RESPONSE OF DIFFERENT CULTIVARS OF GREENGRAM (*Vigna radiata* L.) TO INTEGRATED NUTRIENT MANAGEMENT UNDER SOUTH GUJARAT CONDITION

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CERTIFICATE

This is to certify that the thesis entitled "**RESPONSE OF DIFFERENT CULTIVARS OF GREENGRAM (*Vigna radiata* L.) TO INTEGRATED NUTRIENT MANAGEMENT UNDER SOUTH GUJARAT CONDITION**" submitted by **PATEL RINKU D.** in partial fulfillment of the requirements for award of the degree of **Master of Science (Agriculture)** in the subject of **Agronomy** of the **Navsari Agricultural University,** is a record of bonafide research work carried out by her under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : Navsari

Date : 19/07/2012

(D. D. Patel)

Major Advisor

DECLARATION

This is to declare that the whole of the research work reported here in this thesis for partial fulfillment of the requirements for the degree of the **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY** by the undersigned is the results of investigation carried out by me under the direct guidance and supervision of **Dr. D. D. Patel**, Associate Professor of Agronomy, Navsari Agricultural University, Bharuch and no part of the work has been submitted for any other degree so far.

Place : Navsari **(R. D. Patel)**

Date : 19/**July, 2012**

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Place : Navsari

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ABSTRACT

RESPONSE OF DIFFERENT CULTIVARS OF GREENGRAM (*Vigna radiata* L.) TO INTEGRATED NUTRIENT MANAGEMENT UNDER SOUTH GUJARAT CONDITION

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ABSTRACT

A field experiment was conducted during summer season of 2011 at the College Farm, Navsari Agricultural University, Navsari to study the "Response of different cultivars of greengram (*Vigna radiata* L.) to integrated nutrient management under south Gujarat condition". The soil of the experimental field was clayey in texture having medium to poor drainage, low in available nitrogen, medium in available phosphorus and fairly rich in available potassium and sulphur with 7.8 pH.

Total twenty treatment combinations consisting of two varieties *viz.*, Meha (V_1) and GM 3 (V_2), three levels of inorganic fertilizer (F_1: 100 per cent RDF i.e. 20-40-00 kg NPK/ha, F_2: 75 per cent RDF and F_3: 50 per cent RDF) and three treatments of biofertilizers (B_1: *rhizobium* seed inoculation, B_2: Phosphate solubilizing bacteria (PSB) seed inoculation and B_3: *rhizobium* +

PSB seed inoculation) combine with two additional treatments (AT_1- Meha with 100% RDF only) and AT_2 (GM 3 with 100% RDF only) were evaluated in factorial randomized block design with factorial concept in three replications.

Almost all the growth and yield attributes such as plant height, number of branches, dry matter accumulation, number of root nodules, pods per plant, seeds per pod, test weight per plant were significantly influenced by levels of inorganic fertilizer. Significantly higher values of all the above parameters were recorded with 100% RDF (20-40-00 kg NPK kg/ha) which were found superior to rest of the treatments except F_2 (75% RDF). Consequently, plots receiving 100% RDF (F_1) recorded significantly higher seed (1365 kg/ha) and stover (3491 kg/ha) yields as compared to treatments F_2 (75% RDF) and F_3 (50% RDF). Remarkable improvement in quality, nutrient content as well as their uptake was also observed with the treatment of 100 and 75% RDF. Nutrient status of soil after harvest of crop was also improved with the treatment of 100% and 75% RDF. From economic point of view, the maximum net realization of ₹ 63280/ha and ₹ 58237/ha with BCR of 5.29 and 5.00 were achieved with 100 and 75% RDF, respectively, in greengram.

Various treatments of biofertilizers also produced significant variation in growth as well as yield attributes. The crop sown with dual inoculation of *rhizobium* and PSB showed significant improvement in plant height, number of branches, dry matter accumulation, number of seeds per pod, test weight but remained at par to PSB inoculation. However, significantly the highest number of pods per plant (18.84), seed yield (1345 kg/ha) and stover yield (3545 kg/ha) were obtained in the treatment B_3 as compared to treatments B_1 (*rhizobium*) and B_2 (PSB). Considerable improvement in quality, nutrient content as well as their uptake was also noticed under dual inoculation treatment. Nutrient status of soil after the harvest of crop was also appreciably increased by inoculating the seed either by *rhizobium* and PSB alone or in combination. With regard to economics, dual inoculation of *rhizobium* and PSB achieved higher net realization of ₹ 63320/ha with BCR of 5.75 as compared to biofertilizer treatment alone.

With respect to interaction effect, it is interesting to note that the seed yield recorded with 75 per cent RDF + dual inoculation of *rhizobium* and PSB or PSB alone were found as good as the yield obtained with 100 per cent RDF + dual inoculation of *rhizobium* and PSB, indicates 25 per cent saving of inorganic fertilizer.

On the basis of results obtained in the present investigation, following conclusions could be made.

- Meha is better variety of greengram for the south Gujarat condition in summer season over cv. GM 3.
- For getting more remunerative production of greengram, crop should be fertilized with 100% RDF (20-40-0 kg NPK/ha).

- Seed inoculation with *rhizobium* and PSB is more profitable for greengram as compared to inoculated with either *rhizobium* or PSB alone.
- Compared to treatment combinations as well as control, F_1B_3 (100 % RDF with dual seed inoculation of *rhizobium* and PSB) found more productive and economical which closely followed by the treatment combination of F_2B_3 (75% RDF with dual inoculation of *rhizobium* and PSB) and F_2B_2 (75% RDF with seed inoculation with PSB) indicating 25% saving of inorganic fertilizer through use of dual inoculation of *rhizobium* and PSB or PSB alone.

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After successfully completing the long educational journey, I look back and find that though mind has been a fairly sail, it has been memorizing extra vaganza of memorable experiences. At this gratifying moment of completion of my research problem, I feel obliged to record my gratitude to those who have helped me. I feel immense pleasure in expressing my deep sense of gratitude and indebtedness to my Major Advisor ***Dr. D. D. Patel**, Associate Professor, Department of Agronomy, N. M. College of Agriculture, Navsari Agricultural University, Navsari for his versatile advise, constant inspiration, encouragement, for his attention and magnanimous attitude right from the first day, to understand and analyze the obstacles by which any researcher would fail. It has a privilege that he was always available, easily approachable and ever willing to solve the intricate problems that would arise during the course of research and thesis writing. He furnished moral and me with unremitting source of boost up, both intellectuals that made my task much simpler than it would have fulfilling this ordeal.*

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Last, but far from the least, I could like to place on record my sincere regard deepest gratitude, soulfull respect and a million thanks to 'God ' the almighty, who helped me on every path of my life and made every step a great success.

Place : Navsari **(Rinku D. Patel)**

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INTRODUCTION

I. INTRODUCTION

Pulses are integral part of Indian dietary system because of its richness in proteins and other important nutrients such as Ca, Fe and vitamins *viz.*, carotene, thiamine, riboflavin and niacine. Indian population is predominantly vegetarian and protein requirement for the growth and development of the human being is mostly met with pulses. They are said to be poor man's meat and rich man's vegetables. As per recommendation of World Health Organization (WHO) minimum requirement of pulses is 80 g/ capita/ day. Apart from the human diet, pulses form an important fraction of cattle feed and fodder as hay, green fodder and concentrates. Due to their short duration crop habit they can be grown as main, intercrop, catch and green manure crop. Pulses are known to improve soil fertility as they fix atmospheric nitrogen through symbiotic nitrogen fixation with the help of bacterium called *rhizobia*. Thus, every pulse plant is a mini-fertilizer factory itself.

The origin of cultivated greengram is India and central Asia. In India, it occupied an area of 3.44 million hectares having total production of 1.4 million tons of grain with productivity of 410 kg/ha (Anon., 2011). In India, major greengram producing states are Orissa, Madhya Pradesh, Rajasthan, Maharashtra, Gujarat and Bihar. In Gujarat, it is grown on an area of 1.62 lakh ha with the production of 0.701 lakh tones and productivity of 433 kg/ha (Anon., 2009).

Greengram is also known as *mung, moong, mungo,* goldengram, chickasaw pea and oregon pea. It contains about 25 per cent protein, 1.3 per cent fat, 3.5 per cent minerals, 4.1 per cent fiber and 56.7 per cent carbohydrate. The protein content of greengram is two to three times more than that of cereals. It is consumed as a whole grains as well as dal in a variety of way in homes; being easily digestible it is preferred by patients. It is valued for its excellent taste, flavour, high digestibility and free from the "flatulency effect" which is associated with other pulses. When moongbeans are allowed to sprout, ascorbic acid (vitamin C) is synthesized besides riboflavin and thiamine is also increased.

Development of short duration as well as photo and thermo insensitive varieties provided excellent opportunity for greengram cultivation both in *kharif* as well as in summer season, where adequate irrigation facilities are available. In south Gujarat, greengram is cultivated mainly in summer season because during *kharif,* fields remain wet for a longer time, which is not suitable for this crop.

Fertilizers play key role for obtaining higher crop production. Nitrogen plays an important role in crop nutrition. Though greengram can fix atmospheric nitrogen, an application of 15 to 20 kg nitrogen per hectare as a starter dose at sowing, depending upon the initial fertility of the soil appeared to be optimum for the crop. However, the degree of response depends on inherent soil fertility, soil moisture, temperature and the cropping patterns followed.

Phosphorus plays a key role in various physiological processes like root growth and dry matter production, nodulation and nitrogen fixation and also in metabolic activities especially in protein synthesis. It also helps in establishing seedling quickly and also hastens maturity as well as improves the quality of crop produce. The most obvious effect of phosphorus is on the root system of plants. It promotes the formation of lateral and fibrous roots, which facilitates to bacteria for nodulation and ultimately increases the nitrogen fixation in leguminous crops.

Inadequate and imbalanced nutrient application by farmers is the most important limiting factor in pulse crop production. It is now increasingly being realized that no single nutrient source could fully meet the nutritional requirement of crop. Moreover injudicious use of chemicals enhanced the soil and plant health problems. In this context, use of alternative sources of plant nutrients such as bio-fertilizers is the need of the time.

Among various biofertilizers, *rhizobium* inoculation is a cheapest, easiest and safest method of supplying nitrogen to greengram through well known symbiotic nitrogen fixation process. It increases the yield and improves the quality of legumes, also adds substantial amount of residual nitrogen in soil for subsequent crops. *Rhizobium* inoculation can increase the grain yield of most of the pulse crops to the tune of 10 to 15 per cent (Ali and Chandra, 1985). Inoculation of appropriate strain enhances nodule formation resulting in better nitrogen fixation.

Only about a quarter of water soluble phosphate is taken up by plants in the season of its application and the remaining is converted into insoluble, unavailable forms. Phosphate solublizing bacteria (PSB) have the consistent capacity to increase the availability of phosphate to plant by mineralizing organic phosphorus compounds. It solubilizes insoluble inorganic phosphorus compounds by exerting organic acids, which is the primary mechanism for solubilization of insoluble inorganic phosphates. Besides organic acids, production of chelating substances, mineral acids, siderophores and proton extrusion mechanism are also involved (Gaur, 1990).

In context of biofertilizers, positive effect of PSB and plant growth promoting rhizobacteria (PGPR) on legume *rhizobia* symbiosis particularly in the early events and synergism between these organisms might increase competitiveness and efficiency of *rhizobium* inoculation in pulse crops.

Also co-inoculation of phosphate solubilizing bacteria has been found to improve nodulation, nitrogen fixation and yield of legumes by increasing phosphorus availability (Alagawadi and Gaur, 1988).

Therefore, it becomes imperative to test role of biofertilizers and inorganic fertilizers as a source of nutrients in green gram. With this back ground information, the present experiment was planned at the College Farm, Navsari Agricultural University, Navsari with following objectives:

1. To study the effect of varying levels of inorganic fertilizers on growth, yield and quality of different varieties of greengram.

2. To examine the effect of biofertilizers on growth, yield and quality of different varieties of greengram.
3. To assess the interaction effect of inorganic fertilizers, biofertilizers and different varieties of greengram.
4. To find out the appropriate integrated nutrient management system for different varieties of greengram.
5. To work out economics of different treatments.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Nutrient management is the most critical factor for realizing the yield potential. Integrated use of inorganic, organic and biofertilizers helps to restore and sustain soil fertility and crop productivity. Research work carried out on these aspects is reviewed briefly in this chapter under the following heads:

2.1 Effect of inorganic fertilizer

2.2 Effect of biofertilizers

2.3 Interaction effect

2.1 Effect of inorganic fertilizer

Nitrogen and phosphorus are important elements for crop production. Its requirement depends on crops, soil type and climate. To get better response, both the element should be applied in appropriate quantity. The effect of inorganic fertilizer on growth, yield and quality of greengram and nutrient status in soil after harvest of crop observed under different agro-climatic conditions are reviewed here.

2.1.1 Effect on growth and growth attributes

Patel *et al.* (1992) carried out a field experiment during *kharif* season of 1989 at Sardar krushinagar (Gujarat) on loamy sand soil. They showed that greengram variety K-851 recorded higher number of branches per plant under fertilizer application of 30 kg N and 60 kg P_2O_5 per hectare.

A field experiment carried out at Kolkata (West Bengal) during summer season on Gangetic alluvial soil and observed that nodules per plant of greengram var. T-44 was maximum due to combine application of 20 kg N + 40 kg P_2O_5/ha (Sarkar *et al.*, 1993).

Badole and Umale (1994) conducted a field experiment during *kharif* season on clayey soil at Dr.PDKV, Akola (MS) and observed that an application of 50 per cent recommended dose of fertilizers gave maximum shoot height and dry weight at the initial growth period of greengram.

Mishra and Misra (1995) carried out a field experiment at Bhubneshwar (Orissa) with blackgram cv.T-9 and indicated that all the fertility levels (i.e. 50,100 and 150 per cent recommended dose) recorded non-significant result in case of growth attributes. Whereas, number of nodules per plant was higher under 50 per cent recommended dose of fertilizers then others.

While studing the effect of various levels of fertilizers on clay loam soil of Devataj (Gujarat), Chaudhari *et al.* (1998) found that application of 20 kg N and 40 kg P_2O_5/ha significantly increased plant height, primary and secondary branches per plant and days to 50% flowering in chickpea over control.

Srinivas and Mohammad (2002) carried out a field experiment at Rajendranagar, Hyderabad during *kharif* season on a red sandy loam soil and revealed that greengram crop var. LGG-450 fertilized with 20 kg N and 25 kg P_2O_5 /ha produced significantly more vegetative growth. The most productive level of phosphorus was 50 kg P_2O_5 /ha.

Plant height (cm) and dry matter (g/plant) of chickpea at harvest ; as well as root nodules and its dry weight (g/plant) at 20 DAS were significantly increased with the application of 40 kg S/ha as compared to control and 20 kg S/ha (Singh *et al.*, 2004)

An experiment carried out by Yakardi *et al.* (2004) during wet season at Rajendranagar, Hyderabad on red sandy loam soil and reveled that application of 20 kg N + 60 kg P_2O_5/ha recorded significantly maximum dry matter production of greengram over control.

Singh *et al.* (2009) conducted a field experiment at the Regional Agricultural Research Station, Rajouri during *kharif* season of 2006-07 and 2007-08 and revealed that the variety CH-812 and VL-65 recorded higher number of branches per plant, days to 50% flowering, plant height than the varieties CHFB-2 and Swarn Priya with the application of 180 kg N/ha in frenchbean.

An experiment carried out by Ghanshyam *et al.* (2010) on sandy loam soil in texture at Hisar during *kharif* and *rabi* season of 2002-2003 and 2003-2004 on greengram var. Muskan (MH 96-1). The results revealed that plant height and nodules/plant showed in increasing trend with application of increasing phosphorus levels at 18 and 9 kg P_2O_5/ha.

Thenua *et al.* (2010) conducted a field experiment at Lakhoti in two consecutive years to study the performance of chickpea *cv.* Pusa 256 and found that application of P_2O_5 in the form of SSP or DAP was better with respect to plant height, nodules per plant and nodule dry weight when compared with rock phosphate.

2.1.2 Effect on yield and yield attributes

An experiment was conducted on sandy clay loam soil of Devataj (Gujarat) to study the response of chickpea to varying levels of nitrogen and phosphorous and reported that application of 20 kg N and 40 kg P_2O_5/ha significantly improved number of pod per plant, seed per pod, 100 seed weight, seed and stover yield and harvest index over control (Chaudhari *et al.*, 1998).

Kulkarni *et al.* (2000) conducted a field experiment on chickpea during *rabi* 1994-96 at Dharwad (Karnataka) and found that application of 25-50 kg NP/ha, where P_2O_5 was applied as single superphosphate recorded significantly higher dry matter accumulation, number of nodules and its dry weight per plant than rock phosphate.

Kumar *et al.* (2002) carried out a field experiment during summer season to study the effect of N and P levels on mungbean. An application of N up to 20 kg/ha and P_2O_5 up to 40 kg/ha significantly increased the yield attributes. However, the optimum dose of N and P for summer mungbean was worked out to be 24.5 and 47.5 kg/ha, respectively.

An application of 15 kg N + 35 kg P_2O_5/ha resulted in significantly higher number of pods per plant, seeds per pod, 100-seed weight, stover and seed yield of greengram over control (Rajkhowa *et al.*, 2002).

A field experiment carried out during *kharif* season at Rajendranagar, Hyderabad and showed that an application of nitrogen @ 20 kg/ha and phosphorus @ 60 kg/ha caused significant increase in number of pods and yield of green gram var. ML-267 (Yakadri *et al.*, 2002).

An experiment was conducted by Chaudhary *et al.* (2003) at Bikaner (Rajasthan) during *kharif* season on loamy sand soil. Entire dose of phosphorus as per treatment alongwith a common dose of 30 kg N/ha was applied as basal. The results revealed that application of 40 kg P_2O_5/ha recorded significantly higher yield and yield attributing characters viz., number of pods per plant, grains per pod and test weight of greengram compared to control and 20 kg P_2O_5/ha.

Sharma *et al.* (2003) carried out a field experiment at Palampur in *kharif* season on silty clay loam soil and reported that significantly higher seed yield of greengram var. PANT U-19 was achieved with a dose of 20 kg N/ha and 60 kg P_2O_5 /ha over control.

Patel *et al.* (2004 a) carried out a field experiment at Main Pulses Research Station, Gujarat Agricultural University, Sardar krushinagar during rainy seasons of 2000 to 2002 and reported that an application of 25 kg N + 50 kg P_2O_5/ha recorded significantly higher seed and straw yields of clusterbean var. Gujarat Gaur-1 than others.

Patel *et al.*(2004 b) carried out a field experiment at Main Pulses Research Station, Gujarat Agricultural University, Sardar krushinagar during summer seasons of 1995 to 1997 and reported that an application of 30 kg N and 40 to 60 kg P_2O_5/ha recorded significantly higher seed yield of mungbean var.GM-3.

An application of 20 kg N+60 kg P_2O_5/ha recorded higher seed and haulm yields of greengram but found at par with an application of 40 kg N + 40 kg P_2O_5/ha (Yakadri *et al.*, 2004).

Gandhi *et al.* (2005) conducted a field experiment at Agronomy Farm, C. P. College of Agriculture, Gujarat Agricultural University during *kharif* season of 1999-2000 and reported that the highest seed, stover yield and protein content in clusterbean var. GG-1 was recorded with the application of 40 kg P_2O_5/ha and 40 kg S/ha.

Meena *et al.* (2005) was conducted a field experiment during 1999-2000 at Agronomy Farm of S.K.N. College of Agriculture, Jobner. The results indicated that application of 40 kg S/ha and 5 kg Zn/ha progressively increased grain yield of chickpea.

Patel *et al.* (2007) conducted a field experiment at Main Pulses Research Station, Gujarat Agricultural University, Sardar krushinagar during summer season of 2001, 2002 and 2003 and revealed that an application of 30 kg N + 60 kg P_2O_5/ha recorded higher growth and yield attributing parameters, seed and straw yields in clusterbean than other treatments.

Singh *et al.* (2007) conducted a field experiment at Department of Soil Science, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) and revealed that *rhizobium* inoculation, 30 kg N and 60 kg P_2O_5/ha produced significantly higher number of pods/plant, length/pod, seed index, protein content, seed and straw yield of cowpea over control.

Gangaiah *et al.* (2008) conducted a field experiment at Indian Agricultural Research Institute, New Delhi (India), during 2005-07 and revealed that the application of 26.4 kg P_2O_5/ha recorded significantly higher growth attributes and chholia production (1.15 t/ha) and harvest index in var. 'ICCV 96029'as compared to var. 'ICCV 96030' (1.09 t/ha) in chickpea.

Singh *et al.* (2009) conducted a field experiment at the Regional Agricultural Research Station, Rajouri during *kharif* season of 2006-07 and 2007-08 and revealed that the variety CH-812 and VL-65 recorded highest number of pods per plant, pod diameter, number of green seeds per pod, green pod yield per plant, and pod length than the varieties CHFB-2 and Swarn Priya with the application of 180 kg N/ha in frenchbean.

Acharya *et al.* (2010) conducted a field experiment at Mohanpur (West Bengal) in 2002-2004 and reported that the highest seed yield of greengram (1.24 tonne/ha) was recorded from application of 75% RDF in conjuction with either Biomax or FYM (1.21 and 1.19 tonne/ha).

Ghanshyam *et al.* (2010) revealed that successive increase in Phosphorus levels had significant effect on grain as well as stover yields of greengram var. Muskan (MH 96-1) over their preceding levels.

A field experiment carried out during *kharif* season at Main Pulses Research Station, Sardar krushinagar showed that an application of 20 kg N+40 kg P_2O_5 per ha recorded significantly higher seed (1219 kg/ha) and straw yield (2756 kg/ha) of cowpea var. GC-5 due to significantly higher values of number of pods per plant, test weight, number of seeds per pod and number of branches per plant (Patel *et al.*, 2010).

Patil *et al.* (2011) conducted a field experiment during *kharif* season of 2007 at the experimental farm of Department of Agronomy, Marathwada Agricultural University, Parbhani (Maharastra). An application of phosphorus @ 50 kg/ha was optimum to harvest maximum yield of greengram and sulphur application @ 40 kg/ha was beneficial to increase growth and yield of greengram var. of BM 2002-1.

Patil *et al.* (2011) conducted a field experiment during *kharif* season of 2007 at Instructional Farm, Junagadh Agricultural University, Junagadh. An application of 100% RDF (20-40-0 kg/ha NPK) recorded higher number of pods per plant, number of seeds per pod, test weight (100 seeds) and seed and straw yields (kg/ha) in black gram var. T-9 than other treatments.

A field experiment was carried out by Nawange *et al.* (2011) at the Phanda Agriculture farm, Bhopal (M.P.) and results revealed that an application of 60 kg P_2O_5/ha produced the highest seed (1761 kg/ha) and stalk (2754 kg/ha) yield of chickpea.

A field experiment was carried out by Singh *et al.* (2011) at the Punjab Agricultural University (PAU), Ludhiana and results revealed that an application of 12.5 kg N + 60 kg P_2O_5/ha produced the highest number of nodules/plant and maximum dry weight of nodules/plant and grain yield of mungbean which were statistically on par with 12.5 kg N + 40 kg P_2O_5/ha.

2.1.3 Effect on quality

Chaudhari *et al.* (1998) at Devataj (Gujarat) found that nitrogen @ 20 kg/ha and phosphorus @ 40 kg/ha significantly increased protein content of seed in chickpea over control.

Reddy and Ahlawat (1998) at IARI, New Delhi noticed higher protein yield with application of nitrogen @ 18 kg/ha and phosphorus @ 46 kg/ha alone or with zinc in chickpea over no fertilizer. Similarly, Garasia (2001) at Navsari (Gujarat) also found that application of 20 kg N and 40 kg P_2O_5/ha increased protein content and protein yield in *rabi* pigeonpea.

Application of 100% RDF significantly increased the protein content (23.78%) in cowpea over control (Dekhane, *et al.*, 2011).

Chesti *et al.* (2012) conducted a field experiment at Crop Research Farm of SKUAST-K, Shalimar Campus on silty clay loam soil and observed that the increasing levels of phosphorus up to 30 kg/ha significantly improved protein content in grain of green gram.

2.1.4 Effect on nutrient content and uptake

Application of 40 kg N and 40 kg P_2O_5 /ha significantly increased N and P uptake in *rabi* pegionpea over control (Garasiya, 2001).

An experiment was carried out by Yakadri *et al.* (2004) at Hyderabad and results revealed that application of 20 kg N + 40 kg P_2O_5 /ha showed maximum uptake of N and P in green gram which was at par with application of 40 kg N + 40 kg P_2O_5/ha.

Gangaiah *et al.* (2008) conducted a field experiment at Indian Agricultural Research Institute, New Delhi (India), during 2005-07 and revealed that the application of 26.4 kg P/ha recorded significantly higher N, P and K uptake and protein content in var. 'ICCV 96029' as compared to var. 'ICCV 96030 (1.09 t/ha) in chickpea.

Ghanshyam *et al.* (2010) revealed that phosphorus application significantly influenced the nutrient uptake. On an average, application of 9 kg P_2O_5/ha increased the total NPK uptake by 25.6, 23.2 and 32.4 per cent, respectively over control in greengram var. Muskan (MH 96-1).

A field experiment carried out at Kota (Rajasthan) to evolve an integrated nutrient management strategy for Kabuli chickpea *cv.* KAK 2 and results revealed that P uptake increased with the application of phosphorus upto 25.8 kg per ha (Tanwar *et al.*, 2010).

A field experiment was conducted at Junagadh on clayey soil by Dekhane *et al.* (2011) revealed that the 100 per cent RDF recorded maximum phosphorus content (0.47 and 0.34%) and uptake (6.89 and 5.69 kg/ha) by grain and stover followed by 75% RDF.

2.1.5 Effect on soil nutrient status

A field experiment carried out by Thenua and Kumar (2007) at Lakhoti during *kharif* season of 2003 and 2004 on a sandy loam soil in texture and reported that application of phosphorous to blackgram var.T-9 recorded higher uptake of nitrogen and phosphorus up to 60 kg P_2O_5/ha and K up to 30 kg P_2O_5 /ha than control.

Tanwar *et al.* (2010) carried out a field experiment at Kota (Rajasthan) to evolve an integrated nutrient management strategy for Kabuli chickpea *cv,* KAK 2 and results revealed that integrated use of phosphorus improved the N and P status in soil.

2.1.6 Effect on economics

Mishra and Misra (1995) showed that summer blackgram produced maximum net profit (₹ 886/ha) and net profit per rupee (0.28) by the application of 50 per cent recommended dose of fertilizers.

While working at Navsari (Gujarat) on greengram (var. GM 3), Ambhore (2004) indicated that maximum net realization (₹ 21978/ha) with BCR (4.30) was achieved with 100 per cent RDF (20: 40: 00 NPK kg/ha).

Patel *et al.* (2004 b) carried out a field experiment at Main Pulses Research Station, Gujarat Agricultural University, Sardar krushinagar during summer seasons of 1995 to 1997 and reported that an application of 30 kg N and 40 to 60 kg P_2O_5/ha recorded significantly higher net profit (₹ 7942/ha) and BCR 2.46 of mungbean var.GM 3 than rest of the treatments.

Tanwar *et al.* (2010) reported that integrated use of Phosphorus (12.9 kg/ha) + FYM produced higher net return (₹ 53,200/ha) than other combinations in chickpea.

Saini *et al.* (2011) reported that an application of nitrogen levels of 50 and 75 kg/ha in soybean gave the highest profit with B:C ratio of 1.73 and 1.66, respectively.

2.2 Effect of biofertilizers

The use of biofertilizers is much economic to farmers in the days of increasing fertilizer price, it is imperative to take advantage from biofertilizers like *rhizobium,* phosphate solubilizing bacteria (PSB), vesicular arbuscular mycorrhizae (VAM) and azolla. Research findings pertaining to the use of organic and biofertilizers in green gram and related crops are reviewed here below.

2.2.1 Effect of biofertilizers on growth and growth parameters

Patel and Patel (1991) reported that *rhizobium* inoculation along with nitrogen @ 25 kg/ha significantly improved plant height, primary and secondary branches and dry matter production per plant over control. Similarly, significant improvement in nodulation, nodule weight and dry matter per plant due to *rhizobium* inoculation in chickpea have been reported by Raut and Kohire (1991) at Parbhani (Maharastra).

Kumpawat and Manohar (1994) studied the response of gram to *rhizobium* inoculation on loamy sand soil of Jobner (Rajasthan). They found that *rhizobium* inoculation significantly increased the number of nodules and its dry weight per plant as compared to no inoculation.

Upadhyay *et al.* (1999) carried out a field experiment at Faizabad (UP) on slightly alkaline and clay loam soil. They reported that *rhizoboium* inoculation significantly enhanced the growth parameters of greengram viz., plant height, number of branches per plant, dry matter and number of nodules per plant as compared to control.

Hazarika *et al.* (2000) conducted an experiment at Jorhat (Assam) of sandy loam soil and results revealed that inoculation with *rhizobium* alone or dual inoculation of VAM fungi + *rhizobium* significantly increased nodulation over uninoculated.

Kumar *et al.* (2001) conducted a pot culture experiment at Hissar (Haryana) on sandy loam soil and reported that germination percentage, plant height and dry weight were found maximum per plant and nodule dry weight per plant was found significantly higher over control.

Nagarajan and Balachandar (2001) carried out a field experiment at Pudukkottai (TN) and results showed that inoculation of *rhizobium* to greengram registered significant enhancement in plant biomass and root nodulation over control.

Balyan *et al.* (2002) conducted a field experiment at Pantnagar on sandy loam soil and results revealed that combined application of PSB and *rhizobium* showed positive effect on nodulation, plant growth and dry matter production in blackgram var. PU-35 over *rhizobium* alone.

A field experiment was conducted at Pantnagar (Uttaranchal) during *kharif* season on sandy loam soil by Prasad *et al.* (2002). They reported that *rhizobium* inoculation increased the number of nodules at 30 and 45 DAS and plant dry weight at all growth stages over control in blackgram.

Seed inoculation either with PSB-1 (*Bacillus megaterium*) and PGPR (*Pseudomonas florescence*) or alone gave significantly more dry matter production in urdbean than the control (Prasad *et al.*, 2002).

A field trial carried out by Sharma *et al.*, (2003) during *kharif* season at Palampur on silty clay loam soil indicated that seed inoculation with *rhizobium* improved the plant height and dry matter accumulation at all the stages of crop growth over control in mungbean (var. PANT U-19).

An experiment carried out on sandy loam soil of IARI, New Delhi and observed that application of PSB significantly enhanced the dry matter production in chickpea at all crop growth stages expect 30 DAS during both the years of experimentation (Meena *et al.*, 2005).

Wani *et al.* (2007) reported that various N fixing and phosphate solubilizing bacteria spp. significantly increased the growth attributes of chickpea as compared to control.

A study was conducted in order to investigate seed inoculation of chickpea with *rhizobium*, N_2-fixing *Bacillus* *subtitles* (OSU-142) and P-solubilizing *Bacillus megaterium* (M-3) and found significant increase in the growth parameters (plant height, shoot, root and nodule dry weight) as compared to control treatments (Elkoca *et al.*, 2008).

2.2.2 Effect of biofertilizers on yield and yield parameters

Ali and Mishra (2000) reported increase in yield of mungbean from 8.5 to 51.3 per cent due to inoculation of *rhizobium* over control.

Nagarajan and Balachandar (2001) carried out a field experiment at Pudukkoti (TN). The results revealed that inoculation of *rhizobium* to greengram registered significant increase in grain yield over control.

Singh and Tarafdar (2001) observed 14 per cent increase in yield of mungbean crop var. T44 due to inoculation of *rhizobium* over control.

Prasad *et al.* (2002) carried out an experiment at Pantnagar during *kharif* on sandy loam soil. The results revealed that *rhizobium* inoculation significantly increased grain and straw yields of blackgram over control.

A field experiment was conducted during *kharif* season at Kanpur (UP) indicated that seed inoculation with *rhizobium* showed substantial increase in grain and stover yields over starter dose of N @ 15 kg/ha (Ram and Dixit, 2000).

The results of an experiment conducted at Jobner (Rajasthan) during *kharif* season on loamy sand soil indicated that seed treatment with PSB significantly increased pods per plant, seeds per pod, pod length, test weight as well as seed and straw yields of clusterbean over uninoculated control (Meena *et al.*,2003).

A field trial carried out at HPKV, Palampur in *kharif* season on silt clay loam soil by Sharma *et al.*, (2003) indicated that seed inoculation significantly increased grain yield of mungbean (var. PANT U-19) over control.

A field experiment conducted at Allahabad (U.P.) on sandy loam soil by Thomas and Lal (2003) revealed that the pod count per plant was significantly higher in treatment PSB + CU (Cow Urine) (71.89) followed by the treatment PSB + *rhizobium* (69.14) in greengram.

A field experiment carried out by Nagar and Meena (2004) at Jobner (Rajasthan) during *kharif* season on loamy sand soil indicated that seed inoculation with PSB significantly increased all the yield component *viz.*, number of pods per plant, seeds per pod, test weight, seed and straw yields over uninoculated control in clusterbean.

Singh *et al.* (2004) conducted an experiment on sandy loam soil of Hissar (Haryana) and revealed that inoculation of *rhizobium* + PSB significantly increased pods per plant, seed yield per plant, seed and straw yields, harvest and appreciation index over single inoculation with PSB or *rhizobium* and no inoculation. However, single inoculation with either PSB or *rhizobium* being at par, were significantly superior to control in chickpea.

Thenua and Kumar (2007) at Lakhoti reported that the *rhizobium* + Phosphate solubilizing bacteria (PSB) significantly improved the growth and yield attributes and yield of blackgram var. Type-9 over control.

The synergistic effects of nitrogen-fixing and phosphate-solubilizing rhizobacteria on yield and yield attributes of chickpea plants were determined by Wani *et al.* (2007) in a sandy clay- loam soil of Aligarh (U.P.).

Elkoca *et al.* (2008) conducted an experiment in order to investigate seed inoculation of chickpea with *rhizobium*, N_2-fixing *Bacillus subtillis* (OSU-142) and P- solubilizing *Bacillus megaterium* (M-3) and found significantly higher pod number, seed yield and total biomass yield as compared to control treatment.

A field experiment was conducted at Shalimar during *kharif* 2005 and results revealed that inoculation of *rhizobium* improved number of pods/plant, number of seeds/pod and 1000-seed weight (g) over the control (Bhat *et al.*, 2010).

Combined inoculation of *rhizobium* + phosphate solubilizing bacteria (PSB) on cowpea var. GC-5 recorded significantly higher yield attributes, seed and straw yields over control (Patel *et al.*, 2010).

A field experiment was conducted at Junagadh on clayey soil by Dekhane *et al.* (2011) revealed that higher grain (1441kg/ha) and stover yield (1716 kg/ha) were recorded with seed inoculation by *rhizobium* over rest of the treatments.

Sahay *et al.* (2011) revealed that the application of *rhizobium* sp. (UP-1) recorded significantly more grain yield by 19% as compared to control in urdbean.

2.2.3 Effect of biofertilizers on quality

Kumpawat and Manohar (1994) at Jobner (Rajasthan) found that *rhizobium* inoculation in gram significantly increased protein content over control. Significant improvement in protein content and protein yield in gram with *rhizobium* inoculation along with 25 kg nitrogen/ha over control have been reported by Patel (1990) at Navsari (Gujarat).

A field experiment was conducted at Junagadh on clayey soil by Bhalu *et al.* (1995) revealed that protein content of blackgram significantly increased due to *rhizobium* inoculation compared to control.

Nagarajan and Nanjundappa (1996) conducted a field experiment at Banglore on coarse textured soil and revealed that P-solubilizing inoculant of cowpea significantly increased the protein content over control.

Naidu and Ram (1996) carried out a field experiment on sandy loam soil. They found that *rhizobium* strain USDA-3436 and M_4 showed their positive and significant effect on quality of greengram.

A field trial carried out at Rahuri (MS) on deep black clayey soil indicated that 'P' solubilizer inoculation significantly increased the protein content of pigeonpea grain over control (Pawar and Pawar, 1998).

Significantly higher protein yield in chickpea was obtained with dual inoculation *rhizobium* and PSB (Reddy and Ahlawat, 1998). Similarly, Meena *et al.* (2001) at Jobner (Rajasthan) also found higher protein content with *rhizobium* + PSB over single one.

A field experiment carried out by Singh and Tarafdar (2001) at Kanpur (UP) on sandy loam soil indicated that *rhizobium* inoculation in moong (var. T-44) significantly improved protein content in seed and straw.

A field experiment was conducted at Jobner (Rajasthan) during *kharif* season on loamy sand soil. The results revealed that seed inoculation with PSB significantly increased protein content in clusterbean over control (Nagar and Meena, 2004).

Wani *et al.* (2007) found synergistic effects of nitrogen-fixing and phosphate solubilizing rhizobacteria on grain protein of chickpea plants in a sandy clay-loam soil of Aligarh (U.P.)

2.2.4 Effect of biofertilizers on nutrient content and uptake

Singh *et al.* (1994) carried out a field experiment at Dholi (Bihar) on sandy loam soil during summer and reported that higher N, P and K uptake in greengram and blackgram was observed due to inoculation of *rhizobium*.

Application of either 40 or 20 kg P_2O_5/ha + PSB inoculation recorded higher N, P content and uptake in chickpea (Chauhan, 2000).

A field experiment carried out by Balyan *et al.* (2002) at Pantnagar during *kharif* season on medium black soil revealed that combined application of PSB and *rhizobium* increased the uptake of N in blackgram var. PU-35 over control.

A field experiment was carried out by Prasad *et al.* (2002) at Pantnagar on sandy loam soil during *kharif* season. They observed that *rhizobium* inoculums significantly increased N and P uptake in black gram over control.

Nagar and Meena (2004) revealed that seed inoculation with PSB significantly increased total uptake of N, P and S in clusterbean over uninoculated control.

Singh *et al.* (2004) conducted a field experiment at HAU, Hisar and revealed that combined seed inoculation with *rhizobium* + PSB significantly increased S uptake than alone.

Combined inoculation of *rhizobium* + phosphate solubilizing bacteria (PSB) on greengram var. Type 9 recorded significantly higher N, P, K uptake over other treatments (Thenua and Kumar, 2007).

Wani *et al.* (2007) found the synergistic effects of nitrogen-fixing and phosphate solubilizing rhizobacteria on nutrient uptake of chickpea plants in a sandy clay-loam soil of Aligarh (U.P).

Sahay *et al.* (2011) revealed that the application of *rhizobium* sp. (UP-1) recorded significantly more nitrogen and phosphorus uptake by grain and straw as compared to control in urdbean.

2.2.5 Effect of biofertilizers on soil status after harvesting of crop

Sapatnekar *et al.* (2001) conducted a field experiment at Pune, Maharastra to study the effect of super phosphate and phosphate solubilizer on yield of greengram var. S-8 and showed that inoculation with phosphate solubilizer significantly increased available P in soil after harvesting of crop over control.

The seed inoculation with *rhizobium* + phosphate solubilizing bacteria (PSB) recorded higher N and P status in soil compared to control (Thenua and Kumar, 2007).

Sahay *et al.* (2011) revealed that the application of *rhizobium* sp. (UP-1) recorded significantly more available nitrogen and phosphorus as compared to control in urdbean.

2.2.6 Effect on economics

Bhalu *et al.* (1995) carried out an experiment at Junagadh. They showed that *rhizobium* inoculation of blackgram gave higher net return and net incremental cost : benefit ratio than control.

Patel (2003) conducted a field experiment at Navsari (Gujarat) and revealed that dual inoculation of *rhizobium* and PSB recorded higher net realization over single inoculation of both.

Patel *et al.* (2010) conducted a field experiment on cowpea var. GC-5 at SDAU (Gujarat) during *rainy* season of 2005, 2006 and 2007 on loamy sand soil and revealed that the combination of seed inoculation with *rhizobium* and PSB was the most profitable treatment combination which earned the net profit of ₹ 15918/ha with a BCR value of 2.88 and it was followed by seed inoculation with PSB (net profit ₹ 15451 and BCR 2.81).

2.3 Combined effect of inorganic fertilizers and biofertilizers

Application of phosphorus either @ 40 or 20 kg/ha along with PSB inoculation significantly improved plant height, number of branches, dry matter accumulation, nodule number and its dry weight in chickpea over PSB inoculation alone (Chauhan, 2000).

Srinivasan and Sivasamy (2000) at Srivilliputter (TN) observed that an application of 75 per cent N (18.75 kg/ha) and 100 per cent P_2O_5 (50 kg/ha) in combination with *rhizobium* and phosphobacterium significantly improved pods per plant, 100-

grain weight and grain yield in *rabi* greengram and also found economical.

Garasia (2001) at Navsari (Gujarat) found that application of 40 kg each of N and P_2O_5/ha along with phosphobacterin in *rabi* pigeonpea significantly improved the plant height, dry matter production, pods per plant, stalk yield and N uptake by stalk but remained statistically at par with 40 kg each of N and P_2O_5/ha along with *rhizobium*.

Sapatnekar *et al.* (2001) revealed that an application of SSP along with P- solubilizers increased nodulation and grain yield in greengram var. S-8. Further, P uptake increased with increasing levels of phosphorus.

Patel (2003) carried out an experiment at Navsari and revealed that 100 and 75 per cent RDF along with *rhizobium* and PSB significantly improved pods per plant, number and dry weight of root nodules in gram.

Pathak *et al.* (2003) at Rewa (Madhya Pradesh) reported significant increase in pods per plant, grains per pod, 1000 grain weight and grain yield with the application of 69 kg P_2O_5/ha through DAP + PSB +10 ton FYM and $ZnSO_4$ over control.

A field experiment was carried out by Tanwar *et al.* (2003) at Udaipur (Rajasthan) on clay loam soil and reported that an application of 60 kg P_2O_5/ha with inoculation of *rhizobium* and PSB resulted in higher seed yield of blackgram var. T-9 (10.93 q/ha) and net monetary returns over control.

Ghosh *et al.* (2008) reported significant increase in number of pods/plant, number of seeds/pod, seed yield, stover yield and test weight of greengram var. (Type-44) with inoculation of *rhizobium* + PSB and sulphur @ 30 kg/ha through gypsum.

A field experiment carried out by Singh *et al.* (2008) at Varansi during *kharif* season of 2006 on a fine loamy soil and reported that the application of S, Mo and *rhizobium* alone or in combination significantly increased the vegetative growth, nodule number, grain and straw yields of blackgram var. T-9 over control.

Singh *et al.* (2008) reported that the application of 40 kg P_2O_5/ha through DAP with PSB increased seed yield, plant height, nodulation, branches per plant, leaves per plant and pods per plant in black gram var. JU 2.

A field experiment carried out by Beg and Singh (2009) on silty- clay loam soil and revealed that the highest net income (₹ 19942/ha) and benefit : cost ratio (1.91) were recorded under combined seed inoculation with *rhizobium* and PSB along with application of 20 kg N and 45 kg P_2O_5/ha on green gram var. SKAU M 86.

Rathi *et al.* (2009) carried out a field experiment at the Research Farm of J.V. College, Baraut and observed that integrated use of 60 kg S/ha, *rhizobium* and micronutrients gave higher grain yield in cv.PU-19 as compared to cv. PDU-1 in blackgram.

A field experiment carried out by Sammauria *et al.* (2009) at Bikaner on loamy sand soil and observed that integrated use of 75 per cent RDF (20-17.4 N,P kg/ha) with *rhizobium* + PSB inoculation was increased the growth, yield and yield attributes for clusterbean (var. RCG-936).

Tanwar *et al.* (2010) carried out a field experiment at Kota (Rajasthan) for Kabuli chickpea *cv.* KAK 2 and found maximum net returns obtained from inoculation of PSB along with FYM and chemical fertilizer.

A field experiment carried out by Tanwar *et al.* (2010) at Kota (Rajasthan) on a clayey in textured soil. The results revealed that the use of inorganic P @ 12.9 kg/ha + PSB + FYM had resulted in maximum number of pods/plant (102.6), seed weight (31.88 g) and higher seed yield (2.53 and 2.80 tone/ha) in chickpea var.KAK-2 and improved N and P status of soil.

Thenua *et al.* (2010) carried out a field experiment at Lakhoti and found that soil P status after harvest of crop was increased significantly by inoculation of PSB and VAM with rock-phosphate.

A field experiment was conducted at Junagadh on clayey soil by Dekhane *et al.* (2011) revealed that the combined application of *rhizobium* and 100 per cent RDF recorded the highest nitrogen content in grain (3.73 and 3.77%) of cowpea.

A field experiment was conducted at Junagadh on clayey soil by Dekhane *et al.* (2011) revealed that the combined application of *rhizobium* and 100 per cent RDF significantly increased the available N (196.14 and 196.32 kg/ha) and available P_2O_5 (45.25 and 45.36 kg/ha) respectively after harvest of cowpea.

Gajbhiye *et al.* (2011) carried out a field experiment at the Zonal Agricultural Research Station, Kolhapur and revealed that highest grain yields of soybean (27.7q/ha) were observed by RDF+FYM @ 5 t/ha.

Patel *et al.* (2012) carried out a field experiment at Centre of Excellence for Research on Pulses, S.D. Agricultural University, Sardar krushinagar during rainy season of 2005, 2006 and 2007 and revealed that application of 20 kg N + 40 kg P_2O_5/ha along with *rhizobium*+ PSB inoculation significantly increased seed, straw yield and application of 10 kg N + 20 kg P_2O_5/ha alongwith *rhizobium*+ PSB inoculation recorded the highest BCR value and net return in cowpea var. (GC-5).

MATERIALS AND METHODS

III. MATERIALS AND METHODS

A field experiment entitled "Response of different cultivars of greengram (*Vigna radiata* L.) to integrated nutrient management under south Gujarat condition" was carried out during summer season of 2011. The detail of techniques adopted and material used in the present investigation are described in this chapter.

3.1 Experimental site

The field experiment was conducted at College Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari.

3.2 Climate and weather conditions

Geographically, Navsari is located at 20^0 – 57' N latitude, 72^0 – 54' E longitude and at height of 10 meters above the mean sea level. According to agro climatic condition, Navsari is placed in south Gujarat heavy rainfall zone. The climate of this region is characterized by fairly hot summer, moderately cold winter and humid and warm monsoon with heavy rainfall.

In general, monsoon commences in the second or third week of June and retreats by the end of October. Most of rainfall is received during July and August. Pre-monsoon rains during first week of June and post-monsoon rains during October are not

ıle 1: Meteorological data recorded during the course of investigation (weekly mean)

ıonth	Std. week	Dates	Temperature (°C)		Relative humidity (%)		Sun-shine hours/day
			Max.	Min.	Max.	Min.	
Feb 2011	08	19-25	32.0	14.2	89.00	26.00	9.7
	09	26-4	34.3	16.0	69.00	32.00	9.0
ıarch 2011	10	05-11	34.4	15.6	76.00	24.00	8.8
	11	12-18	37.6	15.9	57.00	15.00	9.6
	12	19-25	34.0	19.8	88.00	37.00	9.7
	13	26-01	36.7	19.0	75.00	30.00	9.5
April 2011	14	02-08	34.2	20.4	83.00	53.00	9.0
	15	09-15	35.8	23.1	84.00	58.00	9.3
	16	16-22	36.0	23.0	83.00	54.00	10.2
	17	23-29	45.1	36.0	86.00	42.00	9.9
	18	30-06	45.8	35.1	80.00	50.00	9.8
May 2011	19	07-13	33.4	25.6	78.00	56.00	9.6
	20	14-20	34.3	26.3	84.00	61.00	8.2
	21	21-27	32.8	27.8	80.00	60.00	9.2
	22	28-05	34.3	26.5	80.00	57.00	9.4

uncommon. During monsoon season most of the days remain cloudy with less sunshine hours.

In Winter season sets usually by the first week of November and continues till end of February. December and January are the coldest months of the season. Usually the summer season commences during the middle of February and the temperature reaches to the maximum in April, hence it is hottest month of the season.

The meteorological data on maximum and minimum temperature, relative humidity and sunshine hours during the period of experimentation (February to June) for the year 2011 recorded at the Meteorological Observatory of the College Farm, N. M. College of Agriculture, Navsari are presented in Table 1 and graphically depicted in Fig. 1.

It could be seen from the meteorological data in Table 1 that during the course of investigation the weekly mean maximum and minimum temperature varies from 32^{0}C to 45.8^{0}C and 14.2^{0}C to 36^{0}C, respectively. Relative humidity ranged from 57 to 89 per cent at 7.30 am and 15 to 61 per cent at 2.30 pm. Bright sunshine hours were available in the range of 9.0 to 10.2 during the crop period. There was no rainfall during crop season. Thus, the weather condition was normal and congenial for satisfactory growth of green gram crop.

Fig. 1 : Meterological data recorded during crop season for the year 2011 (weekly mean)

Table 2: Physico-chemical properties of experimental field

Sr.No.	Particular	Values at 0-30 cm	Methods followed for determination
A.	**Mechanical analysis**		
1.	Sand (%)	13.72	International pipette method (Piper, 1966)
2.	Silt (%)	19.47	
3.	Clay (%)	66.81	
4.	Texture class	Clayey	
B.	**Chemical analysis**		
1.	Soil pH	7.7	Potentiometric (Jackson,1967)
2.	Electrical conductivity (dS/m at 25° C)	0.36	Conductometric (Jackson,1967)
3.	Organic carbon (%)	0.44	Wet oxidation (Jackson, 1967)
4.	Available nitrogen (kg/ha)	230.15	Alkaline permanganate method (Subbiah and Asija, 1956)
5.	Available P_2O_5 (kg/ha)	38.00	Spectro photometric Olsen *et al.* (1954)
6.	Available S (kg/ha)	21.01	Turbidiometric (Williams and Steinbergs, 1959)

3.3 Soil characteristics

The experimental field was fairly levelled and uniform in fertility. The soil popularly known as "Deep Black" soils was an old alluvium of basaltic material by its origin. The soil of the College Farm has been placed under the group of *Ustochrepts*, sub group of *Verti Ustochrepts*, sub order orchrepts and order inceptisols with Jalalpur series. Soils are deep, moderately drained having good water holding capacity. The soil cracks heavily on drying and expands on wetting. The predominant clay mineral is montmorillonite.

Soil samples were collected randomly from selected spots to a depth of 0-30 cm covering entire area of experimental field before application of treatments. The samples were mixed thoroughly and composite sample was prepared and then analysed for various physical and chemical properties of the soil.

Data presented in Table 2 revealed that the soil of experimental plot was clayey in texture with low in available nitrogen, medium in available phosphorus, fairly rich in available potassium as well as sulphur and slightly alkaline in reaction.

3.4 Cropping history of the experimental plot

The details regarding cropping patterns followed on the experimental field during last three years (2008-2009 to 2010-2011) is presented in Table 3.

Table 3: Cropping history of experimental plot

Year	Season	Crop	Fertilizer dose (NPK kg/ha)		
			N	P_2O_5	K_2O
2007-08	*Kharif*	Paddy	100	30	0
	Rabi	Sugar cane	250	125	125
	Summer				
2008-09	*Kharif*	-	-	-	-
	Rabi	-	-	-	-
	Summer	Ratoon sugar Cane	300	62.5	125
2009-10	*Kharif*	-	-	-	-
	Rabi	-	-	-	-
	Summer	Fallow	-	-	-
2010-11	*Kharif*	Paddy	100	30	0
	Rabi	Fallow	-	-	-
	Summer	Greengram (Present investigation)	As per treatment		

3.5 Experimental details

The details of the experiment are given below.

3.5.1 Title

"Response of different cultivars of greengram *(Vigna radiata* L.*)* to integrated nutrient management under south Gujarat condition".

3.5.2 Treatments

Twenty treatment combinations [two cultivars *viz.* Meha and GM 3, three levels of inorganic fertilizers (100, 75 and 50 per cent RDF) and biofertilizers *viz. rhizobium* and PSB alone and combine] were studied in the present investigation with two additional treatments. The detail of the treatments are given as under.

1. **Variety (V)**

   V_1 : Meha
   V_2 : GM-3

2. **Inorganic fertilizer (F)**

   F_1 : 100 per cent RDF (*i.e.* 20-40 -0 kg NPK/ha)
   F_2 : 75 per cent RDF
   F_3 : 50 per cent RDF

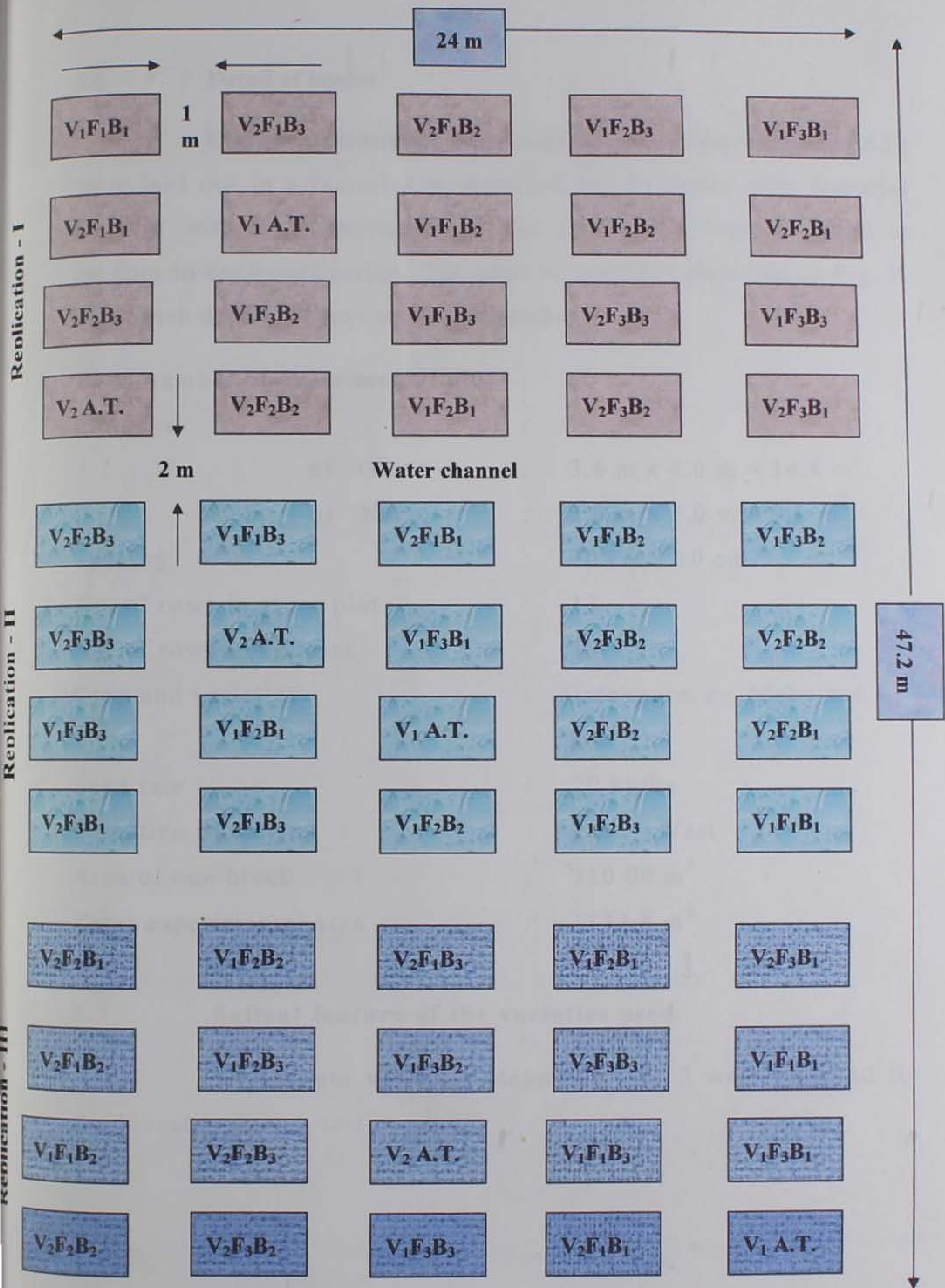
3. **Biofertilizer (B)**

   B_1 : *Rhizobium* seed inoculation
   B_2 : Phosphate solubilizing bacteria (PSB) seed inoculation
   B_3 : *Rhizobium* + PSB seed inoculation

❖ **Additional treatments (control)**

   AT_1 : Meha with 100 % RDF only.
   AT_2 : GM 3 with 100% RDF only.

Fig. 2 : Plan of layout



V_1 : Meha
V_2: GM-3

F_1 : 100 per cent RDF
F_2: 75 per cent RDF
F_3: 50 per cent RDF

B_1 : *Rhizobium*
B_2: PSB
B_3: *Rhizobium* + PSB

AT_1 : Additional treatment 1

AT_2 : Additional treatment 2

3.6 Detail of layout

Eighteen treatment combinations with two controls (AT) were laid out in a factorial randomized block design with factorial concept with three replications. The treatments were assigned at random in each replication. The plan of layout is depicted in Fig. 2. The other details of layout were as under.

Total number of experimental plot	:	60
Plot size	:	
a) Gross	:	3.6 m x 4.0 m = 14.4 m^2
b) Net	:	3.0 m x 3.0 m = 9.0 m^2
Spacing	:	30 cm x 10 cm
No. of rows in gross plot	:	12
No. of rows in net plot	:	10
Crop and varieties	:	Greengram *cv.* Meha and GM 3
Seed rate	:	20 kg/ha
Direction of sowing	:	East – West
Area of one block	:	310.00 m^2
Total experimental area	:	1132.8 m^2

3.7 Salient feature of the varieties used

Greengram varieties Meha and GM 3 were selected for the investigation as test crop.

3.7.1 Meha

The present investigation was carried out on greengram cv. Meha (IPM 99-125) which was released from Indian Institute of Pulses Research (IIPR), Kanpur and introduced in Gujarat by Regional Research Station, Anand Agricultural University, Anand. This variety is cross of Pant mung-2 X AMP 36. It is yellow mosaic virus resistant, short duration variety required 65 days to mature, shiny seed luster, grains dark in colour and yielded about 14 q/ha.

3.7.2 GM 3 (Gujarat moong 3)

GM 3 variety was released from Pulse Research Station, GAU, Sardarkrushinagar in 1993. This variety is cross of 'PIMS-4 x 11/99. It is a dwarf , photoinsensitive, high yielding and short duration variety required about 60-65 days to mature, bold seeded, synchronous in maturity, medium grain size, high yielding and also resistant against yellow mosaic virus disease, grains bright in colour, suited to *kharif* as well as summer climate condition.

3.8 Cultivation details

The calendar of cultural operation carried out in the experimental field during the course of investigation is given in Table 4.

3.8.1 Preparation of land

The experimental field was cultivated by tractor drawn cultivar in both the directions after the harvest of previous crop. Weed and crop residues were removed manually and then planking was done in both the direction to prepare levelled and fine seed bed. Bunds were prepared manually to separate the experimental units and replications as depicted in Fig.2. Furrows were opened at 30 cm distance with the help of *Kudali*.

3.8.2 Fertilizer application

Furrow were opened manually in each plot by keeping spacing 30 x 10 cm between two rows. The full dose of fertilizers were applied according to the treatments manually before sowing the seeds. The sources of nitrogen and phosphorus were urea and single super phosphate, respectively.

3.8.3 Seed treatment and sowing

Seeds of greengram variety Meha and GM 3 were used for sowing. Before sowing, the seeds were treated with biofertilizers as per treatments i.e. *rhizobium* (Spp. *Rhizobium Japonicum*), Phosphate solubilizing bacteria (PSB) and combination of *rhizobium* & PSB. The seeds were dried under the shade and sown as per treatments in previously opened and fertilized furrows at a depth of about 4-5 cm. The seeds were covered properly with the soil.

3.8.4 Gap filling

After twelve days of sowing, gap filling and thinning were carried out to maintain intra row spacing of 10 cm and optimum plant stand in each plot.

Table 4: Calendar of important field operations followed during the period of experimentation

Sr.No.	Field operation	Date
A.	**Pre-sowing operation**	
1.	Ploughing with tractor	16/02/2011
2.	Disking, cleaning and planking by tractor	18/02/2011
3.	Field lay out	20/02/2011
4.	Seed-bed preparation	22/02/2011
5.	Inorganic fertilizers application	24/02/2011
6.	Seed treatment with *rhizobium* and PSB culture	24/02/2011
7.	Sowing	25/02/2011
B.	**Post sowing operation**	
1.	Irrigations	25/02/2011 08/03/2011 23/03/2011 05/04/2011 02/05/2011
2.	Gap filling/thinning	08/03/2011
3.	Two hand weedings and Interculturing	20/03/2011 (HW and IC), 12/04/2011 (HW and IC)
4.	Plant protection measure	29/03/2011
5.	Harvesting	31 /05/2011
6.	Threshing and cleaning	03/06/2011

3.8.5 Irrigation

Greengram crop was irrigated as per requirement.

3.8.6 Weeding and inter-culturing

Two hand weeding and one interculturing were carried out during the early crop growth.

3.8.7 Plant protection measures

Recommended plant protection measures were taken as and when necessary. Spraying of Thiomethoxon 25% WG and Dithane M 45 were done as per time mentained in Table 4.

3.8.8 Harvesting and threshing

When crop attain physiological maturity, both the varieties (Meha and GM 3) harvested on 31/5/2011. The border lines, five sample plants and the net plot were harvested separately from each plot. After four days of sun drying, threshing were done manually by beating the plants with the help of stick. Thereafter, seeds was cleaned manually and weight was recorded as per treatment.

3.9 Biometric observations

The experimental plots were sown at row spacing of 30 x 10 cm. The outermost row on either side was left as border row and the next row adjacent to the border row on both the sides were utilized for plant sampling at periodic interval for recording observations on dry matter accumulation and number of nodules.

Five plants were selected at random from each net plot and tagged for recording observations on growth and yield attributing parameters. The methods followed for recording observation on each parameters are described below.

3.9.1 Plant population

Initial and final plant population per meter row length were recorded at 20 days after sowing (DAS) and before harvesting of the crop, from two spots of each net plot area.

3.9.2 Plant height (cm)

The plant height was measured in centimeters from ground level to the top of the main shoot of randomly selected five tagged plants from each plot of all the three replications at 20, 40 and 60 DAS and at harvest.

3.9.3 Number of branches per plant

Number of branches per plant was counted from five pre tagged plants at 20, 40 and 60 DAS and at harvest. The average value for each plot were worked out and recorded.

3.9.4 Number of nodules per plant

Five plant were dug out randomly from the border rows, in such a way that no nodule detach from the root and remain into the soil. These uprooted plants were kept as such in bowl, full of water for easy washing. Then they were washed with clean water. The observations regarding number of nodules per plant were recorded in each treatment for all the replications at 20, 40 and 60 DAS.

3.9.5 Dry matter production per plant

Five plants randomly selected from the border rows in each treatment were harvested from ground level and dried seperately in shade for 24 hours and subsequently in hot air oven at 65^0C for 72 hours, there after final weight was recorded individually as per treatments at 20, 40, 60 DAS and at harvest.

3.9.6 Days to 50 per cent flowering

The number of days from date of sowing to 50 per cent flowering were recorded for each treatment.

3.9.7 Number of pods per plant

The filled pods from previously tagged five plants were counted for each plot and mean value was worked out and recorded for each treatment.

3.9.8 Number of seeds per pod

Randomly selected 10 pods were used for counting the number of seeds per pod for each treatment.

3.9.9 Seed weight per plant (g)

After complete drying of pods of tagged plants, seeds were separated from pods, cleaned and average weight of seeds per plant was calculated for each treatment.

3.9.10 Test weight (g)

Weight of randomely selected 1000 seeds of greengram was recorded as the test weight for each treatment.

3.9.11 Seed yield (kg/net plot and q/ha)

The produce of each net plot was threshed and cleaned seperately and the seed yield was recorded in kilogrmas per net plot and converted into quintal per hectare, after subjected to sundrying upto constant weight.

3.9.12 Stover yield (kg/net plot and q/ha)

The plot wise stover yield was recorded in kilograms per net plot and converted into quintal per hectare, after subjected to sundrying upto constant weight.

3.9.12 Harvest index (%)

The harvest index was computed by using formula suggested by Donald (1963) and recorded separately for each treatment.

$$\text{Harvest index (\%)} = \frac{\text{Economical yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

3.10 Quality studies

After recording the test weight the same seeds were used for determination of protein content.

3.10.1 Protein content in seed (%)

The nitrogen content in green gram seed was estimated by micro kjeldahl's method as described by Jackson (1967). The protein content of seed was computed by multiplying the nitrogen percentage with 6.25 for each treatment.

3.10.2 Protein yield (kg/ha)

The protein yield was computed by using following formula:

$$\text{Protein yield (kg/ha)} = \frac{\text{Protein content in seed (\%) X seed yield (kg/ha)}}{100}$$

3.11 Chemical studies

Chemical studies pertaining to nitrogen, phosphorus and sulphur content and their uptake by seed and stover and available nitrogen, phosphorus and sulphur status in soil after harvest of crop were determined as per methods described below.

3.11.1 Nutrient content

For estimation of nitrogen and phosphorous content in seed as well as stover, representative sample was drawn from the produce of each plot. The samples were oven dried at 60^0c for 24 hours, powdered by mechanical grinder and nutrient & were estimated using the following methods:

Nutrient	Method	Reference
Total Nitrogen	Modified Kjeldahl's method	Jackson (1967)
Total Phosphrous	Wet digestion (Diacid) Vanadomolybdo phosphoric acid yellow colour method	Jackson (1967)
Total Sulphur	Turbidiometric method	Jackson (1967)

3.11.2 Nutrient uptake

Uptake of nutrients by seed and straw was calculated by using following formula :

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content(\%) X seed + stover yield (kg/ha)}}{100}$$

3.11.3 Nutrient status in soil before sowing (kg/ha)

For estimation of available nitrogen, phosphorus and sulphur in soil after harvest of crop, representative soil samples were drawn from each plot at 30 cm soil depth and analysed for determination of content of respective nutrient using the following methods:

Nutrient	Method	Reference
Available nitrogen	Alkaline potassium permanganate method	Subbiah and Asija (1956)
Available phosphorous	Spectro photometric (0.5M $NaHCO_3$, pH 8.5, blue color)	Olsen *et al.* (1954)
Available sulphur	Turbidiometric method (Extraction with 0.15 % $CaCl_2$)	Williams and Steinbergs (1959)

3.12 Statistical analysis

Statistical analysis of the data on various growth and yield characters studied in the investigation was carried out through the statistical analysis of variance technique as described by Panse and Sukhatme (1967). The method of analysis of variance for RBD was used and treatment effect on all the characters studied were further compared by employing 'F' test at 5 per cent level of significance was used to test the significance of the results summary tables for treatment effects have been prepared and presented with standard error of mean (S.Em±). The critical difference (C.D.) at 5 percent level of significance was given for those treatments which were found significant.

3.13 Economics

The gross realization in terms of rupee per hectare was worked out on the basis of seed and stover yields for each treatment and the prices of the procedure prevailing in the market. The cost of cultivation for each treatment was worked out by taking into consideration the cost of all the operations right from preparatory tillage to harvesting including threshing, cleaning as well as the cost of inputs, *viz.*, seeds, fertilizers and insecticides etc. The net realization was worked out by substracting the total cost of cultivation from gross realization for each treatment and recorded in rupees per hectare accordingly. The benefit cost ratio was also calculated for each combination of variety, inorganic and biofertilizers as following manner.

$$BCR = \frac{\text{Net realization}}{\text{Cost of cultivation}}$$

EXPERIMENTAL RESULTS

IV.EXPERIMENTAL RESULTS

The chapter embodies the results of the present investigation entitled on "Response of different cultivars of greengram (*Vigna radiata* L.) to integrated nutrient management under south Gujarat condition" conducted during the summer season of 2011 at the College Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari. The results pertaining to various growth and yield attributes, seed and stover yields as well as its quality, nutrient uptake, nutrient status of soil after the harvest of crop and economics were subjected to statistical analysis. The data have been tabulated and also illustrated graphically wherever felt necessary alongwith statistical inferences.

4.1 Growth attributes

4.1.1 Plant population

The mean data pertaining to number of plants per meter row length recorded at 20 DAS and at harvest were statistically analysed and presented in Table 5. The data on plant stand at 20 DAS and at harvest as influenced by different treatments revealed that all the factors and their combinations non-significantly influenced on the plant population. The rest of all treatments as compared to control were found better.

4.1.2 Plant height (cm)

The mean data pertaining to plant height of greengram recorded periodically at 20, 40, 60 DAS and at harvest as influenced by different varieties, inorganic fertilizers and biofertilizers and their interactions are presented in Table 6 and

Table 5: Initial and final plant population as influenced by various treatments of summer greengram

Treatment	Plant population per metre row length	
	At 20 DAS	At harvest
A) Variety		
V_1 (Meha)	9.98	9.38
V_2 (GM-3)	9.74	9.27
S.Em.±	0.141	0.127
C.D. (P=0.05)	NS	NS
B) Inorganic Fertilizer		
F_1 (100% RDF)	10.19	9.45
F_2 (75% RDF)	9.76	9.32
F_3 (50% RDF)	9.62	9.22
S.Em.±	0.172	0.155
C.D. (P=0.05)	NS	NS
C) Biofertilizer		
B_1 (*Rhizobium*)	9.75	9.21
B_2 (PSB)	9.80	9.37
B_3 (*Rhizobium*+ PSB)	10.04	9.41
S.Em.±	0.172	0.155
C.D. (P=0.05)	NS	NS
CV%	7.41	7.04
Interaction		
VXF	NS	NS
VXB	NS	NS
FXB	NS	NS
VXFXB	NS	NS
Control $_1$ (Meha)Vs rest	9.00	8.5
Control$_2$ (GM-3) Vs rest	8.63	8.13
S.Em.±	0.127	0.150
C.D. (P=0.05)	NS	NS
CV%	7.20	7.05

NS = Non Significant

graphically depicted in Fig. 3. The rest of all the treatment as compared to control (additional treatments) were found better, looking to the plant height at all the periodical stages.

4.1.2.1 Effect of varieties

An appraisal of the data presented in Table 6 indicated that periodical height of greengram plant was significantly influenced due to varieties at all stages. A perusal of data revealed that the variety Meha registered significantly taller plant height (57.35 cm) as compared to variety GM 3 (51.68 cm).

4.1.2.2 Effect of inorganic fertilizers

A perusal of data presented in Table 6 indicated that plant height subjected to different inorganic fertilizers showed significant differences at 20, 40, 60 DAS and at harvest.

At harvest, treatment F_1 (100% RDF) recorded significantly the highest plant height (59.22 cm) which was found statistically at par with treatment F_2 i.e. 75% RDF (56.58 cm). However, significantly the lowest plant height (47.45 cm) was recorded under the treatment having 50% RDF (F_3). Similar trend was also observed during 20, 40 and 60 DAS.

4.1.2.3 Effect of biofertilizers

A perusal of data presented in Table 6 indicated that plant height subjected to different biofertilizers showed significant differences at 40, 60 DAS and at harvest.

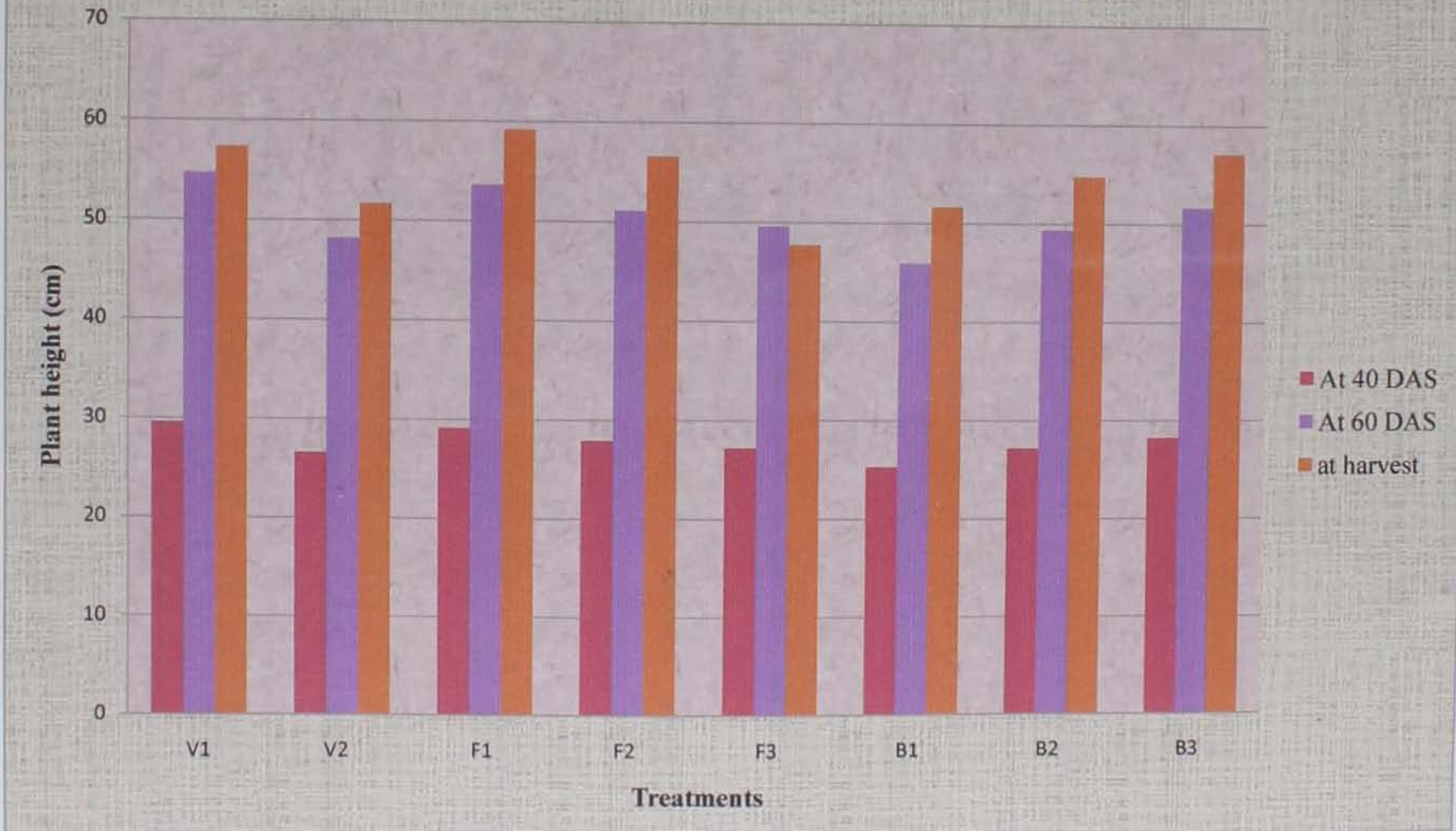
At harvest, treatment B_3 (*rhizobium* + PSB seed inoculation) recorded significantly the highest plant height (57.14 cm) which was statistically at par with treatment B_2 (PSB seed inoculation) (54.76 cm). While, seed inoculated with *rhizobium* (B_1) obtained the lowest plant height (51.64 cm) at harvest. Similar trend was also observed during 40 and 60 DAS.

Table 6: Mean periodical plant height as influenced by various treatments at different growth stages of summer greengram

Treatment	Plant height (cm)			
	At 20 DAS	At 40 DAS	At 60 DAS	At harvest
A) Variety				
V_1 (Meha)	12.19	29.57	51.50	57.35
V_2 (GM-3)	11.21	26.59	46.46	51.68
S.Em.±	0.17	0.44	0.89	0.951
C.D. (P=0.05)	0.49	1.27	2.56	2.73
B) Inorganic Fertilizer				
F_1 (100% RDF)	12.39	29.13	53.62	59.22
F_2 (75% RDF)	11.89	27.95	51.11	56.58
F_3 (50% RDF)	10.82	27.18	42.22	47.75
S.Em.±	0.21	0.54	1.09	1.17
C.D. (P=0.05)	0.60	1.55	3.13	3.35
C) Biofertilizer				
B_1 (*Rhizobium*)	11.36	27.95	45.94	51.64
B_2 (PSB)	11.73	28.10	49.37	54.76
B_3 (*Rhizobium*+ PSB)	12.02	28.21	51.64	57.14
S.Em.±	0.21	0.54	1.09	1.17
C.D. (P=0.05)	NS	1.55	3.13	3.35
CV%	7.56	8.52	9.49	9.07
Interaction				
VXF	NS	NS	NS	NS
VXB	NS	NS	NS	NS
FXB	NS	NS	NS	NS
VXFXB	NS	NS	NS	NS
Control $_1$ (Meha)Vs rest	10.20	24.73	44.33	49.47
Control$_2$ (GM-3) Vs rest	10.13	22.47	39.40	44.27
S.Em.±	0.21	0.52	1.06	1.17
C.D. (P=0.05)	0.60	1.49	3.02	3.35
CV%	7.94	8.57	9.54	9.09

NS = Non Significant

Fig. 3 Periodical plant height (cm) as influenced by various treatments of summer greengram



4.1.2.4 Interaction effect

Interaction effects due to different varieties, inorganic fertilizers and biofertilizers failed to reach the levels of significance.

4.1.3 Number of branches per plant

The mean data on number of branches per plant as influenced by different varieties, inorganic fertilizers and biofertilizers were recorded at 20, 40, 60 DAS and at harvest are presented along with their interactions in Table 7 and graphically depicted in Fig.4. The rest of all the treatments as compared to control (additional treatments) were found better.

4.1.3.1 Effect of varieties

Data presented in Table 7 revealed that different varieties showed significant influence on number of branches per plant at 20, 40, 60 DAS and at harvest.

Data furnished in Table 7 further revealed that significantly higher number of branches per plant (3.71) at harvest was recorded in variety Meha (V_1) as compared to variety GM-3 (V_2) (3.27). Similar trend was also observed at all the periodical stages.

4.1.3.2 Effect of inorganic fertilizer

A perusal of data presented in Table 7 indicated that number of branches per plant subjected to different inorganic fertilizers showed significant differences at 40, 60 and at harvest.

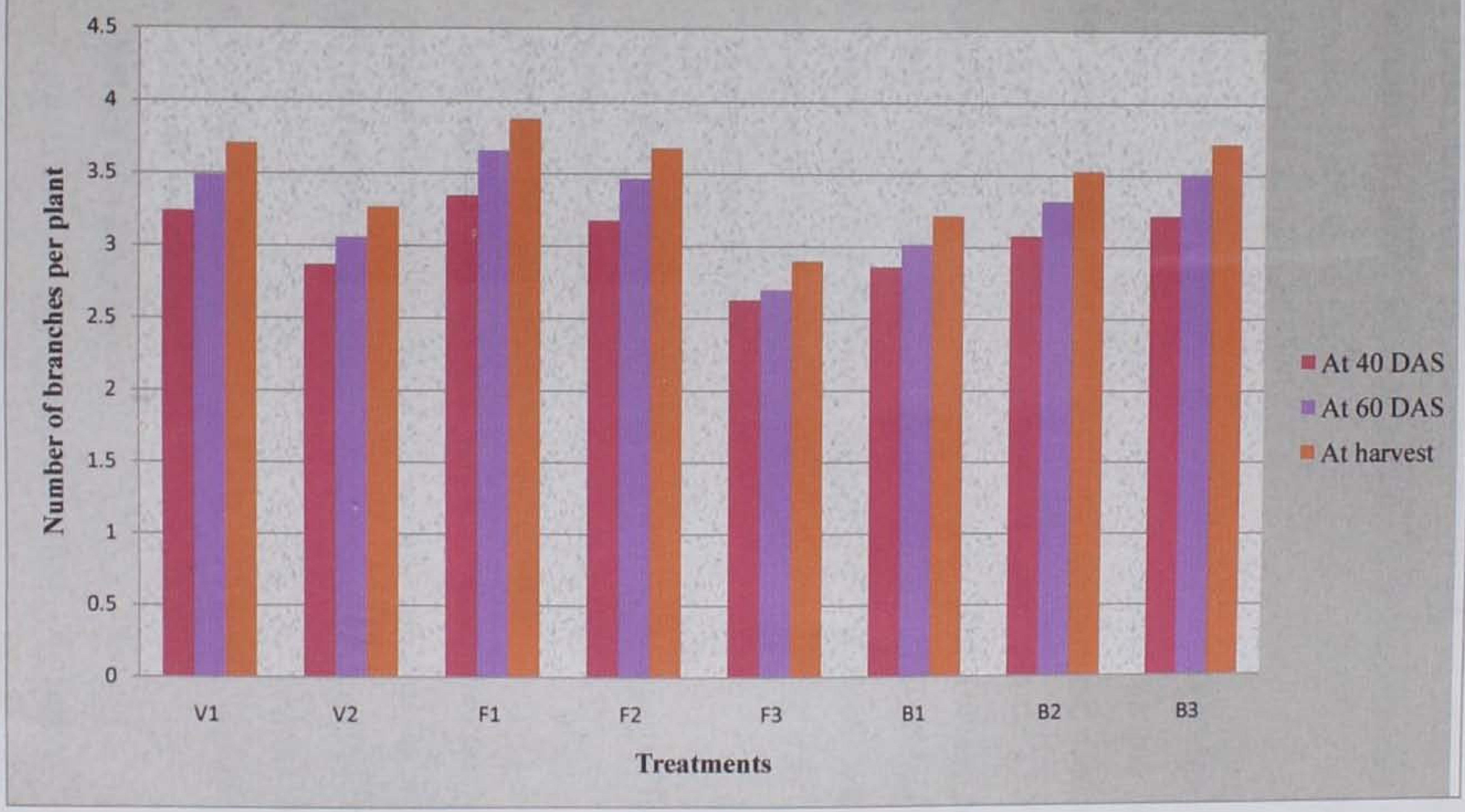
Inorganic fertilizer F_1 (100% RDF) recorded significantly higher number of branches per plant than others but it was found statistical at par with the treatment having 75% RDF (F_2) at 40 and 60 DAS as well as at harvest. While the lowest number of branches per plant (2.90) was obtained under inorganic

Table 7: Number of branches per plant as influenced by various treatments at different growth stages of summer greengram

Treatment	Number of branches per plant			
	At 20 DAS	At 40 DAS	At 60 DAS	At harvest
A) Variety				
V_1 (Meha)	2.55	3.24	3.49	3.71
V_2 (GM-3)	2.38	2.87	3.06	3.27
S.Em.±	0.042	0.06	0.08	0.08
C.D. (P=0.05)	0.12	0.18	0.22	0.23
B) Inorganic Fertilizer				
F_1 (100% RDF)	2.56	3.35	3.66	3.88
F_2 (75% RDF)	2.45	3.18	3.47	3.68
F_3 (50% RDF)	2.38	2.63	2.70	2.90
S.Em.±	0.05	0.08	0.10	0.10
C.D. (P=0.05)	NS	0.22	0.28	0.28
C) Biofertilizer				
B_1 (*Rhizobium*)	2.45	2.86	3.02	3.22
B_2 (PSB)	2.47	3.08	3.32	3.53
B_3 (*Rhizobium*+ PSB)	2.49	3.22	3.51	3.72
S.Em.±	0.051	0.08	0.10	0.10
C.D. (P=0.05)	NS	0.22	0.28	0.28
CV%	8.82	10.81	12.39	11.86
Interaction				
VXF	NS	NS	NS	NS
VXB	NS	NS	NS	NS
FXB	NS	NS	NS	NS
VXFXB	NS	NS	NS	NS
Control $_1$ (Meha)Vs rest	2.13	2.70	3.06	3.08
Control$_2$ (GM-3) Vs rest	2.11	2.36	2.88	2.67
S.Em.±	0.051	0.07	0.09	0.09
C.D. (P=0.05)	0.15	0.21	0.26	0.27
CV%	9.12	10.88	12.53	11.96

NS = Non Significant

Fig. 4: Number of branches per plant as influenced by various treatments of summer greengram



fertilizer treatment F_3 (50% RDF).

4.1.3.3 Effect of biofertilizers

Data furnised in Table 7 revealed that different biofertilizers did not show any significant influence on the number of branches per plant at 20 DAS, while it was markedly influenced at 40, 60 DAS and at harvest.

Treatment B_3 (*rhizobium* + PSB) recorded significantly higher branches per plant which was remained at par with B_2 (PSB) at all growth stages except 20 DAS. At harvest, treatment B_3 recorded significantly higher branches per plant (3.72) and remained statistically at par with B_2 (3.53). The lowest branches per plant was recorded under treatment B_1 (*rhizobium*) at all periodical observation intervals, except at 20 DAS which was stastically compared with treatment B_1.

4.1.3.4 Interaction effect

The interaction & among varieties, inorganic fertilizers and biofertilizers were found non-significant (Table 7).

4.1.4 Dry matter accumulation (g/plant)

The mean data on dry matter accumulation per plant (g/plant) recorded at 20, 40, 60 DAS and at harvest as influenced by different varieties, inorganic fertilizers and biofertilizers and their inoculated are presented in Table 8 and graphically illustrated in Fig. 5. The rest of all the treatment as compared to control (additional treatments) were found better.

4.1.4.1 Effect of varieties

Data (Table 8) revealed that different varieties significantly influenced on dry matter accumulation per plant at 20, 40, 60 DAS and at harvest.

Table 8: Dry matter accumulation per plant as influenced by various treatments at different growth stages of summer greengram

Treatment	Dry matter accumulation (g)			
	At 20 DAS	At 40 DAS	At 60 DAS	At harvest
A) Variety				
V_1 (Meha)	0.32	3.96	14.59	18.69
V_2 (GM-3)	0.30	3.37	13.36	16.37
S.Em.±	0.01	0.10	0.23	0.39
C.D. (P=0.05)	0.02	0.29	0.65	1.11
B) Inorganic Fertilizer				
F_1 (100% RDF)	0.33	4.11	15.03	19.48
F_2 (75% RDF)	0.31	3.89	14.59	18.51
F_3 (50% RDF)	0.3	3.00	12.31	14.63
S.Em.±	0.01	0.12	0.28	0.47
C.D. (P=0.05)	NS	0.35	0.80	1.36
C) Biofertilizer				
B_1 (*Rhizobium*)	0.31	3.38	13.44	16.46
B_2 (PSB)	0.32	3.73	13.99	17.62
B_3 (*Rhizobium*+ PSB)	0.32	3.89	14.51	18.53
S.Em.±	0.01	0.12	0.28	0.47
C.D. (P=0.05)	NS	0.35	0.80	1.36
CV%	10.57	14.17	8.42	11.45
Interaction				
VXF	NS	NS	NS	NS
VXB	NS	NS	NS	NS
FXB	NS	NS	NS	NS
VXFXB	NS	NS	NS	NS
Control $_1$ (Meha)Vs rest	0.26	3.11	12.55	15.06
Control$_2$ (GM-3) Vs rest	0.26	2.56	11.28	12.79
S.Em.±	0.01	0.12	0.27	0.452
C.D. (P=0.05)	0.02	0.34	0.77	1.29
CV%	10.96	14.41	8.49	11.46

NS = Non Significant

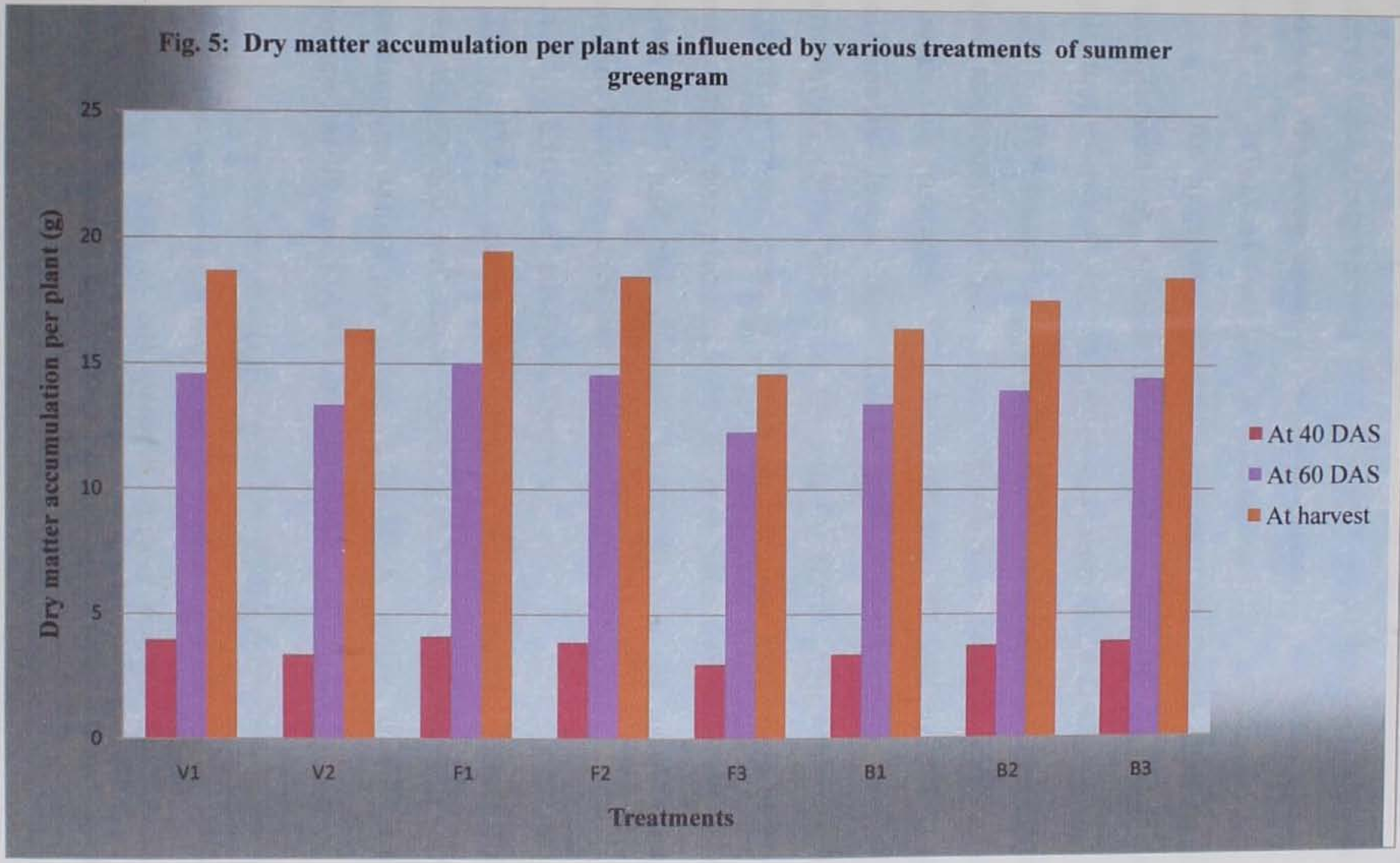


Fig. 5: Dry matter accumulation per plant as influenced by various treatments of summer greengram

Data furnished in Table 8 revealed that significantly higher dry matter accumulation per plant (18.69 g) was recorded under variety Meha than variety GM-3 (16.37 g) at harvest. The similar trend was observed under all growth stages.

4.1.4.2 Effect of inorganic fertilizers

An appraisal of data presented in Table 8 showed that various levels of inorganic fertilizers did not turn out to be significant effect on dry matter production at 20 DAS.

Treatment F_1 (100% RDF) recorded maximum dry matter accumulation per plant, which was remain statistically at par with the treatment 75% RDF (F_2) at 40 and 60 DAS. While, significantly lower dry matter accumulation was noted with treatment F_3 (50% RDF) at 40 and 60 DAS then others. More or less similar trend was observed at harvest. Maximum dry matter accumulation per plant (19.48 g) was recorded with treatment F_1 (100% RDF) and the lowest (14.63 g) was obtained under the treatment F_3 (50% RDF) at harvest.

4.1.4.3 Effect of biofertilizers

Data given in Table 8 revealed that different biofertilizers did not show any significant influence on the dry matter accumulation per plant at 20 DAS, while, it was markedly influenced at 40, 60 DAS and at harvest.

Treatment B_3 (*rhizobium* + PSB) recorded significantly highest dry matter accumulation per plant which was remained at par with B_2 (PSB) at all growth stages except at 20 DAS. At harvest, B_3 recorded significantly highest dry matter accumulation per plant (18.53 g) and remained statistically at par with B_2 (17.62 g). Significantly the lowest dry matter accumulation per plant was recorded under treatment B_1 (*rhizobium*) at all periodical observation intervals, except at 20 DAS.

4.1.4.4 Interaction effect

The interactions due to varieties, inorganic fertilizers and biofertilizers were found non-significant (Table 8).

4.1.5 Number of root nodules per plant

The mean data pertaining to number of root nodules per plant recorded at 20, 40 and 60 DAS as influenced by various treatments and their interactions are presented in Table 9. The rest of all the treatments as compared to control (additional treatments) were found better.

4.1.5.1 Effect of variety

Data (Table 9) revealed that different varieties did not exert any significant influence on number of root nodules per plant at 20, 40, and 60 DAS.

4.1.5.2 Effect of inorganic fertilizers

Data presented in Table 9 indicated that there was non-significant effect of inorganic fertilizers on number of root nodules per plant at 20 DAS. Whereas, at 40 and 60 DAS, significantly higher number of root nodules per plant was found with F_1 (100% RDF) (22.79 and 29.05, respectively) than treatment F_3 but it was statistically at par with F_2 (75% RDF) (22.77 and 29.01, respectively).

4.1.5.3 Effect of biofertilizers

Data given in Table 9 revealed that different biofertilizers significantly influenced the number of root nodules per plant at 40 and 60 DAS.

Table 9: Number of root nodules per plant and days to 50 % flowering as influenced by various treatments at different growth stages of summer greengram

Treatment	Root nodules			Days to 50% flowering
	At 20 DAS	At 40 DAS	At 60 DAS	
A) Variety				
V_1 (Meha)	10.47	21.97	27.85	38.04
V_2 (GM-3)	9.94	20.61	25.88	41.26
S.Em.±	0.19	0.47	0.69	0.63
C.D. (P=0.05)	NS	NS	NS	1.80
B) Inorganic Fertilizer				
F_1 (100% RDF)	10.49	22.79	29.05	38.52
F_2 (75% RDF)	10.22	22.77	29.01	38.67
F_3 (50% RDF)	9.9	18.30	22.53	41.78
S.Em.±	0.23	0.58	0.84	0.77
C.D. (P=0.05)	NS	1.66	2.41	2.20
C) Biofertilizer				
B_1 (*Rhizobium*)	10.11	19.57	24.37	39.61
B_2 (PSB)	10.12	22.03	27.94	39.39
B_3 (*Rhizobium*+ PSB)	10.38	22.27	28.29	39.95
S.Em.±	0.23	0.58	0.84	0.77
C.D. (P=0.05)	NS	1.66	2.41	NS
CV%	9.58	11.54	13.26	8.19
Interaction				
VXF	NS	NS	NS	NS
VXB	NS	NS	NS	NS
FXB	NS	NS	NS	NS
VXFXB	NS	NS	NS	NS
Control $_1$ (Meha)Vs rest	8.68	18.89	23.39	45.33
Control$_2$ (GM-3) Vs rest	8.53	16.51	19.93	47.00
S.Em.±	0.23	0.56	0.81	0.73
C.D. (P=0.05)	0.67	1.61	2.33	2.10
CV%	10.13	11.69	13.47	7.92

NS = Non Significant

Treatment B_3 (*rhizobium* + PSB) recorded significantly higher number of root nodules per plant (22.27 and 28.29) followed by B_2 (PSB) (22.03 and 27.94) at 40 and 60 DAS, respectively. Significantly the lowest number of root nodules per plant (19.57 and 24.37) was recorded under treatment B_1 (*rhizobium*) at 40 and 60 DAS, respectively.

4.1.5.4 Interaction effect

Interaction effects between varieties, inorganic fertilizers and biofertilizers was found to be non-significant with respect to number of root nodules per plant at 20, 40 and 60 DAS (Table 9).

4.1.6 Days to 50 per cent flowering

The mean data on days to 50 per cent flowering as influenced by varieties, inorganic fertilizers, biofertilizers and their interactions are presented in Table 9.

4.1.6.1 Effect of varieties

Data (Table 9) revealed that different varieties significantly influenced days to 50 per cent flowering.

Significantly the more days to 50 per cent flowering (41.26) was recorded under variety GM 3 (V_2). The variety Meha (V_1) recorded significantly less days to 50 per cent flowering (38.04).

4.1.6.2 Effect of inorganic fertilizers

The result presented in Table 9 revealed that different inorganic fertilizers showed significant influence on the days to 50 per cent flowering.

Treatment F_3 (50 % RDF) recorded significantly higher value for days to 50 per cent flowering (41.78) than treatments F_2

or F_1. Significantly the lowest days to 50 per cent flowering was recorded under F_1 (100 % RDF) (38.52) but the differences in days to 50 per cent flowering between treatment F_2 or F_1 was non large.

4.1.6.3 Effect of biofertilizers

Data contanplated in Table 9 revealed that different biofertilizers showed non-significant influence on the days to 50 per cent flowering.

4.1.6.4 Interaction effect

Interaction effects of varieties, inorganic fertilizers and biofertilizers were found to be absent on days to 50 per cent flowering.

4.2 Yield and yield attributes

The mean data on various yield attributes and yield of greengram recorded at the time of harvest are presented in Table 10 to 13.

4.2.1 Number of pods per plant

Data regarding the number of pods per plant as influenced by different varieties, inorganic fertilizers and biofertilizers and their interactions are presented in Table 10 and graphically depicted in Fig. 6. The rest of all the treatment as compared to control (additional treatments) were found better.

4.2.1.1 Effect of varieties

Data pertaining to number of pods per plant given in Table 10 revealed that variety Meha recorded significantly higher pods per plant (18.23) as compared to variety V_2 (GM 3) which recorded the value of 15.51 number of pods per plant.

4.2.1.2 Effect of inorganic fertilizers

A perusal of data in Table 10 revealed that the number of pods per plant was remarkably increased with increasing levels of fertilizer. Maximum number of pods per plant was recorded with F_1 (100% RDF) (18.76) and it was found statistically at par with F_2 (75% RDF) (17.79). However, application of 50% RDF as inorganic fertilizer (F_3) recorded significantly the lowest number of pods per plant (14.05).

4.2.1.3 Effect of biofertilizers

Data further indicated that biofertilizers significantly influenced the number of pods per plant. Significantly higher number of pods per plant was recorded with treatment B_3 (*rhizobium* + PSB) (18.84) as compared to B_1 (*rhizobium*) and B_2 (PSB).

4.2.1.4 Interaction effect

The number of pods per plant was significantly influenced only due to interaction effect between inorganic and biofertilizers.

Data presented in Table 11 revealed that the treatment combination F_1B_3 (100 per cent RDF along with dual inoculation of *rhizobium* + PSB) recorded maximum number of pods per plant (18.80) and found statistically at par with all treatment combinations except F_3B_1 and F_3B_2. The lowest number of pod per plant (14.59) was recorded with F_3B_1 (50 per cent RDF with *rhizobium* seed inoculation only).

4.2.2 Number of seeds per pod

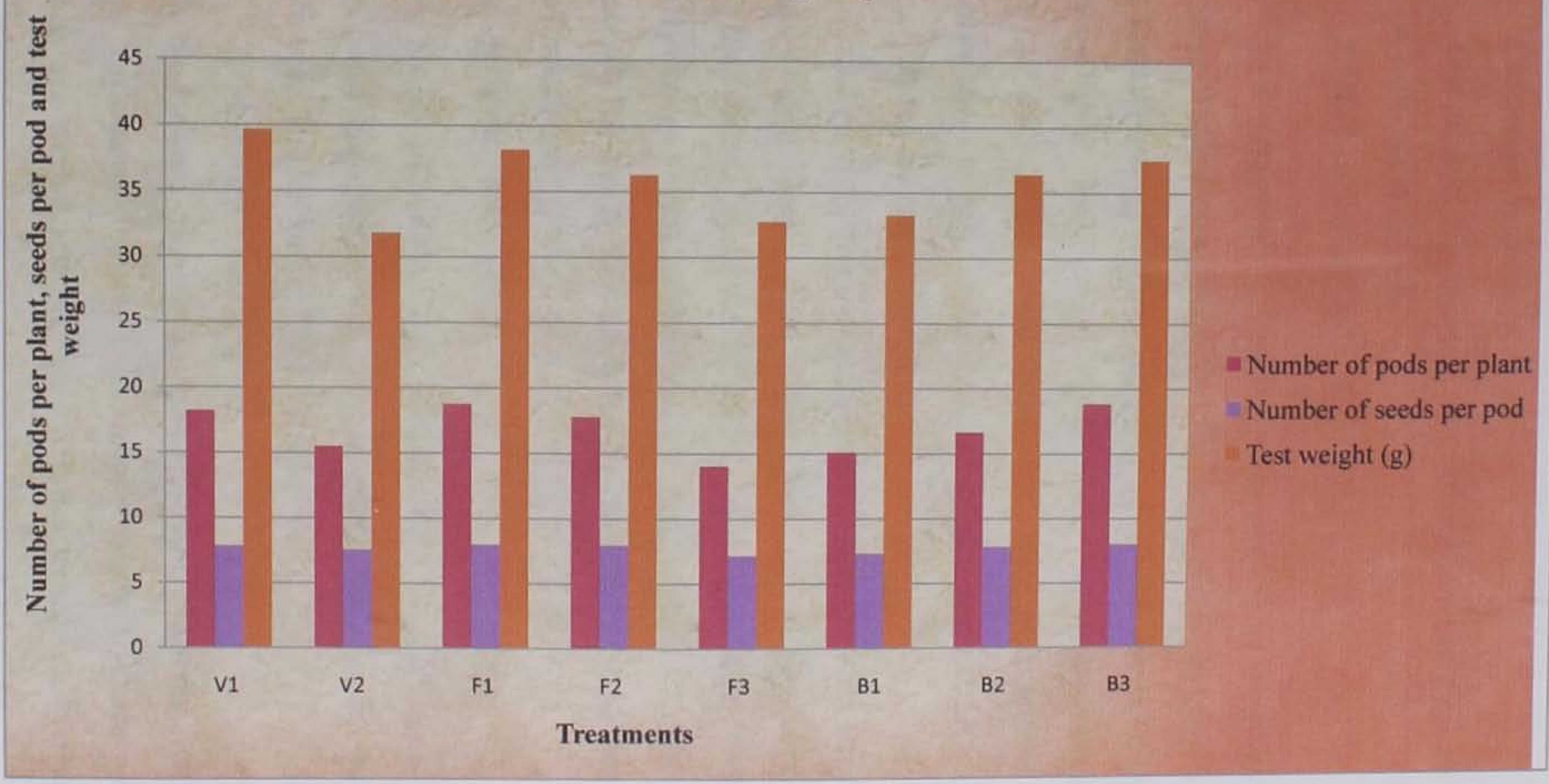
Data pertaining to number of seeds per pod as influenced by various varieties, inorganic fertilizers and biofertilizers and their interactions are presented in table 10.

Table 10: Number of pods per plant, seeds per pod and test weight as influenced by various treatments of summer greengram

Treatment	Number of pods per plant	Number of seeds per pod	Test weight (g)
A) Variety			
V_1 (Meha)	18.23	7.84	39.68
V_2 (GM-3)	15.51	7.59	31.83
S.Em.±	0.44	0.11	0.71
C.D. (P=0.05)	1.26	NS	2.03
B) Inorganic Fertilizer			
F_1 (100% RDF)	18.76	8.01	38.21
F_2 (75% RDF)	17.79	7.95	36.31
F_3 (50% RDF)	14.05	7.18	32.75
S.Em.±	0.54	0.14	0.87
C.D. (P=0.05)	1.55	0.40	2.49
C) Biofertilizer			
B_1 (*Rhizobium*)	15.12	7.33	33.30
B_2 (PSB)	16.66	7.82	36.44
B_3 (*Rhizobium*+ PSB)	18.84	8.00	37.53
S.Em.±	0.54	0.14	0.87
C.D. (P=0.05)	1.55	0.40	2.49
CV%	13.53	7.58	10.27
Interaction			
VXF	NS	NS	NS
VXB	NS	NS	NS
FXB	S	NS	NS
VXFXB	NS	NS	NS
Control $_1$ (Meha)Vs rest	15.27	7.52	30.23
Control$_2$ (GM-3) Vs rest	13.11	7.12	32.05
S.Em.±	0.52	0.13	0.82
C.D. (P=0.05)	1.49	0.38	2.35
CV%	13.68	7.51	10.13

NS = Non Significant, S = Significant

Fig. 6: Number of pods per plant, seeds per pod and test weight as influenced by various treatments of summer greengram



and also depicited in Fig. 6.

4.2.2.1 Effect of varieties

The effect of variety on number of seeds per pod was found to be non-significant.

4.2.2.2 Effect of inorganic fertilizers

The effect of inorganic fertilizers on number of seeds per pod was found significant. The treatment F_1 (100 % RDF) recorded significantly higher number of seeds per pod (8.01) than treatment F_3 but it was statistically at par with the treatment F_2 (75 % RDF) (7.95). The treatment F_3 (50 % RDF) recorded significantly the lowest number of seeds per pod (7.18).

4.2.2.3 Effect of biofertilizers

The effect of biofertilizers on number of seeds per pod was found significant. The treatment B_3 (*rhizobium* + PSB) recorded maximum number of seeds per pod (8.00) but it was statistically at par with treatment B_2 (PSB) (7.82). The treatment B_1 (*rhizobium*) legged behind all by recorded the lowest value of number of seeds per pod (7.33).

4.2.2.4 Interaction effect

None of interaction effects due to varieties, inorganic fertilizers and biofertilizers on number of seeds per pod of greengram was found to be significant.

4.2.3 Test weight per plant

The mean data on test weight per plant as influenced by varieties, inorganic fertilizers and biofertilizers and their interactions are presented in Table 10 and graphically illustrated in Fig. 6.

Table 11: Number of pods per plant as influenced due to F x B interaction

Treatment	Biofertilizer		
Inorganic fertilizer	B_1	B_2	B_3
F_1 (100% RDF)	16.94	17.71	18.80
F_2 (75% RDF)	16.46	17.23	18.32
F_3 (50% RDF)	14.59	15.36	16.46
S.Em.±	0.93		
C.D. (P=0.05)	2.67		

4.2.3.1 Effect of varieties

A persual on data given in Table 10 indicated that the test weight was significantly influenced due to different varieties.

The variety V_1 (Meha) recorded significantly higher (39.68 g) test weight as compared to variety V_2 (GM-3) (31.83 g).

4.2.3.2 Effect of inorganic fertilizers

The effect of inorganic fertilizers on test weight was found significant. The treatment F_1 (100 % RDF) recorded significantly higher test weight (38.21 g) than treatment F_3 but it was statistically at par with treatment F_2 (75 % RDF) (36.31 g). The treatment F_3 (50 % RDF) recorded significantly lowest test weight (32.75 g) than other treatments.

4.2.3.3 Effect of biofertilizers

The effect of biofertilizers on test weight was found to be significant. The treatment B_3 (*rhizobium* + PSB) recorded maximum test weight (37.53 g) but it was remgined at par with treatment B_2 (PSB) (36.45 g). The treatment B_1 (*rhizobium*) recorded significantly the lowest test weight (33.33 g).

4.2.3.4 Interaction effect

There was no any significant interaction observed due to varieties, inorganic fertilizers and biofertilizers on test weight of greengram.

4.2.4 Seed yield (kg/ha)

The seed yield of greengram as influenced by different varieties, inorganic fertilizer, biofertilizers and their interactions are presented in Table 12 and graphically depicted in Fig.7.

4.2.4.1 Effect of varieties

The difference in seed yield of summer greengram due to different varieties was found significant. Variety Meha (V_1) recorded significantly the highest seed yield (1311 kg/ha) than variety GM 3 which recorded the seed yield by 1160 kg/ha.

4.2.4.2 Effect of inorganic fertilizers

The effect of inorganic fertilizers on seed yield was found significant. The treatment F_1 (100 % RDF) recorded significantly higher seed yield (1365 kg/ha) as compared to the treatments F_2 (75 % RDF) (1263 kg/ha) and F_3 (50% RDF). The treatment F_3 (50 % RDF) recorded significantly the lower seed yield (1079 kg/ha).

4.2.4.3 Effect of biofertilizers

The effect of biofertilizers on seed yield was found significant. The treatment B_3 (*rhizobium* + PSB) recorded significantly the higher seed yield (1345 kg/ha) as compared to rest of the treatment. The treatment B_1 (*rhizobium*) recorded significantly the lowest seed yield (1139 kg/ha).

4.2.4.4 Interaction effect

The seed yield was markedly influenced only due to interaction effect between inorganic fertilizers and biofertilizers.

Data presented in Table 13 revealed that the treatment combination F_1B_3 (100 per cent RDF along with dual inoculation of *rhizobium* + PSB) recorded significantly highest seed yield (1355 kg/ha) and it was found statistically at par with all the treatment combinations except F_3B_1 and F_3B_2 and F_2B_1. The lowest seed yield (1109 kg/ha) was recorded with treatment combination F_3B_1 (50 per cent RDF with *rhizobium* seed inoculation only).

4.2.5 Stover yield (kg/ha)

The stover yield of greengram as influenced by different varieties, inorganic fertilizer, biofertilizers and their interactions are presented in Table 12 and graphically depicted in Fig.7.

4.2.5.1 Effect of varieties

With respect to stover yield variety Meha recorded significantly higher stover yield (3706 kg/ha) over variety GM 3 which recorded the stover yield of 2944 kg/ha.

4.2.5.2 Effect of inorganic fertilizers

The results in respect of stover yield as influenced by inorganic fertilizers were found to be significant. Treatment F_1 recorded significantly higher value of stover yield than treatment F_3 barring treatment F_2 which was found to be at par with treatment F_1. In general, treatment F_1, F_2 and F_3 recorded stover yield of 3491, 3373 and 3111 kg/ha, respectly.

4.2.5.3 Effect of biofertilizers

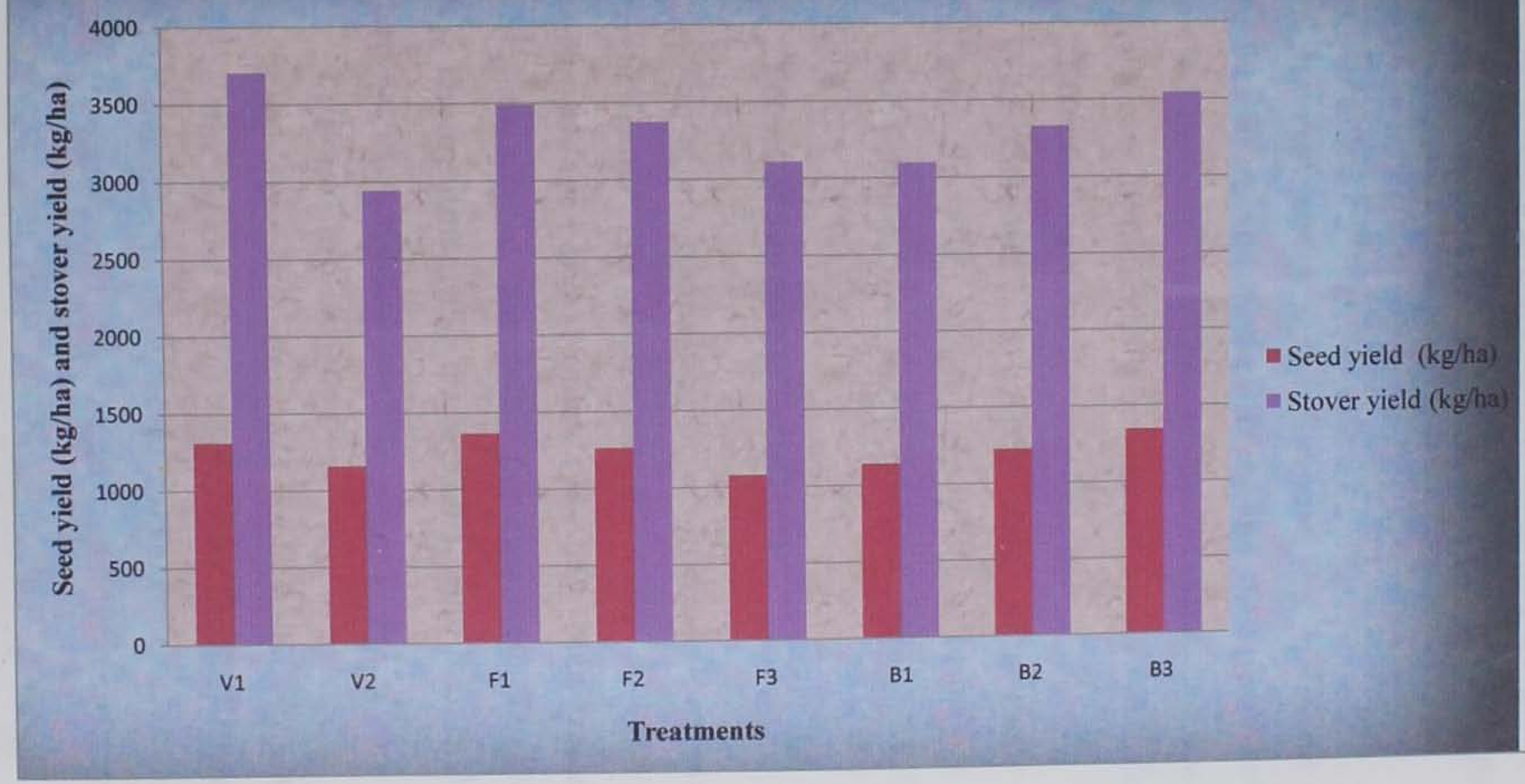
The stover yield was markedly influenced due to various biofertilizers. Wherein, treatment B_1 recorded maximum value of stover yield. Treatment B_3 legged behind all by recording the lower values of stover yield. In general, the value of stover yield under treatments B_1, B_2 and B_3 were 3545, 3331 and 3100 kg/ha, respectly.

Table 12: Seed yield, stover yield and harvest index as influenced by various treatments of summer greengram

Treatment	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
A) Variety			
V_1 (Meha)	1311	3706	26.13
V_2 (GM-3)	1160	2944	28.27
S.Em.±	24.36	49.45	0.46
C.D. (P=0.05)	70.02	142.12	1.33
B) Inorganic Fertilizer			
F_1 (100% RDF)	1365	3491	28.11
F_2 (75% RDF)	1263	3373	27.24
F_3 (50% RDF)	1079	3111	25.75
S.Em.±	29.84	60.57	0.57
C.D. (P=0.05)	85.81	174.07	1.63
C) Biofertilizer			
B_1 (*Rhizobium*)	1139	3100	26.87
B_2 (PSB)	1224	3331	26.87
B_3 (*Rhizobium*+ PSB)	1345	3545	27.51
S.Em.±	29.84	60.57	0.57
C.D. (P=0.05)	85.81	174.07	NS
CV%	10.24	7.73	8.86
Interaction			
VXF	NS	NS	NS
VXB	NS	NS	NS
FXB	S	NS	NS
VXFXB	NS	NS	NS
Control $_1$ (Meha)Vs rest	1147	2750	29.39
Control$_2$ (GM-3) Vs rest	1027	2898	26.19
S.Em.±	28.91	57.65	0.54
C.D. (P=0.05)	82.78	165.05	1.56
CV%	10.32	7.67	8.71

NS = Non Significant, S = Significant

Fig. 7 : Seed yield, stover yield as influenced by various treatments of summer greengram



4.2.5.3 Interaction effect

Interaction affects due to varieties, inorganic fertilizers and biofertilizers on stover yield of greengram were found to be absent.

4.2.6 Harvest Index (%)

Harvest index as influenced by different varieties, inorganic fertilizers and biofertilizers and their interaction effects are presented in table 12. The results revealed that harvest index of greengram was significantly influenced by all variables.

4.2.6.1 Effect of varieties

The difference in harvest index of summer greengram due to different varieties was found significant. Variety GM 3 (V_2) recorded significantly the higher harvest index (28.27 %) than variety Meha (26.13 %).

4.2.6.2 Effect of inorganic fertilizers

The effect of inorganic fertilizers on harvest index was found significant. The treatment F_1 (100 % RDF) recorded significantly higher harvest index (28.11%) than treatment F_3 but it was statistically at par with the treatment F_2 (75 % RDF) (27.24%). The treatment F_3 (50 % RDF) recorded significantly the lowest harvest index (25.75%).

4.2.7.3 Effect of biofertilizers

The harvest index did not reach to the level of significance due to the effect of various biofertilizers treatments however, in general, the values of harvest index under treatments B_1, B_2 and B_3 were 27.51, 26.87 and 26.87 %, respectly.

Table 13: Seed yield as influenced due to F x B interaction

Treatment	**Biofertilizer**		
Inorganic fertilizer	B_1	B_2	B_3
F_1 (100% RDF)	1252	1295	1355
F_2 (75% RDF)	1201	1244	1304
F_3 (50% RDF)	1109	1152	1212
S.Em.±	51.68		
C.D. (P=0.05)	148.64		

4.2.7.4 Interaction effect

There was no significant interaction was observed due to varieties, inorganic fertilizers and biofertilizers on harvest index of greengram.

4.3 Quality parameters

The mean data pertaining to protein content of greengram are presented in Table 14 and graphically depicited in Fig. 8.

4.3.1 Protein content (%) in seed

The mean data on protein content in seed as influenced by different varieties, inorganic fertilizers, biofertilizers and their interactions are presented in Table 14 and graphically depicted in Fig. 8.

4.3.1.1 Effect of varieties

The difference in protein content of summer greengram due to different varieties was found significant. Variety Meha recorded significantly the higher protein content (20.06%) than variety GM 3 (19.11%).

4.3.1.2 Effect of inorganic fertilizers

The effect of inorganic fertilizers on protein content was found significant. The treatment F_1 (100 % RDF) recorded significantly higher protein content (20.27%) than treatment F_3 but it was statistically at par with the treatment F_2 (75 % RDF) (19.70%). The treatment F_3 (50 % RDF) recorded significantly the lowest protein content (18.79%).

4.3.1.3 Effect of biofertilizers

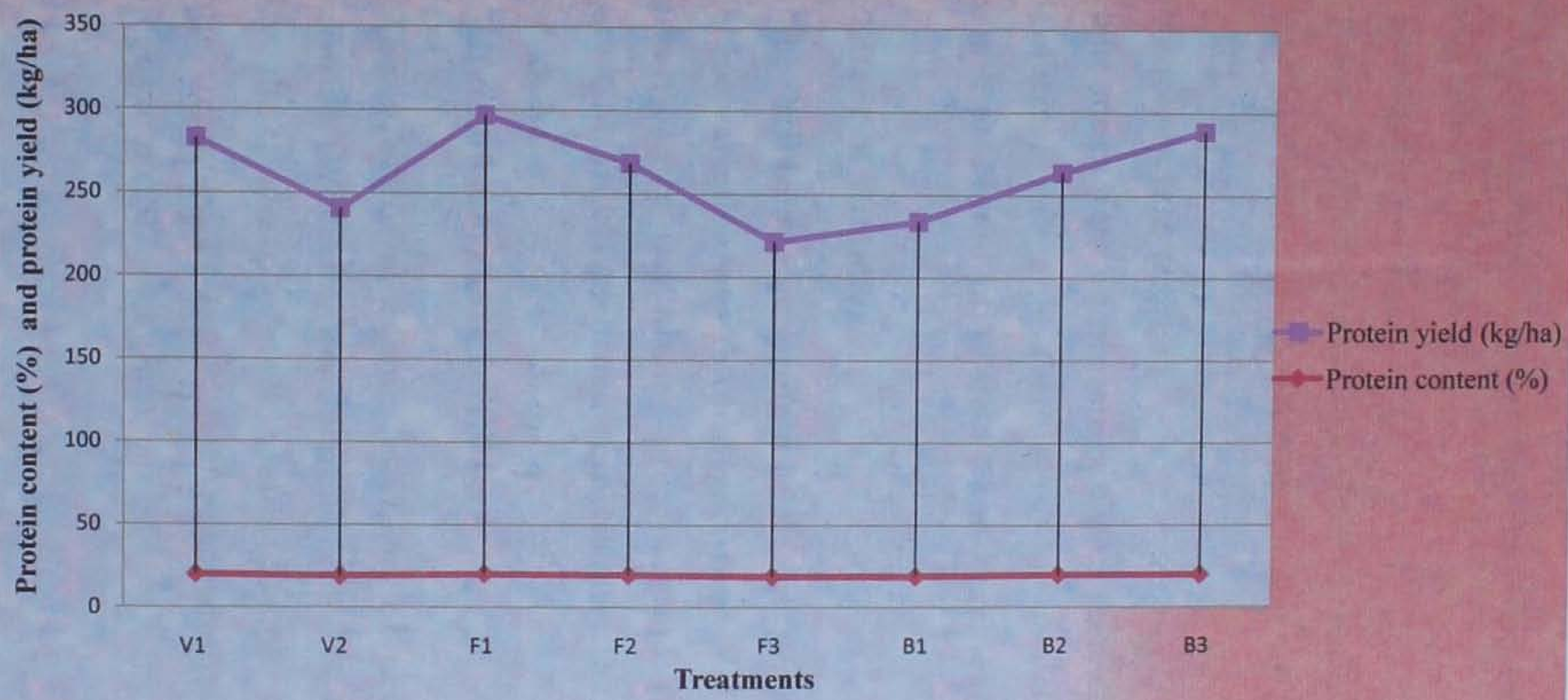
The effect of biofertilizers on protein content was found significant. The treatment B_3 (*rhizobium* + PSB) recorded

Table 14 : Protein content and protein yield as influenced by various treatments of summer greengram

Treatment	Protein content (%)	Protein yield (kg/ha)
A) Variety		
V_1 (Meha)	20.06	262.99
V_2 (GM-3)	19.11	221.68
S.Em.±	0.17	4.84
C.D. (P=0.05)	0.50	13.90
B) Inorganic Fertilizer		
F_1 (100% RDF)	20.27	276.69
F_2 (75% RDF)	19.70	248.81
F_3 (50% RDF)	18.79	202.74
S.Em.±	0.21	5.92
C.D. (P=0.05)	0.61	17.02
C) Biofertilizer		
B_1 (*Rhizobium*)	18.89	215.16
B_2 (PSB)	19.93	243.94
B_3 (*Rhizobium*+ PSB)	20.00	269.00
S.Em.±	0.21	5.92
C.D. (P=0.05)	0.61	17.02
CV%	4.40	10.32
Interaction		
VXF	NS	NS
VXB	NS	NS
FXB	NS	NS
VXFXB	NS	NS
Control $_1$ (Meha)Vs rest	20.58	213.22
Control$_2$ (GM-3) Vs rest	19.49	205.81
S.Em.±	0.21	5.79
C.D. (P=0.05)	0.60	16.57
CV%	4.33	11.64

NS = Non Significant,

Fig. 8:Protein content and protein yield as influenced by various treatments of summer greengrm



significantly highest protein content (20.00%) than treatment B_3 but it was statistically at par with the treatment B_2 (PSB) (19.93%). The treatment B_1 (*rhizobium*) recorded significantly the lowest protein content (18.84%).

4.3.1.4 Interaction effect

None of the interactions due to varieties, inorganic fertilizers and biofertilizers on protein content of greengram was found to be significant.

4.3.2 Protein yield (kg/ha)

The mean data on protein yield in seed as influenced by different varieties, inorganic fertilizers, bio-fertilizers and their interactions are presented in Table 14 and graphically depicited in Fig. 8.

4.3.2.1 Effect of varieties

The difference in protein yield of summer greengram due to different varieties was found significant. Variety (V_1) Meha recorded significantly the higher protein yield (262.99 kg/ha), which variety GM 3 (V_2) recorded significantly the lowest protein yield 221.68 kg/ha.

4.3.2.2 Effect of inorganic fertilizers

The effect of inorganic fertilizers on protein yield was found significant. Wherein, treatment F_1 (100 % RDF) recorded significantly the highest protein yield (276.69 kg/ha) (248.81 kg/ha), while treatment F_3 (50 % RDF) recorded significantly the lowest protein yield (202.74 kg/ha).

4.3.2.3 Effect of biofertilizers

The effect of biofertilizers on protein yield was found significant. The treatment B_3 (*rhizobium* + PSB) recorded significantly the higher protein yield (269.00 kg/ha) as compared to rest of the treatments. The treatment B_1 (*rhizobium*) recorded significantly the lowest protein yield (215.16 kg/ha).

4.3.2.4 Interaction effect

Interaction effects due to varieties, inorganic fertilizers and biofertilizers on protein yield of greengram were found to be non significant.

4.4 Chemical analysis

4.4.1 N, P and S content (%) in seeds of greengram

It is explict from the data in Table 15 that N, P and S content in seed of greengram were not affected significantly by either varieties, inorganic fertilizers and biofertilizers or their interactions but control as non of the treatments should significant influence on them.

4.4.2 N, P and S content (%) in stover

The effect of different varieties, inorganic fertilizers and biofertilizers and their interactions on N, P and S content of stover of greengram was not significantly.

4.4.3 Nutrient uptake (kg/ha) in seed and stover

4.4.3.1 Uptake of nitrogen (N)

The mean values on N uptake by seed and stover as influenced by different varieties, inorganic fertilizers and biofertilizers and their interactions are presented in Table 16.

4.4.3.1.1 Effect of varieties

Data furnished in Table 16 indicated that impact of varieties on N uptake by seed and stover of summer greengram was found significant. Variety (V_1) Meha (44.57 kg/ha) recorded significantly higher N uptake by seed than variety GM- 3 (V_2) (38.16 kg/ha). Same trend was observed in case of stover.

4.4.3.1.2 Effect of inorganic fertilizers

The effect of inorganic fertilizers on N uptake by seed and stover found significant. The treatment F_1 (100 % RDF) recorded significantly higher N uptake by seed (47.09 kg/ha) and stover (25.14 kg/ha) as compared to the treatments F_2 (75% RDF) and F_3 (50% RDF). The treatment F_3 (50 % RDF) recorded significantly lower N uptake by seed (33.88 kg/ha) and stover (20.84 kg/ha).

4.4.3.1.3 Effect of biofertilizers

The effect of biofertilizers on N uptake in seed and stover were found significant. The treatment B_3 (*rhizobium* + PSB) recorded significantly higher N uptake in seed (46.27 kg/ha) and in stover (25.31 kg/ha) as compared to treatments B_1 and B_2. The treatment B_1 (*rhizobium*) recorded significantly lowest N uptake in seed (36.22 kg/ha) and stover (20.15 kg/ha).

4.4.3.1.4 Interaction effect

Interaction effects due to varieties, inorganic fertilizers and biofertilizers on N uptake by seed and stover of greengram were found to be absent.

Table 15: N, P and S content in seeds and stover as influenced by various treatments of summer greengram

Treatment	N content (%)		P content (%)		S content (%)	
	Seed	Stover	Seed	Stover	Seed	Stover
A) Variety						
V_1 (Meha)	3.40	0.71	0.71	0.25	0.40	0.31
V_2 (GM-3)	3.29	0.65	0.69	0.24	0.37	0.30
S.Em.±	0.028	0.006	0.007	0.002	0.007	0.003
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
B) Inorganic Fertilizer						
F_1 (100% RDF)	3.45	0.72	0.73	0.26	0.42	0.32
F_2 (75% RDF)	3.44	0.69	0.72	0.25	0.40	0.31
F_3 (50% RDF)	3.14	0.67	0.65	0.24	0.37	0.30
S.Em.±	0.034	0.008	0.008	0.002	0.008	0.004
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
C) Biofertilizer						
B_1 (*Rhizobium*)	3.18	0.65	0.65	0.24	0.38	0.30
B_2 (PSB)	3.42	0.711	0.71	0.25	0.41	0.31
B_3 (*Rhizobium*+ PSB)	3.44	0.714	0.72	0.26	0.41	0.32
S.Em.±	0.034	0.008	0.008	0.002	0.008	0.004
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
CV%	4.33	4.84	5.16	2.88	5.26	5.15
Interaction						
VXF	NS	NS	NS	NS	NS	NS
VXB	NS	NS	NS	NS	NS	NS
FXB	NS	NS	NS	NS	NS	NS
VXFXB	NS	NS	NS	NS	NS	NS
Control $_1$ (Meha)Vs rest	3.29	0.68	0.69	0.26	0.41	0.32
Control$_2$ (GM-3) Vs rest	3.12	0.64	0.64	0.25	0.40	0.31
S.Em.±	0.034	0.008	0.008	0.002	0.008	0.004
C.D. (P=0.05)	0.10	0.02	0.02	0.01	0.02	0.01
CV%	4.40	4.91	5.27	3.09	5.46	5.04

NS = Non Significant

4.4.3.2 Uptake of phosphrous (P)

The mean values on P uptake by seed and stover as influenced by different varieties, inorganic fertilizers and biofertilizers or their interactions are presented in Table 17.

4.4.3.2.1 Effect of varieties

Data furnished in Table 16 indicated that impact of varieties on P uptake by seed and stover of summer greengram was found significant. Variety (V_1) Meha (9.31 kg/ha) recorded significantly the higher P uptake by seed than variety GM- 3 (V_2) (8.00 kg/ha). Same trend was observed in case of stover.

4.4.3.2.2 Effect of inorganic fertilizers

The effect of inorganic fertilizers on P uptake by seed and stover was found significant. The treatment F_1 (100 % RDF) recorded significantly higher P uptake by seed (9.96 kg/ha) and stover (9.08 kg/ha) as compared to treatments F_2 (75% RDF) and F_3 (50% RDF). The treatment F_3 (50 % RDF) recorded significantly the lowest P uptake by seed (7.01 kg/ha) and stover (7.47 kg/ha).

4.4.3.2.3 Effect of biofertilizers

The effect of biofertilizers on P uptake in seed and stover was found significant. The treatment B_3 (*rhizobium* + PSB) recorded significantly the highest P uptake in seed (9.68 kg/ha) and stover (9.22 kg/ha) as compared treatments to B_1 and B_2. The treatment B_1 (*rhizobium*) recorded significantly lowest P uptake by seed (7.40 kg/ha) and stover (7.44 kg/ha).

Table 16: N, P and S uptake by seed and stover as influenced by various treatments of summer greengram

Treatment	N uptake		P uptake		S uptake	
	seed	stover	Seed	Stover	Seed	Stover
A) Variety						
V_1 (Meha)	44.57	26.31	9.31	9.27	5.24	11.49
V_2 (GM-3)	38.16	19.14	8.00	7.07	4.29	8.83
S.Em.±	0.86	0.42	0.18	0.06	0.13	0.23
C.D. (P=0.05)	2.47	1.21	0.52	0.18	0.30	0.66
B) Inorganic Fertilizer						
F_1 (100% RDF)	47.09	25.14	9.96	9.08	5.73	11.17
F_2 (75% RDF)	43.45	23.27	9.09	8.43	5.05	10.46
F_3 (50% RDF)	33.88	20.84	7.01	7.47	3.99	9.33
S.Em.±	1.05	0.52	0.22	0.08	0.099	0.10
C.D. (P=0.05)	3.02	1.49	0.64	0.23	0.28	0.24
C) Biofertilizer						
B_1 (*Rhizobium*)	36.22	20.15	7.40	7.44	4.33	9.30
B_2 (PSB)	41.86	23.68	8.69	8.33	5.02	10.33
B_3 (*Rhizobium*+ PSB)	46.27	25.31	9.68	9.22	5.51	11.34
S.Em.±	1.05	0.52	0.22	0.08	0.099	0.10
C.D. (P=0.05)	3.02	1.49	0.64	0.23	0.28	0.24
CV%	10.71	9.45	10.94	10.71	7.90	7.30
Interaction						
VXF	NS	NS	NS	NS	NS	NS
VXB	NS	NS	NS	S	NS	NS
FXB	NS	NS	NS	NS	NS	NS
VXFXB	NS	NS	NS	NS	NS	NS
Control $_1$ (Meha)Vs rest	37.76	18.70	7.87	2.82	6.80	13.73
Control$_2$ (GM-3) Vs rest	31.98	18.49	6.58	2.63	6.47	12.57
S.Em.±	1.01	0.48	0.21	0.08	0.15	0.27
C.D. (P=0.05)	2.89	1.38	0.61	0.22	0.44	0.77
CV%	10.73	9.25	10.98	10.93	7.60	7.30

NS = Non Significant, S = Significant

4.4.3.2.4 Interaction effect

The P uptake by stover was significantly influenced only due to interaction effect of variety and bio-fertilizers. Data presented in Table 17 revealed that the treatment combination V_1B_3 (Meha with dual inoculation of *rhizobium* + PSB) recorded the highest P uptake by stover. The lowest P uptake was recorded with V_2B_1 (GM 3 with *rhizobium* seed inoculation only).

4.4.3.3. Uptake of sulphur (S)

The mean values on S uptake by seed, stover as influenced by different varieties, inorganic fertilizers and biofertilizers and their interactions are presented in Table 16.

4.4.3.3.1 Effect of varieties

Data furnished in Table 16 indicated that impact of varieties on S uptake by seed and stover of summer greengram was found significant. Variety (V_1) Meha (5.24 kg/ha) recorded significantly higher S uptake by seed than variety GM 3 (V_2) (4.29 kg/ha). Same trend was observed in case of stover.

4.4.3.3.2 Effect of inorganic fertilizers

The effect of inorganic fertilizer on S uptake by seed and stover was found significant. The treatment F_1 (100 % RDF) recorded significantly the highest S uptake by seed (5.73 kg/ha) and stover (11.17 kg/ha). While treatment F_3 (50 % RDF) recorded significantly the lowest S uptake by seed (3.99 kg/ha) and stover (9.33 kg/ha).

Table 17: P uptake by stover as influenced due to V x B interaction

Treatments	Biofertilizer		
Varieties	B_1	B_2	B_3
V_1 (Meha)	8.35	8.80	9.24
V_2 (GM-3)	7.25	7.70	8.24
S.Em.±	0.13		
C.D. (P=0.05)	0.36		

4.4.3.3.3 Effect of biofertilizers

The effect of biofertilizers on S uptake in seed and stover was found significant. Dual inoculation of *rhizobium* + PSB (B_3) recorded significantly the highest S uptake in seed (5.51 kg/ha) and stover (11.34 kg/ha). The treatment B_1 (*rhizobium*) recorded significantly lowest S uptake in seed (4.33 kg/ha) and stover (9.30 kg/ha) than others.

4.4.3.3.4 Interaction effect

None of the interactions due to varieties, inorganic fertilizers, biofertilizers on S uptake by seed and stover of greengram was significant.

4.4.3.4 Available N, P_2O_5 and S in soil after harvest

The mean values of available N, P_2O_5 and S in soil after harvest as influenced by different varieties, inorganic fertilizers, biofertilizers and their interactions are presented in Table 18.

4.4.3.4.1 Effect of varieties

Data revealed that different varieties did not exert any significant influence on available N, P_2O_5 and S in soil after harvest (Table 18).

4.4.3.4.2 Effect of inorganic fertilizers

The effect of inorganic fertilizers on available N, P_2O_5 and S in soil after harvest was found significant. The treatment F_1 (100 % RDF) recorded significantly higher available N, P_2O_5 and S in soil after harvest (264.58, 42.79 and 29.49, respectively) than treatment F_3 but it was statistically at par with the treatment F_2 (75 % RDF). The treatment F_3 (50 % RDF) recorded significantly the lowest available N, P_2O_5 and S in soil after harvest (219.32, 35.48 and 28.00, respectively).

4.4.3.4.3 Effect of biofertilizers

The effect of biofertilizers on available N, P_2O_5 and S in soil after harvest was found significant. The treatment B_3 (*rhizobium* + PSB) recorded significantly highest available N, P_2O_5 and S in soil after harvest (257.01, 41.57, 28.42 kg/ha, respectively) which was statistically at par with treatment B_2 (PSB). The treatment B_1 (*rhizobium*) recorded significantly lowest available N (233.35 kg/ha), P_2O_5 (37.75 kg/ha) and S (25.06 kg/ha) in soil after harvest than others.

4.4.3.4.4 Interaction effect

Interaction effects of varieties, inorganic fertilizers and biofertilizers on available N, P_2O_5 and S status in soil after harvest were found to be non significant.

4.5 Economics

An economics indicating gross realization in rupees per hectare was worked out from the seed and stover yields of greengram by taking into account the prevailing market selling prices. The total cost of cultivation per hectare was worked out for the individual treatment combination (Appendix III). The data on economics of different treatments are presented in Table 19.

4.5.1 Effect of varieties

Data presented in Table 19 indicated that higher net realization (₹ 62182/ha) and BCR (5.77) was secured under variety Meha (V_1) as compared to GM 3 (V_2) with the net realization of ₹ 53108/ha and BCR (4.93).

Table 18: Available N, P_2O_5 and S in soil after harvest as influenced by various treatments of summer greengram

Treatment	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available S (kg/ha)
A) Variety			
V_1 (Meha)	250.68	40.55	27.52
V_2 (GM-3)	241.78	39.11	26.26
S.Em.±	3.61	0.58	0.51
C.D. (P=0.05)	NS	NS	NS
B) Inorganic Fertilizer			
F_1 (100% RDF)	264.58	42.79	29.49
F_2 (75% RDF)	254.78	41.21	28.00
F_3 (50% RDF)	219.32	35.48	23.07
S.Em.±	4.43	0.72	0.63
C.D. (P=0.05)	12.72	2.06	1.80
C) Biofertilizer			
B_1 (*Rhizobium*)	233.35	37.75	25.06
B_2 (PSB)	248.33	40.86	27.18
B_3 (*Rhizobium*+ PSB)	257.01	41.57	28.42
S.Em.±	4.43	0.72	0.63
C.D. (P=0.05)	12.72	2.06	1.80
CV%	7.62	7.63	9.89
Interaction			
VXF	NS	NS	NS
VXB	NS	NS	NS
FXB	NS	NS	NS
VXFXB	NS	NS	NS
Control $_1$ (Meha)Vs rest	232.97	37.68	25.01
Control$_2$ (GM-3) Vs rest	214.00	34.61	22.32
S.Em.±	4.29	0.69	0.61
C.D. (P=0.05)	12.28	1.99	1.71
CV%	7.66	7.66	9.98
Mean	246.23	39.83	26.85
Initial Value	230.15	38.00	21.01

NS = Non Significant,

4.5.2 Effect of inorganic fertilizer

A perusal of data presented in Table 19 revealed that the highest net realization (₹ 63280/ha) was inclued under the treatment F_1 (100% RDF) with the BCR value of 5.29. The next better treatment in view of net realization was treatment F_2 (75% RDF) which recorded the net realization of ₹ 58237/ha with the BCR value of 5.0. The lower net realization of ₹ 48806/ha was noticed under treatment F_3 (50% RDF) with the BCR value of 4.29.

4.5.3 Effect of biofertilizers

A perusal of data presented in Table 19 revealed that the highest net realization (₹ 63320/ha) was inclued under the treatment B_1 (*rhizobium* + PSB) with the BCR value of 5.75. The next better treatment in view of net realization was treatment B_2 (PSB) which recorded the net realization of ₹ 56962/ha with the BCR value of 5.23. The lower net realization of ₹ 52250/ha was noticed under treatment B_3 (*rhizobium*) with the BCR value of 4.79.

Table 19: **Economics of summer greengram as influenced by varieties, inorganic fertilizer and biofertilizers**

Treatment	Yield (kg/ha)		Gross realization (₹/ha)	Cost of production (₹/ha)	Net realization (₹/ha)	BCR
	Seed	Stover				
Variety (V)						
Meha	1311	3706	72962	10780	62182	5.77
GM-3	1160	2944	63888	10780	53108	4.93
Inorganic fertilizer (F)						
F_1 (100% RDF)	1365	3491	75232	11952	63280	5.29
F_2 (75% RDF)	1263	3373	69896	11659	58237	5.00
F_3 (50% RDF)	1079	3111	60172	11366	48806	4.29
Biofertilizer (B)						
B_1 (*Rhizobium*)	1139	3100	63150	10900	52250	4.79
B_2 (PSB)	1224	3331	67862	10900	56962	5.23
B_3 (*Rhizobium* + PSB)	1345	3545	74340	11020	63320	5.75

A = **Selling rate of product**

Greengram Seed : ₹ 50 kg^{-1} (Meha)
₹ 50 kg^{-1} (GM-3)

Greengram Stover : ₹ 2 kg^{-1}

Table 20 : Economics of various treatment combination of varieties, inorganic fertilizers and biofertilizers

Sr. No.	Treatment combination	Yield (kg/ha)		Gross realization (₹/ha)	Cost of production (₹/ha)		Total cost (₹/ha)	Net realization (₹/ha)	BCR
		Seed	Stover		Fixed	Variable			
1	$V_1F_1B_1$	1384	3813	76826	10780	1292	12072	64754	5.36
2	$V_1F_1B_2$	1418	3914	78728	10780	1292	12072	66656	5.52
3	$V_1F_1B_3$	1591	4017	87584	10780	1412	12192	75392	6.18
4	$V_1F_2B_1$	1236	3397	68594	10780	999	11779	56815	4.82
5	$V_1F_2B_2$	1386	3885	77070	10780	999	11779	65291	5.54
6	$V_1F_2B_3$	1506	3990	83280	10780	1119	11899	71381	6.00
7	$V_1F_3B_1$	991	3141	55832	10780	706	11486	44346	3.86
8	$V_1F_3B_2$	1131	3587	63724	10780	706	11486	52238	4.55
9	$V_1F_3B_3$	1159	3608	65166	10780	826	11606	53560	4.61
10	V_1A.T.	1147	2750	62850	10780	1172	11952	50898	4.26
11	$V_2F_1B_1$	1182	2881	64862	10780	1292	12072	52790	4.37
12	$V_2F_1B_2$	1244	2946	68092	10780	1292	12072	56020	4.64
13	$V_2F_1B_3$	1373	3374	75398	10780	1412	12192	63206	5.18
14	$V_2F_2B_1$	1070	2747	58994	10780	999	11779	47215	4.01
15	$V_2F_2B_2$	1119	2973	61896	10780	999	11779	50117	4.25
16	$V_2F_2B_3$	1258	3244	69388	10780	1119	11899	57489	4.83
17	$V_2F_3B_1$	968	2618	53636	10780	706	11486	42150	3.67
18	$V_2F_3B_2$	1045	2678	57606	10780	706	11486	46120	4.02
19	$V_2F_3B_3$	1182	3035	65170	10780	826	11606	53564	4.62
20	V_2A.T.	1027	2898	57146	10780	1172	11952	45194	3.78

A = Selling rate of product

Greengram Seed : ₹ 50 kg^{-1} (Meha)
₹ 50 kg^{-1} (GM-3)
Greengram Stover : ₹ 2 kg^{-1}

DISCUSSION

V. DISCUSSION

An experiment was conducted with two varieties *viz.*, Meha (V_1) and GM-3 (V_2), three levels of inorganic fertilizers *viz.*, F_1 (100% RDF), F_2 (75% RDF) and F_3 (50% RDF), and three levels of biofertilizers *viz.*, B_1 (*rhizobium*), B_2 (PSB) and B_3 (*rhizobium*+PSB) and two additional treatments (controls) *viz.*, AT_1 - Meha with 100% RDF and AT_2 – GM 3 with 100% RDF in FRBD design with three replications at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, during summer season of 2011. In this chapter, an attempt has been made to discuss the probable causes for observed variations in the growth, yield, nutrient content and uptake through seed as well as stover and quality parameters of crop have been described in preceding chapter with help of statistical yardstick. Here, an attempt has been made to discuss the important results of present study in the context of earlier findings along with appropriate scientific reasoning.

For the brevity, this chapter has been divided into following sub-heads.

5.1 Effect of weather on summer greengram

5.2 Effect of varieties

5.3 Effect of inorganic fertilizers

5.4 Effect of biofertilizers

5.5 Economics

5.6 Interaction effects

5.1 Effect of weather on summer greengram

Among the various factors responsible for the performance of crop, the weather plays a key role. From weather data (Table 1 and Fig. 1), it appears that the weather conditions prevailed during crop season were favourable and congenial for the normal growth and development of greengram crop.

However, the maximum and minimum temperature recorded during period of present investigation revealed that weather conditions were congenial for growth and development of mungbean under irrigated condition. The mean minimum temperature ranged from 14.2^{0}C to 36.0 ^{0}C and mean maximum temperature ranged from 32.0^{0}C to 45.8 ^{0}C during crop season of the year 2011. The maximum and minimum relative humidity ranged between 89 to 57 and 15 to 61 per cent, respectively and daily sunshine hours from 9.0 to 10.2 hours. In general, the weather was normal and quite favourable for satisfactory growth and development of summer mungbean. Besides, no severe incidences of disease and insect pests were observed during crop growth period. Thus, the differences observed in growth and yield attributes of crop were only due to different treatments.

5.2 Effect of varieties

5.2.1 Effect on growth characters

Plant population did not show any significant effect due to different varieties. All growth characters like periodical plant height (Table 6 and Fig.3), number of branches per plant (Table 7 and Fig. 4), dry matter accumulation per plant (Table 8 and Fig. 6) and days to 50 per cent flowering were significantly influenced due to different varieties (Table 9). Variety Meha (V_1) recorded significantly higher plant height (57.35 cm), number of branches per plant (3.71) and dry matter accumulation per plant (18.69 g) as compared to variety GM 3. Significant differences in plant height, number of branches per plant and dry matter accumulation per plant in these varieties were observed due to their genetical different growth habit. Number of effective root nodules per plant (Table 9) was not significantly influenced by different varieties. Similar results were also reported by Gangaiah *et al.* (2008) and Singh *et al.* (2009).

Days taken to 50 per cent flowering was due to varieties. Significantly more number of days to 50 per cent flowering (41.26) was recorded in variety GM 3 (V_2). The variety Meha (V_1) recorded significantly less days to 50 per cent flowering. The difference observed in days to 50% flowering on varieties is only due to its inherent characteristics. Similar observations were also made by Gangaiah *et al.* (2008).

5.2.2 Effect on yield attributes

All yield attributing parameters (Table 10 to 12 and Fig. 6) like pods per plant, number of seeds per pod and test weight were significantly influenced due to different varieties. Significantly higher number of pods per plant (18.23) and test weight (39.68 g) were registered under variety Meha (V_1) as compared to variety GM 3 (V_2). This difference in yield attributing characters between two varieties might be due to genetic constitution of these varieties. These results are in accordance with the findings of those reported by Singh *et al.* (2009).

5.2.3 Effect on seed and stover yields

It is evident from the results presented in Table 12 and Fig. 7 that there was significant differences in seed and stover yield of greengram due to varieties. The variety Meha (V_1) registered significantly higher seed (1311 kg/ha) and stover yields (3706 kg/ha) as compared to variety GM-3 (V_2) for seed (1160 kg/ha) and stover yields (2944 kg/ha). This might be due to a variety of crop differed in its genetic built up and hence resulted in the yield potential. The above findings are in complete aggrement with earlier work of Gangaiah *et al.* (2008) and Rathi *et al.* (2009).

Significantly higher harvest index was recorded under variety GM-3 (28.27) as compared to Meha (26.13). This difference in harvest index due to different varieties was due to varying capacity of varieties of source-sink relationship. Similar results were also reported by Gangaiah *et al.* (2008).

5.2.4 Effect on quality

The quality of greengram in terms of protein content and protein yield are presented in Table 14 and Fig. 8. The different varieties showed significant effect on protein content and yield. Variety Meha (V_1) recorded significantly higher protein content (20.06%) and protein yield (262.99 kg/ha) as compared to variety GM-3. These differences in protein content and yield in different varieties occured due to their varying genetic make up. Similar observations were also made by Gangaiah *et al.* (2008).

5.2.5 Effect on nutrient content and uptake

At harvesting, treatment-wise, seed and stover samples were collected and analysed for N, P and S content. Using content and yield values, uptake of these nutrients were calculated separately for seed and stover. The content of N, P and S (Table 15) in seed as well as in stover were not affected significantly due to different varieties. However, uptake of these nutrients was affected significantly due to different varieties (Tables 16 and Fig. 9). In all these cases (seed and stover), Meha (V_1) showed significantly higher uptake of all nutrients as compared to variety GM 3. These differential uptakes by different varieties were might be due to the significant yield variation between varieties. Similar results were also reported by Gangaiah *et al.* (2008).

5.2.6 Effect on nutrient status in soil after harvest of crop

Different varieties were non-significantly influenced the nutrient status of soil (Table 18) after the harvest of green gram cultivars.

5.3 Effect of inorganic fertilizers

5.3.1 Effect on growth characters

Plant population was not significantly influenced due to different inorganic fertilizers. The periodical plant height (Table 6 and Fig. 3), number of branches per plant (Table 7 and Fig. 4) and dry matter accumulation per plant (Table 8 and Fig. 5) were significantly influenced by different inorganic fertilizers, at all the growth periods except at 20 DAS. Significantly the taller plant height was recorded by F_1 (100% RDF) (59.22 cm) which was statistically at par with treatment F_2 (75% RDF) (56.58 cm). Treatment F_3 (50% RDF) recorded significantly the lowest plant height (47.75 cm) in all growth stages. Crop fertilized with 100 per cent RDF (F_1) made vigorous growth as would be evident from the data on plant height (59.22 cm) as compared with those fertilized with 75 per cent RDF (F_2) and 50 per cent RDF (F_3). Similar results are in accordance with the findings of Chaudhari *et al.* (1988), Singh *et al.* (2004), Ghanshyam *et al.* (2010), Thenua *et al.* (2010) with respect to plant height.

Maximum number of branches per plant (Table 7 and Fig. 4) was recorded by 100 per cent RDF (F_1) (3.88) which was statistically at par with the treatment 75 per cent RDF (F_2) (3.68). 50 per cent RDF (F_3) recorded the lowest number of branches per plant (2.90). These might be due to adequate supply of N and P under higher level. Moreover, nitrogen being essential constituent of various amino acids and proteins as well as structural constituent of cell influenced different physiological processes such as cell division and elongation. Phosphorus has important role in conversion of solar energy into chemical energy and it has also beneficial effect on root proliferation that increases the absorption of plant nutrients and moisture from soil. These findings are substantiated with those reported by Patel *et al.* (1992), Chaudhari *et al.* (1988) and Patel *et al.* (2010).

Maximum dry matter accumulation per plant was recorded by 100 per cent RDF (F_1) (19.48 g) which was statistically at par with the treatment 75 per cent RDF (F_2) (18.51g). The treatment having 50 per cent RDF (F_3) recorded the lowest dry matter accumulation per plant (14.63 g). Moreover, nitrogen and phosphorus might have increased the photosynthetic efficiency and thus increased the production of photosynthates. These results were also in conformity with the result of those reported by Kulkarni *et al.* (2000), Singh *et al.* (2004), Yakardi *et al.* (2004).

Significant differences were observed due to different inorganic fertilizers on root nodules per plant (Table 9) at 40 and 60 DAS. The treatment F_1 (100% RDF) recorded maximum number of effective root nodules per plant (29.05), followed by the treatment F_2 (75% RDF) (29.01). The lowest number of root nodules was observed under the treatment F_3 (50% RDF) (22.53). This might be due to beneficial effect of phosphorous on root growth which provided more root surface for bacterial infection and enhanced the nodulation. Similar observatios were also made by Sarkar *et al.* (1993), Mishra and Misra (1995), Kulkarni *et al.* (2000), Ghanshyam *et al.* (2010), Thenua *et al.* (2010) and Singh *et al.* (2011).

Days to 50 per cent flowering (Table 9) differed significantly due to different levels of inorganic fertilizers. Treatment F_3 (50% RDF) taken maximum number of days to 50 per cent flowering (41.78). The treatment F_1 (38.52) recorded lesser number of days to 50 per cent flowering, followed by the treatment F_2 (75% RDF). This might be due to the fulfillment of nutrient requirement leads to early flowering. These results are in accordance with the findings of Chaudhari *et al.* (1998).

5.3.2 Effect on yield attributes

The yield attributing parameters like pods per plant, seeds per pod and test weight (Tables 10 to 12 and Fig. 6) were significantly influenced by different levels of inorganic fertilizers. Significantly higher number of pods per plant (18.76), seeds per pod (8.01) and test weight (38.21g) were recorded under the treatment F_1 (100% RDF) which was statistically at pat with the treatment F_2 (75% RDF). Both the treatments (F_1 & F_2) were found significantly superior over the treatment F_3 (50% RDF) for number of pods per plant, seeds per pod and test weight. This was largely attributed to better growth of plant which resulted in adequate supply of photosynthates for developement of sink under higher level of inorganic fertilizer. Positive response in terms of yield attributies to inorganic fertilizers have also been reported by Chaudhari *et al.* (1998), Rajkhowa et al. (2002), Yakadri *et al.* (2002), Chaudhary *et al.* (2003), Singh *et al.* (2007), Singh *et al.*, (2009), Patel *et al.* (2010) and Patil *et al.* (2011) with respect to pods per plant, seeds per pod and test weight.

5.3.3 Effect on seed and stover yields

It is evident from the results presented in Table 12 and Fig. 7 that there were significant differences in seed and stover yields of greengram due to different inorganic fertilizers. 100 per cent RDF (F_1) registered significantly higher seed (1365 kg/ha) and stover yields (3491 kg/ha) which was found statistically at par with treatment F_2 (75% RDF) with respect to stover yield only. Treatment (F_3) (50% RDF) produced the lowest seed (1079 kg/ha) and stover (3111 kg/ha) yields. The results were supported by the findings of Gandhi *et al.* (2005), Meena *et al.* (2005), Patel *et al.* (2007), Singh *et al.* (2007), Gangaiah *et al.* (2008), Acharya *et al.* (2010), Ghanshyam *et al.* (2010), Patel *et al.* (2010), Patil *et al.* (2011), Nawange *et al.* (2011) and Singh *et al.* (2011).

So far as harvest index is concerned, inorganic fertilizers treatments showed significant effect on this character. This was due to corresponding increase in both seed and stover yields. These results are akin to those reported by Chaudhari *et al.* (1998).

5.3.4 Effect on quality

The quality of greengram in terms of protein content and yield are presented in Table 14 and Fig. 8. Protein content and yield were influenced significantly due to different inorganic fertilizer treatments. Significantly higher protein content (20.27) and yield (276.69 kg/ha) was recorded under treatment F_1 (100% RDF) as compared to treatments F_2 (75% RDF) and F_3 (50% RDF). The lowest protein content and yield were recorded under treatment F_3 (50% RDF). Similar results found by Gandhi *et al.* (2005), Singh *et al.* (2007) and Chesti *et al.* (2012).

5.3.5 Effect on nutrient content and uptake

At harvesting, treatment wise, seed and stover samples were collected and analyzed for N, P and S content. Using content and yield values, uptake of these nutrients were calculated separately for seed and stover. The content of N, P and S in seed as well as in stover was not affected significantly. However, uptake of these nutrients was affected significantly due to different inorganic fertilizers (Table 16 and Fig. 9). In all these cases (seed and stover), treatment F_1 (100% RDF) showed superiority over rest of the fertilizer levels *viz.*, F_2 and F_3. This increased uptake by seed and stover might be due to increased yield of seed and stover under treatment F_1. The higher removal of N, P and S with this level might be due to better development of root and shoot with this treatment resulted in higher N, P and S uptake. These results are in accordance with the results of those reported by Garasia *et al.* (2001), Yakardi *et al.* (2004), Meena *et al.* (2005), Kumar *et al.* (2006), Thenua and Praveen

Kumar *et al.* (2007), Ghanshyam *et al.* (2010), Tanwar *et al.* (2010), Dekhane *et al.* (2011) and Chesti *et al.* (2012) with respect to N, P and S content and uptake.

5.3.6 Effect on nutrient status in soil after harvest of crop

Various levels of inorganic fertilizers significantly influenced the nutrient status of soil (Table 18) after the harvest of green gram. Significantly higher values of available nitrogen, phosphorus and sulphur were recorded with 100 per cent RDF. The favourable effect of applied phosphate on *rhizobial* activity and nitrogen fixation might be the possible reason for favourable balance of nitrogen in the soil. The available P status of the soil after green gram harvest was also improved with the addition of phosphorus and this might be due to residual effect of phosphatic fertilizer. The status of the soil after harvest was also improved and this might be due to residual effect of sulphur fertilizer. Almost similar findings were also reported by Tanwar *et al.* (2010).

5.4 Effect of biofertilizer

5.4.1 Effect on growth characters

Plant population was not significantly influenced due to different biofertilizers. At all the periodical growth stages, plant height (Table 6 and Fig. 3), number of branches per plant (Table 7 and Fig. 4) and dry matter accumulation per plant (Table 8 and Fig.5) were significantly influenced by different biofertilizers, except at 20 DAS. Significantly taller plant height was recorded by treatment B_3 (*rhizobium* + PSB) (57.14 cm) which was statistically at par with the treatment B_2 (PSB) (54.76

cm). Treatment B_1 (*rhizobium*) recorded significantly the lowest plant height (51.64 cm) in all growth stages.

Similarly, maximum number of branches per plant (Table 8 and Fig. 4) was also recorded by treatment B_3 (*rhizobium* + PSB) (3.72) which was statistically at par with the treatment B_2 (PSB) (3.53). Treatment B_1 (*rhizobium*) recorded the lowest number of branches per plant (3.22). This might be due to dual inoculation benefited the plants by providing atmospheric N and rendering the insoluble phosphorus into available form. The enhanced availability of P favoured N fixation and rate of photosynthesis and consequently led to better plant height and branches per plant. Almost similar findings were also reported by Patel and Patel (1991) and Upadhyay *et al.* (1999).

Maximum dry matter accumulation per plant was recorded by the treatment B_3 (*rhizobium* + PSB) (18.53 g) which was significantly at par with treatment B_2 (PSB) (17.62 g). Treatment B_1 (*rhizobium*) recorded the lowest dry matter accumulation per plant (16.46 g). The present results are in accordance with the results of those reported by Patel and Patel (1991), Upadhyay *et al.* (1999), Balyan *et al.* (2002), Prasad *et al.* (2002), Sharma *et al.* (2003) and Meena *et al.* (2005).

Significant difference observed due to different biofertilizer on effective root nodules per plant (Table 9) at 40 and 60 DAS. The treatment B_3 (*rhizobium* + PSB) recorded maximum number of effective root nodules plant (28.29), which was remained statistically at par with the treatment B_2 (PSB). The lowest number of root nodules were recorded under the treatment B_1 (*rhizobium*) (24.37). This might be due to more population of *rhizobium* and phosphate solubilizing bacteria and they live in root nodules, their symbiotic relationship with plants and hence number of root nodules increases ultimately with *rhizobium* + phosphate solubilizing bacteria inoculation. Almost similar findings were reported by Patel and Patel (1991), Kumpawat and Manohar (1994), Upadhyay *et al.* (1999), Hazarika *et al.* (2000), Nagarajan and Balachandar (2001), Balyan *et al.* (2002) and Prasad *et al.* (2002).

Days to 50 per cent flowering was found to be non significant due to different biofertilizer treatments.

5.4.2 Effect on yield attributes

The yield attributing parameters like pods per plant, number of seeds per pod and test weight (Tables 10 to 12 and Fig. 6) were significantly influenced by different biofertilizers. Significantly higher number of pods per plant, number of seeds per pod and test weight (18.84, 8.00 and 37.53, respectively) were registered under the treatment B_3, but it was found statistically at par with the treatment B_2 with respect to number of seeds per pod (7.82) and test weight (36.44 g) only. Significantly the lowest number of pods per plant, number of seeds per pod and test weight were recorded with the treatment B_1. The results are corroborated the findings of Meena *et al.* (2003), Thomas and Lal (2003), Nagar and Meena (2004), Singh *et al.* (2004), Elkoca *et al.* (2008) and Bhat *et al.* (2010).

5.4.3 Effect on seed and stover yields

It is evident from the results presented in Table 12 and Fig. 7 that there was significant differences in seed and stover yields of greengram due to different biofertilizers. Treatment B_3 (*rhizobium* + PSB) registered significantly higher seed (1345 kg/ha) and stover (3545 kg/ha) yields as compared to other treatments. Treatment B_1 (*rhizobium*) produced the lowest seed (1139 kg/ha) and stover (3100 kg /ha) yields. These might be due to significant and progressive effect of dual inoculation of *rhizobium* + PSB on yield attributies resulted in higher seed and stover yields. Almost similar results were also reported by Ali and Mishra (2000), Nagarajan and Balachandar (2001), Singh and Tarafdar (2001), Prasad *et al.*, (2002), Ram *et al.* (2002), Meena *et al.* (2003), Sharma *et al.* (2003), Nagar and Meena (2004), Singh *et al.* (2004), Thenua and Kumar (2007), Elkoca *et al.* (2008), Patel *et al.* (2010), Dekhane *et al.* (2011) and Sahay *et al.* (2011).

So far as harvest index is concerned, biofertilizer treatments showed significant effect on this character. This was due to corresponding increase in both seed and stover yields. These results are corroborated the findings of Singh *et al.* (2004).

5.4.4 Effect on quality

The quality of greengram in terms of protein content and yield is presented in Table 14 and Fig. 8. Protein content and yield were influenced significantly due to different biofertilizer treatments. The highest protein content (20.00) and yield (269.00 kg/ha) was recorded under treatment B_3 (*rhizobium* + PSB) which was statistically at par with the treatment B_2 (PSB) with respect to protein content (19.93%) only. The lowest protein content and yield were recorded under the treatment B_1 (*rhizobium*). These results are in accordance with the results of those reported by Kumpawat and Manohar (1994), Bhalu *et al.* (1995), Nagaraju and Nanjundappa (1996), Pawar and Pawar (1998), Reddy and

Ahlawat (1998), Meena *et al.* (2001), Singh and Tarafdar (2001), Nagar and Meena (2004).

5.4.5 Effect on nutrient content and uptake

At harvesting, treatment wise, seed and stover samples were collected and analysed for N, P and S content. Using content and yield values, uptake of these nutrients were calculated separately for seed and stover. The content of N, P and S in seed as well as in stover was not affected significantly. However, uptake of these nutrients was affected significantly due to different biofertilizers (Tables 16 and Fig. 9). In all these cases (seed and stover), treatment B_3 (*rhizobium* + PSB) showed superiority over rest of the biofertilizer treatments *viz.*, B_2 and B_1. This increased uptake by seed and stover might be due to increased yield of seed and stover under the treatment B_3. Similar results were also observed by Singh *et al.* (1994), Chauhan (2000), Balyan *et al.* (2002), Prasad *et al.* (2002), Nagar and Meena (2004), Singh *et al.* (2004), Thenua and Kumar (2007) and Sahay *et al.* (2011).

5.4.6 Effect on nutrient status in soil after harvest of crop

Nutrient status (Table 18) of soil after the harvest of green gram crop was significantly influenced due to biofertilizers. *Rhizobium* and PSB inoculation alone or in combination significantly increased available nitrogen, phosphorus and sulphur. This could be due to higher mobilization of N, P and S. This indicates that crop might not have been utilised all the available nutrients native to the soil. These findings lend support to the report of Sapatnekar *et al.* (2001), Thenua and Kumar (2007) and Sahay *et al.* (2011).

5.5 Effect on economics

The choice and adoption of any technology by the farmers are mainly guided by the economics *i.e.*, net income generated. A critical analysis of the economics was therefore essential. An economic analysis of the data revealed that variety (Table 18) V_1 (Meha) secured higher net realization (62182 ₹/ha) and BCR (5.77) while V_2 (GM-3) obtained lower net returns (53108 ₹/ha) and BCR (4.93).

Among inorganic fertilizer, F_1 (100% RDF) maintained its superiority by recording the highest net realization (63280 ₹/ha) and BCR (5.29) followed by 75% RDF (F_2). The lowest value of net realization (48806 ₹/ha) and BCR (4.29) were registered with 50% RDF (F_3). Similar results was also reported by Mishra and Misra (1995), Ambhore (2004), Patel *et al.* (2004 a), Tanwar *et al.* (2010) and Saini *et al.* (2011) with respect to higher net income and BCR.

The results (Table 19) indicated that the highest net realization (63320 ₹/ha) and BCR (5.75) were registered in treatment B_3 (*rhizobium* + PSB) followed by treatment B_2 (PSB). The lowest net realization value (52250 ₹/ha) and BCR (4.79) registered under treatment B_1 (*rhizobium*). These results corroborates with the findings of Bhalu *et al.* (1995), Patel (2003), Patel *et al.* (2010) and Patel and Patel (2010).

5.6 Interaction effect

Interaction effects of varieties, inorganic fertilizers and biofertilizers were found to be significant in almost all characters except F x B (Table 10 & 12) for number of pods per plant or seed yield of V x B for P uptake (Table 16). The maximum values number of pods per plant and seed yield were observed with the treatment combination of F_1B_3 (100 per cent RDF with dual inoculation of *rhizobium* and PSB) followed by the treatment combination F_1B_2 (100 per cent RDF with PSB inoculation), F_1B_1 (100 per cent RDF with *rhizobium* inoculation), F_2B_3 (75 per cent RDF with dual inoculation of *rhizobium* and PSB) and F_2B_2 (75 per cent RDF with PSB inoculation) indicating 25 per cent saving of inorganic fertilizer through use of dual inoculation of *rhizobium* and PSB. Almost similar findings were also reported by Srinivasan and Sivasamy (2000), Sapatnekar *et al.* (2001), Patel (2003), Pathak *et al.* (2003), Tanwar *et al.* (2003), Ghosh *et al.* (2008), Singh *et al.* (2008), Rathi. *et al.* (2009), Sammauria *et al.* (2009) and Gajbhiye *et al.* (2011) with respect to pods per plant and seed yield.

Looking to the economics of variety Meha (V_1) recorded maximum net return (₹ 75392/ha) when fertilized with the application of 100% RDF and inoculated with *rhizobium* + PSB followed by variety GM 3. The net realization of ₹ 63206 /ha was noticed under variety GM 3 under similar treatment with refer to BCR, Meha also recorded maximum value of 6.18. These results are in conformity with those reported by Beg and Singh (2009), Tanwar *et al.* (2010) and Patel *et al.* (2012) with respect to higher net income and BCR.

SUMMARY AND CONCLUSION

VI. SUMMARY AND CONCLUSION

An experiment was conducted at the College Farm, Navsari Agricultural University, Navsari on "Response of different cultivars of green gram (*Vigna radiata* L.) to integrated nutrient management under south Gujarat condition" during summer season of 2011. In all, twenty treatment combinations comprising of two varieties of green gram *viz.*, Meha (V_1) and GM 3 (V_2), three levels of inorganic fertilizers *viz.*, 100 per cent RDF (F_1), 75 per cent RDF (F_2) and 50 per cent RDF (F_3) and three treatments of biofertilizers *viz.*, *rhizobium* seed inoculation (B_1), phosphate solubilizing bacteria (PSB) seed inoculation (B_2) and *rhizobium* + PSB seed inoculation (B_3) and two additional treatments (controls) *viz.*, AT_1 – Meha with 100% RDF and AT_2 – GM 3 with 100% RDF were evaluated in factorial randomized block design with three replications. The soil of the experimental field was medium in available nitrogen and phosphorus and high for potassium. The soil was slightly alkaline in reaction. The green gram cv. Meha and GM 3 were sown on Twenty fifth February, 2011.

The results presented and discussed in preceeding chapters are summarized here.

6.1 Effect of varieties

- Variety did not affect significantly on plant population. Among the growth parameters, plant height, number of branches per plant and dry matter accumulation were significantly influenced due to varieties. Variety had non significant effect on number of root nodules. Variety V_1 (Meha) registered maximum values of plant height, number of branches and dry matter accumulation per plant. While minimum number of branches and dry matter accumulation per plant were registered in variety V_2 (GM 3).

- ❖ The yield attributing characters such as number of pods per plant and test weight were found higher number variety V_1 (Meha) as compared to variety V_2 (GM 3). However, number of seeds per pod was failed to influence significantly. Variety Meha recorded significantly the highest seed (1311 kg/ha) and stover (3706 kg/ha) yields as compared to variety GM 3.
- ❖ In general, significantly higher values of most of the yield attributing characters were registered under variety V_1 (Meha) as compared to variety V_2 (GM 3).
- ❖ Variety V_1 (Meha) registered the lowest harvest index.
- ❖ With respect to quality parameters, protein content and yield were significantly influenced by variety. Variety V_1 (Meha) registered the higher protein content and yield.
- ❖ Nutrients contents (N, P and S) in seed and stover were not significantly influenced by different varieties. However, the nutrients uptakes by seed and stover were significantly influenced by different varieties. The N, P and S uptakes by seed and stover were significantly higher under variety V_1 (Meha) as compared to the variety V_2 (GM 3).
- ❖ Higher net realization (₹ 62182/ha) was obtained with variety V_1 (Meha) and the lowest (₹ 53108/ ha) with variety V_2 (GM 3).

6.2. Effect of inorganic fertilizers

- Inorganic fertilizer had no significant effect on plant population. Inorganic fertilizer level F_1 (100% RDF) recorded appreciably higher values of almost all the growth parameters *viz.*, plant height, number of branches per plant, dry matter accumulation, number of root nodules per plant at 40, 60 DAS and at harvest except in early stage (20 DAS). However, it was statistically identical with inorganic fertilizer level F_2 (75% RDF). Significantly the lowest values were recorded under inorganic fertilizer level F_3 (50% RDF) in all the growth attributing characters.

- Yield attributing characters *viz.*, number of pods per plant, number of seeds per pod and test weight were significantly influenced by different inorganic fertilizer treatments. Significantly higher number of pods per plant, number of seeds per pod and test weight were recorded under F_1 (100% RDF) which were statistically at par with treatment F_2 (75% RDF). Significantly the lowest number of pods per plant, number of seeds per pod and test weight were recorded under the inorganic fertilizer level F_3 (50% RDF).

- Fertilizer level F_1 (100% RDF) recorded significantly the highest seed and stover yields. Both, F_1 (100% RDF) and F_2 (75% RDF) treatments obtained significantly higher seed and stover yields as compared to the treatment F_3 (50% RDF).

- Harvest index was recorded maximum under fertilizer treatment level F_1 (100% RDF) followed by treatment F_2 (75%

RDF). Significantly the lowest harvest index was recorded under F_3 (50% RDF).

- Protein content and protein yield in seed were significantly influenced by different inorganic fertilizers. Significantly higher protein content and yield was recorded under the inorganic fertilizer treatment F_1 (100% RDF) followed by the F_2 (75% RDF).

- The N, P and S contents in seed and stover were not affected significantly due to different inorganic fertilizers. However, in general, uptake of these nutrients by seed and stover was significantly the highest under treatment F_1 (100% RDF) as compared to treatments F_2 and F_1. Significantly the lowest nutrients uptakes was observed under F_3 (50% RDF).

- Inorganic fertilizers treatment F_1 (100% RDF) registered maximum net realization of ₹ 63280/ha followed by treatment F_2 (75% RDF) which accured the net realization of ₹ 58237/ha. The lowest net realization of ₹ 48806/ha was registered under F_3 treatment (50% RDF). The similar trend was also noticed for BCR values and treatment F_1, F_2 and F_3 recorded the BCR values of 5.29, 5.00 and 4.29, respectively.

6.3 Effect of biofertilizer

- Biofertilizer had no significant effect on plant population. Biofertilizer B_3 (*rhizobium* + PSB) recorded appreciably higher values of almost all the growth parameters *viz.*, plant height, number of branches per plant, dry matter accumulation (g/plant), number of root nodules per plant at 40, 60 DAS and at harvest except in early stage (20 DAS). However, it was statistically identical with biofertilizer B_2 (PSB). Significantly the lowest values were recorded under biofertilizer B_1 (*rhizobium*) in all of the growth attributing characters.

- ❖ Yield attributing characters *viz.*, number of pods per plant, number of seeds per pod and test weight were significantly influenced by different biofertilizer treatments Significantly higher number of pods per plant, number of seeds per pod and test weight were recorded under treatment B_3 (*rhizobium* + PSB) which was statistically at par with B_2 (PSB). Significantly the lowest number of pods per plant was recorded under treatment B_1 (*rhizobium*)
- ❖ Biofertilizer B_3 (*rhizobium* + PSB) recorded significantly higher seed and stover yields as compared to treatments B_2 (PSB) and B_1 (*rhizobium*).
- ❖ Harvest index was found non-significant due to different biofertilizer treatments.
- ❖ Protein content and protein yield in seed was significantly influenced by different biofertilizers. Dual inoculation of seed with *rhizobium* + PSB (B_3) recorded significantly higher protein content and yield over others.
- ❖ The N, P and S contents in seed and stover were not affected significantly due to different biofertilizers. However, in general, uptake of these nutrients by seed and stover was significantly higher under treatment B_3 (*rhizobium* + PSB). Significantly the lowest uptake was observed under the treatment B_1 (*rhizobium*).
- ❖ From the economics point of view, dual inoculation of seed with *rhizobium* + PSB (B_3) registered higher net profit (₹ 63320 /ha) which was followed by treatment PSB (B_2) (₹ 56962

/ha) and the lowest with *rhizobium* (B_1) (₹ 52250/ha). The higher BCR of 5.75 was recorded under treatment B_3.

6.4 Interaction effect

- Interaction effects of varieties, inorganic fertilizers or biofertilizers were found non significant with respect to almost all the characters studied except interaction F x B for number of pods per plant or seed yield significant V x B for P uptake. Treatment combination F_1B_3 (100 % RDF along with dual seed inoculation of *rhizobium* and PSB) recorded significantly higher number of pods per plant and seed yield followed by the treatment and combinations F_2B_3, F_1B_2, F_1B_1, F_2B_2 and F_3B_1. Treatment combination V_1B_3 (variety Meha inoculated with *rhizobium* + PSB) recorded significantly higher P uptake as compared to other treatment combination.

CONCLUSION

On the basis of results obtained in the present investigation, following conclusions could be made.

- Meha is better variety for the south Gujarat condition in summer season over cv. GM 3.
- For getting more remunerative production of greengram, crop should be fertilized with 100% RDF (20-40-0 kg NPK/ha).
- Seed inoculation of *rhizobium* and PSB is more profitable for greengram as compared to biofertilizer alone.
- Application of 100% RDF with seed inoculation of *rhizobium* and PSB found more productive and economical which closely followed by the treatment combination of F_2B_3 (75% RDF with dual inoculation of *rhizobium* and PSB) and F_2B_2 (75% RDF

with seed inoculation with PSB) indicating 25% saving of inorganic fertilizer.

FUTURE LINE OF WORK

1. This experiment need to be repeated for two or more years for valid conclusion.
2. Study should be conducted under different agro- ecological situations of the zone to make valid recommendation for farmers.
3. Other agronomic practices may be studied to maximize the yield of summer greengram.
4. Different varieties of summer greengram may be tested for maximization of yield.

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APPENDIX

Appendix I: Cost of cultivation (₹/ ha) of greengram

Sr. No.	Particulars	Cost (₹)
	(A) Fixed cost	
1.	Land preparation, layout, bund forming, opening of furrows and channels	2000
2.	Cost of greengram seed 20kg @ ₹ 50/kg	1000
3.	Application of fertilizers and sowing of seed	400
4.	Gapfilling	300
5.	Weeding and interculturing a. Two hand weedings and interculturing	2600
6.	Irrigation charges (5 irrigation @ ₹ 150/Irri.)	750
7.	Plant protection charges	1000
8.	Harvesting threshing and cleaning	2000
9.	Land revenue ₹ 50/ha /annum (4 months)	30
10,080	**Total cost**	
10.	Interest on working capital @ 12% (4 months)	400
11.	Supervision charges @ 10% of total cost (4 months)	300
10,780	**Fixed cost total**	
	(B) Rates used for cultivation and inputs	
1.	Tractor cultivation	160/hr
2.	Tractor planking	120/hr
3.	Labour charges	100/day
4.	Thiomethoxon 25% WG	2100/kg
5.	Dithane M.45	420/kg

Cont….

Sr. No.	Particulars	Cost (₹)
	(C) Variable cost	
1.	Biofertilizer	
	a. *Rhizobium*	120/kg
	b. PSB	120/kg
	c. *Rhizobium* + PSB	240/kg
2.	Cost of Nitrogen and phosphorus in the form of urea and SSP @ 44.14 kg/ha N @ ₹ 278/50 kg and 256 kg/ha P_2O_5 @ ₹ 181/50 kg, respectively	
	a. 100 per cent RDF	1172.14
	b. 75 per cent RDF	879.11
	c. 50 per cent RDF	586.07
(D) Selling rates of produce		
	a. Greengram seed	50/kg
	b. Greengram stover	2/kg

CERTIFICATE

This to certify that I have no objection for supplying to any scientist only one copy or any part of this thesis at a time through reprographic process, if necessary for rendering reference services in a library or documentation centre.

Place: Navsari

Date: 19 July, 2012

(Patel R. D.)