

**Effect of sowing date and varietal selection on the growth and yield of blackgram  
(*Vigna mungo* L.) under rainfed farming in the context of climate change in Sagar  
(Madhya Pradesh)**

**THESIS**

*Submitted in partial fulfillment of the requirements for the award of the*

*Degree of*

**MASTER OF SCIENCE (AGRICULTURE)**

**IN**

**AGRONOMY**

**BY**

**PARMOD KUMAR**



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This is to certify that the study conducted by **Mr. Parmod Kumar, Id. No. 12MSAGRO015**, during **2012-2014** as reported in the present thesis was under my guidance and supervision. The results reported by him are genuine and the candidate himself has written the script of the thesis. His thesis entitled, “**Effect of sowing date and varietal selection on the growth and yield of blackgram (*Vigna mungo* L.) under rainfed farming in the context of climate change in Sagar (Madhya Pradesh)**”, is therefore, being forwarded for the acceptance in partial fulfillment of the requirements for the award of the degree of **Master of Science (Agriculture) in Agronomy**, of the Allahabad School of Agriculture, Faculty of Agriculture, Sam Higginbottom Institute of Agriculture, Technology & Sciences, (Deemed-to-be-University), Allahabad – 211007 (U.P).

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*Allahabad*

*Date:*

*Parmod Kumar*

*Dedicated  
to*



*My  
Beloved  
Parents and All  
Farmers*



## ABSTRACT

The experiment was carried out during *Kharif* season 2013 at Sagar District On Farm Adaptive Research (OFAR), Allahabad (U.P.) to study the “Effect of sowing date and varietal selection on the growth and yield of blackgram (*Vigna mungo* L.) under rainfed farming in the context of climate change in Sagar (Madhya Pradesh)”. The result recorded that the highest plant height (49.81 cm) was recorded in the treatment T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikar 3). Highest number of leaves plant<sup>-1</sup> (52.12), number of branches plant<sup>-1</sup> (6.68), number of nodules plant<sup>-1</sup> (77.56) T<sub>2</sub> (sowing in 3<sup>rd</sup> week of June + *Khajua*). The higher yield and yield attributes recorded in the treatment T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikar 3), viz., number of pods plant<sup>-1</sup> (29.00), number of grains pod<sup>-1</sup> (6.50), test weight (32.85 g), seed yield (680 kg ha<sup>-1</sup>), stover yield (2412.50 kg ha<sup>-1</sup>) and harvest index (22.21). Higher protein content (23.12%) recorded in the treatment T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikar 3).

**Key words:** Blackgram, sowing dates, variety, yield, economics, protein.



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## LIST OF ABBREVIATIONS

₹	:	Rupees
%	:	Percentage
&	:	and
*	:	Replicated twice
/	:	per
@	:	at the rate of
<sup>-1</sup>	:	per
AGDD	:	Accumulated growing degree days
ANOVA	:	Analysis of Variance
APTU	:	Accumulated photo thermal unit
Avg.	:	Average
CD	:	Critical Difference
CGR	:	Crop Growth Rate
cm	:	Centimeter(s)
d.f.	:	Degrees of freedom
DAS	:	Days after sowing
DPO	:	District Project Officer
<i>e.g.</i>	:	For example
EC	:	Electrical Conductivity
ESS	:	Error Sum of Squares
<i>et al.</i>	:	And others
<i>etc</i>	:	Exactara
F (cal.)	:	F calculated
F (tab.)	:	F table
FCLA	:	Farmers' Collective Led Approach
Fig.	:	Figure
FPDCS	:	Food Production, Distribution and Consumptive system
ft.	:	Feet
g	:	gram
GDD	:	Growing degree days



ha	:	Hectare
<i>i.e.</i>	:	That is
ITK	:	Indigenous Technical Knowledge
kg	:	Kilogram
m	:	Meter(s)
m <sup>2</sup>	:	Square meter(s)
max.	:	Maximum
MESS	:	Error Mean Sum of Squares
min.	:	Minimum
mm	:	Millimeter
MSS	:	Mean Sum of Squares
mt	:	Million tonnes
N	:	Normality/nitrogen
N	:	Nitrogen
N, P, K	:	Nitrogen, Phosphorus, Potassium
NEPZ	:	North Eastern Plain Zone
NGO	:	Non Government Organization
No.	:	Number
NS	:	Non-significant
°C	:	Degree Centigrade or Celsius
OFAR	:	On Farm Adaptive Research
OFR	:	On Farm Research
P	:	Phosphorus
pp	:	Pages
PRA	:	Participatory Rural Appraisal
r	:	Number of replications
Res	:	Research
RGR	:	Relative Growth Rate
RH	:	Relative Humidity
RO	:	Research Officer
RSS	:	Replication Sum of Squares
S	:	Significant
S	:	Sulphur

S. Ed.	:	Standard error of deviation
SAF-BIN	:	Strengthening Adaptive Farming in Bangladesh, India and Nepal
Sc.	:	Science
SHIATS	:	Sam Higginbottom Institute of Agriculture, Technology & Sciences
SS	:	Sum of Squares
SV	:	Source of Variation
t ha <sup>-1</sup>	:	Tonnes per hectare
T	:	Treatment
Temp.	:	Temperature
TrSS	:	Treatment sum of squares
TSS	:	Total Sum of Squares
<i>viz.</i>	:	Namely
VRA	:	Village Research Assistant



## *CHAPTER - 1*

# *INTRODUCTION*

## CHAPTER 1

### INTRODUCTION

Blackgram is scientifically known as *Vigna mungo* L. and it is commonly known as urad in India. Blackgram has been distributed mainly in tropical to sub-tropical countries. India is its primary origin and is mainly cultivated in Asian countries including Pakistan, Myanmar and parts of southern Asia. About 70% of world's blackgram production comes from India. India is the largest producer as well as consumer of blackgram. It produces about 1.09 million tonnes of urad annually from about 3.5 million hectares of area, with an average productivity of 500 kg ha<sup>-1</sup>. Blackgram output accounts for about 10% of India's total pulse production (GOI, 2013).

In India, blackgram is very popularly grown in Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Uttar Pradesh and West Bengal, Punjab, Haryana and Karnataka (Singh and Singh, 2011). In Madhya Pradesh, blackgram is grown in an area of 6,40,900 hectares with an annual production of 2,64,800 tonnes and productivity is 413 kg ha<sup>-1</sup> (2012-13). In Sagar district, blackgram is grown in an area of 29,200 hectares with an annual production of 13,300 tonnes and productivity 455 kg ha<sup>-1</sup> (GOMP, 2013).

This crop is grown in the cropping systems as a mixed crop, catch crop, sequential crop besides growing as sole crop under residual moisture conditions after the harvest of other summer crops under semi-irrigated and dryland conditions. Its seeds are highly nutritious with protein (25-26%), carbohydrates (60%), fat (1.5%), minerals, amino acids and vitamins. Seed are used in the preparation of many popular dishes. It is one of the most important components in the preparation of famous south Indian dishes, *e.g.*, dosa, idli, vada *etc.*, besides, it adds about 42 kg nitrogen per hectare in soil. Blackgram is boiled and eaten whole or after splitting into dal. The pods are eaten as vegetables and they are highly nutritious. The hulls or the outer covering of blackgram and straw are used as cattle feed ([www.sikkimagrisnet.org](http://www.sikkimagrisnet.org)).

Dryland agriculture is largely rainfall-dependent, especially in India where the quantity and distribution of summer monsoon rain decides the crop production. Since the food production in India depends largely on the monsoon behaviour, many efforts have been made to understand and predict the monsoon variability. Yet the variability of summer monsoon is still less predictable, except in very recent years when the onset and distribution of summer monsoon rains are measuring up to the numerical predictions. Numerical prediction of climate variability has gained high

importance in recent decades, as the global climate has started showing signs of abnormalities upon accumulated anthropogenic forcings, with impacts on all aspects of life, especially agriculture and allied activities. The results of climate models are therefore studied by agricultural scientists to find out their likely impacts on future production and to suggest adaptation measures to maintain crop production. Agriculture is not only sensitive to climate change but is also one of the major drivers of climate change. Scientific evidence about the seriousness of the climate threat to agriculture is now unambiguous, but the exact magnitude is uncertain because of the complex interactions and feedback processes in the ecosystem and the economy. (Sharma *et al.*, 2006).

According to Karthick and Mani (2013) the climate change is one of the greatest threats to development and will remain so even in the near future. Farmers perception about temperature and precipitation shows that temperature increased considerably whereas the rainfall decreased over the years. The farmers perception of temperature and precipitation was cross-checked with climatic data obtained from meteorological stations, which showed that farmers' perception are in line with short term trends, rather than long-term trends. They opined that one of the major adaptation options of farmers included manipulating the sowing and harvesting date.

Climate change affects agriculture and agriculture also has its adverse impacts on climatic conditions in the long run. Higher temperature, reduced rainfall and increased rainfall variability reduce crop yield and threaten food security in low income and agriculture-based economies. Climate has changed in the past and will continue to change in the future and therefore it underlines the need to understand how farmers' perceive and adapt to climate change. Farmers view about the ongoing changes in climate, its causes and impacts can be entirely different from what science has explained about climate change. Farmers take up coping mechanism according to their perception on climate change. Therefore, it is important to first understand how farmers understand the climate and how climate interacts with their livelihood activities. Unless adaptation policies and related projects address the local perceptions, it cannot be expected that the community will agree and adopt the recommended practices (Karthick and Mani, 2013).

The climatic parameters like rainfall and temperature are the major determinants of pulse productivity besides other factors like quality seed availability and associated biotic stresses (Dubey *et al.*, 2011 and Ali and Gupta, 2012).

There are many constraints responsible for the low yield of urdbean (blackgram). Among those, diseases are considered to be the most important. A total of twenty diseases of urdbean have been

recorded. Of which four and two diseases are major in field and stored condition respectively. Yellow Vein Mosaic Virus Disease, Cercospora leaf spot, Powdery mildew (*Erysiphe polygoni*) and Leaf rot (*Sclerotinia sclerotiorum*) are the four major diseases found in the field. Among the diseases Cercospora leaf spot (*Cercospora cruenta* Sacc.) and the yellow mosaic incited by yellow vein mosaic virus are the most important and damaging diseases of mungbean and urdbean that incurred significant yield reductions every year. The early infected plants showed more severe symptom of yellow mosaic than that of the late infected plants. The incidence and severity of yellow mosaic virus were considered to be directly related with availability and abundance of insect vector and depend upon the time of infection (Rashid *et al.*, 2013). This problem is also relevant in this OFAR (On Farm Adaptive Research) as observed by the participating farmers.

Sowing time, a non-monetary input, is the single most important factor to obtain optimum yield. Hence determination of optimum sowing time for blackgram is inevitable. Optimum time of sowing of blackgram may vary from genotype to genotype. Therefore, there must be a specific sowing period during the relevant season for different genotypes to obtain maximum yield, as opined by Kalra *et al.* (2008) for spring season.

The rate of plant development for any genotype is directly related to temperature, so the length of time between the different stages will vary as the temperature varies, both between and within growing seasons. Changes in seasonal temperature affect the productivity through the changes in phenological development process of the crop. All the crops are vulnerable to different temperature stresses during the crop season and differential response of temperature change to various crops has been noticed under different production environments (Kalra *et al.*, 2008)

High yielding varieties and suitable sowing time may be the important factors for increase the yield (Hussain *et al.*, 2004).

Legumes in a cropping system improves the structure and productivity of soil and increases the plant growth owing to provision of nitrogen and other growth promoting factors (Abraham and Lal, 2003).

Experimental OFR is performed for bio-physical, technical and economic assessment of alternative systems or treatments within the framework of standard experimental designs. Bio-physical assessment aims at determining the system's biological and physical yield and productivity, while economic assessment inquires into the availability of labor, cash and other resources for meeting

the projected needs of the alternative system and looks into the level and dependability of profit (Krah, 1988).

SAF-BIN is an action research programme under the European Union Global programme on Agriculture Research for development (ARD). It is a multi-dimensional research that address the agricultural development challenges of developing and emerging countries. It is an initiative to promote local food and nutritional security through adaptive small scale farming in four rainfed Agro Ecosystem (AES) in South Asia.

During this OFAR (On Farm Adaptive Research) much emphasis on utilization of available local resources, for the promotin of local food and nutritional security has been given. It is an action research under the European Union Global programme on Agriculture Research for Development (ARD). It is a multi-dimensional research that addresses the agricultural development challenges of developing and emerging countries.

In the changing scenario of research, the programme, particularly where greater thrust is essential in the real crisis of farming, adaptive farming, which is what the farming community consciously or unconsciously execute, will flourish better if a platform is provided. Thus in the current experiment ‘On Farm Adaptive Research’ approach has been adhered to, which was conducted under the sponsorship of a project entitled “Building Resilience to climate change through strengthening adaptive small scale farming system in rainfed areas in Bangladesh, India and Nepal”. In the contrast of the traditional ‘hierarchical’ approach, the autonomy and participation of the farming community was given due consideration, which included the integration of traditional practices, technique (ITKs) *etc.* has been included in SAF-BIN programme by Caritas India.

This was done so that the existing constraints would be addressed through a ‘farmers’-scientists-stake-holders’ interaction to deliver a sustainable package for the FPDCS in the context of climate change. In the present experiment PRA tools and other means were widely used to solicit the possible cause and agronomic solution for blackgram under rainfed condition of Sagar district.

As per the farmers of the SHFCs (ITK), spray of neem oil for grain legume like blackgram, protect the crop from attack of whitefly (vector of transmission of YVMV). These are following possible solutions, which may address the afore stated constraints and increase the production of blackgram.

Therefore, keeping the above some of the facts in view, the present investigation entitled, “Effect of sowing date and varietal selection on the growth and yield of blackgram (*Vigna mungo* L.) under

rainfed farming in the context of climate change in Sagar (Madhya Pradesh)”, was carried out as an OFAR (On Farm Adaptive Research), in 10 Villages of Shahgarh *Tehsil* and Block in Sagar (Madhya Pradesh) during the *Kharif* season of 2013 to evaluate the performance of indigenous variety and high yielding variety of blackgram with respect to date of sowing in rainfed farming and climate change condition under the SAF-BIN project of Caritas India with the help of associate partner of SHIATS, Allahabad, with the following objectives.

### **OBJECTIVES**

1. To study the effect of different sowing date on the growth and yield of blackgram.
2. To assess the suitability of blackgram cultivars.
3. To determine economics of different treatment combinations.





*CHAPTER - 2*  
*REVIEW*  
*OF*  
*LITERATURE*

## **CHAPTER 2**

### **REVIEW OF LITERATURE**

This chapter reviews important and relevant research work done by various scientists, concerning “Effect of sowing date and varietal selection on the growth and yield of blackgram (*Vigna mungo* L.) under rainfed farming in the context of climate change in Sagar (Madhya Pradesh)” under the OFAR (On Farm Adaptive Research) in 10 Villages of Shahgarh *Tehsil* and Block in Sagar district of Madhya Pradesh.

The salient features pertaining to the present investigation are presented under the following headings.

- 2.1 OFAR (On Farm Adaptive Research)
- 2.2 Effect of climate on the growth and yield of blackgram
- 2.3 Effect of sowing dates on the growth and yield of blackgram
- 2.4 Blackgram varietal features pertaining to growth and yield

## 2.1 OFAR (On Farm Adaptive Research)

According to Nene (1993) OFAR (On Farm Adaptive Research) must relate to farmers of various strata, *i.e.*, marginal (very small), small, medium, medium-large and large farmers. Besides other, stake-holders like researchers, extension functionary, policy makers, *etc* also play definite role. Asia represents the old world with a very long history of farming. There is practical wisdom accumulated over many centuries, and therefore, it would be unwise to treat farmer as ‘backward’ or ignorant. No one should make the mistake of assuming that the knowledge base of these farmers is limited. It is often said, and rightly so, that seeing is believing. Results of OFAR have to be seen and approved by farmers and their families. The role of women in influencing the decision-making process must not be underestimated.

According to Krah (1988) On-farm Research (OFR) can be defined in its simplest terms as research carried out on farmers’ field and in a farmers’ environment. From this simple definition, one can identify key elements in OFR. These are:

- The farmer.
- The farmers’ land.
- The farmers’ involvement, and
- The farmers’ environment

The research should be carried out on a plot of land belonging to the farmer and within the farm environment of the farmer. Off-station research is, therefore, not synonymous with on-farm research, though all on-farm research is by definition “off-station”. The nature of the farmers’ involvement in any OFR activity is very important as it influences the interpretation of output and results obtained.

### **Joint Researcher/Farmer-managed Trials**

Rocheleau *et al.* (1988) observed that, such trials in which management and operation are the joint responsibility of farmer and researcher, trials need to be made simpler than the researcher-managed trials, since an increased level of farmers’ involvement is required. Simplicity ensures a better understanding of the trial by the farmer in Kenya (Africa).

The farmers’ role may be termed active involvement, as the farmer is directly involved in carrying out some or all of the management operations in the trial.

### **Adaptive Research**

Murithi (2000) reported that, in the early stages of FSA-RET, the involvement of farmers in the development and refinement of technologies had been minimal. In later stages, farmer participatory

research (FPR) started to be emphasized in order to strengthen the involvement of farmers. Farmer participatory research considers farmers as equal partners in problem diagnosis, identification and implementation of interventions, monitoring and evaluation, dissemination, assessing adoption and impact, and providing feedback. Farmers' indigenous technical practices are considered alongside other proposed interventions.

Gryseels *et al.* (1988) observed that, research tended to focus on perceived problems of farmers and was largely commodity and single-discipline oriented. In addition, there was lack of consideration of the factors that influence farmers, decisions such as the environment, economy, culture, beliefs, attitudes, enterprises produced and policies of rural societies.

## **2.2 Effect of climate on the growth and yield of blackgram**

Crop growth and yield depend on its growth characters like leaf area index, dry matter production and partitioning, *etc.* These growth characters are greatly influenced by environment factors (*i.e.*, temperature, photoperiod, *etc.*) (Biswas *et al.*, 2002)

Guriqbal *et al.* (2011) conducted a field experiment in Ludhiana during *Kharif* 2005-2006. Accumulated agro climatic indices, *i.e.*, growing degree days and photo thermal units computed for urdbean genotypes under different dates of planting also indicated that days taken to 50% flowering and physiological maturity, in general decreased as the planting was delayed. The planting date of 5 July recorded 50% flowering at 45 DAS and physiological maturity at 80 DAS, planting date of 5 August recorded 50% flowering at 37 DAS and physiological maturity at 71 DAS.

Siddique *et al.* (1999) and Basu *et al.* (2009) reported that increased in minimum temperature as well as temperature difference had lesser influence on yield reduction of pulses as compared to increased in the maximum temperature. The greater influence of increased temperature on the yield reduction of pulses could be explained on the ground that the critical crop growth stages of pulses like flowering and seed filling stage and pod setting stage are extremely sensitive to temperature rise and thereby consequent yield reduction.

Kalra *et al.* (2008) reported that all the crops are vulnerable to different temperature stresses during the crop season and differential response of temperature change to various crops has been noticed under different production environments.

Phogat *et al.* (1984) reported that the response of a crop to water stress varies with crop species, crop growth stage, soil type, environment and season. Water stress reduces the rate of

photosynthesis and uptake of nutrient in greengram. Water stress also affects crop phenology, leaf area development, flowering, pod setting and finally results in low yield.

Shrivastava and Shrivastava (1995) reported that blackgram is a dominant rainy season pulse crop of the Bundelkhand zone of M.P. and is generally grown on marginal soils without any fertilizer application.

Singh and Gurha (1994) reported that the effect of climate on biology and distribution of vector (*Bemisia tabaci* Genn). It was noticed that the crop infected at early stages suffered more with severe symptoms with almost all the leaves exhibiting yellow mosaic and complete yellowing and puckering. Invariably white flies were found feeding in most of the fields surveyed along with jassids, thrips, pod borers and pulse beetles in some of the fields.

Murugesan and Chelliah (1977) reported that higher temperature prevailing during summer are favorable for whitefly vector (*Bemisia tabaci* Genn.) to develop and multiply.

### **2.3 Effect of sowing dates on the growth and yield of blackgram**

Time of sowing determines time of flowering and it has great influence on dry matter accumulation, seed set and seed yield (Sofield *et al.*, 1977).

Malik *et al.* (2006) reported that sowing dates had significant effect on plant height. Significantly higher plant height (85.51cm) was attained in D<sub>1</sub> (3<sup>rd</sup> week of June sowing) while minimum plant height (64.73 cm) was recorded in D<sub>3</sub> (3<sup>rd</sup> week of July sowing). More plant height in D<sub>1</sub> was attributed to time available for the plants and high rainfall during growing season. Sowing dates also significantly affected the leaf area per plant at flowering. Maximum leaf area (1465.72 cm<sup>2</sup>) was produced by D<sub>1</sub> (3<sup>rd</sup> week of June) against minimum LAI (1141.34 cm<sup>2</sup>) by D<sub>3</sub> (3<sup>rd</sup> week of July). Maximum leaf area in D<sub>1</sub> may be due to long vegetative period and high rainfall which favoured more vegetative growth.

Ramzan *et al.* (1992) reported that plant height was generally reduced in delayed sowing in case of mungbean.

Ahn *et al.* (1989) found that LAI (1465.72 cm<sup>2</sup>) was greater with early sowing as compared to lower LAI (1141.34) under late sowing in soybean. Leaf area was also significantly affected by planting patterns. Leaf area in all planting patterns differed significantly from one another.

Patel *et al.* (1997) reported that the high leaf area index (LAI) persistence and interception of photosynthetically active radiation interception, coinciding with the podding phase, appeared to be primarily responsible for the increased yield in early sowing.

Singh *et al.* (2008 and 2009) reported that the blackgram sown on 5<sup>th</sup> August showed significantly higher plant height, leaf area plant<sup>-1</sup> and pods plant<sup>-1</sup> than other sowing dates. Crop sown on 25<sup>th</sup> August recorded significantly higher grain and haulm yield over crop sown on 5<sup>th</sup> and 15<sup>th</sup> August. Kumar *et al.* (2008) reported that lower plant growth and yield attributes in case of delayed sowing. Days to 50% flowering and heat unit required for 50% flowering were almost similar for 20<sup>th</sup> May to 10<sup>th</sup> June sowing and increased under 20<sup>th</sup> and 30<sup>th</sup> of June sowing. They further, reported that lower value of plant growth and yield attributes occurred under delayed sowing.

Ihsanullah *et al.* (2002) observed that on mungbean maturity is affected by different dates of sowing. In early sown 5<sup>th</sup> July crop, higher agro climatic indices (AGDD and APTU) were required for the crop to attain 50% flowering and maturity. Similarly when planting was delayed later than 5<sup>th</sup> August, comparatively lower agro climatic indices were calculated.

Sharma *et al.* (2000) remarked that wide variability among various lines (cultivars) was observed: some of them were superior to the check(s) for different character(s); They further reported, that days to emergence, days to flowering, days to maturity, yield and yield components were different for various date of sowing. The data regarding days to emergence showed that with delay in sowing emergence enhanced. Maximum days to emergence (8.8) was recorded for 1<sup>st</sup> June, and minimum days to emergence (6.6) for 1<sup>st</sup> August.

Ihsanullah *et al.* (2002) observed that *Vigna mungo* cultivars, when sown delayed after 6<sup>th</sup> the July the seed yield decreased. Various planting dates and varieties significantly influenced the biological yield while their interaction was non-significant. Plots sown on 15<sup>th</sup> June recorded highest biological yield of (6000 kg ha<sup>-1</sup>). As sowing was delayed, biological yield also decreased. The lowest biological yield (1790 kg ha<sup>-1</sup>) was noted in plots sown on 15<sup>th</sup> August. The probable reason for it could be that early-planted crop had sufficient time for its growth and development and *vice-versa*.

Ibrahim (2012) conducted a field trial for two consecutive seasons (2009/10 and 2010/11), at the Gezira Research Station, Central Sudan, to study the effect of sowing date on grain yield and yield components of irrigated soybean. Sowing date had a significant effect on grain yield. The highest grain yield was obtained at mid June sowing date, in both seasons. In the first season, TGx 1905-2E variety achieved a maximum grain yield at mid June sowing date (2335 kg ha<sup>-1</sup>) but declined 12.4% when sowing date was delayed to late June (2022 kg ha<sup>-1</sup>). In the second season, TGx 1905-2E variety achieved a maximum grain yield at mid June sowing date (2209 kg ha<sup>-1</sup>) but declined 19.9% when sowing date was delayed to late June (1812 kg ha<sup>-1</sup>). The result of this study illustrates the

importance of early sowing for maximizing the yield potential of irrigated soybean. The optimum sowing date for irrigated soybean in central Sudan is mid June.

Kasundra *et al.* (1995) reported that maximum number of pods plant<sup>-1</sup> (30.2) was recorded in plots sown on 1<sup>st</sup> July, while minimum number of pods plant<sup>-1</sup> (9.4) for 1<sup>st</sup> August sowing. The result showed that the crop given performed better under early sowing condition.

Mittal (1999) opined that considering both reduced disease incidence and increased yield, the second fortnight of June is may be proposed as the optimum time for sowing blackgram in the region.

Yadahalli and Palled (2004) reported that among the agronomic practices of field crops, sowing at optimum time is an important non-cash input that results in considerable increase in the yield under rainfed conditions. This means favorable soil and climatic conditions are made available for the expression of genetic potential. Blackgram sown early on 16<sup>th</sup> June recorded maximum seed yield (1068.87 kg ha<sup>-1</sup>) when compared to crop sown on 1<sup>st</sup> July and 16<sup>th</sup> July. The crop sown on 16<sup>th</sup> June registered 117.59 and 44.03% higher yield over crop sown on 16<sup>th</sup> July and 1<sup>st</sup> July respectively. Blackgram sown on 16<sup>th</sup> June recorded significantly higher haulm yield (1814.38 kg ha<sup>-1</sup>) over 1<sup>st</sup> July (1555.59 kg ha<sup>-1</sup>) and 16<sup>th</sup> July (1243.42 kg ha<sup>-1</sup>). The highest harvest index (38.05%) was also noticed in early sown crop over other dates of sowing, which was mainly due to higher seed yield kg ha<sup>-1</sup>.

Kumar *et al.* (2009) observed that sowing of summer mungbean on 25<sup>th</sup> march recorded significantly higher grain yield (1346 kg ha<sup>-1</sup>) with 14% increase over late sowing on 10<sup>th</sup> April. This was mainly because of the fact that almost all the yield-attributing characters were favorably influenced due to early sowing and therefore yield increased.

Singh *et al.* (2010) recorded that there was decline in grain yield with delayed sowing of *Kharif* mungbean from 5<sup>th</sup> July to 5<sup>th</sup> August.

Adjei and Splittstoesser (1994) reported that seed yield, seed size and protein content decreased by delaying sowing.

Biswas *et al.* (2002) conducted an experiment to determine optimum sowing time for blackgram in Jmalpur region (AEZ-9) in Bangladesh. Sowing dates exerted significant effect on seed yield. Earliar sowing 31<sup>st</sup> August produced significant and highest seed yield (1168 kg ha<sup>-1</sup>), while the lowest seed yield (541 kg ha<sup>-1</sup>) was obtained in the latest 28<sup>th</sup> September sowing.

Reddy *et al.* (2001) reported that early sowing resulted in lower incidence of lepidopteran pod borers, viz., *Maruca testulalis*, *Exelastis atomosa* and *Helicoverpa armigera* and highest grain yield was recorded in early sowing of indeterminate varieties in blackgram.

Dubey and Singh (2006) reported that sowing dates may influence the grain yield not only by their effect on growth and yield attributes but also on incidence of disease.

## **2.4 Blackgram varietal features pertaining to growth and yield**

Varieties play a vital role in the success of crop production. Yield can be increased to a greater extent provided high yielding varieties are identified and planted at suitable time. High yielding varieties are of primary importance for potential yield (Rehman *et al.*, 2009).

Hari *et al.* (2011) reported that the plant height was significantly influenced by the genotypes in 2008. The highest plant height was recorded in variety 'SL 525' which was statistically on par with variety 'SL 744', but significantly higher than variety 'SL 790'. Although the results were non-significant during 2009, the variety 'SL 790' recorded lower plant height as compared to 'SL 525' and 'SL 744'. It might however be due the varietal character. The pod per plant is the major yield contributing character which may reflect the performance of the variety. The variety 'SL 744' recorded highest pods, which was statistically at par with 'SL 790' but significantly higher than. The variety 'SL 525' in both the years of study.

Patel and Munda (2001) evaluated the growth pattern and yield potential of five cultivars (T-9, PU-19, PDU-1, PDU-88-1 and DPU-88-31) of blackgram. The number of pods plant<sup>-1</sup> was highest with T-9 (47.6) and lowest in PU-19 (33.3). They also reported from another trial that among the varieties maximum number of seeds pod<sup>-1</sup> (4.94) was recorded for NARC Mash-3 while minimum number of seeds pod<sup>-1</sup> (4.3) for NARC Mash-2.

Uddin *et al.* (2009) carried out an experiment in Dhaka, Bangladesh to investigate the interaction effect of variety and fertilizers on the growth and yield of summer mungbean during 2007. Results showed that BARI Mung 6 obtained highest number of nodules plant<sup>-1</sup> and higher dry weight of nodule. It also obtained highest number of pods plant<sup>-1</sup>, seeds pod<sup>-1</sup>, test weight and seed yield.

Miah *et al.* (2009) had sown four mungbean [*Vigna radiata* (L.) Wilczek] varieties, viz., BINA Mung 2, BINA Mung 5, BINA Mung 6 and BINA Mung 7, 10 day intervals starting from 20 February to 11 April to identify the suitable varieties for getting maximum yield of summer mungbean. Among the varieties BINA Mung 7 was ranked first in terms of seed yield (938.40 kg



ha<sup>-1</sup>) followed in order of BINA Mung 6 (711.72 kg ha<sup>-1</sup>), BINA Mung 5 (684.00 kg ha<sup>-1</sup>) and BINA Mung 2 (547.80 kg ha<sup>-1</sup>). BINA Mung 6 matured earlier than the other three varieties.

Jagannath *et al.* (2014) conducted a field experiment in Dapoli, Maharashtra during summer season of 2011. Results showed that growth and yield attributes, viz., plant height, dry matter accumulation plant<sup>-1</sup>, pods plant<sup>-1</sup>, grains pod<sup>-1</sup> and test weight were recorded highest with variety 'TAU-1'. Further, among the different varieties of blackgram studied, 'TAU-1' has produced maximum and significantly higher grain (1040 kg ha<sup>-1</sup>) and stover (1510 kg ha<sup>-1</sup>) yield over rest of the varieties, while the minimum and maximum harvest index was obtained with variety 'T-9' and 'TAU-1', respectively.

Rabbani *et al.* (2013) carried out an experiment in Mymensingh, Bangladesh during the period from January to May 2010 to study the effect of sowing date on the performance of mungbean varieties. Four mungbean [*Vigna radiata* (L.) Wilczek] varieties, viz., BINA Mung 2, BINA Mung 5, BINA Mung 6 and BINA Mung 7 were sown at 15-day intervals starting from 31 January to 2 March 2010 to identify the suitable variety for getting maximum yield. Among the varieties BINA Mung 7 was ranked first in terms of seed yield (1.85 t ha<sup>-1</sup>) which was statistically at par BINA Mung 6 (1.84 t ha<sup>-1</sup>) and BINA Mung 5 (1.51 t ha<sup>-1</sup>). BINA Mung 6 matured earlier than the other three varieties.

Renganayaki and Sreeregasamy (1992) evaluated twenty blackgram [*Vigna mungo* L.] genotypes grown during summer season at Coimbatore. Highest yielding varieties were recorded in Agra Black and M12/3 (6.12 and 7.55 dry weight g plant<sup>-1</sup> respectively).

Renganayaki and Sreerengasamy (1992), Amanullah and Hatam (2000) and Singh and Singh (2000) reported that NARC Mash-1 produced maximum grain yield (557.1 kg ha<sup>-1</sup>) followed by NARC Mash-4 (520.8 kg ha<sup>-1</sup>) and minimum grain yield (430.8 kg ha<sup>-1</sup>) was for NARC Mash-2. Difference in production potential for different varieties recorded may be due to phenotypic and genotypic characters.

Chaudhary *et al.* (1994) reported that NARC Mash-97 registered maximum biological yield (4400 kg ha<sup>-1</sup>) although it was at par with NARC Mash-1 (4372 kg ha<sup>-1</sup>) and NARC Mash-3. Minimum biological yield (3901 kg ha<sup>-1</sup>) was for NARC Mash-2. These differences can be related to the genetic potential of the varieties. They also reported that CV. Type 9, UG 218, Pant U 19 and UPU 9-40-4 produced mean seed yield of 0.84, 0.82, 0.83 and 0.75 t ha<sup>-1</sup> respectively. UG 218 gave the tallest plants, whereas Type 9 had the highest number of trifoliate leaves and gave the highest DM per plant.

Amanullah and Hatam (2000) planted ten blackbean (*Vigna mungo* L.) germplasm lines and reported significant variation for yield and yield components.

Naeem *et al.* (2000) reported there was variation in plant height, biological yield, pods plant<sup>-1</sup>, seeds pods<sup>-1</sup>, 100 grains weight and harvest index for various *Vigna mungo* L. cultivars.

Ahmad *et al.* (2000) reported that differences in genetic potential of varieties as recorded variation among different varieties.

Biswas *et al.* (2002) conducted an experiment to determine the suitable variety for blackgram in region (AEZ-9) in Bangladesh. Pooled analysis exhibited a significant variation among the varieties. In respect of seed yield Barimash 3 produced the highest seed yield (977 kg ha<sup>-1</sup>), which was statistically at par to that of Binamash 1 (960 kg ha<sup>-1</sup>). Barimash 2 produced the lowest seed yield (866 kg ha<sup>-1</sup>).

Ihsanullah *et al.* (2002) reported that among the varieties highest number of pods plant<sup>-1</sup> (20.60) was recorded for NARC Mash-1 followed by (20.3) pods plant<sup>-1</sup> for NARC Mash-2. They stated that it might be due to differences in genetic potential of varieties as variation among different varieties.

Gupta *et al.* (2005) observed that variety UG-218 produced significantly higher seed yield than Pant U-19 and Type-9, whereas Pant U-19 recorded significantly higher seed yield over Type-9 only during the first year of study. The increase in seed yield of variety UG-218 was 17.7 and 19.3% over Pant U-19 and 33.3 and 23.7% over Type-9 during 2000 and 2001, respectively.

Hari *et al.* (2011) reported that the highest number of nodules plant<sup>-1</sup> was observed in 'AL 1507', which was statistically at par with 'AL 1492'. Again in 2006, genotype 'AL 1507' produced significantly higher nodules plant<sup>-1</sup> over all other genotypes. Highest nodule dry weight plant<sup>-1</sup> was observed in 'AL 1507', which was statistical at par with other genotypes during 2005, but significantly higher than all other genotypes during 2006.

Mwale *et al.* (2007) reported that during initial stages of growth, an increasing rate of leaf number was recorded in all the varieties of blackgram and greengram. When reproductive stage, more defoliation was observed in PU-39 (C<sub>2</sub>) variety of blackgram and TMB 37 (C<sub>4</sub>) variety of greengram compared to other varieties. On re-watering better recovery was not seen in these two varieties. On the other hand, the T9 (C<sub>1</sub>) variety of blackgram was maintaining a good number of leaves and was almost at par with the control T<sub>1</sub> plants.

Podder *et al.* (1999) reported that irrespective of treatment difference BARI Mung 6 produced maximum number of pods plant<sup>-1</sup> (30.80) and 1000-seed weight (50.67g) while lowest number of pods plant<sup>-1</sup> (21.43) and test weight (39.13g) were found in BARI Mung 5 under control condition,

*i.e.*, BARI Mung 5 variety with no fertilization but in case of number of seeds pod<sup>-1</sup> the maximum was produced by BARI Mung 5 (12.48) in inoculated plants by *Bradyrhizobium* with chemical fertilizers N, P and K followed by BARI Mung 6 × bio-fertilizer with P + K and there was no significant difference between above two treatments for production of seeds plant<sup>-1</sup>.

Guriqbal *et al.* (2011) reported that genotypes 'KUG 114' was tallest plant (40.2) of all the genotypes, although these genotypes did not differ in branching habit. However, number of pods plant<sup>-1</sup> (22.5) was significantly higher in 'KUG 114' than in 'Mash 338', whereas 'KUG 114' recorded significantly higher seeds pod<sup>-1</sup> (6.5) over other two genotypes. 'KUG 173' recorded the highest 100-seed weight (3.78), which was significantly higher than in 'Mash 338'. Nodules number and its dry weight plant<sup>-1</sup> were significantly higher in 'KUG 114' than in 'Mash 338'. During 2005, the highest seed yield (1239 kg ha<sup>-1</sup>) was recorded in 'KUG 114' and was significantly superior to 'KUG 173' and 'Mash 338'. However, during 2006, 'KUG 114' and 'KUG 173' were on par with respect to seed yield, yet were significantly higher over 'Mash 338'. On an average (for two years), 'KUG 114', gave 22.2 and 5.9% higher seed yield than 'Mash 338' and 'KUG 173', respectively.

Gupta *et al.* (2006) reported that the variety Type 9 recorded significantly higher grain yield (1351 kg ha<sup>-1</sup>), harvest index (38.87%), net returns (16599 ₹ ha<sup>-1</sup>) and benefit cost ratio (2.32) than CV. Pant Urd 35 and Vallabh Urd 1. Among the varieties, Type 9 was significantly superior. Significantly more plant height and longer root as observed in this study in case of Type 9 might have contributed to its superiority in terms of grain yield, harvest index, net returns and benefit: cost ratio over Pant Urd 35 and Vallabh Urd 1. Higher grain of 1351 kg ha<sup>-1</sup> was observed by Type 9, which was significantly higher than other two varieties.



*CHAPTER - 3*

*MATERIALS*

*AND*

*METHODS*

## CHAPTER 3

### MATERIALS AND METHODS

The experimental work for this master's thesis was conducted as part of an international Project entitled, "Building Resilience to climate change through Strengthening Adaptive Small Scale farming system in Rainfed Areas in Bangladesh, India and Nepal" (SAF-BIN) program, an on-farm adaptive research (OFAR) with associate research partner (SHIATS) and participant farmers of rainfed area of Sagar district of Madhya Pradesh.

The research trial was conducted with a multi-stake-holders' participative approach by the SHFCs and pro-active team of DPO, Student Researcher, RO and the VRAs. As stated in the earlier chapters, during the planning and formulation of the current experiment through a Farmer-Scientist-Extension personnel-stake-holders' interaction approach, PRA tools and other means were extensively used to thrash out the plausible cause and agronomic solution for blackgram under rainfed condition of Sagar district, particularly in the context of climate change.

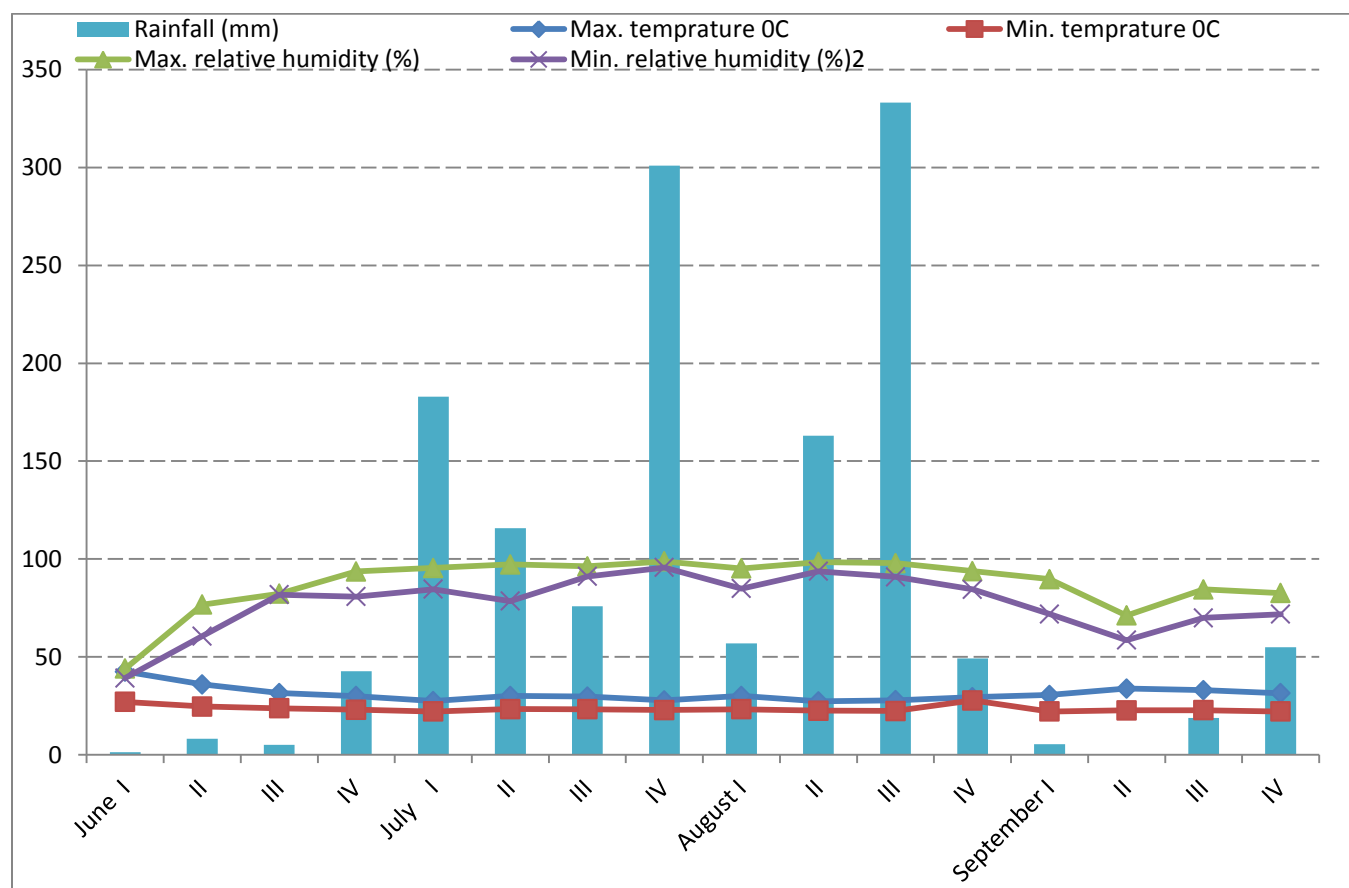
The process followed in the current OFAR had several important steps, viz., formation of smallholder farmers' collectives (SHFCs) identification and ranking of the major problems of agriculture related to climate change and prioritizing the problems, particularly for food crops like blackgram, identifying the farmers' solution, deliberations with the internal stakeholders like agricultural scientists, research personnel and extension officers, NGO representatives, *etc*, blending of the traditional and recommended practices in optimal ratios for developing and refining the trial design, which was facilitated by the SAF-BIN and the implementation of trials in the farmers' field.

The materials, methodology and techniques adopted during the course of the investigation entitled, "Effect of sowing date and varietal selection on the growth and yield of blackgram (*Vigna mungo* L.) under rainfed farming in the context of climate change in Sagar (Madhya Pradesh)", under the OFAR (On Farm Adaptive Research) of SAF-BIN Research and Development programme are described in this chapter under the following heads.

### 3.1 Experimental site

The experiment was conducted during the *Kharif* season of 2013, in 10 Villages of Shahgarh *Tehsil* and Block in Sagar district of Madhya Pradesh, in central India in a picturesque situation on a spur of the Vindhya range. It is around 180 km northeast of state capital, Bhopal and at an altitude of 1758 ft above mean sea level.

The Sagar district is located in the north central region of Madhya Pradesh and lies between north latitude  $23^{\circ} 10''$  to  $24^{\circ} 27''$  and east longitude  $78^{\circ} 4''$  to  $79^{\circ} 21''$ . The experimental site was about 80 km away from Sagar railway station ([www.mapsofindia.com](http://www.mapsofindia.com)).



**Figure: 3.1 Meteorological observations and total rainfall (weekly) during the experimental period (*Kharif*, 2013)**

### 3.2 Soil of the experimental field

The soil samples were collected randomly from the 0 to 15 cm depth from 5 spots of the experimental field just before layout of experiment from the clusters covering 10 villages. The soils of 10 villages were divided into two clusters, viz., 1<sup>st</sup> cluster (vertisols) covered villages Kanikheri, Vanpura, Khushipura and Shashan and 2<sup>nd</sup> cluster (Alfisols) covered Amarmau, Hanumantora, Ratanpura, Bagrohi, Beela and Khargatora villages. The representative homogenous composite sample was drawn by mixing all these soil samples together, which was analyzed to determine the physico-chemical properties of the soil. The result of analysis along with the methods used for determination is presented under the following heads.

#### 3.2.1 Mechanical analysis of the soil

The mechanical analysis of soil (0 to 15 cm depth) is presented in Table 3.1.a and 3.1.b.

**Table 3.1.a Mechanical analysis of the soil of farmers' field of 1<sup>st</sup> cluster (Vertisols)**

Mineral fraction	Value (unit)	Method (references)
Sand	25.13 (%)	Bouyoucos hydrometer method (Bouyoucos, 1927)
Silt	46.27 (%)	
Clay	28.60 (%)	
Textural class	Clay loam	

**Table 3.1.b Mechanical analysis of the soil of farmers' field of 2<sup>nd</sup> cluster (Alfisols)**

Mineral fraction	Value (unit)	Method (references)

Sand	39.33 (%)	
Silt	43.40 (%)	Bouyoucos hydrometer method
Clay	17.27 (%)	(Bouyoucos, 1927)
Textural class	Silt loam	

### 3.2.2 Chemical analysis of soil

Chemical analysis of the soil (0 to 15 cm depth) is presented in Table 3.2.a and 3.2.b.

**Table 3.2.a Chemical analysis of soil at pre experiment stage of 1<sup>st</sup> cluster (Vertisols)**

Parameter	Value (unit)	Method (references)
Available nitrogen	219.40 kg ha <sup>-1</sup>	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus	17.00 kg ha <sup>-1</sup>	Olsen's colorimetric method (Olsen <i>et al.</i> , 1954)
Available potassium	339 kg ha <sup>-1</sup>	Flame Photometer method (Toth and Prince, 1949)
Organic carbon	0.26 (%)	Walkley and Black method (Jackson, 1973)
pH	7.74	Glass electrode pH meter (Jackson, 1973)
EC	0.13 (dS m <sup>-1</sup> )	Method No.4 USDA Hand Book No.16 (Richards, 1954)

**Table 3.2.b  
Chemical  
analysis of  
soil at pre  
experiment  
stage of 2<sup>nd</sup>  
cluster  
(Alfisols)**

Parameter	Value (unit)	Method (references)
Available nitrogen	131.60 kg ha <sup>-1</sup>	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus	11.00 kg ha <sup>-1</sup>	Olsen's colorimetric method (Olsen <i>et al.</i> , 1954)
Available potassium	309 kg ha <sup>-1</sup>	Flame Photometer method (Toth and Prince, 1949)
Organic carbon	0.17 (%)	Walkley and Black method (Jackson, 1973)
pH	7.90	Glass electrode pH meter (Jackson, 1973)
EC	0.16 (dS m <sup>-1</sup> )	Method No.4 USDA Hand Book No.16 (Richards, 1954)

**3.3  
Cropping  
history**  
Different  
crops grown  
in  
successive  
season in  
the



experimental plot No.1 to 20 were recorded for the last 5 years to get an idea about the different species grown. On the basis of availability of irrigation facility, experimental field of 10 villages were divided into two clusters, viz., 1<sup>st</sup> cluster consisted of villages Kanikheri, Vanpura, Khushipura, Amarmau, Hanumantora, Ratanpura, Bagrohi and Khargatora and 2<sup>nd</sup> cluster (Alfisols) covered Beela and Shashan villages, which invariably raised crops like chickpea and mustard rather than wheat during the post rainy season of *Rabi*. Cropping history of the experimental field for the last five years is presented in Table 3.3.a and 3.3.b.

**Table 3.3.a Cropping history of the experimental field of 1<sup>st</sup> cluster**

Years	Cropping season		
	<i>Kharif</i>	<i>Rabi</i>	<i>Zaid</i>
2008-09	Sesamum	Fallow	Fallow
2009-10	Blackgram	Wheat	Fallow
2010-11	Blackgram	Wheat	Fallow
2011-12	Blackgram	Wheat	Fallow
2012-13	Blackgram	Wheat	Fallow
2013-14	Blackgram (experimental crop)	Wheat	Fallow

**Table 3.3.b Cropping history of the experimental field of 2<sup>nd</sup> cluster**

Cropping season
-----------------

<b>Years</b>	<b><i>Kharif</i></b>	<b><i>Rabi</i></b>	<b><i>Zaid</i></b>
2008-09	Sesamum	Chickpea	Fallow
2009-10	Greengram	Mustard	Fallow
2010-11	Sesamum	Chickpea	Fallow
2011-12	Blackgram	Mustard	Fallow
2012-13	Blackgram	Chickpea	Fallow
2013-14	Blackgram (experimental crop)	Wheat	Fallow

### 3.4 Climate and Weather condition

Sagar has a borderline humid subtropical climate (Koppen climate classification) and tropical savanna climate (Koppen climate classification) with hot summers, a somewhat cooler monsoon season and cool winters. Very heavy rainfalls in the monsoon season from June to September ([www.mapsofindia.com](http://www.mapsofindia.com)). Table 3.4 Depict the mean of weekly weather parameters and total rainfall during the cropping season (*Kharif*, 2013).

**Table 3.4 Mean of weekly weather parameters and total rainfall during the cropping season (*Kharif*, 2013)**

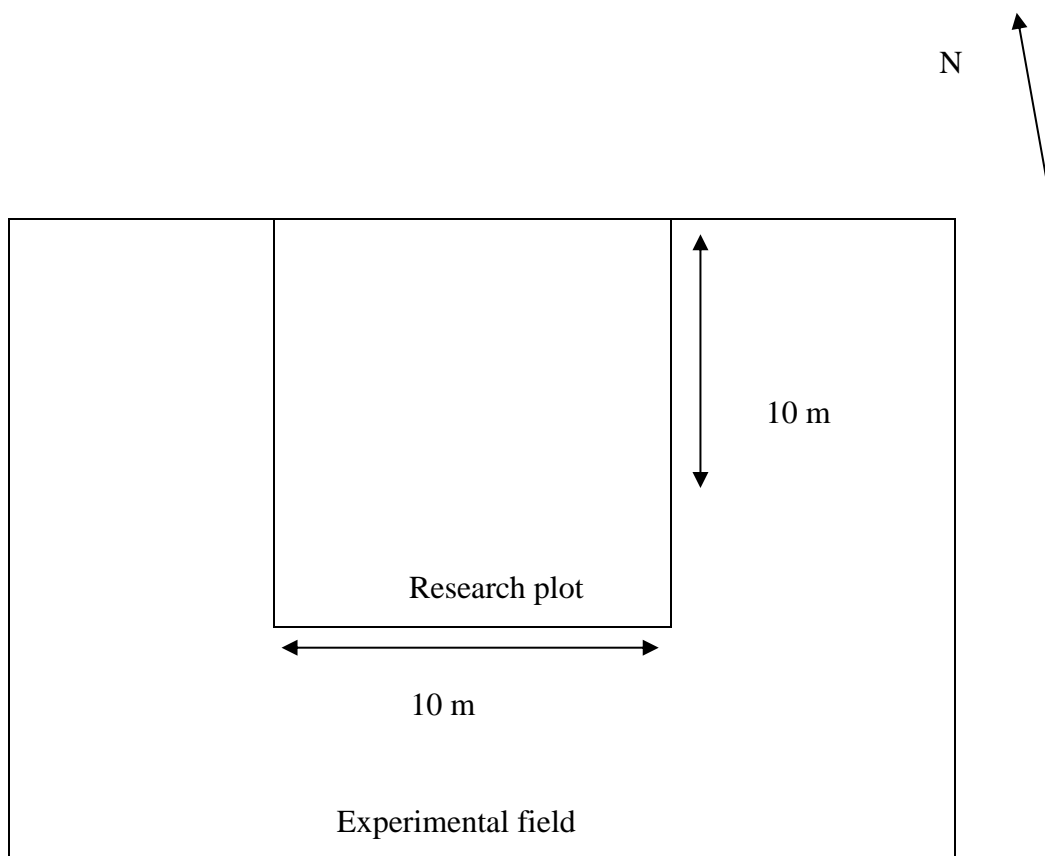
<b>Months</b>	<b>Week</b>	<b>Temperature (<sup>0</sup>C)</b>		<b>Relative humidity (%)</b>		<b>No. of rainy days</b>	<b>Total rainfall (mm)</b>
		<b>Max.</b>	<b>Min.</b>	<b>Max.</b>	<b>Min.</b>		
<b>June</b>	III	31.48	23.72	82.25	81.75	6	5.08
	IV	29.92	22.97	93.62	80.75	6	42.67
<b>July</b>	I	27.38	22.11	95.42	84.57	5	182.90
	II	30.05	23.30	97.25	78.50	8	115.70
	III	29.66	23.21	96.25	91.12	8	75.80
	IV	27.72	22.81	98.75	95.62	8	300.90
	I	30.02	23.20	95.14	84.85	4	56.80

<b>August</b>	II	27.22	22.52	98.42	93.71	8	162.90	<b>Source:</b> Regional Meteorological Centre, Nagpur (2013)
	III	27.80	22.32	97.87	90.87	8	333.10	
	IV	29.36	27.72	93.75	84.50	0	49.20	
<b>September</b>	I	30.51	22.10	89.71	71.85	3	5.40	
	II	33.78	22.68	71.14	58.57	0	0.00	
	III	33.00	22.72	84.50	69.87	3	18.80	
<b>Grand total = 67</b>							<b>1,349.25</b>	

**Table 3.5 Calendar of sowing as per treatment and location**

<b>Treatments</b>		<b>Date</b>
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	18.06.2013 to 22.06.2013
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	19.06.2013 to 21.06.2013
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	22.06.2013 to 26.06.2013
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	22.06.2013 to 26.06.2013
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	04.07.2013 to 05.07.2013
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	04.07.2013 to 07.07.2013

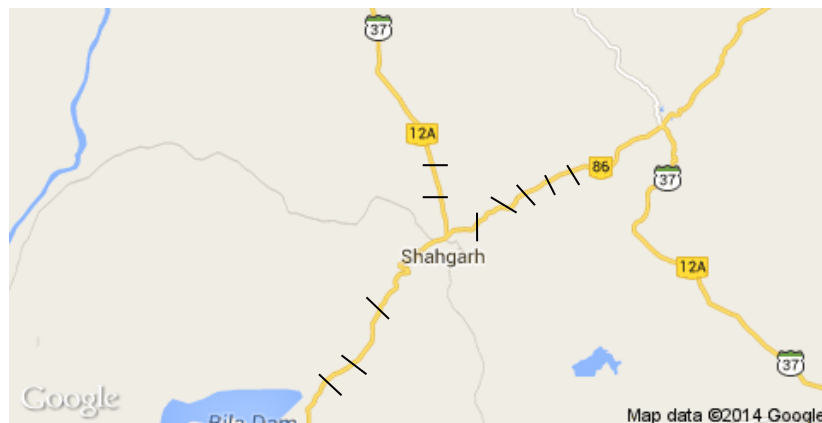
\*Treatment T<sub>5</sub> and T<sub>6</sub> were replicated twice



**Fig 3.2 Layout of one plot (representative layout) in farmers' field, which included total of 20 plots in 10 villages in Shahgarh *Tehsil* and block**



**Fig. 3.3 Map of Sagar district ([www.mapsofsagar.com](http://www.mapsofsagar.com))**



\ = Village

**Fig. 3.4 Map of Shahgarh Tehsil and Block, where the experimental field plots of farmers were laid out ([www.mapsofsagar.com](http://www.mapsofsagar.com))**

### **3.5 Experimental details of the OFAR (On Farm Adaptive Research)**

#### **3.5.1 Experimental design**

The experiment was conducted in randomized block design consisting of 6 treatment combinations with 4 replications and was laid out with the different treatments allocated randomly in each replication.

#### **3.5.2 Details of layout**

Experimental design : RBD

Number of treatments	: 4 + 2*
Number of replication	: 4
Total no. of plots	: 16 + 4*
Net plot size	: 10 × 10 m
Length of field	: 40 + 20 m*
Width of the field	: 40 + 20 m*
Net cultivated area	: 2000 m <sup>2</sup>
Gross cultivated area	: 2000 m <sup>2</sup>

\*Treatment T<sub>5</sub> and T<sub>6</sub> were replicated twice

### 3.5.3 Details of crop cultivation

Crop : Blackgram

#### Factors of the trial:

##### Factor 1: Different sowing dates

- (i) Sowing in 3<sup>rd</sup> week of June
- (ii) Sowing in 4<sup>th</sup> week of June
- (iii) Sowing in 1<sup>st</sup> week of July

## **Factor 2: Different varieties**

- (i) Shikhar 3
- (ii) *Khajua*

- ❖ DAP was applied as basal dose in all plots @ 125 kg ha<sup>-1</sup> (57.5 kg P<sub>2</sub>O<sub>5</sub> and 22.5 kg N)
- ❖ PSB Culture @ 25 g kg<sup>-1</sup> seed
- ❖ Carbendazim @ 2 g kg<sup>-1</sup> seed

### **3.5.4 Treatment combination**

T<sub>1</sub> : Sowing in 3<sup>rd</sup> week of June + Shikhar 3

T<sub>2</sub> : Sowing in 3<sup>rd</sup> week of June + *Khajua*

T<sub>3</sub> : Sowing in 4<sup>th</sup> week of June + Shikhar 3

T<sub>4</sub> : Sowing in 4<sup>th</sup> week of June + *Khajua*

Under the OFAR, additionally 2 more treatments had been added (which was replicated only twice)

T<sub>5</sub> : Sowing in 1<sup>st</sup> week of July + Shikhar 3

T<sub>6</sub> : Sowing in 1<sup>st</sup> week of July + *Khajua*

### 3.6 Details of raising the test crop

The schedule of different pre and post sowing/planting operations carried out in the experimental field has been given in Table 3.6.

**Table 3.6 Chronological record of agro-techniques (Calendar of operations)  
during experiment**

S. No.	Operations	Date	DAS
1	2	3	4
1	Field preparation (Ploughing + Harrowing + Planking)	08.06.013	
2	Layout and leveling	15.06.2013	
3	Basal application of fertilizer DAP	18.06.2013 to 07.07.2013	
4	Weeding (Manual) by the farmers	08.08.2013 to 10.08.2013	32 to 44
5	Plant protection measures for YVMV control  Neem oil spray (0.33%)	  11.08.2013	  35
6	Harvesting and pod picking of blackgram	04.09.2013 to 07.09.2013	77 to 80



## OBSERVATIONS RECORDED

### 3.7 Growth parameters

#### 3.7.1 Plant height (cm)

Four plants were selected randomly from each plot and tagged. The height (cm) of these plants was measured from base of the blackgram to tip of the main axis. Plant height was recorded at 15, 30, 45, and 60 DAS.

#### 3.7.2 Number of branches plant<sup>-1</sup>

From the four-tagged plants of each plot, number of branches at different growth stages were recorded at 30, 45 and 60 DAS and the average number of branches plant<sup>-1</sup> was calculated for each observation.

#### 3.7.3 Plant dry weight (g)

Four plants were randomly uprooted without damaging the root from each plot at 15, 30, 45 and 60 DAS. The samples were air dried and then kept in oven for 72 hours at 70<sup>0</sup> C, their dry weight was determined without root and the average dry weight plant<sup>-1</sup> was calculated.

#### 3.7.4 Crop growth rate (CGR)

It represents dry weight gained by a unit area of crop in a unit time expressed as g m<sup>-2</sup> day<sup>-1</sup> (Radford, 1967). The values of plant dry weight at 0 to 15, 15 to 30, 30 to 45 and 45 to 60 DAS intervals were used for calculating the CGR.

$$\text{Crop growth Rate (g m}^{-2}\text{ day}^{-1}\text{)} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

$W_1$  = Initial dry weight of plant (g)

$W_2$  = Final dry weight of plant (g)

$t_1$  = Initial time period

$t_2$  = Final time period

### 3.7.5 Relative growth rate (RGR)

It was described by Fisher, 1921, which indicates the increase in dry weight per unit dry matter over any specific time interval and it was calculated by the following equation:

$$\text{Relative growth rate (g g}^{-1} \text{ day}^{-1}) = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where,

$\log_e W_1$  = natural log of initial ( $t_1$ ) dry weight (g) of the plant

$\log_e W_2$  = natural log of dry weight (g) of the plants after an interval of time ( $t_2$ )

$t_1$  = initial time (days)

$t_2$  = time after a certain interval

It was calculated for the time intervals, *i.e.*, 15 to 30, 30 to 45 and 45 to 60 DAS using the data obtained from dry weight of plants.

## 3.8 Yield attributes and yield

### 3.8.1 Number of pods plant<sup>-1</sup>

The pods on four randomly selected plants were counted after harvest, to calculate the mean number of pods plant<sup>-1</sup>.

### **3.8.2 Number of grains pod<sup>-1</sup>**

Grains from the four randomly selected mature pods were counted separately which were obtained randomly from the tagged plants and their average was recorded.

### **3.8.3 Test weight (g)**

One thousand seeds were randomly counted from the pods obtained from each plot and weighed and recorded as test weight (g) at 14% moisture of the seed.

### **3.8.4 Seed yield (kg ha<sup>-1</sup>)**

An area of 2.00 m<sup>2</sup> of the crop was harvested from a random spot of the plot by leaving border rows. The harvested plants were left in the field for 3 to 4 days for curing. Sun dried, threshing and winnowed at the threshing floor. The grain yield was calculated in kg ha<sup>-1</sup>.

### **3.8.5 Stover yield (kg ha<sup>-1</sup>)**

Stover from the above tagged bundles were weighed separately from each plot for calculation of the stover yield in kg ha<sup>-1</sup>.

### **3.8.6 Biological yield**

Prior to threshing of the tagged bundles from 2.00 m<sup>2</sup> area, was dried in sun, the weight was recorded for calculating the biological yield kg ha<sup>-1</sup>.

### **3.8.7 Harvest Index (%)**

Harvest index was obtained by dividing the economic yield (grain yield) by the biological yield (grain + stover). It was calculated for each of the plots and was represented in percentage. The following formula was used (Donald, 1962).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

### 3.9 Post harvest qualitative studies

Approximately 100 g seed samples were collected at the time of threshing from each plot and thereafter ground into powder with the help of electric mini grinder. The qualitative parameter, *viz.*, protein (%) in grains were evaluated. The methodology which was adopted are described in the following page.

#### 3.9.1 Protein (%) in grain

It is calculated by the formula, Protein (%) = N (%) x 6.25. The nitrogen content of grains was analyzed by Micro-Kjeldahl's method (AOAC, 1965).

The Micro-Kjeldahl's method for total nitrogen content (%) essentially involves digestion of the sample to convert N compounds in the sample to NH<sub>4</sub> form. The grain sample was digested with sulphuric acid and catalyst mixture (K<sub>2</sub>SO<sub>4</sub> + CuSO<sub>4</sub>) was added to each digestion tube to raise the temperature of digestion and thereafter, cooled to room temperature. The digest was transferred to distillation flask with granulated zinc added to it (which acts as anti bumping agent). Thirty to 50 ml NaOH was poured into the distillation flask where NH<sub>4</sub> was captured in the flask containing boric acid and the ethylene blue indicator was mixed in receiving flask. Titration of the sample was done by using 0.05 N HCl. Similar procedure for blank sample was followed. The N (%) content was calculated using the formula:

$$\text{Nitrogen (\%)} = \frac{(\text{Sample titre} - \text{Blank titre}) \times 0.05 \text{ N HCl} \times 14 \times 100}{\text{Weight of sample} \times 1000}$$

### 3.10 Economic Analysis

Cost of cultivation, gross return, net return and benefit cost ratio was worked out to evaluate the economics of each treatment, based on the existing market prices of inputs and output. The data of this parameter (Cost of cultivation, gross return, net return and benefit cost ratio) is presented in the appendices of this thesis.

#### 3.10.1 Cost of Cultivation (₹ ha<sup>-1</sup>)

The cost of cultivation for each treatment was worked out separately, taking into consideration all the cultural practices followed in the cultivation.

### **3.10.2 Gross return (₹ ha<sup>-1</sup>)**

The gross return from each treatment was calculated

Gross return (₹ ha<sup>-1</sup>) = Income from grain (₹ ha<sup>-1</sup>) + income from stover (₹ ha<sup>-1</sup>)

### **3.10.3 Net return (₹ ha<sup>-1</sup>)**

The net profit from each treatment was calculated separately, by using the following formula

Net return = Gross return (₹ ha<sup>-1</sup>) – Cost of cultivation (₹ ha<sup>-1</sup>)

### **3.10.4 Benefit cost ratio**

The benefit cost ratio was calculated using the following formula

$$\text{Benefit cost ratio} = \frac{\text{Gross return (₹ha}^{-1}\text{)}}{\text{Total Cost of cultivation (₹ ha}^{-1}\text{)}}$$

### 3.11 Statistical analysis

Data recorded on different aspects of crop, viz., growth, yield attributes and yield were tabulated and subjected to statistical analysis as per Gomez and Gomez, 1976. Significance of difference between treatment means was tested through ‘F’ test and the critical difference (CD) was worked out wherever ‘F’ value was found to be significant for treatment effect. If calculated value exceeded the table value, the effect was considered to be significant. The analysis of variance for the data has been given in appendices at the end of this Thesis. Table 3.6 depicts the skeleton of ANOVA.

**Table 3.7 Skeleton of ANOVA table**

Source of variation	Df	SS	MSS	F Cal	F Tab at 5%
Due to replications	(r-1)	RSS	$\frac{RSS}{(r-1)}$	$\frac{MSS(r)}{EMSS}$	
Due to treatments	(t-1)	TrSS	$\frac{TrSS}{(t-1)}$	$\frac{MSS(t)}{EMSS}$	
Due to error	(r-1) (t-1)	ESS	$\frac{ESS}{(r-1) (t-1)}$		
Total	(rt-1)	TSS			

Where,

#### Standard Error Deviation (SEd)

Standard error of mean was calculated by the following formula:

$$SEd = \sqrt{\frac{2 \times MSSE}{r}}$$

#### Co-efficient of variation (CV)

$$CV (\%) = \frac{\sigma}{\bar{x}} \times 100$$

Where,

**Critical difference (CD)**

Critical difference was calculated by the following formula:

$\bar{x}$  = Mean

$\sigma$  = Standard deviation

CD =  $SEd \times 't'$  error degree of freedom at 5%

df = Degree of freedom

ESS = Error sum of squares

EMSS = Error mean sum of squares

MSS(r) = Mean sum of squares due to replication

MSS(t) = Mean Sum of squares due to treatment

r = Number of replication

RSS = Sum of squares due to replication

SS = Sum of squares

SEd = Standard error deviation

TrSS = Sum of squares due to treatment

TSS = Total sum of squares



## *CHAPTER - 4*

# *RESULTS AND DISCUSSION*



## CHAPTER 4

### RESULTS AND DISCUSSION

The findings of the present experiment entitled, “Effect of sowing date and varietal selection on the growth and yield of blackgram (*Vignamungo* L.) under rainfed farming in the context of climate change in Sagar (Madhya Pradesh)”, under the OFAR (On Farm Adaptive Research) are being presented and discussed in the following pages under appropriate headings. Data on pre-harvest (pertaining to growth attributes) and post-harvest (relating to yield and yield attributes) observations were analyzed and discussion on experiment findings in the light of scientific reasoning has been stated.

#### OBSERVATIONS RECORDED

##### A. Pre-harvest observations (at 15, 30, 45 and 60 DAS)

4.1 Plant height (cm)

4.2 Number of leaves plant<sup>-1</sup>

4.3 No of branches plant<sup>-1</sup>

4.4 No. of nodules plant<sup>-1</sup>

4.5 Plant dry weight (g)

4.6 CGR (g m<sup>-2</sup> day<sup>-1</sup>) at 0 to 15, 15 to 30, 30 to 45 and 45 to 60 DAS intervals

4.7 RGR (g g<sup>-1</sup> day<sup>-1</sup>) at 15 to 30, 30 to 45 and 45 to 60 DAS intervals

##### B. Post-harvest observations

4.8 Yield and yield attributes [Number of pods plant<sup>-1</sup>, Number of grains pod<sup>-1</sup>, Test weight (g), Stover yield (kg ha<sup>-1</sup>), Seed yield (kg ha<sup>-1</sup>), Harvest index (%)].

##### C. Qualitative observations

4.9 Protein content (%) in grain

## D. Economics

4.10 Cost of cultivation (₹ ha<sup>-1</sup>), Gross return (₹ ha<sup>-1</sup>), Net return (₹ ha<sup>-1</sup>), Benefit cost ratio

## E. Analysis of soil

4.11 Post harvest chemical analysis of soil [Organic carbon (%), Available P (%), Available K(%), pH, EC]

## GROWTH PARAMETERS OF BLACKGRAM

### A. Pre-harvest observations

#### 4.1 Plant height (cm)

The observations of plant height are being presented in the table 4.1 and figure 4.1. A perusal of the table 4.1, reveals that the plant height differed no significant in all observations recorded at 30 DAS, 45 DAS and 60 DAS to except 15 DAS in T<sub>5</sub> (sowing in 1<sup>st</sup> week of July + Shikhar 3) and T<sub>6</sub> (sowing in 1<sup>st</sup> week of July + *Khajua*).

At 15 DAS, 30 DAS and 45 DAS the highest plant height 7.14 cm, 19.78 cm and 35.52 cm was recorded under treatment T<sub>2</sub> (sowing in 3<sup>rd</sup> week of June + *Khajua*), which was 26.59, 27.61 and 25.91% higher than the lowest value 5.64 cm in T<sub>3</sub> (sowing in 4<sup>th</sup> week of June + Shikhar 3) and 15.50 and 28.21 in T<sub>4</sub> (sowing in 4<sup>th</sup> week of June + *Khajua*). At 15 DAS, T<sub>4</sub> (sowing in 4<sup>th</sup> week of June + *Khajua*) and T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikhar 3) were found to be statistically at par to that obtained under T<sub>2</sub> (sowing in 3<sup>rd</sup> week of June + *Khajua*). At 60 DAS the highest plant height 49.81 cm was recorded under T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikhar 3), which was 19.64% higher than the lowest value 41.63 cm in T<sub>4</sub> (sowing in 4<sup>th</sup> week of June + *Khajua*).

Between treatments T<sub>5</sub> (sowing in 1<sup>st</sup> week of July + Shikhar 3) and T<sub>6</sub> (sowing in 1<sup>st</sup> week of July + *Khajua*), at 15 DAS and 45 DAS the highest plant height 10.12 and 31.11 cm respectively was recorded under T<sub>6</sub> (sowing in 1<sup>st</sup> week of July + *Khajua*). However, at 30 DAS and 60 DAS the highest plant height 21.00 and 36.30 cm respectively was recorded under T<sub>5</sub> (sowing in 1<sup>st</sup> week of July + Shikhar 3).

The probable reasons for increasing height may be due to different sowing dates and varieties. Varieties differed in plant height but were mostly at par. The variety Shikhar 3 produced taller plants than the *Khajua*. Similar finding was reported by Gupta *et al.* (2005). Also this variety was resistant to yellow vein mosaic virus and pod borer. Further, variety Shikhar 3 was also observed to be tolerant to environmental stress (water logging condition). During this OFAR (On

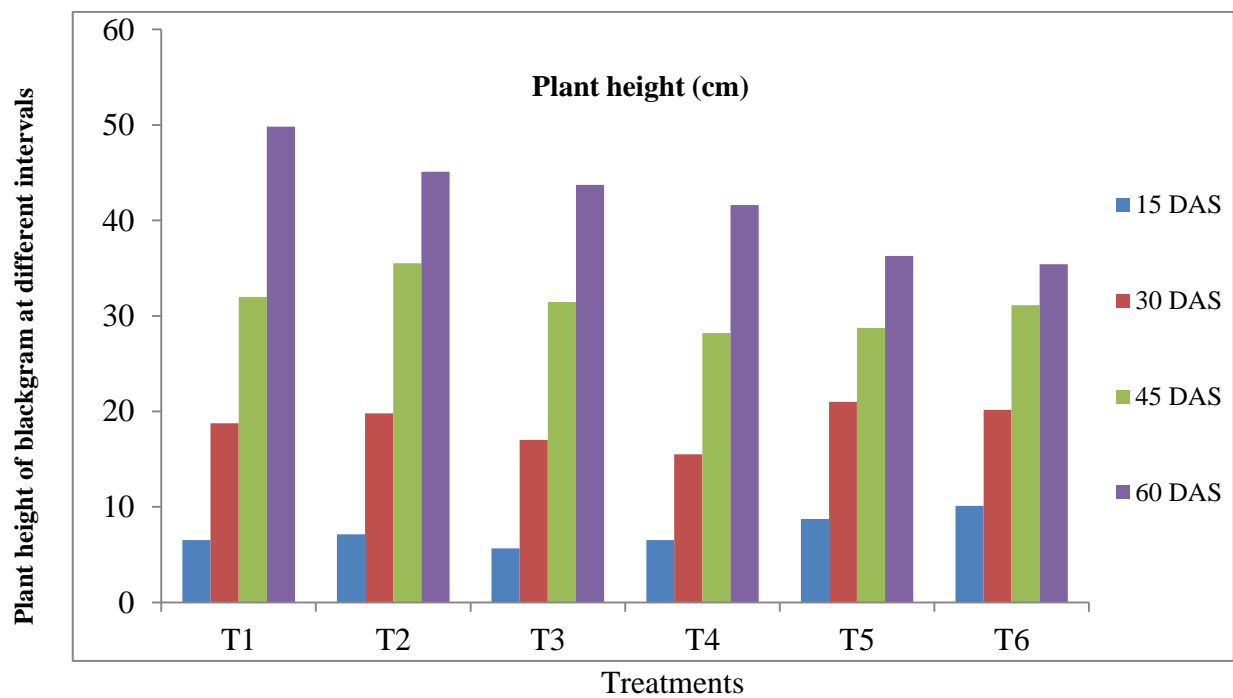
Farm Adaptive Research)it was found that soybean crop wascompletely damaged due to heavy rainfall and yellow vein mosaic virus but blackgram variety Shikhar 3 was able to survive well and attained increasing growth.

Increasing plant height under early sowing may be attributed to availability ofrelatively more time by the plants and high rainfall during growing season. Plant height was generally reduced in delayed sowing in case of blackgram. Similar finding was reported by Ramzan*et al.* (1992).

**Table 4.1. Effect of sowing dates and varietal selection on plant height of blackgram at different intervals**

Treatments		Plant height (cm)			
		15 DAS	30 DAS	45 DAS	60 DAS
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	6.53	18.75	32.00	49.81
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	7.14	19.78	35.52	45.11
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	5.64	17.00	31.46	43.72
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	6.54	15.50	28.21	41.63
	S Ed ( $\pm$ )	0.50	3.16	4.50	6.98
	CD (P=0.05)	1.10	NS	NS	NS
	CV (%)	7.09	17.24	14.32	16.14
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	8.75	21.00	28.75	36.30
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	10.12	20.18	31.11	35.42
	S Ed ( $\pm$ )	0.70	4.46	6.37	9.87
	CD (P=0.05)	NS	NS	NS	NS
	CV (%)	9.92	24.34	20.27	22.83

**\*Replicated twice**



**Fig. 4.1** Effect of sowing dates and varietal selection on plant height (cm) of blackgram

#### 4.2 Number of leaves plant<sup>-1</sup>

Observations regarding the effect of different sowing date and varietal selection on the leaves plant<sup>-1</sup> of blackgram are given in table 4.2 and figure 4.2. It was noticed that successive stage there was an incremental trend.

The observation showed that all growth stages there was no significant difference between the treatments. At 15,30,45 and 60 DAS all growth stages the highest number of leaves 7.06, 24.68, 40.87 and 52.12 plant<sup>-1</sup> respectively was observed in T<sub>2</sub> (sowing in 3<sup>rd</sup> week of June + *Khajua*), which was 21.51% and 36.20% higher than lowest value 5.81 and 18.12 leaves plant<sup>-1</sup> respectively in treatment T<sub>3</sub> (sowing in 4<sup>th</sup> week of June + Shikhar 3) and 12.55 and 8.87% higher than lowest value 36.31 and 47.87 leaves plant<sup>-1</sup> respectively in T<sub>4</sub> (sowing in 4<sup>th</sup> week of June + *Khajua*) at 45 and 60 DAS.

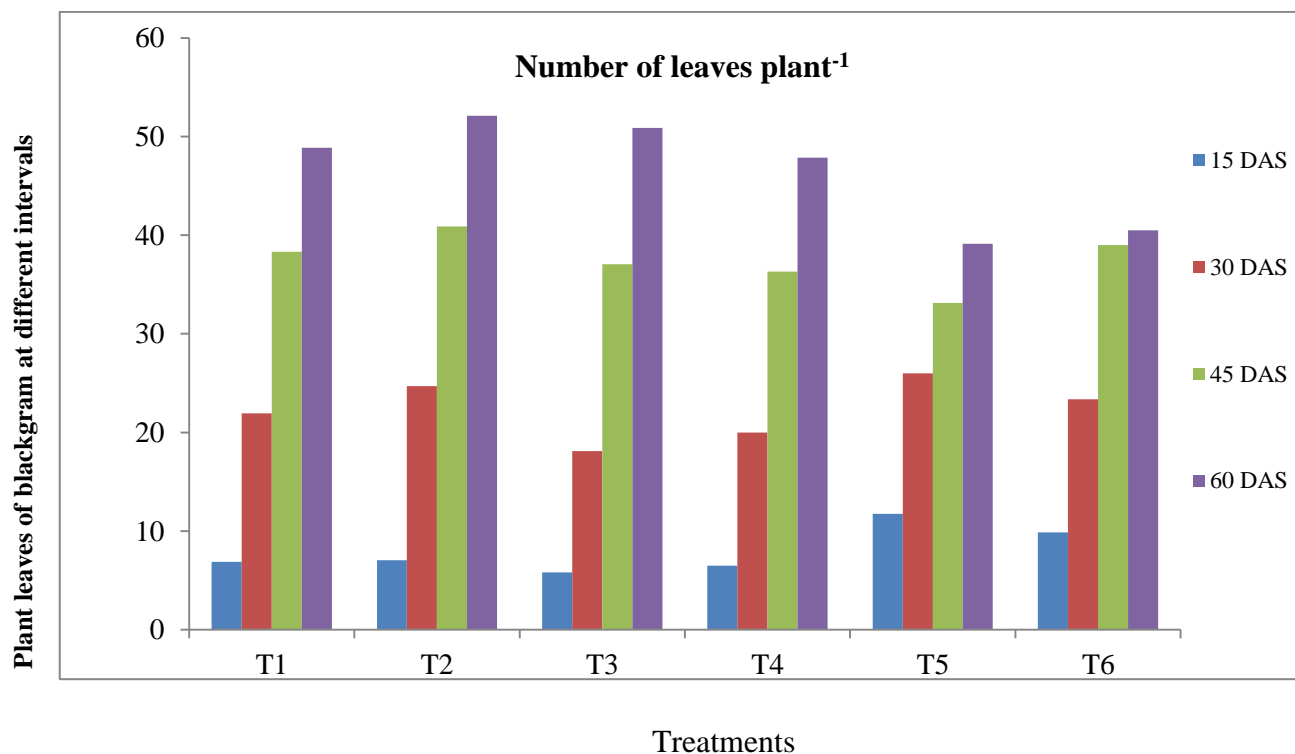
Between T<sub>5</sub> (sowing in 1<sup>st</sup> week of July + Shikhar 3) and T<sub>6</sub> (sowing in 1<sup>st</sup> week of July + *Khajua*), the former registered the highest number of leaves 11.75 and 26.00 plant<sup>-1</sup> respectively at 15 and 30 DAS. However, at 45 and 60 DAS the highest number of leaves 39.00 and 40.50 plant<sup>-1</sup> was observed in latter.

The increased number of leaves may be due to early sowing date. Maximum leaf area in early sowing may be due to long vegetative period and high rainfall which favoured more vegetative growth. Similar finding reported in soybean by Ahnet *al.* (1989)

**Table 4.2. Effect of sowing dates and varietal selection on number of leaves of blackgram at different intervals**

Treatments		No. of leaves plant <sup>-1</sup>			
		15 DAS	30 DAS	45 DAS	60 DAS
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	6.87	21.93	38.31	48.87
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	7.06	24.68	40.87	52.12
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	5.81	18.12	37.06	50.87
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	6.50	20.00	36.31	47.87
	S Ed (±)	1.44	2.02	6.58	5.60
	CD (P=0.05)	NS	NS	NS	NS
	CV (%)	19.43	9.20	17.44	11.68
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	11.75	26.00	33.12	39.12
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	9.87	23.37	39.00	40.50
	S Ed (±)	2.04	2.86	9.31	7.93
	CD (P=0.05)	NS	NS	NS	NS
	CV (%)	27.53	13.00	24.68	16.55

**\*Replicated twice**



**Fig. 4.2** Effect of sowing dates and varietal selection on number of leaves plant<sup>-1</sup> of blackgram



### 4.3 Number of branches plant<sup>-1</sup>

Observations regarding the effect of different sowing date and varietal selection on number of branches plant<sup>-1</sup> of blackgram are given in table 4.3 and figure 4.3. It was noticed that successive stage there was an increasing trend.

The observation showed that all growth stages there was no significant difference between the treatments. At 30 and 45 DAS the highest branches 0.62 and 2.93 plant<sup>-1</sup> respectively recorded in treatment T<sub>4</sub> (sowing in 4<sup>th</sup> week of June + *Khajua*), which was 24.4 and 42.23% higher than the lowest value 0.18 and 2.06 plant<sup>-1</sup> respectively in T<sub>3</sub> (sowing in 4<sup>th</sup> week of June + Shikhar 3) and T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikhar 3). At 60 DAS the highest value 6.68 branches plant<sup>-1</sup> was observed in T<sub>2</sub> (sowing in 3<sup>rd</sup> week of June + *Khajua*).

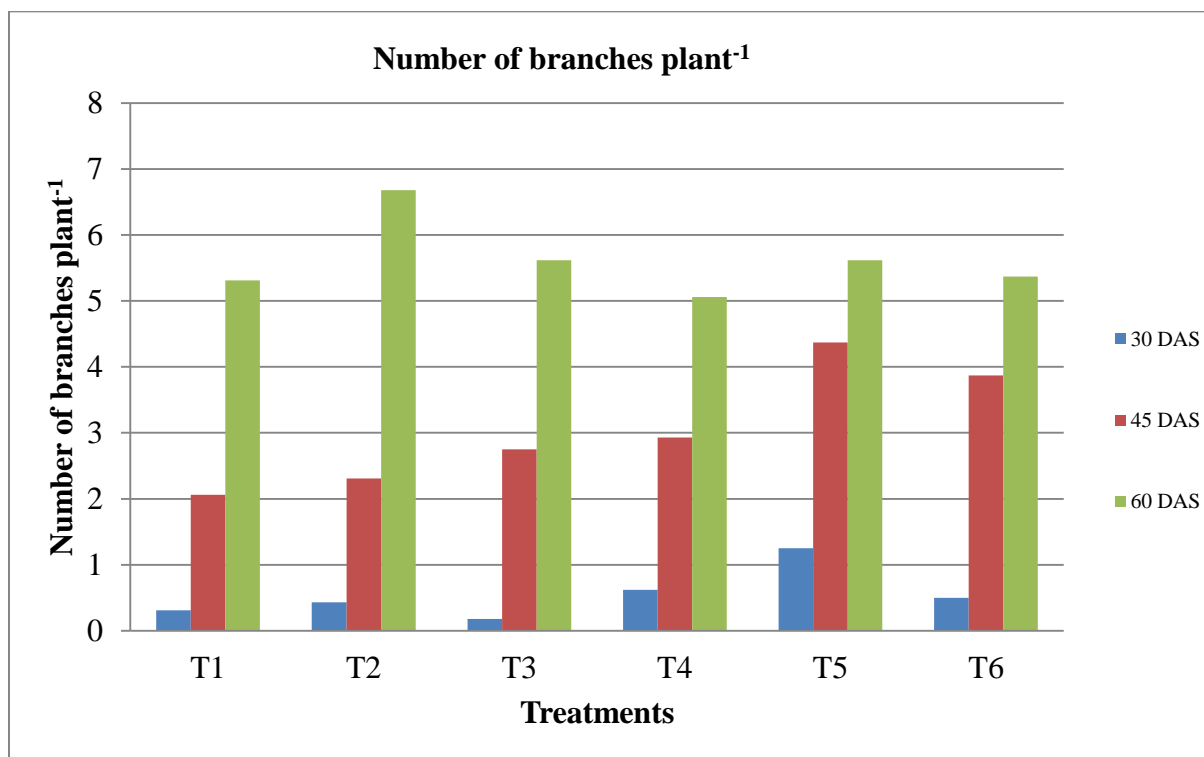
Between T<sub>5</sub> (sowing in 1<sup>st</sup> week of July + Shikhar 3) and T<sub>6</sub> (sowing in 1<sup>st</sup> week of July + *Khajua*), the former showed the highest branches 1.25, 4.37 and 5.62 plant<sup>-1</sup> at all growth stages.

The probable reason for increasing branches plant<sup>-1</sup> may be due to variety. The varietal characteristic of *Khajua* is spreading and dwarf type growth habit and have more number of branches. Similar finding was reported by Gupta *et al.* (2005). According to Trivedi (1996), Yadav and Shrivastava (1997) phosphorus application resulted in improved branches plant<sup>-1</sup> under the influence of P due to stimulation of root growth and increased metabolic activities.

**Table 4.3. Effect of sowing dates and varietal selection on number of branches of blackgram at different intervals**

Treatments		Branches plant <sup>-1</sup>		
		30 DAS	45 DAS	60 DAS
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	0.31	2.06	5.31
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	0.43	2.31	6.68
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	0.18	2.75	5.62
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	0.62	2.93	5.06
	S Ed ( $\pm$ )	0.29	0.65	1.09
	CD (P=0.05)	NS	NS	NS
	CV (%)	60.41	22.96	19.36
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	1.25	4.37	5.62
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	0.50	3.87	5.37
	S Ed ( $\pm$ )	0.41	0.93	1.54
	CD (P=0.05)	NS	NS	NS
	CV (%)	85.41	32.86	27.35

**\*Replicated twice**



**Fig. 4.3** Effect of sowing dates and varietal selection on number of branches plant<sup>-1</sup> of blackgram

#### 4.4 Number of Nodules plant<sup>-1</sup>

Observations regarding the effect of different sowing date and varietal selection on number of nodules plant<sup>-1</sup> of blackgram are given in table 4.4 and figure 4.4. It was noticed that successive stage there was an incremental trend.

The observation showed that all growth stages there was no significant difference between treatments, except to 15 DAS in treatments T<sub>5</sub> (sowing in 1<sup>st</sup> week of July + Shikhar 3) and T<sub>6</sub> (sowing in 1<sup>st</sup> week of July + *Khajua*).

At 15 DAS and 45 DAS the highest number of nodules 8.62 and 53.81 plant<sup>-1</sup> respectively were observed in T<sub>4</sub> (sowing in 4<sup>th</sup> week of June + *Khajua*), which was 115.5 and 26.61% higher than lowest value 4.00 and 42.50 plant<sup>-1</sup> respectively in the treatment T<sub>3</sub> (sowing in 4<sup>th</sup> week of June + Shikhar 3) and T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikhar 3). However, at 30 and 60 DAS, highest number of nodules 29.56 and 77.56 plant<sup>-1</sup> respectively were observed in T<sub>2</sub> (sowing in 3<sup>rd</sup> week of June + *Khajua*), which was 61.44 and 19.78% higher than lowest value 18.31 and 64.75 plant<sup>-1</sup> respectively in the treatment T<sub>4</sub> (sowing in 4<sup>th</sup> week of June + *Khajua*) and T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikhar 3).

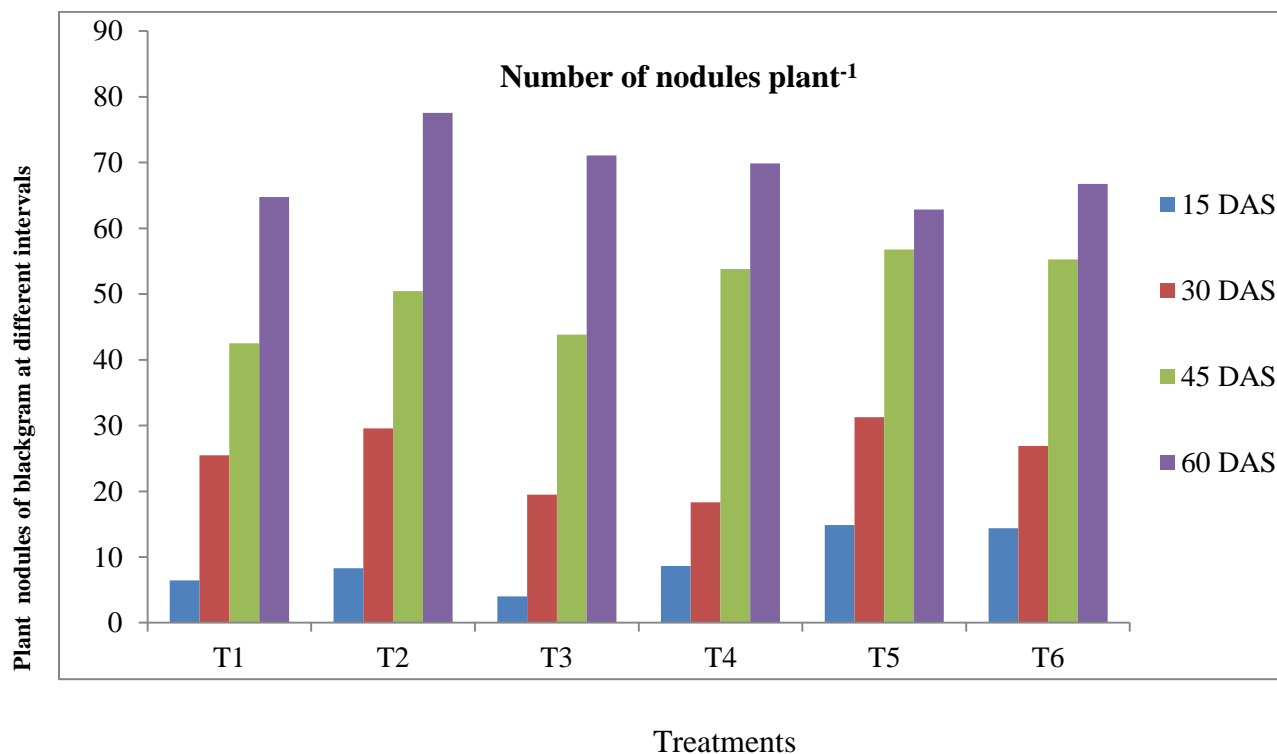
Between T<sub>5</sub> (sowing in 1<sup>st</sup> week of July + Shikhar 3) and T<sub>6</sub> (sowing in 1<sup>st</sup> week of July + *Khajua*), former observed the highest nodules 14.87, 31.25 and 56.75 plant<sup>-1</sup> at 15, 30 and 45 DAS respectively. However, at 60 DAS latter recorded maximum nodules 66.75 plant<sup>-1</sup>.

Probable reason for increased nodules may be due to inoculation with PSB culture. Similar finding was reported by Yadav (1990). Kumawat *et al.* (2008 and 2009) reported that the PSB enhanced the availability of P to the plants which may have contributed in greater root development and nodulation.

**Table 4.4. Effect of sowing dates and varietal selection on number of nodules plant<sup>-1</sup> of blackgram at different intervals**

Treatments		No. of nodules plant <sup>-1</sup>			
		15 DAS	30 DAS	45 DAS	60 DAS
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	6.43	25.50	42.50	64.75
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	8..31	29.56	50.43	77.56
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	4.00	19.50	43.81	71.06
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	8.62	18.31	53.81	69.87
	S Ed (±)	0.78	5.00	5.52	6.73
	CD (P=0.05)	1.71	NS	NS	NS
	CV (%)	8.45	20.50	11.19	9.66
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	14.87	31.25	56.75	62.87
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	14.37	26.87	55.25	66.75
	S Ed (±)	1.10	7.00	7.80	9.52
	CD (P=0.05)	NS	NS	NS	NS
	CV (%)	13.09	28.71	15.81	13.67

**\*Replicated twice**



**Fig. 4.4** Effect of sowing dates and varietal selection on number of nodules plant<sup>-1</sup> of blackgram

#### 4.5 Plant dry weight (g plant<sup>-1</sup>)

Observations regarding the effect of different sowing date and varietal selection on plant dry weight of blackgram are given in table 4.5 and Figure 4.5. It was noticed that successive stage there was an incremental trend.

The observation showed that all growth stages there was no significant difference between treatments, except at 30 DAS in treatment T<sub>5</sub> (sowing in 1<sup>st</sup> week of July + Shikhar 3) and T<sub>6</sub> (sowing in 1<sup>st</sup> week of July + *Khajua*).

At 15 DAS, 30 DAS and 45 DAS the highest dry weight 0.16, 1.34 and 4.32 g plant<sup>-1</sup> respectively were observed in T<sub>2</sub> (sowing in 3<sup>rd</sup> week of June + *Khajua*), which were 60, 63.41 and 46.44% higher than the lowest value 0.10 g plant<sup>-1</sup> in T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikhar 3) at 15 DAS and 0.82 and 2.95 g plant<sup>-1</sup> respectively in T<sub>4</sub> (sowing in 4<sup>th</sup> week of June + *Khajua*), at 30 and 45 DAS. However, at 60 DAS the highest dry weight 8.78 g plant<sup>-1</sup> was observed in T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikhar 3), which was 55.39% higher than lowest value 5.65 g plant<sup>-1</sup> in the treatment T<sub>4</sub> (sowing in 4<sup>th</sup> week of June + *Khajua*) at 60 DAS.

However, T<sub>5</sub> (sowing in 1<sup>st</sup> week of July + Shikhar 3) and T<sub>6</sub> (sowing in 4<sup>th</sup> week of July + *Khajua*) were significant at 30 DAS. Former was registered the highest dry weight 0.36, 2.33, 3.80 and 8.95 g plant<sup>-1</sup> respectively at all growth stages.

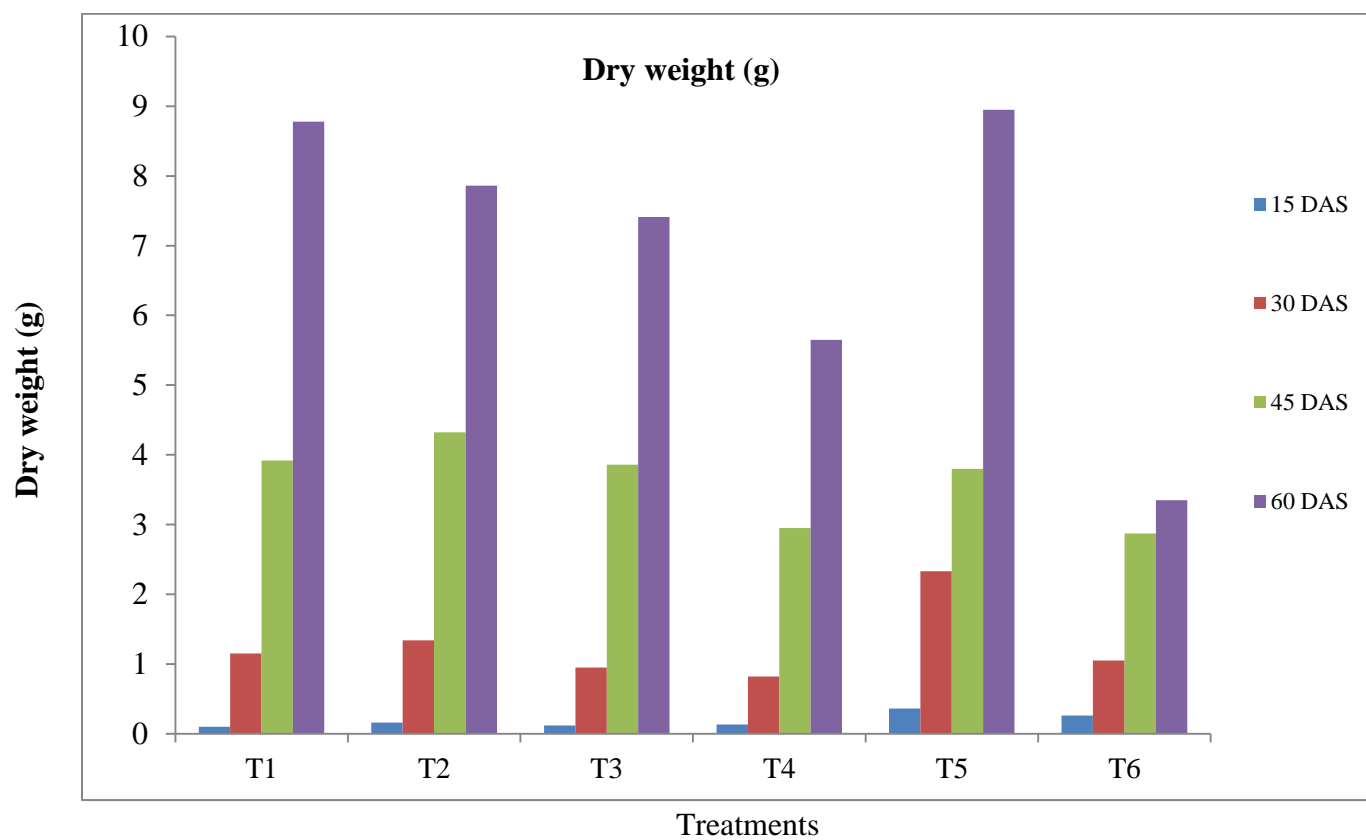
Probable reason for increasing dry matter accumulation of plant may be due to level of phosphorus and date of sowing. Singh *et al.* (2006) reported that increasing level of phosphorus increased dry matter accumulation plant. Phosphorus application might have resulted in root proliferation and increased density of root nodules, which in turn resulted in higher microbial activities in the root and hence better availability of N and P to plant occurred. This increased uptake of nutrient manifested in increased growth. According to Rabbani *et al.* (2013) plant dry weight were affected by date of sowing.

**Table 4.5. Effect of sowing dates and varietal selection on dry weight (g plant<sup>-1</sup>) of blackgram at different intervals**

Treatments		Dry weight (g plant <sup>-1</sup> )			
		15 DAS	30 DAS	45 DAS	60 DAS
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	0.10	1.15	3.92	8.78
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	0.16	1.34	4.32	7.86
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	0.12	0.95	3.86	7.41
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	0.13	0.82	2.95	5.65
	S Ed (±)	0.07	0.29	1.02	2.65
	CD (P=0.05)	NS	NS	NS	NS
	CV (%)	43.75	24.30	27.71	36.95
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	0.36	2.33	3.80	8.95
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	0.26	1.05	2.87	3.35
	S Ed (±)	0.10	0.41	1.45	3.74
	CD (P=0.05)	NS	0.90	NS	NS
	CV (%)	62.50	34.36	39.40	52.16

**\*Replicated twice**





**Fig. 4.5** Effect of sowing dates and varietal selection on dry weight ( $\text{g plant}^{-1}$ ) of blackgram

#### 4.6 Crop growth rate ( $\text{g m}^{-2} \text{ day}^{-1}$ )

Observation regarding the effect of different sowing date and varietal selection on crop growth rate ( $\text{g m}^{-2} \text{ day}^{-1}$ ) of blackgram are given in table 4.6 and figure 4.6. It was noticed that successive stage there was an incremental trend.

The observation showed that all growth stages there was no significant difference between treatments, except to 0 to 15 DAS and 15 to 30 DAS in  $T_5$  (sowing in 1<sup>st</sup> week of July + Shikhar 3) and  $T_6$  (sowing in 1<sup>st</sup> week of July + *Khajua*).

At 0 to 15 DAS and 15 to 30 DAS the highest crop growth rate 0.43 and  $3.14 \text{ g m}^{-2} \text{ day}^{-1}$  respectively in treatment  $T_2$ , which were 48.27 and 70.65% higher than the lowest value 0.29 and  $1.84 \text{ g m}^{-2} \text{ day}^{-1}$  respectively in treatments  $T_1$  (sowing in 3<sup>rd</sup> week of June + Shikhar 3) and  $T_4$  (sowing in 4<sup>th</sup> week of June + *Khajua*). However, at 30 to 45 DAS highest crop growth rate  $8.34 \text{ g m}^{-2} \text{ day}^{-1}$  recorded in  $T_3$  (sowing in 4<sup>th</sup> week of June + Shikhar 3), which was 47.34 higher than lowest value  $5.66 \text{ g m}^{-2} \text{ day}^{-1}$  in  $T_4$  (sowing in 4<sup>th</sup> week of June + *Khajua*) and 45 to 60 DAS the highest crop growth rate  $14.00 \text{ g m}^{-2} \text{ day}^{-1}$  was recorded in  $T_1$  (sowing in 3<sup>rd</sup> week of June + Shikhar 3), which was 94.71% higher than lowest value  $7.19 \text{ g m}^{-2} \text{ day}^{-1}$  in also  $T_4$  (Sowing in 4<sup>th</sup> week of June + *Khajua*).

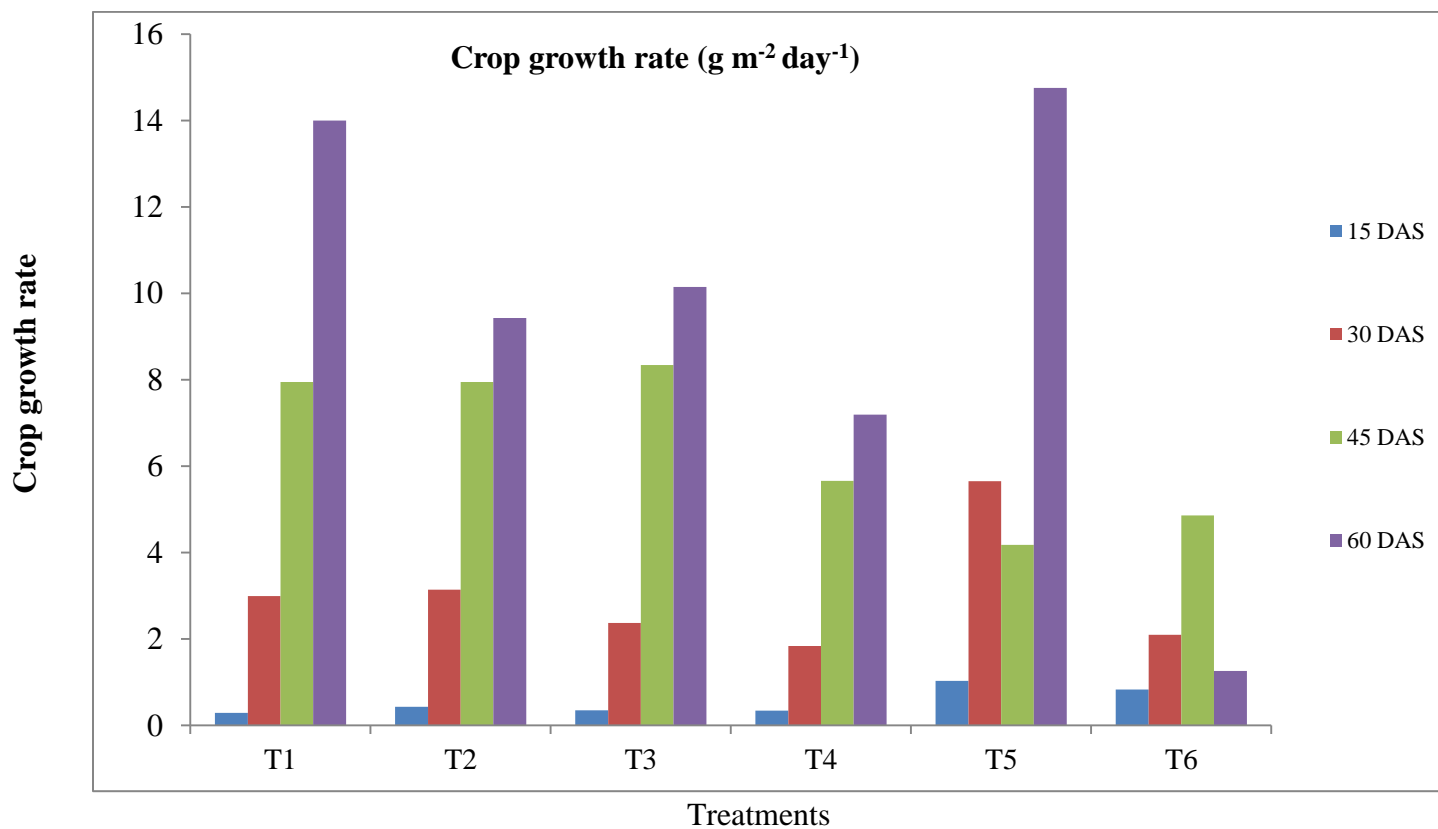
However, between  $T_5$  (sowing in 1<sup>st</sup> week of July + Shikhar 3) and  $T_6$  (Sowing in 1<sup>st</sup> week of July + *Khajua*), former was recorded highest value 1.03, 5.65 and  $14.74 \text{ g m}^{-2} \text{ day}^{-1}$  respectively at 0 to 15, 15 to 30 and 45 to 60. However, latter was recorded the higher value  $4.86 \text{ g m}^{-2} \text{ day}^{-1}$  at 30 to 45 DAS.

Increased CGR may be due to the early sowing resulting in better growth under suitable climate and higher moisture availability. Similar finding was reported by Baghel and Yadav (1992), Mendheet *al.* (2002) and Singh and Singh (2002).

**Table 4.6. Effect of sowing dates and varietal selection on CGR ( $\text{g m}^{-2} \text{ day}^{-1}$ ) of blackgram at different intervals**

Treatments		Crop growth rate ( $\text{g m}^{-2} \text{ day}^{-1}$ )			
		Growth Interval			
		0 to 15 DAS	15 to 30 DAS	30 to 45 DAS	45 to 60 DAS
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	0.29	2.99	7.95	14.00
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	0.43	3.14	7.95	9.43
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	0.35	2.37	8.34	10.15
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	0.34	1.84	5.66	7.19
	S Ed ( $\pm$ )	0.14	0.78	2.03	5.41
	CD (P=0.05)	NS	NS	NS	NS
	CV (%)	29.78	27.46	33.83	55.43
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	1.03	5.65	4.18	14.76
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	0.83	2.10	4.86	1.26
	S Ed ( $\pm$ )	0.20	1.11	2.87	7.65
	CD (P=0.05)	0.40	2.44	NS	NS
	CV (%)	42.55	39.08	41.71	78.38

**\*Replicated twice**



**Fig. 4.6** Effect of sowing dates and varietal selection on CGR (g m<sup>-2</sup> day<sup>-1</sup>) of blackgram

#### 4.7 Relative growth rate ( $\text{g g}^{-1} \text{ day}^{-1}$ )

Observation regarding the effect of different sowing date and varietal selection on relative growth rate ( $\text{g g}^{-1} \text{ day}^{-1}$ ) of blackgram are given in table 4.7 and figure 4.7. It was noticed that successive stage there was an incremental trend.

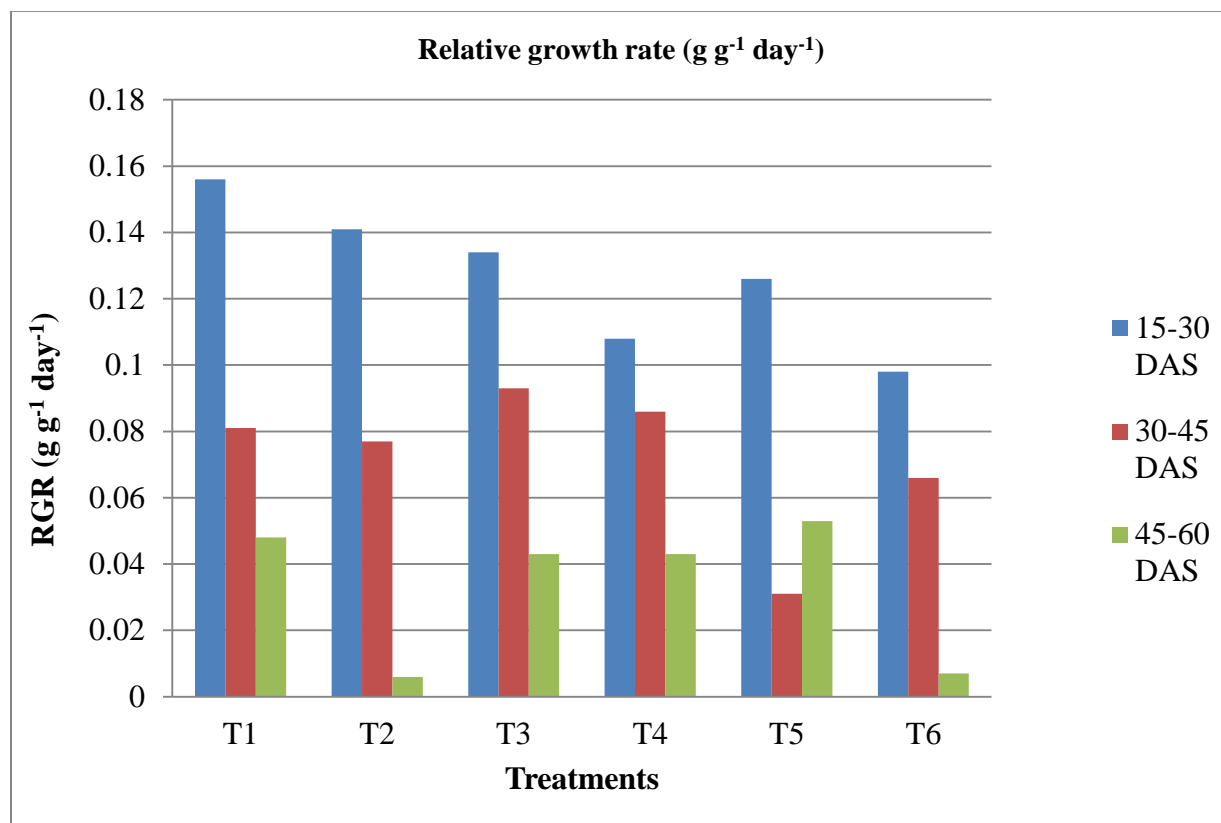
The observation showed that all growth stages there was no significant different between treatments. At 15 to 30 and 45 to 60 DAS maximum relative growth rate  $0.156$  and  $0.081 \text{ g g}^{-1} \text{ day}^{-1}$  in  $T_1$  (sowing in 3<sup>rd</sup> week of June +Shikhar 3), which was 44.44% higher than lowest value  $0.108 \text{ g g}^{-1} \text{ day}^{-1}$  in  $T_4$  (sowing in 4<sup>th</sup> week of June +*Khajua*) and 11.62% higher than lowest value  $0.006 \text{ g g}^{-1} \text{ day}^{-1}$  in  $T_2$  (sowing in 3<sup>rd</sup> week of June +*Khajua*). However, 30 to 45 DAS maximum relative growth rate  $0.093 \text{ g g}^{-1} \text{ day}^{-1}$  recorded in  $T_3$  (sowing in 4<sup>th</sup> week of June +Shikhar3), which was 20.77% higher than lowest value  $0.077$  in  $T_2$  (sowing in 3<sup>rd</sup> week of June +*Khajua*).

Between  $T_5$  (sowing in 1<sup>st</sup> week of July +Shikhar3) and  $T_6$  (sowing in 1<sup>st</sup> week of July +*Khajua*), former was recorded maximum value at 15 to 30 and 45 to 60 DAS. However, at 30 to 45 DAS latter was recorded higher value  $0.066 \text{ g g}^{-1} \text{ day}^{-1}$ .

**Table 4.7. Effect of sowing dates and varietal selection on RGR ( $\text{g g}^{-1} \text{ day}^{-1}$ ) of blackgram at different intervals**

Treatments		Relative growth rate ( $\text{g g}^{-1} \text{ day}^{-1}$ )		
		Growth Interval		
		15 to 30 DAS	30 to 45 DAS	45 to 60 DAS
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	0.156	0.081	0.048
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	0.141	0.077	0.006
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	0.134	0.093	0.043
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	0.108	0.086	0.043
	S Ed ( $\pm$ )	0.017	0.017	0.009
	CD (P=0.05)	NS	NS	NS
	CV (%)	13.07	22.00	24.16
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	0.126	0.031	0.053
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	0.098	0.066	0.007
	S Ed ( $\pm$ )	0.020	0.026	0.014
	CD (P=0.05)	NS	NS	NS
	CV (%)	15.38	33.76	34.17

**\*Replicated twice**



**Fig. 4.7** Effect of sowing dates and varietal selection on RGR ( $\text{g g}^{-1} \text{ day}^{-1}$ ) of blackgram

#### 4.8 Yield and yield attributes

Observation regarding the effect of different sowing date and varietal selection on yield and yield attributes of blackgram are given in table 4.8 and figure 4.8.

The observation showed that yield and yield attributes there was no significant difference between treatments, except to seed yield ( $\text{kg ha}^{-1}$ ) and harvest index (%). However, in seed yield  $T_3$  (sowing in 4<sup>th</sup> week of June + Shikhar 3) was recorded statistically at par to that obtained under  $T_1$  (sowing in 3<sup>rd</sup> week of June + Shikhar 3) and in harvest index (%),  $T_1$  (sowing in 3<sup>rd</sup> week of June + Shikhar 3) also was recorded statistically at par to that obtained under  $T_3$  (sowing in 4<sup>th</sup> week of June + Shikhar 3).

With regard to yield and yield attributes the highest value viz., 29.00 pods  $\text{plant}^{-1}$ , 6.50 grains  $\text{pod}^{-1}$ , 32.85 g, 680.00 and 2412.50  $\text{kg ha}^{-1}$  were registered in the treatment  $T_1$  (sowing in 3<sup>rd</sup> week of June + Shikhar 3), which were 90.16, 5.17, 10.97, 170 and 40.15% higher than the lowest value of 15.25 pods  $\text{plant}^{-1}$ , 6.18 grains  $\text{pod}^{-1}$ , 29.60 g, 251.25 and 1721.25  $\text{kg ha}^{-1}$  in the treatment  $T_2$  (sowing in 3<sup>rd</sup> week of June + *Khajua*). However,  $T_3$  (sowing in 4<sup>th</sup> week of June + Shikhar 3) showed higher value of 23.09% which was 66.83% higher than lowest value 13.84% in  $T_2$  (sowing in 3<sup>rd</sup> week of June + *Khajua*).

Between  $T_5$  (sowing in 1<sup>st</sup> week of July + Shikhar 3) and  $T_6$  (sowing in 1<sup>st</sup> week of July + *Khajua*), the former registered the highest value 21.25 in number of pods  $\text{plant}^{-1}$ , 617.50 in seed yield ( $\text{kg ha}^{-1}$ ), 1540 in stover yield ( $\text{kg ha}^{-1}$ ) and 28.03 in harvest index (%) and latter registered the highest value 6.62 and 30.90 respectively in number of grains  $\text{pod}^{-1}$  and test weight (g). In some of the growth parameters variety *Khajua* performed better. However, in the yield parameters variety Shikhar 3 performed better under heavy rainfall (1349.25 mm received from 67 rainy days) condition. Further, it was observed that the infestation of YVMV on variety *Khajua* was consequential in reducing the yield.

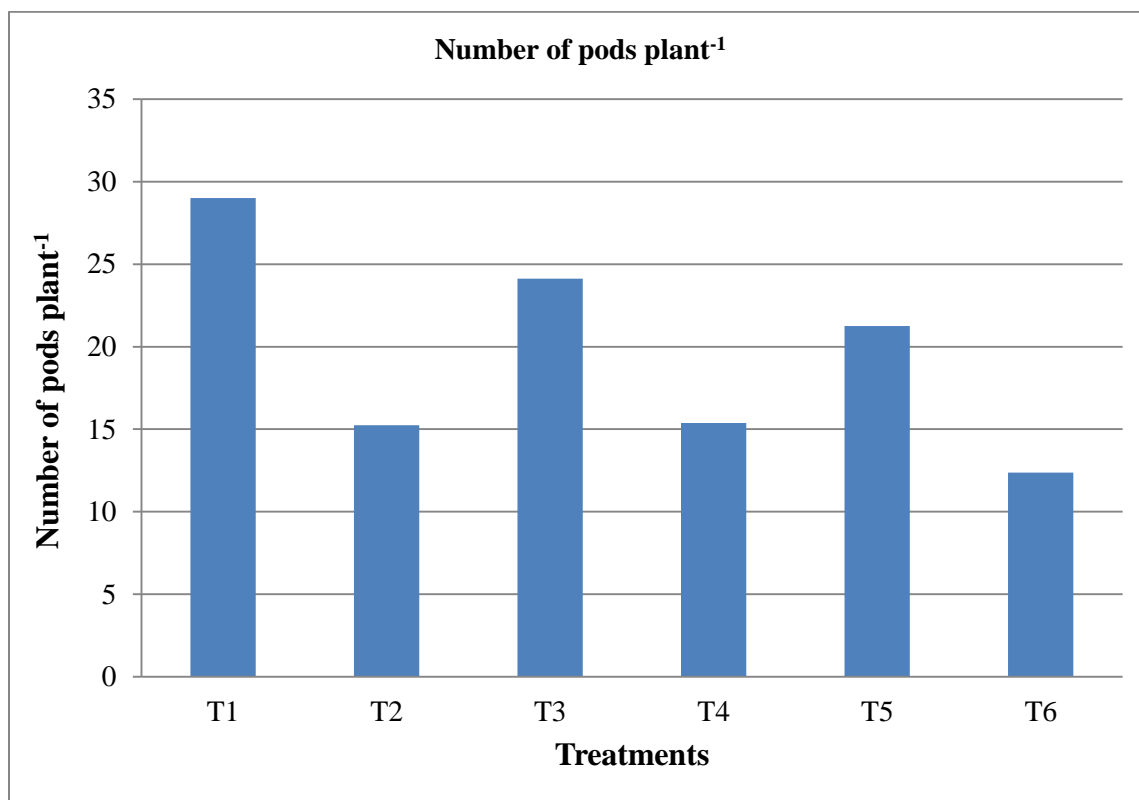
The highest seed yield  $\text{ha}^{-1}$  may be due to early sown crop (Yadahalli and Palled, 2004) and more uptake of P (Singh and Singh, 2000) as expressed due to variety (Ihsanullah *et al.*, 2006).



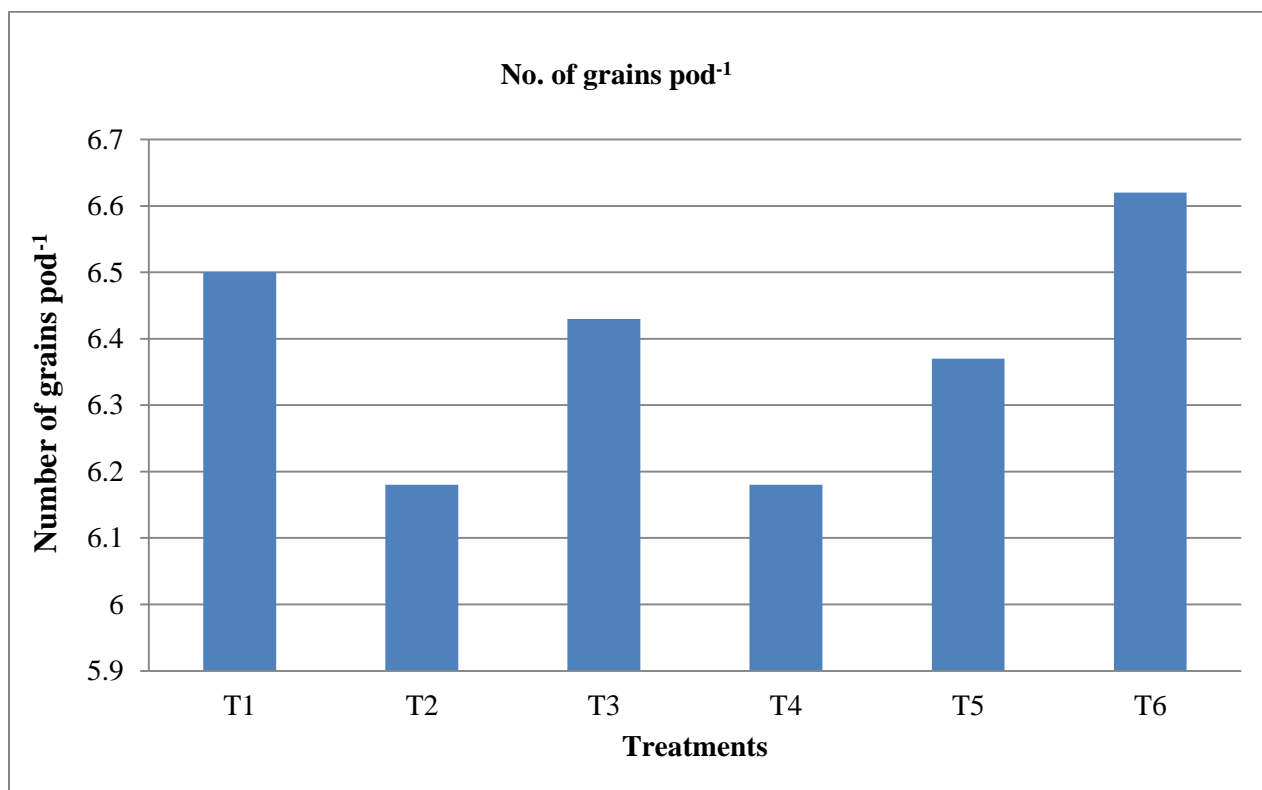
Further, the harvest index increase may also be due to the varietal feature as reported by Gupta *et al.* (2006).

**Table 4.8. Effect of sowing dates and varietal selection on yield and yield attributes of blackgram**

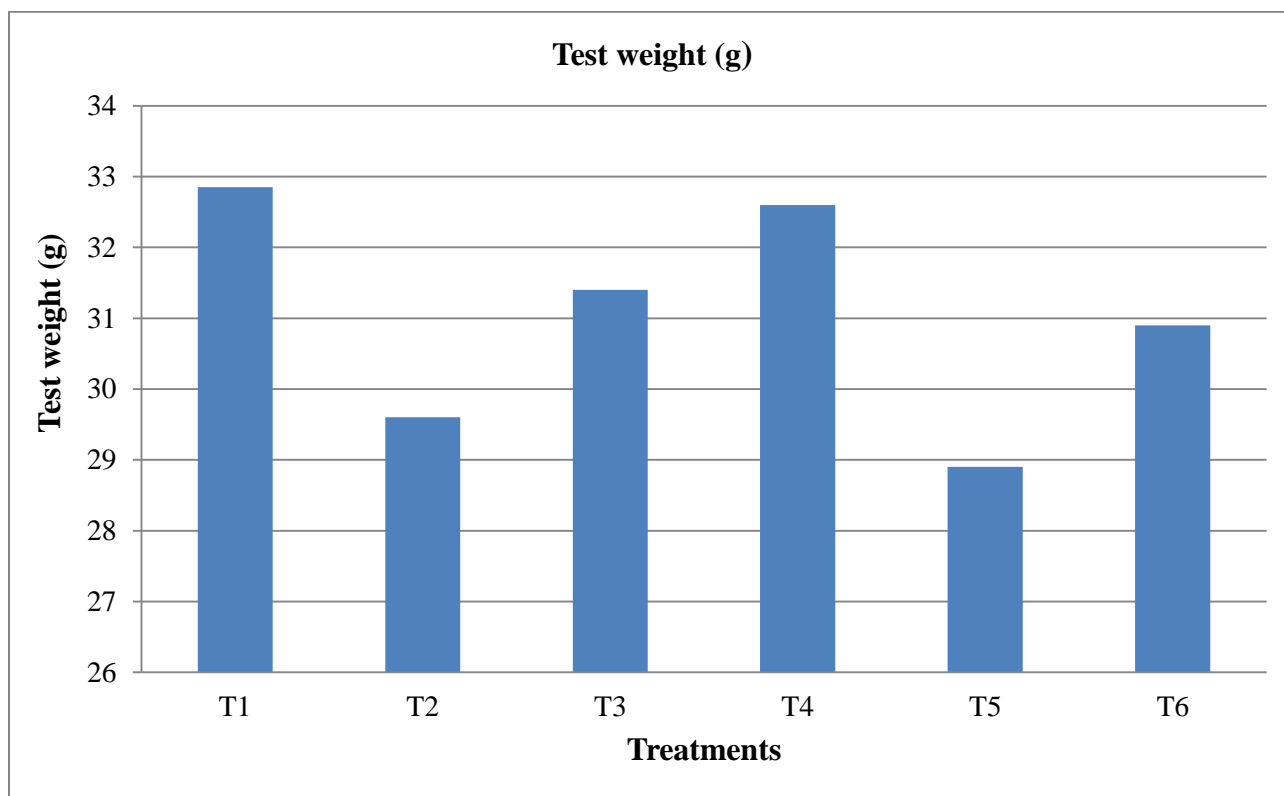
Treatments		Yield and yield attributes					
		No. of pods plant <sup>-1</sup>	No. of grains pod <sup>-1</sup>	Test weight (g)	Seed yield (kg ha <sup>-1</sup> )	Stover yield (kg ha <sup>-1</sup> )	Harvest index (%)
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	29.00	6.50	32.85	680.00	2412.50	22.21
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	15.25	6.18	29.60	251.25	1721.25	13.84
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	24.12	6.43	31.40	625.00	2060.00	23.09
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	15.37	6.18	32.60	338.75	1966.25	15.11
	S Ed (±)	6.59	0.60	3.38	125.40	461.22	3.45
	CD (P=0.05)	NS	NS	NS	276.00	NS	7.59
	CV (%)	32.76	9.43	10.80	26.22	24.25	17.15
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	21.25	6.37	28.90	617.50	1540.00	28.03
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	12.37	6.62	30.90	375.00	1155.00	24.55
	S Ed (±)	9.32	0.86	4.78	177.35	652.26	4.88
	CD (P=0.05)	NS	NS	NS	NS	NS	NS
	CV (%)	46.34	13.52	15.28	37.08	34.30	24.26



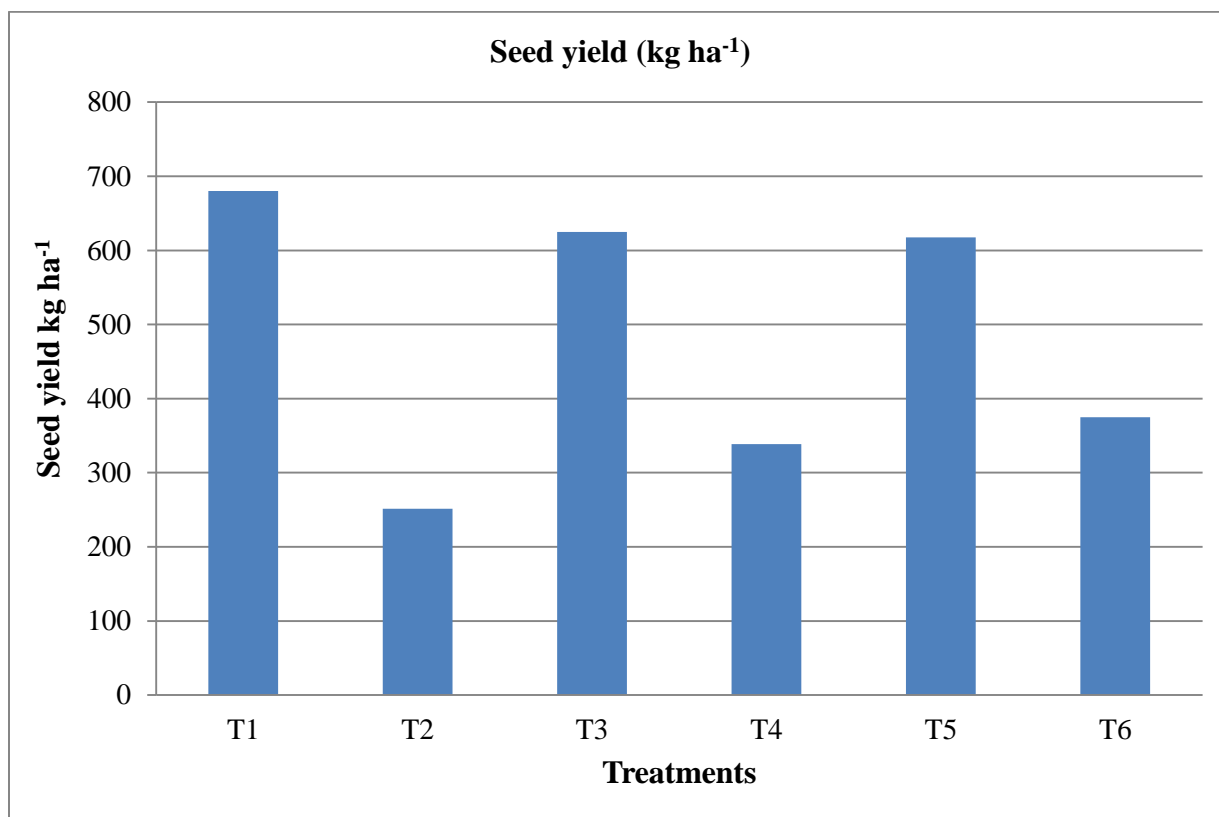
**Fig. 4.8.1** Effect of sowing dates and varietal selection on number of pods plant<sup>-1</sup> of blackgram



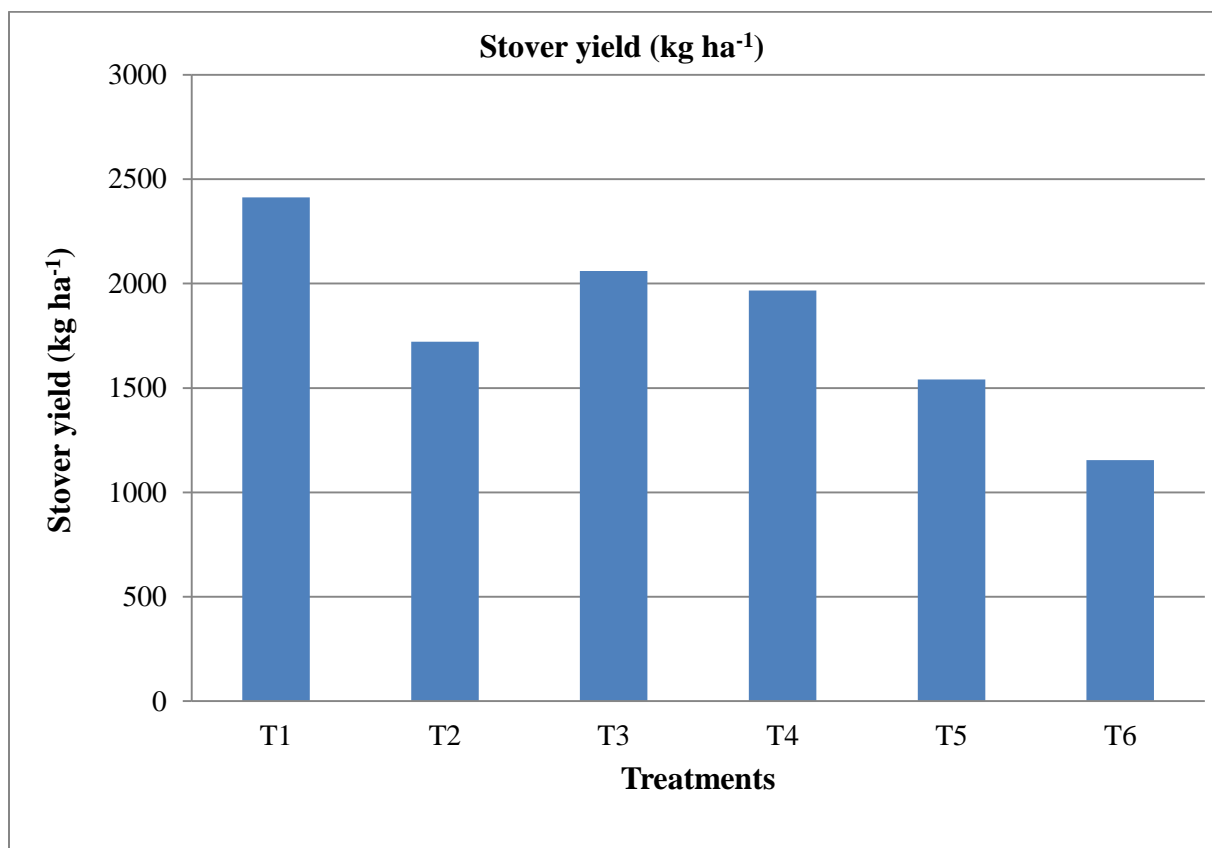
**Fig. 4.8.2** Effect of sowing dates and varietal selection on number of grains pod<sup>-1</sup> of blackgram



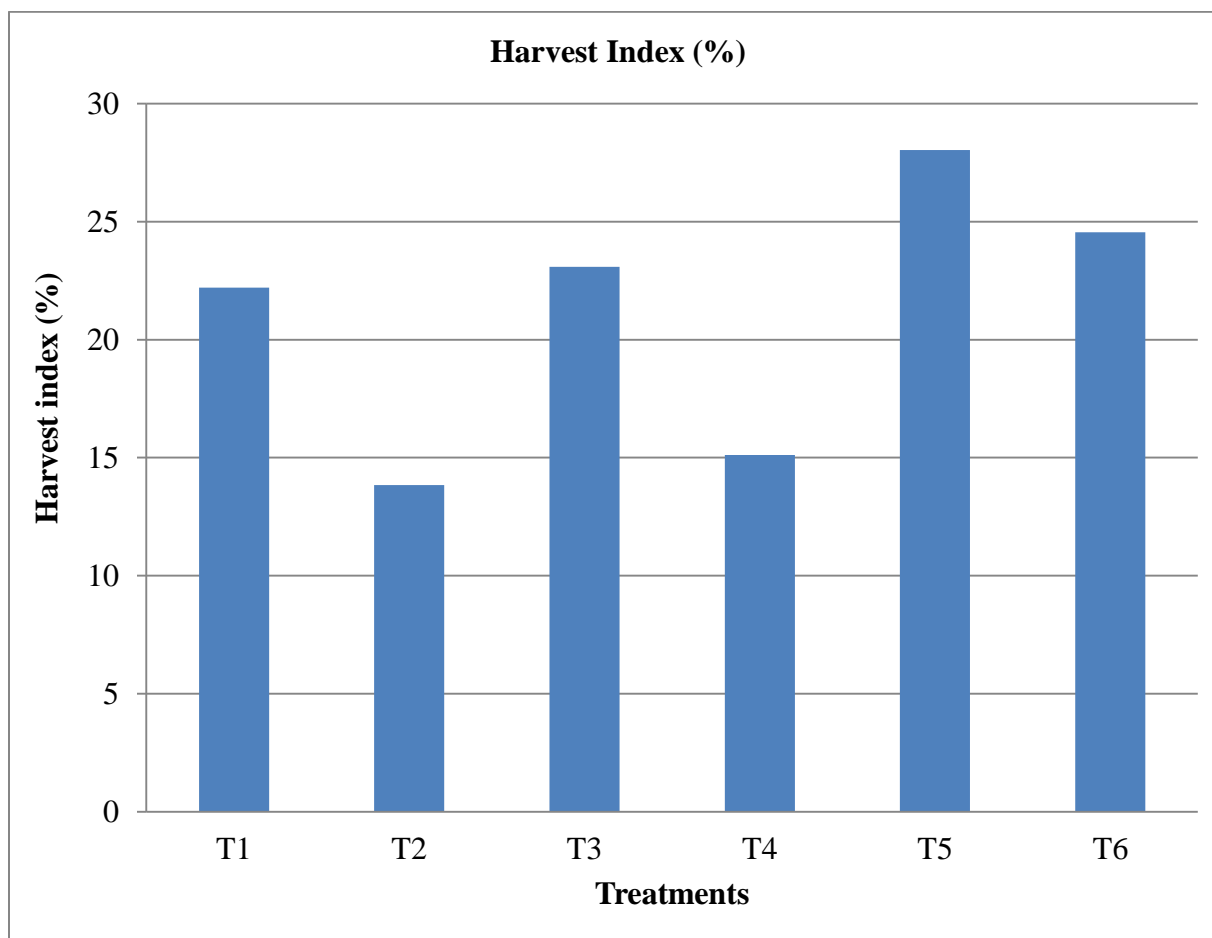
**Fig. 4.8.3** Effect of sowing dates and varietal selection on test weight (g) of blackgram



**Fig. 4.8.4** Effect of sowing dates and varietal selection on seed yield (kg ha<sup>-1</sup>) of blackgram



**Fig. 4.8.5** Effect of sowing dates and varietal selection on stover yield (kg ha<sup>-1</sup>) of blackgram



**Fig. 4.8.6** Effect of sowing dates and varietal selection on harvest index (%) of blackgram

#### 4.9 Protein content

Observations regarding the effect of different sowing date and varietal selection on protein content of blackgram are given in table 4.9.

With regard to protein content highest protein content 23.12% was recorded in treatment T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikhar 3).

The high protein content may be due to early sowing. Similar finding was reported by Adjei and Splittstoesser (1994) in soybean. Decline in protein content may be due to delayed sowing. The seed size get reduced under the delayed sowing (Ball *et al.*, 2000; Herbert and Litchfield, 1984) due to insufficient vegetative growth and yield attributes under late sown conditions.



**Table 4.9. Effect of sowing dates and varietal selection on protein content of blackgram**

Treatments		Protein (%)
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	23.12
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	22.00
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	22.10
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	22.60
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	21.90
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	21.10
*Replicated twice		

#### 4.10 Economics of treatments

Observations regarding the effect of different sowing date and varietal selection on economic of blackgram are given in table 4.10.

The highest gross return ₹28625.00 ha<sup>-1</sup>, net return ₹19175.00 ha<sup>-1</sup> and BC ratio 3.02 was registered in treatment T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikhar 3).

The highest net return and benefit cost ratio may be due to combination effect of early sown and varietal feature. Similar finding was reported by Yadahalli and palled (2004) and Verma *et al.* (2011).

This can be attributed to higher blackgram yield in this treatment combination over others.

**Table 4.10. Economics of different treatments**

	<b>Treatments</b>	<b>Sale rate (₹) grain ha<sup>-1</sup></b>	<b>Sale rate (₹) stover ha<sup>-1</sup></b>	<b>Gross return (₹ ha<sup>-1</sup>)</b>	<b>Cost of cultivation (₹ ha<sup>-1</sup>)</b>	<b>Net return (₹ ha<sup>-1</sup>)</b>	<b>B:C ratio</b>
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	23800.00	4825.00	28625.00	9450	19175.00	3.02
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	8793.75	3442.50	12236.25	8850	3386.25	1.38
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	21875.00	4120.00	25995.00	9450	16545.00	2.75
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	11856.25	3932.50	15788.75	8850	6938.75	1.78
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	21612.50	3080.00	24692.50	9450	15242.50	2.61
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	13125.00	2310.00	15435.00	8850	6585.00	1.74

**\*Replicated twice**

Note: Selling price of blackgram grain = ₹ 35 kg<sup>-1</sup>

Selling price of blackgram stover = ₹ 2 kg<sup>-1</sup>

**Table 4.11. Post harvest chemical analysis of soil**

	<b>Treatments</b>	<b>Organic carban (%)</b>	<b>Available P (%)</b>	<b>Available K (%)</b>	<b>pH</b>	<b>E.C.</b>
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	0.43	13.5	268	7.3	1.115
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	0.45	22.5	313	7.1	1.125
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	0.39	22.5	313	7.1	1.135
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	0.37	13.5	302	7.9	1.141
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	0.42	13.5	302	7.4	1.145
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	0.40	18.0	313	7.3	1.165

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**\*Replicated twice**



## *CHAPTER - 5*

### *SUMMARY AND CONCLUSION*

## CHAPTER 5

### SUMMARY AND CONCLUSION

An experiment entitled, “Effect of sowing date and varietal selection on the growth and yield of blackgram (*Vigna mungo* L.) under rainfed farming in the context of climate change in Sagar (Madhya Pradesh)”, was carried out under the On Farm Adaptive Research, in Shahgarh *Tehsil* and Block of Sagar (Madhya Pradesh) during the *Kharif* season of 2013, in Randomized Block Design having six treatments and four replications. The experiment was conducted to study the agronomic performance of two cultivars of blackgram as influenced by different sowing dates. The experimental findings based on treatment factors are summarized below.

#### 1. To study the effect of different sowing dates on the growth and yield of blackgram.

The sowing in 3<sup>rd</sup> week of June recorded maximum plant height (49.81 cm), number of leaves plant<sup>-1</sup> (52.12), number of branches plant<sup>-1</sup> (6.68), number of nodules plant<sup>-1</sup> (77.56) at 60 DAS and relative growth rate (0.048 g g<sup>-1</sup> day<sup>-1</sup>) at 45-60 DAS. Further, the same sowing date registered higher number of pods plant<sup>-1</sup> (29.00), number of grains pod<sup>-1</sup> (6.50), test weight (32.85 g), seed yield (680 kg ha<sup>-1</sup>), stover yield (2412.50 kg ha<sup>-1</sup>).

#### 2. To assess the suitability of blackgram cultivars.

With regard to some growth parameters at 60 DAS, cultivar Shikhar 3 registered higher value of plant height (49.81 cm), dry weight (8.95 g plant<sup>-1</sup>); crop growth rate (14.76 g m<sup>-2</sup> day<sup>-1</sup>), relative growth rate (0.053 g g<sup>-1</sup> day<sup>-1</sup>) both at 45 to 60 DAS interval and yield attributes and yield, viz., number of pods plant<sup>-1</sup> (29.00), number of grains pod<sup>-1</sup> (6.50), test weight (32.85 g), seed yield (680 kg ha<sup>-1</sup>), stover yield (2412.50 kg ha<sup>-1</sup>).

However, variety *Khajua* registered higher number of leaves plant<sup>-1</sup> (52.12), number of branches plant<sup>-1</sup> (6.68) and number of nodules plant<sup>-1</sup> (77.56) at 60 DAS.

#### 3. To determine economics of different treatment combinations

The highest gross return (₹ 28625.00 ha<sup>-1</sup>), net return (₹ 19175.00 ha<sup>-1</sup>) and benefit cost ratio (3.02) was registered in treatment T<sub>1</sub> (sowing in 3<sup>rd</sup> week of June + Shikhar 3), which was 133.93%, 466.26% and 118.83% respectively higher compared to the lowest value (₹ 12236.25 ha<sup>-1</sup>, ₹ 3386.25 ha<sup>-1</sup> and 1.38 respectively) in the treatment T<sub>2</sub> (Sowing in 3<sup>rd</sup> week of June + *Khajua*).

### **Farmers' feedback / opinion**

- Among different dates of sowing 3<sup>rd</sup> week of June was found appropriate for growth and yield of rainfed blackgram (Urdbean) for this region.
- Among both varieties the variety Shikhar 3 was found to be suitable for this climatic condition and also found resistant against yellow vein mosaic virus and observed to possess the higher yield attributes and yield compare to variety *Khajua*.
- The variety Shikhar 3 was observed to be more profitable for the farmers as evinced by maximum net returns and BC ratio.
- Neem oil (0.33%) was found to be the best for safe control of YVMV (yellow vein mosaic virus) as against ineffective chemical pesticides.

### **CONCLUSION**

It may be concluded that among the different dates of sowing 3<sup>rd</sup> week of June in combination with variety Shikhar 3 was found to be the best for obtaining highest seed yield and benefit cost ratio in blackgram under rainfed condition of Sagar district of Madhya Pradesh. The stakeholders of SAF-BIN programme in the region also are in consensus with the findings. Therefore, the learning of the current experiment may be scaled-up for further, strengthening the model of FPDCS for the greater course of sustainable among small-holders farmers.



## *CHAPTER – 6*

# *BIBLIOGRAPHY*



## CHAPTER 6

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# *APPENDICES*



**Plate 1 Field observation for data on plant growth of blackgram in Beela village of Shahgarh Tehsil and Block.**

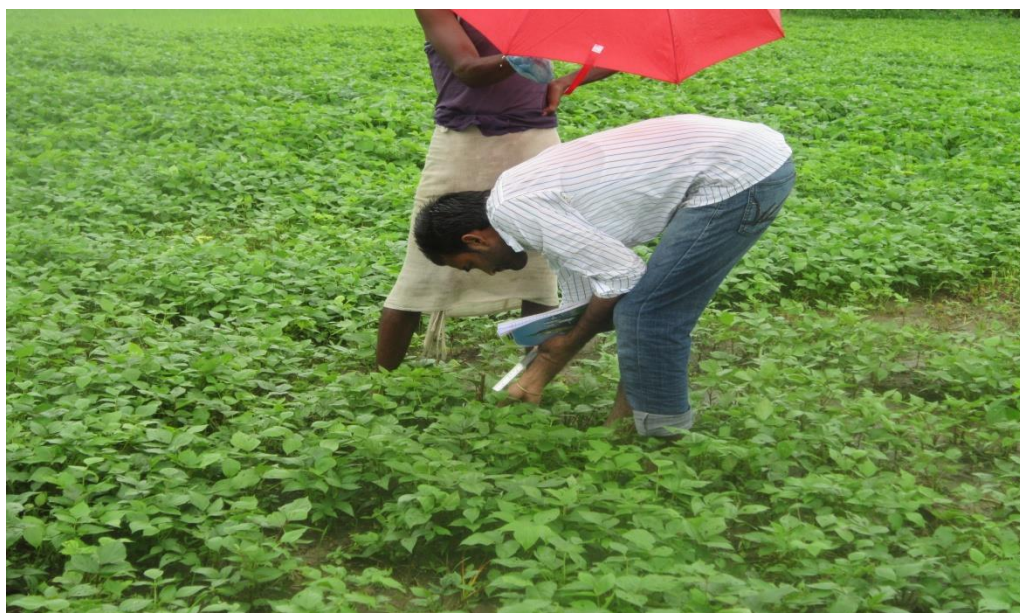


**Plate 2 Field observation with Research Officer of SAF-BIN for data on plant growth of blackgram in Shashan village of Shahgarh Tehsil and block**





**Plate 3** Field observation with VRA for data on plant growth of blackgram in Kanikheri village of Shahgarh *Tehsil* and block



**Plate 4** Field observation for data on plant growth of cultivar Shikhar 3 of blackgram in Bagrohi village of Shahgarh *Tehsil* and block



**Plate 5** Shikhar 3 cultivar of blackgram at 30 DAS was observed to be YVMV resistant in Khushipura village of Shahgarh Tehsil and Block



**Plate 6** *Khajua* cultivar of blackgram at 30 DAS was observed to be YVMV susceptible, perhaps due to the indirect impact of climate variation

## APPENDIX-I

**ANOVA Table 1. Plant height (cm) of blackgram at 15 DAS**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	4.5	1.5	3	3.59	NS
Due to treatments	5	34.75	6.95	13.9	3.20	S
Due to Error	11	5.57	0.50			
Total	19	44.82	2.35			

**ANOVA Table 2. Plant height (cm) of blackgram at 30 DAS**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	72.19	24.06	1.20	3.59	NS
Due to treatment	5	69.4	13.88	0.69	3.20	NS
Due to error	11	219.84	19.98			
Total	19	361.43	19.022			

**ANOVA Table 3. Plant height (cm) of blackgram at 45 DAS**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	54	18	0.44	3.59	NS
Due to treatment	5	124.35	24.87	0.61	3.20	NS
Due to error	11	447.18	40.65			
Total	19	625.53	32.92			



**ANOVA Table 4. Plant height (cm) of blackgram at 60 DAS**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	37.87	12.62	0.129	3.59	NS
Due to treatment	5	416.84	83.368	0.855	3.20	NS
Due to error	11	1072.43	97.49			
Total	19	1527.14	80.37			

**ANOVA Table 5. Number of leaves plant<sup>-1</sup> of blackgram at 15 DAS**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	11.09	3.696	2.505	3.59	NS
Due to treatment	5	64.965	12.99	8.806	3.20	NS
Due to error	11	16.225	1.475			
Total	19	92.28	4.85			

**ANOVA Table 6. Number of leaves plant<sup>-1</sup> of blackgram at 30 DAS**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	180.29	60.09	7.31	3.59	S
Due to treatment	5	139.11	27.82	2.52	3.20	NS
Due to error	11	90.38	8.21			
Total	19	409.78	21.56			

**ANOVA Table 7. Number of leaves plant<sup>-1</sup> of blackgram at 45 DAS**

<b>SV</b>	<b>df</b>	<b>SS</b>	<b>MSS</b>	<b>F Cal</b>	<b>F Tab (5%)</b>	<b>Result</b>
Due to replication	3	47.73	15.91	0.18	3.59	NS
Due to treatment	5	96.37	19.27	0.22	3.20	NS
Due to error	11	954.9	86.80			
Total	19	1099	57.84			

**ANOVA Table 8. Number of leaves plant<sup>-1</sup> of blackgram at 60 DAS**

<b>SV</b>	<b>df</b>	<b>SS</b>	<b>MSS</b>	<b>F Cal</b>	<b>F Tab (5%)</b>	<b>Result</b>
Due to replication	3	162.34	54.11	0.85	3.59	NS
Due to treatment	5	374.13	74.82	1.18	3.20	NS
Due to error	11	693.17	63.01			
Total	19	1229.64	64.71			

**ANOVA Table 9. Number of branches plant<sup>-1</sup> at 30 DAS**

<b>SV</b>	<b>df</b>	<b>SS</b>	<b>MSS</b>	<b>F Cal</b>	<b>F Tab (5%)</b>	<b>Result</b>
Due to replication	3	0.95	0.316	1.82	3.59	NS
Due to treatment	5	1.72	0.344	2	3.20	NS
Due to error	11	1.89	0.17			
Total	19	4.56	0.24			



**ANOVA Table 10. Number of branches plant<sup>-1</sup> at 45 DAS**

<b>SV</b>	<b>df</b>	<b>SS</b>	<b>MSS</b>	<b>F Cal</b>	<b>F Tab (5%)</b>	<b>Result</b>
Due to replication	3	9.3	3.1	3.56	3.59	NS
Due to treatment	5	10.46	2.09	2.40	3.20	NS
Due to error	11	9.64	0.87			
Total	19	29.4	1.54			

**ANOVA Table 11. Number of branches plant<sup>-1</sup> at 60 DAS**

<b>SV</b>	<b>df</b>	<b>SS</b>	<b>MSS</b>	<b>F Cal</b>	<b>F Tab (5%)</b>	<b>Result</b>
Due to replication	3	5.04	1.68	0.7	3.59	NS
Due to treatment	5	6.29	1.25	0.52	3.20	NS
Due to error	11	26.42	2.40			
Total	19	37.75	1.98			

**ANOVA Table 12. Number of nodules plant<sup>-1</sup> of blackgram at 15 DAS**

<b>SV</b>	<b>df</b>	<b>SS</b>	<b>MSS</b>	<b>F Cal</b>	<b>F Tab (5%)</b>	<b>Result</b>
Due to replication	3	108.38	36.12	29.36	3.59	S
Due to treatment	5	248.32	49.66	40.37	3.20	S
Due to error	11	13.58	1.23			
Total	19	370.28	19.48			

**ANOVA Table 13. Number of nodules plant<sup>-1</sup> of blackgram at 30 DAS**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	68.82	22.94	0.45	3.59	NS
Due to treatment	5	461.80	92.36	1.84	3.20	NS
Due to error	11	550.3	50.02			
Total	19	1080.92	56.89			

**ANOVA Table 14. Number of nodules plant<sup>-1</sup> of blackgram at 45 DAS**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	126.79	42.26	0.69	3.59	NS
Due to treatment	5	573.84	114.76	1.88	3.20	NS
Due to error	11	670.96	60.99			
Total	19	1371.59	72.18			

**ANOVA Table 15. Number of nodules plant<sup>-1</sup> of blackgram at 60 DAS**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	155.63	51.87	0.57	3.59	NS
Due to treatment	5	463.24	92.64	1.02	3.20	NS
Due to error	11	997.79	90.70			
Total	19	1616.66	85.08			

**ANOVA Table 16. Plant dry weight (g) of blackgram at 15 DAS**

<b>SV</b>	<b>df</b>	<b>SS</b>	<b>MSS</b>	<b>F Cal</b>	<b>F Tab (5%)</b>	<b>Result</b>
Due to replication	3	0.01	0.003	0.3	3.59	NS
Due to treatment	5	0.11	0.02	2	3.20	NS
Due to error	11	0.16	0.01			
Total	19	0.28	0.014			

**ANOVA Table 17. Plant dry weight (g) of blackgram at 30 DAS**

<b>SV</b>	<b>df</b>	<b>SS</b>	<b>MSS</b>	<b>F Cal</b>	<b>F Tab (5%)</b>	<b>Result</b>
Due to replication	3	1.08	0.36	2.11	3.59	NS
Due to treatment	5	3.5	0.7	4.11	3.20	S
Due to error	11	1.93	0.17			
Total	19	6.51	0.34			

**ANOVA Table 18. Plant dry weight (g) of blackgram at 45 DAS**

<b>SV</b>	<b>df</b>	<b>SS</b>	<b>MSS</b>	<b>F Cal</b>	<b>F Tab (5%)</b>	<b>Result</b>
Due to replication	3	5.99	1.99	0.94	3.59	NS
Due to treatment	5	5.50	1.1	0.52	3.20	NS
Due to error	11	23.31	2.11			
Total	19	34.8	1.83			

**ANOVA Table 19. Plant dry weight (g) of blackgram at 60 DAS**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	10.19	3.39	0.24	3.59	NS
Due to treatment	5	57.38	11.47	0.81	3.20	NS
Due to error	11	154.74	14.06			
Total	19	222.31	11.70			

**ANOVA Table 20. Crop growth rate ( $\text{g m}^{-2} \text{ day}^{-1}$ ) of blackgram at 0 to 15 DAS interval**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	0.15	0.05	1.25	3.59	NS
Due to treatment	5	1.12	0.224	5.5	3.20	S
Due to error	11	0.54	0.041			
Total	19	1.81	0.095			

**ANOVA Table 21. Crop growth rate ( $\text{g m}^{-2} \text{ day}^{-1}$ ) of blackgram at 15 to 30 DAS interval**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	6.29	2.09	1.67	3.59	NS
Due to treatment	5	22.21	4.44	3.55	3.20	S
Due to error	11	13.83	1.25			
Total	19	42.33	2.22			

**ANOVA Table 22. Crop growth rate ( $\text{g m}^{-2} \text{ day}^{-1}$ ) of blackgram at 30 to 45 DAS interval**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	48.1	16.03	1.93	3.59	NS
Due to treatment	5	46.32	9.26	1.11	3.20	NS

Due to error	11	91.26	8.29
Total	19	185.68	9.77

**ANOVA Table 23. Crop growth rate ( $\text{g m}^{-2} \text{ day}^{-1}$ ) of blackgram at 45 to 60 DAS interval**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	50.13	16.71	0.28	3.59	NS
Due to treatment	5	293.86	58.77	1.00	3.20	NS
Due to error	11	644.89	58.62			
Total	19	988.88	52.04			

**ANOVA Table 24. Relative growth rate ( $\text{g g}^{-1} \text{ day}^{-1}$ ) of blackgram at 15 to 30 DAS interval**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	0.001	0.0003	0.5	3.59	NS
Due to treatment	5	0.006	0.001	2.0	3.20	NS
Due to error	11	0.007	0.0006			
Total	19	0.014	0.0007			

**ANOVA Table 25. Relative growth rate ( $\text{g g}^{-1} \text{day}^{-1}$ ) of blackgram at 30 to 45 DAS interval**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	0.006	0.002	2.85	3.59	NS
Due to treatment	5	0.005	0.001	1.42	3.20	NS
Due to error	11	0.008	0.0007			
Total	19	0.019	0.001			

**ANOVA Table 26. Relative growth rate ( $\text{g g}^{-1} \text{day}^{-1}$ ) of blackgram at 45 to 60 DAS interval**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	0.0011500	0.000383	0.0975	3.59	NS
Due to treatment	5	0.00229845	0.004596	1.17038	3.20	NS
Due to error	11	0.00431975	0.003927			
Total	19	0.0077682	0.0004			

**ANOVA Table 27. Number of pods  $\text{plant}^{-1}$  of blackgram**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	77.95	25.98	0.29	3.59	NS
Due to treatment	5	687.02	137.40	1.57	3.20	NS
Due to error	11	956.69	893.75			
Total	19	1721.66	86.97			

**ANOVA Table 28. Number of grains pod<sup>-1</sup> of blackgram**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	1.57	0.52	0.70	3.59	NS
Due to treatment	5	0.48	0.096	0.129	3.20	NS
Due to error	11	8.24	0.74			
Total	19	10.29	0.54			

**ANOVA Table 29. Grain yield kg ha<sup>-1</sup> of blackgram**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	172253.33	57417.77	1.82	3.59	NS
Due to treatment	5	593013.75	118602.75	3.77	3.20	S
Due to error	11	318228.33	31454.24			
Total	19	1083495.41	57026.07			

**ANOVA Table 30. Stover yield kg ha<sup>-1</sup> of blackgram**

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Due to replication	3	1368307.08	456102.36	1.07	3.59	NS
Due to treatment	5	2667592.5	533518.5	1.25	3.20	NS
Due to error	11	4679955.42	425450.49			
Total	19	8715854.58	458729.1884			

**ANOVA Table 31. Test weight (g) of blackgram**

<b>SV</b>	<b>df</b>	<b>SS</b>	<b>MSS</b>	<b>F Cal</b>	<b>F Tab (5%)</b>	<b>Result</b>
Due to replication	3	9.85	3.28	0.14	3.59	NS
Due to treatment	5	39.8	7.96	0.34	3.20	NS
Due to error	11	252.36	22.94			
Total	19	302.01	15.89			

**ANOVA Table 32. Harvest index (%) of blackgram**

<b>SV</b>	<b>df</b>	<b>SS</b>	<b>MSS</b>	<b>F Cal</b>	<b>F Tab (5%)</b>	<b>Result</b>
Due to replication	3	131.72	43.90	1.84	3.59	NS
Due to treatment	5	474.9	94.98	3.98	3.20	S
Due to error	11	262.08	23.82			
Total	19	868.7	45.72			



## APPENDIX- II

**Table. Cost of cultivation**

Particulars		Unit	Cost Unit (₹)	Cost of cultivation (₹)
(A)	Land preparation			
i	Ploughing with M.B. plough	4 hours	300 ₹ /hours	1200
ii	Ploughing with disc harrowing and planking	4 hours	250 ₹ /hours	1000
(B)	Seed treatment			
i	PSB	375 gm	20 ₹/250 gm (packet)	30
ii	Carbendazim	30 gm	80 ₹/20 gm (packet)	120
(C)	Fertilizer application			
i	DAP	125 gm	1300 ₹/50 kg(packet)	3250
(D)	After sowing operation			
i	One Hand weeding	8 labor	130 ₹ /day/labour	1040
(E)	Insect control			
i	Neem oil	1 liter	200 ₹/liter	200
ii	Labour for foliar spray	2 labor	130 ₹ /days/labour	260
(F)	Harvesting and threshing	10 labor	130 ₹ /days/labour	1300
Common cost		8400		

**Table. Economic cost of treatments**

	Treatments	Treatments cost (₹/ha)	Common cost (₹/ha)	Total cost
T <sub>1</sub>	Sowing in 3 <sup>rd</sup> week of June + Shikhar 3	1050	8400	9450
T <sub>2</sub>	Sowing in 3 <sup>rd</sup> week of June + <i>Khajua</i>	450	8400	8850
T <sub>3</sub>	Sowing in 4 <sup>th</sup> week of June + Shikhar 3	1050	8400	9450
T <sub>4</sub>	Sowing in 4 <sup>th</sup> week of June + <i>Khajua</i>	450	8400	8850
*T <sub>5</sub>	Sowing in 1 <sup>st</sup> week of July + Shikhar 3	1050	8400	9450
*T <sub>6</sub>	Sowing in 1 <sup>st</sup> week of July + <i>Khajua</i>	450	8400	8850

**\*Replicated twice**

Seed rate 15 kg ha<sup>-1</sup>

Variety Shikhar 3 @ ₹ 70 kg<sup>-1</sup> seed

Variety *Khajua* @ ₹ 30 kg<sup>-1</sup> seed