# Response of Indigenous Cultivars of Blackgram (*Vigna mungo* L.) to Method of Sowing and Nutrient Management under Rainfed Farming and 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**

**RAJ MOHAN SINGH**

**2013**

**DEPARTMENT OF AGRONOMY,**
**ALLAHABAD SCHOOL OF AGRICULTURE,**
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**ID. No. 11MSAGRO012**

**Response of indigenous cultivars of blackgram (*Vigna mungo* L.) to method of sowing and nutrient management under rainfed farming and climate change in Sagar (Madhya Pradesh)**

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**ABSTRACT**

A field experiment was conducted during the kharif season of 2012 at the farmer's fields in 10 villages of Sagar district, to study indigenous cultivars of blackgram to method of sowing and nutrient management in rainfed farming condition under supervision of SAFBIN programme of Caritas with the help of associate partner of SHIATS, Allahabad. The main objectives of experiment, *viz.*, to evaluate the suitable variety/cultivars from indigenous germplasm, to find out appropriate methods of sowing in rainfed condition, to find out appropriate nutrient management practice in blackgram and to determine economics of different treatment combinations. The soils of 10 villages (in Sagar) were divided into two clusters; $1^{st}$ cluster (vertisols) and $2^{nd}$ cluster (alfisols) The experiment was conducted in Random Block Design (RBD) consisting of 3 factors; two indigenous cultivars *viz*., *Khajua* and *Chikna*, two nutrient sources inorganic (DAP) and INM (FYM + DAP) and two sowing methods *viz*., broadcasting and line sowing. Among the indigenous cultivar, *Khajua* recorded higher plant height (44.77 cm at 60 DAS), higher number of nodules plant$^{-1}$ (57.70 at 45 DAS), plant dry weight (9.19 g at 60 DAS), CGR (70.88 g day$^{-1}$ m$^{-2}$ at 45 DAS) and stover yield (3870.50 kg ha$^{-1}$). However, cultivar *Chikna* registered higher number of branches plant$^{-1}$ (16.85 at 60 DAS), number of leaves plant$^{-1}$ (48.80 at 60 DAS), RGR (0.13 g g$^{-1}$ day$^{-1}$ at 45 DAS), number of pods plant$^{-1}$ (29.95), number of seeds pod$^{-1}$ (7.80), test weight (38.80 g), seed yield (1389.00 kg ha$^{-1}$) and harvest index (33.37%). Among method of sowing, line sowing recorded highest plant height (44.77 cm at 60 DAS), number of branches plant$^{-1}$(17.15 at 60 DAS), number of leaves plant$^{-1}$ (50.70 at 60 DAS), number of nodules plant$^{-1}$ (56.62 at 45 DAS) plant dry weight (9.72 g at 60 DAS) and RGR (0.14 g g$^{-1}$ day$^{-1}$ at 45 DAS). However, Broadcasting recorded significantly superior values of CGR (69.58 g day$^{-1}$ m$^{-2}$ at 45 DAS), higher number of pods plant$^{-1}$ (29.95), number of seeds pod$^{-1}$ (7.80), significant test weight (38.80 g), seed yield (1389.00 kg ha$^{-1}$) and stover yield (3870.50 kg ha$^{-1}$ ) and harvest index (30.63%). And regarding nutrient management, INM recorded highest plant height (47.09 cm), higher number of leaves plant$^{-1}$ (50.82), higher number of nodules plant$^{-1}$ (59.60 at 45 DAS), RGR (0.15g g$^{-1}$ day$^{-1}$ at 45 DAS), number of pods plant$^{-1}$ (34.37), test weight (38.80 g) seed yield (1557.00 kg ha$^{-1}$), stover yield (4400.00 kg ha$^{-1}$) and protein content (24.70%). Highest number of branches plant$^{-1}$, significant higher plant dry weight (1.05 g) and harvest index (30.63%) were observed in inorganic nutrient management. INM recorded the highest gross return with ₹ 50900.00 $ha^{-1}$, net return of ₹ 21762.50 $ha^{-1}$ and a B: C ratio of 1.74.

**Key word:** Blackgram, Indigenous cult**Thomas Abraham**, ***D. Phil*****.,**

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## CERTIFICATE OF ORIGINAL WORK

This is to certify that the study conducted by **Mr. Raj Mohan Singh** during **2012-13** 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, **"Response of indigenous cultivars of blackgram (*Vigna mungo* L.) to method of sowing and nutrient management under rainfed farming and 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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## CERTIFICATE OF ACCEPTANCE OF EVALUATION COMMITTEE

This thesis entitled, **"Response of indigenous cultivars of blackgram (*Vigna mungo* L.) to method of sowing and nutrient management under rainfed farming and climate change in Sagar (Madhya Pradesh)",** has been prepared and submitted by **Mr. Raj Mohan Singh** in partial fulfillment of the requirements for the award of degree of **Master of Science (Agriculture) in Agronomy (Id. No. 11MSAGRO012)** 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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**Evaluation Committee**
ivars, Method of sowing, Nutrient management.

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## SELF ATTESTATION

Certified that I have personally worked on the thesis titled, **"Response of indigenous cultivars of blackgram (*Vigna mungo* L.) to method of sowing and nutrient management under rainfed farming and climate change in Sagar (Madhya Pradesh)".** The data presented in the thesis have been generated during the work and are genuine. None of the findings/information pertaining to the work has been concealed. The results embodied in this thesis have not been submitted to any other university or institute for the award of any degree or diploma.

Place: Allahabad **Raj Mohan Singh**

Date:

## *ACKNOWLEDGEMENT*

*This endeavor is the result of two years of hard work, whereby I am highly indebted to many people who directly and indirectly helped me for its successful completion.*

*First and foremost I would like to place on record my ineffable indebtedness to my Advisor* ***Prof. (Dr.) Thomas Abraham,*** *Department of Agronomy, SHIATS, Allahabad, for his conscientious guidance and constructive suggestions at every step during the thesis work. I thank him for his creative criticism and valuable suggestions for improving the quality of thesis. His role as the Nodal Officer of SAFBIN (at SHIATS) Project certainly made it possible for me to be introduced to a totally unknown field and type of research work for the partial fulfillment of the requirements for the award of the* ***Master's*** *degree programme. I think, through it all, I have gained immensely, despite the hardships faced.*

*I express my gratitude to the Chairperson, Evaluation Committee,* ***Dr. (Mrs.) Sobita Simon, Professor and Former Head,*** *Department of Plant Protection, SHIATS, Allahabad for the valuable suggestions.*

*I gratefully record my indebtedness to* ***Dr. Rajesh Singh,*** *Assistant Professor, Department of Agronomy, SHIATS, my Co-Advisor, for his constant encouragement and support, particularly in analyzing the data of my thesis work.*

*I wish to express my deep sense of gratitude and appreciation to* ***Prof. Dr. Gautam Ghosh,*** *Head of the Department of Agronomy and Dean, Allahabad School of Agriculture, SHIATS Allahabad, who has been a constant source of inspiration and strength and I am indebted to him for his excellent guidance, valuable suggestions, and close counsel.*

*I imbibed a lot of knowledge and valuable suggestions from* ***Dr. (Ms.) Shalini Masih,*** *Assistant Professor, Department of Mathematics & Statistics, SHIATS, Allahabad. I am grateful to her for correcting the draft of the thesis strenuously and also in time.*

*I am thankful to all my teachers* ***Prof. (Dr.) P. J. George, Dr. Joy Dawson, Associate Professor*** *and* ***Dr. Vikram Singh, Assistant Professor,*** *Department of Agronomy, SHIATS, for their cooperation and help which added to the success of this work.*

*The financial support rendered through Fellowship offered under the Project entitled, "Strengthening Adaptive Small Scale Farming System in Rainfed Areas in Bangladesh, India and Nepal" (SAFBIN), which was funded by the European Union and sponsored by Caritas Austria and Caritas India is being gratefully acknowledged. The opportunity to work in such a prestigious program is indeed an honor for me. I am thankful to all SAF-BIN Project members, particularly* ***Er. Sunil Simon (****Program* ***Manager for SACU and India), Dr. Pranab Choudhury (Program Consultant), Mr. M.K. Saju (Program Coordinator), Mr. V. D. Pankaj (Research Officer)*** *and* ***Mr. Manish Kumar, DPO, Sagar,*** *for the physical and technical support and their cooperation extended throughout the planning, execution and evaluation of this Thesis.*

*There are no words to express my feelings of adoration, love, respect and obligation to my beloved parents, who moulded me to what I am now. They taught me to lead an obedient, trustworthy and well-planned life, which constantly guided me as a lighted lamp towards my destination. My beloved father* ***Shri. Sahab Singh*** *and mother* ***Smt. Rajesh Kumari,*** *younger brother* ***Yashpal Singh*** *and Sister* ***Aradhna***

***Raja*** *who always backed me throughout my life and helped me in my academic life including the research work.*

*I am fortunate to have seniors here. I am thankful for the emotional support from my seniors* ***Puspendra, Harishanker Suman, Puneet Kumar Mishra, Shivam Dubey, Rajeev Nandan*** *and* ***Ankur Jha.***

*I am fortunate to have Classmates here. I am thankful for the emotional support from all my Friends* ***Jaykrit Singh, Gajendra Nagar, Sameer, Lina Shinde, Snehil Shrivastav, Yogesh Kumar, Nagendra Patel, Hemraj Kumawat, Amandeep Singh*** *and* ***Jamana Lal Jat.***

*I am thankful for the emotional support from all juniors.*

*This record will be incomplete if I forget the valuable services extended to me by all the staff in the department, especially* ***Mr. S. S. Ali, Mr. Vikas (William), Mr. Mustak, Mr. Vikas Saroj, Mr. Roshanlal*** *and* ***Mr. Ram Murat.***

*This record will be incomplete if I forget the valuable services extended to me by some VRAs during the on farm adaptive Research in Sagar, particularly* ***Mr. Prakash Vishvkarma , Mr. Rajesh , Mr. Dharmendra Vishvkarma,*** *and* ***Mr. Ravindra Yadav.***

*Foremost I thank "Almighty God" with solicits and imploreness to express my deepest sense of gratitude for HIS blessing, mercy, faithfulness and thus enabling me to accomplish this venture.*

**Allahabad** **Raj Mohan Singh**

**Date:**

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| | |
|---|---|
| % | Percent |
| ₹ | Rupees |
| & | And |
| $^{-1}$ | Per |
| @ | at the rate of |
| $^{0}C$ | Degree Centigrade or Celsius |
| AEZ | Agro ecological zone |
| Agri. | Agriculture |
| Ann. | Annals |
| ANOVA | Analysis of Variance |
| Avg. | Average |
| BARI | Bangladesh Agriculture Research Institute |
| BINA | Bangladesh Institute of Nuclear Agriculture |
| CD | Critical Difference |
| CGR | Crop Growth Rate |
| Cm | Centimeter (s) |
| $CuSO_4$ | Copper Sulphate |
| CV | Coefficient of variation |
| DAE | Day After Emergence |
| DAS | Days after sowing |
| Df | Degrees of freedom |
| DPO | District Project Officer |
| *e.g.* | For example |
| EC | Electrical Conductivity |
| EMS | Error mean sum of squares |
| ESS | Error sum of squares |
| *et al.* | And others |
| *etc.* | And so on |
| F Cal | F calculated |

| | |
|---|---|
| FCLA | Farmers' Collective Led Approach |
| F Tab | F table |
| Fig. | Figure |
| FPDCS | Food Production, Distribution and Consumption System |
| FYM | Farmyard Manure |
| G | Gram |
| Ha | Hectare |
| *i.e.* | That is |
| IMD | India Meteorological Department |
| INM | Integrated nutrient management |
| ITK | Indigenous Technical Knowledge |
| kg | Kilogram |
| LAI | Leaf Area Index |
| m | Meter(s) |
| $m^2$ | Square meter(s) |
| m ha | Million hectares |
| max. | Maximum |
| Mg | Milligram |
| min. | Minimum |
| Ml | Milliliter |
| Mm | Millimeter |
| MSS(r) | Mean sum of squares due to replication |
| MSS(t) | Mean Sum of squares due to treatment |
| MSSE | Mean sum of squares due to error |
| Mt/mt | Million tonnes |
| MYMV | Mungbean yellow mosaic virus |
| NaOH | Sodium hydroxide |
| NEPZ | North Eastern Plain Zone |
| NEV | Net Estimated Volume |

| | |
|---|---|
| nm | Nanometer |
| No. | Number |
| NPK | Nitrogen, Phosphorus, Potassium |
| NS | Non-significant |
| OC | Organic carbon |
| OD | Optical density |
| OFR | On-Farm Research |
| OFAR | On Farm Adaptive Research |
| OM | Organic Matter |
| Ph | *Power of hydrogen ion* |
| pp. | Pages |
| PRA | Participatory Rural Appraisal |
| Q | Quintal |
| R | Replications |
| RBD | Randomized Block Design |
| RDF | Recommended Dose of Fertilizer |
| Ref | References |
| Res. | Research |
| RF | Ridge and Furrow |
| RGR | Relative Growth Rate |
| RH | Relative Humidity |
| RO | Research Officer |
| rpm | Rotation per minute |
| RSS | Sum of Squares due to Replication |
| S | Significant |
| SAFBIN | Strengthening Adaptive Farming in Bangladesh India and Nepal |
| SE | Standard error |
| SEd(±) | Standard error deviation |
| SHF | Small Holder Farmer |
| SHFC | Small Holder Farming Community |
| SS | Sum of Squares |

| | |
|---|---|
| SV | Source of Variation |
| T | Treatment |
| TCA | Tri chloroacetic acid |
| Temp. | Temperature |
| t | Tonnes |
| TrSS | Sum of squares due to treatment |
| TSS | Total Sum of Squares |
| *viz* | Namely |
| VRA | Village Research Assistant |
| wt. | Weight |
| ZUC | Zone of United Corridor |

# CHAPTER - 1

# INTRODUCTION

# CHAPTER - 1

# INTRODUCTION

India is major pulse growing country in the world with 30 to 35% and 27 to 28% of the total area and production, respectively. With rapid increase in population, increase in pulse production has been only marginal and the availability of pulse has gone down from 30 g per capita per day during 2002 to around 26 g per capita per day at present. To fulfill our future needs, must follow scientific production of pulses (Singh *et al*., 2009).

Blackgram (*Vigna mungo* L.) is an important pulse crop belonging to leguminous family. Blackgram is the fourth important pulse crop grown in the country on 3.29 million hectares with a total production of 1.60 million tonnes with an average productivity of 485 kg $ha^{-1}$ (Ahlawat and Shivakumar, 2002). It has the habit of root nodulation, leaf fall and overall low C:N ratio with higher N content play an important role in maintaining soil fertility. Blackgram contributes 13% in total pulse area and 10% in total pulse production of India. It is consumed in the form of Dal (whole or split, husked and unhusked) or parched. It is used as a nutritive fodder specially for milch cattle. It is also used as a green manuring crop (Singh *et al*., 2010).

India constitutes the single largest unit where plants make the major source of protein to more than half of its predominantly vegetarian population. Pulses by virtue of their high protein content (220 to 250 g $kg^{-1}$) which is next to fish (dry) with (335 g protein $kg^{-1}$) and easy digestibility provide an answer to the persisting problem of malnutrition. Blackgram is highly prized in vegetarian diets in India. It can be boiled or eaten whole and grains are ground into flour used to make porridge or baked into bread and biscuits. Dried blackgram contains about 9.7% water, 23.4% protein, 1.0% fat, 57.3% carbohydrate and 3.8% fiber along with 154 mg calcium, 9.1 mg iron 0.37 mg riboflavin and 0.42 mg thiamin in each gram of blackgram (Sharoar *et al*., 2006).

Inspite of being widely adopted crop in India, its productivity is very low. The major causes of low yield could be traditional method of sowing and improper plant population and particular variety, which is growing in particular area. The low yield of seed legume compared to other crop is due to low yield potential of existing cultivars, plant growth rate, slow rate of dry matter accumulation and not responding to high inputs. Major hurdles in increasing the productivity are the poor soil in which crop is grown and improper fertilization (Sharma and Abraham, 2009).

Aberrations in South-West monsoon, which include delay in onset, long dry spells and early withdrawal, all of which affect the crops, strongly influence the productivity levels. Most of dryland crops like millets, pulses and oilseeds are growing during *kharif* season. Relationship between anomaly of *kharif* rainfall and crop production by IMD indicate that deficit rainfall has more impact compared to above normal rainfall. However, recent experiences across the country indicate even in dryland which receive low to medium rainfall, excess rainfall (high rainfall event in a single day) could cause heavy damage to crops. during *kharif* 2008, it was observed that groundnut crop in Rayalaseema district of Andhra Pradesh showed very poor peg development and pod formation due to heavy rainfall and dry spells at key development stages (Singh and Venkateswarlu, 2009).

Another important weather variable which affects dryland crops is the temperature. Last three decades saw a sharp rise in all India mean annual temperature. Though most dryland crops tolerate high temperature, rainfed crops grown during *rabi* are vulnerable to changes in minimum temperatures (Singh and Venkateswarlu, 2009).

Singh *et al.*, 2012 opined that generally farmers are unaware of the coping strategies and mechanisms, which they could adopt to reduce the risks and effects of drought due to lower level of education and lesser accessibility to external inputs and technologies. Extensive research and study is required to find out the suitable cropping pattern and coping strategies to reduce the effect of drought.

In Bundelkhand region of Madhya Pradesh, average productivity of blackgram continues to be lower (336 to 386 kg $ha^{-1}$) mainly due to its cultivation on marginal lands under poor management and without input except seed. The major constraints responsible for lower yield are inappropriate production technology, *viz*., susceptible cultivars, broadcast method of sowing, no use of fertilizers, mungbean yellow mosaic virus (MYMV) and untimely weed management (Raikwar *et al.*, 2011). Day to day increase in the cost of fertilizers and timely available of these fertilizers in desired quantity is always a question mark (Sarkar *et al*., 1993).

The crop appears to have wide adaptability to various weather factors, which have direct impact on MYMV incidence, which can inflict yield losses up to 85%. Widely applicable and economical technology to manage YMV is the host plant resistance, though apparently, there seem to be no variety of greengram completely and consistently resistant to MYMV (Kaur *et al*., 2010).

In the changing scenario of research, the programme, "Building Resilience to Climate Change through Strengthening Adaptive Small Scale Farming System in Rainfed Areas in Bangladesh, India and Nepal", conducting 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 scaffolding is provided. Thus, in the current experiment, 'on farm adaptive research' approach has been adhered to. In contrast to the conventional 'hierarchical' approach, the autonomy and participation of the farming community was given due consideration, which included the integration of traditional practices, techniques (ITKs) *etc*. Farmers' Collective Led Approach (FCLA) has been inducted in SAFBIN programme by *Caritas India*, which is somewhat new in India and lays emphasis on people's collective initiative in bettering the agricultural development process. It can be defined in its simplest term as research conducted in farmer's situation, by farmer's participation, in an area of farmer's inclination. Unlike the conventional On-Farm Research (OFR), OFAR focuses on "Farmer Designed" and "Farmer Implemented" action research where farmers are the leaders and all other stakeholders have the limited role of "facilitation". The key elements of OFAR also include – farmer's land and farmer's environment.

However, while formulating the various treatments of the trial, where necessary, refinement in the ITKs was done, which were appropriately integrated along with the advanced and relevant recommendations. This was done so that the existing constraints would be addressed through a Farmer-Scientist-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.

There are following possible solutions, which may address afore stated constructed and increase the production of blackgram.

The yield of blackgram could be increased by 95-188% with adoption of improved technologies such as improved cultivars, recommended and need based application of fertilizer, weed management and plant protection. (Shrivastava and Shrivastava, 1995) and (Das *et al*., 1998).

Introduction of pulses like blackgram in cropping system provides good scope to utilize the land and increase the cropping intensity, innate yield potential of crop can be realized by input intensive management practices. But some time the monetary constraint of the farmer limits the proper use of modern technology. It is thus obvious to enrich the farmer with such an alternative technology that can give comparable yield with minimum expenditure. Suitable sowing time, variety, plant population and spacing are important non cash input to achieve synchronous maturity and higher production of blackgram. The information on the effective exploitation of non-monetary or low value inputs to sustain the growth of blackgram during *kharif* season is meagre (Pal, 2008). For high productivity of blackgram the physiological basis of yield improvement with a view to find out the optimum population density to achieve higher seed yield of blackgram (Biswas *et al*., 2002).

The traditional agriculture aimed at increasing the production through two dimensions, *viz*., expanding cultivated area and increasing the yield per unit area of crop. The modern agriculture adds two more dimension, time and space (Dwivedi and Shrivastava, 2011). Therefore, line sowing and good spacing ensure better crop production.

Of the various factors of production, proper fertilizer management practice plays a vital role in enhancing yield of blackgram. Among various nutrients phosphorus application has been found beneficial but its efficiency is very low under moisture stress condition (Singh, 2006). Several workers have emphasized that nutrient requirement of pulse like greengram, particularly nitrogen could be met through integrated use of biofertilizers or organic manures or both (Badfole and Umale, 1995).

Pulses are grown under rainfed condition in soils of low fertility and poor nutrient management. Research evidences show that the application of organic manure (including INM) to drylands not only improves the soil fertility status but also improves the water holding capacity of the soil. Judicious nutrient management encompassing organic manure and inorganic fertilizers could bring a definite improvement in the cost of utilization of nutrient with increased nutrient use efficiency and will certainly improve the productivity and economic returns.

In addition to nitrogen, which is fixed in the soil from the atmosphere, FYM is another important element, which enhances the nitrogen fixation capacity of the crop. In addition to biologically fixed nitrogen, crop also requires nitrogen through fertilization to meet its initial requirement (Sharma and Abraham, 2009). Phosphorus application is essential for energy transfer in living cells enhancing root growth, besides increasing the mobility of symbiotic bacteria in the root zone, which ultimately results in more nitrogen fixation. Phosphorus ensures uniform and openly ripening of crop and also involved in transformation of energy in higher value of growth and yield attributes and also that due to phosphorus early development translocation of food materials in plant body resulted in better uptake of nutrients and ultimately in better seeds and stover yield (Parmar and Thanki, 2007). The yield attributes, *viz*., number of pods plant$^{-1}$, number of seeds pod$^{-1}$, test wt., seed and stover yield increased significantly. Phosphorus application also resulted in significant increase in N and P uptake in seed and stover (Gupta *et al*., 2006).

Nutrient requirement of crop cannot be fully met by organic alone, the conjoint use of organic and inorganic fertilizers must be made for the balanced nutrition, keeping in view of the needs of crop and sustainable farming. Suitable sowing time, variety, plant population and spacing are important non cash input to achieve synchronous maturity and higher production of blackgram.

In ITKs, application of Gomutra culture (mixture of cow urine, *besaram* leaves and madaar leaves) in blackgram field protect crop from attack of whitefly, vector of important yellow mosaic disease to the maximum extent.

Being short duration, this crop fits well in different cropping systems and is grown under mono, mixed and multiple cropping systems during rainy, spring and summer seasons under wider range of agro-climatic condition among the four major blackgram growing states, *viz.*, Uttar Pradesh, Maharashtra, Madhya Pradesh and Karnataka (Tomar *et al*., 2009).

In view of the aforestated constraints and scope, the present investigation entitled, “Response of indigenous cultivars of blackgram (*Vigna mungo* L.) to method of sowing and nutrient management under rainfed farming and climate change in Sagar (Madhya Pradesh)”,**.** A field experiment was conducted during the *kharif* season of 2012 at the farmers’ fields in 10 villages of Sagar district, to study indigenous cultivars of blackgram with respect to method of sowing and nutrient management in rainfed farming condition under supervision of SAFBIN programme of Caritas India with the help of associate partner of SHIATS, Allahabad.

**OBJECTIVES:-**

1. To evaluate the suitable variety/cultivars of blackgram from indigenous germplasm.

2. To find out the appropriate method of sowing in rainfed condition.

3. To find out appropriate nutrient management practice in blackgram.

4. To determine economics of different treatment combinations.

# CHAPTER - 2

# REVIEW OF LITERATURE

# CHAPTER - 2

# REVIEW OF LITERATURE

In this chapter, attempt has been made to review the important and relevant research work related to the present thesis entitled, "Response of Indigenous Cultivars of Blackgram (*Vigna mungo* L.) to Method of Sowing and Nutrient Management under Rainfed Farming and Climate Change in Sagar (Madhya Pradesh)", and the work is classified under appropriate headings.

As stated in the earlier chapter (Introduction), while formulating the current experiment through a 'Farmers-Scientists-Stakeholders' interaction approach, PRA tools and other means were extensively used to sort out the possible cause and agronomic solution for blackgram under rainfed condition of Sagar district, particularly in the context of climate change. However, it may be noted that there is a lack of availability of critically analyzed, peer reviewed, comprehensively documented evidence of innovations in SHF-FPDCS carried out through participatory research at multiple locations in the context of climate change (Simon and Choudhury, 2012).

## 2.1 Vulnerability of pulse crops (including blackgram) to the climate change

Kelkar, 2009 stated that climate change impacts on agriculture are likely to be negative. According to Singh and Venkateswarlu (2009) a large area of land under dryland agriculture is expected to undergo changes in rainfall pattern and temperature over the next several decades due to climate change, thus making rainfed agriculture a risk prone venture. The recent trends in climate are increasing this risk further and likely to make key production systems more vulnerable. Long term data for India indicates that rainfed areas witness 3-4 drought years in every 10 years period. Of these, 2-3 are of moderate and one may be of severe intensity.

The impact of climate change has been evident on pulse crops, hence their vulnerability does have negative effects on overall performance of these crops, which has been reported by research workers.

Singh *et al.*, 2012 observed that extreme climate variability increases pest and disease incidence on crop and livestocks.

Raikwar *et al.* (2011) observed that in general, the average productivity of blackgram continues to be lower (336-386 kg $ha^{-1}$) in Bundelkhand region of Madhya Pradesh, mainly due to its cultivation on marginal lands under poor management and without inputs
except seed. The major constraints responsible for lower yield are inappropriate production technology, *viz.*, broadcasting method of sowing, use of mungbean yellow mosaic virus (MYMV) susceptible cultivars such as TAU 1, T 9, minimal or no use of fertilizer and untimely weed management.

Kaur *et al*. (2010) in their correlation studies done between mean weekly meteorological parameters, whitefly population and yellow mosaic virus from 2006 to 2008 on greengram growing season revealed that whitefly population was significantly correlated with number of rainy days and minimum temperature, so was also yellow mosaic virus. The concordant correlation result of these two meteorological parameters could be taken as positive correlation between yellow mosaic virus and whitefly population.

Anonymous (2004) reported that higher yellow mosaic incidence in Bidar (22.64%) and Gulbarga (17.81%) districts of Karnataka could be correlated to higher temperature and dry climate prevailing in these districts, which apparently had directly influenced the vector population and its migration behaviour.

The effect of climate on biology and distribution of vector has been noticed, which evinces 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 as reported by Singh and Gurha (1994) and Nath and Saikia (1995). Previously, Nene (1972) had revealed that 5 to 100% yellow mosaic incidence had caused up to 100% damage in early infected plants.

Murugesan and Chelliah (1977) observed that higher temperature prevailing during summer is favourable for whitefly vector to develop and multiply.

### 2.2 Performance of cultivars of pulse crops (including blackgram) under rainfed farming

In a study conducted by Kaur *et al*. (2010), it was observed that out of 54 genotypes of mungbean, 14 showed consistent yellow mosaic virus resistance, depicting resistance governed by major gene. The low yield of seed legume compared to other crop is due to low yield potential of existing varieties, shoot growth duration, slow rate of dry matter accumulation and not responding to high inputs (Biswas *et al.*, 2002).

Raikwar *et al.* (2011) reported that the productivity of blackgram in Chhatarpur district of M.P. under use of MYMV resistant variety ranged between 450 and 930 kg $ha^{-1}$ with mean yield of 821 kg $ha^{-1}$. Additional yield under use of MYMV resistant variety over farmers' practice ranged from 161 to 387 kg $ha^{-1}$ with a mean yield advantage of 266 kg $ha^{-1}$.

Pal (2008) reported that improved variety 'Sarada' was found to influence significantly the growth characters like number of branches $plant^{-1}$, dry matter accumulation at 15 DAS. However, the LAI at 15, 30 and 83 DAS was not significantly different in both the varieties (local and improved). Nevertheless, the local variety recorded comparatively higher plant height over improved variety. In case of both the varieties, LAI and CGR increased up to 60 DAS and thereafter decreased, which may be due to the limit of physiological growth stages. He also observed that more dry matter accumulation may be due to better growth in improved variety.

The yield of blackgram could be increased by 95-188% with adoption of improved varieties, which was opined by Das *et al.* (1998) and Shrivastava and Shrivastava (1995).

Gupta *et al.* (2006) reported that the variety UG 218 produced the highest number of pods $plant^{-1}$ which was significantly superior to Pant U 19 and Type 9 during 2001 and in pooled data. Variety UG 218 was at par with Pant U 19 during 2000. Varieties UG 218 and Pant U 19 recorded higher number of seeds $pod^{-1}$ than Type 9, but the significant difference were observed during 2000 only. Varieties UG 218 recorded the maximum 1000 seeds weight being significantly superior to Pant U 19 and Type 9 during both the years and in pooled data. The highest number of pods $plant^{-1}$ in UG 218, showed significant superiority of the variety with respect to growth characters. The maximum 1000 seeds weight in varieties UG 218 was probably owing to more production and translocation of synthesized carbohydrates into seeds. Varieties UG 218 gave significantly higher seed and stover yield than Pant U 19 and Type 9 during both the years. In pooled data, the increase in seed yield with UG 218 over Pant U 19 and Type 9 was 18.5 and 28.1% higher respectively.

Biswas *et al.* (2002) reported that accumulation of total dry matter of two blackgram varieties, *viz*., BARI Maash 1 and BINA Maash 3, which inherently was rather slow, differed with the population densities. Dry matter production resembled to that of the leaf area development up to 57 DAE, which was explained to be due to better relationship between leaf area and dry matter production. The physiological efficiency of high dry matter production with concurrent partitioning leading to enhanced productivity was observed to be a highly desirable trait.

**2.3 Effect of improved agronomic techniques (including method of sowing) on blackgram and other seed legumes under rainfed farming**

Dwivedi and Shrivastava (2010) reported that traditional agriculture aimed at increasing the production through two dimensions, *viz*., extending cultivated area and increasing the yield per unit area of crop. The modern agriculture adds two more dimensions, *viz*., time (most favourable time of sowing) and space, perhaps by varying the architecture of crop stand (optimum spacing), which may result in higher yields.

Agrotechniqes like sowing method, *etc* does influence the growth parameters. Pal (2008) reported that line sowing significantly increased the number and dry wt. of nodules plant$^{-1}$, number of branches plant$^{-1}$, dry matter accumulation at later growth stages and CGR over broadcast method of sowing. But sowing methods were found to be non significant in influencing the plant height, LAI, dry matter up to 45 DAS and CGR at 15-30 DAS interval. In case of line sowing, increased dry matter accumulation at later growth stages may be due to greater light interception and less competition between the plants. Similar findings were reported by Singh and Singh (2002).

Biswas *et al.* (2002) opined that leaf area of crop is an important determinant of dry matter production and seed yield of blackgram and it can be altered by manipulating planting density (spacing). For high productivity of blackgram, yield improvement with a outlook to find out the optimum population density (appropriate spacing) will achieve higher seed yield of blackgram. They further, reported that higher seed yield was recorded from intermediate population density due to the highest number of pods per unit area.

Tomar *et al.* (2009) reported that average seed yield was 893 kg ha$^{-1}$ in blackgram when line sowing of blackgram was adopted, which was 117% higher than that obtained with farmer’s practice.

Prasad and Yadav (1990) reported that in Northern India, inter-row spacing of 22.5 cm produced highest seed yield of the pulses (greengram and blackgram) followed by 15 cm spacing. Average figures of two years with inter-row spacing of 22.5 cm showed about 31.3% higher seed yield than 30 cm spacing. Similar trend (spacing) was noted in biological yield also.

Parihar *et al.* (2005) found that plant spacing (35 x 15 cm) recorded significantly higher number of branches plant$^{-1}$, dry matter accumulation, number of pods plant$^{-1}$ and number of seeds pod$^{-1}$ as compared to lower plant spacing (18 x 8 cm) of clusterbean.

Verma *et al.* (2011) reported that the effect of seed rate on performance of blackgram showed that appropriate seed rate worked as a developed good roots higher seed yield (1455 kg ha$^{-1}$), net returns (₹18634 ha$^{-1}$) and B:C ratio (2.65) of blackgram. Variation of seed rate did affect on population of plants such as low seed rate (line sowing) treatment had optimum population and high seed rate (broadcast) had more population, which created the problem of competition between plants.

Asaduzzaman *et al.* (2010) reported that spacing of 30 × 10 cm performed the best, giving the highest seed yield of 1580 kg ha$^{-1}$. Optimum spacing and two weeding in blackgram crop significantly increased number of pods plant$^{-1}$ and number of seeds pod$^{-1}$.

### 2.4 Effect of nutrient management on performance of blackgram and other seed legumes under rainfed farming

Singh *et al.* (2006) found that among *kharif* pulses, area of blackgram ranks next to pigeonpea in dryland tracts of NEPZ. Farmers of the region generally grow this crop either in mixture or as pure crop, but they harvest very poor yield due to one or other reasons. Of the various factors of production, proper fertilizer management practice plays a vital role in enhancing yield of blackgram. Among various nutrients, phosphorus application has been found beneficial but its efficiency is very low under moisture stress condition. Application of 40 kg $P_2O_5$ ha$^{-1}$ increased seed yield (712.00 kg ha$^{-1}$) to the extent of 18.7 and 78.8% respectively over 20 kg $P_2O_5$ ha$^{-1}$ and control.

Sahu *et al.* (2002) in their study found that nitrogen requirement of pulses is substantially met through symbiotic N-fixation. The application of N as a starter dose helps in establishment of the crop which ultimately leads to extensive development of root nodules and these bacteria present in them fulfill the need of the crop for N.

Malik *et al.* (2004) in their study found that *rhizobium* species in the presence of phosphorus not only fix more N through increased number of nodules but the protein content, dry-matter and seed yield of various legume crops. NO **(DATA)**

Bhat *et al.* (2010) reported that phosphorus deficiency is a major limiting factor for growth of legumes in various soils, where P stress may be accompanied by N stress, due to high P requirement of nodule activity.

Parmar and Thanki (2007) in their trial came up with the conclusion that phosphorus ensures uniform and better ripening of crop and also involved in transformation of energy in higher value of growth (nodules, branches, CGR) and yield attributes. Phosphorus played a role of increasing translocation of food materials in plant body and worked in better uptake of nutrients in the soil, ultimately in enhanced seed and stover yield of blackgram. NO **DATA**

Singh and Tripathi (1999) stated that increasing level of P from 0 to 60 kg $ha^{-1}$ increased yield attributes, seed yield and biomass yield of greengram significantly over control. Phosphorus was the second most crucial plant nutrient, but for pulses it assumes primary importance owing to its important role in root proliferation and thereby atmospheric nitrogen assimilation. Application of nitrogen and phosphorus singly or in combination could significantly increase the uptake of potassium, magnesium, calcium and sulphur. Similar findings were reported by Singh *et al.* (1999).

Kumawat *et al.* (2010) found that application of 15 kg N + 20 kg $P_2O_5$ $ha^{-1}$ significantly increased the plant height, number of branches $plant^{-1}$, number of nodules $plant^{-1}$ and statistically at par with the treatment of 20 kg N + 30 kg $P_2O_5$. Since P has a specific role in nodule formation and microbial activities in soil, the adequate supply of this nutrient might have increased the utilization of smaller dose of nitrogen.

Parihar *et al.* (2005) reported that application of 40 kg P $ha^{-1}$ significantly increased the plant height, branches $plant^{-1}$, dry matter accumulation over control and 20 kg $ha^{-1}$ P in clusterbean.

Das *et al.* (1998) and Shrivastava and Shrivastava (1995) opined that the productivity of blackgram had a potential to be augmented by up to 188% with adoption of recommended dose of fertilizer. ONLY **DATA**

Singh and Pareek (2003) in their study of greengram crop found that the dry matter accumulation per meter row length significantly increased up to 30 kg $P_2O_5$ $ha^{-1}$ at 50 DAS, but 45 kg $P_2O_5$ $ha^{-1}$ application increased yield. Further, number of pods $plant^{-1}$, number of seeds $pod^{-1}$, test weight and seed yield also increased significantly with application of 45 kg $P_2O_5$ $ha^{-1}$ over all the lower levels of P. **NO DATA**

Muthuvel *et al.* (1985) reported that farmyard manure application significantly increased the soil moisture status besides addition of nutrients. Drylands are usually low in organic matter status due to rapid decomposition and lesser addition of crop residues. In such lands, addition of organic manures or waste become necessary for increasing water holding capacity and to improve the fertility status. Similar findings were reported by Harisudan *et al.* (2009).

Pawar *et al.* (2009) in their three years' field experimentation revealed that application of FYM at 5000 kg $ha^{-1}$ resulted in significantly higher chickpea seed yield over no FYM application.

Raikwar *et al.* (2011) reported that additional yield under improved technology (including integrated nutrient management) over farmers' practice ranged from 161 to 387 kg $ha^{-1}$ with a mean yield 266 kg $ha^{-1}$. In comparison to farmers' practice, there was an increase of 33.6%, 28.0% and 30.2% in productivity of blackgram under integrated nutrient management in 2007-08, 2008-09 and 2009-10. The increased seed yield with integrated nutrient management was mainly because of DAP, which worked as a starter dose of nitrogen and phosphorus for nodulation and root growth though the FYM completely conserved moisture with the organic manure have improved macro and micro nutrients availability in a slow manner and conserved moisture.

Singh and Singh (2006) found that application of FYM @ 5000 kg $ha^{-1}$ significantly increased the plant height (64.5 cm) at maturity stage compared to treatment without FYM. Improvement was mainly owing to the fact that FYM application would help in conversion of unavailable nutrients to available form through increased microbial activity and enabled the crop to remove plant nutrients in high quantity. FYM resulted in significantly higher seed (1493 kg $ha^{-1}$) and biological yield (3886 kg $ha^{-1}$) than the control. Phosphorus application @ 40 kg $ha^{-1}$ resulted in significantly more plant height (63.9 cm) and nodule development than control and 20 kg $ha^{-1}$ being at par with 40 kg $ha^{-1}$ phosphorus.

Sarkar *et al.* (1993). Several workers have emphasized that nutrient requirement of greengram particularly nitrogen could be met through integrated use of biofertilizers or organic manures or both.

Mehra *et al.* (2009) recorded that the number **REMO** of nodules $plant^{-1}$ and dry weight of nodules $plant^{-1}$ increased slightly with the advancement of crop growth till 45 DAS. INM registered maximum values of root nodules and their dry weight. Number of nodules $plant^{-1}$ under INM were significantly higher over control. **DATA NOT**

Rani *et al.* (1991) found that application of farmyard manure along with inorganic fertilizers increased the blackgram yield by 8.6 per cent over control. **DATA not**

**2.5 Effect of nutrient management on soil status of rainfed food legumes**

The unsustainable crop production in the drylands is a result of large degree of heterogeneties in term of soil, quantity and distribution of rainfall and other natural endowment relevant to agriculture. The prime factor of this unstable production is high variability in the spatial and temporal rainfall distribution (Rao *et al.*, 2011). Soils in drylands are not only thirsty but also hungry. Widespread deficiencies of macro and micro nutrients occur due to loss of nutrients through surface soil erosion and inadequate nutrients application (Singh and Venkateswarlu, 2009).

Singh and Singh (2006) perceived that higher availability of nutrients, *viz.*, NPK due to the application of organic source like FYM enabled a balanced fertility status leading to acceptable uptake and productivity. They further reported that total nutrient uptake under blackgram-wheat cropping sequence revealed that farmyard manure @ 5000 kg $ha^{-1}$ significantly increased the total N, P and K uptake in comparison to control. Phosphorus level of 20 and 40 kg $P_2O_5$ $ha^{-1}$, being at par, resulted in significantly higher total nutrient uptake over control. The probable reason for this increase was that farmyard manure applied to blackgram, upon decomposition, might have improved nutrient availability in soil and thus benefited the wheat. Secondly, higher yield levels obtained with farmyard manure and phosphorus application than the control also resulted to more uptake of nutrients from soil. Highest uptake of N, P and K was observed under 100% recommended and need based application of dose which was statistically at par with 75% recommended and need based application of dose but significantly higher than 50% recommended and need based application of dose. Higher uptake at maximum fertility levels might be due to more nutrient content and yields, which extract more nutrient from soil.

Kumawat *et al.* (2010) reported that the nitrogen fertilization to greengram crop increased
the cation exchange capacity of roots, thereby enabling them to absorb more phosphorus from the soil. Application of 15 kg N + 20 kg $P_2O_5$ $ha^{-1}$ also fetched significantly higher net return over control and 10 kg N + 10 kg $P_2O_5$ $ha^{-1}$.

Harisudan and Latha (2007) suggested that integration of enriched farmyard manure and inorganics will increase the nutrient uptake as a result of release of nutrients due to chelative effect of organic acids released during decomposition of organic matter.

Bhardwas and Omanvar (1994) also opined that available N, P, K and organic carbon in soil at harvest were increased with increase in FYM levels. Increase in the availability of N, P and K (from initial levels) in the soil with FYM may be attributed to addition of nutrients. Besides, FYM reacts with native nutrients present in the soil and thereby improved the soluble and available forms of nutrients.

Pal (1997) reported that increased nitrogen availability may be due to increase in symbiotic activities and higher nodules number in soybean crop, as root nodules also release some part of fixed nitrogen to soil.

Tiwari *et al.* (2011) reported that pigeonpea and blackgram, being legume crops, are likely to make liberal use of atmospheric nitrogen by symbiotic process and thus, may add in the fertility status of soil resulting improvement in the physical condition of soil. **DATA**

## 2.6 Effect of agronomic management on economics of blackgram under rainfed farming

Raikwar *et al.,* 2011 reported from their study of improved production technologies in rainfed condition of Bundelkhand region in Madhya Pradesh clearly brought out the economic potential. The additional cost increased in the improved technologies was mainly due to more cost involved in balanced fertilizer, improved seed and weed management practices. Cultivation of blackgram under improved technologies gave higher net return which ranged from ₹ 9415 to 11045 $ha^{-1}$, with a mean of ₹ 10399 $ha^{-1}$ as compared to the farmers' practices, which recorded ₹ 4435 to 6783 $ha^{-1}$, with a mean of ₹ 5964 $ha^{-1}$. There was an additional net return of ₹ 4370 in 2007-08, ₹ 4980 in 2008-09 and ₹ 3995 in 2009-10 under demonstration plots. The improved technologies also gave higher benefit cost ratio of 2.45, 2.24 and 2.26 compared to 2.17, 1.82 and 2.02 under local check in the corresponding season.

Beg and Singh (2009) found that under moderate fertility level, *i.e.*, 45 kg $P_2O_5$ $ha^{-1}$ proved beneficial for boosting seed yield and gave maximum net income and B:C ratio. Further, the dry-matter accumulation and developmental attributes contributed towards improvement in seed yield. The results conformed with the findings of Bhomick *et al.*, 2006. The same treatment recorded the highest net income (₹ 19,942 $ha^{-1}$) and benefit cost ratio (1.91). This was due to the fact that at higher level beyond 20 kg N and 45 kg $P_2O_5$ $ha^{-1}$, the cost of inputs was proportionately more than the income.

Mani *et al.* (2001) studied on integrated nutrient management of pulse crop and concluded that integrated package involving the recommended inorganic fertilizer with 5000 kg $ha^{-1}$ farm yard manure would be the best nutrient management practice for obtaining higher net returns.

# CHAPTER - 3

# MATERIALS AND METHODS

# CHAPTER - 3
# MATERIALS AND METHODS

The current experiment 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” (SAFBIN) program, an on farm adaptive research (OFAR) with Associate research Partner (SHIATS) and participant farmers of rainfed area of Sagar district, Madhya Pradesh.

Research trial was conducted by the SHFCs with active participation of the DPO, student researcher, RO and the VRAs. As stated in the earlier chapters, while formulating the current experiment through a Farmers-Scientists-Stake-holders’ interaction approach, PRA tools and other means were extensively used to sort out the possible 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 salient 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, indentifying the farmers’ solution, deliberations with the external stakeholders like agricultural scientists, research personnel and extension officers, NGO representatives *etc*, blending of the traditional and recommended practices in optimal ratios for developing the trial design, which was facilitated by the SAFBIN and the implementation of trials in the farmers’ field.

The materials, methodology and techniques which were adopted during the course of the investigation entitled, “Response of indigenous cultivars of blackgram (*Vigna mungo* L.) to method of sowing and nutrient management under rainfed farming and climate change in Sagar (Madhya Pradesh)”, are briefly described in this chapter under the following heads:

### 3.1 Experimental site

The on farm adaptive research of rainfed blackgram was carried out during *Kharif* season 2012 at the 60 farmers’ field of 10 villages of Shahgarh in Sagar district (MP). The Sagar district is situated in AEZ 6 of FAO. The 10 villages are located at $23^0$ 83’ 22” N latitude, $78^0$ 74’ 49” E longitude and 567.09 m altitude above the mean sea level. The Shahgarh block is situated between north of Bandri and Sagar city in Madhya Pradesh.

### 3.2 Soil of the experimental field

Prior to laying out of the experiment, soil samples were collected randomly from the 2 clusters covering 10 villages. Soil samples were taken from 5 spots of the experimental field upto a depth of 15 cm. A representative homogenous composite sample was drawn by mixing all these soil samples together, which was analyzed to determine the physio-chemical properties of the soil. The soils of 10 villages were divided into two clusters, *viz.,* 1st cluster (vertisols) covered villages *Kanikhedi, Vanpura, Khusipura* and *Shashan* and 2nd cluster (alfisols) covered *Amarmau, Hanumantora, Ratanpura, Bagrohi, Beela* and *Khargatora* villages. The results 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 Tables 3.1.1 and 3.1.2.

**Table 3.1.1 Mechanical analysis of the soil of farmers' field of 1st cluster (vertisols)**

| Mineral fraction | Value (unit) | Method (references) |
|---|---|---|
| Sand | 23.60 (%) | |
| Silt | 46.27 (%) | Bouyoucos hydrometer method |
| Clay | 29.13 (%) | (Bouyoucos, 1927) |
| Textural class | Clay loam | |

**Table 3.1.2 Mechanical analysis of the soil of farmers' field of 2nd cluster (alfisols)**

| Mineral fraction | Value (unit) | Method (references) |
|---|---|---|
| Sand | 38.20 (%) | |
| Silt | 41.57 (%) | Bouyoucos hydrometer method |
| Clay | 19.23 (%) | (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 Tables 3.2.1 and 3.2.2.

**Table 3.2.1 Chemical analysis of soil at pre experimental stage of soil of 1st cluster (vertisols)**

| Parameter | Value (unit) | Method (references) |
|---|---|---|
| Available nitrogen | 215.50 kg $ha^{-1}$ | Alkaline permanganate method (Subbiah and Asija, 1956) |
| Available phosphorus | 18.00 kg $ha^{-1}$ | Olsen method (Olsen *et al.*, 1954) |
| Available potassium | 336.00 kg $ha^{-1}$ | Flame Photometer method (Toth and Prince, 1949) |
| Organic carbon | 0.25 (%) | Walkley and Black method (Jackson, 1973) |
| pH | 7.80 | Glass electrode pH meter (Jackson, 1973) |
| EC | 0.13 (dS $m^{-1}$) | Method No.4 USDA Hand Book No.16 (Richards, 1954) |

**Table 3.2.2 Chemical analysis of soil at pre experimental stage of soil of 2nd cluster (alfisols)**

| Parameter | Value (unit) | Method (references) |
|---|---|---|
| Available nitrogen | 129.30 kg $ha^{-1}$ | Alkaline permanganate method (Subbiah and Asija, 1956) |
| Available phosphorus | 9.00 kg $ha^{-1}$ | Olsen method (Olsen *et al.*, 1954) |
| Available potassium | 313.00 kg $ha^{-1}$ | Flame Photometer method (Toth and Prince, 1949) |
| Organic carbon | 0.15 (%) | Walkley and Black method (Jackson, 1973) |
| pH | 7.70 | Glass electrode pH meter (Jackson, 1973) |
| EC | 0.07 (dS $m^{-1}$) | Method No.4 USDA Hand Book No.16 (Richards, |

1954)

### 3.3 Cropping history

Different crops grown in successive years and seasons in the experimental field of farmers plots of 10 villages (Sagar) were recorded for the last 4 years to get an idea about the different species grown. On the basis of availability of irrigation facility, the experimental field of 10 villages were divided into two clusters, *viz.*, 1st cluster (irrigation facility) covered villages: *Amarmau, Hanumantora, Ratanpura, Bagrohi, Kanikhedi, Vanpura, Khusipura* and *Khargatora* and 2nd cluster (no irrigation facility) covered villages: *Beela* and *Shashan* are presented in Tables 3.3.1 and 3.3.2.

**Table 3.3.1 Cropping history of the experimental field of farmers in 1st cluster (irrigation facility).**

| Years | Cropping season | | |
|---|---|---|---|
| | ***Kharif*** | ***Rabi*** | ***Zaid*** |
| 2008-09 | Sesame | Chickpea | Fallow |
| 2009-10 | Soybean | Wheat | Fallow |
| 2010-11 | Soybean | Wheat | Fallow |
| 2011-12 | Blackgram | Wheat | Fallow |
| 2012-13 | Blackgram (trial) | Wheat | Fallow |

**Table 3.3.2 Cropping history of the experimental field of farmers in 2nd cluster (no irrigation facility)**

| Years | Cropping season | | |
|---|---|---|---|
| | ***Kharif*** | ***Rabi*** | ***Zaid*** |
| 2008-09 | Sesame | Chickpea | Fallow |
| 2009-10 | Greengram | Mustard | Fallow |
| 2010-11 | Sesame | Chickpea | Fallow |
| 2011-12 | Blackgram | Mustard | Fallow |
| 2012-13 | Blackgram (trial) | Chickpea | Fallow |

### 3.4 Climate and weather condition

Based on the Agro Climatic Zones, Sagar district comes under Vindhya Range and AEZ 6 (FAO) of Madhya Pradesh. It has sub-tropical and semi-arid climate with the monsoon commencing from mid June and withdrawing by the end of September. The rainfall is unevenly distributed and most of it is received between July and September.

Apart from this, a few winter and summer showers are also received. The total rainfall and weekly distribution of rainfall recorded at Sagar during the period of field experiment is presented in table 3.4 and figure 3.1.

**Table 3.4 Rainfall distribution during the cropping season (*Kharif*, 2012) in Sagar M.P.** MAKE CORR

| Months | Week | Total rainfall (mm) | Number of rainy days |
|---|---|---|---|
| **1** | **2** | **3** | **4** |
| **June** | I | 0 | 0 |
| | II | 0 | 0 |
| | III | 123.04 | 4 |
| | IV | 7.26 | 1 |
| | I | 33.04 | 3 |
| **1** | **2** | **3** | **4** |
| **July** | II | 6.96 | 1 |
| | III | 59.76 | 3 |
| | IV | 85.4 | 5 |
| **Aug** | I | 104.16 | 5 |
| | II | 42 | 4 |
| | III | 136.24 | 3 |
| | IV | 71.26 | 3 |
| **Sep** | I | 18.24 | 4 |
| | II | 30.96 | 3 |
| | III | 40.96 | 3 |
| | IV | 0 | 0 |
| **Oct** | I | 0 | 0 |
| | II | 0 | 0 |
| | III | 0 | 0 |
| | IV | 0 | 0 |
| | Grand Total | 759.28 mm | |

Source: IMD (Pune).

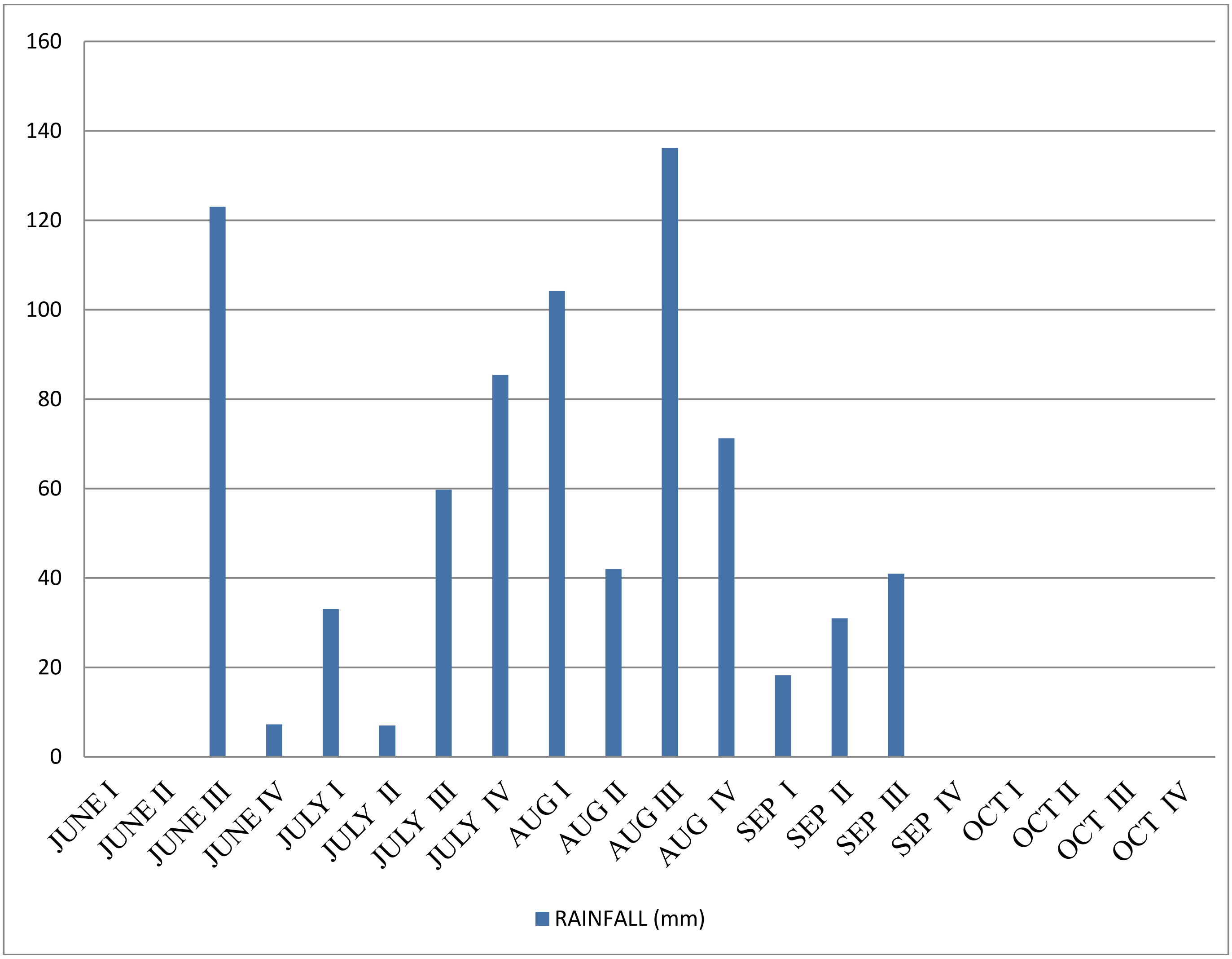


**Fig. 3.1 Rainfall during the cropping season (*Kharif*, 2012) in Sagar M.P.**

## 3.5 Experimental details

The experimental details are given below under different headings:

### 3.5.1 Experimental design

The experiment was conducted in Randomized Block Design (RBD) consisting of 3 factors, *viz*., two cultivars, two sowing method and two nutrient management. The elective combination of these factors leads to the formation of 6 treatments with 10 replications, which were allocated randomly.

### 3.5.2 Details of layout

| | |
|---|---|
| Experimental design | : RBD |
| Number of treatments | : 6 |
| Number of replications | : 10 |
| Total number of plots | : 60 |
| Net plot size | : 5.0 m x 4.0 m (20.0 $m^2$) |
| Width of bund | : 0.3 m |
| Width of main irrigation channel | : 1.0 m |
| Width of sub irrigation channel | : 0.5 m |
| Length of the field | : 57.3 m |
| Width of the field | : 27.1 m |
| Net cultivated area | : 1200 $m^2$ |
| Gross cultivated area | : 1552.83 $m^2$ |

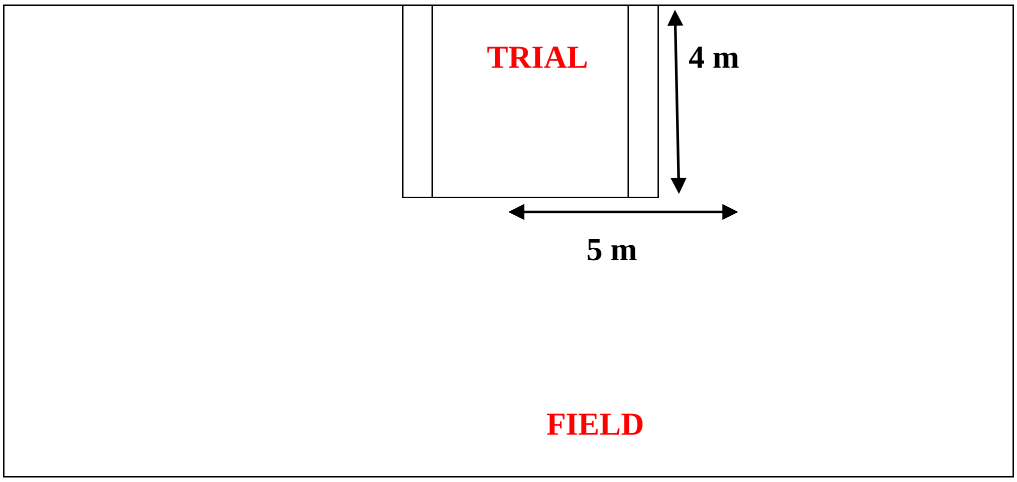


**Fig. 3.2 Layout of farmers' field, in which experiment plot was laid out**


**Fig. 3.3** Map of Shahgarh block (Sagar), where the experimental field plots of Farmers were laid out

### 3.5.3 Details of crop cultivation

Crop : Blackgram

Indigenous cultivars : *Khajua* and *Chikna*

**Spacing**

Broadcasting : 10 cm x 5 cm (managed through practice of thinning)

Line sowing : 25 cm x 10 cm

Duration : 75 days

### 3.5.4 Treatment factors

**Type of trial : On Farm Research**

**Factor I. Two Indigenous cultivars**

**$V_1$:** *Khajua*

**$V_2$:** *Chikna*

**Factor II. Two Sowing methods**

**$S_1$:** Broadcasting

**$S_2$:** Line sowing

**Factor III. Two Nutrient Management**

**$N_1$:** INM (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$)

**$N_2$:** Inorganic (DAP 62.5 kg $ha^{-1}$)

FYM: Farmyard manure

INM: Integrated Nutrient Management

DAP: Diamonium phosphate

### 3.6 Details of raising the test crop

The schedule of different pre and post sowing operations carried out in the experimental field has been given in Table 3.5.

**Table 3.5 Chronological record of agro-techniques (calendar of operations) during experiment**

| S. No. | Operations | Date range | DAS |
|---|---|---|---|
| 1 | Field preparation (ploughing + harrowing + planking) | 24.06.2012 to 27.06.2012 | |
| 2 | Layout and leveling | 28.06.2012 to 29.06.2012 | |
| 3 | Basal application of organic manure (FYM @ 5000 kg $ha^{-1}$) | 02.07.2012 | |
| 4 | Basal application of inorganic fertilizer (DAP) before sowing | 07.07.2012 to 15.07.2012 | |
| 5 | Sowing of blackgram seeds | 07.07.2012 to 15.07.2012 | |
| 6 | Thinning | 25.07.2012 to 28.07.2012 | 18 - 21 |
| 7 | Weeding – 1st weeding | 27.07.2012 to 31.07.2012 | 18 - 22 |
| | 2nd weeding | 01.09.2012 to 05.09.2012 | 58 - 62 |
| 8 | Irrigation | - | - |
| 9 | Plant protection measures | | |
| | Foliar spray of *Gomutra* culture | 10.08.2012 | 32 |
| 10 | Harvesting | 26.09.2012 to 05.10.2012 | 80 – 89 |
| 11 | Threshing | 01.10.2012 to 09.10.2012 | 83 – 91 |

### 3.6.1 Land preparation

The experimental field was ploughed with the help of tractor drawn plough followed by two harrowing and planking in different clusters. However, in some fields of the villages land was prepared by disc harrow and cultivator only. After that layout of the experiment plot was prepared in the 6 farmers' fields in each of the 10 villages.

### 3.6.2 Germination test

Indigenous blackgram cultivars (*Khajua* and *Chikna*) were taken as test varieties in this investigation. One hundred seeds were tested to ascertain the germinability of blackgram seeds by dropping seeds in water and ensure viability test and appearance. The overall germination percentage was 84% observed in *Khajua* cultivar and 72% in *Chikna* cultivar. The seed quantity was adjusted accordingly.

### 3.6.3 Sowing

Among 6 treatment plots, seeds were sown in lines in two treatment plots, *i.e.*, *Khajua* cultivar in one treatment and *Chikna* cultivar in other treatment and in rest 4 treatment plots, seeds were broadcasted in each of 10 villages respectively. Line sowing was done at a spacing of 25×10 cm and in the broadcasted plots the appropriate spacing of 10 × 5 cm managed through thinning, *etc*.

### 3.6.4 Thinning

Thinning was done in the 4 broadcast treatment plots to removes congested plants and managed the optimum plant population.

### 3.6.5 FYM application

In 2 treatments plots, 7 days before sowing, FYM was applied at the rate of 5000 kg $ha^{-1}$.

### 3.6.6 Application of DAP

DAP was applied @ 62.5 kg $ha^{-1}$ in 6 treatment plots at the time of sowing of seeds.

### 3.6.7 Intercultural operation

Based on treatments, weeding was done two times with the help of hand weeding, first weeding between 18 and 22 DAS and the second between 58 and 62 DAS by two labourers, which took up to two days. Weeding was done in all 6 treatments. Weeding in broadcast plots helped in maintaining spacing between rows to around 10 cm and between plants to around 5 cm.

### 3.6.8 Irrigation

Blackgram was grown as rainfed crop. In Sagar, it was grown on poor farmers' fields. Among 60 farmers, irrigation facility is available in maximum farmers' fields. And remaining farmers are depending only on rainfall.

### 3.6.9 Application of botanical pesticide

*Gomutra* culture, as refinement to the ITK formulating use, was prepared with a mixture of three components in the ratio of 5:2:2, *viz.*, cow urine, madaar leaf and *besaram* **BN** leaf respectively, which was fermented for 15-20 days. *Gomutra* culture 3% solution was prepared by adding 300 ml prepared and filtered solution in

10 liters of water, and applied as foliar spray after 20 days of emergence of blackgram crop as per the treatment. This formulation helps in restoring health and soil fertility as well as works as a prophylactic measure against the attack of termite. The mixing of *besaram* leaves in *Gomutra* culture, protected blackgram crop from attack of whitefly to some extent.

### 3.6.10 Harvesting

The crop (*Khajua* and *Chikna*) was harvested when pods of plants turned from dark yellow to black. Harvest area (net plot) of 2.0 $m^2$ from each plot was marked and the same was manually harvested using sickles between September 26 to October 05, 2012, *i.e.*, 80 to 89 DAS. Thereafter, the produce from net plot was tied in bundles separately and then tagged. The tagged bundles were allowed for sun drying in fields and house roofs. After drying, the weight of bundles was recorded for obtaining biological yield.

### 3.6.11 Threshing

Threshing of blackgram was done manually by beating pods on the branches with wooden baton and then seeds were separated by winnowing with the aid of soop.

### Observations recorded

Agronomic observations regarding the experimental parameters were recorded with the cooperation of Village Research Assistants (VRAs) as per the schedule proposed in the synopsis. The interval of observations had a variation between 2 to 3 days, because of various technical reasons, including the distance. The field samples, both of plants and soil were taken and brought to the Laboratory of the Dept. of Agronomy, SHIATS in Allahabad for necessary analyses.

## 3.7 Growth parameters

### 3.7.1 Plant height (cm)

Four plants were selected randomly from each plot and tagged. The heights of these plants were measured from the ground level up to the apical bud of blackgram. Plant height was recorded at 15 to 16, 30 to 31, 45 to 46 and 60 to 61 DAS based on the scheduled date of Sagar district tour to record of raw data.

### 3.7.2 Number of branches plant$^{-1}$

Number of branches plant$^{-1}$ was recorded at 30 to 31, 45 to 46 and 60 to 61 DAS based on the scheduled date of Sagar district tour.

### 3.7.3 Number of leaves plant$^{-1}$

Number of leaves plant$^{-1}$ was recorded at 15 to 16, 30 to 31, 45 to 46 and 60 to 61 DAS based on the scheduled date of tour. These were counted from four tagged plants in each plot.

### 3.7.4 Number of nodules plant$^{-1}$

Number of nodules plant$^{-1}$ was recorded at 15 to 16, 30 to 31, 45 to 46 and 60 to 61 DAS based on the scheduled date of Sagar district tour. These were counted from four tagged plants in each plot.

### 3.7.5 Plant dry weight (g)

Four plants were randomly uprooted without damaging the root from each plot at 15 to 16, 30 to 31, 45 to 46 and 60 to 61 DAS. The samples were air dried and then kept in oven for 72 hours at $70^0$ C, their dry weight was determined and the average dry weight plant$^{-1}$ was calculated.

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

It represents dry weight gained by a unit area of crop in a unit time expressed as g m$^{-2}$ day$^{-1}$ (Fisher, 1921). 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. The value of CGR is expressed in g m$^{-2}$ day$^{-1}$.

$$\text{Crop growth Rate} = \frac{W_2 - W_1}{t_2 - t_1}$$

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

### 3.7.7 Relative growth rate (g $g^{-1}$ $day^{-1}$)

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:

$$\text{Relative growth rate (RGR)} = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where,

loge = Natural logarithm

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

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

$t_1$ = Initial time period

$t_2$ = Final time period

It is also called efficiency index (y) and can be expressed in g $g^{-1}$ $day^{-1}$.

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

## 3.8 Yield and Yield attributes

### 3.8.1 Number of pods $plant^{-1}$

Number of pods were observed at the time of harvest randomly from four tagged plants and their averages were recorded.

### 3.8.2 Number of seeds $pod^{-1}$

Seeds from the one pod were counted separately which were obtained randomly from four tagged plants and their averages were recorded.

### 3.8.3 Test weight (g)

One thousand seeds were randomly counted from pods obtained from each plot and weighed and recorded as test weight (g) at 10% moisture.

### 3.8.4 Seed yield (kg ha$^{-1}$)

Seeds from harvest area (2.0 m$^2$) were dried in sun, cleaned and weighed separately from each plot for calculating the seed yield in kg ha$^{-1}$.

### 3.8.5 Stover yield (kg ha$^{-1}$)

Biological yield from harvest area (2.0 m$^2$) was dried in sun, bundled, tagged and weighed separately from each plot and after taking seeds, remaining material was calculated for the stover yield in kg ha$^{-1}$.

### 3.8.6 Harvest index (%)

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

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

### 3.9 Economic analysis

Common cost of production hectare$^{-1}$ was estimated by adding all the expenses, except cost of variable inputs of treatments, incurred in producing the crop.

Gross return ha$^{-1}$ for different treatments was calculated by adding the seed and stover yield prices. Net return ha$^{-1}$ was obtained by deducting the total cost of production from gross return ha$^{-1}$ for different treatments. Net return in terms of rupees per ₹ invested was obtained by dividing the net return ha$^{-1}$ with the cost of production ha$^{-1}$ for different treatments which reflects the efficiency of capital used.

### 3.10 Post-harvest qualitative studies

Approximately 60 g seed samples were collected at the time of threshing from each plot, and thereafter, ground into powder with the help of manual grinder. The qualitative parameter, *viz*., protein (%) in seeds was evaluated. The methodology which was adopted is described in 3.10.1.

### 3.10.1 Protein (%) in seed by Lowry's method:

**Procedure**

One g powder material of blackgram was taken and it was homogenized with 10 ml buffer solution, after that content was filtered and 10 ml filtrate was taken and it was mixed with 10 ml 10% TCA, after that it was kept for half an hour and then filtered. The residue was dissolved in 5 ml 0.1 % concentrated N NaOH. Further, 1 ml filtrate was taken and 5 ml alkaline copper reagent was added. Solution was mixed well by centrifuge at 5000 rpm and kept for 10 minutes at room temperature. Half ml folic reagent was added and kept for 30 minutes. Finally the intensity was recorded at 660 nm.

It was calculated by the formula,

$$\text{Protein (\%)} = \frac{100 \times \text{OD} \times \text{total volume made up} \times 100}{0.12 \times W \times 10}$$

Where,

OD = Optical density

W = Weight of sample

i. TCA Solution (10%) : 10 g TCA was weighed and dissolved in 100 ml water

$$\text{ii. 0.1 N NaOH NEV} = \frac{0.1 \times 40 \times 100}{1000} = 0.4$$

weight 0.4 g and dissolved in 100 ml of distilled water

iii. Alkaline copper reagent

a) 4% sodium carbonate in 0.1% N NaOH

b) 0.5% $CuSO_4$ in 1% sodium potassium tartarate

50 ml reagent (i) and 2 ml reagent (ii)

iv. Folic reagent 1:1 ratio with distilled water

### 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. The analysis of variance for the data has been given in appendix at the end of this thesis. Table 3.6 depicts the Skelton of ANOVA.

**Table 3.6 Skeleton of ANOVA table**

| Source of variation | Df | SS | MSS | F Cal | F Tab (5%) |
|---|---|---|---|---|---|
| Due to replications | (r-1) | RSS | RSS (r-1) | MSS(r) EMS | |
| Due to treatments | (t-1) | TrSS | TrSS (t-1) | MSS(t) EMS | |
| Due to error | (r-1)(t-1) | ESS | ESS (r-1)(t-1) | | |
| Total | (rt-1) | TSS | | | |

Where,

**Standard Error Deviation (SEd)**

Standard error of mean was calculated by the following formula:

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

**Critical difference (CD)**

Critical difference was calculated by the following formula:

CD = SEd × 't' error degree of freedom at 5%

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

Co-efficient of variation was calculated by the following formula

$$C.V. (\%) = \frac{\sigma}{\bar{X}} \times 100$$

Where,

$$\sigma = SE \times \sqrt{n}$$

| | | |
|---|---|---|
| r | = | Number of replication |
| df | = | Degree of freedom |
| SS | = | Sum of squares |
| RSS | = | Sum of squares due to replication |
| TrSS | = | Sum of squares due to treatment |
| TSS | = | Total sum of squares |
| ESS | = | Error sum of squares |
| MSS(r) | = | Mean sum of squares due to replication |
| MSS(t) | = | Mean Sum of squares due to treatment |
| EMS | = | Error mean sum of squares |
| SEd | = | Standard error deviation |
| SE | = | Standard error |
| n | = | Number of observation |

# CHAPTER - 4

# RESULTS AND DISCUSSION

# CHAPTER - 4

# RESULTS AND DISCUSSION

Despite the development and adoption of several new technologies, the productivity of crops has remained stagnant in recent years. Farmers are encountering new challenges in terms of rising production cost, uncertain markets and more recently, increased climatic risks. Though rainfed areas contribute only 40% of the food grains, it has remained a priority area for the Govt. of India in the context of equitable growth of disadvantageous areas. Therefore, rainfed agriculture continues to receive high priority in terms of research and development support at the national level (Singh and Venkateswarlu, 2009).

The findings of the present experiment entitled, "Response of Indigenous Cultivars of Blackgram (*Vigna mungo* L.) to Method of Sowing and Nutrient Management under Rainfed Farming and Climate Change in Sagar (Madhya Pradesh)", are being presented in this chapter. In the changing scenario of research, the programme: "Building Resilience to Climate Change through Strengthening Adaptive Small Scale Farming System in Rainfed Areas in Bangladesh, India and Nepal" is conducting. Data on pre-harvest and post harvest observations were analyzed and discussion on experimental findings in the light of scientific reasoning has been stated in the chapter with appropriate headings.

## OBSERVATIONS RECORDED

### A. Pre-harvest observations (at 15 to 16, 30 to 31, 45 to 46 and 60 to 61 DAS)

4.1 Plant height (cm)

4.2 Number of branches plant$^{-1}$

4.3 Number of leaves plant$^{-1}$

4.4 Number of nodules plant$^{-1}$

4.5 Plant dry weight (g)

4.6 CGR (g m$^{-2}$ day$^{-1}$) at 0 to 15, 15 to 30, 30 to 45 and 45 to 60 DAS intervals

4.7 RGR (g g$^{-1}$ day$^{-1}$) at 15 to 30, 30 to 45 and 45 to 60 DAS intervals

### B. Post harvest observations

4.8 Number of pods plant$^{-1}$

4.8 Number of seeds pods$^{-1}$

4.8 Test weight (g)

4.8 Seed yield ( kg ha$^{-1}$)

4.8 Stover yield (kg ha$^{-1}$)

4.8 Harvest Index (%)

**C. Quality parameter**

4.9 Protein content in seeds (%)

**D. Soil status**

4.10 Soil pH

4.10 Electrical conductivity (dsm$^{-1}$)

4.10 Available nitrogen (kg ha$^{-1}$)

4.10 Available phosphorus (kg ha$^{-1}$)

4.10 Available potassium (kg ha$^{-1}$)

4.10 Available organic carbon (%)

**E. Economics**

4.11 Cost of cultivation ( ₹ ha$^{-1}$)

4.11 Gross return ( ₹ ha$^{-1}$)

4.11 Net return ( ₹ ha$^{-1}$)

4.11 Benefit cost ratio

## GROWTH PARAMETERS OF BLACKGRAM

### A. Pre-harvest findings

#### 4.1 Plant height (cm)

Observation regarding the effect of indigenous cultivars, method of sowing and nutrient management on plant height (cm) of blackgram are presented in table 4.1 and figure 4.1.

During successive intervals of growth, plant height continued to increase (485.66% mean plant height from 15 to 60 DAS) in all factors. However, method of sowing showed decline in plant height value from 45 DAS to 60 DAS.

**Effect of indigenous cultivars**

It was observed that treatment $V_1$ (*Khajua*) recorded 7.84, 19.38 and 44.77 cm plant height, which were 9.04% higher at 15 DAS, 12.02% higher at 30 DAS and 1.03% higher at 60 DAS than $V_2$ (*Chikna)* respectively. However, at 45 DAS, treatment $V_2$ (*Chikna)* showed 42.79 cm plant height, which was 5.60% higher than $V_1$ (*Khajua*).

**Effect of method of sowing**

It was observed that treatment $S_2$ (Line sowing) recorded plant height values of 7.82, 20.16 and 48.06 cm, which were 8.76% higher at 15 DAS, 4.02% higher (significant) at 30 DAS and 18.60% higher (significant) at 45 DAS than $S_1$ (Broadcasting) respectively. However, at 60 DAS, treatment $S_1$ (Broadcasting) with 44.77 cm plant height was 1.91% higher than $S_2$ (Line sowing).

**Effect of nutrient management**

It was observed that treatment $N_1$ (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) showed 8.13, 46.93 and 47.09 cm plant height, which were 3.69% higher at 15 DAS, 9.72% higher at 45 DAS and 5.18% higher at 60 DAS than $N_2$ (DAP 62.5 kg $ha^{-1}$) respectively. However, at 30 DAS, treatment $N_2$ (DAP 62.5 kg $ha^{-1}$) recorded 20.16 cm height which was 6.61% higher than $N_1$ (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$).

It was found that line sowing method favoured higher plant height because of lesser competition, good interception of light, *etc* (Pal, 2008). INM showed better result than sole inorganic management in the form of DAP as nutrient source. In INM, DAP worked as a starter dose of nitrogen and phosphorus for nodulation and root growth. FYM worked as it enhanced the macro and micro nutrients availability in a slow manner and conserved moisture. It is similar to the findings of Singh and Singh (2006).

**Table 4.1 Effect of indigenous cultivars, method of sowing and nutrient management on plant height (cm) of blackgram**

| Treatments | Plant height (cm) | | | |
|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | 60 DAS |
| **Indigenous cultivars** | | | | |
| **$V_1$:** *Khajua* | 7.84 | 19.38 | 40.52 | 44.77 |
| **$V_2$:** *Chikna* | 7.19 | 17.30 | 42.79 | 44.31 |
| SEd (±) | 1.57 | 1.49 | 1.51 | 2.79 |
| CD (P = 0.05) | - | - | - | - |
| CV (%) | 12.79 | 7.77 | 5.24 | 9.34 |
| **Method of sowing** | | | | |
| **$S_1$:** Broadcasting | 7.19 | 19.38 | 40.52 | 44.77 |
| **$S_2$:** Line sowing | 7.82 | 20.16 | 48.06 | 43.93 |
| SEd (±) | 0.22 | 1.48 | 2.12 | 3.92 |
| CD (P = 0.05) | 0.50 | - | 4.81 | - |
| CV (%) | 1.81 | 7.45 | 7.14 | 13.17 |
| **Nutrient management** | | | | |
| **$N_1$:** INM (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) | 8.13 | 18.91 | 46.93 | 47.09 |
| **$N_2$:** Inorganic (DAP 62.5 kg $ha^{-1}$) | 7.84 | 20.16 | 42.77 | 44.77 |
| SEd (±) | 0.40 | 2.34 | 2.98 | 4.05 |
| CD (P = 0.05) | - | - | - | - |
| CV (%) | 3.18 | 11.83 | 9.96 | 13.35 |

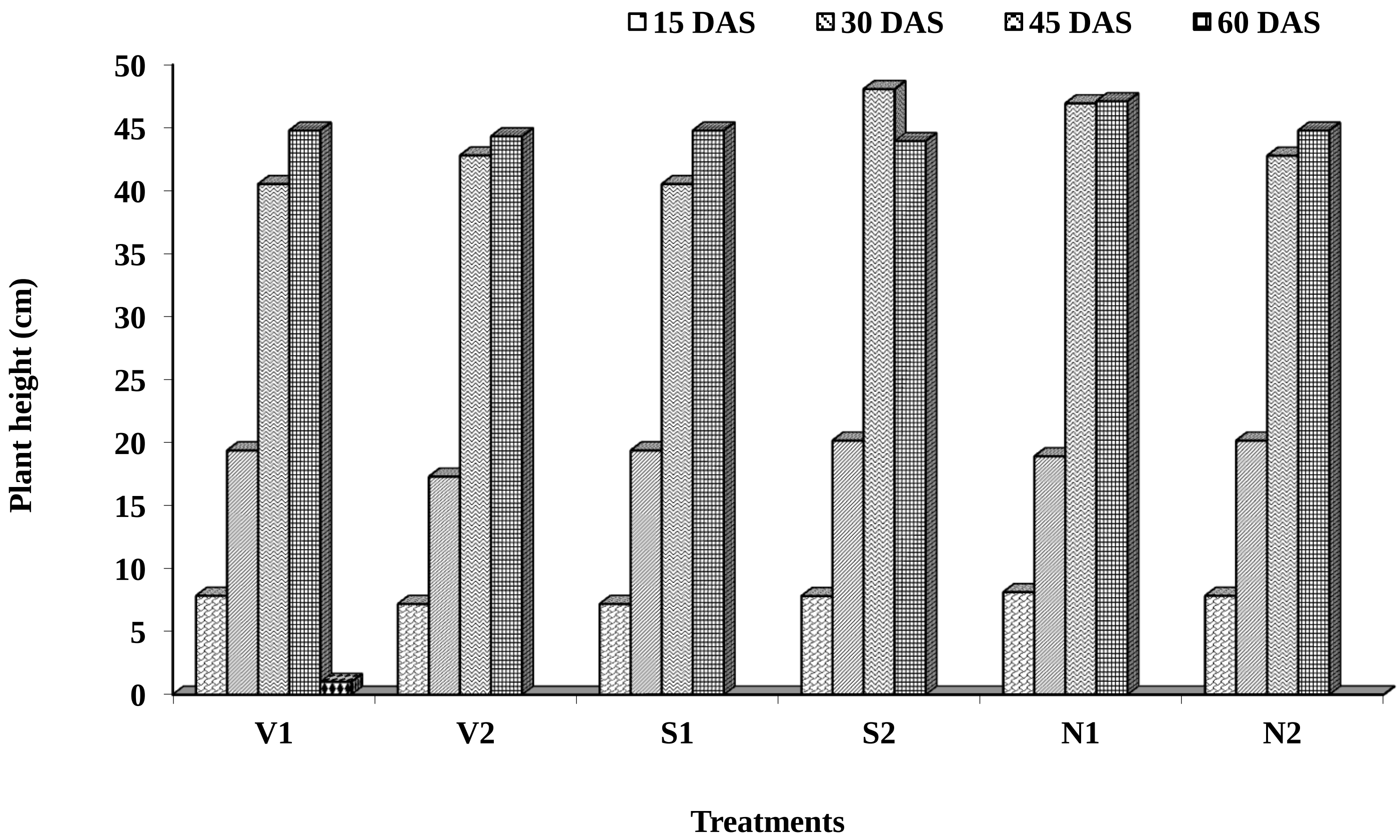


**Fig. 4.1 Effect of indigenous cultivars, method of sowing and nutrient management on plant height (cm) of blackgram**

## 4.2 Number of branches plant$^{-1}$

Observation regarding the effect of indigenous cultivars, method of sowing and nutrient management on number of branches plant$^{-1}$ on blackgram are presented in table 4.2 and figure 4.2.

During successive intervals of growth, number of branches plant$^{-1}$ continue to increased (198.66% mean number of branches plant$^{-1}$ from 30 to 60 DAS) in all factors.

**Effect of indigenous cultivars**

It was observed that treatment $V_1$ (*Khajua*) gave 5.70 number of branches plant$^{-1}$, which was 6.15% higher than treatment $V_2$ (*Chikna)* at 30 DAS. However, treatment $V_2$ (*Chikna)* gave 10.70 and 16.85 number of branches plant$^{-1}$, which were 3.38% higher than $V_1$ (*Khajua)* at 45 DAS and 8.36% higher than $V_1$ (*Khajua*) at 60 DAS respectively.

**Effect of method of sowing**

It was observed that treatment $S_2$ (Line sowing) showed 6.00 (significant difference), 13.37 and 17.15 number of branches plant$^{-1}$, which were 54.26% higher at 30 DAS, 24.95% higher at 45 DAS and 1.78% higher at 60 DAS than treatment $S_1$ (Broadcasting) respectively.

**Effect of nutrient management**

It was observed that treatment $N_1$ (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$) recorded 5.47, number of branches plant$^{-1}$, which were 0.36% higher than $N_2$ (DAP 62.5 kg ha$^{-1}$) at 30 DAS. Both treatments were found at par number of branches plant$^{-1}$ 16.85 at 60 DAS. However, at 45 DAS, treatment $N_2$ (DAP 62.5 kg ha$^{-1}$) recorded 13.37 number of branches plant$^{-1}$which was 5.69% higher than $N_1$ (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$).

It was found that line sowing method is more suitable for increasing the number of branches plant$^{-1}$ because line sowing provides appropriate space, lesser competition, *etc.* to the plant for better growth and root development as reported by Pal (2008). The INM contributed to the initial supply of nitrogen for better nodulation and phosphorus for healthy root development. Parihar *et al.* (2005) also reported that the effect of line sowing and phosphorus were advantageous in increasing number of branches plant$^{-1}$.

**Table 4.2 Effect of indigenous cultivars, method of sowing and nutrient management on number of branches plant$^{-1}$ of blackgram**

| Treatments | Number of branches plant$^{-1}$ | | |
|---|---|---|---|
| | **30 DAS** | **45 DAS** | **60 DAS** |
| **Indigenous cultivars** | | | |
| **$V_1$:** *Khajua* | 5.70 | 10.35 | 15.55 |
| **$V_2$:** *Chikna* | 5.37 | 10.70 | 16.85 |
| SEd (±) | 0.32 | 1.19 | 1.42 |
| CD (P = 0.05) | - | - | - |
| CV (%) | 3.01 | 8.17 | 7.89 |
| **Method of sowing** | | | |
| **$S_1$:** Broadcasting | 5.70 | 10.70 | 16.85 |
| **$S_2$:** Line sowing | 6.00 | 13.37 | 17.15 |
| SEd (±) | 0.13 | 1.44 | 2.25 |
| CD (P = 0.05) | 0.29 | - | - |
| CV (%) | 1.18 | 9.31 | 12.21 |
| **Nutrient management** | | | |
| **$N_1$:** INM (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$) | 5.47 | 12.65 | 16.85 |
| **$N_2$:** Inorganic (DAP 62.5 kg ha$^{-1}$) | 5.45 | 13.37 | 16.85 |
| SEd (±) | 0.29 | 1.06 | 1.72 |
| CD (P = 0.05) | - | - | - |
| CV (%) | 2.77 | 6.60 | 9.35 |

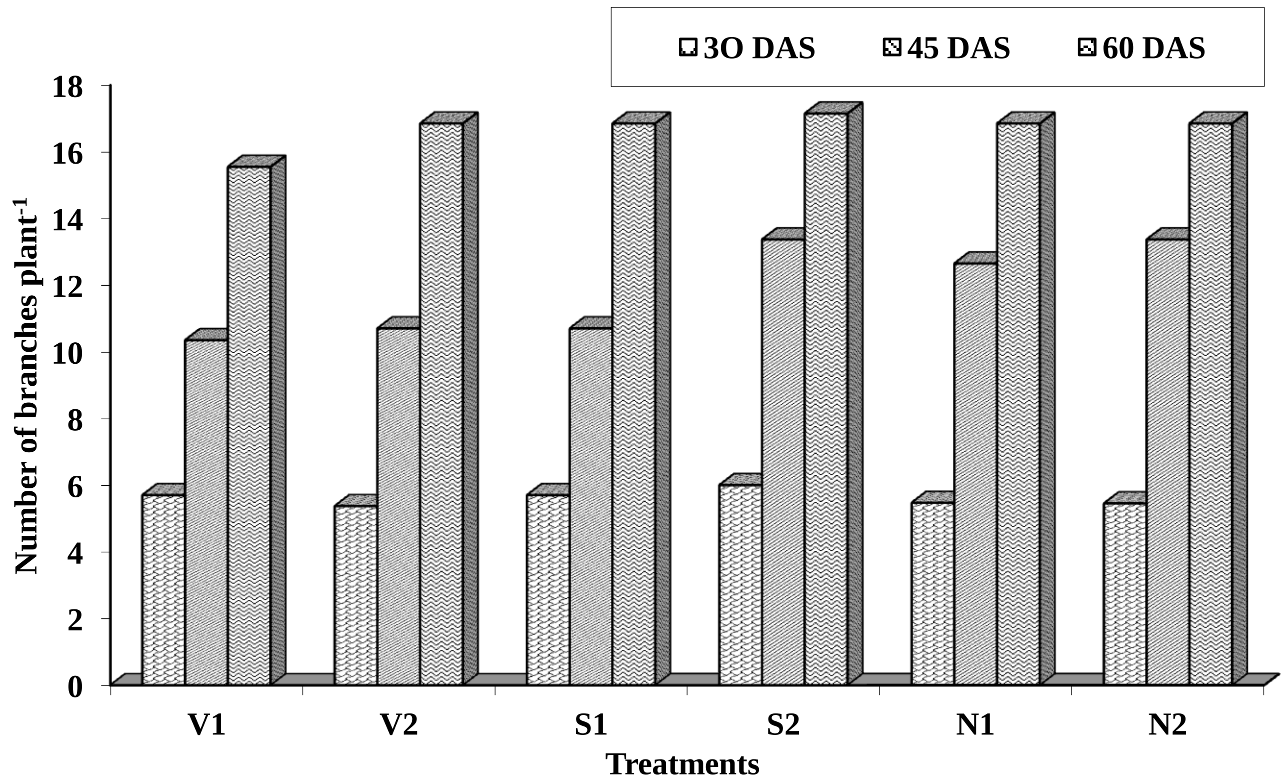


**Fig. 4.2 Effect of indigenous cultivars, method of sowing and nutrient management on number of branches plant$^{-1}$ of blackgram**

### 4.3 Number of leaves plant$^{-1}$

Observation regarding the effect of indigenous cultivars, method of sowing and nutrient management on number of leaves plant$^{-1}$ of blackgram are presented in table 4.3 and figure 4.3.

During successive intervals of growth, number of leaves plant$^{-1}$ continues to increased (597.66% mean number of leaves plant$^{-1}$ from 15 to 60 DAS) in all factors.

**Effect of indigenous cultivars**

It was observed that treatment $V_1$ (*Khajua*) recorded 6.95, 41.27 number of leaves plant$^{-1}$, which were 2.65% higher at 15 DAS and 15.69% higher at 45 DAS than $V_2$ (*Chikna)*. However, at 30 and 60 DAS treatment $V_2$ (*Chikna)* showed 14.67 and 48.80 number of leaves plant$^{-1}$, which were 4.43% higher and 11.61% higher than $V_1$ (*Khajua*).

**Effect of method of sowing**

It was observed that treatment $S_1$ (Broadcasting) showed 6.95 number of leaves plant$^{-1}$, which was 1.45% higher than $S_2$ (Line sowing) at 15 DAS. However, treatment $S_2$ (Line sowing) showed 16.00, 44.50 and 50.70 number of leaves plant$^{-1}$, which were 9.06% higher at 30 DAS, 7.82% higher at 45 DAS and 3.89% higher at 60 DAS than $S_1$ (Broadcasting) respectively.

**Effect of nutrient management**

It was observed that treatment $N_1$ (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$) recorded 7.33, 14.95, 46.74 and 50.82 number of leaves plant$^{-1}$, which were 5.46% higher at 15 DAS, 1.90% higher at 30 DAS, 13.25% higher at 45 DAS and 4.13% higher at 60 DAS than $N_2$ (DAP 62.5 kg ha$^{-1}$) respectively.

It was found that line sowing method is favoured for higher number of leaves plant$^{-1}$ because of better growth of the plants and good space for vigorous growth. Similar findings were observed by Pal (2008). The role of DAP as a initial supply of nitrogen and phosphorus for critical period may have contributed to plant for higher growth. Further, FYM provided at least some macro and micro element and conserved moisture, which were fulfilled by treatment with INM.

**Table 4.3 Effect of indigenous cultivars, method of sowing and nutrient management on number of leaves plant$^{-1}$ of blackgram**

| Treatments | Number of leaves plant$^{-1}$ | | | |
|---|---|---|---|---|
| | **15 DAS** | **30 DAS** | **45 DAS** | **60 DAS** |
| **Indigenous cultivars** | | | | |
| **$V_1$:** *Khajua* | 6.95 | 14.02 | 41.27 | 43.72 |
| **$V_2$:** *Chikna* | 6.77 | 14.67 | 35.67 | 48.80 |
| SEd (±) | 0.26 | 1.17 | 4.39 | 5.00 |
| CD (P = 0.05) | - | - | - | - |
| CV (%) | 2.19 | 6.92 | 15.83 | 16.43 |
| **Method of sowing** | | | | |
| **$S_1$:** Broadcasting | 6.95 | 14.67 | 41.27 | 48.80 |
| **$S_2$:** Line sowing | 6.85 | 16.00 | 44.50 | 50.70 |
| SEd (±) | 0.22 | 1.80 | 3.33 | 6.70 |
| CD (P = 0.05) | - | - | - | - |
| CV (%) | 1.88 | 10.28 | 11.38 | 21.23 |
| **Nutrient management** | | | | |
| **$N_1$:** INM (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$) | 7.33 | 14.95 | 46.74 | 50.82 |
| **$N_2$:** Inorganic (DAP 62.5 kg ha$^{-1}$) | 6.95 | 14.67 | 41.27 | 48.80 |
| SEd (±) | 0.30 | 1.28 | 3.65 | 4.77 |
| CD (P = 0.05) | - | - | - | - |
| CV (%) | 2.54 | 7.42 | 12.31 | 15.12 |

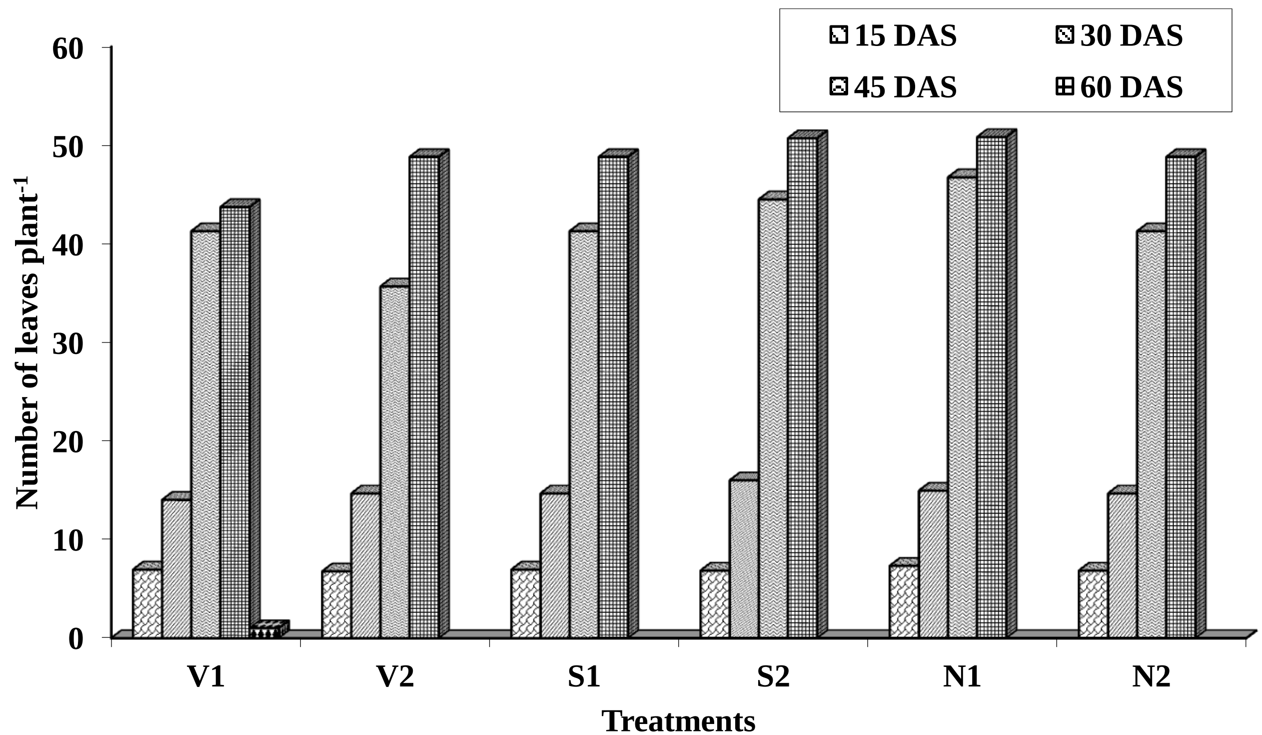


**Fig. 4.3 Effect of indigenous cultivars, method of sowing and nutrient management on number of leaves plant$^{-1}$ of blackgram**

## 4.4 Number of nodules plant$^{-1}$

Observation regarding the effect of indigenous cultivars, method of sowing and nutrient management on number of nodules plant$^{-1}$ of blackgram are presented in table 4.4 and figure 4.4.

During successive intervals, there was a remarkable increase in the nodules count (504.66% mean number of nodules plant$^{-1}$ from 15 to 60 DAS), which may become indicator that the suitable condition was formed for microbial activity. Indigenous cultivars showed significant difference in the number of nodules plant$^{-1}$ only at 60 DAS

**Effect of indigenous cultivars**

It was observed that treatment $V_1$ (*Khajua*) showed increased nodules plant$^{-1}$ at all intervals, which were 14.28, 5.15% higher than 13.58 in $V_2$ (*Chikna)* at 15 DAS, 28.47, 1.11% higher than 28.15 in $V_2$ (*Chikna)* at 30 DAS, 57.70, 6.75% higher than 54.05 at 45 DAS respectively. At 60 DAS, number of nodules plant$^{-1}$ 94.42 was found to be significant, which was 30.23% higher than $V_2$ (*Chikna*).

**Effect of method of sowing**

It was observed that treatment $S_2$ (Line sowing) recorded higher number of nodules plant$^{-1}$ at 15, 30 and 45 DAS, which were 13.89, 2.12% higher, 30.30, 6.42% higher and 56.62, 4.75% higher than treatment $S_1$ (Broadcasting) respectively. However, at 60 DAS, treatment $S_1$ (Broadcasting) recorded 94.42 number of nodules plant$^{-1}$, which was 15.83% higher than $S_2$ (Line sowing).

**Effect of nutrient management**

It was observed that treatment $N_1$ (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$) obtained maximum number of nodules plant$^{-1}$ at 15, 45 and 60 DAS, which were 14.40, 6.03% higher, 59.60, 5.26% higher and 89.35, 23.24% higher than treatment $N_2$ (DAP 62.5 kg ha$^{-1}$) respectively. However, at 30 DAS, treatment $N_2$ (DAP 62.5 kg ha$^{-1}$) recorded 28.47 number nodules plant$^{-1}$, which was 2.52% higher than $N_1$ (INM =DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$).

It was found that line sowing method is more suitable for expression of nodulation because line sowing provides suitable space, lesser struggle, *etc.* to the plant for better growth and root development. Pal (2008) stated similar finding about sowing methods. The DAP worked as a starter dose of nitrogen for nodulation and phosphorus for root development. Some of the macro and micro nutrients supplied through INM system consisting of both inorganic and organic forms ensured the availability in a slow release manner for longer time. Further, INM worked well as it conserved soil moisture for a longer time also, which is very essential in rainfed farming. Sharoar *et al.* (2006) stated similar findings about nutrient management. Phosphorus play an important role in root proliferation and thereby atmospheric nitrogen assimilation, as reported by Singh and Tripathi (1999).

**Table 4.4 Effect of indigenous cultivars, method of sowing and nutrient management on number of nodules plant$^{-1}$ of blackgram**

| Treatments | Number of nodules plant$^{-1}$ | | | |
|---|---|---|---|---|
| | **15 DAS** | **30 DAS** | **45 DAS** | **60 DAS** |
| **Indigenous cultivars** | | | | |
| **$V_1$:** *Khajua* | 14.28 | 28.47 | 57.70 | 94.42 |
| **$V_2$:** *Chikna* | 13.58 | 28.15 | 54.05 | 72.50 |
| SEd (±) | 0.64 | 2.94 | 4.59 | 8.57 |
| CD (P = 0.05) | - | - | - | 19.39 |
| CV (%) | 3.81 | 12.35 | 13.72 | 20.97 |
| **Method of sowing** | | | | |
| **$S_1$:** Broadcasting | 13.58 | 28.47 | 54.05 | 94.42 |
| **$S_2$:** Line sowing | 13.89 | 30.30 | 56.62 | 81.51 |
| SEd (±) | 0.59 | 2.10 | 2.62 | 11.04 |
| CD (P = 0.05) | - | - | - | - |
| CV (%) | 3.56 | 8.66 | 7.89 | 26.32 |
| **Nutrient management** | | | | |
| **$N_1$:** INM (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$) | 14.40 | 27.77 | 59.60 | 89.35 |
| **$N_2$:** Inorganic (DAP 62.5 kg ha$^{-1}$) | 13.58 | 28.47 | 56.62 | 72.50 |
| SEd (±) | 0.65 | 3.09 | 3.08 | 13.62 |
| CD (P = 0.05) | - | - | - | - |
| CV (%) | 3.90 | 13.01 | 9.03 | 33.86 |

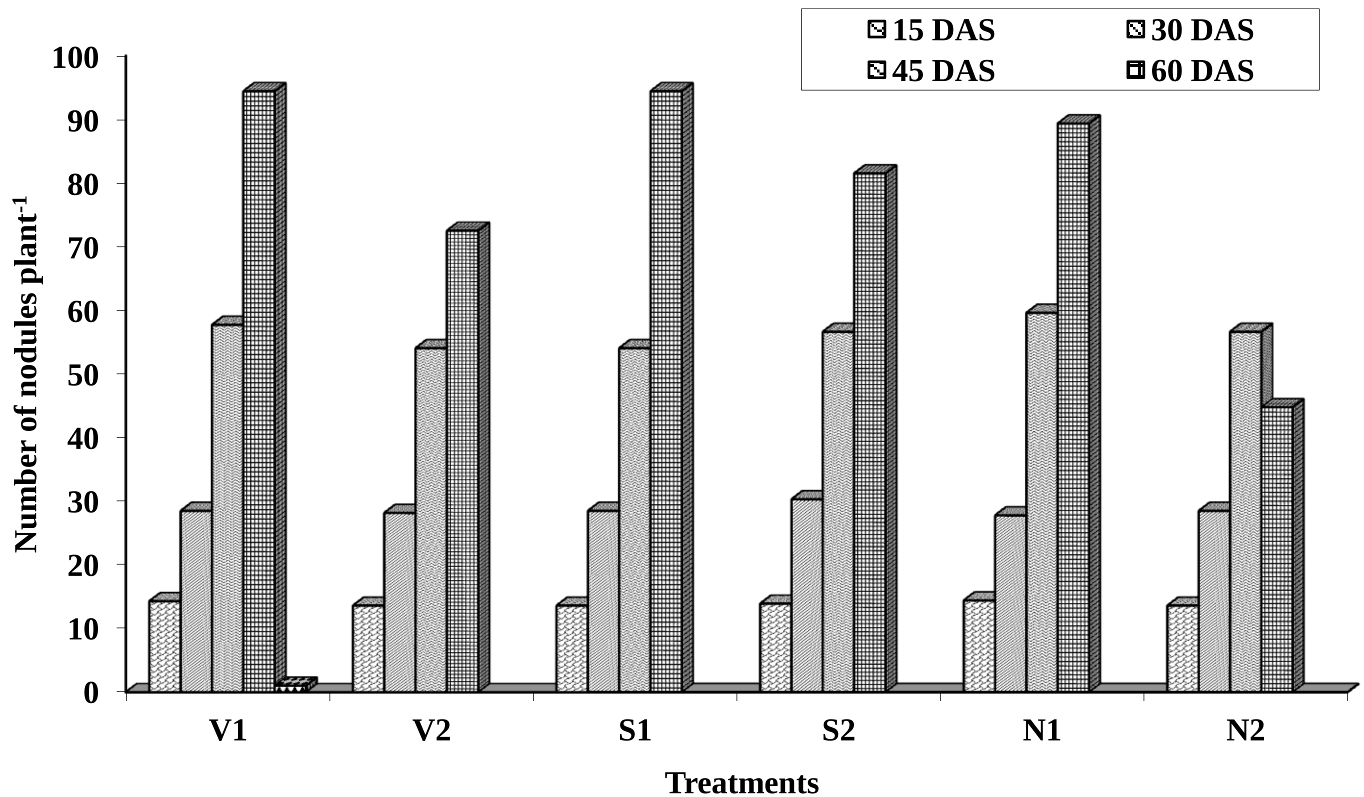


**Fig. 4.4 Effect of indigenous cultivars, method of sowing and nutrient management on number of nodules plant$^{-1}$ of blackgram**

### 4.5 Plant dry weight (g)

Observation regarding the effect of indigenous cultivars, method of sowing and nutrient management on plant dry weight (g**)** of blackgram are presented in table 4.5 and figure 4.5.

During successive intervals of growth, there was continues to increasing plant dry weight (g) in the treatments in all factors.

**Effect of indigenous cultivars**

It was observed that treatment $V_1$ (*Khajua*) recorded 0.22, 1.05, 6.37 and 9.19 (g) plant dry weight, which were 10.00% higher at 15 DAS, 20.68% higher at 30 DAS, 4.42% higher at 45 DAS and 10.72% higher at 60 DAS than treatment $V_2$ (*Chikna)* respectively.

**Effect of method of sowing**

It was observed that treatment $S_2$ (Line sowing) was found 0.24, 1.10, 6.87 and 9.72 g plant dry weight, which were 9.09% higher at 15 DAS, 4.76% higher at 30 DAS, 7.84% higher at 45 DAS and 5.76% higher at 60 DAS than treatment $S_1$ (Broadcasting) respectively.

**Effect of nutrient management**

The data observed that treatment $N_1$ (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$) gave 0.25 and 6.54 g plant dry weight, which were 13.63% higher at 15 DAS and 2.66% higher at 45 DAS than $N_2$ (DAP 62.5 kg ha$^{-1}$). However, treatment $N_2$ (DAP 62.5 kg ha$^{-1}$) gave 1.05 g (significant) and 9.19 g plant dry weight, which were 38.15% higher at 30 DAS and 3.14% higher at 60 DAS than $N_1$ (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$).

It was found that line sowing method is lone well in the higher plant dry weight (g), because appropriate spacing did optimum growth space between plants, sunlight to each plant and lesser competition for nutrient and water. Similar findings reported by Pal (2008). DAP supplied full nitrogen need for nodulation bacteria's and phosphorus for good root establishment as a appetizer dose. Improvement was mainly owing to the fact that FYM application would help in conversion of unavailable nutrients to available form through increased microbial activity and enable the crop to remove plant nutrients in high quantity.

**Table 4.5 Effect of indigenous cultivars, method of sowing and nutrient management on plant dry weight (g) of blackgram**

| Treatments | Plant dry weight (g) | | | |
|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | 60 DAS |
| **Indigenous cultivars** | | | | |
| **$V_1$:** *Khajua* | 0.22 | 1.05 | 6.37 | 9.19 |
| **$V_2$:** *Chikna* | 0.20 | 0.87 | 6.10 | 8.30 |
| SEd (±) | 0.03 | 0.11 | 0.40 | 0.61 |
| CD (P = 0.05) | - | - | - | - |
| CV (%) | 1.33 | 2.41 | 3.62 | 4.59 |
| **Method of sowing** | | | | |
| **$S_1$:** Broadcasting | 0.22 | 1.05 | 6.37 | 9.19 |
| **$S_2$:** Line sowing | 0.24 | 1.10 | 6.87 | 9.72 |
| SEd (±) | 0.03 | 0.12 | 0.47 | 0.67 |
| CD (P = 0.05) | - | - | - | - |
| CV (%) | 1.28 | 2.52 | 4.08 | 4.90 |
| **Nutrient management** | | | | |
| **$N_1$:** INM (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) | 0.25 | 0.76 | 6.54 | 8.91 |
| **$N_2$:** Inorganic (DAP 62.5 kg $ha^{-1}$) | 0.22 | 1.05 | 6.37 | 9.19 |
| SEd (±) | 0.05 | 0.07 | 0.57 | 0.61 |
| CD (P = 0.05) | - | 0.17 | - | - |
| CV (%) | 2.39 | 1.74 | 4.99 | 4.53 |

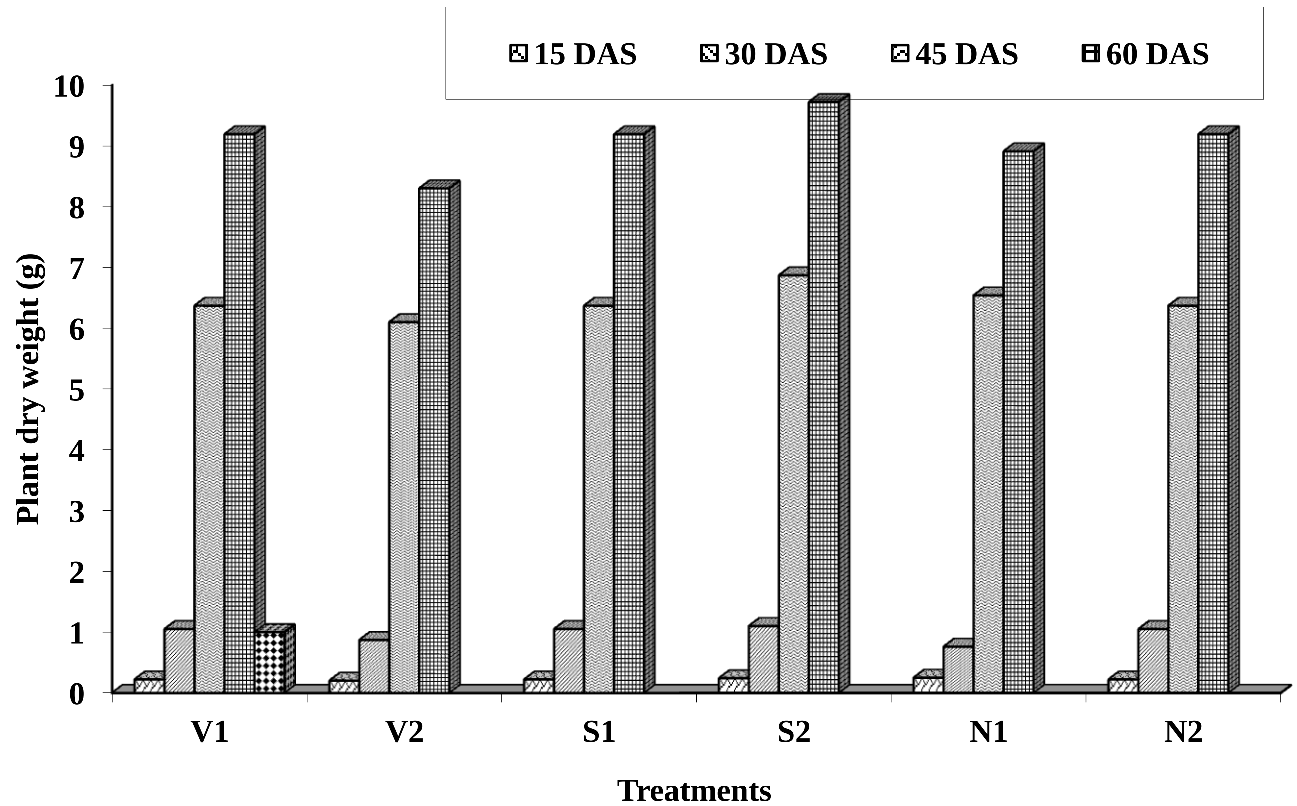


**Fig. 4.5 Effect of indigenous cultivars, method of sowing and nutrient management on plant dry weight (g) of blackgram**

## 4.6 Crop Growth Rate (g $m^{-2}$ $day^{-1}$)

Observation regarding the effect of indigenous cultivars, method of sowing and nutrient management on crop growth rate (g $m^{-2}$ $day^{-1}$) of blackgram are presented in table 4.6 and figure 4.6.

During successive intervals of growth, CGR (g $m^{-2}$ $day^{-1}$) continued to increase (485.66% mean plant height from 15 to 60 DAS) in all factors. However, treatments showed decline in CGR value from 45 DAS to 60 DAS intervals.

**Effect of indigenous cultivars**

It was observed that treatment $V_1$ (*Khajua*) recorded higher CGR 2.95, 10.98, 70.88 and 44.26 (g $m^{-2}$ $day^{-1}$), which were 11.74% higher at 0 to 15 DAS interval, 23.64% higher at 15 to 30 DAS interval, 1.86% higher at 30 to 45 DAS interval and 38.39% higher at 45 to 60 DAS interval than treatment $V_2$ (*Chikna)* respectively.

**Effect of method of sowing**

It was observed that treatment $S_1$ (Broadcasting) registered significant CGR 2.95, 10.98, 69.58 and 44.26 (g $m^{-2}$ $day^{-1}$), which were 360.93% higher at 0 to 15 DAS interval, 385.84% higher at 15 to 30 DAS interval, 227.43% higher at 30 to 45 DAS interval and 355.34% higher than treatment $S_2$ (Line sowing) at 45 to 60 DAS interval respectively.

**Effect of nutrient management**

It was observed that treatment $N_1$ (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) recorded CGR 3.05, 78.40 (g $m^{-2}$ $day^{-1}$), which were 3.38% higher at 0 to 15 DAS interval and 12.67% higher at 30 to 45 DAS interval than treatments $N_2$ (DAP 62.5 kg $ha^{-1}$). However, treatment $N_2$ (DAP 62.5 kg $ha^{-1}$) showed CGR 10.98 (significant) and 44.26 (g $m^{-2}$ $day^{-1}$), which were 85.47% higher at 15 to 30 DAS interval and 11.99% higher at 45 to 60 DAS interval than $N_1$ (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) respectively.

It was recorded that broadcast method was suitable for higher CGR because of higher number of plants per unit area. Both INM and DAP played significant role in CGR value. In INM, DAP provided nutrients for higher growth rate and slow release manner of nutrient from FYM. Further, FYM conserved soil moisture for a long time and increased organic matter in soil. The highest CGR value was obtained from higher population density and lowest from lower population density of blackgram. Decrease of CGR in blackgram at later stages may be due to decrease of leaf area of crop. The highest population density of blackgram showed the faster decrease of CGR than the lowest density of blackgram. Similar finding were reported by Biswas *et al*. (2002). The increase level of P from 0 to 60 kg $ha^{-1}$ increased yield attributes, seed yield and biomass yield of greengram significantly over control reported by Singh and Tripathi (1999).

**Table 4.6 Effect of indigenous cultivars, method of sowing and nutrient management on crop growth rate of plant ($g\ m^{-2}\ day^{-1}$) of blackgram**

| Treatments | CGR ($g\ m^{-2}\ day^{-1}$) | | | |
|---|---|---|---|---|
| | Intervals | | | |
| | 15 DAS | 30 DAS | 45 DAS | 60 DAS |
| **Indigenous cultivars** | | | | |
| **$V_1$:** *Khajua* | 2.95 | 10.98 | 70.88 | 44.26 |
| **$V_2$:** *Chikna* | 2.64 | 8.88 | 69.58 | 31.98 |
| SEd (±) | 0.35 | 1.57 | 5.74 | 6.44 |
| CD (P = 0.05) | - | - | - | - |
| CV (%) | 4.64 | 11.15 | 15.32 | 23.32 |
| **Method of sowing** | | | | |
| **$S_1$:** Broadcasting | 2.95 | 10.98 | 69.58 | 44.26 |
| **$S_2$:** Line sowing | 0.64 | 2.26 | 21.25 | 9.72 |
| SEd (±) | 0.22 | 1.53 | 12.10 | 10.53 |
| CD (P = 0.05) | 0.51 | 3.45 | 27.38 | 23.81 |
| CV (%) | 3.74 | 13.27 | 40.16 | 45.30 |
| **Nutrient management** | | | | |
| **$N_1$:** INM (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) | 3.05 | 5.92 | 78.4 | 39.52 |
| **$N_2$:** Inorganic (DAP 62.5 kg $ha^{-1}$) | 2.95 | 10.98 | 69.58 | 44.26 |
| Ed (±) | 0.64 | 2.09 | 8.32 | 12.67 |
| CD (P = 0.05) | - | 4.74 | - | - |
| CV (%) | 8.29 | 16.10 | 21.63 | 43.76 |

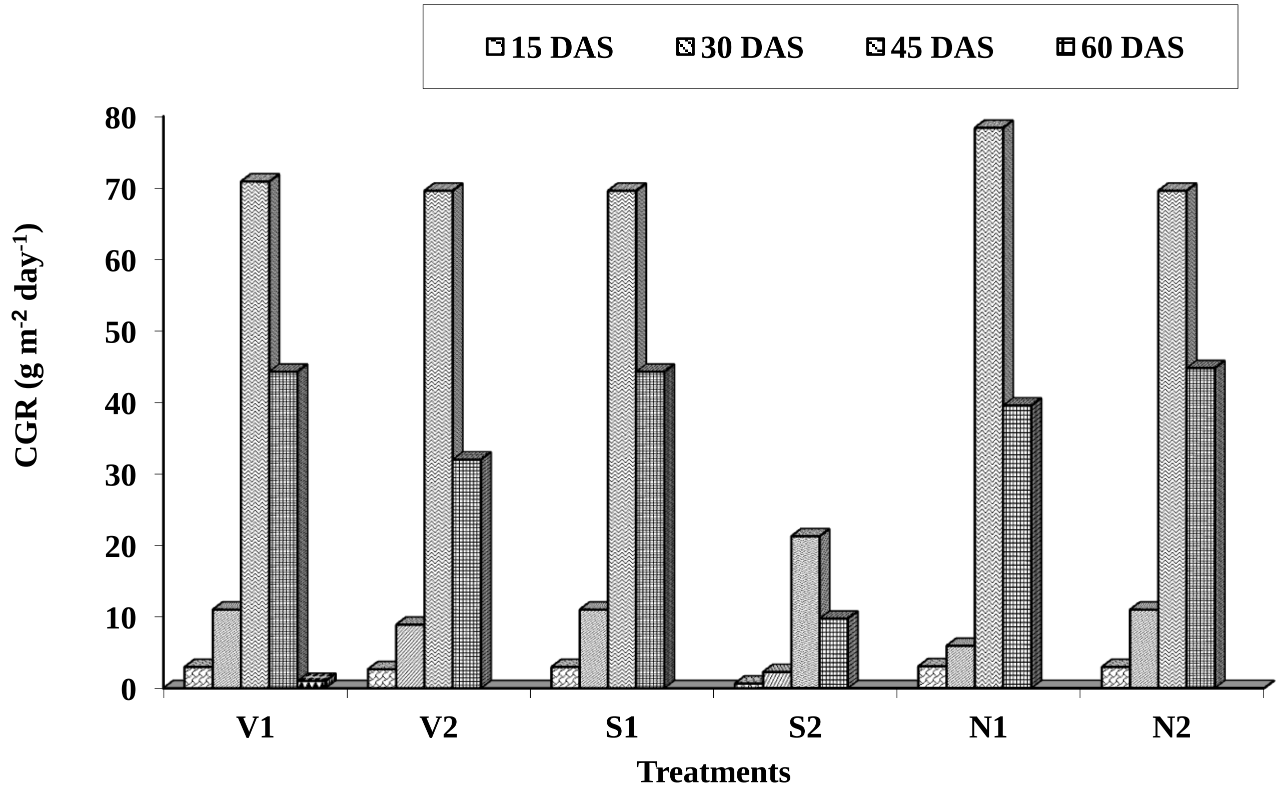


**Fig. 4.6 Effect of indigenous cultivars, method of sowing and nutrient management on crop growth rate of plant (g m$^{-2}$ day$^{-1}$) of blackgram**

## 4.7 Relative Growth Rate (g $g^{-1}$ $day^{-1}$)

Observation regarding the effect of indigenous cultivars, method of sowing and nutrient management on relative growth rate (g $g^{-1}$ $day^{-1}$) of blackgram are presented in table 4.7 and figure 4.7.

During successive intervals of growth, treatments showed no significant difference in the relative growth rate.

**Effect of indigenous cultivars**

It was observed that treatment $V_1$ (*Khajua*) showed RGR 0.10 (g $g^{-1}$ $day^{-1}$), which was 11.11% higher than $V_2$ (*Chikna*) at 15 to 30 DAS interval and $V_2$ (*Chikna*) showed RGR 0.13 (g $g^{-1}$ $day^{-1}$), which was 8.33% higher than $V_1$ (*Khajua*) at 30 to 45 DAS interval respectively. However, at 45 to 60 DAS interval, both treatments were found at par RGR 0.02 (g $g^{-1}$ $day^{-1}$).

**Effect of method of sowing**

It was observed that treatment $S_1$ (Broadcasting) showed RGR 0.10 (g $g^{-1}$ $day^{-1}$), which was 11.11% higher than $S_2$ (Line sowing) at 15 to 30 DAS interval and $S_2$ (Lines owing) gave RGR 0.14 (g $g^{-1}$ $day^{-1}$), which was 7.69% higher than $S_1$ (Broadcasting) at 30 to 45 DAS interval respectively. At 45 to 60 DAS interval, both treatments gave at par RGR.

**Effect of nutrient management**

It was observed that treatment $N_1$ (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) recorded RGR 0.15 (g $g^{-1}$ $day^{-1}$), which was 15.38% higher than $N_2$ (DAP 62.5 kg $ha^{-1}$) at 30 to 45 DAS interval. However, treatment $N_2$ (DAP 62.5 kg $ha^{-1}$) recorded RGR 0.10 and 0.02 (g $g^{-1}$ $day^{-1}$), which were 42.85% higher at 15 to 30 DAS interval and 10.00% higher at 45 to 60 DAS interval than $N_1$ (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$).

It was observed that both broadcasting and line sowing method are suitable for at par RGR (g $g^{-1}$ $day^{-1}$) in rainfed farming. Similar findings observed by Pal (2008). DAP supplied nutrients as starter nitrogen and phosphorus to the plants for higher RGR in g per g per day. Nitrogen play a role of vigorous growth of plant and phosphorus for well developed root system and more branches.

**Table 4.7 Effect of indigenous cultivars, method of sowing and nutrient management on relative growth rate ($g\ g^{-1}\ day^{-1}$) of blackgram**

| Treatments | Relative growth rate ($g\ g^{-1}\ day^{-1}$) Intervals | | |
|---|---|---|---|
| | **30 DAS** | **45 DAS** | **60 DAS** |
| **Indigenous cultivars** | | | |
| **$V_1$:** *Khajua* | 0.10 | 0.12 | 0.02 |
| **$V_2$:** *Chikna* | 0.09 | 0.13 | 0.02 |
| SEd (±) | 0.01 | 0.01 | 0.01 |
| CD (P = 0.05) | - | - | - |
| CV (%) | 1.00 | 0.69 | 0.86 |
| **Method of sowing** | | | |
| **$S_1$:** Broadcasting | 0.10 | 0.13 | 0.02 |
| **$S_2$:** Line sowing | 0.09 | 0.14 | 0.02 |
| SEd (±) | 0.01 | 0.01 | 0.01 |
| CD (P = 0.05) | - | - | - |
| CV (%) | 0.66 | 0.52 | 1.04 |
| **Nutrient management** | | | |
| **$N_1$:** INM (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) | 0.07 | 0.15 | 0.01 |
| **$N_2$:** Inorganic (DAP 62.5 kg $ha^{-1}$) | 0.10 | 0.13 | 0.02 |
| SEd (±) | 0.01 | 0.02 | 0.01 |
| CD (P = 0.05) | - | - | - |
| CV (%) | 0.84 | 1.04 | 1.49 |

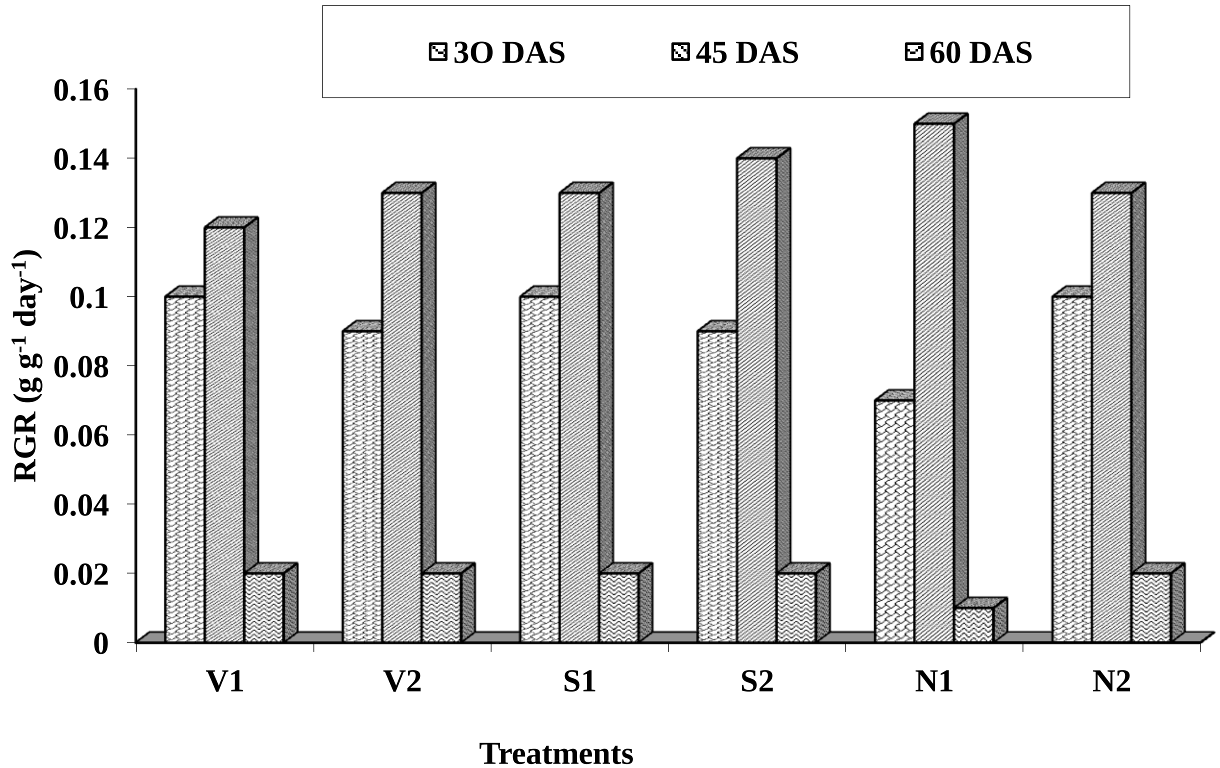


**Fig. 4.7 Effect of indigenous cultivars, method of sowing and nutrient management on relative growth rate (g $g^{-1}$ $day^{-1}$) of blackgram**

## 4.8 Yield and yield attributes

Observation regarding the effect of indigenous cultivars, method of sowing and nutrient management on yield and yield attributes of blackgram are presented in table 4.8 and figure 4.8.1 and 4.8.2.

The treatments related to number of pods plant$^{-1}$, number of seeds pod$^{-1}$, seed yield, stover yield and harvest index showed no significant difference but treatments of method of sowing in test weight showed significant difference.

**Effect of indigenous cultivars**

It was observed that treatment $V_2$ (*Chikna*) recorded higher number of pods plant$^{-1}$, number of seeds pod$^{-1}$, test weight, seed yield and harvest index, which were 29.95, 3.63% higher, 7.80, 4.41% higher, 38.80 (g), 3.19% higher, 1389.00 (kg ha$^{-1}$), 24.74% higher and 33.37%, 26.93% higher than treatment $V_1$ (*Khajua*). However, treatment $V_1$ (*Khajua*) recorded higher stover yield 3870.50 (kg ha$^{-1}$), which was 14.88% higher than $V_2$ (*Chikna*).

**Effect of method of sowing**

It was observed that treatment $S_1$ (Broadcasting) showed higher number of pods plant$^{-1}$, number of seeds pod$^{-1}$, test weight, seed, stover yield and harvest index which were 29.95, 9.62% higher, 7.80, 0.38% higher, 38.80 (g), 1.04% higher, 1389 (kg ha$^{-1}$), 0.79% higher, 3870.50 (kg ha$^{-1}$), 6.71% higher and 30.63%, 11.74% higher than treatment $S_2$ (Line sowing).

**Effect of nutrient management**

It was observed that treatment $N_1$ (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$) recorded maximum number of pods plant$^{-1}$, number of seeds pod$^{-1}$, test weight, seed and stover yield, which were 34.37, 14.75% higher, 7.80, 4.41% higher, 38.80 (g), 3.19% higher, 1557.00 (kg ha$^{-1}$), 12.09% higher and 4400.00 (kg ha$^{-1}$), 13.69% higher than treatment $N_2$ (DAP 62.5 kg ha$^{-1}$). However, higher harvest index was observed in treatment $N_2$ (DAP 62.5 kg ha$^{-1}$), which was 30.63%, 5.29% higher than $N_1$ (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$).

It was recorded that broadcast method and INM played important role in maximum production of number of pods plant$^{-1}$, number of seeds pod$^{-1}$, seed yield, stover yield and test weight. Broadcast method treatment had more plants per unit area, so perhapes made larger biomass. Similar findings were reported by Prasad and Yadav (1990) and Parihar *et al*. (2005). The DAP, the component of INM, provides dose of nitrogen for nodulation and phosphorus for root development, increased number of pods plant$^{-1}$, number of seeds pod$^{-1}$, seed yield, stover yield and test weight at maturity stage of crop. Parihar *et al*. (2005) and Singh *et al*. (2006) reported that 40 kg $P_2O_5$ ha$^{-1}$ gave high number of pods plant$^{-1}$, number of seeds pod$^{-1}$, seed and stover yield. They also reported that high density of plants gave more seed and stover yield. Some of the macro and micro nutrients supplied through INM system consisting of both inorganic and organic forms ensured the availability in a slow release manner for longer time. Further, INM may have contributed in conserving the soil moisture for a longer time, which is very vital in rainfed farming. Similar findings were reported by Rani *et al.* (1991) and Harisudan *et al*. (2009). Singh and Singh (2006) and Raikwar *et al*. (2011) also observed similar findings about integrated nutrient management.

Biswas *et al.* (2002) reported that higher density of plants gave more number of seeds pod$^{-1}$, test weight and seed yield. High production of seed and stover yield in above treatments also may be due to the adequate availability of rainfall during experiment. Since, blackgram is a rainfed crop, it may have reprehensive productivity under this farming condition.

**Table 4.8 Effect of indigenous cultivars, method of sowing and nutrient management on yield and yield attributes of blackgram**

| Treatments | Yield and yield attributes | | | | | |
|---|---|---|---|---|---|---|
| | **Number of pods $plant^{-1}$** | **Number of seeds $pod^{-1}$** | **Test weight (g)** | **Seed yield (kg $ha^{-1}$)** | **Stover yield (kg $ha^{-1}$)** | **Harvest Index (%)** |
| **Indigenous cultivars** | | | | | | |
| **$V_1$:** *Khajua* | 28.90 | 7.47 | 37.60 | 1113.50 | 3870.50 | 26.29 |
| **$V_2$:** *Chikna* | 29.95 | 7.80 | 38.80 | 1389.00 | 3369.00 | 33.37 |
| SEd (±) | 6.26 | 0.20 | 0.63 | 146.68 | 838.54 | 3.80 |
| CD (P = 0.05) | - | - | - | - | - | - |
| CV (%) | 25.82 | 1.60 | 2.28 | 92.72 | 311.65 | 15.57 |
| **Method of sowing** | | | | | | |
| **$S_1$:** Broadcasting | 29.95 | 7.80 | 38.80 | 1389.00 | 3870.50 | 30.63 |
| **$S_2$:** Line sowing | 27.32 | 7.77 | 38.40 | 1378.00 | 3627.00 | 27.41 |
| SEd (±) | 3.08 | 0.16 | 0.78 | 178.12 | 896.02 | 4.60 |
| CD (P = 0.05) | - | - | 1.76 | - | - | - |
| CV (%) | 12.88 | 1.25 | 2.80 | 107.08 | 327.23 | 19.11 |
| **Nutrient management** | | | | | | |
| **$N_1$:** INM (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) | 34.37 | 7.80 | 38.80 | 1557.00 | 4400.00 | 29.09 |
| **$N_2$:** Inorganic (DAP 62.5 kg $ha^{-1}$) | 29.95 | 7.47 | 37.60 | 1389.00 | 3870.50 | 30.63 |
| SEd (±) | 6.28 | 0.31 | 0.85 | 169.93 | 1091.48 | 5.27 |
| CD (P = 0.05) | - | - | - | - | - | - |
| CV (%) | 24.77 | 2.54 | 3.09 | 99.00 | 379.53 | 21.57 |

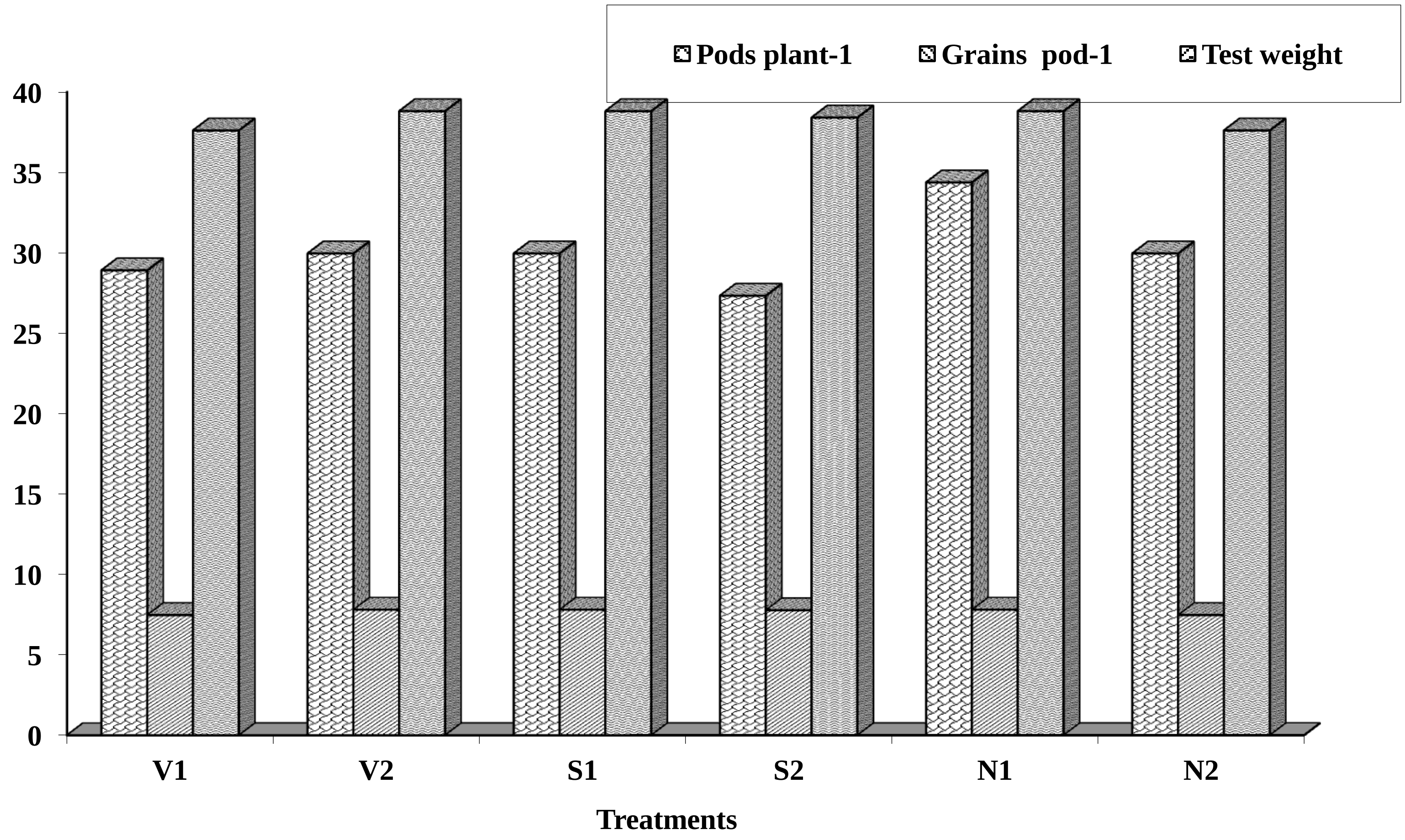


**Fig. 4.8.1 Effect of indigenous cultivars, method of sowing and nutrient management on yield attributes of blackgram**

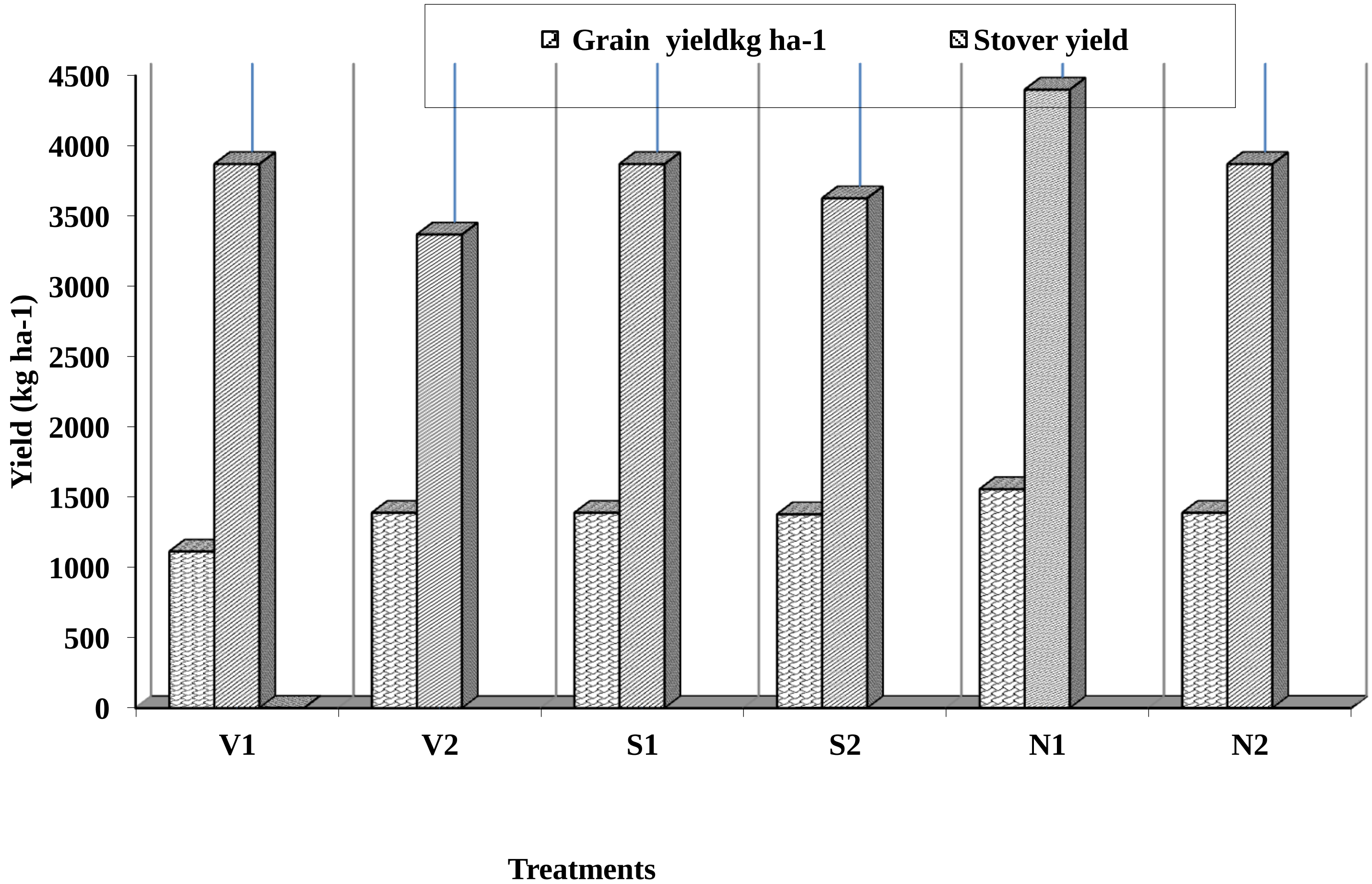


**Fig. 4.8.2 Effect of indigenous cultivars, method of sowing and nutrient management on yield of blackgram**

## C. Quality parameter

### 4.9 Protein content in seeds (%)

Observation regarding the effect of indigenous cultivars, method of sowing and nutrient management on protein content (%) of blackgram are presented in table 4.9.

**Effect of indigenous cultivars**

Treatment $V_2$ (*Chikna*) recorded highest content of protein 24.00%, which was 2.12% higher than $V_1$ (*Khajua*).

**Effect of method of sowing**

Highest content of protein 24.00% was found in the treatment $S_1$ (Broadcasting), which was 0.84% higher than $S_2$ (Line sowing).

**Effect of nutrient management**

Protein content 24.70% was found maximum in the treatment $N_1$ (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$), which was 2.91% higher than $N_2$ (DAP 62.5 kg $ha^{-1}$).

It was found that *Chikna* cultivar and integrated nutrient management were recorded maximum percentage of protein. And there were no more difference between treatment $S_1$ (Broadcasting) and $S_2$ (Line sowing). Similar findings reported by Singh *et al.* (2006) and Malik *et al.* (2004). Formally, interaction between the cultivars, broadcasting and INM may have been the reason for higher content of protein.

**Table 4.9 Effect of indigenous cultivars, method of sowing and nutrient management on protein content (%) of blackgram**

| Treatments | Protein content (%) |
|---|---|
| **Indigenous cultivars** | |
| **$V_1$:** *Khajua* | 23.50 |
| **$V_2$:** *Chikna* | 24.00 |
| **Method of sowing** | |
| **$S_1$:** Broadcasting | 24.00 |
| **$S_2$:** Line sowing | 23.80 |
| **Nutrient management** | |
| **$N_1$:** INM (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) | 24.70 |
| **$N_2$:** Inorganic (DAP 62.5 kg $ha^{-1}$) | 24.00 |

## E. Soil status

Observations regarding the nutrient status of soil before sowing and after harvesting of blackgram under using inorganic and integrated source of nutrient management, method of sowing and two cultivars of blackgram are given in the table 4.10.

The data showed that after harvesting of blackgram crop nutrient status in soil was increased in two clusters (but phosphorus and potassium were decreased). At post experimental stage, available nitrogen is 284.46 (kg $ha^{-1}$), which was 32.00% higher, and organic carbon is 0.33 (%), 32% higher than pre experimental stage in the 1st cluster (vertisols). However, in the 1st cluster (vertisols), the data of pre experimental stage of soil, available phosphorus was 18.00 (kg $ha^{-1}$), 4.65% higher and available potassium was 336 (kg $ha^{-1}$), 23.07% higher than post experimental stage. In the 2nd cluster (alfisols) of post experimental stage of soil was found available nitrogen is 215.50 (kg $ha^{-1}$), 66.66% higher, available phosphorus is 20.83 (kg $ha^{-1}$), 131.44% higher and organic carbon 0.25 (%), 66.66% higher than 2nd cluster of pre experimental stage. However, pre experimental stage of soil found available potassium 313 (kg $ha^{-1}$), which was 18.26% higher than post experimental soil in 2nd cluster (alfisols).

Application of DAP and FYM in blackgram crop, increased the available nitrogen, phosphorus and organic carbon might be due to the organic acids, which were released during microbial decomposition of organic matter (FYM). Kumawat *et al.* (2010) reported that the nitrogen fertilization to greengram crop increase the cation exchange capacity of roots, thereby enabling them to absorb more phosphorus from the soil. Bhardwas and Omanvar (1994) also opined that available N, P, K and organic carbon in soil at harvest were increased with increase in FYM levels. Integration of farmyard manure and inorganics were increase the nutrient uptake as a result of release of nutrients due to chelative effect of organic acids released during decomposition of organic matter, reported by Harisudan and Latha (2007).

**Table 4.10 Effect of indigenous cultivars, method of sowing and nutrient management of blackgram on soil status**

| Parameters | Pre - experimental stage | | Post - experimental stage | |
|---|---|---|---|---|
| | 1st cluster (vertisols) | 2nd cluster (alfisols) | 1st cluster (vertisols) | 2nd cluster (alfisols) |
| Available nitrogen (kg $ha^{-1}$) | 215.50 | 129.30 | 284.46 | 215.50 |
| Available phosphorus (kg $ha^{-1}$) | 18.00 | 9.00 | 17.20 | 20.83 |
| Available potassium (kg $ha^{-1}$) | 336.00 | 313.00 | 273.00 | 264.66 |
| Organic carbon (%) | 0.25 | 0.15 | 0.33 | 0.25 |

**E. Economics**

Observation regarding the economics is given in the table 4.11 and economic of the analyzed three factors are described separately.

**Effect of indigenous cultivars**

It was observed that treatment $V_2$ (*Chikna*) recorded maximum gross return, net return and B:C ratio, which were 44760.00 ( ₹ $ha^{-1}$), 20.41% higher, 18122.50 ( ₹ $ha^{-1}$), 72.06% higher and 1.68, 20.86% higher than $V_1$ (*Khajua*). Though the cost of cultivation, which was 26637.50 ( ₹ $ha^{-1}$) was equal in both treatments.

**Effect of method of sowing**

It was observed that treatment $S_1$ (Broadcasting) recorded 45270.00 ( ₹ $ha^{-1}$) gross return, which was 1.22% higher than $S_2$ (Line sowing). However, treatment $S_2$ (Line sowing) recorded more net return and B:C ratio, which were 19104.50 ( ₹ $ha^{-1}$), 2.53% higher and 1.74, 2.95% higher than $S_1$ (Broadcasting). Further, the cost of cultivation of treatment $S_2$ (Line sowing) was 25615.50 ( ₹ $ha^{-1}$), which was 3.98% lesser than $S_1$ (Broadcasting).

**Effect of nutrient management**

It was observed that treatment $N_1$ (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) recorded higher gross return, net return and B:C ratio, 50900.00 ( ₹ $ha^{-1}$), 12.43% higher, 21762.50 ( ₹ $ha^{-1}$), 16.79% higher and 1.74, 2.35% higher than treatment $N_2$ (DAP 62.5 kg $ha^{-1}$). However, the cost of cultivation of treatment $N_2$ (DAP 62.5 kg $ha^{-1}$) was 26637.50( ₹ $ha^{-1}$) n, which was 9.38% lesser than $N_1$ (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$).

The economic viability of improved technologies over traditional farmers practices was calculated depending on prevailing prices of input and output cost. Raikwar *et al*. (2011) reported that line sowing was found lower cost of production, high net return and B:C ratio. It was found that cost of production of blackgram in treatment $N_1$ (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) 29137.50 ( ₹ $ha^{-1}$) as against 25615.50 ( ₹ $ha^{-1}$) in treatment $S_2$ (Line sowing). The additional cost increased in the improved technologies was mainly due to more cost involved in balanced fertilizer and weed management practices. Similar findings were reported by Mani, *et al*. (2001).

**Table 4.11 Economics of different treatment combinations of indigenous cultivars, sowing methods and nutrient management of blackgram**

| Treatments | Economics | | | |
|---|---|---|---|---|
| | Gross return (₹ $ha^{-1}$) | Cost of cultivation (₹ $ha^{-1}$) | Net return (₹ $ha^{-1}$) | B:C ratio |
| **Indigenous cultivars** | | | | |
| **$V_1$:** *Khajua* | 37170.00 | 26637.50 | 10532.50 | 1.39 |
| **$V_2$:** *Chikna* | 44760.00 | 26637.50 | 18122.50 | 1.68 |
| **Method of sowing** | | | | |
| **$S_1$:** Broadcasting | 45270.00 | 26637.50 | 18632.50 | 1.69 |
| **$S_2$:** Line sowing | 44720.00 | 25615.50 | 19104.50 | 1.74 |
| **Nutrient management** | | | | |
| **$N_1$:** INM (INM = DAP 62.5 kg $ha^{-1}$ + FYM 5000 kg $ha^{-1}$) | 50900.00 | 29137.50 | 21762.50 | 1.74 |
| **$N_2$:** Inorganic (DAP 62.5 kg $ha^{-1}$) | 45270.00 | 26637.50 | 18632.50 | 1.70 |

# CHAPTER - 5

# SUMMARY AND CONCLUSION

# CHAPTER - 5

# SUMMARY AND CONCLUSION

An experiment entitled, "Response of indigenous cultivars of blackgram (*Vigna mungo* l.) to method of sowing and nutrient management under rainfed farming and climate change in Sagar (Madhya Pradesh)", was carried out during *kharif* season of 2012 at 60 farmers' fields in Shahgarh block of Sagar district. The on farm research trial was laid out in Randomized Block Design having six treatments replicated ten times, covering 10 villages in district Sagar. The experiment was conducted with active participation of the Research Officer (RO), District Project Officer (DPO), 10 Village Research Assistants (VRAs) and the small holding farming community (SHFC), who are part of an on-going project entitled, "Building Resilience to Climate Change through Strengthening Adaptive Small Scale Farming System in Rainfed Areas in Bangladesh, India and Nepal", to study the effect of sowing method and nutrient management, of two cultivars on growth, yield, economic and quality of blackgram. The experimental findings are summarized based on the objectives and are stated as follows.

## 1. To evaluate the suitable variety/cultivars from indigenous germplasm

It was observed that treatment $V_1$ (*Khajua*) recorded higher plant height, number of nodules plant$^{-1}$, plant dry weight (g), CGR (g m$^{-2}$ day$^{-1}$) at all intervals. However, treatment $V_2$ (*Chikna*) registered higher number of branches plant$^{-1}$ than $V_1$ (*Khajua*). Both treatments $V_1$ (*Khajua*) and $V_2$ (*Chikna*) were found with at par values with regard to the number of leaves plant$^{-1}$. Number of nodules plant$^{-1}$ at 60 DAS growth stage was significant in treatment $V_1$ (*Khajua*), which was 94.42, and variety $V_2$ (*Chikna*) was statistically at par with the treatment $V_1$ (*Khajua*). Treatment $V_2$ (*Chikna*) recorded higher number of pods plant$^{-1}$, number of seeds pod$^{-1}$, test weight (g), seed yield (1389.00 kg ha$^{-1}$) and harvest index (33.37%). However, the treatment $V_1$ (*Khajua*) registered higher stover yield (3870.50 kg ha$^{-1}$).

## 2. To find out the appropriate method of sowing in rainfed condition

It was observed that treatment $S_2$ (Line sowing) recorded highest plant height, number of branches plant$^{-1}$, number of leaves plant$^{-1}$ and plant dry weight at all stages and it was significant at 45 DAS with 48.06 cm, which was 18.60% higher than $S_1$ (Broadcasting). The treatment $S_2$ (Line sowing) showed significantly higher number of branches plant$^{-1}$ (6.00 cm) at 30 DAS. However, treatment $S_1$ (Broadcasting) recorded significantly superior values of CGR (g m$^{-2}$ day$^{-1}$) at all growth intervals. Treatment $S_1$ (Broadcasting) recorded higher number of pods plant$^{-1}$, number of seeds pod$^{-1}$, seed yield and stover yield, harvest index and significant test weight (38.80 g).

**3. To find out the appropriate nutrient management practice in blackgram**

Treatment $N_1$ (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$) recorded highest plant height, higher number of leaves plant$^{-1}$ and RGR (g g$^{-1}$ day$^{-1}$) than $N_2$ (DAP 62.5 kg ha$^{-1}$). Highest number of branches plant$^{-1}$, significant and highest plant dry weight (1.05 g) were observed in treatment $N_2$ (DAP 62.5 kg ha$^{-1}$). Both treatment $N_1$ (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$) and $N_2$ (DAP 62.5 kg ha$^{-1}$) were found with at par values with regard to CGR value (g g$^{-1}$ day$^{-1}$). Highest number of pods plant$^{-1}$ (34.37), seed yield (1557.00 kg ha$^{-1}$), stover yield (4400.00 kg ha$^{-1}$) and protein content (24.70%) were recorded in treatment $N_1$ (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$). However, the treatment $N_2$ (DAP 62.5 kg ha$^{-1}$) recorded higher harvest index.

**4. To determine the economics of different treatment combinations**

Treatment $N_1$ (INM = DAP 62.5 kg ha$^{-1}$ + FYM 5000 kg ha$^{-1}$) recorded the highest gross return with ₹ 50900.00 ha$^{-1}$, net return of ₹ 21762.50 ha$^{-1}$ and a B:C ratio of 1.74 (at par with $S_2$, Line sowing), which were 36.93%, 106.62% and 25.17% higher than the lowest values (₹ 37170.00 ha$^{-1}$, 10532.50 ₹ ha$^{-1}$ and 1.39 respectively) in the treatment $V_1$ (*Khajua*) respectively.

## CONCLUSION

It may be concluded that among the three factors, indigenous cultivar *Chikna*, broadcast method of sowing and integrated nutrient management were found to be the best for obtaining highest seed yield, gross return, net return and benefit cost ratio in blackgram under rainfed farming condition of Sagar. Since the findings are based on the research done in one season, it may be repeated for confirmation.

# BIBLIOGRAPHY

## BIBLIOGRAPHY


Ahlawat, I.P.S. and Shivakumar, B.G. 2002. *Kharif Pulses*. In Text–book of field crop production (Rajendra Prasad Ed.). ICAR. p.261.

Anonymous 2004. Fully revised Estimates of Principal Crops in Karnataka for the Year 2001 – 02. *Directorate of Economic Statistics*, Govt. of Karnataka, Bangalore, p.118.

Asaduzzaman, M., Sultana, S., Roy, T.S. and Masum, M. 2010. Weeding and plant spacing effect on the growth and yield of blackgram. *Bangladesh Research Publication Journal*. **35**(4-5): 111-113.

Azeez, J.O and Adetunji, M.T. 2008. *International Journal of Tropical Agriculture*, **26**(3-4): 457-461. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – A Review. *Agriculture Research Communication Centre. Agriculture Review* **30**(3): 224-228

Bhat, M. I., Rashid, A., Rasool, F., Mahdi, S. S., Haq, S. A. and Bhat, R. A. 2010. Effect of *Rhizobium* and Vascular arbuscular mycorrhizae fungi on greengram (*Vigna radiata* L. Wilczeck) under temperate conditions. *Research Journal of Agricultural Sciences* **1**(2): 113-118.

Bhardwas, V. and Omanvar, P. K. 1994. Impact of long term fertility treatment on bulk density, water content and microbial population of soil. *Journal of Indian Society of Soil Science* **49**: 553-555.

Beg, M.A. and Singh, J.K. 2009. Effect of biofertilizers and fertility levels on growth, yield and nutrient removal of greengram (*Vigna radiata*) under Kashmir conditions. *Indian Journal of Agricultural Sciences* **79**(5): 388-390.

Biswas, D.K., Haque, M.M., Hamid, A., Ahmed, J.U. and Rehman M.A. 2002. Influence of plant population density on growth and yield of two blackgram varieties. *Pakistan Journal of Agriculture* **1**(2-3): 83-85.

Bouyoucos, G.J. 1927. The hydrometer as a new method for the mechanical analysis of soils. *Soil Sci.* **23**: 343-353.

Das, P., Das, S.K., Mishra, P.K, Mishra, A. and Tripathi, A.K. 1998. Farming system analysis of results of front line demonstration on pulse crop conducted in different agro-climatic zones of Madhya Pradesh and Orissa. ZUC for TOT Project Zone VII, Jabalpur. p. 37.

Donald, C.M. (1962) In search of yield, *Journal of Australian Institute of Agriculture Science* **28**: 171-178.

Dwivedi, S.K. and Shrivastava, G.K. 2011. Planting geometry and weed management for maize-blackgram intercropping system under rainfed vertisols. *Indian Journal of Agronomy* **56**(3): 202-208.

Fisher, R.A. 1921**.** Some remarks on the methods formulated in a recent article in, "The quantitative analysis of plant growth". *Annals of Applied Biology* **7**: 367-369.

Gomez, K.A. and Gomez, A.A. 1976. Three or more factor expacts. In: *Statistical Procedure for Agricultural Research* 2nd, 139 -141.

Gupta, A., Sharma, V.K., Sharma, G.D. and Chopra, P. 2006. Effect of biofertilizers and phosphorus levels on yield attributes, yield and quality of blackgram. *Indian Journal of Agronomy* **51**(2): 142-144.

Harisudan, C., Latha, K.R., Subbian, P. and Manivannan, V. 2009. Nutrient Management for Rainfed Pulses – A Review. Agricultural Research Communication Centre. *Agriculture Review* **30** (3): 224-228.

Harisudan, C. and Latha, K.R. 2007. *New Agriculturist*., **18(**1,2): 1-4. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – A Review. *Agriculture Research Communication Centre. Agriculture Review* **30**(3): 224-228.

Harisudan, C. *et al*. 2008. *International Journal of Tropical Agriculture*, **26**(3-4**)**: 309-310. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – A Review. *Agriculture Research Communication Centre. Agriculture Review* **30**(3): 224-228.

Harisudan, C. *et al*. 2009. Proc. Int. Conference on Grain Legumes, February 14-16, *Indian Institutes of Pulse Research*, Kanpur, p 247. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – A Review. *Agriculture Research Communication Centre. Agriculture Review* **30**(3): 224-228.

Hossain, M.M. 1977. Nodule formation in *Phaseolus mungo* L. in response to different combination of nitrogen, phosphorus and potassium fertilizers. *Bangladesh Journal of Botanicals*, **6**: 1-7.

IMD (India Meteorological Department), 2012.

Jackson, K.L. 1973. Soil Chemical Analysis. Prentice Hall of India. Pvt. Ltd. New Delhi. pp. 38-43.

Kaur, Livinder, Gill, K.K., Cheema, H.K., Dhaliwal, L.K., Sirari, A. and Kingra, P.K. 2010. Meteorological factors attributing Yellow mosaic virus severity on greengram. *Indian J. of Agri. Sci.* **80**(11): 1007–9.

Kelkar, G. 2009. Climate change and vulnerability of indigenous women. *Adivasi Women Engaging With Climate Change*. UNIFEM South Asia Office: New Delhi. In: Rao, V.U.M., Rao B.B., Linitha, Nair, Patel, H.R. 2011. Climate variability and productivity of rainfed groundnut in middle Gujarat Agroclimate Zone. *Indian J. of Dryland Agric. Res. and Dev.* **26**(2): 44-49.

Krishnasamy, R. *et al*. 1985. *Madras Agriculture Journal* **72**(4): 181-184. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – *A Review*. *Agriculture Research Communication Centre. Agriculture Review* **30**(3): 224-228.

Kumawat, A., Pareek, B.L. and Yadav, R.S. 2010. Response of greengram (*Vigna radiata*) to biofertilizers under different fertility levels. *Indian Journal of Agricultural Sciences* **80**(7): 655-57.

Kumawat, N., Kumar, R.R. and Sharma, O.P. 2010. Nutrient uptake and yield of greengram as influenced by organic manures, PSB and phosphorus fertilization. *Agronomy Digest* **8 & 9:** 8-9.

Lowry, O.H., Rosebrough, N.J., Farr, A.L. and Randall, R.J. 1951. The original method. *J. of Biol.Chem*. **19**(3): 265.

Mani, A.K. *et al*. 2001. *Mysore Journal of Agriculture Science*, **35**:44-49. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – A Review. *Agriculture Research Communication Centre. Agriculture Review* **30**(3): 224-228.

Malik, M. A., Husain, S., Warraich, E. A., Habib, A. and Ullah, S. 2004. Effect of seed inoculation and phosphorus application on growth, seed yield and quality of greengram (*Vigna radiata* L.) cv. NM-98 *International Journal of Agricultural Biology* **4**(4): 285-288.

Mehra, J.P., Naik, K.R. and Jha, A. 2009. Integrated nutrient management in summer greengram. *Agronomy Digest* ***8&9*****:** 12-13.

Murugesan, S. and Chelliah, S. 1977. Influence of sowing time on the incidence of the vector *Bemisia tabaci* (Genn.) and yellow mosaic disease of greengram. *Madras Agric. J.*, **64**(2): 128-130.

Muthuvel, P.R. *et al*. 1985. *Madras Agriculture Journal*, **72**(1):22-24. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – A Review. *Agriculture Research Communication Centre. Agriculture Review* **30**(3): 224-228.

Nath, P.D. and Saikia, A.K. 1995. Effect of time of sowing on the incidence of greengram yellow mosaic virus disease and whitefly population in greengram. *Ann. Agri. Res*., **16**(4): 483-484.

Nene, Y.L. 1972. A survey of viral disease of pulse crops in Uttar Pradesh. *Research Bulletin No. 4*, Uttar Pradesh Agri. Univ., Pantnagar, 191.

Olsen, S.R., Cole, C.V., Watanable, F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *U.S. Dept. Agr. Circ*. **939**.

Pal, A.K. 2008. Growth of blackgram as influenced by non-monetary and low value inputs. *Journal of Soil and Crop* **18**(2): 257-265.

Pal, SS. 1997. Acid tolerant strains of PSB and their interactions in soybean wheat crop sequence. *Journal of Indian Society of Soil Science* **45**: 742-746.

Parihar, C.M., Kaushik M.K. and Palsaniya D.R. 2005. Effect of varieties, plant spacing and phosphorus levels on growth and yield of clusterbean. *Annals of Agriculture Research* **26**(1**)**: 5-7.

Parmar, P.P. and Thanki, J.D. 2007. Effect of irrigation, phosphorus and biofertilizers on growth and yield of *rabi* greengram (*Vigna radiata* L.) under south Gujarat condition. *Crop Research* **34**(1, 2 & 3): 100-102.

Pawar, S.B. *et al*. 2009. *Proc. Int. Conference on Grain Legumes*, February **14-16**, Indian Institutes of Pulse Research, Kanpur, p 195. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – A Review. *Agriculture Research Communication Centre. Agriculture Review* **30**(3): 224-228.

Prasad, Tripurari and Yadav, D.S. 1990. Effect of irrigation and plant density on yield attributes of greengram and blackgram. *Indian Journal of Agronomy* **35**(3)**:** 99-101.

Raikwar, R.S., Tripathi, A.K. and Shrivastav, V.P. 2011. Performance of improved production technology of blackgram in Bundelkhand region of Madhya Pradesh. *Journal of Food Legumes* **24**(4): 341-342.

Rani, Perumal *et al.* 1991. Integrated Nutrient Management in Tamil Nadu, Tamil Nadu Agric. Univ., Coimbatore, pp. 35-37. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – *A R*– A Review *eview*. *Agriculture Research Communication Centre. Agriculture Review* **30**(3): 224-228.

Rao, V.U.M., Rao B.B., Linitha, Nair, Patel, H.R. 2011. Climate variability and productivity of rainfed groundnut in middle Gujarat Agroclimate Zone. *Indian J. of Dryland Agric. Res. and Dev.* **26**(2): 44-49.

Richards, L.S. 1954. *Diagnosis and improvement of saline and alkali soils*. USDA Hand Book No.16.

Sahu, J.P., Singh, N.P., Kaushik, M.K., Sharma, B. B. and Singh, V. K. 2002. Effect of *Rhizobium*, phosphorus and potassium application on the productivity of lentil. *Indian J. of Pulses Research.* **15**(1): 39-42.

Sarkar, R.K., Karmakar, S. and Chakraborty, A. 1993. Response of summer greengram to N, P application and bacterial inoculation. *Indian Journal of Agronomy*. **38**(4): 578-581.

Sharma, Vishal and Abraham, Thomas, 2009. Effect of nitrogen, zinc and farmyard manure on blackgram. *Agronomy Digest* **9:** 17-18.

Sharoar, M.G., Deb, A.C. and Khalekue, M.A. 2006. Effect of different doses of fertilizer at different ages on some root characteristics, nodules and yield component in blackgram. *Asian Journal of Plant Science* **5**(4): 717-720.

Shrivastava, G.P. and Shrivastava, V.C. 1995. Contribution of production factors in growth, yield and economics of blackgram. *India Journal of Agronomy* **40**: 64-69.

Singh, Ram, Saravanan, R., Feroze S.M., Devarani L. and Paris, T.R. 2012. A case study of drought and its impact on rural livelihood in Meghalaya. *Indian J. of Dryland Agric. Res. and Dev*. **27**(1): 90-94

Singh, A.K. and Venkateswarlu, B. 2009. Climate change and rainfed agriculture. *Indian J. of Dryland Agric. Res. and Dev*. **24**(2): 1-9

Singh, C., Singh, P. and Singh, R. 2010. In: *Modern Techniques of Raising Field Crops.* Oxford and IBH Publishing Co. PVT. LTD. New Delhi. pp. 256-263.

Singh, R.A. and Gurha, S.N. 1994. Influence of cropping season on the incidence of yellow mosaic disease in greengram genotypes. *Indian J. Pulses Res*., **7**(12): 206-208.

Singh, A. and Singh, N.P. 2006. Direct and residual effect of organic and inorganic sources of nutrient under blackgram - wheat cropping sequence in foot-hills of Uttaranchal. *Indian Journal of Agronomy* **51**(2): 97-99.

Singh, D.K. and Singh, V.K. 2002. Growth and nitrogen uptake pattern of promising blackgram genotypes under different sowing dates and plant densities during rainy season. *Ann. of Agri. Res.* **21**(3): 456-458.

Singh, O.P., Naushad, M. and Panotra, N. 2009. Varietal performance of blackgram under different dates of sowing. *Agronomy Digest* **9:** 99-100.

Singh, R.P. Singh, Y. and Singh, B. 2006. Response of rainfed blackgram to phosphorus and sulphur application. *Indian Journal of Dryland Agricultural Research and Development* **21**(1): 80-81.

Singh, B. and Pareek, R. G. 2003. Effect of phosphorus and biofertilizers on growth and yield of greengram. *Indian Journal of pulses Research* **16**(1): 31-33.

Singh, O. B., Sharma, H. B. and Singh, V. K. 1999. Effect of nitrogen, phosphorus and *Rhizobium* culture on yield and yield attributes of lentil under dryland conditions. *Indian Journal of Pulses Research* **12**(2): 260-262.

Singh, G B. and Dwivedi, B.S. 1996. *Indian Farming*. **41**(8):9-15. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – A Review. *Agriculture Research Communication Centre. Agriculture Review* **30**(3): 224-228.

Simon, Sunil and Choudhury, Pranab, 2012. *Operation Manual*. In: Project Proposal of Building resilience to climate change through strengthening adaptive small scale farming systems in rainfed areas in Bangladesh, India and Nepal. pp. 199.

Singh, Raj and Tripathi, K.P. 1999. *Journal of Eco-Physiology*, **2(**4): 135-138. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – A Review. *Agriculture Research Communication Centre. Agriculture Review* **30**(3): 224-228.

Subbiah, B.V. and Asija, C.L. 1956**.** A rapid procedure for the estimation of available Nitrogen in soil. *Soil Sci*. **25**: 328.

Sundaravadivel, K. *et al*., 1999. *Madras Agriculture Journal* **86**(7-9**)**:384-388. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – A Review. *Agriculture Research Communication Centre. Agriculture Review* **30**(3): 224-228.

Tiwari, Dinesh, Sharma, B.B. and Singh, V.K. 2011. Effect of integrated nutrient management in pigeonpea based intercropping system. *Journal of Food Legumes* **24**(4): 304-309, Tomar, R.K.S., Shau, B.L., Singh, R.K. and Prajapati, R.K. 2009. Productivity enhancement of blackgram (*Vigna mungo*) through improved production technologies in farmer's field. *Journal of Food Legumes* **22**: 202-204.

Toth, S.J. and Prince, A.L. 1949. Estimation of cation exchange capacity and exchangeable Ca, K and Na content of soil by flame photometer technique. *Soil Sci*. **67**: 439-445.

Venkateswaralu, J. 1987. *Advance Soil Science* **7**:166-208. In: Harisudan C., Latha, K.R., Subbian, P. and Manivannan, V., 2009. Nutrient Management for Rainfed Pulses – A Review. *Agriculture Research Communication Centre*. *Agriculture Review* **30**(3): 224-228.

Verma, C.K., Yadav, R.B., Dhyani, B.P. and Tomar, S.S. 2011. Effect of seed rate and foliar spray of urea on performance of blackgram varieties. *Indian Journal of Agriculture Science* **81**(9): 881- 82.

# APPENDICES

## APPENDIX -I

**ANOVA TABLES**

**Factor 1. Indigenous cultivars**

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

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 100.10 | 11.12 | 0.90 | 3.17 | NS |
| Treatment | 1 | 2.11 | 2.11 | 0.17 | 5.11 | NS |
| Error | 9 | 110.63 | 12.29 | | | |
| Total | 19 | 2.11 | 0.11 | | | |

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

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 245.06 | 27.22 | 2.46 | 3.17 | NS |
| Treatment | 1 | 21.67 | 21.67 | 1.95 | 5.11 | NS |
| Error | 9 | 99.58 | 11.06 | | | |
| Total | 19 | 21.67 | 1.14 | | | |

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

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 899.94 | 99.99 | 8.75 | 3.17 | Significant |
| Treatment | 1 | 25.33 | 25.33 | 2.21 | 5.11 | NS |
| Error | 9 | 102.78 | 11.42 | | | |
| Total | 19 | 25.33 | 1.33 | | | |

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

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 857.12 | 95.23 | 2.44 | 3.17 | NS |
| Treatment | 1 | 1.07 | 1.071 | 0.02 | 5.11 | NS |
| Error | 9 | 349.94 | 38.88 | | | |
| Total | 19 | 1.071 | 0.056 | | | |

**Factor 2. Sowing method**

**ANOVA Table 5 Plant height (cm) of blackgram at 15 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 5.57 | 0.61 | 2.52 | 3.17 | NS |
| Treatment | 1 | 1.98 | 1.98 | 8.07 | 5.11 | Significant |
| Error | 9 | 2.21 | 0.24 | | | |
| Total | 19 | 1.98 | 0.10 | | | |

**ANOVA Table 6 Plant height (cm) of blackgram at 30 DAS**

| SV | Df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 200.39 | 22.26 | 2.02 | 3.17 | NS |
| Treatment | 1 | 3.04 | 3.04 | 0.27 | 5.11 | NS |
| Error | 9 | 98.85 | 10.98 | | | |
| Total | 19 | 3.04 | 0.16 | | | |

**ANOVA Table 7 Plant height (cm) of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 1004.22 | 111.58 | 4.94 | 3.17 | Significant |
| Treatment | 1 | 284.18 | 284.18 | 12.59 | 5.11 | Significant |
| Error | 9 | 203.08 | 22.56 | | | |
| Total | 19 | 284.18 | 14.95 | | | |

**ANOVA Table 8 Plant height (cm) of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 2142.22 | 238.02 | 3.09 | 3.17 | NS |
| Treatment | 1 | 3.55 | 3.55 | 0.04 | 5.11 | NS |
| Error | 9 | 692.83 | 76.98 | | | |
| Total | 19 | 3.55 | 0.18 | | | |

**Factor 3. Nutrient management**

**ANOVA Table 9 Plant height (cm) of blackgram at 15 DAS**

| SV | Df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 15.72 | 1.74 | 2.16 | 3.17 | NS |
| Treatment | 1 | 0.42 | 0.42 | 0.52 | 5.11 | NS |
| Error | 9 | 7.26 | 0.80 | | | |
| Total | 19 | 0.42 | 0.02 | | | |

**ANOVA Table 10 Plant height (cm) of blackgram at 30 DAS**

| SV | Df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 125.70 | 13.96 | 0.510 | 3.17 | NS |
| Treatment | 1 | 7.88 | 7.88 | 0.288 | 5.11 | NS |
| Error | 9 | 246.24 | 27.36 | | | |
| Total | 19 | 7.88 | 0.41 | | | |

**ANOVA Table 11 Plant height (cm) of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 949.66 | 105.51 | 2.37 | 3.17 | NS |
| Treatment | 1 | 86.23 | 86.23 | 1.93 | 5.11 | NS |
| Error | 9 | 400.18 | 44.46 | | | |
| Total | 19 | 86.23 | 4.53 | | | |

**ANOVA Table 12 Plant height (cm) of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 1719.07 | 191.00 | 2.33 | 3.17 | NS |
| Treatment | 1 | 26.81 | 26.81 | 0.32 | 5.11 | NS |
| Error | 9 | 736.97 | 81.88 | | | |
| Total | 19 | 26.81 | 1.41 | | | |

**Factor 1. Indigenous cultivars**
**ANOVA Table13 Number of branches plant$^{-1}$ of blackgram at 30 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 5.00 | 0.55 | 1.11 | 3.17 | NS |
| Treatment | 1 | 0.52 | 0.52 | 1.055 | 5.11 | NS |
| Error | 9 | 4.50 | 0.50 | | | |
| Total | 19 | 0.52 | 0.02 | | | |

**ANOVA Table14 Number of branches plant$^{-1}$ of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 123.17 | 13.68 | 1.94 | 3.17 | NS |
| Treatment | 1 | 0.61 | 0.61 | 0.08 | 5.11 | NS |
| Error | 9 | 63.20 | 7.02 | | | |
| Total | 19 | 0.61 | 0.03 | | | |

**ANOVA Table 15 Number of branches plant$^{-1}$ of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 319.76 | 35.52 | 3.51 | 3.17 | Significant |
| Treatment | 1 | 8.45 | 8.45 | 0.83 | 5.11 | NS |
| Error | 9 | 90.86 | 10.09 | | | |
| Total | 19 | 8.45 | 0.44 | | | |

**Factor 2. Sowing method**

**ANOVA Table16 Number of branches plant$^{-1}$ of blackgram at 30 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 3.11 | 0.34 | 4.22 | 3.17 | Significant |
| Treatment | 1 | 0.45 | 0.45 | 5.49 | 5.11 | Significant |
| Error | 9 | 0.73 | 0.08 | | | |
| Total | 19 | 0.45 | 0.02 | | | |

**ANOVA Table17 Number of branches plant$^{-1}$ of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 171.50 | 19.05 | 1.82 | 3.17 | NS |
| Treatment | 1 | 35.77 | 35.77 | 3.43 | 5.11 | NS |
| Error | 9 | 93.87 | 10.43 | | | |
| Total | 19 | 35.77 | 1.88 | | | |

**ANOVA Table18 Number of branches plant$^{-1}$ of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 683.62 | 75.95 | 2.99 | 3.17 | NS |
| Treatment | 1 | 0.45 | 0.45 | 0.01 | 5.11 | NS |
| Error | 9 | 228.05 | 25.33 | | | |
| Total | 19 | 0.45 | 0.023 | | | |

**Factor 3. Nutrient management**

**ANOVA Table19 Number of branches plant$^{-1}$ of blackgram at 30 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 10.75 | 1.19 | 2.84 | 3.17 | NS |
| Treatment | 1 | 0.003 | 0.003 | 0.007 | 5.11 | NS |
| Error | 9 | 3.778 | 0.419 | | | |
| Total | 19 | 0.0031 | 0.0001 | | | |

**ANOVA Table 20 Number of branches plant$^{-1}$ of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 248.34 | 27.59 | 4.87 | 3.17 | Significant |
| Treatment | 1 | 2.62 | 2.62 | 0.46 | 5.11 | NS |
| Error | 9 | 50.96 | 5.66 | | | |
| Total | 19 | 2.62 | 0.13 | | | |

**ANOVA Table 21 Number of branches plant$^{-1}$ of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 425.1125 | 47.23 | 3.20 | 3.17 | Significant |
| Treatment | 1 | 1.10 | 1.20 | 1.10 | 5.11 | NS |
| Error | 9 | 132.43 | 14.71 | | | |
| Total | 19 | 2.13 | 3.10 | | | |

**Factor 1. Indigenous cultivars**

**ANOVA Table 22 Number of leaves plant$^{-1}$ of blackgram at 15 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 3.22 | 0.35 | 1.09 | 3.17 | NS |
| Treatment | 1 | 0.16 | 0.16 | 0.49 | 5.11 | NS |
| Error | 9 | 2.95 | 0.32 | | | |
| Total | 19 | 0.16 | 0.008 | | | |

**ANOVA Table 23 Number of leaves plant$^{-1}$ of blackgram at 30 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 380.05 | 42.22 | 6.15 | 3.17 | Significant |
| Treatment | 1 | 2.11 | 2.11 | 0.30 | 5.11 | NS |
| Error | 9 | 61.76 | 6.86 | | | |
| Total | 19 | 2.11 | 0.11 | | | |

**ANOVA Table 24 Number of leaves plant$^{-1}$ of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 1279.90 | 142.21 | 1.47 | 3.17 | NS |
| Treatment | 1 | 157.02 | 157.02 | 1.62 | 5.11 | NS |
| Error | 9 | 868.17 | 96.46 | | | |
| Total | 19 | 157.02 | 8.26 | | | |

**ANOVA Table 25 Number of leaves plant$^{-1}$ of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 2077.34 | 230.81 | 1.84 | 3.17 | NS |
| Treatment | 1 | 128.77 | 128.77 | 1.03 | 5.11 | NS |
| Error | 9 | 1123.44 | 124.82 | | | |
| Total | 19 | 128.77 | 6.77 | | | |

**Factor 2. Method of sowing**

**ANOVA Table 26 Number of leaves plant$^{-1}$ of blackgram at 15 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 5.25 | 0.58 | 2.38 | 3.17 | NS |
| Treatment | 1 | 0.05 | 0.05 | 0.20 | 5.11 | NS |
| Error | 9 | 2.20 | 0.24 | | | |
| Total | 19 | 0.05 | 0.0026 | | | |

**ANOVA Table 27 Number of leaves plant$^{-1}$ of blackgram at 30 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 209.50 | 23.27 | 1.43 | 3.17 | NS |
| Treatment | 1 | 8.77 | 8.77 | 0.54 | 5.11 | NS |
| Error | 9 | 145.87 | 16.20 | | | |
| Total | 19 | 8.77 | 0.46 | | | |

**ANOVA Table 28 Number of leaves plant$^{-1}$ of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 1435.55 | 159.50 | 2.87 | 3.17 | NS |
| Treatment | 1 | 51.87 | 51.87 | 0.93 | 5.11 | NS |
| Error | 9 | 499.59 | 55.51 | | | |
| Total | 19 | 51.87 | 2.73 | | | |

**ANOVA Table 29 Number of leaves plant$^{-1}$ of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 5664.62 | 629.40 | 2.80 | 3.17 | NS |
| Treatment | 1 | 18.05 | 18.05 | 0.08 | 5.11 | NS |
| Error | 9 | 2018.32 | 224.25 | | | |
| Total | 19 | 18.05 | 0.95 | | | |

**Factor 3. Nutrient management**

**ANOVA Table 30 Number of leaves plant$^{-1}$ of blackgram at 15 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 3.48 | 0.38 | 0.83 | 3.17 | NS |
| Treatment | 1 | 0.72 | 0.72 | 1.56 | 5.11 | NS |
| Error | 9 | 4.15 | 0.46 | | | |
| Total | 19 | 0.72 | 0.038 | | | |

**ANOVA Table 31 Number of leaves plant$^{-1}$ of blackgram at 30 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 306.07 | 34.00 | 4.16 | 3.17 | Significant |
| Treatment | 1 | 0.37 | 0.37 | 0.046 | 5.11 | NS |
| Error | 9 | 73.40 | 8.15 | | | |
| Total | 19 | 0.37 | 0.01 | | | |

**ANOVA Table 32 Number of leaves plant$^{-1}$ of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 1461.97 | 162.44 | 2.43 | 3.17 | NS |
| Treatment | 1 | 149.49 | 149.49 | 2.24 | 5.11 | NS |
| Error | 9 | 600.60 | 66.73 | | | |
| Total | 19 | 149.49 | 7.86 | | | |

**ANOVA Table 33 Number of leaves plant$^{-1}$ of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 3512.04 | 390.23 | 3.42 | 3.17 | Significant |
| Treatment | 1 | 20.50 | 20.50 | 0.18 | 5.11 | NS |
| Error | 9 | 1024.64 | 113.85 | | | |
| Total | 19 | 20.50 | 1.07 | | | |

**Factor Factor 1. Indigenous cultivars**

**ANOVA Table 34 Number of nodules plant$^{-1}$ of blackgram at 15 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 138.42 | 15.38 | 7.60 | 3.17 | Significant |
| Treatment | 1 | 2.45 | 2.45 | 1.21 | 5.11 | NS |
| Error | 9 | 18.19 | 2.02 | | | |
| Total | 19 | 2.45 | 0.12 | | | |

**ANOVA Table 35 Number of nodules plant$^{-1}$ of blackgram at 30 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 767.51 | 85.27 | 1.97 | 3.17 | NS |
| Treatment | 1 | 0.52 | 0.52 | 0.01 | 5.11 | NS |
| Error | 9 | 388.44 | 43.16 | | | |
| Total | 19 | 0.52 | 0.02 | | | |

**ANOVA Table 36 Number of nodules plant$^{-1}$ of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 2671.43 | 296.82 | 2.82 | 3.17 | NS |
| Treatment | 1 | 66.61 | 66.61 | 0.63 | 5.11 | NS |
| Error | 9 | 946.63 | 105.18 | | | |
| Total | 19 | 66.61 | 3.50 | | | |

**ANOVA Table 36 Number of nodules plant$^{-1}$ of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 7502.31 | 833.59 | 2.27 | 3.17 | NS |
| Treatment | 1 | 2403.52 | 2403.52 | 6.54 | 5.11 | Significant |
| Error | 9 | 3304.56 | 367.17 | | | |
| Total | 19 | 2403.52 | 126.50 | | | |

**Factor 2. Method of sowing**

**ANOVA Table 37 Number of nodules plant$^{-1}$ of blackgram at 15 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 111.95 | 12.43 | 7.15 | 3.17 | Significant |
| Treatment | 1 | 0.48 | 0.48 | 0.27 | 5.11 | NS |
| Error | 9 | 15.65 | 1.73 | | | |
| Total | 19 | 0.48 | 0.02 | | | |

**ANOVA Table 38 Number of nodules plant$^{-1}$ of blackgram at 30 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 484.77 | 53.86 | 2.44 | 3.17 | NS |
| Treatment | 1 | 16.65 | 16.65 | 0.75 | 5.11 | NS |
| Error | 9 | 198.12 | 22.01 | | | |
| Total | 19 | 16.65 | 0.87 | | | |

**ANOVA Table 39 Number of nodules plant$^{-1}$ of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 3456.69 | 384.07 | 11.15 | 3.17 | Significant |
| Treatment | 1 | 33.15 | 33.15 | 0.96 | 5.11 | NS |
| Error | 9 | 309.81 | 34.42 | | | |
| Total | 19 | 33.15 | 1.74 | | | |

**ANOVA Table 40 Number of nodules plant$^{-1}$ of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 15936.07 | 1770.67 | 2.90 | 3.17 | NS |
| Treatment | 1 | 835.27 | 835.27 | 1.37 | 5.11 | NS |
| Error | 9 | 5482.69 | 609.18 | | | |
| Total | 19 | 835.27 | 43.96 | | | |

**Factor 3. Nutrient management**

**ANOVA Table 41 Number of nodules plant$^{-1}$ of blackgram at 15 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 130.40 | 14.48 | 6.79 | 3.17 | Significant |
| Treatment | 1 | 3.36 | 3.36 | 1.57 | 5.11 | NS |
| Error | 9 | 19.18 | 2.13 | | | |
| Total | 19 | 3.36 | 0.17 | | | |

**ANOVA Table 42 Number of nodules plant$^{-1}$ of blackgram at 30 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 321.56 | 35.72 | 0.75 | 3.17 | NS |
| Treatment | 1 | 2.45 | 2.45 | 0.05 | 5.11 | NS |
| Error | 9 | 428.55 | 47.61 | | | |
| Total | 19 | 2.45 | 0.12 | | | |

**ANOVA Table 43 Number of nodules plant$^{-1}$ of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 2064.58 | 229.39 | 4.83 | 3.17 | Significant |
| Treatment | 1 | 44.25 | 44.25 | 0.93 | 5.11 | NS |
| Error | 9 | 426.90 | 47.43 | | | |
| Total | 19 | 44.25 | 2.32 | | | |

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**NOVA Table 44 Number of nodules plant$^{-1}$ of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 5879.04 | 653.22 | 0.70 | 3.17 | NS |
| Treatment | 1 | 1419.78 | 1419.78 | 1.52 | 5.11 | NS |
| Error | 9 | 8351.89 | 927.98 | | | |
| Total | 19 | 1419.78 | 74.72 | | | |

**Factor 1. Indigenous method**

**ANOVA Table 45 Plant dry weight (g) of blackgram at 15 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 0.025 | 0.002 | 0.75 | 3.17 | NS |
| Treatment | 1 | 0.002 | 0.002 | 0.53 | 5.11 | NS |
| Error | 9 | 0.0335 | 0.003 | | | |
| Total | 19 | 0.002 | 0.0001 | | | |

**ANOVA Table 46 Plant dry weight (g) of blackgram at 30 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 2.37 | 0.26 | 4.72 | 3.17 | Significant |
| Treatment | 1 | 0.15 | 0.15 | 2.73 | 5.11 | NS |
| Error | 9 | 0.50 | 0.05 | | | |
| Total | 19 | 0.15 | 0.008 | | | |

**ANOVA Table 47 Plant dry weight (g) of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 40.41 | 4.49 | 5.49 | 3.17 | Significant |
| Treatment | 1 | 0.36 | 0.36 | 0.44 | 5.11 | NS |
| Error | 9 | 7.35 | 0.81 | | | |
| Total | 19 | 0.36 | 0.02 | | | |

**ANOVA Table 48 Plant dry weight (g) of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 31.49 | 3.49 | 1.89 | 3.17 | NS |
| Treatment | 1 | 4.00 | 4.00 | 2.16 | 5.11 | NS |
| Error | 9 | 16.62 | 1.84 | | | |
| Total | 19 | 4.00 | 0.21 | | | |

**Factor 2. Sowing method**

**ANOVA Table 49 Plant dry weight (g) of blackgram at 15 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 0.097 | 0.010 | 2.82 | 3.17 | NS |
| Treatment | 1 | 0.003 | 0.003 | 0.81 | 5.11 | NS |
| Error | 9 | 0.034 | 0.003 | | | |
| Total | 19 | 0.003 | 0.0001 | | | |

**ANOVA Table 50 Plant dry weight (g) of blackgram at 30 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 3.387 | 0.376 | 5.53 | 3.17 | Significant |
| Treatment | 1 | 0.012 | 0.012 | 0.18 | 5.11 | NS |
| Error | 9 | 0.612 | 0.068 | | | |
| Total | 19 | 0.012 | 0.0006 | | | |

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 28.134 | 3.126 | 2.835 | 3.178 | NS |
| Treatment | 1 | 1.255 | 1.255 | 1.138 | 5.117 | NS |
| Error | 9 | 9.921 | 1.102 | | | |

| Total | 19 | 1.255 | 0.066 | | | |
|---|---|---|---|---|---|---|

**ANOVA Table 51 Plant dry weight (g) of blackgram at 45 DAS**

**ANOVA Table 52 Plant dry weight (g) of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 96.742 | 10.749 | 4.740 | 3.178 | Significant |
| Treatment | 1 | 1.388 | 1.388 | 0.612 | 5.117 | NS |
| Error | 9 | 20.406 | 2.267 | | | |
| Total | 19 | 1.388 | 0.073 | | | |

**Factor 3. Nutrient management**

**ANOVA Table 53 Plant dry weight (g) of blackgram at 15 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 0.078 | 0.008 | 0.641 | 3.178 | NS |
| Treatment | 1 | 0.005 | 0.005 | 0.423 | 5.117 | NS |
| Error | 9 | 0.122 | 0.013 | | | |
| Total | 19 | 0.005 | 0.0003 | | | |

**ANOVA Table 54 Plant dry weight (g) of blackgram at 30 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 3.012 | 0.334 | 12.194 | 3.178 | Significant |
| Treatment | 1 | 0.420 | 0.420 | 15.321 | 5.117 | Significant |
| Error | 9 | 0.247 | 0.027 | | | |
| Total | 19 | 0.425 | 0.022 | | | |

**ANOVA Table 55 Plant dry weight (g) of blackgram at 45 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 24.377 | 2.708 | 1.687 | 3.178 | NS |
| Treatment | 1 | 0.149 | 0.149 | 0.093 | 5.117 | NS |
| Error | 9 | 14.447 | 1.605 | | | |
| Total | 19 | 0.149 | 0.007 | | | |

**ANOVA Table 56 Plant dry weight (g) of blackgram at 60 DAS**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 27.332 | 3.036 | 1.634 | 3.178 | NS |
| Treatment | 1 | 0.400 | 0.400 | 0.215 | 5.117 | NS |
| Error | 9 | 16.724 | 1.855 | | | |
| Total | 19 | 0.400 | 0.021 | | | |

**Factor 1. Indigenous cultivar**

**ANOVA Table 57 Crop growth rate (g $m^{-2}$ $day^{-1}$) of blackgram at 0 to 15 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 4.102 | 0.455 | 0.753 | 3.178 | NS |
| Treatment | 1 | 0.426 | 0.426 | 0.704 | 5.117 | NS |
| Error | 9 | 5.447 | 0.605 | | | |
| Total | 19 | 0.426 | 0.022 | | | |

**ANOVA Table 58 Crop growth rate (g $m^{-2}$ $day^{-1}$) of blackgram at 15 to 30 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 379.602 | 42.178 | 3.417 | 3.178 | Significant |
| Treatment | 1 | 22.050 | 22.050 | 1.786 | 5.117 | NS |
| Error | 9 | 111.090 | 12.343 | | | |
| Total | 19 | 22.050 | 1.160 | | | |

**ANOVA Table 59 Crop growth rate (g $m^{-2}$ $day^{-1}$) of blackgram at 30 to 45 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 6756.722 | 750.746 | 4.554 | 3.178 | Significant |
| Treatment | 1 | 8.450 | 8.450 | 0.051 | 5.117 | NS |
| Error | 9 | 1483.650 | 164.850 | | | |
| Total | 19 | 8.45 | 0.444 | | | |

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

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 10492.35 | 1165.817 | 5.623 | 3.178 | Significant |
| Treatment | 1 | 753.992 | 753.992 | 3.637 | 5.117 | NS |
| Error | 9 | 1865.688 | 207.298 | | | |
| Total | 19 | 753.992 | 39.683 | | | |

**Factor 2. Method of sowing**

**ANOVA Table 61 Crop growth rate (g $m^{-2}$ $day^{-1}$) of blackgram at 0 to 15 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 4.126 | 0.458 | 1.822 | 3.178 | NS |
| Treatment | 1 | 26.657 | 26.657 | 105.974 | 5.117 | Significant |
| Error | 9 | 2.263 | 0.251 | | | |
| Total | 19 | 26.657 | 1.403 | | | |

**ANOVA Table 62 Crop growth rate (g $m^{-2}$ $day^{-1}$) of blackgram at 15 to 30 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 184.931 | 20.547 | 1.763 | 3.178 | NS |
| Treatment | 1 | 380.192 | 380.192 | 32.636 | 5.117 | Significant |
| Error | 9 | 104.843 | 11.649 | | | |
| Total | 19 | 380.192 | 20.010 | | | |

**eANOVA Table 63 Crop growth rate (g m$^{-2}$ day$^{-1}$) of blackgram at 30 to 45 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 1608.404 | 178.711 | 0.244 | 3.178 | NS |
| Treatment | 1 | 11677.980 | 11677.980 | 15.945 | 5.117 | Significant |
| Error | 9 | 6591.264 | 732.362 | | | |
| Total | 19 | 11677.980 | 614.630 | | | |

**ANOVA Table 64 Crop growth rate (g m$^{-2}$ day$^{-1}$) of blackgram at 45 to 60 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 5244.424 | 582.713 | 1.051 | 3.178 | NS |
| Treatment | 1 | 5962.295 | 5962.295 | 10.762 | 5.117 | Significant |
| Error | 9 | 4985.746 | 553.971 | | | |
| Total | 19 | 5962.295 | 313.805 | | | |

**F**

**actor 3. Nutrient management**

**ANOVA Table 65 Crop growth rate (g m$^{-2}$ day$^{-1}$) of blackgram at 0 to 15 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 6.232 | 0.692 | 0.335 | 3.178 | NS |
| Treatment | 1 | 0.044 | 0.044 | 0.021 | 5.117 | NS |
| Error | 9 | 18.557 | 2.061 | | | |
| Total | 19 | 0.044 | 0.002 | | | |

**ANOVA Table 66 Crop growth rate (g m$^{-2}$ day$^{-1}$) of blackgram at 15 to 30 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 151.850 | 16.872 | 0.769 | 3.178 | NS |
| Treatment | 1 | 128.018 | 128.018 | 5.841 | 5.117 | Significant |
| Error | 9 | 197.242 | 21.915 | | | |
| Total | 19 | 128.018 | 6.737 | | | |

**ANOVA Table 67 Crop growth rate (g m$^{-2}$ day$^{-1}$) of blackgram at 30 to 45 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 5129.898 | 569.988 | 1.646 | 3.178 | NS |
| Treatment | 1 | 388.962 | 388.962 | 1.123 | 5.117 | NS |
| Error | 9 | 3114.698 | 346.077 | | | |
| Total | 19 | 388.962 | 20.471 | | | |

**ANOVA Table 68 Crop growth rate (g m$^{-2}$ day$^{-1}$) of blackgram at 45 to 60 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 5813.898 | 645.988 | 0.805 | 3.178 | NS |
| Treatment | 1 | 112.338 | 112.338 | 0.140 | 5.117 | NS |
| Error | 9 | 7220.682 | 802.298 | | | |
| Total | 19 | 112.338 | 5.912 | | | |

**Factor 1. Indigenous cultivars**

**ANOVA Table 69 Relative growth rate (g $g^{-1}$ $day^{-1}$) of blackgram at 15 to 30 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 0.0052 | 0.0005 | 0.6005 | 3.1788 | NS |
| Treatment | 1 | 0.0002 | 0.0002 | 0.2238 | 5.1173 | NS |
| Error | 9 | 0.0087 | 0.0009 | | | |
| Total | 19 | 0.0002 | 0.0012 | | | |

**ANOVA Table 70 Relative growth rate (g $g^{-1}$ $day^{-1}$) of blackgram at 30 to 45 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 0.0150 | 0.0016 | 2.8167 | 3.1788 | NS |
| Treatment | 1 | 0.0003 | 0.0003 | 0.5930 | 5.1173 | NS |
| Error | 9 | 0.0053 | 0.0005 | | | |
| Total | 19 | 0.0003 | 0.0002 | | | |

**ANOVA Table 71 Relative growth rate (g $g^{-1}$ $day^{-1}$) of blackgram at 45 to 60 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 0.0111 | 0.0012 | 8.2054 | 3.1787 | Significant |
| Treatment | 1 | 0.0142 | 0.0012 | 0.0331 | 5.1173 | NS |
| Error | 9 | 0.0013 | 0.0001 | | | |
| Total | 19 | 0.0004 | 2.6314 | | | |

**Factor 2. Method of sowing**

**ANOVA Table 72 Relative growth rate (g $g^{-1}$ $day^{-1}$) of blackgram at 15 to 30 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 0.0123 | 0.0013 | 3.2737 | 3.1788 | Significant |
| Treatment | 1 | 0.0003 | 0.0003 | 0.8015 | 5.1173 | NS |
| Error | 9 | 0.0037 | 0.0004 | | | |
| Total | 19 | 0.0003 | 1.7712 | | | |

**ANOVA Table 73 Relative growth rate (g $g^{-1}$ $day^{-1}$) of blackgram at 30 to 45 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 0.0175 | 0.0019 | 5.3361 | 3.1788 | Significant |
| Treatment | 1 | 0.0008 | 0.0008 | 2.2114 | 5.1173 | NS |
| Error | 9 | 0.0032 | 0.0003 | | | |
| Total | 19 | 0.0008 | 4.2421 | | | |

**ANOVA Table 74 Relative growth rate (g $g^{-1}$ $day^{-1}$) of blackgram at 45 to 60 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 0.0110 | 0.0012 | 5.5144 | 3.1788 | Significant |
| Treatment | 1 | 2.4512 | 2.4506 | 0.0109 | 5.1173 | NS |
| Error | 9 | 0.0020 | 0.0002 | | | |
| Total | 19 | 2.4512 | 1.2902 | | | |

**Factor 3. Nutrient management**

**ANOVA Table 75 Relative growth rate (g $g^{-1}$ $day^{-1}$) of blackgram at 15 to 30 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 0.0145 | 0.0016 | 2.5949 | 3.1788 | NS |
| Treatment | 1 | 0.0030 | 0.0030 | 4.9112 | 5.1173 | NS |
| Error | 9 | 0.0055 | 0.0006 | | | |
| Total | 19 | 0.0030 | 0.0001 | | | |

**ANOVA Table 76 Relative growth rate (g $g^{-1}$ $day^{-1}$) of blackgram at 30 to 45 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 0.0155 | 0.0017 | 1.1270 | 3.1788 | NS |
| Treatment | 1 | 0.0019 | 0.0019 | 1.2899 | 5.1173 | NS |
| Error | 9 | 0.0138 | 0.0015 | | | |
| Total | 19 | 0.0019 | 0.0001 | | | |

**ANOVA Table 77 Relative growth rate (g $g^{-1}$ $day^{-1}$) of blackgram at 45 to 60 DAS interval**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 0.0122 | 0.0013 | 3.104 | 3.178 | NS |
| Treatment | 1 | 4.2203 | 4.223 | 0.096 | 5.117 | NS |
| Error | 9 | 0.0039 | 0.0004 | | | |
| Total | 19 | 4.220 | 2.212 | | | |

**Factor 1. Indigenous cultivars**

**ANOVA Table 78 Number of pods $plant^{-1}$ of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 1798.575 | 199.841 | 1.018 | 3.178 | NS |
| Treatment | 1 | 5.512 | 5.512 | 0.028 | 5.117 | NS |
| Error | 9 | 1765.802 | 196.203 | | | |
| Total | 19 | 5.512 | 0.290 | | | |

**Factor 2. Method of sowing**

**ANOVA Table 79 Number of pods $plant^{-1}$ of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 3005.091 | 333.899 | 7.027 | 3.178 | Significant |
| Treatment | 1 | 34.453 | 34.453 | 0.725 | 5.117 | NS |
| Error | 9 | 427.640 | 47.515 | | | |
| Total | 19 | 34.453 | 1.813 | | | |

**Factor 3. Nutrient management**

**ANOVA Table 80 Number of pods $plant^{-1}$ of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 1517.628 | 168.622 | 0.854 | 3.178 | NS |
| Treatment | 1 | 97.903 | 97.903 | 0.496 | 5.117 | NS |
| Error | 9 | 1776.323 | 197.372 | | | |
| Total | 19 | 97.903 | 5.152 | | | |

**Factor 1. Indigenous cultivars**
**ANOVA Table 81 Number of grains pod$^{-1}$ of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 3.403 | 0.378 | 1.941 | 3.178 | NS |
| Treatment | 1 | 0.528 | 0.528 | 2.711 | 5.117 | NS |
| Error | 9 | 1.753 | 0.194 | | | |
| Total | 19 | 0.528 | 0.027 | | | |

**Factor 2. Method of sowing**
**ANOVA Table 82 Number of grains pod$^{-1}$ of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 2.190 | 0.243 | 2.008 | 3.178 | NS |
| Treatment | 1 | 0.003 | 0.003 | 0.025 | 5.117 | NS |
| Error | 9 | 1.090 | 0.121 | | | |
| Total | 19 | 0.003 | 0.0001 | | | |

**Factor 3. Nutrient management**
**ANOVA Table 83 Number of grains pod$^{-1}$ of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 3.71 | 0.41 | 0.83 | 3.17 | NS |
| Treatment | 1 | 0.52 | 0.52 | 1.07 | 5.11 | NS |
| Error | 9 | 4.44 | 0.49 | | | |
| Total | 19 | 0.52 | 0.02 | | | |

**Factor 1. Indigenous cultivars**
**ANOVA Table 84 Test weight (g) of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 8.20 | 0.91 | 0.46 | 3.17 | NS |
| Treatment | 1 | 7.20 | 7.20 | 3.64 | 5.11 | NS |
| Error | 9 | 17.80 | 1.97 | | | |
| Total | 19 | 7.20 | 0.37 | | | |

**Factor 2. Method of sowing**
**ANOVA Table 85 Test weight (g) of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 42.80 | 4.75 | 1.57 | 3.17 | NS |
| Treatment | 1 | 0.80 | 0.80 | 0.26 | 5.11 | NS |
| Error | 9 | 27.20 | 3.02 | | | |
| Total | 19 | 0.80 | 0.04 | | | |

**Factor 3. Nutrient management**
**ANOVA Table 86 Test weight (g) of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 45.20 | 5.02 | 1.37 | 3.17 | NS |
| Treatment | 1 | 7.20 | 7.20 | 1.97 | 5.11 | NS |
| Error | 9 | 32.80 | 3.64 | | | |
| Total | 19 | 7.20 | 0.37 | | | |

**Factor 1. Indigenous cultivars**

**ANOVA Table 87 Grain yield (kg $ha^{-1}$) of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 2053456 | 228161.80 | 2.12 | 3.17 | NS |
| Treatment | 1 | 379501.3 | 379501.30 | 3.52 | 5.11 | NS |
| Error | 9 | 968136.3 | 107570.70 | | | |
| Total | 19 | 379501.3 | 19973.75 | | | |

**Factor 2. Method of sowing**

**ANOVA Table 88 Grain yield (kg $ha^{-1}$) of blackgram**

| SV | Df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 5343255 | 593695 | 3.742575 | 3.17 | Significant |
| Treatment | 1 | 605 | 605 | 0.003814 | 5.11 | NS |
| Error | 9 | 1427695 | 158632.80 | | | |
| Total | 19 | 605 | 31.84211 | | | |

**Factor 3. Nutrient management**

**ANOVA Table 89 Grain yield (kg $ha^{-1}$) of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 3115220 | 346135.60 | 2.39 | 3.17 | NS |
| Treatment | 1 | 141120 | 141120 | 0.97 | 5.11 | NS |
| Error | 9 | 1299380 | 144375.60 | | | |
| Total | 19 | 141120 | 7427.36 | | | |

**Factor 1. Indigenous cultivars**

**ANOVA Table 90 Stover yield (kg $ha^{-1}$) of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 78590386 | 8732265 | 2.48 | 3.17 | NS |
| Treatment | 1 | 1257511 | 1257511 | 0.35 | 5.11 | NS |
| Error | 9 | 31641576 | 3515731 | | | |
| Total | 19 | 1257511 | 66184.80 | | | |

**Factor 2. Method of sowing**

**ANOVA Table 91 Stover yield (kg $ha^{-1}$) of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 58290706 | 6476745 | 1.61 | 3.17 | NS |
| Treatment | 1 | 296461.3 | 296461.30 | 0.07 | 5.11 | NS |
| Error | 9 | 36128126 | 4014236 | | | |
| Total | 19 | 296461.3 | 15603.22 | | | |

**Factor 3. Nutrient management**

**ANOVA Table 92 Stover yield (kg $ha^{-1}$) of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 89343061 | 9927007 | 1.66 | 3.17 | NS |
| Treatment | 1 | 1401851 | 1401851 | 0.23 | 5.11 | NS |
| Error | 9 | 53609361 | 5956596 | | | |
| Total | 19 | 1401851 | 73781.64 | | | |

**Factor 1. Indigenous cultivars**
**ANOVA Table 93 Harvest index (%) of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 1350.56 | 150.06 | 2.07 | 3.17 | NS |
| Treatment | 1 | 250.56 | 250.56 | 3.46 | 5.11 | NS |
| Error | 9 | 651.12 | 72.34 | | | |
| Total | 19 | 250.56 | 13.18 | | | |

**Factor 2. Method of sowing**
**ANOVA Table 94 Harvest index (%) of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 1226.59 | 136.28 | 1.28 | 3.17 | NS |
| Treatment | 1 | 51.68 | 51.68 | 0.48 | 5.11 | NS |
| Error | 9 | 953.94 | 105.99 | | | |
| Total | 19 | 51.68 | 2.72 | | | |

**Factor 3. Nutrient management**
**ANOVA Table 95 Harvest index (%) of blackgram**

| SV | df | SS | MSS | F Cal | F Tab (5%) | Result |
|---|---|---|---|---|---|---|
| Replication | 9 | 1184.28 | 131.58 | 0.94 | 3.17 | NS |
| Treatment | 1 | 11.88 | 11.88 | 0.085 | 5.11 | NS |
| Error | 9 | 1250.09 | 138.89 | | | |
| Total | 19 | 11.88 | 0.62 | | | |

**Appendix II- a**
**Cost of cultivation of different treatments combination of sowing methods and nutrient management of blackgram**

| S. No. | | Particulars | Unit | Qty. | Rate unit$^{-1}$ (₹) | Cost (₹ ha$^{-1}$) |
|---|---|---|---|---|---|---|
| A | | Pre sowing land preparation | | | | |
| | 1 | Ploughing and disc harrowing | Tractor (hrs) | 5 | 400.00 | 2000.00 |
| B | | Land preparation | | | | |
| | 1 | Ploughing and planking | Tractor (hrs) | 4 | 400.00 | 1600.00 |
| | 2 | Layout | Labourer | 10 | 130.00 | 1300.00 |
| B | | Nutrient application | | | | |
| | 1 | DAP | Kg | 62.50 | 25.00 | 1562.50 |
| D | | Interculture | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 1 | Weeding | Labourer | 8 | 130.00 | 1040.00 |
| E | | Plant protection measures | | | | |
| | 1 | Gomutra culture (5%) | Litre | 14 | 10.00 | 140.00 |
| F | | Harvesting and threshing | Labourer | 21 | 130.00 | 2730.00 |
| G | | Rental value of land | Months | 3 | 2083.33 | 6250.00 |
| H | | Supervision charge | Months | 4 | 1000.00 | 4000.00 |
| I | | Transport charges | Truck load | 2 | 2000.00 | 4000.00 |
| | | | Total fixed cost = | 24622.50 | | |

**Appendix II- b**

**Variable cost for all treatments**

| | Seed@ ₹ 80 $kg^{-1}$ | Seed treatment with Bavistin @ 2g $kg^{-1}$ Seed | Sowing cost 2 labourers | Interculture thinning 4 Labourers | FYM 5000 kg $ha^{-1}$ @ ₹ 0.50 $kg^{-1}$ | Total variable cost |
|---|---|---|---|---|---|---|
| $V_1$ | 1200 | 35 | 260.00 | 520.00 | - | 2015.00 |
| $V_2$ | 1200 | 35 | 260.00 | 520.00 | - | 2015.00 |
| $S_1$ | 1200 | 35 | 260.00 | 520.00 | - | 2015.00 |
| $S_2$ | 960 | 33 | - | - | - | 993.00 |
| $N_1$ | 1200 | 35 | 260.00 | 520.00 | 2500 | 4515.00 |
| $N_2$ | 1200 | 35 | 260.00 | 520.00 | | 2015.00 |