ORGANIC NUTRIENT MANAGEMENT IN CLUSTER BEAN (*Cyamopsis tetragonoloba* L. Taub)

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
in partial fulfilment of the requirement
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MASTER OF SCIENCE
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(VEGETABLE SCIENCE)

By
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DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the Thesis entitled “**ORGANIC NUTRIENT MANAGEMENT IN CLUSTER BEAN (*Cyamopsis tetragonoloba* L. Taub)*”***or part thereof has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis/ publication of any University or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

Place: Akola **(BANTE PAYAL BHOJRAJ)**

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CERTIFICATE

This is to certify that, the thesis entitled **"ORGANIC NUTRIENT MANAGEMENT IN CLUSTER BEAN (*Cyamopsis tetragonoloba* L. Taub)"**submitted in partial fulfilment of the requirements for the degree of **"Master of science in Horticulture (Vegetable Science)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **BANTE PAYAL BHOJRAJ** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

Place: Akola
Date: / /2019

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Place : Akola **(BANTE PAYAL BHOJRAJ)**

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D) Abbreviations

%	-	Percentage
/	-	Per
°C	-	Degree Celcius
Anon.	-	Anonymous
$acre^{-1}$	-	Per acre
B:C ratio	-	Benifitn Cost ratio
c.f.	-	Cited from
CD at 5%	-	Critical difference
Cm^2	-	Days after planting
Cv.	-	Cultivar
DAP	-	Days after planting
day^{-1}	-	Per day
e.g.	-	Exampli gratia (for example)
et al.	-	Et alia (and others)
etc.	-	Etcetera
Fig.	-	Figure
FYM	-	Farm Yard Manure
G	-	Gram (s)
ha^{-1}	-	Per hectare
Hr	-	Hours
Hw	-	Hand weeding
i.e	-	That is
Kg.	-	Kilogram
M^2	-	Square meter
Max.	-	Maximum
Mg	-	Miligram
Min	-	Minimum
Ml	-	Milliliter

MW	-	Meterological week
No.	-	Number
NS	-	Non Significant
Plant $^{-1}$	-	Per plant
plot^{-1}	-	Per plot
Ppm	-	Parts Per Million
PSB	-	Phosphorus Solublising Bacteria
RBD	-	Randomized Block Design
RDF	-	Recommended Dose of Fertilizer
Q	-	Quintal
RH	-	Relative Humidity
Rs.	-	Rupees
SE (m)±	-	Standerd mean error
Sig.	-	Significant
T	-	Ton (s)
Vc	-	Vermicompost
Viz.,	-	Vide licet (namely)
WS	-	Wind Speed

E) THESIS ABSTRACT

a)	**Title of the thesis**	**:**	**“ORGANIC NUTRIENT MANAGEMENT IN CLUSTER BEAN (*Cyamopsis tetragonoloba* L. Taub)**
b)	**Full name of student**	**:**	**Bante Payal Bhojraj**
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ABSTRACT

An experiment entitled “Organic nutrient management in cluster bean (*Cyamopsis tetragonoloba* L. Taub)” was carried out during *summer* season of 2018, at Instructional farm, Department of vegetable science, Faculty of Horticulture, Dr. PDKV, Akola. The experiment was laid out in a Randomize block design (RBD) with three replications and twelve treatments. Data on growth (plant height, number of leaves, number of

branches and leaf area), pod yield (pod yield plant^{-1}) and, its attributes (pod clusters^{-1}, clusters plant^{-1}, pods plant^{-1}, length and width of pod) and pod quality (protein content %) were recorded.

Morphological characters like plant height, number of leaves plant^{-1} at all stages of growth were found significantly increased with the application of 100% RDF through (25:50:50kg NPK ha^{-1}) + Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10g kg^{-1} of seed inoculation) treatment T_{11} over other treatments. Whereas, treatment T_{12} i.e. application of Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) has recorded poor growth at all the crop stages over other treatments. Plants that received 100% RDF through (25:50:50kg NPK ha^{-1}) + Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) also showed early flowering, as well as significantly highest pod yield (54.86 q ha^{-1}), while T_{12} i.e. application of biofertilizers only, recorded lower pod yield (39.38 q ha^{-1}) while, maximum number of pods (84.77 pods plant^{-1}), weight of pods (74.01 g) and highest protein content (22.50 %).observed in treatment $T_{11.}$

Significantly maximum nitrogen, phosphorus and potassium status in soil after harvest and uptake by plant was found in application of 100% RDF through (25:50:50kg NPK ha^{-1}) + Rhizobium (25g kg^{-1} of seed inoculation) + PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) treatment T_{11}.

Highest net returns (RS 66557) and highest B:C ratio (2.54) was recorded with the application of 100% RDF through (25:50:50kg NPK ha^{-1}) + Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) due to highest yield and found to be most remunerative as per the B:C ratio.

These results are, however based on single season data and therefore needs repetition over more seasons is required for confirmation.

CHAPTER I

INTRODUCTION

Vegetables are called as protective food as their consumption can prevent several diseases. Vegetables are richest and cheapest source of carbohydrates, proteins, fats, vitamins and minerals which the human body needs to maintain good health. According to dietitians, an individual should consume about 300 g of vegetables daily as a balanced diet which includes 125 g of green leafy vegetables, 100 g of roots and 75 g of other vegetables (Salaria. 2009).

India is the second largest producer of vegetables in the world. The area under vegetable crops in India is 10.3 million ha, with the production of 175 MT and productivity is 17.01 MT ha^{-1}. The area under vegetable crops in Maharashtra is about 693.15 thousand ha, production of 10360.76 MT and productivity 14.7 metric tons ha^{-1}. (Anon. 2016).

1.1Background information

Cluster bean *(Cyamopsis tetragonoloba* (L.) Taub*)* commonly known as 'guar' is one of the important leguminous vegetable belonging to Family Fabaceae. The diploid chromosome number is 2n=14. India is considered to be the centre of origin for cluster bean. It is grown for seed, green vegetable, fodder, green manuring crop in arid and semi arid regions, Its green and tender pods are cooked and consumed as vegetable, which is also known for cheap source of protein (3.2 g), moisture (81), energy (16 Kcal), fat (1.4 g), carbohydrates (10.8 g), vitamins A (65.3 IU), vitamin C (49 mg), Calcium (57 mg) and Iron (4.5mg) present in 100 g of edible portion (Kumar and Singh 2002). Besides using pods as vegetable, cluster bean has been also recognized as a good source of gum which is found in endosperm of the seeds. An extraction of galactomannan gum is used as binding agent in many industries, chiefly textile. It is used as a stabilizer and thickener of cheese cream and ice cream.

It is very hardy and drought tolerant crop. Its deep penetrating roots enable the plant to utilize available moisture more efficiently and thus offer better scope for rainfed cropping. The crop also survives even at moderate saline and alkaline conditions. There is no other legume crop so hardy and drought tolerant as cluster bean (Kherawat *et al.* 2013).Cluster bean can grown in diverse range of environmental conditions due to its drought tolerance capacity. As a dual purpose (food and feed) legume, it can be grown as a monocrop or in intercrop systems. In India cluster bean is mostly cultivated to a large extent in states viz., Rajasthan, Gujarat, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, Tamil Nadu, Maharashtra, Karnataka and Andhra Pradesh. Due to its hardy nature, it is popular vegetable crop grown in summer season.

In India the acreage might be slightly above 3 million hectares in 2011 compared to 2.6 million hectares recorded in 2010. Global production during 2013-14 as 3 million metric tons while total production in 2013 was 2.7 million metric tons. According to data during 2005-06, the area under cluster bean in Maharashtra was only 4671 hectare with production of 19735 tones having productivity of 4225 MT ha^{-1}. Beed district was having maximum area of 865 hectare under cultivation. Pune ranks first in production (3693 tones) and Kolhapur having greatest productivity of 16.2MT ha^{-1}. Whereas in Vidarbha, about 1551 ha area was under cluster bean cultivation with total production of 6128 tones having productivity of 3.951 MT ha^{-1}.Particularly in Akola district, area under cluster bean was only 218 ha with production of 466 tones and productivity of 2.138 MT ha^{-1} (Late,2007).

This legume is very valuable plant within a crop rotation cycle as it gives in symbiosis with nitrogen fixing bacteria. Cluster bean is one of the soil improving crop which contain the nitrogen fixing bacteria *Rhizobium japonica* on its root nodules, which adds about 50-150 kg nitrogen ha^{-1} by mechanism of nitrogen fixation in soil (Mal,1969).Due to vigorous growth, it quickly provides the canopy over the land which prevent erosion and thus conserves the soil from the action of wind and rain. The green foliage adds considerable quantity of organic matter, thus the cluster bean is a crop of high biological value. The growth, yield and quality of crop are largely influenced by the fertility status of the soil. Therefore, altering the soil nutrients and fertility status by providing balanced and adequate nutrients as per the crop requirement is one of the way to boost the crop productivity of cluster bean. Being a legume crop it has the capacity to fix atmospheric nitrogen by its effective root nodules the major part of nitrogen is met through *Rhizobium* present in the root nodules. It can fix approximately 37-196 kg atmospheric nitrogen per hectare per year in soil. Sometimes it is used in reclamation of saline and alkaline soils. (Mahata *et al*., 2009).

Organic manures are the important constituents of the plant nutrient management system. FYM, vermicompost and neem cake provide nutrients to the plant with beneficial effects on physiochemical biological properties of soil. According to Roy and Singh (2006), the use of vermicompost is being advocated for sustaining soil fertility in various field crops. Use of organic manures to meet the nutrient requirement of crop would be an inevitable practice in the years to come for sustainable agriculture since, organic manures generally improve the soil physical, chemical and biological properties along with conserving the moisture holding capacity of soil and thus resulting in enhanced crop productivity along with maintaining the quality of crop produce (Maheswarappa *et al*., 1999). Although the organic manures contain plant nutrients in small quantities as compared to the fertilizers, the presence of growth promoting principles like enzymes and hormones, besides plant nutrients make them essential for improvement of soil fertility and productivity (Bhuma, 2001). Further the sustainability in agriculture production refers to the capacity to remain productive while maintaining the soil fertility and increasing biodiversity, use of manures and biologically active preparations of animal and plant origin is most commonly used by those farmers who aim for sustainable production.

To meet the demand of qualitative higher production some chemical fertilizers are repeatedly used. It leads to the hazardous effects on human health and environment. Biofertilizers mainly *Rhizobium* and PSB and organic manures like fym, vermicompost, neem cake which are commonly used, have an enormous potential to increase the nutrient use efficiency. Application of organic manure in combination with biofertilizers for increasing growth and yield of cluster bean.

1.2 Importance and need of study

Inspite of huge potential, the cluster bean is being cultivated in limited area due to its low productivity levels and can be attributed mainly due to inadequate fertilization. Intensive crop cultivation requires use of chemical fertilizers, but continuous use of inorganic fertilizers may adversely affect the soil health there by lowering productivity levels. Moreover price of chemical fertilizers has gone up considerably and resulted increase in cost of production. The timely availability of chemical fertilizers has also overcome major constraints. Whereas; use of organic manures exclusively may not result in the sustained yields as well as economic returns because of their low nutrient content, slow nutrient releasing nature. Improved varities requires higher amount of nutrients to reap higher yields, but continuous usage of chemical fertilizers without any or little addition of organic manures may not sustain soil fertility, further they show their ill effects on environment. It has become necessary to minimize the use of chemical fertilizers by addition of organic manures and biofertilizers of microbial origin (Subbiah *et al*,1982 and Dart, 1986).In such conditions, organic nutrient sources along with biofertilizers seems to be a viable alternative method to produce higher yields in cluster bean with acceptable quality. Biofertilizers are eco-friendly, low cost, easy origin and easy to use. Biofertilizer application have shown good results in case of leguminous crops (Ganie *et.al*. 2009). It may increase yield of crops by 10-30 percent (Khandelwal *et.al*. 2012)

Organic manures have been reported to play a vital role in the nutrient management of crops through amelioration of physical and biological conditions of soil and supply macro and micronutrients to the crops (Sarkar and Rattan, 1995). Response of cluster bean to organic manures has been studied by several workers and significant increase in the pod yield have been reported with the application of organic manures in combination with biofertilizers (Patel *et al,* 2018).Biofertilizers, which are formulated cultures of microorganisms, play an important role in sustaining productivity of soil through biological N_2 fixation and enhancing native P availability to crops. Biofertilizers and organic manures together can make significant contribution in maintaining soil health and balancing soil fertility through supply of plant nutrients at an optimum level (Swaminathan, 1992).

Biofertilizer is a substance which contains living organisms which applied to seed, plant surface or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plants. Phosphorus deficiency is common nutritional problem in crop production. A large portion of inorganic phosphates applied to soil as fertilizer is rapidly fixed after application and becomes unavailable to plants. Seed or soil inoculation with PSB is known to improve solublization of fixed soil phosphorus and so applied phosphates results in improvement of plant growth and higher yield. Bio-fertilizers are economically cheaper and work as ecofriendly.

With the use of chemical fertilizer resulted in the search of alternative nutrient source for the crops through organic manures and fertilizers of biological origin (bio-fertilizers).The benefits of integration of organic, nutrient sources in combination with bio fertilizers are well known in other vegetables and same information is lacking in cluster bean. Being a legume crop, cluster bean can response better to fertilizers for making the major as well as micronutrient in available form.

1.3 Objective of Study

The present study was conducted to find out the effect of organic nutrient management on yield and quality of the cluster bean. In view of above, a field experiment was planned in summer season with following objectives.

Objectives:

1) To study the effect of different source of organic manures alone or in combination with biofertilizers on growth, yield and quality of cluster bean.
2) To find out the suitable combinations of organic sources of nutrients alone or with biofertilizers for higher yield, better quality of cluster bean.

1.4 Hypothesis

It is well realized that to safeguard the soil health and productivity a manure nutrient usages are essential. The supplementary and complimentary use of FYM, vermicompost and neem cake may augment the efficiency of all the manure to maintain a high level of soil productivity and production. Organic manures supplies some nutrients for plants and the carbon containing compounds are food for soil flora and fauna. This manure improves aeration and encourage good root growth by providing enough spores in the rhizosphere. For optimum productivity and good soil health, it is essential that suitable packages be identified and developed with judicious utilization of biofertilizers, and organic manures.

The sole use of inorganic fertilizers depleted the natural resources. Excessive application of these fertilizers not only pollute underground water but also produce some undesirable chemicals through processes like, volatilization, denitrification, etc., thereby causing various diseases in plants and animals and also play a role in destroying the productive ozone layer in atmosphere. Organic manures also useful in improving soil properties such as water holding capacity (Rupela *et al*.2006).

Continuous addition of chemical fertilizers yields a bumper crop but, posses' problems like toxicity due to high amount of salt as residue of fertilizers, deterioration of physical properties of soil, importing aeration and soil water relationship which result in decrease productivity. so the combine use of organic manure and bio-fertilizer is essential to make optimum use of each type of fertilizers and achieve balanced nutrient management for crop growth on various parameters *viz.,* nodulation, plant dry weight, microbial count, pod yield and nutrient uptake in plant decreases soil pollution ,improve soil fertility and result in better crop production.

Productivity of cluster bean can be improved through the use of organic nutrients and biofertilizers as balanced and efficient fertilizers application is essential for increasing the yield and for replenishment of large removal of soil nutrients. Organic nutrient management systems include use of organic fertilizers along with biofertiolizers. The basic principle of organic nutrient management is to maintenance of soil fertility, sustaining agricultural production, profitability through judicious and efficient use of organic manures and biofertilizers with RDF.

1.5 Scope and Limitations

Keeping in view the various nutritional and medicinal values of cluster bean the present experiment was designed to study the organic nutrient management in cluster bean. During summer, the avaibility of green vegetables is limited, cluster bean can luxuriously grow, provide fresh produce to consumer as well as gives a good economic return to grower. Though irrigation requirement for cluster bean is less but unavailability of irrigation resource bound limitation for cluster bean cultivation in summer season.

Biofertilizers and organic fertilizers comparatively low in nutrient content, so larger volume is needed to provide enough nutrients for crop growth. This can be mitigated by on farm production of organic manures *viz.,* fym, vermicompost, slurry which will ensure availability of inputs and will also minimize the cost of production. The nutrient release rate is too slow to meet crop requirements in short time, hence some nutrient deficiency may occur. The major plant nutrients may not exists in organic fertilizer in sufficient quantity to sustain maximum crop growth.

CHAPTER II

REVIEW OF LITERATURE

The experiment entitled "Organic nutrient management in cluster bean (*Cyamopsis tetragonoloba* (L). Taub)", was carried out during *summer* season of the year 2018, at Instructional farm, Department of Vegetable Science, Faculty of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

In the past, attempts have been made to find out response of organic fertilizers for various beans by number of investigators; however cluster bean got very little attention. The work done by different workers revealed on various aspects of this research topic is briefly reviewed in this chapter under appropriate headings and subheading.

2.1 Effect of organic fertilizers on growth, yield and yield attributes:

2.1.1 *Rhizobium*

Taneja *et al*. (1981) revealed that, seed treatment with *Rhizobioum* culture resulted in increase in the protein content in cluster bean.

Raut and Ali (1983) stated that, *Rhizobium* inoculation significantly increased the number of pods per plant and seed yield in cluster bean.

Kumavat and Khangarot (2002) reported that, application of *Rhizobium* inoculation in cluster bean significantly increased the seed yield over control.

Meena *et al.* (2002) conducted a field experiment with phosphorous and biofertilizers (*Rhizobium* and PSB) on cluster bean and reported that, seed inoculation with Rhizobium, PSB and *Rhizobium*+PSB significantly enhanced seed straw yields.

Rathod *et al.* (2004) carried out an experiment with sole and integrated application of nutrients to cluster bean with inoculation of *Rhizobium*, phosphate solubilizing bacteria and *Rhizobium* +PSB and observed increase in growth and yield.

Sammauria *et al*. (2009) conducted experiment to assess the effect of *Rhizobium* and phosphorous solubilizing bacteria (PSB) and noticed that the combined inoculation of *Rhizobium* and PSB was more promising from productivity and profitability point of view as compared to their sole inoculation.

Ibrahim *et al.* (2010) reported that, the *Bradyrhizobium* strains significantly increased plant height, number of fruiting branches per plant and number pods per plant in cluster bean.

Chairman and Singh (2011) found that, the efficiancy of *Rhizobium* spp., Azotobacter spp. and Azospirillum spp., present in the bioniculum had increased the various growth parameters in *Cyamopsis tetragonoloba* and capsicum annum.

Vidhale *et al.* (2012) revealed that, significantly highest growth and yield over control were observed with *Rhizobium* inoculation in cluster bean.

2.1.2 Other vegetables

Rahate (1985) reported that, *Rhizobium* inoculation significantly increased the yield of green pods plant^{-1} over control in cowpea.

Ramchandra *et al*. (1987) stated that, the response of *Rhizobium* culture showed significantly increase in number of pods plant^{-1} and finally in yield of French bean.

Prasad and Maurya (1989) found that, *Rhizobium* inoculation significantly increase the plant height, fresh and dry weight of plants and pod yield of garden pea.

Solaiappan and Ramiah (1990) observed, seed treatment with *Rhizobium* resulted in higher pod number and pod weight per plant as well as higher grain yield in pigeonpea over control.

Prasad and Prasad (1993) noticed that, inoculation of seed with *Rhizobium* increased plant height, no. of leaves plant^{-1} in french bean.

Krishna *et al*. (1995) reported that, *Rhizobium* inoculation significantly increased the growth characters and yield of soybean over uninoculated.

Mishra and Solanki (1996) studied that, in cowpea the starter dose of 20 kg N ha^{-1} *Rhizobium* inoculation increased the height of plant, number of branches $plant^{-}$1, number of pods $plant^{-1}$, yield ha^{-1} and dry matter significantly.

Hazarika *et al.* (2000) revealed that, seed inoculation with *Rhizobium* alone or dual inoculation of VAM fungi + *Rhizobium* significantly increased nodulation over uninoculated in green gram crop.

Singh and Tarfdar (2001) observed 14 % increase in yield of mung bean crop var. T-44 due to inoculation of *Rhizobium* over control.

Arunkumar and Chandrayan (2002) reported that, inoculation of *Rhizobium* and PSB with pseudomonas, P solublizer and VAM enhance the plant growth and yield in many legume crops.

De *et al*. (2006) conducted an experiment in vegetable pea cultivars with biofertilizers i.e. *Rhizobium* + press mud + Azotobactor + PSB which resulted in higher plant height, fresh root, root weight, pod yield and seed yield.

Sajitha *et al.* (2007) carried out an experiment on garden bean cv. Konkan Bhushan with application of *Rhizobium*, VAM, vermicompost and vermiwash, alone and in co-inoculation results in highest yield, highest fibre, highest protein, provide all nutrients in available form.

Patel (2012) stated that, *Rhizobium* + PSB +KSB inoculation was the best for all the growth characters of green gram.

Ganie *et al.* (2009) conducted an experiment on garden pea with biofertilizer like Azotobacter, *Rhizobium* and PSM alone or in combination and they found that, maximum plant height, minimum days to flowering, maximum fresh weight of nodules, maximum pod length, number of pods $plant^{-1}$, were recorded with co-inoculation treatment.

Khan *et al.* (2015) reported that, seed inoculation to cowpea with *Rhizobium* + PSB significantly increased total and effective nodules plant^{-1} over control.

2.1.3 Phosphorus Solubilizing Bacteria

Raut and Ali (1983) reveled that, phosphate application significantly increased number of branches per plant. Number of pods plant^{-1} was significantly influenced with phosphate fertilization as well as seed inoculation in cluster bean.

Nagar and Meena (2004) found that, the inoculation of cluster bean seed with PSB culture significantly increased the pods plant^{-1}, length of pod, seeds pod^{-1} and protein content.

Prajapati (2000) noted that, an increase in the plant height by inoculation of seeds with PSB in vegetable cluster bean.

Dadhich *et al.* (2001) observed that, seed inoculation with PSB improved the N, P and gum content in seed of cluster bean over no inoculation.

Meena *et al*. (2002) in an experiment conducted at Jobner observed that, seed inoculation with PSB significantly increased pods per plant, seed pod^{-1}, pod length and test weight of cluster bean over no inoculation.

Rathore *et al.* (2004) reported that, inoculation of Rhizobium, PSB and Rhizobium + PSB recorded higher plant height and dry matter accumulation than control in cluster bean.

Sammauria *et al*. (2009) revealed that, yield attributes and yield increased significantly due to inoculation of cluster bean with biofertilizers. Combined inoculation of *Rhizobium* and PSB was, more promising from productivity and profitability point of view as compared to their sole inoculation.

Anuradha *et al.* (2017) observed maximum plant height recorded in treatment with the application of 75% recommended dose of fertilizers+ PSB + Zinc, It also significantly increased the plant height and number of branches plant^{-1}.

2.1.4 Other vegetables

Pawar and Pawar (1998) reported that, seed inoculation with ‘P’ solublizer produced significantly higher seed and stick yields and protein content in pigeonpea.

Shivran *et al*. (2000) found that, the inoculation of pigeon pea seed with phosphate solublising bacteria numerically increased plant height, number of branches plant^{-1}.

Bothe *et al*. (2001) observed that, seed inoculation with P solublizer culture significantly increased the growth, yield and dry matter over inoculated in soybean.

Ramna *et al*. (2010) noticed that, effect of VAM and PSB in french bean significantly increased in plant height, number of branches per plant, leaf area (cm^2) and test weight of plant.

2.2 Effect of organic manure on Growth, yield and Quality of Cluster bean

2.2.1 FYM

Vijay Kumar and Balsubhramaniyan (1990) evaluated the effect of organic manures on cluster bean varities. They reported that, manuring of prepared with a manure of 25 t ha^{-1} FYM Guar- 80 was found the tallest height and gave more branches plant^{-1} in cluster bean cv. Pusa Navbahar.

Tarafdar and Rao (2001) revealed that, yield of cluster bean increased, and soil fertility was also improved by inoculation or with the application of FYM.

Gomma and Mohammad (2007) concluded that, application of FYM in combination of rhizobium resulted in increase in number of pods plant^{-1} and number of seeds pod^{-1},

Baviskar *et al*. (2010) reported that, application of biocompost @ 5 tons’ ha^{-1} has significantly increased green pod yield and protein yield in cluster bean.

Rawat and Upma (2008) revealed that, combine application of FYM @ 5 t ha^{-1} with inoculation of PSB recorded the maximum number of branches in cluster bean.

Patel *et al*. (2017) observed that, significant increase in plant height, number of clusters plant^{-1}, number of pods cluster^{-1}, length of green pods cluster^{-1} by the application of FYM @ 5 t ha^{-1} in cluster bean.

Ramavat and Yadav (2017) recorded that, application of farm yard manure + *Rhizobium* + pseudomonas fluorescence yielded maximum plant height, number of branches, number of leaves and number of clusters plant^{-1}.

Patel *et al*, (2018) studied that, application of FYM @ 5 t ha^{-1}+ Rhizobium culture @ 20ml kg^{-1} seed + PSB @ 20ml kg-1 seed + KSB @ 20 ml kg^{-1} seed recorded significantly highest number of cluster plant^{-1}, number of pod cluster^{-1},length of green pod, green pod kg $^{-1}$, green pod kg^{-1}.

2.2.2 Other vegetables

Batra *et al*. (1992) reported that, the soil nitrogenous activities were increased with the application of FYM in french bean.

Sharma and Mishra (1997) stated that, application of 6 t FYM ha^{-1} significantly increased plant height, leaf area and number of nodule plant^{-1} there was also increased protein content and protein yield of soybean.

Kundu *et al*. (1998) observed that, FYM application @ 4,8 and 16 t ha^{-1} significantly increased the seed yield of soybean by 37.2%, 6.9% and 64.5% respectively over control.

Tomar (1998) reported that, application of FYM @ 5 t. ha^{-1} combined with PSB @ 10g kg^{-1} seed gave maximum grain and straw yield of black gram.

Sharma and Namdeo (1999) stated that, FYM played indirect role in increasing the number of root nodules plant $^{-1}$. Application of FYM @ 5 t. ha^{-1} produced significantly higher number of root nodules plant^{-1} over control.

Reddy and Swamy (2000) found that, application of FYM @10 t. ha^{-1} increased the number of pods per plant and seed yield of mung bean by 9.2 and 6.5 percent respectively.

Lakhpale *et al*. (2003) observed significant increase in number of branches $plant^{-1}$ chick pea when they applied 2.5 t FYM ha^{-1} over no FYM application in Vertisol.

Kumar *et al*. (2004) stated that, application of 50 t FYM ha^{-1} recorded the highest plant height, no of pods, weight of pods $plant^{-1}$, length of pod in french bean.

Dhaliwal *et al*. (2007) reported that, application of FYM significantly increased the yield and yield attributes of green gram over control.

Sharma *et al*. (2009) recorded that, application of FYM @ 5 t. ha^{-1} combine with 50% and 100% RDF increased in the yield of pigeon pea over untreated.

Shinde *et al*. (2009) studied that, application of FYM @ 5 t. ha^{-1} combine with 100% RDF significantly increased the number of seeds and pods $plant^{-1}$, weight of pods $plant^{-1}$, test weight and yield of soybean over control.

Sharma and Abraham (2010) revealed that, the plant height, pods $plant^{-1}$, seeds pod^{-1}, seed and Stover yield of black gram were significantly higher with the application of FYM @ 10 t ha^{-1} over no FYM application.

Jat *et al*. (2012) concluded that, application of FYM @ 5 t ha^{-1} significantly increased the yield attributes and yield of green gram over no application of FYM.

2.2.3 Vermicompost

Sivakumar *et al*. (2007) reported that, application of 50% vermicompost + 50% RDF recorded maximum N uptake in cluster bean.

Reddy *et al*. (2012) revealed that, application of 75% of RDF in combination with 25% RDF through Vermicompost + Biofertilizers increased the pod length and diameter in cluster bean.

2.2.4 Other vegetables

Bhide *et al*. (1993) revealed that, the benefits derived from the regular use of vermicompost to the various crops for obtaining increase in yield, lusture, colour, taste and keeping quality.

Bachhav and Sabale (1996) found that, seed yield and protein content of soybean increased significantly due to application of 50% RDF+ 50% vermicompost.

Karmegan and Daniel (2000) reported that, fresh and dry weight and yield of cowpea was greatest in soil amended with vermicompost.

Thanunathan *et al*. (2002) recorded higher growth, nodulation and yield values when vermicompost was applied at 12.5 t ha^{-1} and 750 kg ha^{-1} in enriched form in soybean.

Mathur *et al*. (2003) revealed that, application of vermicompost recorded significantly higher number of pods in mungbean.

Rajkhowa *et al*. (2003) observed that, application of vermicompost @ 2.5 t ha^{-1} significantly increased in number of pods $plant^{-1}$ and number of seeds in green gram.

Maho and Yadav (2005) stated that, soil application of vermicompost (25.0 q ha^{-1}) and DAP (100 kg ha^{-1}) as basal dose and foliar spray with vermiwash (10.0%) in pea has significantly increased the number of $pods^{-1}$ and fresh yield of green seeds $plant^{-1}$.

Chauhan *et al*. (2010) reported that, sowing of pea with the application of vermicompost @10t ha^{-1} and NPK @ 25:60:50 kg ha^{-1} was found most effective to best growth of pea crop.

Singh *et al*. (2011) observed that, the shoot growth traits, namely shoot length, number of primary branches, shoot fresh weight and shoot dry weight in french bean were increased by 28-63% through application of N, P_2O_5, K_2O 8:13:10 kg ha^{-1} + vermicompost. 3.75 t. ha^{-1} and by 5-50% in organic mulching treatments.

2.2.5 Neem cake

Kumar *et al*. (1997) reported that, application of neem cake significantly increased plant height, number of leaves and number of branches $plant^{-1}$ in tomato.

Rao and Shrinivas (2001) recorded highest leaf number, leaf area in brinjal when applied with combination of organic manures like neem cake.

Pandey *et al*. (2005) noticed that, application of neem cake gave higher growth, number of root nodules and decreased the nematode population in chickpea.

Rajsekharan *et. al.* (2011) stated that, combined inoculation of biofertilizer with neem cake resulted in increasing the number of branches, number of seeds pod^{-1}, pod length and protein content in black gram.

Rajesh and Arun (2017) observed that, the highest plant height, maximum number of branches, with application of 100% FYM: PSB + 100% Neem cake in field pea.

Ramavat and Yadav (2017) revealed that, by the application of neem cake+ *Rhizobium*+ PS maximum number of pods $plant^{-1}$, pod yield $plot^{-1}$, and pod yield ha^{-1}.

2.3 Effect of inorganic fertilizers on Growth, yield and quality of cluster bean

Kumavat and Khangarot (2002) noted the effect of phosphorus at the rate of 60 kg ha^{-1} as increase in height of plant, and number of branches $plant^{-1}$ in cluster bean crop.

Gomma and Mohamed (2007) observed that, the application of 20:30:30 kg NPK ha^{-1} increase the plant height, number of branches $plant^{-1}$ and protein content.

Patil *et al.* (1995) noticed that in the lablab bean cv. Konkan Bhushan the application of nitrogen @ 75 kg and phosphorous @ 50 kg ha^{-1} increased in plant height, number of branches $plant^{-1}$, number of pods plant. $^{-1}$

Kalmani *et al*. (2002) found that, in french bean plant height, number of branches plant^{-1} was increased at fertilizer level of 80:75:30 kg $^{-1}$.

Ilhe *et al*. (2007) observed that, the application of 50:40:40 kg NPK ha^{-1} improved the plant height, number of pods plant^{-1} in vegetable pea.

Merwade *et al*. (2008) reported that, significantly increase in plant height, number of branches plant^{-1}, highest seed yield, less days required to 50% flowering at fertilizer rate of 33:67:33 kg NPK ha^{-1} in lablab bean.

2.4 Effect of organic fertilizers on uptake of nutrients

2.3.1 Cluster bean

Meena *et al*. (2002) noted that seed inoculation with *Rhizobium* + PSB significantly increased the N and P uptake in cluster bean.

Prajapati *et al*. (2000) reported increase in residual N_2O, P_2O_5 and K_2O after harvest by combined application of Phosphorus and PSB in vegetable cluster bean cv. Pusa Navbahar.

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

2.3.2 Other vegetables

Rao and Dart (1980) during their experiment on pigeon pea at Dharwad (Karnataka) found that application of FYM significantly increased the N and P uptake in pigeon pea.

Sharma and Mishra (1997) observed that, uptake of N, P and K by the crop were increased with the 6 tones FYM ha^{-1} as compared to control in soya bean.

Kundu *et al*. (1998) revealed that, the total uptake by seed and straw of soya bean were significantly increased by application of 5 t ha^{-1} of fym over control.

Parmar and Sharma (1985) found that, in vegetable pea the application of FYM significantly increased that N and P uptake in the Alfisol and Vertisol soil.

Patil (2000) found that, application of 5 tonnes FYM ha^{-1} significantly increased N_2O, P_2O_5 and K_2O content in grain and straw and available form in the soil after the harvest of the crop in pigeon pea.

Prasad *et al*. (2002) observed that, *Rhizobium* inoculants significantly increased N and P uptake in black gram over control.

Thenua and Kumar (2007) observed that, combined inoculation of *Rhizobium* + PSB on green gram var. type 9 recorded significantly higher N, P and K uptake over other treatments in an experiment conducted to study the effect of biofertilizers on performance of black gram.

Ghanshyam *et al*. (2010) an application of Vermicompost 5 t ha^{-1} being at par with FYM 5 t ha^{-1} and significantly enhanced the total N, P and K uptake by green gram crop over no organic manure.

Nawlakhe and Mankar (2011) recorded higher total nitrogen uptake with application of FYM (5 t ha^{-1}) in green gram over control.

Khandelwal *et al*. (2012) stated that, PSB + *Rhizobium* significantly enhanced N, P content and total N, P uptake over control in cowpea.

Singh *et al*. (2013) revealed that seed inoculation with *Rhizobium* + PSB inoculation resulted in significantly higher N and P uptake over *Rhizobium* alone and uninoculation in pigeon pea.

CHAPTER III

MATERIAL AND METHODS

The present study entitled "Organic nutrient management in cluster bean (*Cyamopsis teragonoloba* (L). Taub.)," was conducted during year 2018-19. The details of the material used, and methods adopted during the course of present investigation are presented in this chapter under appropriate headings.

3.1 Experimental site

The experiment entitled "Organic nutrient management in (*Cyamopsis teragonoloba* (L). Taub)," was carried out at Instructional farm, Department of Vegetable science, Faculty of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *summer* season of 2018-19.

3.2 Climate and weather condition

Akola is situated in 22^0. 42^1 N latitude and 77^0 02^1E longitude at an attitude of 307.42 m above mean sea level. The climate of Akola is semi arid and characterized by three distinct season i.e. hot and dry summer from March to May, warm humid and rainy monsoon from June to October and mild cold winter from November to February. The meteorological data in respect of rainfall, humidity, maximum and minimum temperature for the period of experimentation recorded at department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola in 2018 and is presented in Annexure I.

3.3 Soil

The land used under the experiment layout was fairly uniform with gentle slope. The soil was medium black with uniform in texture, colour and having good drainage. Before laying out the experiment, initial soil samples were drawn at five randomly selected spots at a depth of 0-30 cm from the field and the composite samples were analyzed for physical and chemical characteristics as per the method suggested against each parameter.

Table 1. Physical analysis of the experimental soil

Ingredient	Quantity (%)
Sand	17.2
Silt	21.7
Clay	60.9

Table 2. Chemical analysis of the experimental soil

Chemical ingredient	Quantity (Kg ha^{-1})	Method adopted
Available Nitrogen	188.16	Alkaline permagnate method (Subbaiah and Asija,1956)
Available phosphorous	17.85	Olsen's method (Olsen *et al.*,1954)
Available potassium	349.44	Flame photometer method (Jackson,1967)

Cropping history of experimental plot

The field was kept barren for a year without cultivating of any crop.

3.4 Materials

3.4.1 Crop cultivar

The cluster bean cv. Phule Guar used for study was developed by Mahatma Phule Krishi Vidyapeeth, Rahuri. Its plant height is 74-90 cm, medium tall, profusely branched leaves pubescent and with serrated leaf margin, broad leaves with pubescent hairy and whitish tinge over surface of leaves. The pod colour is light green with medium size. It is slightly resistant to powdery mildew.

3.4.2 (a) Experimental Details

1. **Name of crop** : Cluster bean
2. **Botanical name** : *Cyamopsis tetragonoloba* (L.) Taub
3. **Family** : Fabaceae
4. **Variety** : Phule Guar
5. **Spacing** : 45×30cm
6. **Season** : Summer 2018
7. **Plot size** : 1.8m×1.8m
8. **Number of plots** : 36
9. **Treatment combination** : 12
10. **Design** : Randomized Block Design
11. **Replications** : 3
12. **Layout** : Flat bed

3.4.3 (b) Treatment Details

T_1	100% RDF(25:50:50 kg ha^{-1} NPK) (check)
T_2	100% RDF through FYM (3t ha^{-1})
T_3	100% RDF through Vermicompost (2.5t ha^{-1})
T_4	100% RDF through Neemcake (0.5t ha^{-1})
T_5	100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)
T_6	100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)
T_7	100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)

Design : Randomized block Design (RBD)

Treatment : 12

Replication : 3

Fig 1. Plan of Layout

T_8	75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)
T_9	75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)
T_{10}	75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)
T_{11}	100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)
T_{12}	Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)

3.5 Cultivation details

3.5.2 Rhizobium culture

The culture of *Rhizobium japonicum* strain was obtained from Biofertilizer unit, Post Graduate Institute, Dr. PDKV Akola. Seeds of cluster bean were coated @ 25 g kg^{-1} of seeds with slurry of *Rhizobium* culture in jaggery solution and seeds were dried in shade for 30 minutes before sowing.

3.5.3 Phosphorus Solublizing Bacteria

Phosphorus Solublising Bacteria (PSB) is recommended for soil and seed inoculation @ 25g kg^{-1} and 5 kg^{-1} throughly incorporate in soil before sowing of seeds. The culture of *Bacillus megatherium* strain was obtained from Biofertlizer unit, Post Graduate Institute, Dr. PDKV, Akola. Applied along with respective organic manures (FYM and Vermicompost) @ 5 kg ha^{-1} and thoroughly incorporated into the soil before sowing of seeds.

Plate 1. General view of experimental plot

3.5.4 Farm Yard Manure

Well decomposed farm yard manure was collected from, Instructional farm, Department of Vegetable Science, Faculty of Horticulture, Dr. PDKV Akola.

3.5.5 Vermicompost

The vermicompost for the experiment was obtained from Instructional farm, Department of Vegetable Science, Faculty of Horticulture, Dr. PDKV Akola.

3.5.6 Neem Cake

The neem cake for the experiment was obtained from Instructional farm Department of Vegetable Science, Faculty of Horticulture, Dr. PDKV Akola.

3.6. Preparatory tillage

The experimental field was ploughed, cross harrowing and clod crushing was done for obtaining fine texture. It was leveled uniformly, and the plots were laid out as per the plan of the experiment.

3.6.1 Seeds and Sowing

Seeds were dibbled at 3-5 cm depth @ two seeds hill^{-1} at recommended spacing. Uniform plant population was maintained by thinning one week after germination and gap filling was done after ten days of sowing. Second thining was done in all the treatments at seven days after gap filling, retaining one healthy seedling per hill.

3.6.2 Application of manures and Fertilizers

The recommended dose of nutrients applied to the cluster bean is 25 kg N, 50 kg P_2O_5, 50 kg K_2O ha^{-1}. Nitrogen was applied as per treatments in the form of urea in two equal splits viz., first dose at the time of sowing (as basal dose) and second dose as top dressing at 30 days after sowing (DAS). Entire quantity of phosphorous and potassium was applied as basal through single super phosphate and murate of potash, respectively is used as check. Well decomposed FYM (10 t ha^{-1}), Vermicompost (2 t ha^{-1}), Neem cake (2 t ha^{-1}) were applied after calculated on the basis as per treatment to different treatment plot before 15 days to sowing. Soil application of *Rhizobium*, PSB were given as per the treatments.

3.6.3 Irrigation

Light Irrigation was given immediately after sowing and subsequent irrigations were given to plots at an interval of 6-7 days during the period of experimentation as per requirement of soil moisture conditions.

3.6.4 Intercultural operations

Weeding was carried out at an interval of 15 days up to10 weeks to keep plot free from weeds.

3.6.5 Plant protection measures

To control the pest and diseases, necessary plant protection measures were taken to keep the plants free from pests and diseases as per the recommended package of practices for cluster bean.

3.6.6 Harvesting

The harvesting of green pod was started when pods attained the proper size suitable for vegetable purpose. The pods were picked when they are fresh green.

3.6.7. Growth observations

For recording growth observations, five plants were selected randomly from each plot.

3.7.1 Plant height (cm)

Plant height was measured from the ground level to the tip of the main axis of randomly selected plants at 45^{th}, 60^{th}, 75th days after sowing and expressed in centimeters.

3.7.2 Number of branches plant^{-1}

Number of branches arising from main stem plant^{-1} was counted for each of the observational plants. After computing mean it was recorded as branches of cluster bean plant^{-1}. The branches were counted at 45^{th}, 60th, and 75^{th} DAS.

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

Total number of leaves on the same five plants in each treatment were counted at 45^{th}, 60^{th} and 75^{th} days after sowing and mean values were expressed as number of leaves per plant.

3.7.4 Leaf area (cm^2)

Fifth trifoliate leaf from each observation plant and replication were selected and average leaf area was taken at 60 DAS. Average per leaf area was calculated by using graph paper and presented as sq. cm $plant^{-1}$.

3.7.2 Flowering characters

3.7.2.1 Number of days to first flowering

From the day after sowing each plot was observed daily and, on the basis, number of days required for first flowering was recorded in different plot.

3.7.2.2 Number of days to 50% flowering

The days were counted from the date of sowing to appearance of flowering in 50% plants in each plot.

3.7.3 Yield parameters

3.7.3.1 Number of clusters $plant^{-1}$

Total number of clusters per plant was recorded from each individual plant from five randomly selected plants of each treatment combination and average was worked out.

3.7.3.2 Number of pods $cluster^{-1}$

Counted pods per cluster in five randomly selected plants, mean of five plants was expressed as no of pods $cluster^{-1}$.

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

Total number of green pods per plant was measured after multiplying number of clusters per plant with number of pods $cluster^{-1}$ from each treatment combination after computing mean it was recorded, as number of pods $plant^{-1}$.

3.7.3.4 Length of pods $plant^{-1}$ (cm)

After harvesting of pods length was recorded and the average length of pod under each plot was calculated.

3.7.3.5 Diameter of pods (mm)

Pod diameter (at center part of pod) was measured for randomly selected ten pods from each treatment plot and their mean values taken as pod diameter in millimeters.

3.7.3.6 Weight of pods plant^{-1} (g)

The weight of green pods from the five randomly selected plants per treatment combination was recorded and average pod weight plant^{-1} was worked out in g.

3.7.3.7 Pod yield plot^{-1} (kg)

The yield of green pods from the five randomly selected plant per treatment combination was recorded and average pod yield per plant was worked out and yield plot^{-1} was calculated in kg.

3.7.3.8 Pod yield hector^{-1} (q ha-^{1})

The yield of green pod from the five randomly selected plants per treatment combination was recorded and average pod yield per plant was worked out and yield plot^{-1} calculated and converted in yield in quintal^{-1}.

3.7.3.9 Number of seeds pod^{-1}

The green pods from each experimental plot were randomly picked at the time of harvesting and seeds were counted and average number of seeds pod^{-1} was worked out.

3.7.4 Quality Parameter

3.7.4.1 Protein content of pods (%)

Nitrogen content of cluster bean pods from each treatment combination was determined by Microkjadhal’s method. Protein content was calculated by multiplying nitrogen content of the pods with the conversion factor of 6.25.

Protein % = Nitrogen content of pod × 6.25

3.7.5 Soil and Plant Nutrient analysis

3.7.5.2.1 Available nitrogen (kg ha^{-1})

Available nitrogen from soil before sowing and after harvest was determined by Alkaline permanganate method (Subbiah and Asija, 1956).

3.7.5.2 Available Phosphorous (kg ha^{-1})

Available phosphorous from soil before sowing and after harvest was determined by Olsen method (Olsen *et al*, 1954).

3.7.5.3 Available potassium (kg ha^{-1})

Available potassium from soil before sowing and after harvest was determined by neutral normal ammonium acetate method using Flame photometer method.(Jakson, 1967).

3.7.5.4 Nitrogen uptake by plant (kg ha^{-1})

Plant samples of above ground parts were collected for recording dry weight were further used for chemical analysis. The samples were ground well separately, and total analysis was done. The nitrogen content in plant samples were determined by using Micro-Kjeldhal method (Piper ,1966).

3.7.5.5 Phosphorous uptake by plant (kg ha^{-1})

Plant samples of above ground parts were collected for recording dry weight were further used for chemical analysis.The phosphorous content in plant samples were determined by using Vanadomolybdate Yellow Colour method (Piper, 1966).

3.7.5.6 Potassium uptake by plant (kg ha^{-1})

Plant samples of above ground parts collected for recording dry weight were further used for chemical analysis. The samples were ground well separately, and total analysis was done. The potassium content in plant samples were determined by using Flame photometrically from triacid extract (Piper, 1966).

3.7.5.7 Statistical analysis

The data obtained on various characters were statistically analyzed by Randomized Block Design by Panse and Sukhatme (1985). Critical difference for examining treatment means for their significance was calculated at 5% level of significance. The significance of difference was judge and suggested by Fisher applying F test.

3.8 Economics

The cost of cultivation, gross and net returns (Rs ha^{-1}) and B:C ratio for various treatments were calculated at prevailing market rates.

3.8.1 Cost of cultivation (Rs ha^{-1})

Cost of cultivation was calculated by adding cost of items used in cultivation (Rs ha^{-1}) while total expenditure was calculated by adding cost of cultivation with the treatment cost.

3.8.2 Gross monetary returns (Rs ha^{-1})

The value from the produce obtained under each treatment was computed on the basis of existing market price of the produce as the gross monetary returns (GMR) per hectare under different treatments.

3.8.3 Net monetary returns (Rs ha^{-1})

The net monetary returns (NMR) per hectare under each treatment were determined by substracting the cost of cultivation from the GMR of the same treatment.

Net monetary return (Rs.) = Gross monetary return – Total cost of cultivation

3.8.4 Benefit – Cost ratio

Benefit cost ratio is the index indicating monetary return over each rupee investment under different treatments and it is also termed as profitability. It was calculated by using the following formula:

$$\frac{\text{Gross monetary return (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs ha}^{-1}\text{)}} \times 100$$

CHAPTER IV

RESULTS AND DISCUSSION

The experiment entitled "Organic nutrient management in cluster bean (*Cyamopsis tetragonoloba* (L.) Taub)" was carried out on variety "Phule Guar" during *summer* season of 2018, at Instructional farm of Department of vegetable science, Faculty of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola and results are presented in this chapter. The observations were recorded on various parameters governing growth, yield and quality of cluster bean were discussed under appropriate headings and subheadings as below.

4.1 Growth Observations

4.2 Flowering Characters

4.3 Yield and Yield Attributes

4.4 Quality Parameters

4.5 Nutrient Analysis

4.6 Cost Economics

4.1 Growth Observations

4.1.1 Height of plant (cm)

From the data presented in Table 3 and depicted in Fig.2. it is revealed that, the plant height was found influenced by various treatments of organic nutrient management at different crop stages i.e. at 45, 60, 75 DAS.

At 45 DAS, where significantly maximum plant height (29 cm) was recorded in T_{11} i.e. application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) which was statistically at par with the treatment T_1 (28.38 cm),T_5 (27.05 cm) and T_6 (27.25 cm). However, minimum plant height was observed in T_{12} (24.60 cm).

Table 3. Height of the plant (cm) as influenced by organic nutrient management

Treatments	Height of plant (cm)		
	45 DAS	**60 DAS**	**75 DAS**
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	28.38	37.11	50.49
T_2-100% RDF through FYM (3t ha^{-1})	25.73	32.47	46.12
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	25.95	34.80	46.79
T_4-100% RDF through Neemcake (0.5t ha^{-1})	25.84	34.49	46.58
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	27.05	35.71	49.95
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	27.75	36.43	50.44
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	26.61	35.64	49.53
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	26.40	35.19	48.51
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	26.07	35.38	49.01
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	26.37	35.13	48.01
T_{11}-100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	29.00	38.50	54.93
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	24.60	29.67	42.90
'F' Test	**Sig**.	**Sig**.	**Sig**.
SE (m) ±	0.64	0.99	1.34
CD @ 5%	1.89	2.95	3.96

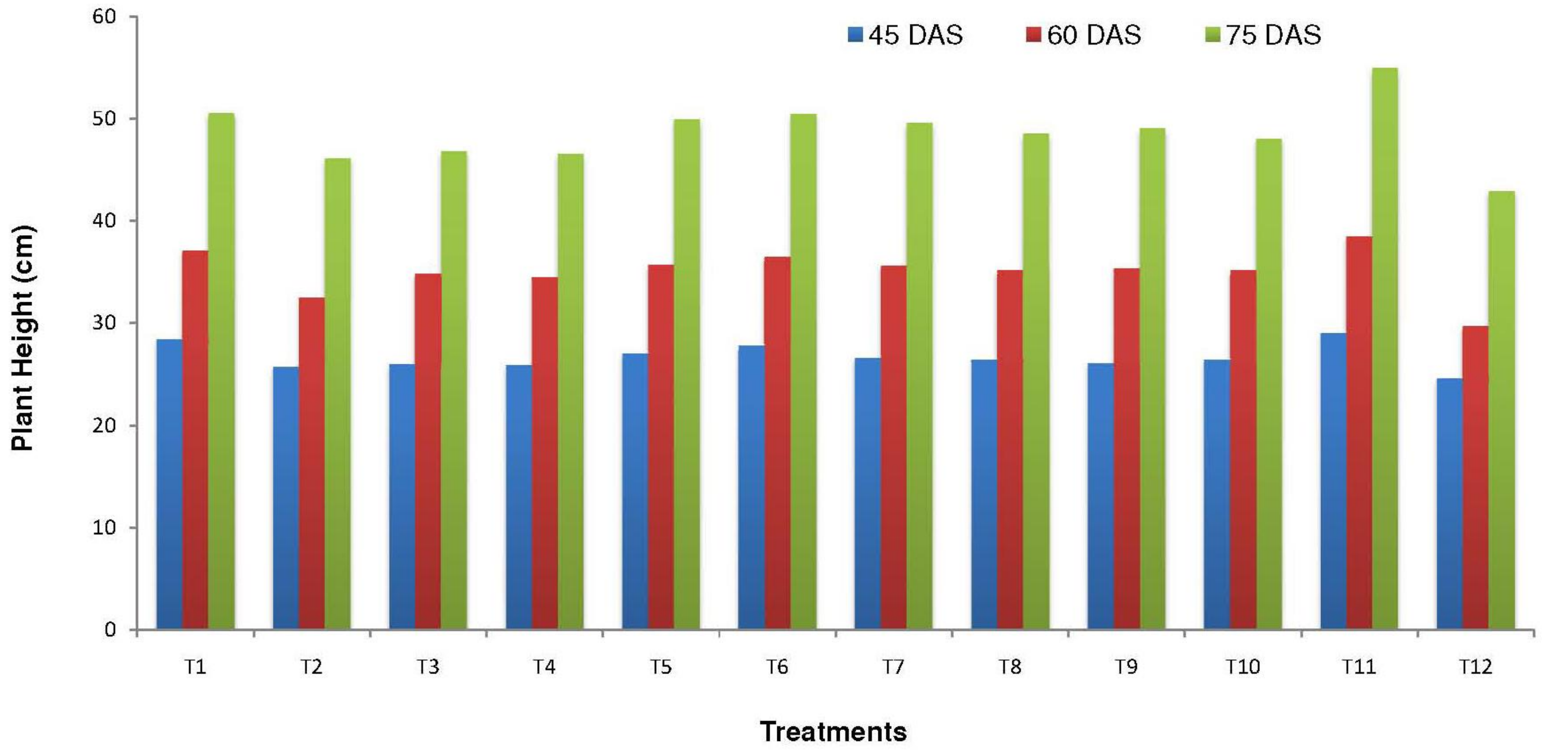

Fig. 2. Height of the plant (cm) as nfluenced by organic nutrient management

Same trend was observed at 60 and 75 DAS where the maximum plant height was observed in treatment T_{11} (38.50 and 29.67 cm) followed by at 60 DAS T_1 (37.11 cm), T_5 (35.71 cm) and T_6 (36.43 cm) which were at par with each other and superior over rest of the treatments. However, the minimum plant height was observed in treatment T_{12} (29.67 and 42.90 cm).

Plant growth is described as an irreversible increase in size, shape and is effected by the interaction between the environmental factors and plant physiological processes and also influences by the experimental inputs such as water and nutrients etc. In the present experiment application of inorganic fertilizers in combination with biofertilizers has exerted a significant influence on morphological characters on plant height.

Increase in the plant height might be due to the nitrogen application which increased growth of plant, since nitrogen as major component of protoplasm helps in photosynthesis and enhances metabolic rate, cell division and cell elongation which thereby, allow plant growth faster and phosphorous enhances root elongation, leaf expansion and cell elongation. Combine application of inorganic nutrients and bio fertilizers increase the use efficiency of added nutrients and supply it continuously to the plant throughout the crop growth period and promoted various physiological activities in plant which are being considered indispensable for proper growth and development. As nitrogen is involved in photosynthesis, which results in increased vegetative growth while, phosphorus encourages the formation of new cells, promotes plant vigour and root growth, hastens leaf development which helps in harvesting more solar energy and later utilization of nitrogen which can be attributed for higher plant height. These results corroborate with the findings of Singh *et al*. (1983) and Rajkhowa *et al*. (2003).

4.1.2 Branches per plant

The result on total number of branches per plant at 45, 60 and 75 DAS as influenced by various treatments of organic nutrient management are presented in Table 2. Effect of organic nutrient management in cluster bean on number of branches per plant were statistically found nonsignificant at all (45, 60, 75 DAS) plant growth stages.

Table 4. Number of branches per plant as influenced by organic nutrient management

Treatments	Branches per plant		
	45 DAS	60 DAS	75 DAS
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	1.17	1.93	2.40
T_2-100% RDF through FYM (3t ha^{-1})	0.93	1.57	2.10
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	0.97	1.63	2.17
T_4-100% RDF through Neemcake (0.5t ha^{-1})	0.92	1.60	2.13
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	1.12	1.80	2.33
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	1.13	1.87	2.37
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	1.07	1.77	2.30
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	1.03	1.70	2.23
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	1.02	1.73	2.27
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	1.00	1.67	2.20
T_{11}-100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	1.20	2.00	2.43
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	0.87	1.50	2.07
'F' Test	**NS**	**NS**	**NS**
SE (m) ±	-	-	-
CD @ 5%	-	-	-

4.1.3 Number of leaves per plant

Table 5. Number of leaves per plant as influenced by organic nutrient management

Treatments	Number of leaves per Plant		
	45 DAS	**60 DAS**	**75 DAS**
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	9.39	19.67	26.33
T_2-100% RDF through FYM (3t ha^{-1})	8.49	17.87	21.96
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	8.69	18.40	23.89
T_4-100% RDF through Neemcake (0.5t ha^{-1})	8.56	18.25	22.76
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	9.00	19.31	25.69
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	9.11	19.40	25.96
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	8.98	19.09	25.22
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	8.94	18.92	24.63
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	8.91	18.82	24.69
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	8.87	18.56	24.38
T_{11}-100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	9.70	19.69	27.00
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	8.38	17.22	20.75
'F' Test	**Sig**.	**Sig**.	**Sig**.
SE (m) ±	0.22	0.372	0.468
CD @ 5%	0.66	0.465	1.381

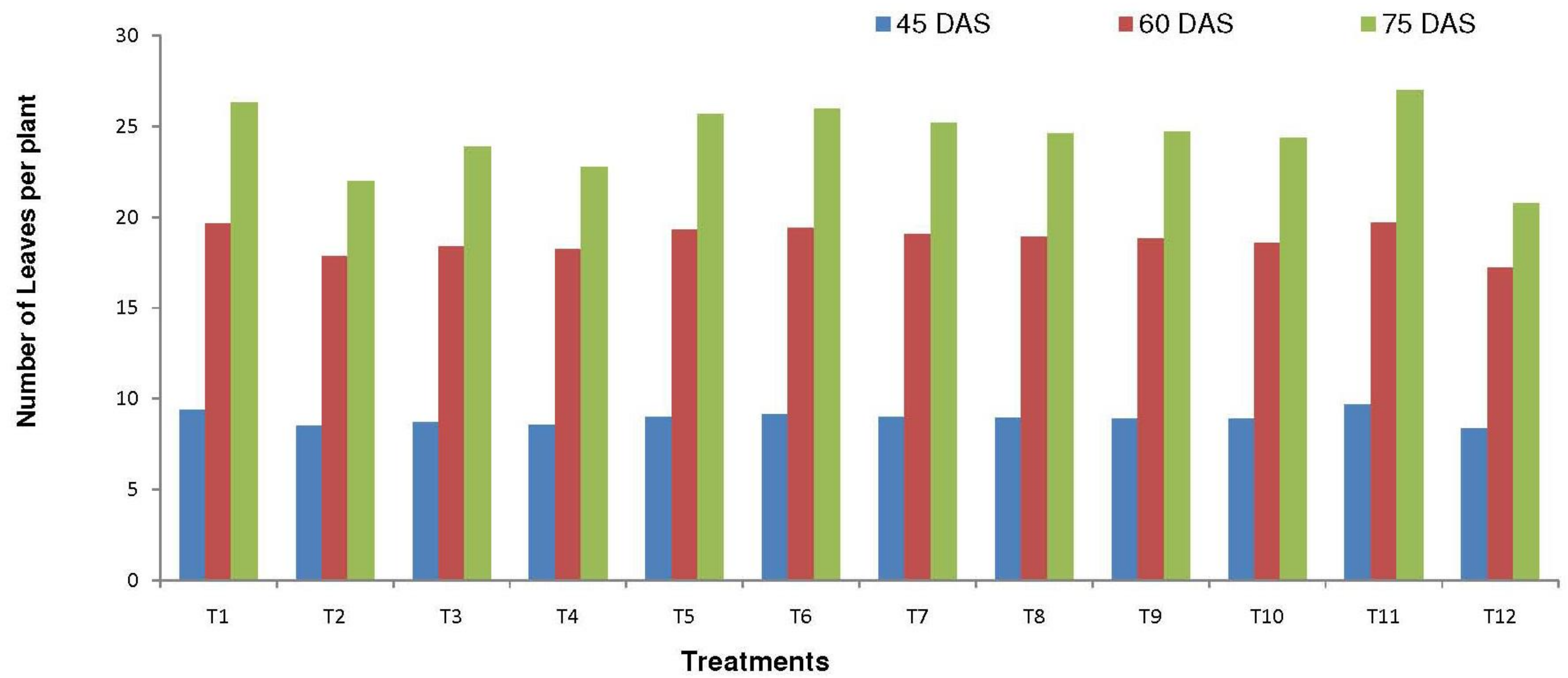

Fig. 3. Number of leaves per plant as influenced by organic nutrient management

A perusal of data presented in the Table 5 and depicted in Fig. 3 clearly indicates that, there was significant influence by various treatments of organic nutrient management on number of leaves per plant at different stages of crop growth i.e. at 45,60,75 DAS.

At 45 DAS, treatment T_{11} i.e. application of 100% RDF through (25:50:50 kg NPK ha^{-1})+ Rhizobium (25 gm kg-^{1}of seed inoculation + PSB (5 kg ha^{-1} of soil application and 10 gm kg^{-1} of seed inoculation) .recorded significantly maximum (9.70 leaves) no. of leaves $plant^{-1}$ followed by the treatments *viz.* T_1 (9.7 leaves) and T_5 (9.11 leaves), which was at par with each other. Whereas, treatment T_{12} recorded minimum (8.38 leaves) number of leaves $plant^{-1}$.

At 60 and 75 DAS also T_{11} recorded significantly maximum (19.69 and 27.00) number of leaves $plant^{-1}$ which was at par with the treatments T_1, (19.67 and 26.33 leaves) and T_5 (19.31 and 25.69 leaves). Whereas treatment T_{12} recorded minimum (17.22 and 20.75 leaves) number of leaves $plant^{-1}$.

The production of maximum number of leaves can be due to higher metabolic activity because of optimum N supplies resulting in higher production of carbohydrates and phytoharmones which were main infested in form of enhanced growth as explained by Govindum and Purushottam (1984) and Kumar *et al*. (2009) in french bean.

4.1.4 Leaf area (cm^2)

A perusal of data presented in the Table 6 and depicted in Fig. 4 clearly indicates that, there was significant influence by various treatments of organic nutrient management on leaf area (cm^2) per plant at 60 DAS.

Table 6. Leaf area (cm^2) as influenced by organic nutrient management

Treatments	Leaf area (cm^2)
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	20.7
T_2-100% RDF through FYM (3t ha^{-1})	15.4
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	16.3
T_4-100% RDF through Neemcake (0.5t ha^{-1})	16.0
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	18.7
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	19.7
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	17.5
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	16.8
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	17.0
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	16.6
T_{11}-100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	21.5
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	15.4
'F' Test	**Sig**.
SE (m) ±	0.995
CD @ 5%	2.920

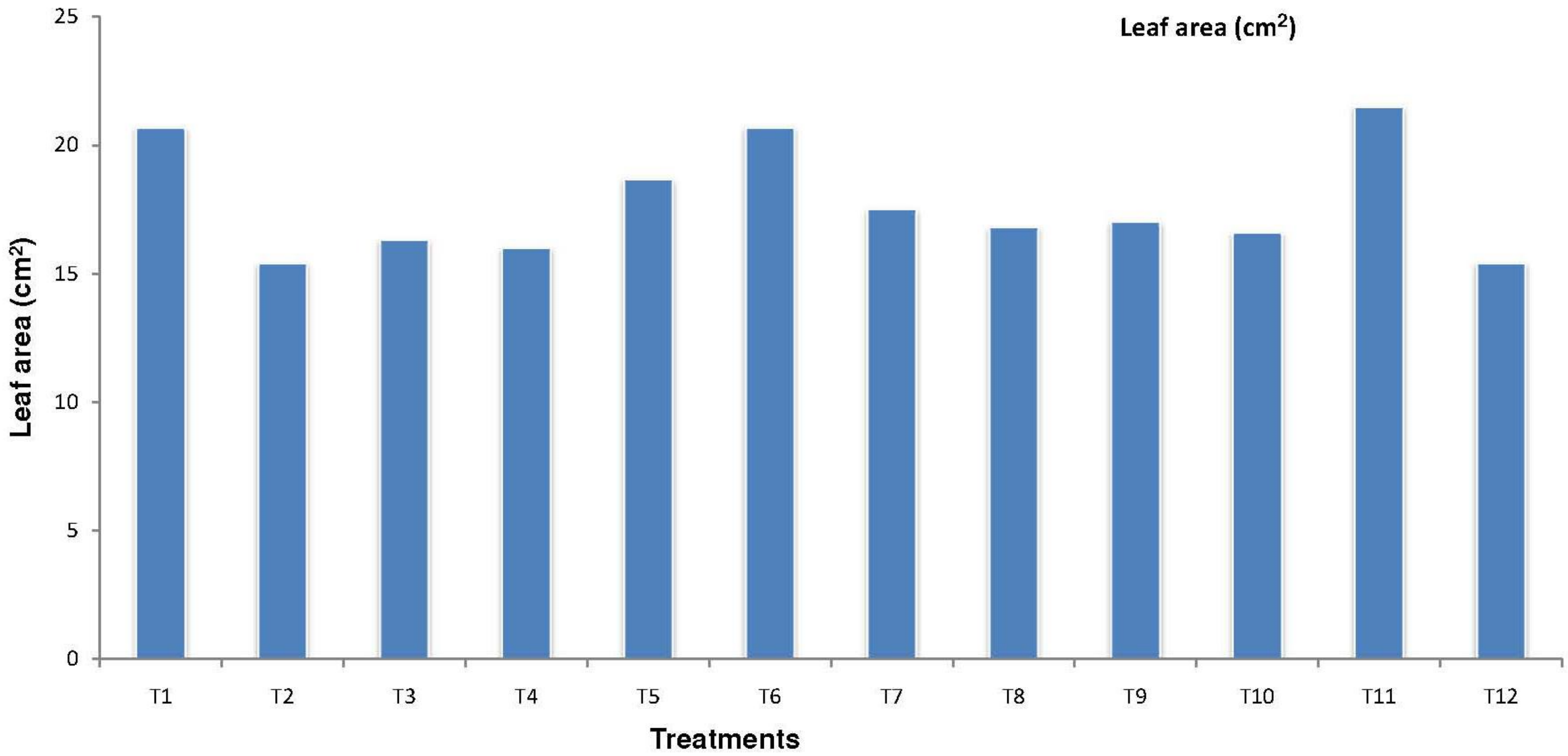

Fig. 4. Leaf area (cm^2) as influenced by organic nutrient management

The data presented in Table 6 shows that, significantly maximum leaf area (21.5 cm^2) was recorded with the treatment T_{11} i.e. application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation), which was statistically at par with T_1 (20.7 cm^2), T_5 (18.7 cm^2) and T_6 (19.7 cm^2).However, minimum (15.4 cm^2) leaf area recorded in treatment T_{12} i.e. application of Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation).

By dual inoculation of PSB and Rhizobium in combination with inorganic fertilizers increase in vegetative growth might be due to increased number of leaves and leaf area which determines the photosynthetic efficiency of plants, dry matter production and ultimately the yield. The increased in the leaf area might be attributed due to enhanced availability of uptake of nutrients by the plant might have favoured better cell division and elongation, amino acid and protein synthesis and assimilation in producing maximum leaf area. Similar results were found Nagar and Meena (2004) in cluster bean, and Kumar *et al*. (2004) in french bean.

4.2 Flowering characters

4.2.1 Number of days to initiation of flowering

Significant difference among the treatments means where seen in number of days to initiation of flowering as influenced by organic nutrient management in Table 7 and depicted in Fig. 5.

Table 7. Number of days to initiation of flowering as influenced by organic nutrient management

Treatments	Number of days to initiation of flowering
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	33.00
T_2-100% RDF through FYM (3t ha^{-1})	34.80
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	34.36
T_4-100% RDF through Neemcake (0.5t ha^{-1})	34.53
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	33.73
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	33.60
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	33.86
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	34.13
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	34.16
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	34.23
T_{11}-100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	32.40
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	35.06
'F' Test	**Sig**.
SE (m) ±	0.312
CD @ 5%	0.915

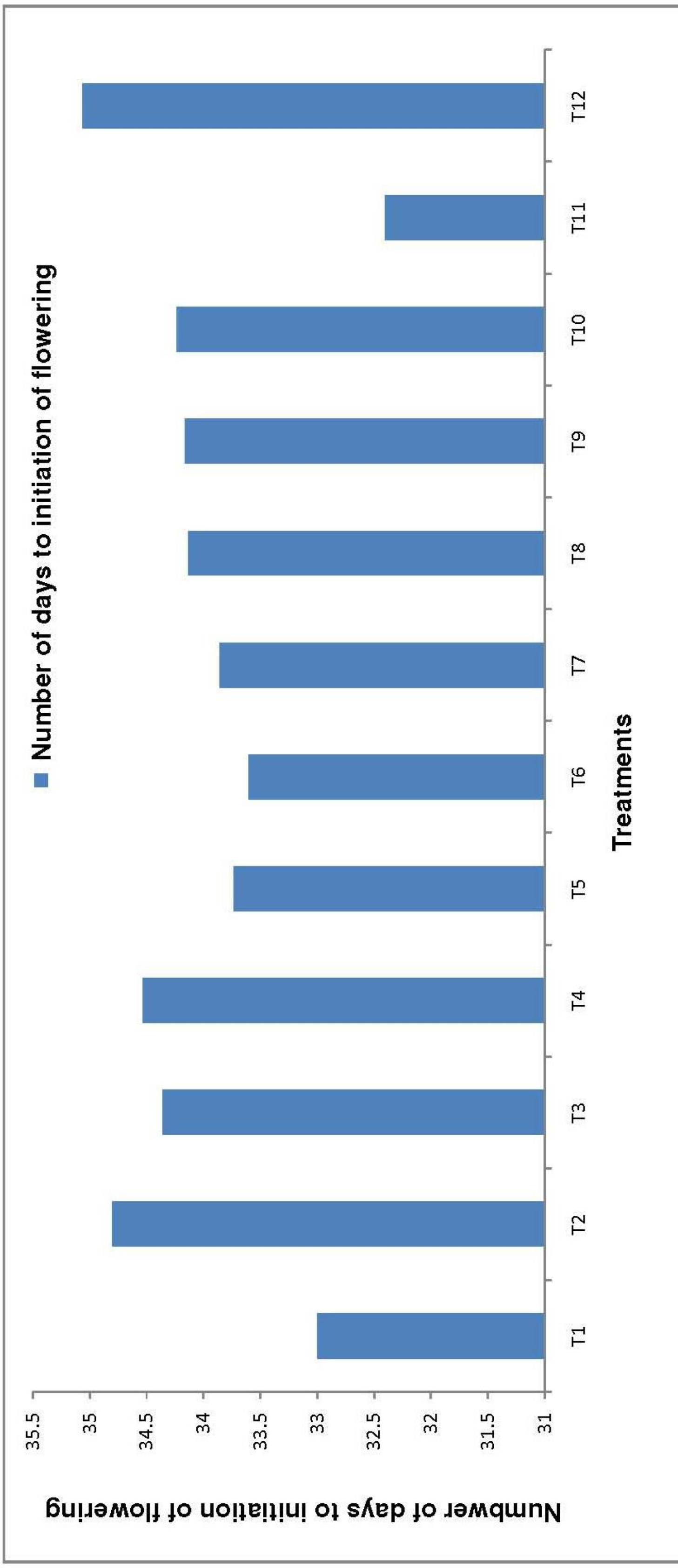

Fig. 5. Number of days to initiation of flowering as influenced by organic nutrient management

The treatment T_{11} i.e. 100% RDF through (25:50:50 kg NPK ha^{-1})+ Rhizobium (25 gm $kg^{-1}$of seed inoculation + PSB (5 kg ha^{-1} of soil application and 10 gm kg^{-1} of seed inoculation) recorded significantly minimum number of days (32.40 days) required to initiation of flowering, followed by the treatment T_1 (33 days), which were statistically at par with each other and superior over rest of the treatments. However, the maximum number of days required to initiation of flowering (35.06 days) was recorded in the treatment T_{12} i.e. application of only biofertilizers.

Combined inoculation of chemical fertilizers along with biofertizers induced early flowering. This might be due to better nutritional status of the plants which was favoured by the treatments. Increased production of leaves might help to elaborate more photosynthates and induce flowering stimules, thus affecting early initiation of flower bud. This result is in conformity with the findings with Ganie *et al.* (2010) in pea.

4.2.2 Number of days to 50% flowering

The data regard to Number of days to 50 % flowering influenced by organic nutrient management is presented in the Table 8. and depicted in Fig. 6.

The data presented in Table 8 revealed that the minimum number of days required to 50 % flowering (40 days) was recorded in the treatment T_{11}. i.e. 100% RDF through (25:50:50 kg NPK ha^{-1})+ Rhizobium (25 gm $kg^{-1}$of seed inoculation + PSB (5 kg ha^{-1} of soil application and 10 gm kg^{-1} of seed inoculation) which was at par with T_1 (40.33 days), T_5 (41days) T_6 (40.67 days) and T_7 (41.33 days). Whereas, maximum number of days required to 50% flowering (45 days) was recorded in T_{12}.

This results be perhaps attributed to the levels of phosphorus nutrient which might have induced early reproductive phases over other fertilizers levels. There was a considerable and significant reduction in days to 50% flowering with inoculation treatments of biofertilizers compared to other treatments which could be due to attainment of phonological stages early in the ontogeny of the crop due to acceleration in growth. The results are conformity with the findings of Patil *et al*. (2004) in cluster bean crop and Ashwini (2005) in french bean.

Table 8. Number of days to 50% of flowering as influenced by organic nutrient management

Treatments	Number of days to 50% flowering
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	40.33
T_2-100% RDF through FYM (3t ha^{-1})	44.67
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	44.00
T_4-100% RDF through Neemcake (0.5t ha^{-1})	44.33
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	41.00
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	40.67
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	41.33
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	42.67
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	41.67
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	43.67
T_{11}-100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	40.00
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	45.00
‘F’ Test	**Sig**.
SE (m) ±	0.994
CD @ 5%	2.916

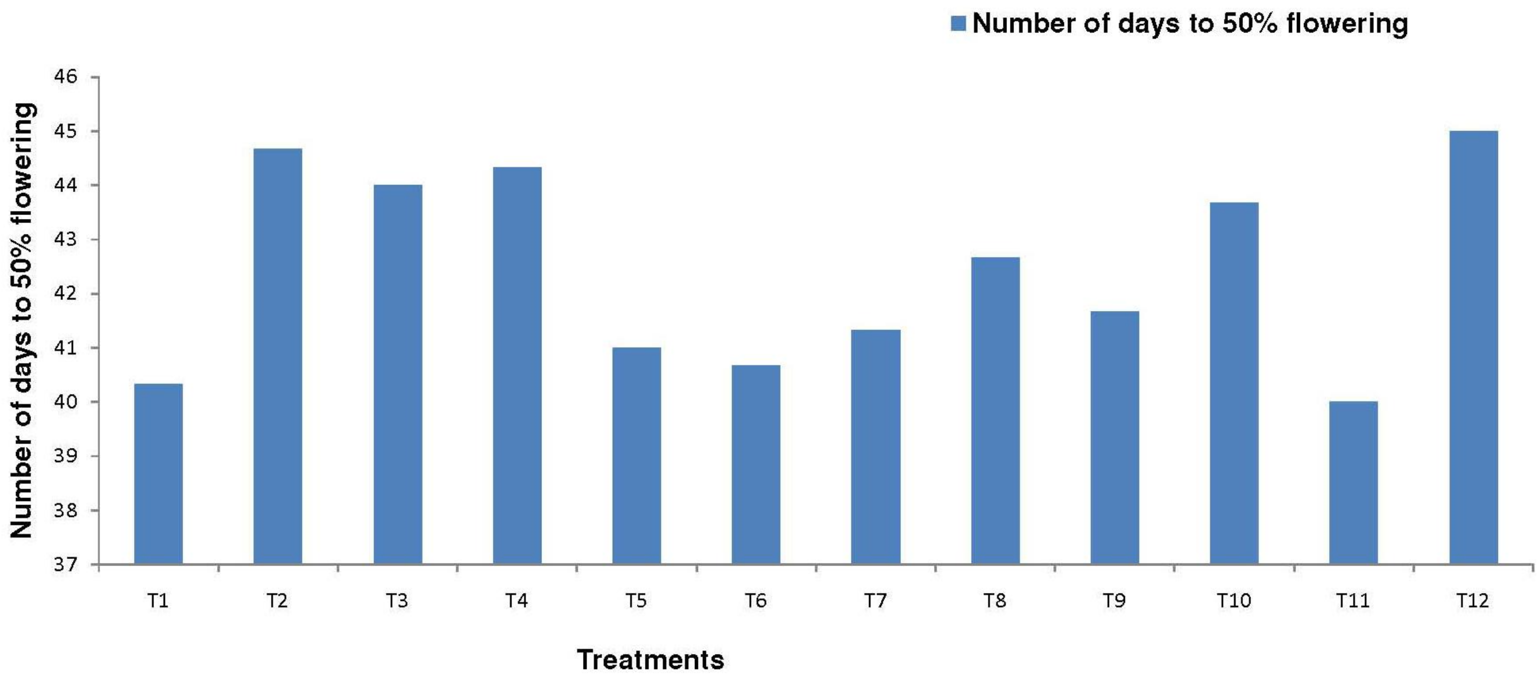

Fig. 6. Number of days to 50% of flowering as influenced by organic nutrient management.

4.3 Yield and Yield attributes

4.3.1 Number of clusters per plant

The data regarding with number of clusters per plant as influenced by different treatments of organic nutrient management is presented in Table 9. and depicted in Fig. 7.

Table 9. Number of clusters per plant as influenced by organic nutrient management

Treatments	Number of clusters per plant
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	10.87
T_2-100% RDF through FYM (3t ha^{-1})	9.47
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	9.80
T_4-100% RDF through Neemcake (0.5t ha^{-1})	9.60
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	10.53
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	10.70
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	10.33
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	10.10
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	10.33
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	10.03
T_{11}-100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	11.13
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	8.97
'F' Test	**Sig**.
SE (m) ±	0.249
CD @ 5%	0.732

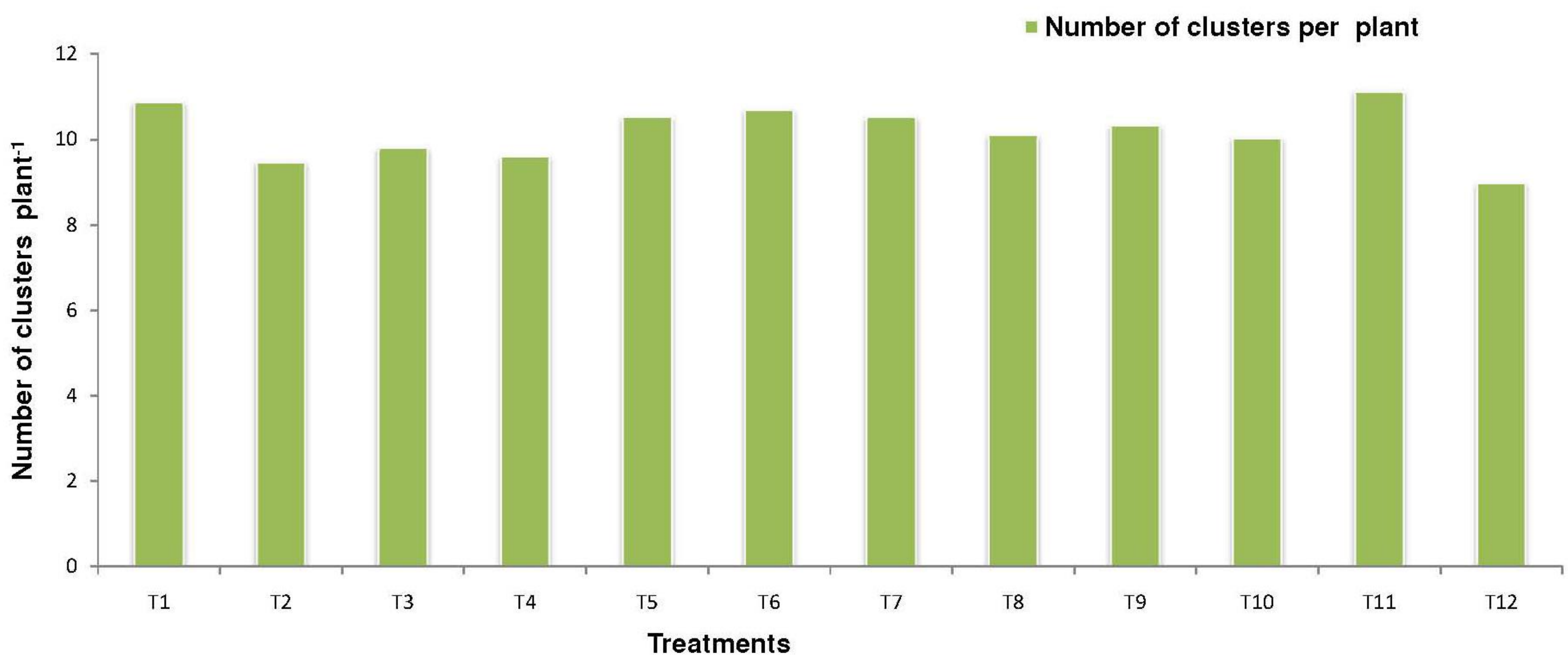

Fig. 7. Number of clusters per plant as influenced by organic nutrient management

Data presented in Table 9 revealed that number of clusters plant^{-1} was significantly influenced due to application of various combinations of chemical fertilizers, organic manure and biofertilizers. significantly maximum number of clusters plant^{-1} (11.3 clusters plant^{-1}) was recorded in treatment T_{11} i.e. application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) which was statistically at par with T_1 (10.87) and T_5 (10.53) were significantly superior over other treatments. Whereas, the minimum number of clusters per plant (8.97cluster plant^{-1}) was observed in treatment T_{12} i.e. application of Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation).

It is evident from the above data that, number of clusters per plant increased due to enhanced availability and nutrient uptake by plant fertilized with fertilizers in combination with biofertilizers which have favoured better cell division and elongation, amino acid and protein synthesis. Which was responsible for more vegetative and reproductive growth due to release of more nutrient and organic acid from soil. Similar results have been recorded by Kumar *et al*. (2004) and Ramna *et al*. (2010) in French bean.

4.3.2 Number of pods per cluster

The data presented in Table 10 and depicted in Fig. 8. indicated that, there was a significant influence on Number of pods per cluster by various treatment of organic nutrient management.

Significantly maximum number of pods (8.33 pods cluster^{-1}) was recorded with the treatment T_{11} i.e. (100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) which was statistically at par with the T_1 (8.07 pods cluster^{-1}) and T_6 (8.00 pods cluster^{-1}).Whereas, the minimum number of pods (6.90 pods cluster^{-1}) was recorded in the treatment T_{12} i.e. Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation).

Table 10. Number of pods per cluster as influenced by organic nutrient management

Treatments	Number of pods per clusters
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	8.07
T_2-100% RDF through FYM (3t ha^{-1})	7.03
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	7.20
T_4-100% RDF through Neemcake (0.5t ha^{-1})	7.17
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	7.63
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	8.00
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	7.57
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	7.30
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	7.33
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	7.23
T_{11}-100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	8.33
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	6.90
'F' Test	**Sig**.
SE (m) ±	0.281
CD @ 5%	0.824

Phosphorous play vital role in productive phase of crop. It enhances carbohydrate synthesis and metabolic activities, root growth and

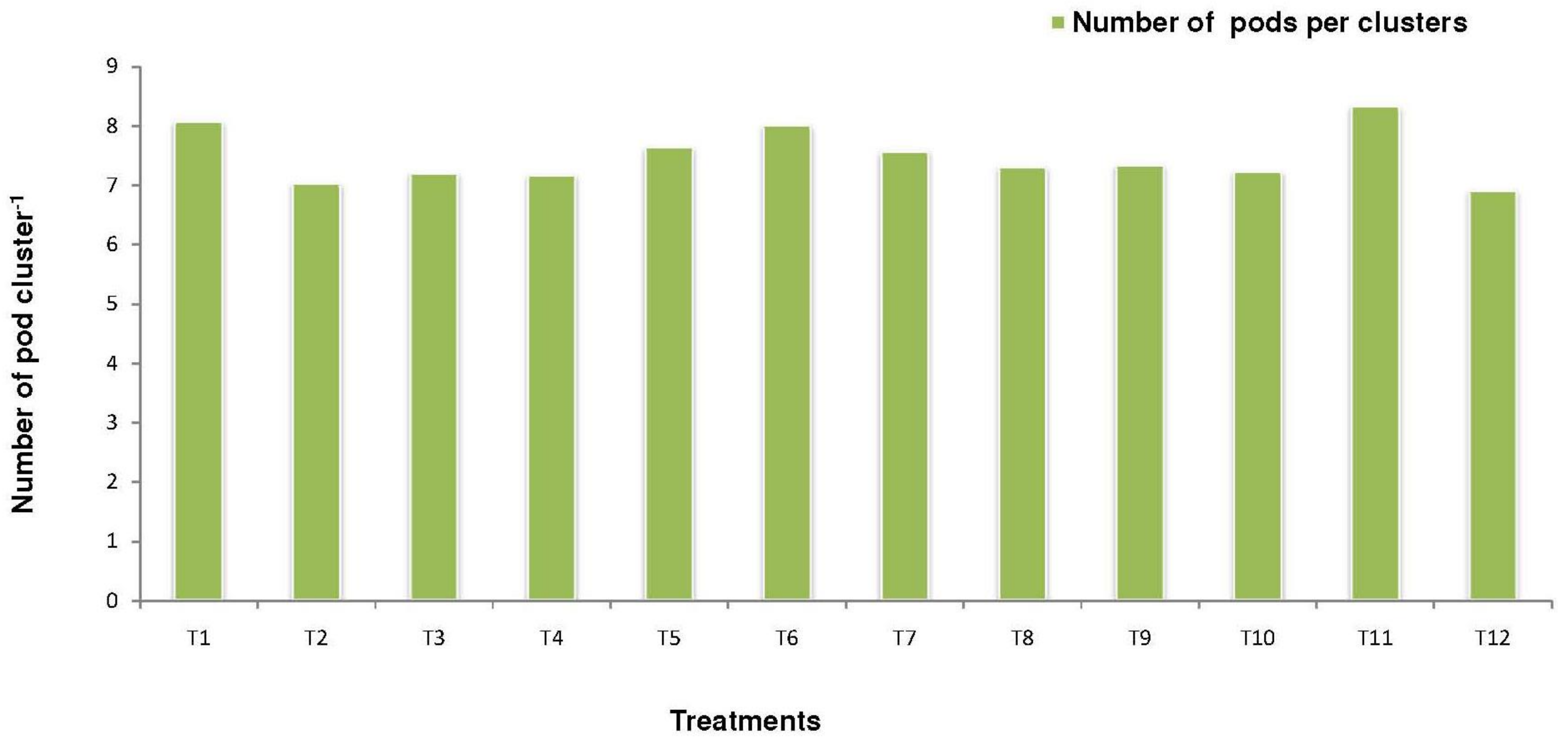

Fig. 8. Number of pods per cluster as influenced by organic nutrient management

root nodulation. Due to better assimilation of photosynthates and better partitioning into developing pod clusters might have taken place and improved yield attributing characters like pods in clusters ultimately increased pod yield plant^{-1}. These results are close conformity with the Nirmala and Vadivel (1978) in cucumber, Reddy (2012) in cluster bean and Rajkhowa *et al.* (2003) in green gram.

4.3.3 Number of pods per plant

The data regarding number of pods per plant as influenced by different treatments of organic nutrient management are presented in the Table 11. and depicted Fig. 9. A perusal data indicated that, significant difference is there among the treatments for number of pods per plant.

It revealed from the Table 11. that, pods plant^{-1} of cluster bean was influenced significantly due to application of chemical fertilizers, organic manure and biofertilizers. Among the different treatments T_{11} i.e. (100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) recorded to be superior in number of pods plant^{-1} (84.77 pods plant^{-1}) which was statistically at par with treatments T_1 (81.53 pods plant^{-1}), T_6 (80.73 pods plant^{-1}), T_5 (79.67 pods plant^{-1}) and T_7 (78.20 pods plant^{-1}).The minimum number of pods per plant (60.57 pods plant^{-1}) was observed in T_{12} i.e. Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation).

This might be due to fact that *Rhizobium* inoculation increased the root volume through better root development, increased photosynthetic activities, translocation and accumulation of photosynthetic from source to the developing sinks (seeds) nodulation, more nutrient availability resulting in vigorous plant growth and dry matter production which in turn resulted in better flowering and pod formation. The present results are in accordance with the findings of Noor *et al*. (1992) in hyacinth bean, Sammauria *et al*. (2009) in cluster bean, Ganie *et al*. (2010), Rajput and Singh (1996), Gandhi *et al*. (1991) and Mishra and Baboo (2002) in cowpea.

Table 11. Number of pods per plant as influenced by organic nutrient management

Treatments	Number of pods per plant
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	81.53
T_2-100% RDF through FYM (3t ha^{-1})	73.80
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	74.87
T_4-100% RDF through Neemcake (0.5t ha^{-1})	74.07
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	79.67
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	80.73
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	78.20
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	76.60
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	77.80
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	76.40
T_{11}-100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	84.77
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	60.57
'F' Test	**Sig**.
SE (m) ±	2.806
CD @ 5%	8.284

4.3.4 Length of pod (cm) of cluster bean

The data presented in the Table 12 and depicted in Fig. 10. indicated that, there was a significant influence on pod length by various treatments of Organic Nutrient Management.

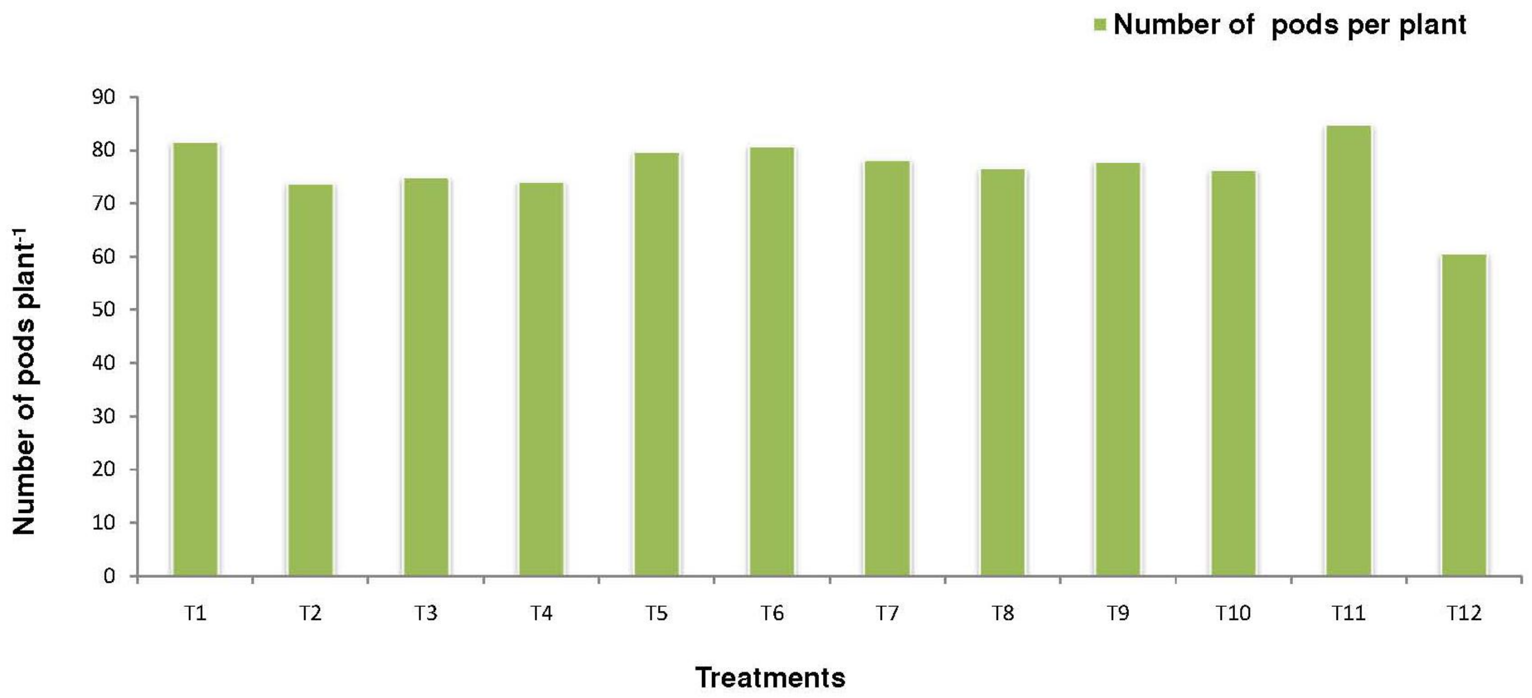

Fig. 9. Number of pods per plant as influenced by organic nutrient management

Table 12. Length of pod (cm) as influenced by organic nutrient management

Treatments	Pod length (cm)
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	6.01
T_2-100% RDF through FYM (3t ha^{-1})	5.64
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	5.77
T_4-100% RDF through Neemcake (0.5t ha^{-1})	5.70
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	5.90
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	5.96
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	5.88
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	5.82
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	5.84
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	5.79
T_{11}-100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	6.09
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	4.83
'F' Test	**Sig.**
SE (m) ±	0.139
CD @ 5%	0.410

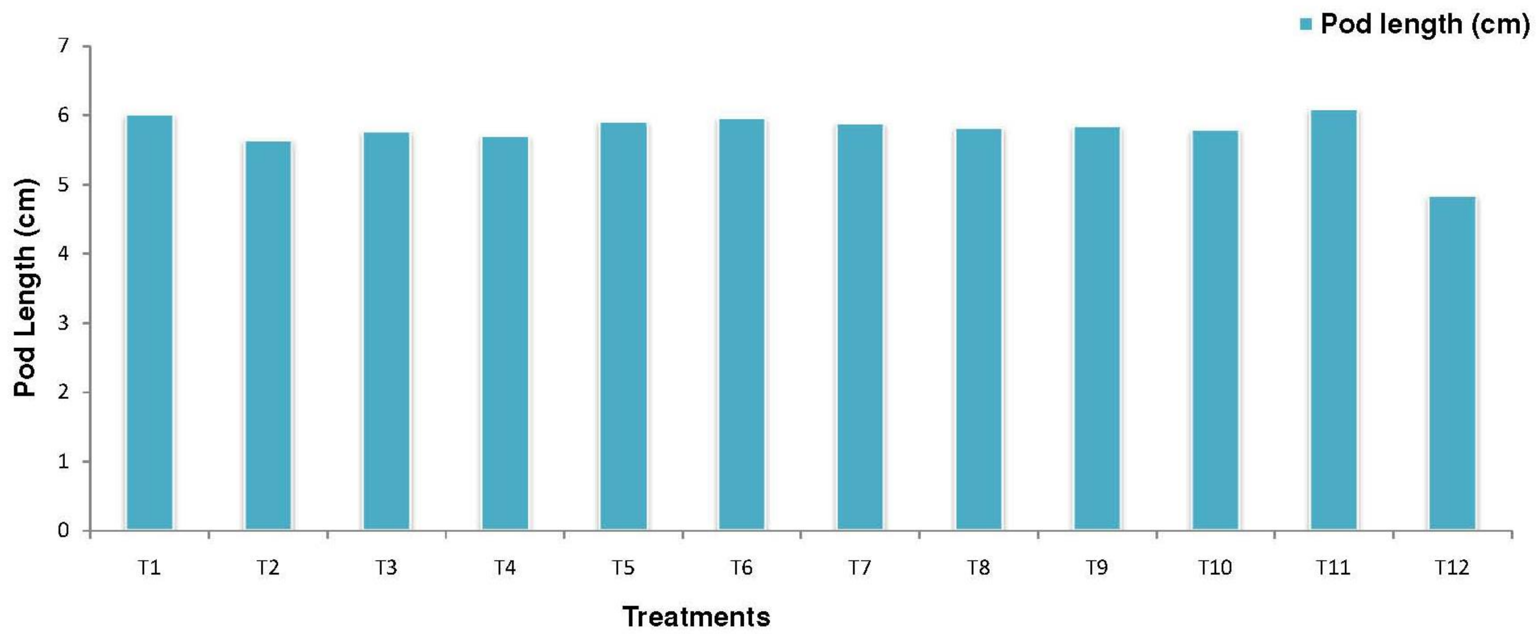

Fig. 10. Pod length (cm) as influenced by organic nutrient management

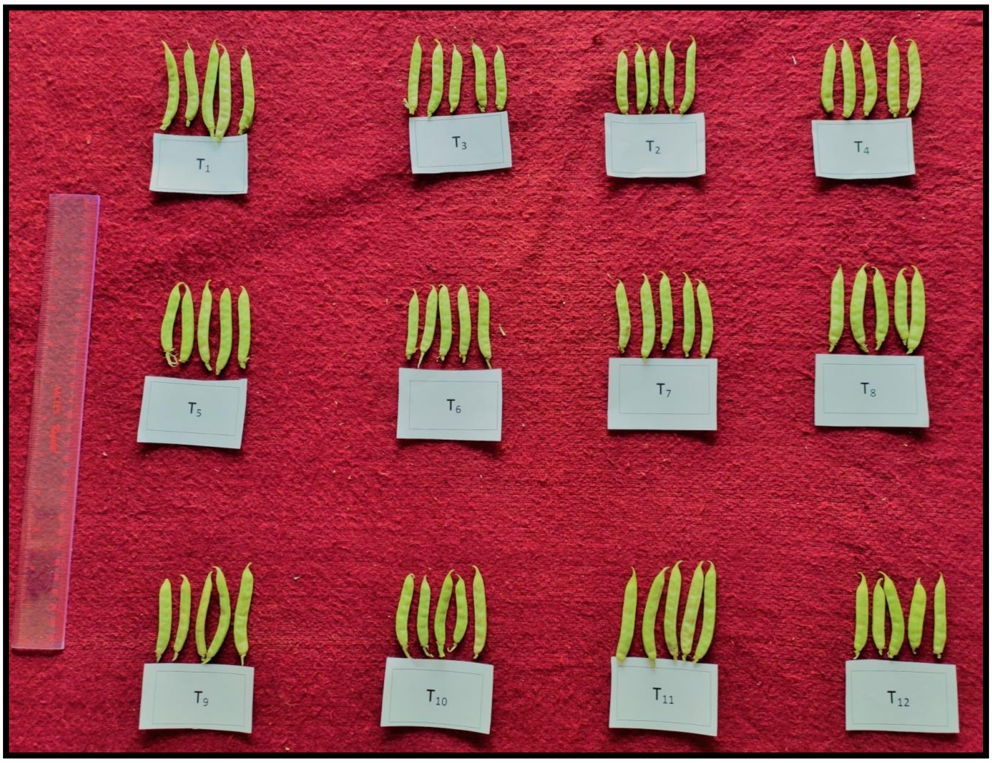

Plate 2. Effect of organic nutrient management on pods of cluster bean

Treatment T_{11} had significantly maximum pod length (6.01 cm). Followed by treatments T_1 (6.01 cm), T_5 (5.90 cm), T_6 (5.96 cm), T_7 (5.88 cm), T_9 (5.84 cm) and T_8 (5.82 cm) which were found at par with each other. However, minimum pod length was recorded in treatment T_{12} (4.83 cm).

Due to better assimilation of photosynthates and better partioning into developing pod clusters might have taken place and improving yield attributing characters like pod length, diameter, pods in a cluster plant^{-1} and ultimately increased the pod yield plant^{-1}. Similar results are in accordance with the Ved *et al*. (2008) in mung bean and Ashwini (2005) in french bean.

4.3.5 Diameter of pod (cm) of cluster bean

The data presented in the Table 13 and depicted in Fig. 11. indicated that, there was a significant influenced on pod diameter by various treatments of Organic Nutrient Management.

Plant supplied with a (100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) recorded maximum pod diameter (0.60 cm) which was found to be statistically at par with the treatment T_1 (0.59 cm), T_6 (0.58 cm), T_5 (0.57 cm) and T_7(0.56 cm) and significantly superior over rest of the treatments. whereas, lowest pod diameter (0.49 cm) recorded in treatment T_{12}.

Due to better assimilation of photosynthates and better partioning into developing pod clusters might have taken place and improved yield attributing characters like pod diameter. Similar observations were also recorded by Nirmala and Vadivel (1978) in cucumber.

Table 13. Diameter of pod (cm) as influenced by organic nutrient management

Treatments	Pod diameter (cm)
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	0.59
T_2-100% RDF through FYM (3t ha^{-1})	0.50
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	0.52
T_4-100% RDF through Neemcake (0.5t ha^{-1})	0.51
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	0.57
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seedinoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	0.58
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	0.56
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB(5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	0.54
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	0.55
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	0.53
T_{11}-100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	0.60
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	0.49
'F' Test	**Sig**.
SE (m) ±	0.020
CD @ 5%	0.059

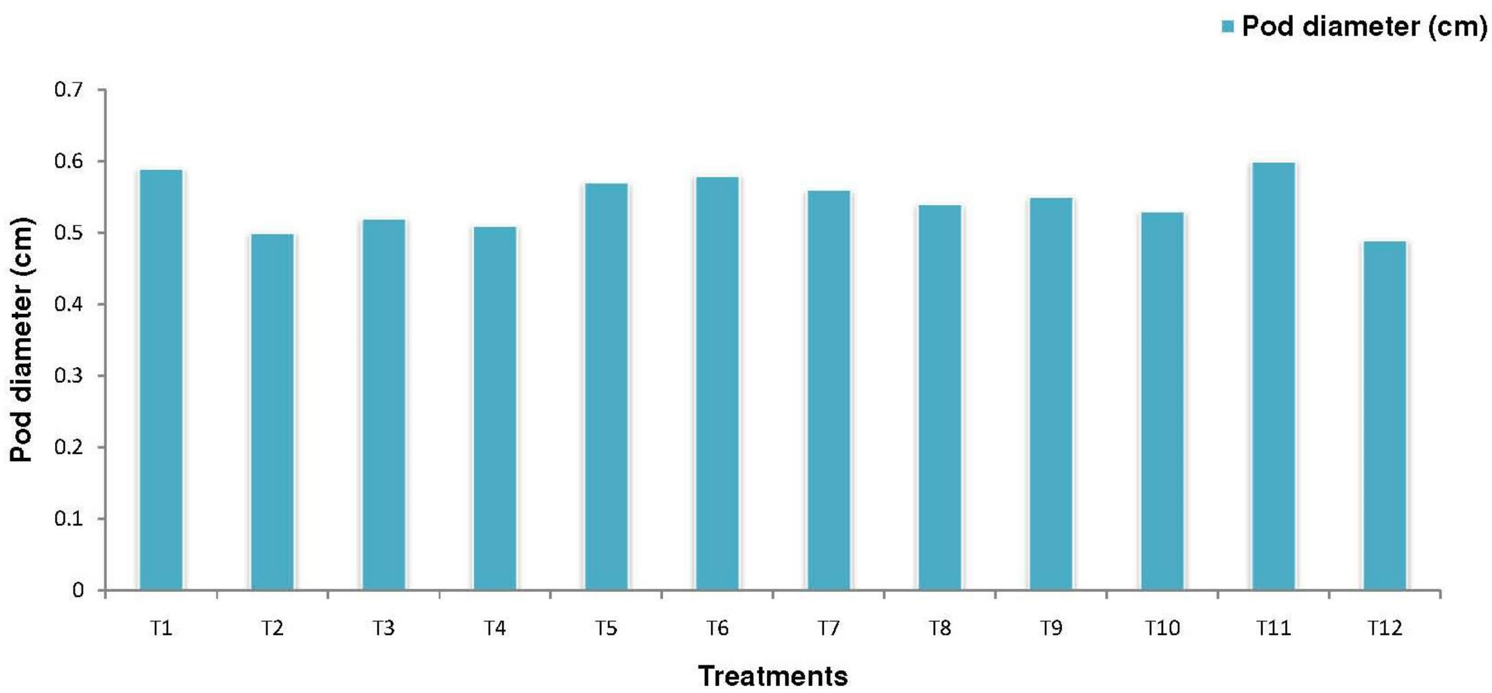

Fig. 11. Pod Diameter (cm) as influenced by organic nutrient management

4.3.6 Weight of pods in (g)

Table 14. Weight of pods (g) as influenced by organic nutrient management

Treatments	Weight of pods (g)
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	70.80
T_2-100% RDF through FYM (3t ha^{-1})	58.80
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	61.50
T_4-100% RDF through Neemcake (0.5t ha^{-1})	60.30
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	69.40
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	70.30
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	68.80
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	65.10
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	64.10
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	66.27
T_{11}-100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	74.01
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	53.20
'F' Test	**Sig**.
SE (m) ±	2.301
CD @ 5%	6.793

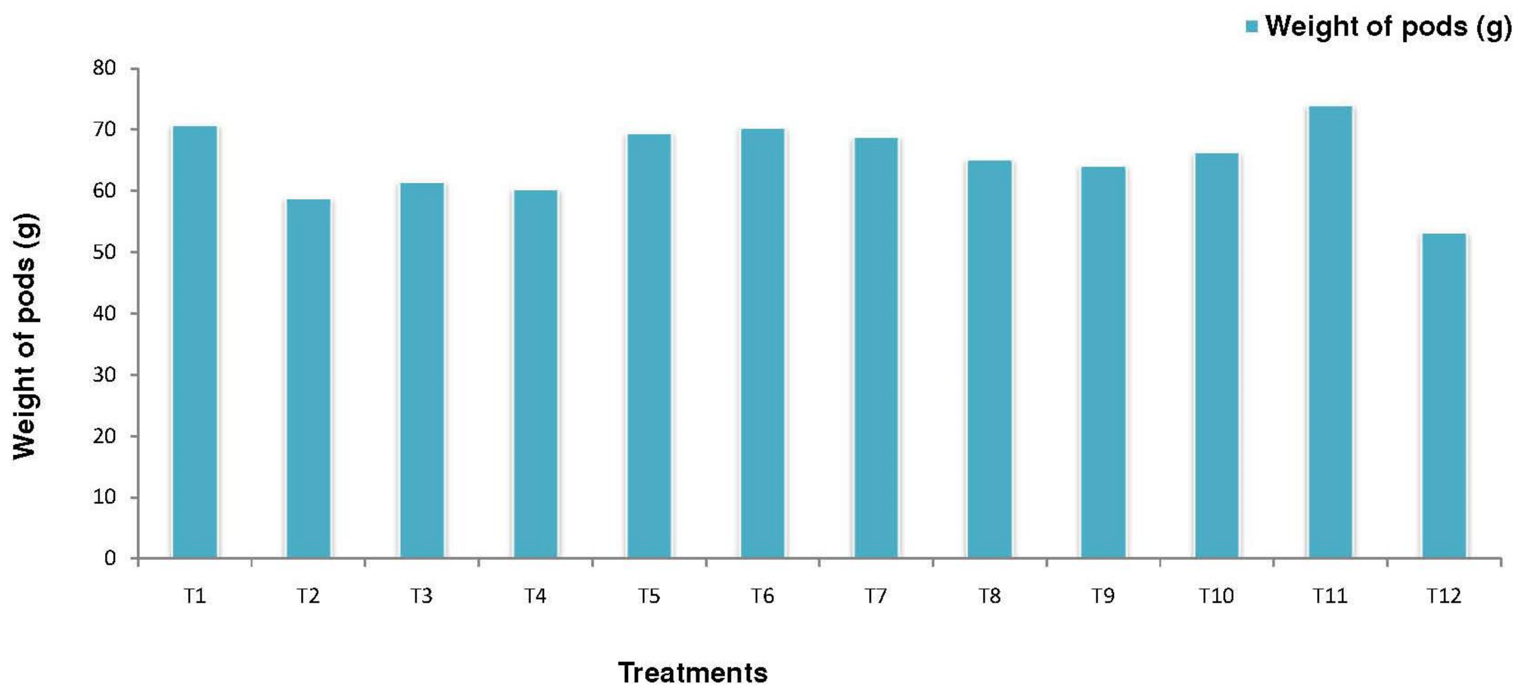

Fig. 12. Weight of pods (g) as influenced by organic nutrient management

The data presented in the Table 14 and depicted in Fig.12. Indicated that, there was a significant influence on weight of pods (g) by various treatments of Organic Nutrient Management.

Weight of pods was found maximum under the treatment T_{11} (74.01 g) which is significantly superior over other remaining treatments followed by T_1 (70.80 g), T_6 (70.30 g), T_5 (69.40 g), T_6 (70.30 g) and T_7 (60.80 g) were found to be statistically at par with each other. The minimum weight of pods found in treatment T_{12} (53.20 g).

The positive increase in relation to yield and yield attributes might be due to superior rate of carbohydrates in reproductive parts of the plant. In conformity with the findings by, Nagar and Meena (2004) in cluster bean, Patel and Patel (1998) and Namdeo and Gupta (1999) in pigeonpea.

4.3.7 Pod yield per plot (kg)

The data presented in the Table 15 and depicted in Fig.13 indicated that, there was a significant influence on a pod yield per plot (kg) by various treatments of Organic Nutrient Management.

From the data presented in the Table 15 reveals that, pod yield per plot (kg) was significantly maximum in T_{11} (1.78 kg) receiving application of (100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation),followed by treatment T_1 (1.70 kg), T_6 (1.69 kg), T_5 (1.67 kg) and T_7 (1.65 kg) which were statistically at par with each other and superior over rest of the treatments. Whereas, treatment T_{12} recorded lowest (1.28 kg) yield per plot.

The additive effect of biofertilizers, might have provided better soil conditions inclusive of improved soil fertility, nitrogen fixation, phosphate solubilization, enhanced the efficacy of applied N and P, are enhanced the activities of other microbes and also release of growth stimulants and many more conversion of insoluble phosphate into soluble form increased in the yield and yield attributes due to translocation of photosynthates. This might be attributed to the increased photosynthetic activities, translocation and accumulation of photosynthates from source to

Table 15. Pod yield per plot (kg) as influenced by organic nutrient management

Treatments	Pod yield per plot (kg)
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	1.70
T_2-100% RDF through FYM (3t ha^{-1})	1.41
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	1.48
T_4-100% RDF through Neemcake (0.5t ha^{-1})	1.45
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	1.67
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	1.69
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	1.65
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	1.56
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	1.58
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	1.54
T_{11}-100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	1.78
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	1.28
'F' Test	**Sig**.
SE (m) ±	0.056
CD @ 5%	0.166

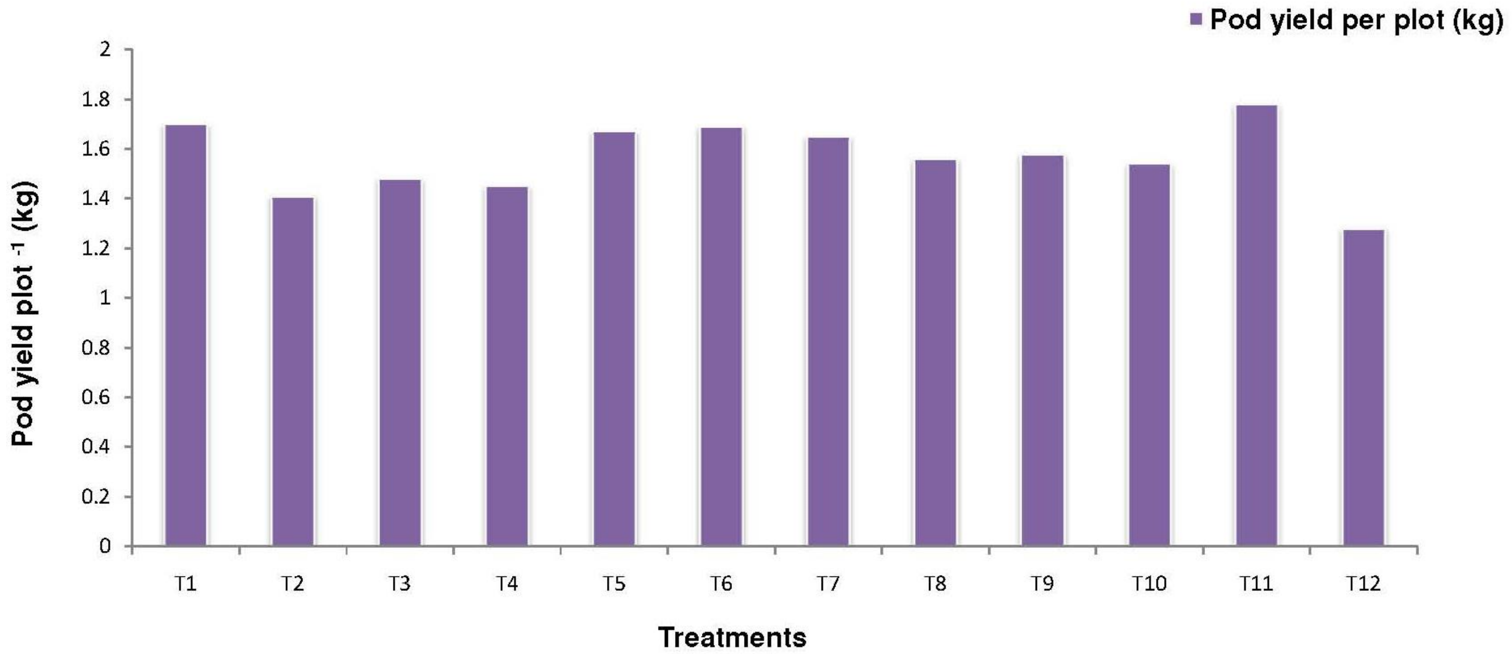

Fig. 13. Pod yield per plot (kg) as influenced by organic nutrient management

the developing seeds resulting into increase in weight of pods per plant. Efficacy of the inorganic fertilizer was pronounced when they are combined with biofertilizers. These results are in agreement with those of Noor *et al*. (1992) in hyacinth bean and Dwivedi *et al*. (2002) in dolichos bean, De *et al*. (2006) in vegetable pea and Reddy (2012) In cluster bean.

4.3.8 Pod yield (q ha^{-1})

The data presented in the Table 16 and depicted in Fig.14 indicated that, there was a significant influence on yield per ha^{-1} by various treatments of Organic Nutrient Management.

The significantly maximum (54.86 q ha^{-1}) yield ha^{-1} was recorded with the treatment T_{11} receiving application of (100% RDF through (25:50:50kg NPK ha^{-1}) + Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation),which was statistically at par with the treatment T_1 (52.44 q ha^{-1}), T_6 (52.05 q ha^{-1}) T_5 (51.41 q ha^{-1}), and T_7 (50.96 q ha^{-1}). Whereas, minimum (39.38 q ha^{-1}) yield ha^{-1} was recorded in treatment T_{12}.

The significant improvement in yield attributes of Cluster bean was due to nitrogen and phosphorus fertilization combined with bioinoculants. This might be due to fact that *Rhizobium* inoculation increased the root volume through better root development, nodulation, more nutrient availability resulting in vigorous plant growth and dry matter production which in turn resulted in better flowering, pod formation and ultimately pod yield. Since, PSB may helps in reducing phosphorus fixation by its chelating effect and also solubilized the fixed phosphorus leading to more uptakes of nutrients and reflected in better yield attributes. The results of present investigation are in conformity with those of Rajput and Singh (1996), Gandhi *et al*. (1991) and Mishra and Baboo (2002) in cowpea.

Table 16. Pod yield per hector (q ha^{-1}) as influenced by organic nutrient management

Treatments	Pod yield per hector (q ha^{-1})
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	52.44
T_2-100% RDF through FYM (3t ha^{-1})	43.56
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	45.53
T_4-100% RDF through Neemcake (0.5t ha^{-1})	44.69
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	51.41
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	52.05
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	50.96
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	47.88
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	48.86
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	47.46
T_{11}-100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	54.86
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	39.38
'F' Test	**Sig.**
SE (m) ±	1.718
CD @ 5%	5.071

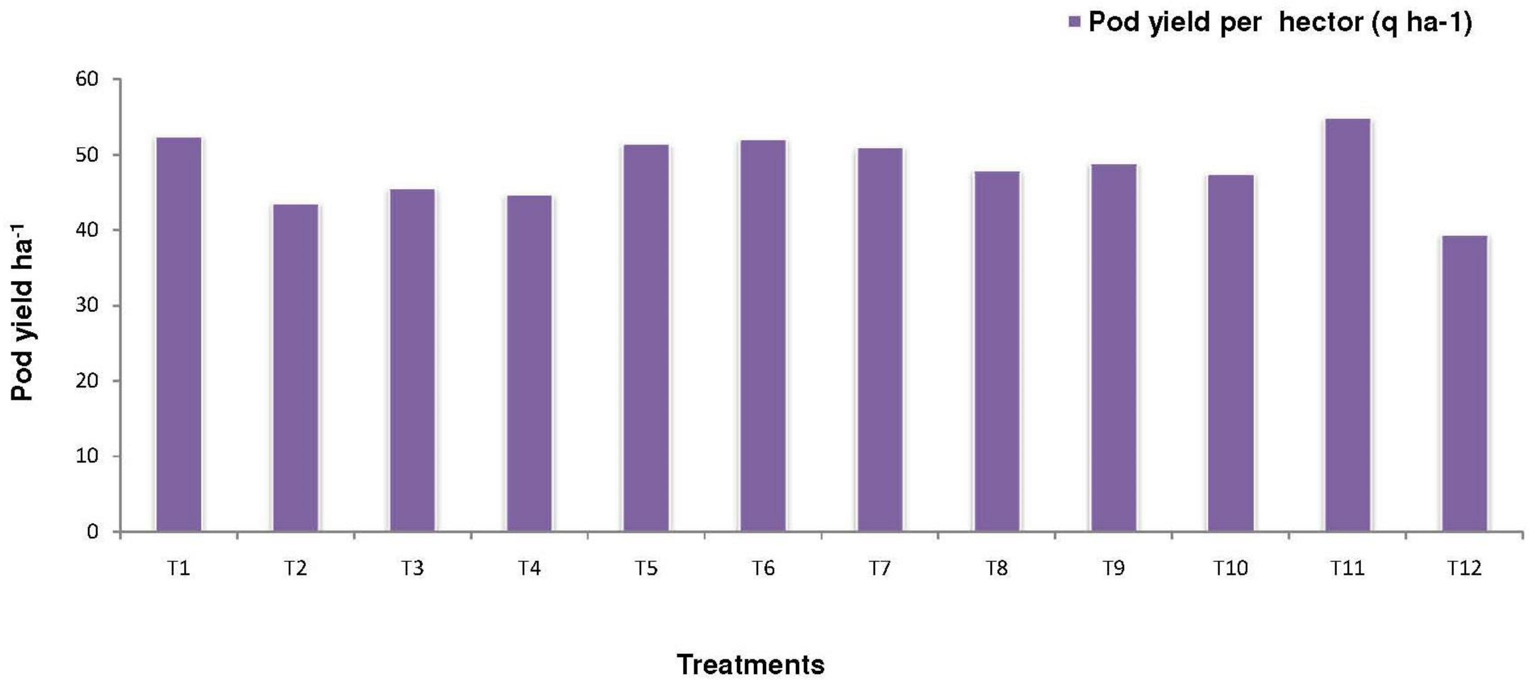

Fig. 14. Pod yield per hector (q ha^{-1}) as influenced by organic nutrient management .

4.3.9 Number of seeds pod^{-1}

. The data presented in the Table 17 and depicted in Fig.15 indicated that, there was a significant influence on seeds pod^{-1} by various treatments of Organic Nutrient Management.

The significantly maximum (6.33 seeds pod^{-1}) number of seeds pod^{-1} was recorded with the treatment T_{11} receiving application of (100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation), which was statistically at par with the treatment T_1(6.07 seeds pod^{-1}),T_6 (6 seeds pod^{-1}) and T_7 (5.67 seeds pod^{-1}). Whereas, minimum (4.33 seeds pod^{-1}) seeds per pod was recorded in treatment T_{12} i.e. application of Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation).

This might be attributed due to increased photosynthetic activities, translocation and accumulation of photosynthetic from source to the developing sinks (seeds) resulting into the higher yield of bolder and heavier seeds. The significant increase in biological yield with the application of nitrogen and phosphorus could be ascribed to increased seed and straw yields. The results of present investigation are in conformity with those of Rajput and Singh (1996), Gandhi *et al*. (1991) and Mishra and Baboo in cowpea (2002), Noor *et al*. (1992) in hyacinth bean, Sammauria *et al*. (2009) in cluster bean and Ganie *et al*. (2010) in cowpea.

Table 17. Number of seeds per pod as influenced by organic nutrient management

Treatments	Number of seeds pod^{-1}
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	6.07
T_2-100% RDF through FYM (3t ha^{-1})	5.20
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	5.40
T_4-100% RDF through Neemcake (0.5t ha^{-1})	5.30
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	5.77
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	6.00
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	5.67
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	5.47
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	5.63
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	5.43
T_{11}-100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	6.33
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	4.33
'F' Test	**Sig**
SE (m) ±	0.235
CD @ 5%	0.690

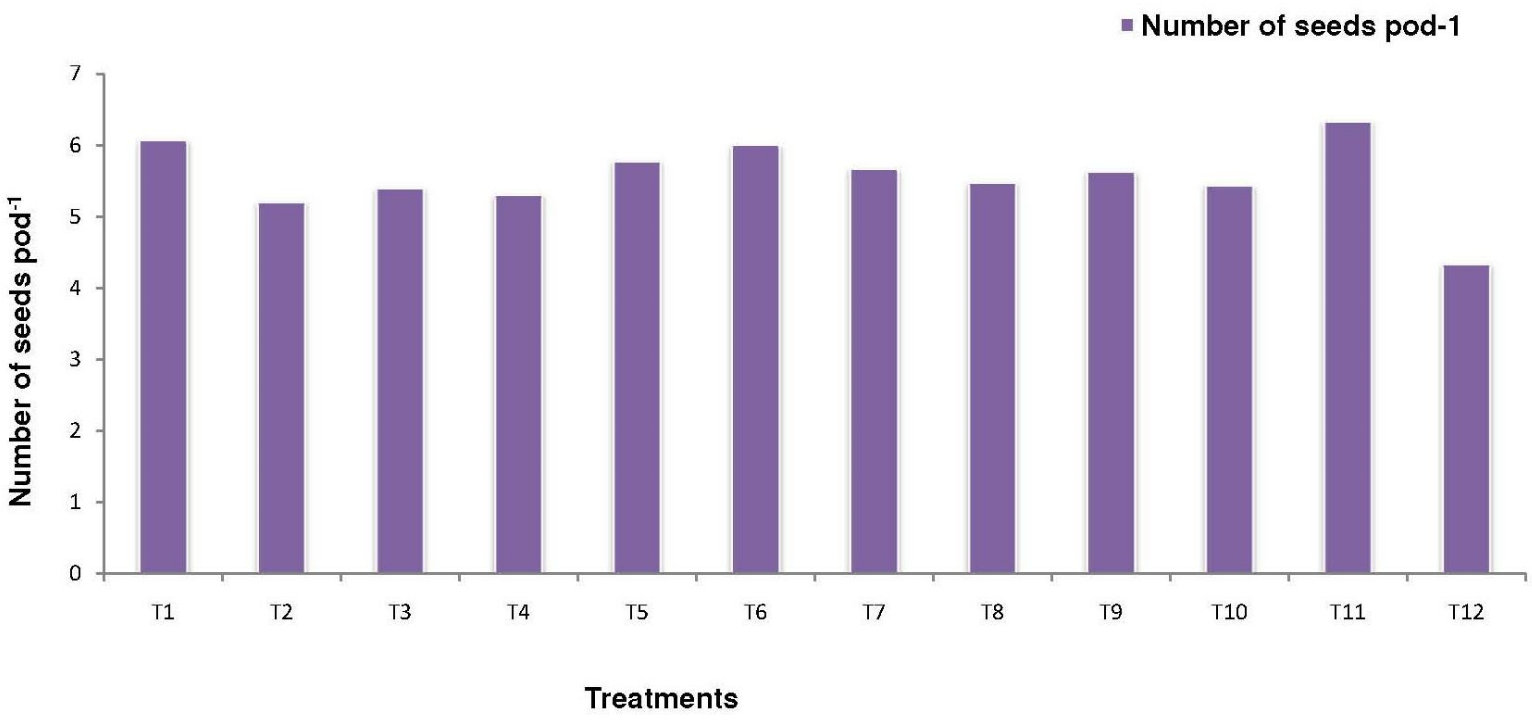

Fig. 15. Number of seeds pod^{-1} as influenced by organic nutrient management

4.4 Quality Parameters

4.4.1 Protein Content (%)

The data presented in the Table 18 and depicted in Fig. 16. indicated that, there was a significant influence on protein content (%) by various treatments of Organic Nutrient Management.

Table 18. Protein content (%) as influenced by organic nutrient management

Treatments	Protein content (%)
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	22.17
T_2-100% RDF through FYM (3t ha^{-1})	18.74
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	19.81
T_4-100% RDF through Neemcake (0.5t ha^{-1})	19.32
T_5-100% RDF through FYM (3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	21.36
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	21.87
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	21.12
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	20.83
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	20.96
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	20.00
T_{11}-100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	22.50
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	16.88
'F' Test	Sig.
SE (m) ±	0.790
CD @ 5%	2.317

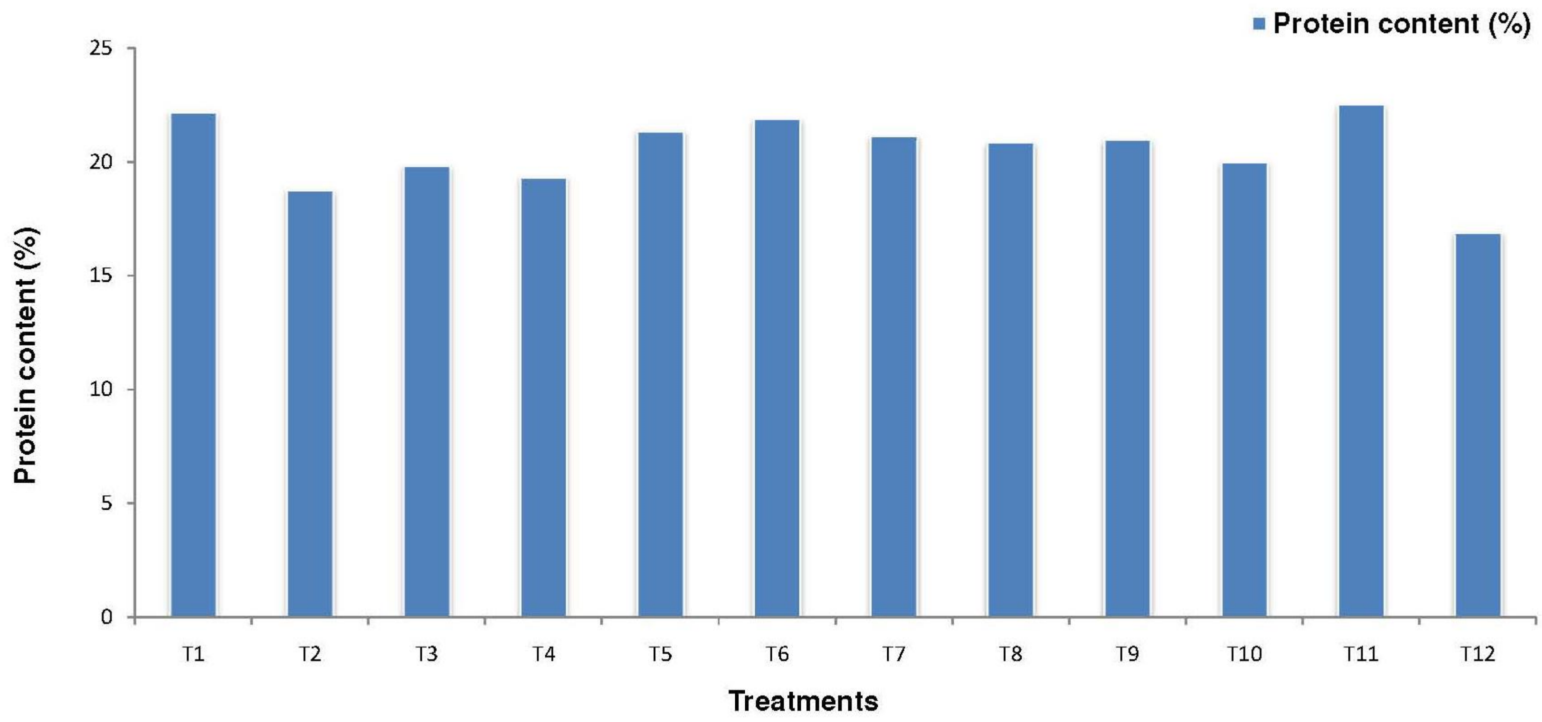

Fig. 16. Protein content (%) as influenced by organic nutrient management

The data presented in Table 18 revealed that, the protein content % of pod was significantly maximum (22.50%)in the treatment T_{11}.i.e. receiving application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation), followed by treatment T_1 (22.17%),T_5 (21.36%), T_6(21.87%) and T_7 (21.12%) which were statistically at par with each other and superior over rest of the treatments. whereas, treatment T_{12} recorded minimum (16.88%) protein content in pod.

Increase in the protein content may be due to the application of chemical fertilizers with biofertilizers attributed to the favorable influence of these nutrient on metabolism and biological activity and its stimulating effect on photosynthetic pigments and enzyme activity, which is favoured better cell division and elongation, amino acid and protein synthesis, vegetative growth and yield of plants and consequently protein content percent. Higher nitrogen in green pod is directly responsible for higher protein because it is a primary component of amino acids which constitute the basis of protein content, similar results were obtained by Pawar and Pawar (1998), and Mishra (2003) in cowpea.

4.5 Soil and Plant Analysis

4.5.1 Soil analysis

The data presented in the Table 19 and depicted in Fig. 17. indicated that, the nutrient status of NPK in the soil after harvest was significantly influenced by various combinations of chemical fertilizers and biofertilizers, organic manure in organic nutrient management system.

The significantly maximum (221.34 kg ha^{-1} and 25.40 kg ha^{-1}) nitrogen and phosphorus was observed in the soil with the treatment T_{11} receiving application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation), after harvest, which was also found to be statistically at par with treatment T_1 (217.47 and 25.34 kg ha^{-1}), T_5 (209.48 and 24.24 kg ha^{-1}), T_6 (216.86 and 24.71 kg ha^{-1}) and T_7 (207.57 and 23.67 kg ha^{-1}). Whereas, minimum (167.19 and 17.58 kg ha^{-1}) nitrogen and phosphorus was recorded in the soil after harvest in the treatment T_{12} i.e. application of Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation).

Table 19. Available soil NPK after harvest (kg ha^{-1})

Treatments	Available soil nitrogen after harvest (kg ha^{-1})	Available soil phosphorus after harvest (kg ha^{-1})	Available soil potassium after harvest (kg ha^{-1})
T_1	217.47	25.34	372.34
T_2	183.83	18.21	333.67
T_3	188.65	19.53	340.30
T_4	185.35	18.93	326.97
T_5	209.48	24.24	367.45
T_6	216.86	24.71	371.63
T_7	207.57	23.67	364.15
T_8	195.95	20.50	355.95
T_9	200.37	21.30	359.11
T_{10}	193.77	19.87	349.95
T_{11}	221.34	25.40	374.71
T_{12}	167.197	17.58	326.97
'F' Test	**Sig.**	**Sig**.	**Sig**
SE (m) ±	6.95	0.79	10.665
CD @ 5%	20.40	2.35	31.481

Significantly maximum (374.71 kg ha^{-1}) potash was recorded in the treatment T_{11}, receiving application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation),which was found to be statistically at par with T_1 (72.34 kg ha^{-1}). Whereas, minimum (326.97 kg ha^{-1}) Potash was recorded in T_{12} i.e. application of Rhizobium

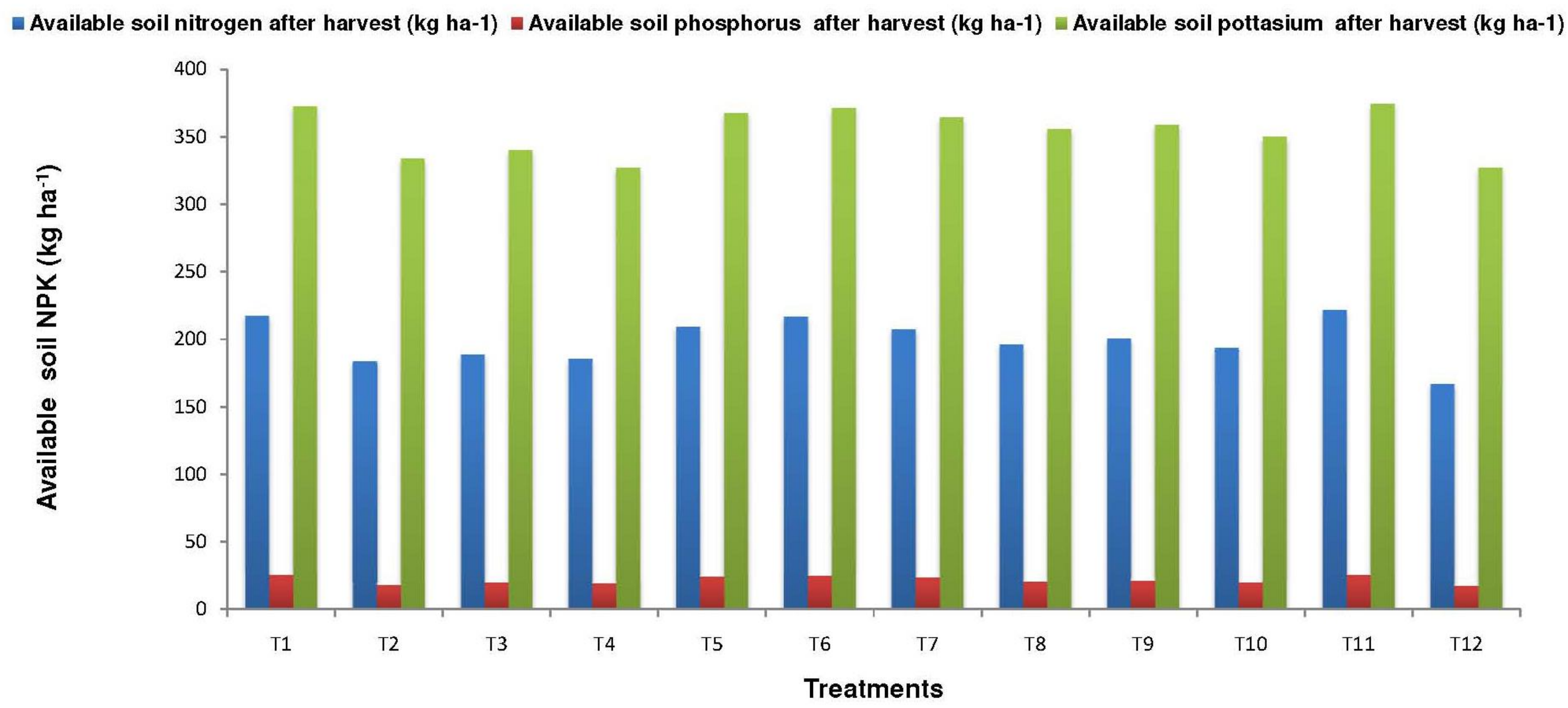

Fig. 17. Available soil NPK after harvest (kg ha^{-1})

(25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10 gm kg^{-1} of seed inoculation).

It was observed that availability of Nitrogen, phosphorus and potassium contents of soil was influenced by organic and inorganic nutrient sources and combination of both sources. Improvement in available NPK nutrient contents in soil was noticed in the organic nutrient management treatments having higher proportion of organic manures, recommended dose of chemical fertilizers along with support of biofertilizers. This may be attributed to delayed mineralization and also release of nutrients through organic manures and biological fixation of Nitrogen by Rhizobium and mobilization of phosphorus by PSB in soil. These results are in conformity with the findings of Jaipul *et al.* (2011) in capsicum and Singh and Singh (1990) in cluster bean.

4.5.2. Uptake of NPK by cluster bean plant (kg ha^{-1})

From the data presented in Table 20 and depicted in Fig. 18. it is revealed that, the uptake of major nutrients like Nitrogen, Phosphorus and Potassium was significantly influenced by various combination of chemical fertilizers, organic manures and biofertilizers in organic nutrient management.

The significantly maximum (60.08, 17.1 and 30 kg ha^{-1} respectively.) NPK uptake by cluster bean plant was recorded in the treatment T_{11} receiving application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation),followed by treatments T_1 (59.4, 16.7 and 29.2 kg ha^{-1}), T_6 (57, 16 and 28.5 kg ha^{-1}) and T_5 (56.7, 15.6 and 28 kg ha^{-1}) respectively, which were found to be statistically at par with each other and significantly superior over rest of the treatments. While, treatment T_{12} (47.8, 10.7 and 20.5 kg ha^{-1} respectively) recorded minimum uptake of NPK. The lower uptake of NPK with the sources of low NPK content in treatment T_{12} i.e. application of only biofertilizers recorded lowest uptake and yield.

Table 20. Uptake of NPK by cluster bean plant (kg ha^{-1}) as influenced by organic nutrient management

Treatments	N uptake by plant (kg ha^{-1})	P uptake by plant (kg ha^{-1})	K uptake by plant (kg ha^{-1})
T_1	59.4	16.7	29.2
T_2	52.6	11.7	21.7
T_3	53.7	13.0	23.3
T_4	53.1	12.3	23.0
T_5	56.7	15.6	28.0
T_6	57.0	16.0	28.5
T_7	56.0	14.5	26.9
T_8	55.0	13.5	27.0
T_9	55.6	14.3	27.8
T_{10}	54.7	13.2	25.2
T_{11}	60.8	17.1	30.0
T_{12}	47.8	10.7	20.5
'F' Test	**Sig**.	**Sig**.	**Sig**.
SE (m) ±	1.72	0.757	1.041
CD @ 5%	5.08	2.220	3.074

Integration of inorganic fertilizers along with bio fertilizers of plant nutrient elements results in more uptake of them as compared to sole use of in organics alone. This may be due to fact that the balanced and combined use of various plant nutrient sources results in proper absorption, translocation and assimilation of those nutrients, ultimately increasing the dry matter accumulation and nutrient contents of plant and thus showing more uptake of elemental nutrients. Combined application of chemical fertilizers and biofertilizers proportionately increases the NPK uptake and yield as result of increases NPK content and the plant yield is positively correlated.

The favorable effect of N is promoting the growth parameters such as plant height, number of leaves might be due to the plant was accelerated by their increased chlorophyll content and the absorbed N

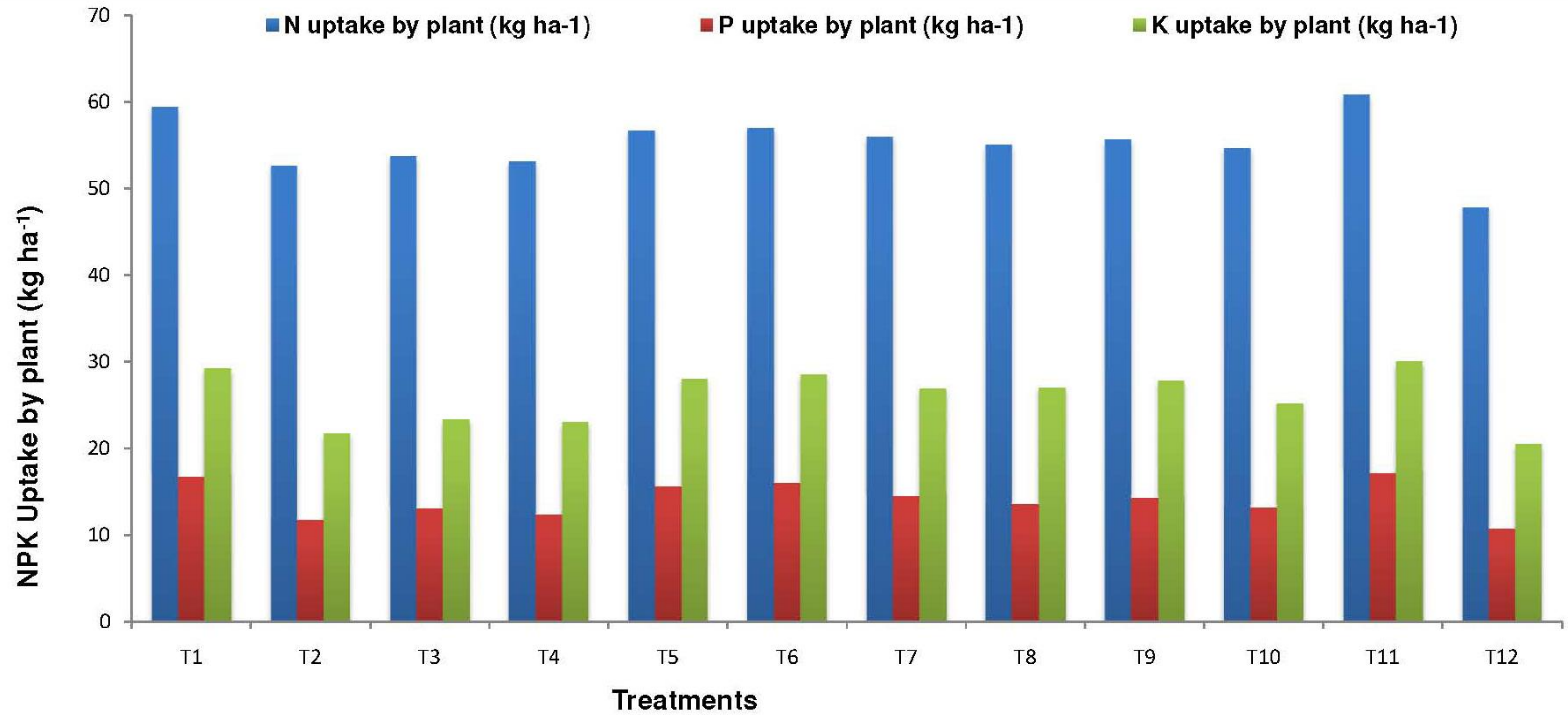

Fig. 18. Uptake of NPK by cluster bean plant (kg ha^{-1}) as influenced by organic nutrient management

helped the formation of food reserve due to higher photosynthetic activity which improved carbohydrate content. (Kumar *et al.* 1997). The application of nitrogen increased in the concentration of nitrogen in plant tissue and the total fresh herbage yield, which ultimately led to the increased uptake of nitrogen (Singh *et al.* 1997).

The increment in P% in plant tissues as a result of biofertilizers which secrete organic acids leading to transfer fixed phosphate to available phosphate. In addition, the increased available phosphorus in the root zone, which increase p uptake (Burger *et al.*1997) the results are in conformity with the findings of Meena and Meena (2002) and Singh and Singh (1990) in cluster bean, Sammauria *et al.* (2009) in cluster bean and Hasan and Abdelgani (2009) in lablab bean.

The increase of root size as result of the increment in root length may explain these increases in potassium percentage. Therefore, it may be attributed to higher available potassium status at the exchangeable and non exchangeable sites, having high cation exchange capacity of soil. The results are in conformity with the findings of Mali (2009) in soybean and Singh (1990) in cluster bean.

The data presented in the Table 21 reveales that, highest net monetary returns (Rs 66557) of cluster bean crop production in one hectare area was recorded in T_{11} i.e. application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation), closely followed by treatment $T_{1,}$ this recorded net return (Rs 62018). Whereas, lowest net returns has recorded in treatment T_{12} (Rs 24955) i.e. application of Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation).

Higher net returns were obtained when the crop was grown with application of inorganic fertilizers, organic manures combined with biofertilizers.

Table 21. Cost economics as influenced by organic nutrient management

Treatments	Gross returns (RS ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net Returns (Rs ha^{-1})	B:C Ratio
T_1- 100% RDF(25:50:50 kg ha^{-1} NPK) (check)	104889	42870.61	62018	2.45
T_2-100% RDF through FYM (3t ha^{-1})	87111	50310.61	36500	1.72
T_3-100% RDF through Vermicompost (2.5t ha^{-1})	44603	53810.61	44603	1.90
T_4-100% RDF through Neemcake (0.5t ha^{-1})	89382	50310.61	42372	1.89
T_5-100% RDF through FYM (3t ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	102814	50610.61	51615	2.06
T_6-100% RDF through Vermicompost (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	104098	54110.61	53488	2.19
T_7-100% RDF through Neemcake (0.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} seed inoculation)	101926	50610.61	49451	2.03
T_8-75% OF FYM (2.5t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	95753	49110.61	47117	1.95
T_9-75% RDF through Vermicompost (1.8t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha-1 of soil application and 10gm kg^{-1} of seed inoculation)	977286	50610.61	48704	1.93
T_{10}-75% RDF through Neemcake (0.3t ha^{-1})+Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of inoculation)	949138	47010.61	46642	1.90
T_{11}-100% RDF through (25:50:50kg NPK/ha)+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	109728	43170.61	66557	2.54
T_{12}-Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation)	786512	41610.61	24955	1.46

Highest gross returns (Rs 109728 ha^{-1}) and net returns (RS 66557 ha^{-1}) were recorded with application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) is due to higher yield and higher net return obtained with comparatively lesser increase in cost of cultivation.

However, it is evident from the data presented in Table 23. that, highest B:C ratio (2.54) was recorded with the application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) i.e. treatment T_{11}. Whereas, lowest B:C ratio (1.46) was recorded with the T_{12} i.e. application of Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) i.e. application of only biofertilizers.Highest B:C ratio obtained when the crop was grown with application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation), is due to considerable higher net return obtained compared to little cost increased on biofertilizers coupled with high yields.

CHAPTER V

SUMMARY AND CONCLUSION

The present investigation entitled "Organic Nutrient Management in Cluster bean" was carried out, at instructional farm, Department of Vegetable Science, Faculty of Horticulture. Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *summer* season of 2018.

The experiment was conducted in a Randomized block design with three replications using cv. Phule Guar, and 12 treatments, *viz.,* three kinds of Organic manures (FYM ,VC and Neem cake) alone and in combination with two kinds of bio-fertilizers (Rhizobium and PSB) and applied recommended dose of chemical fertilizers alone or in combination with bio-fertilizers were tested. The results of the experiment are briefly summarized here under.

1. All the growth parameters like plant height, number of leaves, leaf area etc., increased significantly with recommended dose of chemical fertilizers in combination with bio-fertilizers compared to the exclusive application of organic manures, chemical fertilizers and combined application of both. The plant height was observed to be maximum throughout the growth period (29, 38.50 and 54.93 cm at 45, 60 and 75 DAS respectively) with application of 100% RDF through (25:50:50kg NPK ha^{-1}) + Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) i.e. T_{11}. Whereas, minimum plant height was recorded in the T_{12} i.e. application of Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) (24.60, 29.57 and 42.90 cm DAS).
2. The number of leaves was recorded to be maximum (9.70, 17.22 and 27 leaves plant $^{-1}$DAS) with T_{11} receiving application of 100% RDF through (25:50:50kg NPK ha^{-1}) + Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation). Whereas minimum number of leaves was recorded in the treatment T_{12} i.e. Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg

ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) (8.38, 17.22 and 20.75 leaves plant^{-1} DAS).

3. The leaf area was recorded to be maximum (21.5 cm^2 at 60 DAS, respectively) with application of 100% RDF through (25:50:50kg NPK ha^{-1}) + Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) i.e. treatment T_{11}. Whereas, minimum leaf area (15.4 cm^2 DAS) was recorded in the treatment T_{12} i.e. Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation).
4. In respect of number of days to initiation of flowering of cluster bean, the treatment T_{11} i.e.100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) recorded significantly minimum (32.40 days) number of days to initiation of flowering which was statically at par with treatment T_1 (33 days) and superior to the rest of the treatments. While, maximum days to initiation of flowering (35 days) was recorded in the treatment T_{12} i.e. Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation).
5. In respect to number of days to 50% flowering, the significantly minimum number of days (40 days) was recorded in the treatment T_{11} i.e.100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) which was statistically at par with the treatment T_1 and T_5 and superior to the rest of the treatments. While, maximum number of days to 50 % flowering was recorded (45 days) in the treatment T_{12}.
6. Among the yield attributes, same trend was observed for number of clusters plant^{-1}. Significantly maximum number of clusters plant^{-1} (11.13 cluster plant^{-1}) was recorded in treatment T_{11} i.e. 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) which was statistically at par with the treatment T_{11} and T_5 and superior over

rest of the treatments. Whereas, the minimum number of clusters plant^{-1} (8.97 clusters plant^{-1}) was observed in the treatment T_{12}.

7. Significantly, maximum number of pods cluster^{-1} (8.33 pods cluster^{-1}) was also obtained in treatment T_{11} by application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) followed by treatment T_1 and T_6 which were found statistically at par with each other and superior over rest of the treatments. However, the minimum number of pods cluster^{-1} (6.90 pods cluster^{-1}) was observed in the treatment T_{12}.

8. As regard to the number of pod plant^{-1}, significantly maximum (84.77 pods plant^{-1}) was recorded in the treatment T_{11} by the application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) followed by treatment T_1,T_5 ,T_6 and T_7 which were statistically at par with each other and superior over rest of the treatments. Whereas, the lowest (60.57 pods plant^{-1}) was recorded in the treatment T_{12}.

9. As regard to pod length of cluster bean, treatment T_{11} i.e. plants supplied with 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) recorded maximum (6.09 cm) pod length which is followed by treatment T_1 (6.01 cm) which was at par with each other and superior over rest of the treatments. However, lowest (4.83cm) pod length was recorded in treatment T_{12}.

10. Plant supplied with 100% RDF through (25:50:50 kg NPK ha^{-1}) + Rhizobium (25g kg^{-1} of seed inoculation) +PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) i.e. treatment T_{11} recorded maximum (0.73 cm) pod width. Which was found statistically at par with treatment T_1 (0.68 cm). Whereas, lowest (0.42 cm) pod width recorded in treatment T_{12}.

11. As regard to the weight of pods per plant, significantly highest (74.01 g) was obtained in treatment T_{11} by the application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) followed by treatment $T_{1,}$ T_5, T_6 and T_7 which were at par with each other and superior over rest of the treatments. Whereas, it was lowest (53.20 g) in treatment $T_{12.}$

12. The pod yield $plot^{-1}$ (kg) significantly maximum (1.78 kg) was recorded in the treatment T_{11} receiving application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation), followed by treatment T_1, T_6 and T_7 which were at par with the each other and superior over rest of the treatments. Whereas, treatment T_{12} recorded lowest (1.28 kg) yield $plot^{-1}$.

13. As regard to pod yield $hectar^{-1}$, significantly maximum (54.86 q ha^{-1}) yield per hectare was recorded with the treatment T_{11} receiving application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation), followed by treatment T_1 (52.44 q ha^{-1}), T_5, T_6 and T_7 which were at par with each other and superior over rest of the treatments. Whereas, minimum (39.38 q ha^{-1}) yield ha^{-1} was recorded in treatment T_{12}.

14. As regard to the number of seeds $plant^{-1}$ significantly maximum no of seeds (6.33 seeds pod^{-1}) obtained in treatment T_{11} by application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation),followed by T_1 (6.07 seeds pod^{-1}), T_6 and T_7 which were found statistically at par with each other and superior over rest of the treatments. However, the minimum number of seeds (4.44 pod^{-1}) was recorded in the treatment T_{12}.

15. In respect to protein content of pod significantly maximum (22.50 %) was recorded in the treatment T_{11} receiving application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed

inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation), followed by treatment T_{11} (22.17 %), T_5, and T_6 which were at par with each other and superior over other treatments. Whereas, treatment T_{12} recorded maximum (16.88 %) protein content in pod.

16. Available Nitrogen, Phosphorus and Potash in the soil after harvest of cluster bean crop was recorded highest (221.34, 25.40 and 374.41 NPK kg ha^{-1} respectively) in the treatment T_{11} application of 100% RDF through (25:50:50kg NPK ha^{-1}) + Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation). Whereas minimum Nitrogen, Phosphorus and Potash (167.197, 17.58 and 326.97 kg ha^{-1} respectively) recorded in treatment T_{12}.
17. The highest uptake of Nitrogen, Phosphorus and Potash by cluster bean plant was recorded maximum in the treatment T_{11} (60.08, 17.1 and 30 kg ha^{-1} respectively). Whereas minimum Nitrogen, Phosphorus and Potash by cluster bean plant was recorded in the treatment T_{12} (47.8, 10.7 and 20.5 kg ha^{-1} respectively).
18. Highest net monetary returns and with the highest B:C ratio (Rs 66557 and 2.54) of cluster bean crop production in one hectare area was recorded in treatment T_{11} with application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) lowest net returns, benefit cost ratio (Rs 24955 and 1.46) was observed with treatment T_{12} i.e. Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation).However, lowest B:C ratio (1.46) was recorded with T_{12} i.e. application of biofertilizers only.

Conclusion

In light of the experimental findings summarized above, it may be concluded that, organic nutrient management in cluster bean plant application of chemical fertilizers in combination with biofertilizers recorded numerically positive effects on growth, yield and quality of cluster bean. The biofertizers and organic fertilizers as are low in nutrient content, so larger volume is needed to provide enough and required optimum quality of nutrients for crop growth. Besides nutrient release rate is to slow to meet crop requirement in short time, hence chemical fertilizers are rapidly taken up by plants, and it is available to the plants at proper time of their growth habit.

On the basis of results, it could be concluded that, treatment T_{11} i.e. the application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) to the cluster bean crop found to be significantly superior in respect growth yield and quality parameters. Where it recorded maximum plant height (54.93 cm at 75 DAS), number of leaves (27 at 75 DAS), leaf area (21.5 cm^2), number of clusters $plant^{-1}$ (11.13), no of pod $cluster^{-1}$ (8.33), no of pod $plant^{-1}$ (84.77), weight of pod (74.01 g), pod yield $plot^{-1}$ (1.78 kg), pod yield q ha^{-1} (54.86 q ha^{-1}), pod length (6.09 cm), pod width (0.73 cm), maximum final nutrient status after harvest (221.34, 25.40 and 374.71 kg ha^{-1} nitrogen, phosphorus and potash respectively.) and maximum uptake of major nutrients (64.09, 17.1 and 30 kg ha^{-1} nitrogen, phosphorus, potash respectively).

Minimum days to initiation of flowering (32.40 days), days to 50% flowering (40 days). All above the observations are superior over other treatments.

Maximum (22.50 %) protein content was recorded in T_{11} i.e. application of 100% RDF through (25:50:50kg NPK ha^{-1}) + Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation).

From the overall assessment of results obtained, it may be concluded that, treatment T_{11} i.e. application of 100% RDF through (25:50:50kg NPK ha^{-1})+ Rhizobium (25g kg^{-1} of seed inoculation)+PSB (5kg ha^{-1} of soil application and 10gm kg^{-1} of seed inoculation) Proved economically better as gave highest net profit (Rs 66557) and B:C ratio (2.54) for producing higher yield of cluster bean plant.

The observations are based on the result of experiment conducted for only one season and therefore these results are suggestive and not conclusive. The findings obtained in the present investigations need further confirmation for final recommendations by repeated the trial at least for three consequent seasons

CHAPTER VI

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Appendix

Weekly Weather data for the year 2018 recorded at Meteorological Observatory Department of Agronomy Dr. PDKV., Akola

		Actual				2018										Normal		1971-2000		
Weeks	Dates	T MAX (oC)		T MIN (oC)		BSH (hrs)		WS (km/hr)		RH I (%)		RH II (%)		Evap (mm)		RF (mm)		CRF (mm)	Rainy Days	
		N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A		N	A
5	29-4 Feb	31.1	32.4	12.1	10.9	9.3	8.7	5.8	1.0	61	58	25	15	5.6	6.7	2.8	0.0	0.0	0.2	0.0
6	5-11	31.3	32.3	11.9	16.0	9.1	5.8	5.6	1.9	59	48	23	20	5.9	7.4	4.9	0.0	0.0	0.4	0.0
7	12-18	32.5	29.9	13.4	14.9	9.4	6.1	6.1	3.9	56	70	22	35	6.6	6.6	0.1	0.7	0.7	0.0	0.0
8	19-25	33.0	35.5	13.8	17.9	9.5	8.0	6.5	1.7	57	48	22	18	7.3	7.4	3.3	0.0	0.7	0.5	0.0
9	26-4 Mar	34.7	37.3	14.8	18.5	9.6	8.1	7.0	1.7	50	40	17	13	8.1	7.6	3.4	0.0	0.7	0.3	0.0
10	5-11	36.1	36.7	16.7	22.1	9.6	5.9	6.8	4.0	44	37	18	20	9.0	8.9	2.1	3.0	3.7	0.3	1.0
11	12-18	37.3	34.7	17.5	20.3	9.6	4.8	6.9	2.5	42	56	17	18	9.5	7.3	2.5	0.4	4.1	0.3	0.0
12	19-25	38.5	37.7	18.3	20.4	9.6	8.7	6.9	3.3	37	36	13	14	10.5	10.2	0.3	0.0	4.1	0.1	0.0
13	26-1 Apr	39.0	41.1	19.7	20.0	9.6	9.2	7.6	3.2	36	27	15	7	11.3	11.1	2.9	0.0	4.1	0.3	0.0
14	2-8 Apr	40.1	40.9	21.1	22.7	9.8	7.7	7.9	2.4	36	27	15	11	11.7	10.1	0.6	0.0	4.1	0.1	0.0
15	9-15	40.8	40.4	22.5	24.5	9.9	8.6	9.3	2.9	34	45	12	16	13.4	10.4	0.3	0.3	4.4	0.1	0.0
16	16-22	41.7	42.3	23.5	27.8	10.2	9.9	9.1	5.6	34	30	14	12	13.7	13.8	0.3	0.0	4.4	0.0	0.0
17	23-29	42.1	42.9	24.8	26.4	10.1	10.1	10.2	3.8	37	28	14	7	14.4	11.7	0.0	0.0	4.4	0.1	0.0
18	30- 6 May	42.7	43.5	26.0	28.8	9.9	9.8	11.4	7.7	38	37	14	13	15.4	14.4	0.3	0.0	4.4	0.2	0.0
19	7-13	42.6	43.7	26.5	29.3	10.1	9.4	12.7	6.3	43	30	17	11	16.4	14.9	0.3	0.5	4.9	0.1	0.0
20	14-20	42.6	43.5	27.3	31.1	9.7	8.0	14.6	6.9	48	34	18	14	17.3	14.9	1.8	0.0	4.9	0.2	0.0
21	21-27	42.4	44.3	27.4	31.1	9.8	7.6	15.7	8.8	50	41	20	18	17.0	15.0	4.1	0.0	4.9	0.5	0.0
22	28-3 Jun	41.9	43.1	27.6	29.5	9.7	8.0	16.2	8.8	56	50	23	23	16.3	14.5	5.7	8.5	13.4	0.5	1.0
23	4-10	39.0	37.5	25.8	25.5	8.0	4.0	14.9	10.7	62	73	30	44	13.4	11.2	18.3	72.5	85.9	1.2	2.0
24	11-17	38.2	37.7	25.5	26.5	7.5	6.2	15.4	12.9	71	66	42	31	11.1	10.8	43.3	17.5	103.4	2.0	2.0
25	18-24	35.3	36.0	24.9	24.6	7.1	7.2	15.1	6.5	76	80	50	49	9.1	9.5	52.3	83.1	186.5	2.2	3.0
26	25-1Jul	34.1	32.3	24.2	23.7	5.3	3.9	13.4	5.8	80	86	55	56	7.3	6.4	38.2	111.0	297.5	2.3	5.0
27	2-8	33.5	32.7	24.4	24.3	5.2	3.8	12.9	5.9	81	83	58	61	6.8	6.3	34.7	54.8	352.3	2.4	5.0
28	9-15	32.3	28.4	23.7	23.6	3.8	1.0	12.0	8.2	84	93	62	80	5.5	4.2	52.2	140.3	492.6	2.8	6.0
29	16-22	32.0	29.9	23.9	24.1	3.3	0.6	11.2	7.3	84	88	65	71	5.6	3.2	58.6	35.1	527.7	2.6	3.0
30	23-29	31.7	28.0	23.3	23.5	4.3	0.7	11.9	4.4	85	90	64	74	5.3	3.2	44.2	30.7	558.4	2.6	4.0