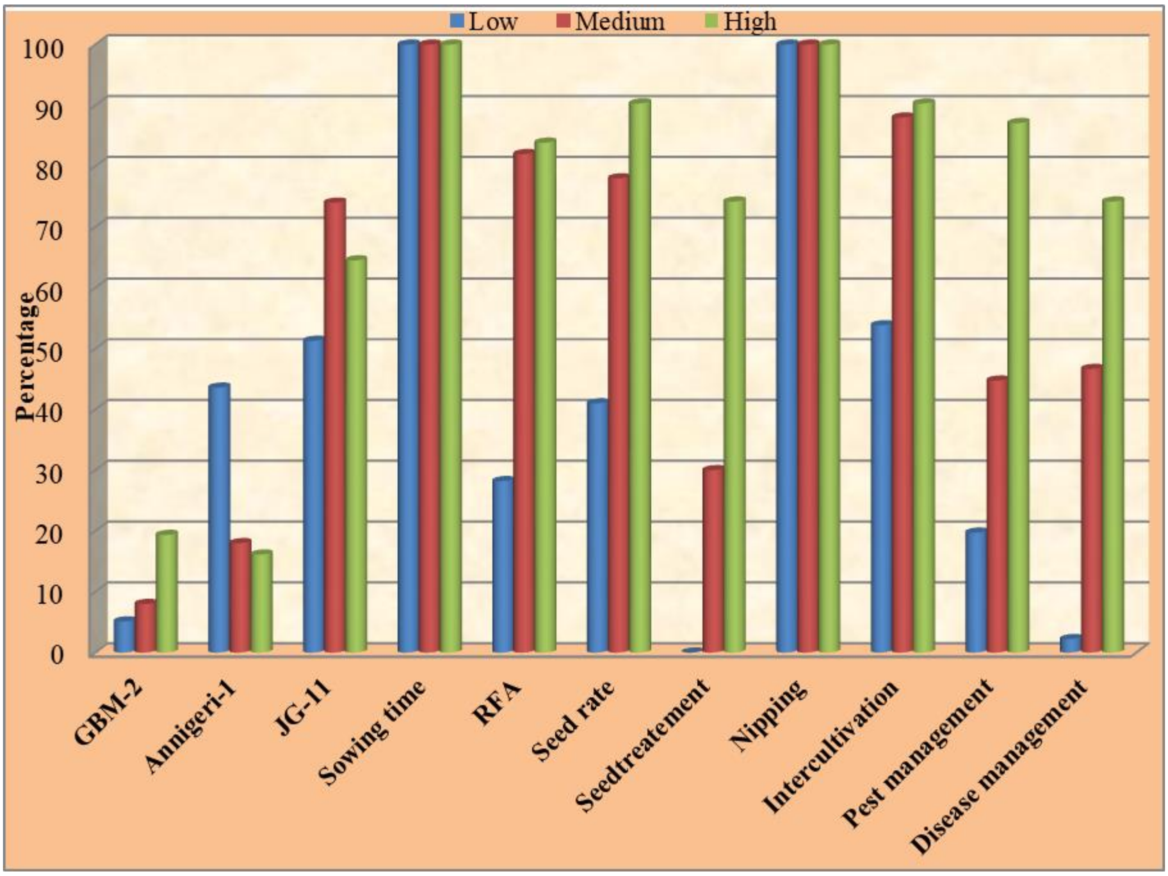


Fig. 4.5 Extent of adoption of improved technologies by bengalgram growers

medium adopter categories (74%) followed by high adopter categories (64.51%). The highest per cent of adoption of GBM-2 variety was observed in high adopter categories (19.35%) followed by medium (8%) and low adopter categories (5.12%). In case of Annigeri-1 variety, the percentage of adoption was the highest in low adopters categories (43.58) followed by medium (18%) and high (16.12%) adopter categories. With respect to production technologies, under low adopter categories none of them practiced seed treatement and very less proportion of them adopted recommended fertilizer application and higher proportion of (53.84%) low adopters adopted intercultivation. However, even under low adopter category. However, all the farmers have adopted proper sowing time and nipping. Among medium and high adopter categories, least per cent of adoption could be observed in seed treatement. The highest per cent of adoption was observed in both seed rate (90.32%) and intercultivation (90.32%) in case of high adopter categories. Whereas, extent of adoption was the highest in intercultivation (88%) in case of medium adopter categories. With respect to protection technologies, per cent of adoption in case of disease management was the highest in the case of high adopter categories (87.09) followed by medium (44.73%) and low (19.73%) adopter categories. The similar trend was observed with respect to insect pest management.

4.1.7 Distribution of selected bengalgram growers on the basis of composite index (CI)

Even though the technology package was developed by the Agricultural Universities for respective region, it is important to examine the extent of adoption and its cost effectiveness. Hence, the method of Principal Component Analysis (PCA) was used to estimate the composite index for individual farmer. Thereafter, all the farmers under study were grouped according to composite index ranging from 0.01 to 0.60, 0.61 to 0.80 and above 0.81 as low, medium and high technology adoption groups. Distribution of selected cultivators showed the adoption of recommended technologies in the bengalgram cultivation.

It is clear from the results presented in Table 4.7 that out of 120 sample cultivators, 37 farmers were categorized as low adopters, 49 cultivators as medium technology adoption group and 34 farmers were grouped in high technology adoption group. The composite index of individual farmer showed the adoption of recommended technologies in bengalgram cultivation.

Table 4.7 Distribution of bengalgram growers on the basis of composite index (CI)

n=120

Sl. No.	Level of adoption	No. of sample farmers	Per cent
1	Low adopters (<0.60)	37	30.83
2	Medium adopters (0.60-0.80)	49	40.83
3	High adopters (>0.80)	34	28.33
	Total	120	100.00

4.2 Distribution of sample farmers according to their socio-economic characteristics

The socio-economic features of sample farmers being post classified based on the level of adoption of recommended technologies are presented in this section.

4.2.1 Socio-economic characteristics of sample farmers

An understanding of characteristic features of sample farmers is expected to provide socio-economic status of farmers in the study area. Therefore, an attempt has been made to analyze some of important characteristic features of sample farmers and the results are presented in Table 4.8. The results presented in the table indicated that majority of the farmers under all the three adopter categories were in the middle age group. The percentage of middle age farmers were more in medium adopters category (76%) followed by high adopters (64.52%) and low adopters (51.28%). The proportion of young age group was found to be higher in case of medium adopters (12%) followed by low adopters (7.69%) and high adopters (6.45%). The per cent of old age group was found to be highest in case of low adopters (41.03%) followed by high adopters (29.03%) and medium adopters (12%).

With respect to education level, it was observed that majority of low adopters were illiterate (51.28%) compared to medium adopters (28%) and high adopters (22.58%). The low adopters had maximum education up to high school level. Among medium adopters, 32 per cent had primary, 28 per cent had high school level education and 12 per cent of them together had pre university or above college level education. In case of high adopters, highest percentage of them had high school level (25.81%), equal percentage of them (19.35%) had primary and pre university level education. More number of high adopters had pre university and above college level education as compared to medium adopters.

Majority of the farm families irrespective of level of adoption fall under nuclear type. However, higher joint families were noticed among high adopters (45.16%) followed by medium adopters (36%) and low adopters (28.21%). Majority of low, medium and high adopters were residing in Pucca houses.

The family size of respondents increased with level of adoption as in case of low, medium and high adopters family size was found to be six, seven and eight respectively.

Table 4.8 Socio-economic characteristics of sample farmers

Sl.No.	Particulars	Adopters					
		Low (n=39)		Medium (n=50)		High (n=31)	
I	**Age**	**No.**	**Per* cent**	**No.**	**Per cent**	**No.**	**Per cent**
a	Young age (<35 years)	3	7.69	6	12.00	2	6.45
b	Middle age (35-55 years)	20	51.28	38	76.00	20	64.52
c	Old age (>55 years)	16	41.03	6	12.00	9	29.03
II	**Education level**						
a	Illiterate	20	51.28	14	28.00	7	22.58
b	Primary	12	30.77	16	32.00	6	19.35
c	High school	7	17.95	14	28.00	8	25.81
d	Pre University	-	-	4	8.00	6	19.35
e	College & above	-	-	2	4.00	4	12.90
III	**Type of family**						
a	Joint	11	28.21	18	36.00	14	45.16
b	Nuclear	28	71.79	32	64.00	17	54.84
IV	**Type of house**						
a	Kaccha	5	12.82	3	6.00	2	6.45
b	Pucca	31	79.48	47	94.00	29	93.55
c	Thatched	3	7.69	-	-	-	-
V	**Average family size**						
a	Men	2	-	3.00	-	3.00	-
b	Women	2	-	2.00	-	2.00	-
c	Children	2	-	2.00	-	3.00	-
	Total	6	-	7.00	-	8.00	-

Sl.No.	Particulars	Adopters					
		Low		Medium		High	
VI	**Average size of operationl landholding**						
a	Owned	2.97	-	3.87	-	4.58	-
b	Leased in	0.13	-	0.36	-	0.47	-
	Total	3.10	-	4.23	-	5.05	-
VII	**Category of farmers**						
a	Marginal (up to 1ha)	6	15.38	3	6.00	-	-
b	Small (1 to 2ha)	14	35.90	12	24.00	7	22.58
c	Medium (2 to 4 ha)	13	33.33	15	30.00	9	29.03
d	Large (> 4ha)	6	15.38	20	40.00	15	48.39
VIII	**Working family labour**						
a	Men	1.10	-	1.23	-	1.43	-
b	Women	0.33	-	0.43	-	0.50	-
	Total	1.43	-	1.66	-	1.93	-
IX	**Farming experience (years)**						
a	Low (Upto 17.9)	10	25.64	18	36.00	7	22.58
b	Medium (17.9-24.24)	8	20.51	23	46.00	17	54.84
c	High (Above 24.24)	21	53.84	9	18.00	7	22.58
X	**Extension contact**						
a	Once in a week	-	-	9	18.00	8	25.81
b	Once in a fort night	3	7.69	5	10.00	9	29.03
c	Once in a month	7	17.95	12	24.00	5	16.13
d	Not at all	29	74.36	24	48.00	9	29.03

Note: *Per cent to respective totals.

There was not much variation in male and female composition in the family size across the different level of adopters. The number of children in a family varied between three in high adopters and two in medium and low adopters. The average size of operational landholding was found to be high in case of high adopters (5.05 ha) followed by medium adopters (4.23ha) and low adopters (3.10 ha).

It was also observed that majority of medium adopters and high adopters were medium and large farmers. Whereas, majority of farmers were small and medium under low adopter category. More number of marginal farmers were found in case of low adopters (15.38%) followed by medium adopters (6.0%). None of marginal farmers were found in case of high adopter category.

With respect to working family labour, more number of working family labour (both men and women) was found in case of high adopters (1.93) followed by medium adopters (1.66) and low adopters (1.43).

Majority of medium (46 %) and high adopters (54.84%) were found in medium level of farming experience of about 17.9 years to 24.24 years. Majority of low adopters (53.84%) had high level of farming experience (above 24.24 years).

With respect to extension contact, majority of low adopters (29) were not having contact with extension agencies followed by medium adopters (24) and high adopters (9). More number of medium adopters and high adopters meet extension agencies weekly, fort nightly and monthly.

4.2.2 Socio-economic characteristics of different level of adopters of bengalgram varieties

Table 4.9 presents socio-economic characteristics of different level of adopters under each variety of bengalgram. Sizeable portion of high adopters of GBM-2 variety growers were fall under middle age group (66.66%) followed by medium adopters (50%). No sample farmers in low adopter category were under middle age grou

Majority of all type of adopters of Annigeri-1 variety were found in middle age group. But sizeable portion of low adopters of Annigeri-1 variety were found in old age group (47.05%). Similar results were observed in case of adopters of JG-11 varie

Table 4.9 Socio-economic characteristics of different level of adopters of bengalgram varieties

Sl. No.	Particulars	Adopters																	
		GBM-2 (n=12)						Annigeri-1 (n=31)						JG-11 (n=77)					
		Low (n=2)		Medium (n=4)		High (n=6)		Low (n=17)		Medium (n=9)		High (n=5)		Low (n=20)		Medium (n=37)		High (n=20)	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	**Age**																		
a	Young (<35 years)	1	50.00	1	25.00	-	-	2	11.76	3	33.33	-	-	-	-	2	5.40	2	10.00
b	Middle age (35-55 years)	-	-	2	50.00	4	66.60	7	41.17	4	44.44	3	60.00	13	76.47	32	86.48	13	65.00
c	Old (>55 years)	1	50.00	1	25.00	2	33.30	8	47.05	2	22.22	2	40.00	7	41.17	3	8.10	5	25.00
II	**Education level**																		
a	Illiterate	1	50.00	2	50.00	2	33.30	10	58.82	5	55.55	-	-	9	45.00	7	18.91	5	25.00
b	Primary	1	50.00	1	25.00	2	33.30	6	35.29	2	22.22	1	20.00	5	25.00	13	35.13	3	15.00
c	High school	-	-	1	25.00	1	16.60	1	5.88	1	11.11	2	40.00	6	30.00	12	32.43	5	25.00
d	College	-	-	-	-	1	16.60	-	-	1	11.11	1	20.00	-	-	3	8.10	4	20.00
e	Above college	-	-	-	-	-	-	-	-	-	-	1	20.00	-	-	2	5.40	3	15.00
III	**Type of family**																		
a	Joint	-	-	1	25.00	2	33.30	5	29.41	4	44.44	3	60.00	6	30.00	13	35.13	12	60.00
b	Nuclear	2	100.0	3	75.00	4	66.60	12	70.58	5	55.55	2	40.00	14	70.00	24	64.86	8	40.00
IV	**Type of house**																		
a	Kaccha	1	50.00	-	-	-	-	2	11.76	1	11.11	-	-	2	10.00	2	5.40	2	10.00
b	Pucca	1	50.00	4	100.00	6	100.00	13	76.47	8	88.88	5	100.00	18	90.00	35	94.59	18	90.00
c	Thatched	-	-	-	-	-	-	2	11.76	-	-	-	-	-	-	-	-	-	00.00
V	**Family size**																		
a	Men	2	-	2	-	3	-	2	-	3	-	3	-	2	-	3	-	3	-
b	Women	2	-	2	-	2	-	2	-	2	-	2	-	2	-	2	-	2	-
c	Children	2	-	3	-	3	-	2	-	2	-	3	-	2	-	2	-	2	-
	Total	6	-	7	-	8	-	6	-	7	-	8	-	6	-	7	-	7	-
VI	**Average size of operational landholding (ha)**																		

a	Owned	2.31	-	3.30	-	4.51	-	3.21	-	4.06	-	4.61	-	3.40	-	4.27	-	4.62	-
b	Leased in	-	-	0.32	-	0.43	-	0.40	-	0.36	-	0.39	-	0.00	-	0.40	-	0.60	-
	Total	2.31	-	3.62	-	4.94	-	3.61	-	4.42	-	5.00	-	3.40	-	4.67	-	5.22	-
VI	**Category of farmers**																				
a	Marginal farmers (up to 1ha)	1	50.00	-	-	-	-	2	11.76	-	-	-	-	3	15.00	3	8.10	-	-
b	Small farmers (1 to 2ha)	-	-	2	50.00	2	33.33	5	29.41	3	33.33	1	20.00	8	40.00	7	18.91	4	20.00
c	Medium farmers (2 to 4 ha)	1	50.00	1	25.00	1	16.66	7	41.17	4	44.44	2	40.00	6	30.00	10	27.02	6	30.00
d	Large farmers (> 4ha)	-	-	1	25.00	3	50.00	3	17.64	2	22.22	2	40.00	3	15.00	17	45.94	10	50.00
IV	**Working family labour**																				
a	Men	1.0	-	1.2	-	1.3	-	1.2	-	1.3	-	1.4	-	1.1	-	1.2	-	1.6	-
b	Women	0.3	-	0.3	-	0.4	-	0.4	-	0.5	-	0.5	-	0.3	-	0.5	-	0.6	-
c	Total	1.3	-	1.5	-	1.7	-	1.6	-	1.8	-	1.9	-	1.4	-	1.7	-	2.2	-
V	**Farming experience (years)**																				
a	Low (Upto 17.9)	1	50.00	2	25.00	1	16.66	4	23.52	2	22.22	2	40.00	5	25.00	17	45.94	4	20.00
b	Medium (17.9-24.24)	-	-	1	50.00	5	83.33	3	17.64	5	55.55	3	60.00	5	25.00	14	37.83	9	45.00
c	High(Above 24.24)	1	50.00	1	25.00	-	-	10	58.82	2	22.22	-	-	10	50.00	6	16.21	7	35.00
VI	**Extension contact**																				
a	Once in a week	-	-	1	25.00	2	33.33	-	-	2	22.22	3	60.00	-	-	6	24.32	4	20.00
b	Once in a fort night	-	-	1	25.00	2	33.33	-	-	2	22.22	2	40.00	3	17.64	2	16.21	4	25.00
c	Once in a month	-	-	0	00.00	1	16.66	2	11.76	1	11.11	-	-	5	29.41	4	10.81	4	15.00
D	Not at all	2	100.00	2	50.00	1	16.66	15	88.23	4	44.44	-	-	12	70.58	18	48.64	8	40.00

Low adopters under GBM-2 variety were studied up to primary level. They were studied up to high school level in both Annigeri-1 variety and JG-11 variety. Majority of them were illiterates under each variety. High adopters and medium adopters were studied upto college level and high school level respectively under GBM-2 variety, whereas, they have completed college and above college level in case of GBM-2 variety and Annigeri-1 variety.

Majority of all type of adopters under each variety had nuclear type of families. Sizeable portion of joint families were noticed under high adopters under each variety.

Sizeable portion of operational holding was noticed in high adopters under each variety followed by medium adopters and low adopters.

4.3 Cropping pattern followed by sample farmers in the study area

The cropping pattern of the sample farmers is presented in Table 4.10. The table reveals that paddy, pigeonpea and cotton were the major crops grown in *kharif* season by sample farmers. Further, soybean, blackgram, greengram and sesamum were also other crops grown by sample farmers in *kharif* season. The total area under all crops in *kharif* season was about 2.76 hectare in low adopters, 3.92 hectare in medium adopters and 4.81 hectare in case of high adopters.

In *rabi* season, the major proportion of area was devoted to bengalgram cultivation followed by jowar by all type of adopters. The proportion of area under bengalgram cultivation was found to be higher in case of high adopters (1.16 hectare) followed by medium adopters (1.14 hectare) and low adopters (0.86 hectare). The area under all crops grown in *rabi* season was found to be the highest in case of high adopters (2.14 hectare) followed by medium adopters (1.84 hectare) and low adopters (1.34 hectare). Accordingly, the gross cropped area was found to be higher (6.95 hectare) in case of high adopters followed by medium (5.76 hectare) and low adopters (4.1 hectare). Further, the cropping intensity was found to be higher in case of high adopters (137.62%) followed by medium (136.17%) and low adopters (132.25%).

Table 4.10 Cropping pattern followed by sample farmers in the study area

	Adopters					
	Low		Medium		High	
	Area (hectare)	Per cent	Area (hectare)	Per cent	Area (hectare)	Per cent
Kharif						
Paddy	0.87	21.17	1.12	19.38	1.19	17.12
Pigeonpea	0.84	20.49	1.02	17.64	1.07	15.40
Cotton	0.70	17.07	0.84	14.58	1.08	15.54
Sesamum	-	-	0.26	4.44	0.28	4.03
Soybean	0.21	5.07	0.42	7.29	0.46	6.62
Blackgram	0.10	2.44	0.17	2.92	0.40	5.76
Greengram	0.05	1.17	0.10	1.74	0.33	4.75
Sub total	2.76	67.41	3.92	67.99	4.81	69.21
Rabi						
Bengalgram	0.86	20.98	1.14	19.79	1.16	16.69
Jowar	0.48	11.80	0.70	12.15	0.98	14.10
Sub total	1.34	32.78	1.84	31.94	2.14	30.79
Gross Cropped area	4.1		5.76		6.95	
Net cropped area	3.10		4.23		5.05	
Cropping intensity (%)	132.25		136.17		137.62	

4.4 Input use pattern in bengalgram cultivation

The input use pattern and its comparison with recommended practices among different level of adopters across different varieties are given in the following paragraphs.

4.4.1 Usage of inputs against recommended practices among different level of adopters of GBM-2 variety

The results on the pattern of input usage against recommended practices among different category of adopters of improved technologies of GBM-2 variety are presented in Table 4.11. A glance at the table indicates that among different level of adopters, the quantity of seeds and chemical fertilizers (N=33.75Kg/ha, P_2O_5 = 86.25 Kg/ha) used by low adopters were found to be higher compared to medium and high adopters. The use of seeds , N and P_2O_5 were higher by 9.09 per cent, 33.75 per cent and 86.25 per cent, respectively than the recommended levels. Low adopters had not used trichoderma for seed treatment. Medium adopters used higher quantity of trichoderma (20g/ Kg) as compared to high adopters (18.50g / Kg) for seed treatment. This was higher by 400.00 per cent in medium adopters and 362.50 per cent in high adopters than the recommended practice. The quantity of usage of FYM was found to be higher in case of high adopters (5tonnes/ha) followed by medium adopters (4.25 tonnes/ha) and low adopters (4.00 tonnes/ha). The use of FYM was found to be lower by 33.33 per cent, 29.16 per cent and 16.66 per cent than the recommended practice in low, medium and high adopters respectively. But all were lower than the RD. The use of PPCs was found to be higher in case of high adopters followed by medium adopters and low adopters. The usage of PPCs was found to be more than recommended practice in all type of adopters.

4.4.2 Usage of inputs against recommended practices among different level of adopters of JG-11 variety of bengalgram

The results on the pattern of input usage against recommended practices among different adopters of improved technologies of JG-11 variety are presented in Table 4.12. A glance at the table indicates that among different level of adopters, the quantity of seeds (72.20 kg/ha) and chemical fertilizers (N=33.75 kg/ha, P_2O_5 = 86.25 kg/ha) used by low adopters were found to be higher as compared to medium and high adopters. This was higher by 5.01 per cent, 39.48 per cent of N and 89.12 per cent of P_2O_5 respectively than

Table 4.11 Usage of inputs against recommended practices among different level of adopters of GBM-2 variety

(Per ha)

Sl. No.	Particulars	Unit	RD*	Low		Medium		High	
				Qty	% Difference	Qty	% Difference	Qty	% Difference
1	Seeds	Kg	62.5-75	75.00	9.09	71.87	4.53	70.82	3.01
2	FYM	Tonnes	6.00	4.00	-33.33	4.25	-29.16	5.00	-16.66
3	Seed treatement with trichoderma	g/Kg	4.00	-	-	20	400.00	18.50	362.50
4	**Fertilizers**								
a	N	Kg	25.00	33.75	35.00	30.93	23.72	26.24	4.96
b	P	Kg	50.00	86.25	72.5	69.47	38.94	67.07	34.14
c	K	Kg	-	-	-	-	-	-	-
5	**PPCs**								
a	Chloranthriniliprole 18.5SC	ml/lit	0.15	0.38	153.33	0.40	266.66	0.46	206.66
b	Propenophos 50EC	ml/lit	2.00	2.33	16.50	2.66	33.00	3.00	50.00
c	Flubendiamide 39.35SC	ml/lit	0.075	0.26	246.66	0.33	340.00	0.40	433.33
d	Emamectinbenzoate 5SG	g/lit	0.20	1.33	565.00	1.33	565.00	1.66	730.00
e	Carbandanzim50WP	g/lit	0.50	1.53	206.00	1.58	216.00	2.1	320.00

Note: % Difference indicates percentage of deviation from recommended dose of inputs.
*Recommended dose

Table 4.12 Usage of inputs against recommended practices among different level of adopters of JG-11 variety

(Per ha)

Sl. No.	Particulars	Unit	RD*	Low		Medium		High	
				Qty	% Difference	Qty	% Difference	Qty	% DifferEnce
1	Seeds	Kg	62.5-75	72.2	5.01	71.87	4.53	69.37	0.90
2	FYM	Tonnes	6.00	4.90	-18.33	5.00	-16.66	5.50	-8.33
3	Seed treatement with trichoderma	g/kg	4.00	-	-	18.26	356.5	21.02	425.5
4	**Fertilizers**								
a	N	Kg	25.00	34.87	39.48	27.18	8.72	25.31	1.24
b	P	Kg	50.00	89.12	78.24	69.47	38.94	64.68	29.36
c	K	Kg	-	-	-	-		-	-
5	**PPCs**								
a	Chloranthriniliprole 18.5SC	ml/lit	0.15	0.33	120.00	0.40	166.66	0.40	166.66
b	Propenophos 50EC	ml/lit	2.00	2.66	33.00	3.16	58.00	3.33	66.50
c	Flubendiamide 39.35SC	ml/lit	0.075	0.20	166.66	0.40	433.33	0.46	513.33
d	Emamectinbenzoate 5SG	g/lit	0.20	1.33	565.00	1.44	620.00	2.00	900.00
e	Carbandanzim50WP	g/lit	0.50	-	-	1.26	152.00	1.34	168.00

Note: % Difference indicates percentage of deviation from recommended dose of inputs
*Recommened dose

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the recommended practice. Low adopters have not used trichoderma for seed treatment. High adopters have used more quantity of trichoderma (21.02g/ Kg) as compared to medium adopters (18.26g / Kg) for seed treatment. This was higher by 425.50 per cent than recommended practice in high adopters and 356.50 per cent more than recommended practice in medium adopters. The quantity of usage of FYM was found to be higher in case of high adopters (5.00 tonnes/ha) followed by medium adopters (4.25tonnes/ha) and low adopters (4.00 tonnes/ha). The use of FYM was found to be lower by 33.33 per cent, 29.16 per cent and 16.66 per cent than the recommended practice in low, medium and high adopters respectively. The use of PPCs was found to be higher in case of high adopters followed by medium adopters and low adopters. The usage of PPCs was found to be more than recommended practice in all type of adopters.

4.4.3 Usage of inputs against recommended practices among different level of adopters of Annigeri-1 variety of bengalgram

The results on the pattern of input usage and extent of deviation against recommended practices among different adopters of improved technologies of Annigeri-1 variety are presented in Table 4.13. A glance at the table indicates that among different level of adopters, the quantity of chemical fertilizers (N=38.38Kg/ha, P_2O_5= 98.03 Kg/ha) used by low adopters was found to be higher as compared to medium and high adopters. This was higher by 53.58 per cent of N and 96.06 per cent of P_2O_5 respectively than the recommended practice. Low adopters have not used trichoderma for seed treatment. Whereas, high adopters have used more quantity of trichoderma (18.78 g/ Kg) as compared to medium adopters (16.99g / Kg) for seed treatment. The quantity of usage of seeds (61.50 kg/ha) and FYM was found to be higher in case of high adopters (5.60 tonne/ha) as compared to medium and low adopters. The use of FYM was found to be lower by 22.5, 12.50 and 12.50 per cents than the recommended practice in low, medium and high adopters respectively. The use of PPCs was found to be higher in case of high adopters followed by medium adopters and low adopters. The usage of PPCs was found to be more than recommended practice in all type of adopters.

4.5 Labour use pattern in bengalgram cultivation

Labour use pattern among different level of adopters across the different varieties of bengalgram is presented in following paragraphs

Table 4.13 Usage of inputs against recommended practices among different level of adopters of Annigeri-1 variety

(Per ha)

Sl. No.	Particulars	Unit	RD*	Low		Medium		High	
				Qty	% Difference	Qty	% Difference	Qty	% Differncee
1	Seeds	Kg	50-62.5	60.25	7.11	61.25	8.88	61.5	9.33
2	FYM	Tonnes	6.00	4.65	-22.5	5.25	-12.50	5.60	-6.66
3	Seed treatement with trichoderma	g/kg	4.00	-	-	16.99	324.75	18.78	369.5
4	**Fertilizers**								
a	N	Kg	25.00	38.38	53.52	29.25	17.00	27.00	8.00
b	P	Kg	50.00	98.03	96.06	74.75	49.50	69.00	38.00
c	K	Kg	-	-	-	-	00.00	-	-
5	**PPCs**								
a	Chloranthriniliprole 18.5SC	ml/lit	0.15	0.37	146.66	0.42	180.00	0.46	206.66
b	Propenophos 50EC	ml/lit	2.00	2.68	34.00	3.12	56.00	3.46	73.00
c	Flubendiamide 39.35SC	ml/lit	0.075	0.26	246.66	0.42	460.00	0.48	540.00
d	Emamectinbenzoate 5SG	g/lit	0.20	1.36	580.00	1.50	650.00	2.02	910.00
e	Carbandanzim50WP	g/lit	0.50	-	-	1.58	216.00	1.76	252.00

Note: % Difference indicates percentage of deviation from recommended dose of inputs
*Recommened dose

4.5.1 Operation-wise labour use pattern in GBM-2 variety

The per hectare operation-wise labour use pattern in GBM-2 variety is presented in Table 4.14 and Fig.4.6. The findings reveals that high adopters used more number of man days for intercultivation (1.51) and cleaning & bagging (2.06) as compared to low and medium adopters. Low adopters (3.30) were required more man days for application of PPCs as compared to medium (2.87) and high adopters (2.62). The number of man days required for preparatory tillage was about 2.50, 3 and 2.50 in case of low, medium and high adopters, respectively. While, number of man days required for application of manures was found to be 3, 4 and 4 in case of low, medium and high adopters respectively. There was equal number of women labour (2.50) required for sowing in all type of adopters. The number of women labour required for weeding was found to be higher in case of adopters (19.15) followed by medium adopters (18.75) and low adopters (16.25). Whereas, the number of women labour required for nipping operation was found to be 2, 2.30 and 2.10 in case of low, medium and high adopters, respectively. The number of hours of machine labour required for land preparation was found to be higher in high adopters (6.65) followed by medium (6.45) and low adopters (6.25). There was equal hours (2.50) of machine labour used for threshing in all type of adopters. More number of bullock pair days were used for preparatory tillage in case of low adopters (0.82) followed by medium (0.72) and high adopters (0.67). The number of bullock pair days required for intercultivation was found to be higher in case of high adopters (1.51) followed by medium (1.41) and low adopters (1.23). The number of bullock pair days required for sowing operation was found to be 0.62, 0.62 and 0.67 in case of low, medium and high adopters respectively.

In all, more number of women labour (22.68/ha) was required to carry out different operations in GBM-2 variety of bengalgram followed by men labour (12.20 man days/ha) machine labour (10.61hrs./ha) and bullock labour (2.78 pair days/ha). Among all operations, the weeding operation was found to be labour intensive in all the categories of adopters.

4.5.2 Operation-wise labour use pattern in JG-11 variety

The per hectare operation-wise labour use pattern in JG-11 variety cultivation is depicted in Table 4.15 and Fig.4.7.The table reveals that high adopters required mor

Table 4.14 Operation-wise labour use pattern in GBM-2 variety **(Per ha)**

Particulars	Low				Medium				High				Overall			
	Men	**WL**	**ML**	**BL**	**Men**	**WL**	**ML**	**BL**	**Men**	**WL**	**ML**	**BL**	**Men**	**WL**	**ML**	**BL**
Preparatory tillage	2.50	-	6.25	0.82	3.00	-	6.45	0.72	2.50	-	6.65	0.67	2.66	-	6.45	0.77
Sowing	-	2.50	-	0.62	-	2.50	2.50	0.62	-	2.50	2.50	0.67	-	2.50	1.66	0.63
Application of manures	3.00	_	_	_	4.00	-	-	-	4.00	-	-	-	3.66	-	-	-
Application of PPC	3.30	-	-	-	2.87	-	-	-	2.62	-	-	-	2.93	-	-	-
Nipping	-	2.00	-	-	-	2.30	-	-	-	2.10	-	-	-	2.13	-	-
Intercultivation	1.23	-	-	1.23	1.41	-	-	1.41	1.51	-		1.51	1.38	-	-	1.38
Weeding	-	16.25	-	-	-	18.75	-	-	-	19.15	-	-	-	18.05	-	-
Harvesting	-	-	2.50	-	-	-	2.50	-	-		2.50	-	-	-	2.50	-
Threshing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cleaning and Bagging	1.20	-	-	-	1.45	-	-	-	2.06	-	-	-	1.57	-	-	-
Total	**11.23**	**20.75**	**8.75**	**2.67**	**12.73**	**23.55**	**11.45**	**2.75**	**12.69**	**23.75**	**11.65**	**2.85**	**12.20**	**22.68**	**10.61**	**2.78**

BL- Bullock labour (Pair days) ML-Machine labour (hrs) Men labour (Man days) WL-Women labour

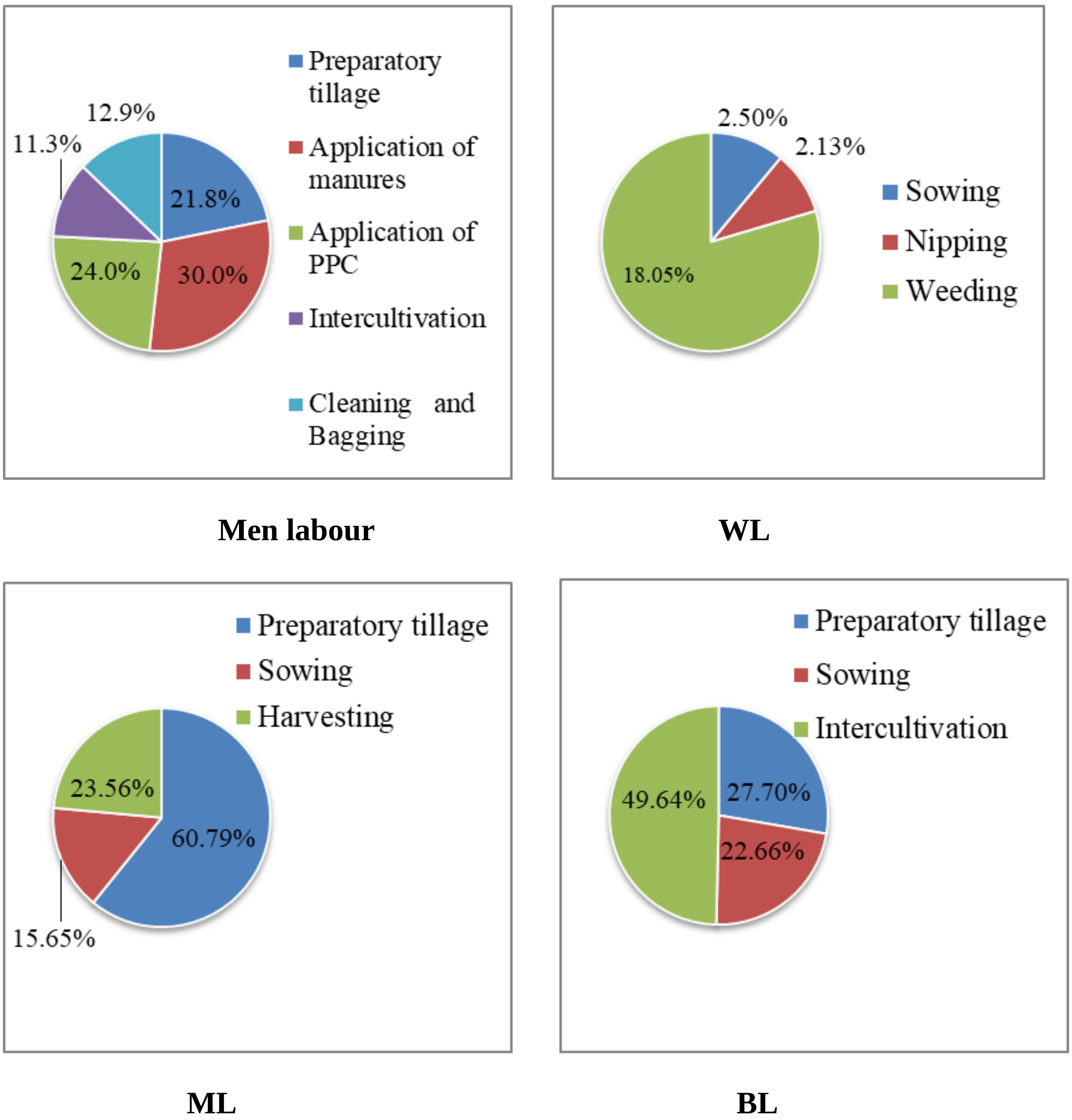

Fig. 4.6 Operation-wise usage of each category of labour in GBM-2 variety

Table 4.15 Operation-wise labour use pattern in JG-11 variety **(Per ha)**

Particulars	Low				Medium				High				Overall			
	Men	**WL**	**ML**	**BL**	**Men**	**WL**	**ML**	**BL**	**Men**	**WL**	**ML**	**BL**	**Men**	**WL**	**ML**	**BL**
Preparatory tillage	3.00	-	6.37	0.77	3.00	-	6.45	0.72	2.50	-	6.62	0.72	2.83		6.48	0.73
Sowing	-	2.50	-	0.72	-	2.50	2.50	0.62	-	2.50	2.50	0.72		2.50	1.66	0.68
Application of manures	3.00	-	-	-	2.50	-	-	-	3.00	-	-	-	2.83	-	-	-
Application of PPC	2.87	-	-	-	2.83	-	-	-	2.77	-	-	-	2.82	-	-	-
Nipping	-	2.10	-	-	-	2.30	-	-	-	2.10	-	-	-	2.16	-	-
Intercultivation	1.15			1.15	1.51			1.51	1.56			1.56	1.40	-	-	1.40
Weeding	-	18.12	-	-	-	19.07	-	-		19.25	-	-		18.81	-	-
Harvesting	-	19.12	-	-		19.15	-	-		19.62	-	-		19.29	-	-
Threshing	2.50	-	2.85	-	2.70	-	6.75	-	2.80	-	6.85	-	2.66	-	5.48	-
Cleaning and bagging	1.62	-	-	-	1.75	-	-	-	2.06	-	-	-	1.81	-	-	-
Total	**14.14**	**41.84**	**9.22**	**2.64**	**14.29**	**43.02**	**15.70**	**2.85**	**14.69**	**43.47**	**15.97**	**3.00**	**14.35**	**42.76**	**13.62**	**2.81**

BL-Bullock labour (Pair days) ML-Machine labour (hrs) Men labour (Man days) WL- Women labour

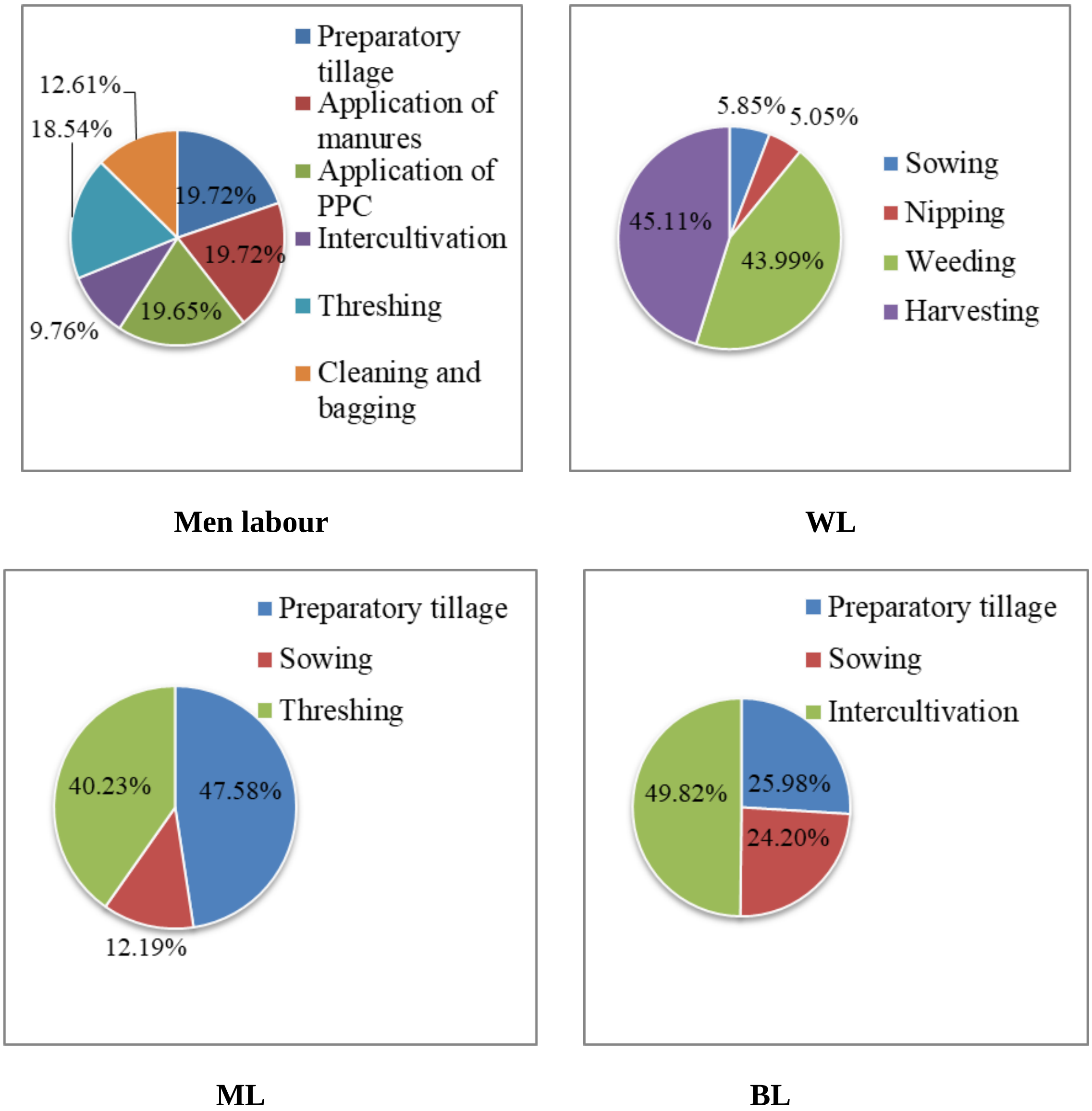

Fig. 4.7 Operation-wise usage of each category of labour in JG-11 variety

days for intercultivation (1.56) and cleaning & bagging (2.06) as compared to low and edium adopters. The labour required under low adopters (2.87 man days) were more for application of PPCs as compared to medium (2.83 man days) and high adopters (2.77man days). The number of man days required for preparatory tillage was about 3.00, 3.00 and 2.50 in case of low, medium and high adopters respectively. While, number of man days required for application of manure was found to be 3.00, 2.50 and 3.00 in case of low, medium and high adopters respectively. There was equal number of women labour required for sowing in all type of adopters. The women labour required for weeding was found to be higher in case of high adopters (19.25) followed by medium adopters (19.07) and low adopters (18.12). Whereas, women labour required for nipping operation was found to be 2.10, 2.30 and 2.10 in case of low, medium and high adopters respectively. The number of women labour required for harvesting was found to be higher in case of high adopters (19.62) followed by medium adopters (19.15) and low adopters (19.12). Among the different operations, the requirement of women labour was found to be higher in all the category of adopters for weeding and harvesting. The number of hours of machine labour required for land preparation was found to be higher in high adopters (6.62) followed by medium (6.45) and low (6.37) adopters. While, the number of hours of machine labour required for threshing was found to be higher in high adopters (6.85) followed by medium (6.75) and low adopters (2.85).More number of bullock pair days was required for preparatory tillage in case of low adopters (0.82) followed by medium adopters (0.72) and high adopters (0.67). The number of bullock pair days required for intercultivation was found to be higher in case of high adopters (1.56) followed by medium adopters (1.51) and low adopters (1.15). The number of bullock pair days required for sowing operation was found to be 0.77, 0.72 and 0.72 in case of low, medium and high adopters respectively.

On an average, more number of women labour (42.76/ha) was required to carry out different operations in JG-11 variety of bengalgram followed by men labour (14.35 man days/ha), machine labour (13.62hrs/ha), and bullock labour (2.81 pair days/ha).

4.5.3 Operation-wise labour use pattern in Annigeri-1 variety

The per hectare operation-wise labour use pattern in Annigeri-1 variety has been presented in Table 4.16 and Fig.4.8. The table reveals that high adopters required more man days for intercultivation (1.47) and cleaning & bagging (1.60) as compared to low and medium adopters. Low adopters (3.00) required more man days for application of PPCs as compared to medium (2.80) and high adopters (2.62). The number of man days required for preparatory tillage was about 3.00, 4.00 and 3.00 in case of low, medium and high adopters respectively. While, number of man days required for application of manure was found to be 2.50, 3.00 and 3.00 in case of low, medium and high adopters respectively. There was equal number of women labour (2.5) required for sowing operation in all type of adopters. The number of women labour required for weeding was found to be higher in case of high adopters (19.50) followed by medium adopters (19.25) and low adopters (18.37). Whereas, the number of women labour required for nipping operation was found to be 1.99, 2.10 and 2.30 in case of low, medium and high adopters respectively. The number of women labour required for harvesting was found to be higher in case of high adopters (20.25) followed by medium (19.75) and low adopters (19.26). The requirement of women labour was found to be more in weeding and harvesting operations in all the categories of adopters. However, for harvesting operation, there was slight increase in requirement with the level of adoption. The number of hours of machine labour required for land preparation was found to be higher in high adopters (6.70) followed by medium (6.50) and low adopters (6.30). While, the number of hours of machine labour required for threshing was found to be higher in high adopters (6.10) followed by medium adopters (5.30) and low adopters (2.12). However, more number of bullock pair days was required for preparatory tillage in case of low adopters (0.82) followed by medium (0.72) and high adopters (0.70). The number of bullock pair days required for intercultivation was found to be higher in case of high adopters (1.47) followed by medium adopters (1.40) and low adopters (1.35). Whereas, the number of bullock pair days required for sowing operation was found to be 0.70, 0.67 and 0.62 in case of low, medium and high adopters respectively.

In all, more number of women labour (43.25/ha) was required to carry out different operations in Annigeri-1 variety of bengalgram followed by men labour (14.10 man days/ha) machine labour (12.66 hrs/ha) and bullock labour (2.80 pair days/ha).

4.6 Costs & Returns in Bengalgram cultivation.

Costs and returns structure in cultivation of different varieties of bengalgram among different level of adopters is presented in detail in following paragraph

Table 4.16 Operation-wise labour use pattern in Annigeri-1 variety **(Per ha)**

Particulars					Medium				High				Overall			
	Men	W L	ML	BL	Men	WL	ML	BL	Men	WL	ML	BL	Men	WL	ML	BL
Preparatory tillage	3.00	-	6.30	0.82	4.00	-	6.50	0.72	3.00	-	6.70	0.70	3.30	-	6.50	0.74
Sowing		2.50		0.70		2.50	2.50	0.67		2.50	2.50	0.62		2.50	1.66	0.66
Application of manures	2.50	-	-	-	3.00	-	-	-	3.00	-	-	-	2.83	-	-	-
Application of PPC	3.00	-	-	-	2.80	-	-	-	2.62				2.80	-	-	-
Nipping	-	1.99	-	-	-	2.10	-	-	-	2.30	-	-	-	2.13	-	-
Intercultivation	1.35			1.35	1.40			1.40	1.47			1.47	1.40	-	-	1.40
Weeding		18.37				19.25				19.50				18.87		
Harvesting		19.26				19.75				20.25				19.75		
Threshing	2.50		2.12		2.50		5.30		2.50		6.10		2.50		4.50	
Cleaning and bagging	0.92				1.22				1.67				1.27			
Total	**13.27**	**42.12**	**8.42**	**2.87**	**14.92**	**43.60**	**14.30**	**2.79**	**14.26**	**44.55**	**15.30**	**2.79**	**14.10**	**43.25**	**12.66**	**2.80**

BL-Bullock labour (Pair days) ML-Machine labour (hrs) Men labour (Man days) WL-

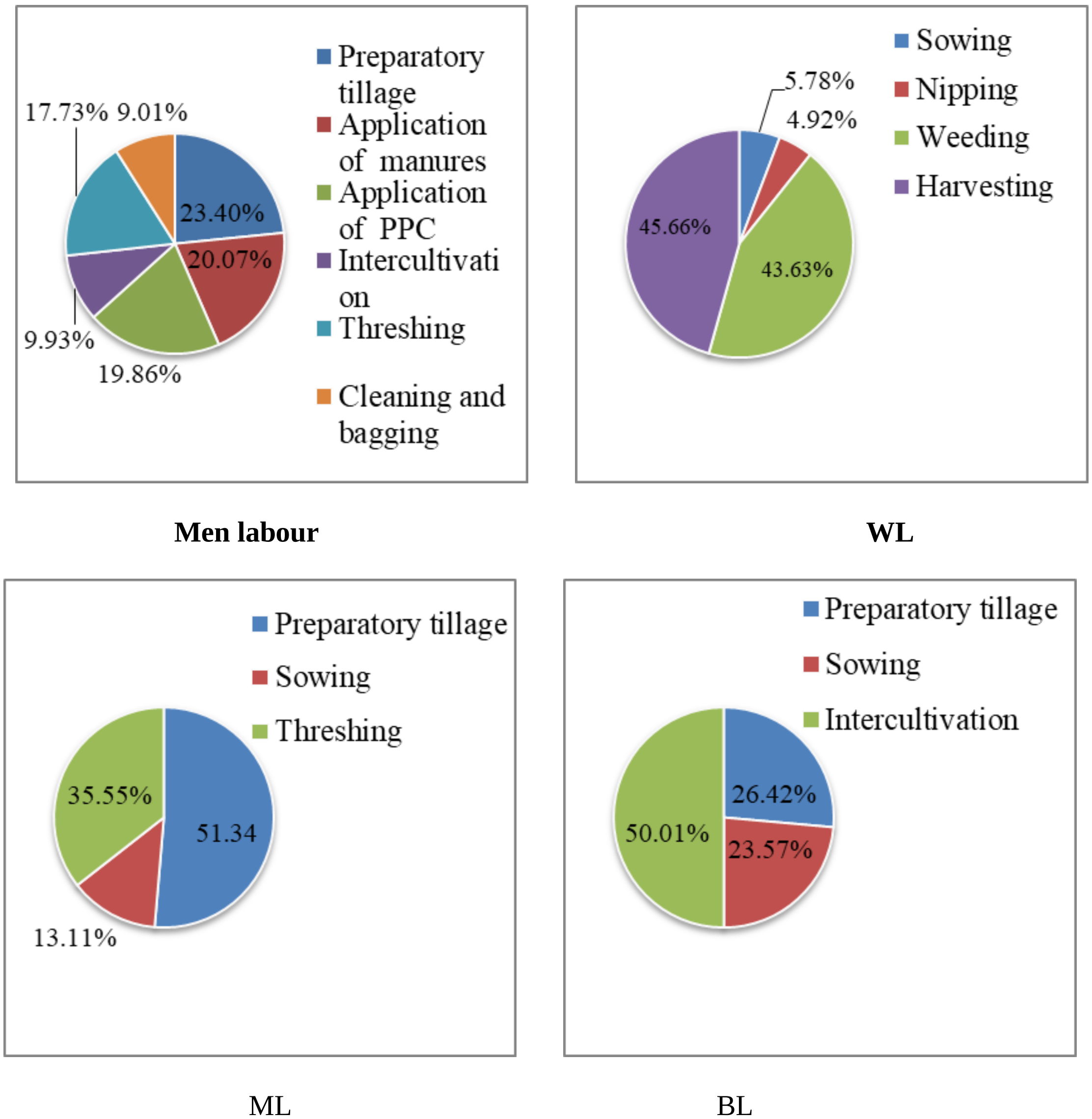

Fig. 4.8 Operation-wise usage of each category of labour in Annigeri-1 variety

4.6.1 Cost and returns among adopters of improved technologies of GBM-2 variety of bengalgram

The details of per hectare cost incurred on variable inputs and fixed inputs in cultivation of GBM-2 variety of bengalgram among different level of adopters have been presented in Table 4.17 and Fig.9. It is clear from the table that the total cost was found to be higher in case of high adopters (₹ 41153.10/ha) followed by medium adopters (₹ 40084.78/ha) and low adopters (₹ 34760.77/ha). The variable cost accounted for chunk share in the total cost of cultivation of GBM-2 variety of bengalgram in high adopters. This was higher by 2.83 per cent and 16.54 per cent than medium and low adopters, respectively. The cost incurred on seeds (14.02%) and chemical fertilizers (13.49%) accounted major share in material cost among low adopters. The cost incurred on seeds was higher by 2.31 per cent than medium and 2.48 per cent than high adopters. While, cost incurred on fertilizers was higher by 2.75 per cent that by medium adopters and 4.65 per cent than high adopters. The cost incurred on PPCs was found to be more in high adopters. This was higher by 32.27 per cent than that by medium adopters and 59.72 per cent more than high adopters. The cost incurred on human labour (₹ 5244/ha), bullock labour (₹ 3866 /ha) and machine labour (₹ 5625.00/ha) was found to be higher in high adopters as compared to medium and low adopters. This was marginally higher by 0.46, 3.80 and 1.41 per cents, respectively than on medium adopters. Whereas, it was higher by 5 per cent, 33.75 per cent and 33.74 per cent, respectively than low adopters. The interest on working capital worked out to be 7.44 per cent and 2.83 per cent higher in high adopters as compared to medium and low adopters respectively.

Depreciation cost was found to be more in high adopters by 5.91 per cent than medium adopters and 19.31 per cent more than low adopters. The interest on fixed capital also found to be 0.96 per cent higher than medium adopters and 3.14 per cent more than low adopters. Hence, total fixed cost was found to be higher by 2.59 per cent than medium adopters and 51.33 per cent more than medium adopters (₹ 4822.72/ha) and 70.32 per cent more than low adopters (₹ 2940.23/ha). Hence, returns per rupee spent was higher in high adopters (1.24) as compared to medium (1.12) and low adopters (1.08).

Table 4.17 Cost and returns among adopters of improved technologies of GBM-2 variety of bengalgram

(₹/ha)

Sl. No	Particulars	Low		Medium		High		Overall	
		Amount	Per cent	Amount	Per cent	Amount	Per cent	Amount	Per cent
A	**Variable cost**								
1	Seeds cost	4875.00	14.02	4687.00	11.69	4750.00	11.54	4770.67	12.22
2	Farm yard manure cost	2160.00	6.21	2295.00	5.73	2700.00	6.56	2385.00	6.11
3	Biopesticide cost	-	-	345.17	0.86	217.50	0.53	281.34	0.72
4	Fertilizers expenditure	4687.50	13.49	4296.87	10.72	3645.82	8.86	4210.06	10.79
5	PPCs cost	1112.50	3.20	1870.70	4.67	2762.30	6.71	1915.17	4.91
6	Irrigation charges	-	-	687.50	1.72	750.00	1.82	718.75	1.84
7	Human labour charges	5244.00	15.09	5944.00	14.83	5972.00	14.51	5720.00	14.66
8	Bullock labour Charges	3866.00	11.12	3919.00	9.78	4074.00	9.90	3953.00	10.13
9	Machine labour charges	5625.00	16.18	8370.00	20.88	8490.00	20.63	7495.00	19.21
10	Intersest on working capital @7.5%	2067.75	5.95	2431.14	6.07	2502.12	6.08	2358.67	6.04
	Sub total	29637.75	85.26	34846.38	86.93	35863.74	87.15	33807.66	86.63
B	**Fixed cost**								

1	Land revenue	62.50	0.18	62.50	0.16	62.50	0.15	62.50	0.16
2	Depreciation	637.52	1.83	743.37	1.85	790.12	1.92	723.67	1.85
3	Land rent	4000.00	11.51	4000.00	9.98	4000.00	9.72	4000.00	10.25
4	Interest on fixed capital @ 9 %	423.00	1.22	432.53	1.08	436.74	1.06	430.76	1.10
	Sub total	5123.02	14.74	5238.40	13.07	5289.36	12.85	5216.93	13.37
C	**Total cost (A+B)**	34760.77	100.00	40084.78	100.00	41153.10	100.00	39024.59	100.00
D	**Production and Returns**								
1	Average yield (q/ha)	10.62	-	12.65	-	14.25	-	12.51	-
2	Price (₹/q)	3550.00	-	3550.00	-	3583.33	-	3561.11	-
3	Gross returns (₹)	37701.00	-	44907.50	-	51062.45	-	44549.49	-
4	Net returns over all costs(₹)	2940.23	-	4822.72	-	9909.36	-	5524.90	-
5	Net returns over all variable cost(₹)	8063.25	-	10061.12	-	15198.71	-	10741.82	-
6	Returns per rupee spent	1.08	-	1.12	-	1.24	-	1.14	-

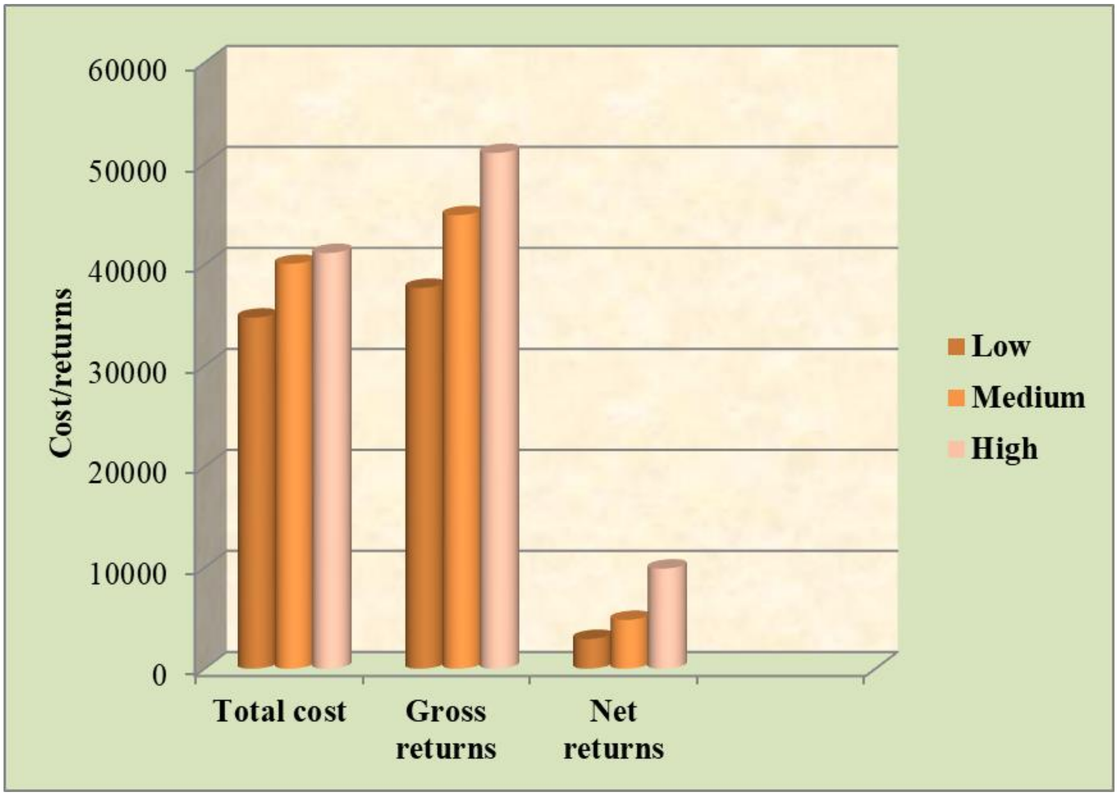

Fig.4.9 Cost and returns among adopters of improved technologies of GBM-2 variety of bengalgram

For the overall category of farmers, per hectare total cost was worked out to be ₹ 39024.59 in GBM-2 variety of bengalgram. The variable and fixed costs incurred were ₹ 33807.66 and ₹ 5216.93, respectively. The average yield realized was about 12.51q. Hence, the per hectare gross and net returns in cultivating GBM-2 variety were ₹ 44562.65 and ₹ 5524.90, respectively. The returns per rupee of expenditure worked out to be 1.14.

4.6.2 Cost and returns among adopters of improved technologies of JG-11 variety of bengalgram

The details of per hectare cost incurred on variable inputs and fixed inputs in cultivation of JG-11 variety of bengalgram among different level of adopters has been presented in Table 4.18 and Fig.410. It was clear from the table that the total cost was found to be higher in case of high adopters (₹ 42103.49/ha) followed by medium adopters (₹ 41731.24/ha) and low adopters (₹ 41387.82/ha).The variable cost accounted chunk share in the total cost of cultivation of JG-11 variety of bengalgram in high adopters. This was higher by 2.99 per cent and 3.73 per cent than medium adopters and low adopters respectively. The cost incurred on seeds (11.23%) and chemical fertilizers (13.11%) accounted for major share in material cost among low adopters. The cost incurred on seeds by low adopters was higher by 0.69 per cent than medium adopters and 3.71 per cent than high adopters. Similarly, the cost of fertilizers was higher by 23.23 per cent than medium adopters and 29.97 per cent than high adopters. The cost incurred on PPCs was found to be higher in high adopters (₹ 2600.52/ha) as compared to medium (₹ 1868.00/ha) and low adopters (₹ 1294.87/ha).Which was higher by 28.16 per cent than medium adopters and 50.20 per cent than high adopters. The cost incurred on human labour, bullock labour and machine labour was found to be higher in high adopters. This was higher by 2.20 per cent, 5.01 per cent and 1.83 per cent respectively than medium adopters and correspondingly, it was higher by 3.78 per cent, 12.72 per cent and 3.82 per cent than low adopters. The interest on working capital worked out to be 4.68 per cent and 5.42 per cent higher in high adopters as compared to medium and low adopters, respectively.

Table 4.18 Cost and returns among adopters of improved technologies of JG-11 variety of bengalgram

(₹/ha)

Sl. No.	Particulars	Low		Medium		High		Overall	
		Amount	Per cent	Amount	Per cent	Amount	Per cent	Amount	Per cent
A	**Variable cost**								
1	Seeds cost	4647.50	11.23	4615.00	11.06	4475.00	10.43	4579.17	10.88
2	Farm yard manure Cost	2646.00	6.39	2700.00	6.47	2970.00	6.92	2772.00	6.58
3	Biopesticide cost	-	-	310.50	0.74	247.50	0.58	279.00	0.66
4	Fertilizers expenditure	5427.62	13.11	4166.65	9.98	3800.65	8.86	4464.97	10.60
5	PPCs cost	1294.87	3.13	1868.00	4.48	2600.52	6.06	1921.13	4.56
6	Human labour charges	10108.00	24.42	10274.00	24.62	10506.00	24.49	10296.00	24.45
7	Bullock labour charges	3739.00	9.03	4069.00	9.75	4284.00	9.99	4030.67	9.57
8	Machine labour charges	5866.00	14.17	5987.00	14.35	6099.00	14.22	5984.00	14.21
9	Intersest on working capital @ 7.5%	2529.67	6.11	2549.26	6.11	2623.70	6.12	2574.52	6.11
	Sub total	36258.66	87.61	36539.41	87.56	37606.37	87.68	36901.46	87.64
B	**Fixed cost**								
1	Land revene	62.50	0.15	62.50	0.15	62.50	0.15	62.50	0.15

2	Depreciation	643.15	1.55	700.65	1.68	786.25	1.83	710.00	1.69
3	Land rent	4000.00	9.66	4000.00	9.59	4000.00	9.33	4000.00	9.50
4	Interest on fixed capital @ 9 %	423.51	1.02	428.68	1.03	436.39	1.02	429.53	1.02
	Sub total	5129.16	12.39	5191.83	12.44	5285.14	12.32	5202.03	12.36
C	**Total cost (A+B)**	41387.82	100.00	41731.24	100.00	42891.51	100.00	42103.49	100.00
D	**Production and Returns**								
1	Average yield (q/ha)	13.52	-	15.65	-	17.97	-	15.71	-
2	Price (₹/q)	3680.53	-	3836.11	-	3862.50	-	3793.05	-
3	Gross returns (₹)	49760.79	-	60035.12	-	69409.12	-	59588.81	-
4	Net returns over all costs (₹)	8372.97	-	18303.88	-	26517.61	-	17485.32	-
5	Net returns over all variable cost (₹)	13502.13	-	23495.71	-	31802.75	-	22687.35	-
6	Returns per rupee spent	1.20	-	1.44	-	1.62	-	1.42	-

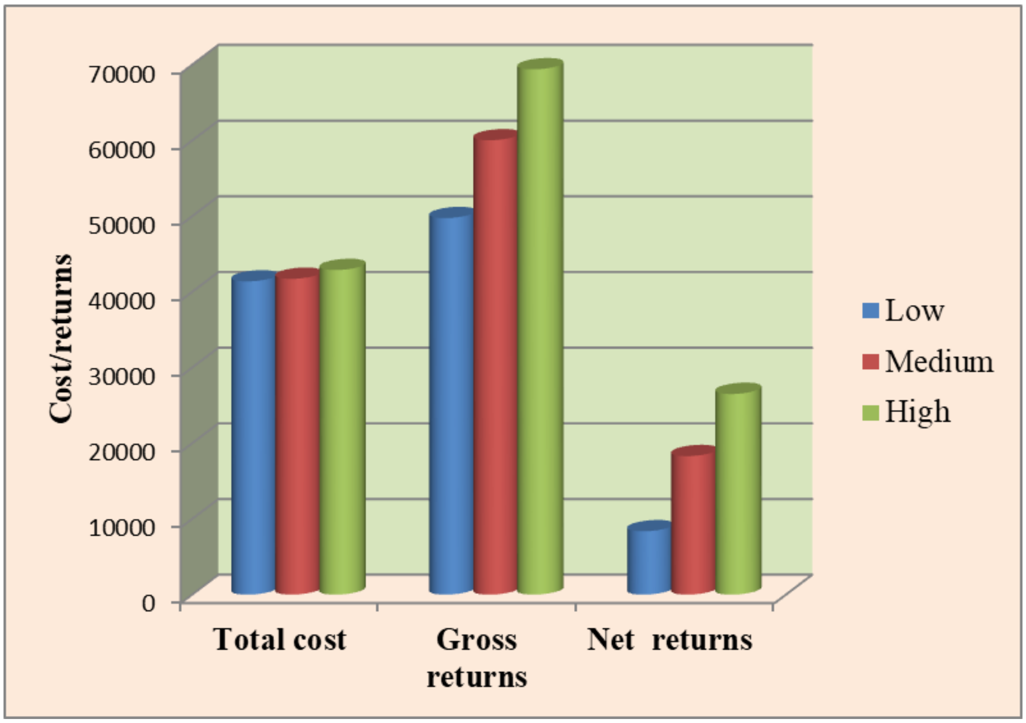

Fig.4.10 Cost and returns among adopters of improved technologies of JG-11 variety of bengalgram

Depreciation cost was found to be higher in high adopters by 10.88 per cent than medium adopters and 18.20 per cent more than low adopters. The interest on fixed capital was also found to be higher by 1.76 per cent than medium adopters and 2.95 per cent more than low adopters. Hence, total fixed cost found to be higher by 1.76 per cent than medium and 2.95 per cent than low adopters.

It was also observed from the table that, there was difference in yield among low (13.52q/ha) medium (15.65q/ha) and high adopters (17.97q/ha). Hence, the gross returns obtained by high adopters (₹ 69409.12/ha) was 1.50 per cent more than medium adopters (₹ 60035.12/ha) and 28.30per cent more than low adopters (₹ 49760.79/ha). The cost of cultivation in case of low adopters (₹ 41387.82/ha) was considerably lower than medium adopters (₹ 41731.24/ha) and high adopters (₹ 42891.51/ha). The net returns earned by high adopters was found to be 30.97 per cent more than medium adopters (₹ 18303.88/ha and 68.42 per cent more than low adopters (₹ 8372.97/ha). Hence, returns per rupee spent were higher in high adopters (1.62) as compared to medium adopters (1.44) and low adopters (1.20).

Overall, per hectare total cost , total variable cost and total fixed cost incurred in JG-11 variety of bengalgram cultivation were worked out to be ₹ 42103.49, ₹ 36901.46 and ₹ 5202.03/ha respectively. The average yield obtained was about 15.71. Hence the gross returns and net returns in cultivating JG-11 variety was found to be ₹ 59588.81 and ₹ 17485.2 respectively. The returns per rupee of expenditure worked out to be 1.42.

4.6.3 Cost and returns among adopters of improved technologies of Annigeri-1 variety of bengalgram

The details of per hectare cost incurred on both variable inputs and fixed inputs in cultivationof Annigeri-1 variety of bengalgram among different level of adopters is presented in Table 4.19 and Fig.4.11. It was clear from the table that the total cost was found to be higher in case of high adopters (₹ 40965.90/ha) followed by medium (₹ 40351.93/ha) and low adopters (₹ 38183.37/ha). The variable cost (₹ 35676.56/ha) accounted chunk share in the total cost of cultivation among high adopters as compared to medium (₹ 35160.53/ha)

Table 4.19 Cost and returns among adopters of improved technologies of Annigeri-1 variety of bengalgram

(₹/ha)

Sl. No.	Particulars	Low		Medium		High		Overall	
		Amount	Per cent	Amount	Per cent	Amount	Per cent	Amount	Per cent
A	**Variable cost**								
1	Seeds cost	2711.25	7.10	2756.25	6.83	2767.50	6.76	2745.00	6.88
2	Farm yard manure cost	2511.00	6.58	2835.00	7.03	3024.00	7.38	2790.00	6.99
3	Biopesticide cost	-	-	312.00	0.77	207.00	0.51	259.50	0.65
4	Fertilizers expenditure	5698.52	14.92	3906.25	9.68	3437.50	8.39	4347.42	10.89
5	PPCs cost	1367.42	3.58	1865.97	4.62	2580.00	6.30	1937.80	4.85
6	Human labour charges	10379.25	27.18	10601.00	26.27	10528.00	25.70	10502.75	26.31
7	Bullock labour Charges	4071.00	10.66	3974.50	9.85	3983.00	9.72	4009.50	10.04
8	Machine labour Charges	4002.60	10.48	6456.50	16.00	6660.50	16.26	5706.53	14.29
9	Intersest on working capital @ 7.5%	2305.58	6.04	2453.06	6.08	2489.06	6.08	2422.39	6.07
	Sub total	33046.62	86.55	35160.53	87.13	35676.56	87.09	34720.89	86.96
B	**Fixed cost**								

1	Land revene	62.50	0.16	62.50	0.15	62.50	0.15	62.50	0.16
2	Depreciation	650.12	1.70	700.25	1.74	790.10	1.93	713.49	1.79
3	Land rent	4000.00	10.48	4000.00	9.91	4000.00	9.76	4000.00	10.02
4	Interest on fixed capital @ 9%	424.14	1.11	428.65	1.06	436.73	1.07	429.84	1.08
	Sub total	5136.76	13.45	5191.40	12.87	5289.33	12.91	5205.83	13.04
C	**Total cost (A+B)**	38183.37	100.00	40351.93	100.00	40965.90	100.00	39926.72	100.00
D	**Production and Returns**								
	Average yield (q/ha)	9.25	-	11.50	-	12.75	-	11.17	-
	Price (₹/q)	3550.58	-	3577.77	-	3560.00	-	3562.78	-
	Gross returns(₹)	32842.87	-	41144.36	-	45390.00	-	39792.41	-
	Net returns over all costs(₹)	-5340.50	-	792.43	-	4424.10	-	-134.31	-
	Net returns over all variable cost (₹)	-203.75	-	5983.83	-	9713.44	-	5071.52	-
	Returns per rupee spent	0.86	-	1.02	-	1.11	-	1.00	-

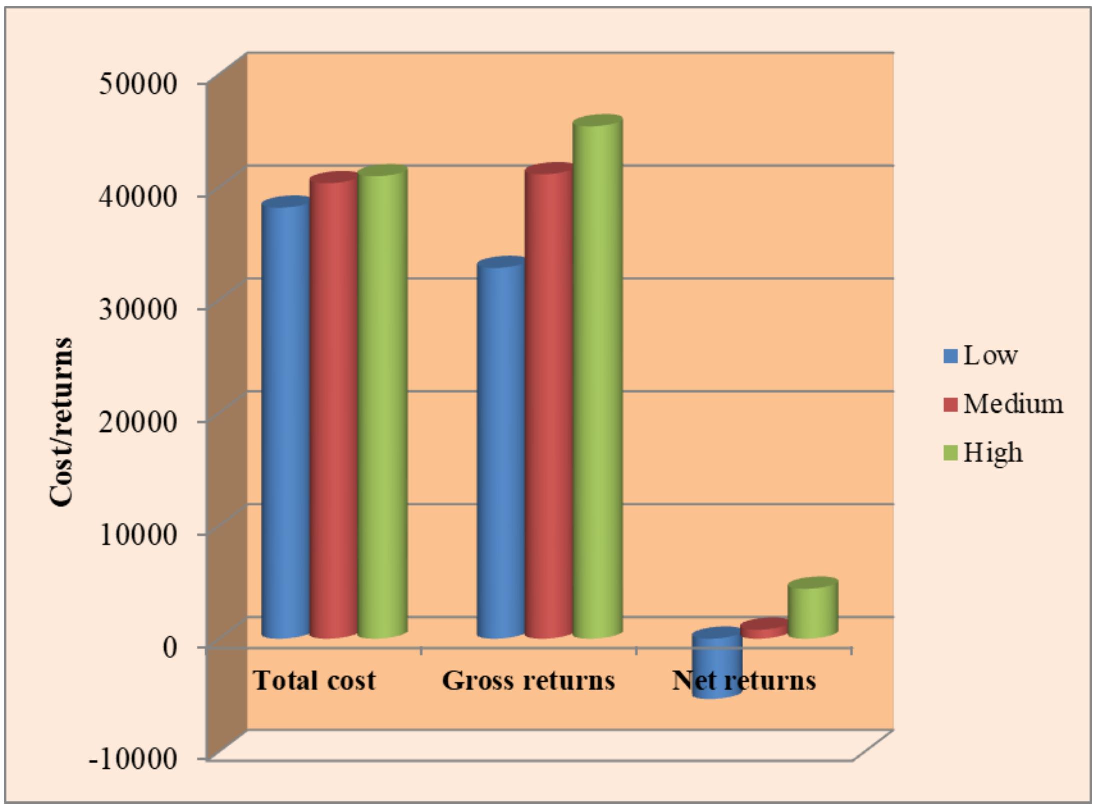

Fig.4.11 Cost andreturns among adopters of improved technologies of Annigeri-1 variety of bengalgram

4.7 Economic impact of bengalgram technologies

Economic impact of varietal technologies and also that of overall adoption of technologies on low, medium and high adopters is presented in following paragraphs**.**

4.7.1 Assessment of net gain or loss in adoption of JG-11 over GBM-2 variety

In order to assess the net gain or loss due to adoption of JG-11 variety over GBM-2 variety, the method of partial budgeting was carried out and the results are presented in Table 4.20. Majority of the inputs distributed between both credit and debit side. On debit side, increase in cost was due to increase in cost of FYM, fertilizers, human labour. and bullock labour. This was summed up to ₹ 5495.57 per hectare. However on credit side, there was decrease in cost with respect to seeds, bio-pesticide, PPCs, protective irrigation and machine labour. This was summed up to ₹ 2429.55 per hectare. However, decrease in returns was nil. Increase in returns due to adoption of JG-11 variety was about ₹ 11395.55 per hectare. Thus, there was net gain of ₹ 8071.03 per hectare due to adoption of JG-11variety over GBM-2 variety.

4.7.2 Assessment of net gain or loss in adoption of GBM-2 variety over Annigeri-1 variety

In order to assess the net gain or loss due to adoption of GBM-2 variety over Annigeri-1 variety, the method of partial budgeting was carried out and the results were presented in Table 4.21. Majority of the inputs were distributed between both credit and debit side. On debit side, increase in cost was due to increase in cost of seeds, bio-pesticide, PPCs, protective irrigation and machine labour. This was summed up to ₹ 4554.73 per hectare. However, on credit side, there was decrease in cost with respect to human labour, bullock labour, fertilizers and FYM. This was summed up to ₹ 5404.46 per hectare. Decrease in returns was nil and increase in returns due to adoption of GBM-2 variety was about ₹ 5270.42 per hectare. Thus, there was net gain of ₹ 6120.15 per hectare due to adoption of GBM-2 variety over Annigeri-1 variety.

Table 4.20 Assessment of net gain or loss in adoption of JG-11 variety over GBM-2 variety through partial budgeting approach

(₹/ha)

JG-11 variety over GBM-2 variety				
Sl. No.	**Debit**	**Amount**	**Credit**	**Amount**
	A. Increase in costs		**C. Decrease in costs**	
1	Farm yard manure	387.00	Seeds	191.50
2	Fertilizers	254.91	Bio-pesticide	2.34
3	Human labour	4776	PPCs	5.96
4	Bullock labour	77.66	Protective irrigation	718.75
5	-	-	Machine labour	1511
	Sub total	5495.57	Sub total	2429.55
	B. Decrease in returns		**D. Increase in returns**	**NIL**
			Main product (qtl/ha)	3.20
			Price (₹/qtl)	3561.11
			Sub total	11395.55
Total(A+B)		**5495.57**	**Total (C+D)**	**13825.10**
Net gain [(C+D)-(A+B)] = ₹ 8071.03/-				

Table 4.21 Assessment of net gain or loss in adoption of GBM-2 variety over Annigeri-1 variety through partial budgeting approach

(₹/ha)

GBM-2 variety over Annigeri-1 variety				
Sl. No.	**Debit**	**Amount**	**Credit**	**Amount**
	A. Increase in costs		**C. Decrease in costs**	
1	Seeds	2025.67	Farm yard manure	405.00
2	Bio –pesticide	21.84	PPCs	22.8
3	Machine labour	1788.47	Fertilizers	137.36
4	Protective irrigation	718.75	Human labour	4782.8
5			Bullock labour	56.5
	Sub total	4554.73	Sub total	5404.46
	B. Decrease in returns	**NIL**	**D. Increase in returns**	
			Main product (qtl/ha)	1.48
			Price (₹/qtl)	3561.1
			Sub total	5270.42
Total (A+B)		**4554.73**	**Total (C+D)**	**10674.88**
Net gain [(C+D)-(A+B)] = ₹ 6120.15/-				

4.7.3 Assessment of net gain or loss of medium adopters of recommended technologies over low adopters

In order to assess the net gain or loss of medium adopters of recommended technologies of bengalgram over low adopters, the method of partial budgeting was carried out and the results are presented in Table 4.22. Majority of the inputs fall on debit side. This is due to increase in cost with respect to FYM, bio-pesticide, PPCs, protective irrigation, human labour, bullock labour and machine labour. This was summed upto ₹ 4022.37 per hectare. On credit side, decrease in cost was due to reduction in cost of seeds and fertilizers. This was summed up to ₹ 1206.06 per hectare. Decrease in returns was nil and increase in returns due to adoption of recommended technologies of bengalgram was about ₹ 7654.58 per hectare. Thus, there was net gain of ₹ 4838.27 per hectare by medium adopters due to adoption of recommended technologies of bengalgram over low adopters.

4.7.4 Assessment of net gain or loss of high adopters of recommended technologies over low adopters

The method of partial budgeting was carried out and the results are presented in Table 4.23. Majority of the inputs fall on debit side which is due to increase in cost with respect to FYM, bio-pesticide, PPCs, protective irrigation, human labour, bullock labour and machine labour. This was summed up to ₹ 5399.23 per hectare. On credit side, decrease in cost was due to decrease in cost of seeds and fertilizers. This was summed up to ₹ 1871.14 per hectare. Decrease in returns was nil and increase in returns due to adoption of recommended technologies of bengalgram was about ₹ 15903.18 per hectare. Thus, there was net gain of ₹ 10504.32 per hectare by high adopters due adoption of recommended technologies of bengalgram over low adopters.

4.7.5 Assessment of net gain or loss of medium adopters of recommended technologies over high adopters

The net gain or loss of high adopters of recommended technologies of bengalgram over medium adopters, the method of partial budgeting was carried out and the results are presented in Table 4.24. Majority of the inputs fall on debit side mainly due to increase in cost with respect to FYM, PPCs, protective irrigation, human labour, bullock labour and

Table 4.22 Assessment of net gain or loss of medium adopters of recommended technologies over low adopters through partial budgeting technique

(₹/ha)

Medium over Low				
Sl. No.	**Debit**	**Amount**	**Credit**	**Amount**
	A. Increase in costs		**C. Decrease in costs**	
1	Farm yard manure	171.00	Seeds	58.1
2	Bio-pesticide	322.55	Fertilizers	1147.96
3	Plant protection chemicals	609.96		
4	Protective irrigation	687.5		
5	Human labour	362.56		
6	Bullock labour	95.5		
7	Machine labour	1773.3		
	Sub total	4022.37	Sub total	1206.06
	B. Decrease in returns	**NIL**	**D. Increase in returns**	**NIL**
			Main Product (qtl)	2.13
			Price(₹/qtl)	3593.70
			Sub total	7654.58
	Total (A+B)	**4022.37**	**Total (C+D)**	**8860.64**
Net gain [(C+D)-(A+B)]= ₹ 4838.27/-				

Table 4.23 Assessment of net gain or loss of high adopters of recommended technologies over low adopters through partial budgeting technique

(₹/ha)

High over Low				
Sl. No.	**Debit**	**Amount**	**Credit**	**Amount**
	A. Increase in costs		**C. Decrease in costs**	
1	Farm yard manure	459.00	Seeds	80.41
2	Bio-pesticide	224.00	Fertilizers	1790.73
3	Plant protection chemicals	1643.22		
4	Protective irrigation	750		
5	Human labour	182.94		
6	Bullock labour	221.66		
	Machine labour	1918.63		
	Sub total	5399.23		
	B. Decrease in returns		**D. Increase in returns**	**NIL**
			Main Product (qtl)	3.86
			Price (₹/qtl)	3635.28
			Sub total	14032.18
Total (A+B)		**5399.23**	**Total (C+D)**	**15903.32**
Net gain [(C+D)-(A+B)]= ₹ 10504.09/-				

Table 4.24 Assessment of net gain or loss of high adopters of recommended technologies over medium adopters through partial budgeting technique

(₹/ha)

High over Medium				
Sl. No.	**Debit**	**Amount**	**Credit**	**Amount**
	A.Increase in costs		**C. Decrease in costs**	
1	Farm yard manure	288	Seeds	21.91
2	Plant protection chemicals	1032.33	Fertilizers	495.26
3	Protective irrigation	12.5	Bio pesticide	98.55
4	Human labour	62.34		
5	Bullock labour	126.16		
6	Machine labour	145.33		
	Sub total	1666.66		
	B.Decrease in returns		**D. Increase in returns**	**NIL**
			Main Product(qtl)	1.73
			Price(₹/qtl)	3654.62
			Sub total	6322.49
Total (A+B)		1666.66	**Total (C+D)**	**6906.48**
Net gain [(C+D)-(A+B)]= ₹ 5239.82/-				

machine labour, which was summed up to ₹ 1666.66 per hectare. On credit side, increase in cost was due to increase in cost of seeds and fertilizers and bio-pesticide. This was summed up to ₹ 583.99 per hectare. Decrease in returns was nil and increase in returns due to adoption of recommended technologies of bengalgram was about ₹ 6322.49 per hectare. Thus, there was net gain of ₹ 5239.82 per hectare by high adopters due to non-adoption of recommended technologies of bengalgram over medium adopters.

4.8 Factors influencing adoption of bengalgram technologies

The factors influencing adoption of bengalgram technologies is presented in detail in following paragraphs.

4.8.1 Different tests for selection of appropriate model (Multi ordinal logistic regression)

Since the dependent variable i.e adoption of technology is ordinal in nature as it is categorized into low, medium and high levels of adoption and also explanatory variables taken in the study are also ordinal in nature. Hence, Multi ordinal logistic regression was used to determine factors influencing adoption of bengalgram technologies instead of using binary logistic regression model.

The data pertinent to factors influencing adoption of bengalgram technologies was analyzed using logit link function in ordinal regression under SPSS software.

Among different models in ordinal logistic regression, Proportional Odds Model (POM) is best fitted to analyze the data. This was due to chi-square test of proportional odds assumption was found non-significant at 5 per cent level of significance with high p-value indicating that data satisfy the proportional odds assumption. This could be evident from Table 4.25. The Log Likelihood Ratio (LRT) value of 244.26 was significant at 5 per cent level, indicated overall fitness of the model. Whereas the Log Likelihood Ratio of test of parallel lines was found non-significant indicated that Ordinal logistic regression should consider instead of Nominal logistic regression.

Table 4.25 Different tests for selection of appropriate model (Multi ordinal logistic regression)

Sl.No.	Tests	Value	P-value	Uses
1	Chi-square test			To test the assumption of POM and also to determine goodness of fit of model
A	Pearson	106.11	0.820	
B	Deviance	100.12	0.910	
2	Log likelihood ratio	244.26	0.000	To test the overall fit of model
3	Pseudo R-square	0.463	-	-
4	Parallel test			-
	Log likelihood ratio	181.67	0.559	

4.8.2 Estimates of multi ordinal proportional odds model for adoption of bengalgram technology

The results of multiple proportional odds model are presented in Table 4.26. The selected covariables such as age, education, land holding and extension contact were found significant at 5 per cent level except farming experience. The estimated parameters (coefficients) don't provide direct information about the effect of changes in the explanatory variables on adoption of bengalgram technologies. Hence, odds ratio is computed to each covariable to interpret the data. The results of POM reveal that the adoption of bengalgram technologies were 1.007 and 1.563 times higher among sample farmers belonged to age group of below 35 years and 35-55 years, respectively compared to sample farmers belonged to age group of above 55 years. The adoption of bengalgram technologies was 0.184 times lower among sample farmers who were illiterate compared to sample farmers who had above college level education. While, it was 1.074, 1.066 and 1.024 times higher among farmers who had primary, high school and college level education as compared to farmers who had above college level education. Farming experience of the farmers is not related to adoption of bengalgram technologies. The adoption of bengalgram technologies in case of marginal, small and medium farmers was 0.224, 0.215 and 0.028 times lesser than large farmers who own land above four hectares. Extension contact was significantly influencing the adoption of bengalgram technologies. Sample farmers who met extension agencies on monthly, fortnightly were less likely to adopt bengalgram technologies as compared to farmers who met extension agencies on weekly basis. Similarly, the sample farmers who did not have contact with extension agenices were 0.630 times less likely to adopt technologies when compared to farmers who met extension agencies on weekly basis.

4.9 Marketing practices followed by bengalgram growers

It is observed from results presented in Table 4.27 that majority of the low (64.10%) medium (54%) and high (51.61%) adopters sold their entire quantity of produce at a time. High adopters followed staggered method to sell the produce to a greater extent (48.38%) than medium adopters (46%) and low adopters (35.89%)

Table 4.26 Estimates of multi ordinal proportional odds model for adoption of bengalgram technology

Covariable	Regression coefficient	Wald	Odds ratio	P-value
Intercept-1	-6.377	12.42	-	0.000
Intercept-2	-3.721	4.52	-	0.033
Sample farmers age [in years] > 55 years as reference				
<35	0.007	0.000	1.007	0.030
35-55	0.447	0.175	1.563	0.026
Education of sample farmers [Above college level as reference]				
College	0.024	5.088	1.024	0.024
High school	0.064	6.107	1.066	0.013
Primary	0.072	5.851	1.074	0.016
Illiterate	-1.691	0.951	0.184	0.009
Farming experience of sample farmers [high level of farming experience as reference]				
Medium	0.203	0.076	1.225	0.783
Low	0.705	0.942	2.023	0.332
Land holding of sample farmers [Large farmers as reference]				
Marginal farmers	-1.492	9.092	0.224	0.003
Small farmers	-1.537	7.326	0.215	0.007
Medium farmers	-3.552	7.234	0.028	0.004
Extension contact of the sample farmers [once in a week as reference]				
Once in month	-0.546	0.820	0.579	0.025
Once in fort Night	-1.551	7.776	0.212	0.005
Not at all	-0.461	0.464	0.630	0.036

Table 4.27 Marketing practices followed by bengalgram growers

Sl. No.	Particulars	Low		Medium		High		Overall	
		No.	%	No.	%	No.	%	No.	%
1	**Quantity sold**								
a	Entire quantity at a time	25	64.10	27	54.00	16	51.61	68	56.66
b	Staggered method of sale	14	35.89	23	46.00	15	48.38	52	43.33
2	**Time of sale**								
a	Immediately after harvesting	23	58.97	27	54.00	16	51.61	66	55.00
b	One month after harvesting	09	23.07	12	24.00	08	25.80	29	24.16
c	2 months after harvesting	05	12.82	07	14.00	05	16.12	17	14.66
d	More than 3 months after harvesting	02	5.12	04	8.00	02	6.45	8	6.66
3	**Place of sale**								
a	Village	06	15.38	08	16.00	06	19.35	20	16.66
b	Regulated market	24	61.53	32	64.00	20	64.51	76	63.33
c	Sandis	09	23.07	10	20.00	05	16.12	24	20.00
4	**Distance of sale**								
a	0 kms	12	30.76	18	36.00	06	19.35	36	30.00
b	0-5kms	8	20.51	09	18.00	12	38.70	29	24.16
c	5-20Kms	10	25.64	12	24.00	08	25.80	30	25.00
d	>20kms	9	23.07	11	22.00	05	16.12	25	20.83
5	**Average price realized (₹/qtl)**	3593.69		3654.62		3668.61		3638.97	

It was also observed from the table that most of the low (30.76%) and medium adopters (36 %) sold their produce on farm itself. Majority of high adopters sold their produce in a distance of about 0- 5 kms. Less proportion of farmers in low, medium and high adopter categories sold their produce in a distance of 5-20 kms and above 20 kms.

The average price realized by high adopters (₹ 3688.61/qtl) was high when compared to medium (₹ 3654.62/ha) and low adopters (₹ 3593.69/ha).

4.10 Constraints faced in adoption of bengalgram technologies developed by UASR

In order to identify the constraints in adoption of bengalgram technologies developed by UASR at a farm level, Garette ranking technique was used and results are presented in Table 4.28. The ranking was done for constraints faced by sample farmers in respective study areas. The constraints were sub divided into production constraints, marketing and technical constraints.

In production constraints, sample farmers stated the top most constraint as non–availability of labour. Similarly, lack of knowledge about bio fertilizers and bio-pesticides as second most important constraint faced by them. The other constraints faced by the sample farmers were high cost of pesticides (III Rank), resistance of pod borer against insecticides (IV Rank), higher cost of harvesting (V Rank), non-availability of required quantity of FYM (VI Rank) and non- availability of bio fertilizers and bio-pesticides in time (VII Rank), *etc*.

Less remunerative price for the produce and high price fluctuation were the top most marketing constraints faced by the sample farmers. The other marketing constraints faced by the sample farmers were lack of processing facility, lack of marketing information and lack of co-operative marketing organization.

With respect to management constraints, sample farmers stated first constraint as lack of knowledge regarding improved agrochemical practices of bengalgram followed by lack of knowledge about seed treatment and inability to attend demonstrations and training programmers.

Table 4.28 Constraints faced by farmers in production and marketing in adoption of bengalgram technologies developed by UASR

Sl. No.	Constraints	Garret Score	Rank
Production			
1	Non-availability of labour	63.65	I
2	Lack of knowledge about bio fertilizers and bio-pesticides	57.87	II
3	High cost of pesticides	53.65	III
4	Resistance of pod borer against insecticides	53.24	IV
5	Harvesting cost is high	52.72	V
6	Non -availability of required quantity of FYM	52.24	VI
7	Non-availability of bio fertilizers and bio-pesticides in time	50.28	VII
8	High cost of improved seed	49.81	VIII
9	Lack of supply of improved seed	40.18	IX
10	Non -availability of fertilizers in time	24.16	X
Marketing			
1	Less remunerative price for produce	69.03	I
2	High Price fluctuation	66.83	II
3	Lack of processing facility	57.01	III
4	Lack of marketing information	56.81	IV
5	Lack of cooperative marketing organization	55.93	V
6	High rate of interest for non-institutional credit	47.58	VI
7	Non acceptance of bengalgram varieties by the community	42.85	VII
8	Regulated market is far off	33.98	VIII

9	High transportation cost	30.72	IX
10	Lack of credit facilities	29.98	X
Technical			
1	Lack of knowledge regarding improved agrochemical practices of bengalgram	65.32	I
2	Lack of knowledge about seed treatement	61.12	II
3	Inability to attend demonstrations & training programmes	57.50	III
4	Not able to contact extension agencies at the time of necessity	55.13	IV
5	Couldn't plan in advance about the incidence & application of inputs	45.20	V
6	Lack of knowledge about control of insect pests & disease control	47.18	VI

Discussion

V. DISCUSSION

The results of the study presented in previous chapters are discussed in detail in this chapter. The main focus is to throw light on reasons responsible for the major observation in the findings. This kind of analysis is hoped to identify the policy measures and execute corrections that can be implemented to overcome the problems encountered by the respondents. Keeping the objectives of the study in a view, the results are discussed under the following headings.

5.1 Spread of bengalgram technologies developed by UASR

5.2 Distribution of sample farmers according to their socio-economic characteristics

5.3 Input use pattern in bengalgram cultivation

5.4 Operation-wise labour use pattern in bengalgram cultivation

5.5 Cost and returns among adopters of improved technologies of bengalgram cultivation

5.6 Economic impact of bengalgram technologies

5.7 Factors influencing adoption of bengalgram technologies

5.8 Constraints faced in adoption of bengalgram technologies developed by UASR

5.1 Spread of bengalgram technologies developed by UASR

There were about 14 technologies developed by UASR related to production, protection and varietal technologies in bengalgram crop. Among the varietal technologies, GBM-2 is a new variety developed by breeder Dr. Mannur at ARS, Kalaburagi and was released for commercial cultivation in 2014-15. The present study was undertaken to assess the extent of spread of the variety in study districts viz., Kalaburagi and Raichur, other districts in NEK region and other parts of Karnataka State and India during 2014-15 to 2017-18. It was evident through Table 4.1, 4.2, 4.3 and 4.4 that the area under this variety was highest in the Chittapur taluk of Kalaburagi district followed by Afzalpur, Sedam and Aland during 2014-15. The area under this variety was less than 50 acres in Chincholi, Kalaburagi and Jewargi taluks. It was also observed from Table 4.1 that the area under this variety has been decreased from 2014-15 to 2016-17. Further, it was increased in 2017-18 to a meager extent in Kalaburagi district. Same trend was followed in case of per cent of bengalgram from 2014-15 to 2017-18. In the year of release, the area under this variety was the highest (402 acres) as compared to subsequent years. This was mainly due to awareness created through demonstrations by ARS, Kalaburagi about this new variety. The farmers who were innovative, curious and aware of this variety have purchased seeds from Seed Unit of ARS, Kalaburagi to a larger extent with an intention of getting more yield. The GBM-2 variety has got characteristics like erected branches and suitable for mechanical harvesting. Labour scarcity is the main problem faced by the farmers. When the farmers came to know the fact that this variety was intentionally developed for mechanical harvesting majority of the farmers purchased seeds and cultivated on larger extent. So, the area under this variety was the highest in 2014-15. The decrease in area under this variety in subsequent years was mainly due to the fact that farmers who were cultivated this variety might have got less yield as compare to other varieties such as JG-11. Another important feature is, this variety requires minimum one protective irrigation in order to obtain higher yield and is relatively long duration variety (100-110 days). Majority of area under bengalgram cultivation in Kalaburagi district was under *rainfed* situation. However, it is not possible to give one protective irrigation to this variety by farmers. It was opinion of the farmers that the seed quality of this variety is poor as compared to JG-11 variety. The poor quality grain led to low market price for GBM-2 as compared to JG-11 (about ₹300/q less price compared to JG-11 variety) and the farmers opinioned that seeds of this variety get powdered while processing. These are the reasons for less spread of this variety in Kalaburagi district during study period.

But in case of Raichur district, the spread of this variety was less in the year of release (2014-15) as evident from Table 4.2. The area under this variety as well as (451.81 acres) per cent of bengalgram area under this variety (3.27%) was the highest in 2016-17. The reasons for less spread of this variety in the year of release were lack of the awareness about this variety among farming community and cultivation of another variety in bengalgram having good yield. When the farmers aware of this variety through demonstrations conducted in Seed Unit of Raichur or from fellow farmers or any other

Plate 1. A view of GBM-2 variety in the farmers' field

any other sources then later purchased seeds in Seed Unit and cultivated this variety to larger extent in their fields. Suitability of this variety for mechanical harvesting may be the major reason for more spread of this variety in 2016-17. Further the area under this variety in 2017-18 was less due to lower yield of GBM-2 variety in farmers field as compared to other varieties such as JG-11. The poor seed quality, poor processing quality and requirement of one protective irrigation to get higher yield were the major reason for non-spread of this variety. Among all taluks, Sindhanur had the highest area under this variety, which may be due to availability of irrigation facility from canals of Tungabhadra dam for paddy and in the residual moisture they have cultivated GBM-2 in *rabi* season. In addition Sindhanur taluk is known for mechanized farming and cultivated GBM-2 due to its suitability for mechanical harvesting.

The spread of this variety other than Raichur and Kalaburagi districts of NEK region (Table 4.3) was also seen in other parts of NEK region *viz.,* Yadgir, Koppal, Bidar and Ballari distrcits from 2014-15 to 2017-18. It was evident from the table that the lowest area was observed (21 acres) in the year of release of this variety. Further, area as well as per cent to total bengalgram area was decreased in 2016-17 and then it was increased in 2017-18 to lesser extent. The reasons for less spread of this variety were obvious as mentioned in the previous section.

Table 4.4 presents spread of GBM-2 variety in other parts of Karnataka State and India. In 2014-15 this variety was spread to Gadag and Belagavi districts of Karnataka, Kolhapur district of Maharashtra and Kurnool district of Andra Pradesh. The area (16.acres) under this variety was least in 2014-15 as compared to other years. This might be due to fact that less aware of this variety among farmers in other parts of Karnataka and across India as spread of any technology requires one or two years to cross the border of its origin. Further, the area under this variety as well as percent to total area was increased in 2015-16 as was observed in the origin districts. The reason for highest area (464.5 acres) under this variety in 2015-16 might be awareness created in farmers about this variety and suitability of this variety for mechanical harvesting as labour cost for harvesting is more in bengalgram. Scarcity of labour is major problem faced by the framers and harvesting operation of bengalgram requires more women labour. The area under this variety has been decreased in subsequent years as compared to 2015-16. The same reasons viz., lower yield, poor processing quality and requirement of at least one protective irrigation may be attributed to this phenomenon. It was evident from the above findings that the hypothesis was made in the beginning of research *i.e* bengalgram technologies developed by UASR was wide spread.is disproved.

The data pertaining to the overall adoption level of the bengalgram technologies was given in Table 4.5. The highest percentage (41.66%) of bengalgram growers had medium level of adoption of various recommended practices while, 32.50 per cent of respondents had low level of adoption. However, 25.83 per cent of bengalgram growers had high level of adoption. This might be due to the fact that most of the medium adopters were found in middle age group and had formal education up to above college level. They also had good extension contact and meet extension agencies weekly, fort nightly and monthly. This made them to adopt recommended technologies of bengalgram to greater extent. Similar results were quoted separately in their studies of Dwivedi *et al*.(2011), Saritha and Pushpa (2012), Beena *et al.* (2014), Umrathiya *et al*.(2015), Choudhary *et al*. (2017) and Singh *et al.* (2017). They reported in their studies that the majority of farmers who adopted different crop technologies were found in medium adopter category.

It was evident from the Table 4.6 that cent percent of adoption of technologies were found in case of sowing time and nipping by all adopter categories. The results were in line with study of Chatterjee *et al* (2003) and Singh *et al* (2017). They reported in their studies that majority of bengalgram growers and blackgram growers have completely adopted the practices *viz.*, time of sowing. It was also evident from the studies of Dwivedi *et al* (2011), Islam *et a*l (2013) and Dhayal and Mehta (2015) the majority of farmers who adopted recommended practices were found to be more w.r.t time of sowing. Most of the farmers in all adopter categories have adopted JG-11 variety. This was due to the fact that JG-11 variety gives relatively higher yield as compared to Annigeri-1 and GBM-2 varieties and this variety fetches higher price in the market. The per cent of adoption of GBM-2 variety by the high adopter category was more as compared to low and medium adopters. This might be due to the fact that the higher adopters were more innovative, optimistic and ready to take risk in the farming. So they have adopted this new variety with a curiosity of obtaining higher yield.

Low adopters adopted Annigeri-1 variety to a greater extent. This was because of most of the farmers in low adopter category belonged to old age group. They were not ready to accept any changes in society and they were last adopters of any new technologies. They were bound to customs and traditions.

With respect to production technologies, none of the low adopters were adopted seed treatment practice. The extent of adoption of seed treatment was less in case of both medium and high adopters. Similar results quoted by Dwivedi *et al*. (2011) and Maraddi *et al*. (2014). They reported in their studies that majority of farmers were not adopted seed treatment due to lack of knowledge. The highest per cent of adoption was found in intercultivation and seed rate in all adopter categories. These results are in conformity with findings of Patel *et al*.(2016) who reported that 96.22 per cent and 85.55 per cent mean score was recorded for tillage and inter cultivation and ranked first and second, respectively in adoption of groundnut production technologies in Banaskantha district in North Gujarat

With respect to protection technologies, least percent of adoption of disease management and pest management was found in low and medium adopters when compared to high adopters. These results got support from studies conducted by Dwivedi *et al*. (2011) and Maraddi *et al*. (2014). It was reported by Dwivedi *et al*. (2011) that plant protection measures were not adopted by majority of the farmers due to lack of knowledge, high cost involved in purchasing agro-chemicals, use of sprayers in standing long duration crop for control of pod fly and pod borer. It was quoted by Maraddi *et al*. (2014) that lesser percentage of respondents noticing in full adopter category in disease management (2.50%). High adopters were adopted pest and disease management to greater extent as they were economically sound as compared to low and medium adopters as the insecticides recommend are costly. They also have good knowledge about seed treatment with trichoderma compared to low and medium adopters.

The method of Principal component analysis (PCA) was used to estimate Composite Index (CI) for individual farmer. Farmers were grouped according to composite index ranging from 0.01 to 0.60, 0.61 to 0.80 and above 0.81 as low, medium and high technology adoption groups. In the total 120 sample farmers, 37 farmers were categorized as low adopters, 49 cultivators categorized in medium technology adoption group and 34 farmers were grouped in high technology adoption group. These results were contradictory to results of Datarkar *et al*. (2015). who used PCA to estimate CI. Most of the sample farmers were found in low adopter category as compared to medium and high adopter category.

5.2 Distribution of sample farmers according to their socio-economic characteristics

The results presented in Table 4.8 indicated that majority of the sample farmers in all adopter categories were found in middle age group. But the highest percentage of middle age group was found in high adopter category and low adopters had old age group to greater extent. Similar results were quoted by Thoke and Gunjal (2010), Dayal and Mehta (2015), Singha *et al.* (2016) and Thinde *et al.(*2017). They reported in their studies that majority of the farmers who adopted different crop technologies were found in middle age group.

With respect to education, most of the low adopters were illiterate. These results gain supported from Siddayya *et al.* (2016) and Thinde *et al.(*2017). It was reported by Siddayya *et al.* (2016) in their study that less percentage of illiterates (30%) were found in adopters of improved technologies of pigeon pea as compared to non-adopters (50%). It was also observed from the study of Thinde *et al.(*2017**)** that most of the farmers who adopted improved production technologies of wheat were literate (89.99%). Low adopters had maximum education up to high school level. Medium and high adopters had education up to pre university and above college level. Less number of medium and high adopters were illiterate. The highest per cent of medium adopters were found in primary level of education. The highest percentage of high adopters was found in high school level of education. This made the medium and high adopters to adopt technologies in bengalgram to a greater extent.

Majority of farm families of all type of adopters were in nuclear type. However, the more percentage of joint families were observed in high adopter category. The results are in conformity with results of Raghav and Sen (2014). They reported in their study that higher percentage of families of sample farmers were nuclear ones (58%) and lesser percentage (42%) of sample famers were living in joint family system and majority of marginal and small farmers follow nuclear family system, whereas the majority of semi-medium, medium and large farmers still live in a joint family system

The overall operational size of land holding was found to be more in high adopters followed by medium and low adopter category. This was due to the fact that larger the size of land holding better the economic position and risk bearing ability to venture into new things. Land holding and adoption of technologies are positively correlated. Since the operational land holding was observed to be more in high adopter category, the sample farmers in high adopter category were found under the category of medium and large farmers. These results are in conformity with Singha *et al.* (2016), who reported in their study that majority of adopters (43.07%) of improved practices of crop and livestock were big farmers with operational land holding size of above 3 hectares.

More number of working family labour was found in high adopter category followed by medium and low adopter category. This might be due to higher number of joint families were noticed in high adopter category followed by medium adopter category and more number of males were noticed in both categories. This eventually contributed more number of working family labours in both categories.

With respect to farming experience, most of medium (46%) and high adopters (54.84%) were possessed medium level of farming experience (between 18 years to 24 years) and the highest percentage of low adopters (53.84%) were possessed high level of farming experience (24 years). These results were contradictory to results of Maraddi *et al.* (2014). They reported in their study that half of respondents (49.17%) possessed low experience followed by medium experience (31.67%) and high experience (19.17%) category.

With respect to extension contact, most of low adopters (29) were not having contact with extension agencies followed by medium (24) and high adopter category (9). More number of medium and high adopters visit extension agencies weekly, fort nightly and monthly as compared to low adopters. This made them to adopt technologies of bengalgram to greater extent as compared to low adopters.

5.3 Input use pattern in bengalgram cultivation

The findings of the study indicated that seeds quantity used by the low adopters growing GBM-2 and JG-11 was more when compared to medium and high adopters.

Whereas, the quantity of seeds used by high adopters who cultivated Annigeri-1 variety was more compared to other adopters. The quantity of seeds used by all the category of adopters was more than recommended dose. This was due to misconception among adopters of all categories that more plant population per acre more would be the yield per unit of area.

Among all adopter categories under each variety the quantity of usage of FYM was lower than recommended dose. However, the quantity of use of FYM was more in case of high adopters as compared to low and medium adopters. This may due to non-availability of FYM in the study area. Due to more livestock possession by the high adopters and they used FYM to greater extent compared to medium and low adopters.

All adopter categories under each variety used more quantity of chemical fertilizers than recommended usage. While, low adopters under each variety used excess quantity of chemical fertilizers than recommended dose when compared to medium and high adopters. This was mainly due to lack of awareness about recommended dose of fertilizers usage among low adopters compared to medium and high adopters. Further, there was misconception among all adopter categories that increased application of fertilizers would lead to higher yield.

Results indicated that none of low adopters under each variety followed seed treatment practice with trichoderma. This was due to lack of awareness about importance of seed treatment and also use of trichoderma for seed treatment as most of low adopters were illiterates. High adopters under JG-11 and Annigeri-1 varieties were used more quantity of trichoderma per kilogram of seeds when compared to medium adopters. Whereas, medium adopters under GBM-2 variety used more quantity of trichoderma per kilogram of seeds as compared to high adopters. This was due to lack of awareness of recommended usage of trichoderma among medium and high adopters.

With respect to PPCs, the quantity of usage of all type of PPCs such as Chloranthriniliprole, Propenophos, Flubendiamide, Emamectinbenzoate and Corbendenzim was more than recommended dose by all adopter categories. But high adopters used more quantity of PPCs under each variety compared to medium and low adopters. This was due to fact that the PPCs recommended by UASR for bengalgram cultivation are very costly as they are more effective as compare to normal pesticides. The cost incurred on PPCs can be borned by high adopters due to better economic condition.

More number of man days were used by high adopters under each variety was more compared to other adopters. This was due to higher requirement of women labour to carry out weeding and harvesting and more number of man days for application of manures, cleaning and bagging operations compared to medium and low adopters.

The quantity of bullock labour and machine labour used by high adopters under each variety was found to be more compared to other adopters. This was on land preparation four to five times before sowing and also most of high adopters carried out intercultivation twice when compared to medium and low adopters.

5.4 Operation-wise labour use pattern in bengalgram cultivation

It was evident from results (Table 4.14, 4.15 and 4.16) that among all operations, women labour usage was higher in all the categories of adopters for all varieties. In case of GBM-2 variety, no human labour were used for harvesting and threshing operations respectively as it has erect branches and suitable for mechanical harvesting. In case of JG-11 and Annigeri-1 varieties number of man days as well as hours of machine labour required to carry out threshing operation was found to be higher in high adopters as compared to medium and low adopters. This was due to direct relationship between labour requirement for threshing and yield levels. On an average, per hectare ₹ 2728 additional cost was incurred for harvesting and threshing operations in JG-11 variety and ₹ 2575 for Annigeri-1 which could be saved by cultivating GBM-2 variety (Labour cost for harvesting =₹ 2500/ha). More man days were used for application of PPCs in case of low adopters followed by medium and high adopter categories in all varieties. This was mainly due to fact that low adopters had used less effective chemicals to control pest and diseases and excess quantity of chemical fertilizers than recommended dose which has resulted in high incidence of pest and diseases. Hence, they used to spray the chemicals one or two times more than medium adopters and two or three times more than high adopters. The cultivation of bengalgram under *rainfed* situation in respective study area and hence, chemical fertilizers was applied at the time of sowing as a basal application and no top dressing was done. Almost all adopter farmers used seed cum fertilizer drill (bullock or tractor drawn) to carry out both sowing and application of fertilizers together. It was also found that more hours of machine labour and more pair days of bullock labour were required by high adopters to carry out land preparation and intercultivation in all the varieties. This was due to intensive operations carried out by high adopters as intercultivation was done twice when compared to medium and low adopters and they also carried out preparatory tillage four to five times before sowing. The number of bullock labour used by low adopters for land preparation was found to be higher as most of the low adopters not used machine labour to carry out land preparation when compared to medium and high adopters.

5.5 Cost and returns among adopters of improved technologies of bengalgram cultivation

It was evident from the previous discussion that among all adopter categories, cost incurred towards human, bullock and machine labour was found to be the highest in high adopters in all the varieties than medium and low adopters. Among all operations, weeding and harvesting operations required more labour by all adopter categories in case of Annigeri-1 and JG-11. Where labour cost on weeding operation was more in GBM-2 variety by all adopter categories. On an average ₹ 2728 additional cost per hectare was incurred for harvesting and threshing operations in JG-11 variety and ₹ 2575 in Annigeri-1 could be saved by cultivating GBM-2 variety (Labour cost for harvesting =₹ 2500/ha) by all adopter categories. The labour cost towards land preparation and intercultivation was found to be higher in high adopters.

The per hectare cost of cultivation of all the varieties varied with level of adoption. Of the total cost of cultivation, labour cost accounted for major share in all varieties among all adopter categories. However, among varieties, it was the highest in JG-11 and Annigeri-1 varieties as labour cost incurred towards weeding and harvesting by all adopter categories was found to be high for these varieties. The cost on seeds and fertilizer per hectare was accounted major share in material cost by all adopter categories and in all varieties. There was not much variation in cost incurred on seed in GBM-2 and JG-11 varieties. But cost incurred towards purchase of seeds in Annigeri-1 variety was 60 per cent lesser than JG-11 variety and 73.77 per cent lesser than GBM-2 variety. Among all adopters, low adopters incurred more cost towards purchase of chemical fertilizers in all the varieties. This was due to lack of awareness about recommended dose of fertilizers among them. Whereas, cost incurred on PPCs by high adopters was found to be higher compared to other adopters. This was due to higher use of recommended PPCs and at the same time PPCs are highly effective. Though, the costs incurred towards purchase of those chemicals higher, high adopters are affordable to purchase costlier PPCs due to their high economic status. Among all varieties, the total variable cost was found be higher under JG-11 variety (₹36901.46/ha) which was higher by 8.38 per cent than GBM-2 variety and 5.90 per cent than Annigeri-1 variety. This was due to more labour cost towards harvesting in JG-11 variety than GBM-2 variety. Though there was not much variation in labour cost for harvesting in JG-11 variety and Annigeri-1 varieties, the cost towards purchase of seeds in JG-11 was found to be higher than Annigeri-1.Hence, Variable cost was found to be higher in JG-11 variety than Annigeri-1 variety. The depreciation cost formed major component in total fixed cost. It was found to be higher in high adopters for all varieties when compared to medium and high adopters. This was mainly due to owning of more equipments and machineries by high adopters their other counterparts. This was further substantiated by the fact that higher proportion of large farmers was observed in high adopters. Hence, higher fixed cost has been incurred by high adopters due to owning of more equipments and machineries.

The profitability of each varieties of bengalgram for all adopter categories has been examined by computing per hectare cost of cultivation and gross returns realized. It was observed that both yield and net returns were found to be higher in high adopters in all varieties than medium and low adopters. This was mainly because,high adopters followed recommended bengalgram technologies in all varieties to a greater extent than medium and low adopters. These results got supported by results of Ramakrishna *et al.* (2005) who reported that the improved production technology gave 53 per cent higher yields than that obtained with farmers' practice yields of 1.37 t ha-1. The additional cost of US$56 ha-1 incurred in the improved technology as compared to farmers practice was mainly due to balanced fertilization (micro-nutrients and additional N and P), additional seed cost, seed treatment, IPM and one additional inter-cultivation. It was also observed the average yield and net returns found to be higher in JG-11 variety which was higher by 20.36 per cent and

68.40 per cent respectively than GBM-2. The yield and net returns in JG-11 were higher by 28.89 than Annigeri-1 variety. There was net loss of about ₹ 134.31 per hectare was observed in Annigeri-1 variety compared to other two varieties. This indicated that the yield and returns were observed in Annigeri-1 was found to be less than GBM-2 and JG- 11varieties. Low adopters of Annigeri-1 variety were incurred loss as their cost overweighs returns. This is mainly due to low performance of Annigeri-1 variety in recent years. Annigeri-1 variety has become less resistant to pest and diseases due to continuous cultivation of this variety year after year. Though GBM-2 variety is suitable for mechanical harvesting this variety was not cultivated by most of the farmers due to relatively low market price and lower yield compared to other two varieties.

The return per rupee spent was found to be higher in high adopters of respective varieties than medium and low adopters. These results are in conformity with results of Ramakrishna *et al.* (2005) who reported that the improved technology resulted in increased mean income of US$190 with a high benefit- cost ratio of 2.9. The returns rupee spent was the highest in JG-11 variety (1.42) as compared to Annigeri-1(1.00) and GBM-2 variety (1.14). This indicated that by spending one rupee, 1.45 rupees of returns can be generated by adopting JG-11 variety, 1.00 rupees by cultivating Annigeri-1 and 1.14 rupees by cultivating GBM-2 variety.

5.6 Economic impact of bengalgram technologies

The findings of partial budgeting technique on assessment of net gain or loss in adoption of JG-11 variety over GBM-2 is presented in Table 4.20 which clearly indicated that there was net gain of ₹ 8071.03 per hectare in adoption of JG-11 variety over GBM-2 variety. Inputs have contributed to both increase as well as decrease in cost. But more debit was observed due to inputs such as FYM, fertilizers, human labour and bullock labour. Increase in returns was found to be ₹ 11,395.55 per hectare by adopting this variety over GBM-2. This was mainly due to higher yield (3.2 q/ha) and high market price for JG-11 than GBM-2 variety.

It was observed from findings of partial budgeting technique on assessment of net gain or loss in adoption of GBM-2 variety over Annigeri-1 (Table 4.21). There was net gain of ₹ 6120.15 per hectare in adoption of GBM-2 variety over Annigeri-1 variety. Majority of inputs were contributed to both increase as well as decrease in cost. But more credit was observed due to inputs such as FYM, fertilizers, human labour, bullock labour and PPCs. Increase in returns was found to be ₹ 5270.42 per hectare by adopting this variety over Annigeri-1. This was mainly due to increase in yield (1.48 q/ha) in GBM-2 than Annigeri-1 variety.

The finding of partial budgeting technique on assessment of net gain or loss of medium adopters of recommended technologies over low adopters was presented in Table 4.22 which clearly indicated that there was net gain by medium adopters over low adopters. Majority of inputs contributed to increase in cost and more dedit was observed due to inputs such as FYM, fertilizers, human labour, bullock labour, protective irrigation, PPCs and bio-pesticide and machine labour. Increase in returns was found to the extent of ₹ 7654.58 per hectare leading to net gain of ₹ 4838.27 per hectare to medium adopters compared to low adopters.

The findings of partial budgeting technique on assessment of net gain or loss of high adopters of recommended technologies over low adopters (Table 4.23) indicated that there was net gain by high adopters over low adopters. Majority of inputs contributed to increase in cost and more debit was observed due to inputs such as FYM, fertilizers, human labour, bullock labour, protective irrigation, PPCs and bio-pesticide and machine labour. Increase in returns was found to be ₹ 14032.18 per hectare. Hence, there was net gain of ₹ 10504.09 per hectare incurred by high adopters over low adopters.

The finding of partial budgeting technique on assessment of net gain or loss of high adopters of recommended technologies over medium adopters is presented in Table 4.24 which clearly indicated that there was net gain by high adopters over medium adopters. Majority of inputs contributed to increase in cost and more debit was observed due to inputs such as FYM, fertilizers, human labour, bullock labour, protective irrigation, PPCs and machine labour. Increase in returns was found to be ₹ 14032.18 per hectare with net gain of ₹ 5239.82 per hectare incurred by high adopters over medium adopters.

Overall, the partial budgeting approach revealed that positive economic impact of recommended technologies on the level of adoption which was true with all the varieties. Further, among the varieties the cultivation of JG-11 variety was found to be more profitable than GBM-2 and Annigeri-1 varieties.

5.7 Factors influencing adoption of bengalgram technologies

The covaribles significantly associated with the adoption of bengalgram technologies were age, education, landholding, and extension contact. Farming experience is not related to adoption of bengalgram technologies**.** It can be evident from the table 4.26 that the farmers who belonged to <35 years and 35-55 years were more likely to adopt bengalgram technologies than farmers belonged to age group of above 55 years. Because the majority of the farmers belonged to young and middle age group and due to better receptivity adopted technologies to higher extent. These results are in contradictory with Nkonya *et al*. (1997) who reported that the age is not the significant factor influencing the adoption of maize technologies. The education of sample farmers significantly influence on adoption of bengalgram technologies. These results were in line with the results of Nkonya *et al.* (1997), Simtowe *et al. (*2010) and Hagos and Zemedu (2015).Who reported that education is significantly influence on adoption of crop technologies. The sample farmers who were illiterate less likely to adopt technologies. Adoption of technologies was the highest in sample farmers who completed primary and high school levels of education when compared to above college level. This was due to carrying of other than farming activities like jobs or business as their level of education increases. Farming experience was not significantly influenced on adoption of technologies. These results were in line with the study of Singh (2011) who reported that farming experience is not significantly influencing adoption of technologies. Land holding had significant influence on adoption of bengalgram technologies. These results were in line with results of Nkonya *et al. (*1997), Singh (2011), Simtowe *et al*. (2011) and Egge *et al*. (2012). It was also observed that marginal farmers, small farmers, medium farmers were less likely to adopt technologies as compared to large farmers. Larger the size of land holding and higher the risk bearing ability and higher probability of adoption of new technologies. Extension contact was significantly influencing adoption of technologies. Similar results were quoted by Nkonya *et al.* (1997), Egge *et al*.

(2012) and Kassa *et al.* *(*2014). Farmers who met extension agencies fortnightly, monthly were less likely to adopt technologies when compared to farmers who met extension agencies on weekly basis.

5.7 Constraints faced in adoption of bengalgram technologies developed by UASR

Details on constraints in adoption of bengalgram technologies at farm level are presented in Table 4.28. Among production constraints, non-availability of labour was stated as important constraint by sample farmers followed by lack of knowledge about bio fertilizers and bio-pesticides. In addition, sample farmers were also faced constraints such as high cost of pesticides, resistance of pod borer against insecticides, high harvesting cost and non-availability of FYM. Which were ranked as III, IV, V and VI respectively.

Less remunerative price for the produce and high price fluctuation were the top most marketing constraints faced by the sample farmers. The other marketing constraints faced by the sample farmers were lack of processing facility, lack of marketing information and lack of co-operative marketing organization etc.

With respect to management constraints, sample farmers stated first constraint as lack of knowledge regarding improved agrochemical practices of bengalgram followed by lack of knowledge about seed treatment and inability to attend demonstrations and training programmers.

SUMMARY AND POLICY IMPLICATIONS

VI. SUMMARY AND POLICY IMPLICATIONS

Agriculture is often characterized by low use of modern technology and low productivity. Improving the productivity, profitability and sustainability of small holder farming is main pathway to reduce poverty. Achieving agriculture productivity growth will not be possible without developing and disseminating cost effective yield increasing technologies because it is no longer possible to meet the needs of growing population by expanding area under cultivation. Agricultural research and technological improvements are therefore crucial to increase agricultural productivity and thereby reducing poverty and meeting demands for food without irreversible degradation of natural resource base.

Major objectives of breeding and releasing high yielding varieties are to reduce hunger, malnutrition, poverty and increase the income of poor people living in marginal areas. Major benefits from improved agricultural technologies are to reduce poverty directly by raising income of farm households, indirectly by raising employment, wage rates of functionally landless labourers and by lowering the price of food staples (Afsaw *et al.* 2012).

New agricultural technologies and improved practices play a key role in increasing agriculture production and hence improving national food security in developing countries. Where, successful adoption of improved technologies could stimulate overall economic growth through inter sector linkages while conserving natural resources. However, several research findings have pointed the fact that the use of new agricultural technology such as high yielding varieties that kick-started the Green Revolution in Asia, could lead to significant increase in agricultural productivity in Africa and stimulate the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy (Awotide *et al.* 2012).

Bengalgram (*cicer ariatinum* L.), is an important legume in India belonged to family fabaceae. It is also known as gram, bengalgram, and *chana* and commonly called as *daals.* It is originated from Western Asia (Turkey). In India, major types of bengalgram cultivated are viz., *desi* and *kabuli* in the ratio of 3:1. It is rich source of protein. The seed contains 21.10 per cent protein, 61.50 per cent carbohydrates and 4.5 per cent fats. Besides, it contains iron, calcium and niacin in sufficient quantity. It is the third most important pulse crop after dry bean and peas, produced in the world. It accounts for 20 per cent of the world pulses production and its global importance has increased considerably during the past three decades.

With this above background, the technologies in agriculture play a significant role in increasing agricultural production, improving the profitability of farmers by reducing poverty, hunger, malnutrition. Hence, technologies ultimately help to achieve food security and nutritional security directly and indirectly by generating employment and increasing wage rates of agricultural labourers. Keeping these aspects in the mind the present study was undertaken in order to assess how far the technologies developed by UASR in bengalgram have been reaching the farmers and also to know to what extent those technologies brought changes in increasing their productivity of bengalgram crop and improving profitability by reducing poverty, increasing their consumption expenditure and improving in their standard of living. The following objectives were designed to assess above issues and suggest suitable policy measures inorder to increase extent of adoption of technologies by the farmers.

Objectives

1. To estimate the spread of bengalgram technologies developed by UASR
2. To study the socio-economic features of bengalgram growers in the study area
3. To study the economic impact of bengalgram technologies developed by UASR
4. To determine the factors influencing the adoption of bengalgram technologies developed by UASR
5. To assess the constraints faced by the farmers in adoption of bengalgram technologies developed by UASR

Keeping in view above objectives, the present study was undertaken in Kalaburagi and Raichur districts of North Eastern Karnataka region (NEK). The Multistage sampling technique was employed for the selection of the district, taluks, villlages and sample farmers based on bengalgram production potential and the technology interventions. Among selected districts, two taluks from each district were selected. Again among selected taluks, three villages from each taluks were selected using same criterion. Accordingly, four taluks, 12 villages and 10 sample farmers from each village were selected. In all 120 sample farmers were selected from two districts of NEK region.

To evaluate the objectives of the study, primary data using pre-tested schedule was collected from the sample respondents with respect to cropping pattern, landholdings, asset position, family size and educational level. Detail regarding input use, output obtained, quantity of produce sold, the price of inputs and output were also obtained from the sample farmers in order to assess economic impact of bengalgram technologies on the farmers income and also to know constraints faced by the farmers during adoption of bengalgram technologies.

Relevant analytical tools like Composite Index, Partial budgeting, Multi ordinal logistic regression analysis, Garett ranking were employed to analyse the collected data from sample farmers.

MAJOR FINDINGS OF THE STUDY

1. The area under GBM-2 bengalgram variety has been decreased from 2014-15 to 2016-17 and was increased in 2017-18 to same extent in Kalaburagi district. Chittapur taluk was the leading taluk in cultivating this variety among different taluks.

2. There was an increasing trend in area under GBM-2 variety both in obsolute and percent to total bengalgram area from 2014-15 to 2017-18 in Raichur district. Sindhanur taluk was the leading taluk in cultivating this variety.

3. There was an increase in area under GBM-2 variety from 2014-15 to 2015-16 in other than study districts of NEK region but declined during succeeding years.

4. The GBM-2 variety was mainly spread to Belagavi, Gadag, Vijayapura, Dharwad, Haveri, Bagalkot and Chitradurga distrcts of Karnataka state, Ananthpur and Kurnool districts of Andrapradesh and Ahmednagar and Kolhapur districts of Maharashtra

state during 2014-15 to 2017-18. The area under GBM-2 variety has been increased during 2014-15 to 2015-16.

5. Maximum number of bengalgram growers (41.66 %) had medium level of adoption while, 32.50 per cent of them had low level of adoption and 25.83 per cent of them had high level of adoption.

6. The practice of nipping and sowing time were adopted by all adopter categories of sample farmers. Extent of adoption of recommended practices as a package was found to be higher in case of high adopters followed by medium adopters and low adopters.

7. None of the farmers in low adopter category were practiced seed treatement. Lesser proportion of farmers in medium adopter category were practiced seed treatement as compared to high adopters. So also the case with disease management and insect pest management.

8. Most of the sample farmers under all adopter categories were belonged to middle age. But the highest percentage of farmers under high adopter category were found in middle age group.

9. Majority of sample farmers in low adopter category were illiterates. Medium and high adopters studied up to college and above college level. Most of the high adopters were completed high school education while most of the medium adopters were completed primary level of education.

10. The operational land holding was found to be higher in high adopters categories followed by medium and low adopters.

11. High adopters and medium adopters category farmers had good extension contact and met extension agencies on weekly, fort-nightly and monthly. Most of the low adopters (74.36%) had no contact with extension agencies as compared to medium (48%) and high adopters (29.03%) categories.

12. The inputs use was found to be higher than the recommended dose in all adopters categories except FYM. The sample farmers in low adopter category used excess quantity of chemical fertilizers than recommended dose as compared to medium and high adopter categories.

13. Application of PPCs was found to be higher in high adopters.

14. Among all operations, weeding was found to be more labour intensive in cultivation of GBM-2 variety. Whereas, harvesting and weeding operations were found to be more labour intensive in cultivation of JG-11 and Annigeri-1 varieties.

15. On an average, per hectare amount of ` 2650 on harvesting and threshing operations could be saved by cultivating GBM-2 variety as this variety is suitable for mechanical harvesting. Though sizeable amount of cost in harvesting and threshing could be saved by cultivating GBM-2 variety, still it is not popular variety among farming community.

16. High adopters used more number of man days, bullock pair days and machine labour hours as compared to medium and low adopters in all varieties of bengalgram cultivation.

17. Among all adopter categories, high adopters incurred more cost and also earned high net returns in cultivation of all varieties of bengalgram.

18. JG-11 variety of bengalgram is most profitable enterprise compared to GBM-2 and Annigeri-1 due to higher yield. It is also fetching higher price compared to other two varieties selected for the study..

19. Farmers had got net gain of about ` 8071 per hectare in cultivation of JG-11 variety compared GBM-2 variety. Whereas, per hectare net gain of about ` 5556.46 was found by cultivating GBM-2 over Annigeri-1.

20. The partial budgeting revealed that net gain was more in high adopters compared to medium and low adopters.

21. The age, education, landholding and extension contact were significantly influencing on adoption of bengalgram technologies.

22. The major production constraints faced by the farmers in adoption of bengalgram technologies were non-availability of labour followed by lack of knowledge about bio fertilizers and bio pesticides.

23. Less remunerative price for the produce and high price fluctuation were important marketing constraints faced by the farmers in adoption of bengalgram technologies.

24. Whereas, lack of knowledge regarding improved practices of bengalgram, lack of knowledge about seed treatment and inability to attend demonstrations and training programmes were the major technical constraints faced by the sample farmers.

POLICY IMPLICATIONS

1. The study revealed that there was 41.66 and 25.83 per cent of farmers were categorized as medium and high adopters indicating the less adoption of technologies. Further many of the farmers are not aware of improved agricultural technologies such as seed treatment, integrated disease and pest management and intercropping system. Hence, there is a need for strengthening of seed distribution center and also extension activities through result demonstrations and method demonstrations and field days before releasing any technologies related to crop in order to bring confidence in the farming community.

2. Majority of farmers used PPCs and fertilizers higher than recommended dose. Hence, there is a need to create awareness among farming community about recommended low cost technologies like seed treatment with bio-pesticide, application of bio fertilizers, seed hardening, soil application of trichoderma by the extension agencies which will go a long way in reducing the cost of cultivation as well as in maintaining soil health.

3. There is a need to develop the varieties suitable for mechanization for harvesting operation without compromising in yield and quality as the prevailing GBM-2 variety is suitable for mechanical harvesting but low yielding compared to JG-11.

4. The majority of technologies released by SAU's are adopted by few farmers who are literate, having high resource base and larger size of land holding. In order to reach the technologies to all section of farmers there is a need to form Farmers Producers Organizations for effective transfer of technologies on collective basis.

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