NUTRIENT MANAGEMENT IN YARD LONG BEAN

(*Vigna unguiculata* subsp. s*esquipedalis* L.)

by

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Nutrient management in yard long bean (*Vigna unguiculata* subsp. s*esquipedalis* L.) "** is a bonafide record of research done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other university or society.

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LIST OF ABBREVIATIONS

@	At the rate of
%	Per cent
AMF	Arbuscular Mycorrhizal Fungi
BCR	Benefit Cost Ratio
C	Carbon
CD	Critical difference
cm	Centimetre
cm^2	Square centimetre
DAS	Days After Sowing
DMP	Dry Matter Production
et al.	And others
Fig.	Figure
FYM	Farmyard manure
g	gram
ha	hectare
ha^{-1}	Per hectare
INM	Integrated Nutrient Management
K	Potassium
K_2O	Potash
KAU	Kerala Agricultural University
Kg ha^{-1}	Kilogram per hectare
Kg	Kilogram
LAI	Leaf Area Index
m	Metre
mg	Milligram
N	Nitrogen
^oC	Degree Celsius
P	Phosphorous
P_2O_5	Phosphate

PGPR	Plant Growth Promoting Rhizobacteria
PM	Poultry manure
PSB	Phosphorous solubilizing bacteria
POP	Package of Practices
RBD	Randomised Block Design
RDF	Recommended Dose of Fertilizer
Rs.	Rupees
S	Sulphur
TSS	Total Soluble Salts
t ha^{-1}	Tonnes per hectare
VAM	Vesicular Arbuscular Mycorrhizae
var.	Variety
WHC	Water Holding Capacity

Introduction

1. INTRODUCTION

Vegetables are universally accepted as protective foods and have been well advocated in solving the problem of food and nutritional security. They play an important role in human nutrition by providing carbohydrates, proteins, minerals and vitamins. The abundant use of inorganic fertilizers in vegetable production has caused a threat not only to soil health but also to human health. Further reduction in cost of cultivation and improvement in yield and quality of agricultural produce are to be ensured. Therefore nutrient management strategy must include a proper blend of organic manures and inorganic fertilizers so as to sustain the production and productivity of the crops as well as soil health.

In Kerala, vegetable production is not sufficient to meet the requirement of the growing population. Also, the extent of cultivated land is limited and as such we have to exploit the potential of vegetable production fully through intensification of agronomic practices. Proper soil management without hampering soil health is a pre-requisite for achieving high productivity from agricultural land.

Among the various vegetables grown in Kerala, vegetable cowpea or yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* L.) occupies a prime position owing to its high nutrient content and consumer preference and hence its yield and quality are important. Being a legume, it has got a role in nitrogen enrichment of soil. It is a warm season crop, well adapted to many areas of the humid tropics and sub tropical zones. Because of the favourable agro climatic conditions it is grown throughout India for its long green vegetable pods.

Fertilizer is considered as the most effective and expensive input in agriculture. It is the primary concern of scientists to help the farmer to derive maximum benefit out of this costly input by increasing the fertilizer use efficiency.

The organic sources are not only the store house of large number of essential nutrients but also improve considerably the physical environment of the soil and judicious mixing of organics with inorganic sources of nutrients minimizes the expenditure on costly fertilizer inputs and improves the efficiency of added fertilizer (Bandyopadhyay and Puste, 2002). Therefore to maintain soil health and to supply plant nutrients in balanced proportion for higher crop yield, it is imperative to practice integrated nutrient supply system through the combined use of organic , biological and chemical sources of plant nutrients.

Organic manure provides a good substrate for the growth of many microorganisms and maintains a favourable nutritional balance and soil physical properties. Organic manure also serves as slow release source of nutrients so that the availability is spread over a number of crop season and has a carry over effect on the succeeding crops. Farmyard manure, the most commonly used organic manure is a good source of both macro and micro nutrients. It has both direct and residual effect in cropping system.

Judicious nutrient management is of prime importance for sustaining soil productivity in any agricultural system. The interactive advantage of combining possible sources of nutrients and their scientific management to the use of individual components has been proved for optimum growth, yield and quality in different crops.

Incorporation of bioinoculants along with organic manure have emerged as a promising component of crop production system as it provides a better physical, chemical and biological environment thereby enhancing higher productivity of crops. Plant growth promoting rhizobacteria are naturally occurring soil bacteria that aggressively colonize plant roots and benefit plant by providing growth promotion. The use of PGPR offers an attractive way to replace chemical fertilizer, pesticides and supplements. Most of the isolates results in a significant increase in plant height, root length and dry matter production of shoot and root of plants. PGPR help in the disease control in plants.

Keeping these views under consideration the present investigation entitled "Nutrient management in yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L)" was carried out with the following objectives.

1. To study the growth, productivity and quality of yard long bean under organic and integrated nutrient management.
2. To work out the economics of production.

Review of literature

2. REVIEW OF LITERATURE

An investigation was carried out at the College of Agriculture, Vellayani during the period from January 2012 to April 2012 to study the growth, productivity and quality of yard long bean under organic and integrated nutrient management (INM) system and to study the economics of production. The important literatures covering various aspects of the present study are briefly reviewed here. Wherever sufficient literatures are not available on the crop tried in this experiment, results of similar experiments conducted on other related crops are cited.

2.1 ORGANIC MANURES

Organic manures serve as slow release source of N, P, S and other micronutrients for plant nutrition and microbial growth. It possesses considerable water holding capacity, acts as buffer against changes in pH of the soil and cements clay and silt particle together contributing to the crumble structure of the soils. It also binds micronutrient metal ions in the soil that otherwise might be leached out (Rammohan *et al.,* 2002). Organic manures provide a good substrate for the growth of many microorganisms and maintain a favourable nutritional balance and soil physical properties.

2.1.1 Effect of organic manures on growth characters

Sivakumar and Wahid (1994) reported the enhanced growth and biomass production in pepper vine by the addition of organic manures. According to Thamburaj (1994) organically grown tomato plants are taller with more number of branches. The growth characters like plant height, LAI, DMP, yield attributes like fruit number per plant, fruit weight, fruit length and fruit yield ha^{-1} were high in organic manure treated okra plants (Asha, 1999). Arunkumar (2000) reported that highest level of FYM and vermicompost (150% POP) maintained their superiority at all growth stages regarding plant height, number of leaves, and number of branches of amaranthus. Sailajakumari and Ushakumari (2001) opined that vermicompost application improved the growth characters and yield of cowpea. The growth characters in cowpea including plant height, number and weight of effective nodules and leaf area index recorded the highest values with vermicompost+ PSM application (Devikrishna, 2005). According to Asha (2006) application of enriched vermicompost recorded improved growth characters like vine length, branches per plant and leaves per plant in slicing cucumber compared to other organic manures.

Different organic manure have found to be very promising in improving the growth characters of various crops.

2.1.2 Effect of organic manures on yield and yield attributes

Gaur *et al.* (1984) observed increased yield of chilli, bhindi, tomato and brinjal by organic manure application. According to Thamburaj (1994) organically grown tomato plants yielded 18-28 t ha^{-1} which was on par with the recommended dose of FYM and NPK (20:100:100). Anitha (1997) observed better yield and yield attributing characters in poultry manure treated chilli plants as compared to FYM and vermicompost application. Jose *et al.* (1988) reported enhanced dry matter production in brinjal with the application of 50 kg N as poultry manure compared with 50 kg N as urea. Yield attributing characters in vegetable cowpea significantly influenced by organic manures included number of flowers and number of pods per plant, fresh pod weight and pod length. Total and marketable pod yield were also significantly influenced by the organic manures (Deepa, 2005).

Different studies reveals that organic manure application helps in increasing the yield attributing characters of crops.

2.1.3 Effect of organic manures on quality characters

Sandor and Eash (1991) observed the activity of cellulose in temperate regions and found out that addition of FYM or green manure stimulated the activity of cellulose. Chilli plants treated with poultry manure recorded maximum ascorbic acid content in fruits as compared to vermicompost and control treatments (Anitha, 1997). According to Rani *et al.* (1997) application of organic manures increased the ascorbic acid in tomato, pyruvic acid in onions and minerals in gourds. Joseph (1998) observed that shelf life of snakegourd grown with organic residues is much higher as compared to that grown with fertilizers. Asha (1999) reported that in bhindi, application of FYM+ enriched compost and FYM + neemcake recorded comparable and lowest crude fibre content and keeping quality of fruits. Sharu (2000) opined that poultry manure application registered maximum keeping quality of fruits compared to vermicompost, neemcake and POP recommendation. According to Renu (2003) the texture, odour and keeping quality of bittergourd was well pronounced in organically treated plots (FYM, vermicompost, poultry manure)than those with integrated and fully inorganic plots. Sheeba (2004) reported that treatments with organic sources of plant nutrients recorded the highest value for beta- carotene content, protein content and the lowest fibre content in amaranthus.

It was observed that organic manures helps in improving the quality characters of crops.

2.1.4 Effect of organic manures on soil properties

According to Lognathan (1990) application of organic amendments namely sawdust, groundnut shell powder and FYM each at 2.5 and 5 t ha^{-1} improved the soil physical characteristics like infiltration rate, total porosity and hydraulic conductivity of red soil with hard pan. More (1994) observed that addition of farm waste and organic manure increased the status of available nitrogen and available phosphorus of the soil. According to Tandon (1994) organic manures constituted a dependable source of major and minor elements. Patiram (1996) found that organic manure application resulted in lowest acidity due to decrease in exchangeable and soluble Al in the soil. Apart from this they have a profound influence on soil physical properties resulting in better structure, greater water retention, more favourable environment for root growth and better infiltration rate of water. Banerjee (1998) found that organic manures contain more or less of all nutrient elements required for plant growth. When it is applied to soil it improved soil aeration, permeability, aggregation, water and nutrient holding capacity. In an experiment conducted in bittergourd, the lowest bulk density, maximum WHC and higher porosity was shown by the application of 100% N as poultry manure and was on par with the application of 100% N as FYM and 100% N as vermicompost (Renu, 2003).

From the above reviews it was observed that organic manures have a significant influence on soil properties.

2.1.5 Effect of organic manures on pest and disease incidence

Lowest incidence of leaf blight in amaranthus with the application of vermicompost was reported by Niranjana (1998). Surekha and Rao (2001) reported that vermicompost was significantly more effective in bringing down the population of aphids in bhindi followed by FYM when compared to NPK as inorganic fertilizer. Adilakshmi *et al.* (2008) observed that the number of fruits damaged by fruit and shoot borer was lowest in the plots fertilised with 75% RDF from neemcake + 25% RDF compared to 100% RDF as inorganic fertiliser alone. In a study conducted by Agu (2008) showed that in African yam bean the occurrence of root gall was low in plants treated with poultry manure and farmyard manure. According to Ahmed *et al.* (2012) the root rot disease caused by *Fusarium solani* in ground nut was found low in poultry manure applied plots.

2.2 FARM YARD MANURE

FYM supplies both major and minor plant nutrients, improves physical condition in the soil and supplies substances that stimulate plant growth. Among the different sources, FYM is the best known and commonly used traditional organic manure in India (Gaur, 1994). Meerabai and Raj (2001) estimated that an average dressing of 25 t ha^{-1} FYM supplies 112 kg N, 56 kg P_2O_5 and 112 kg K_2O.

2.2.1 Effect of FYM on growth characters

Cerna (1980) found that FYM favourably influenced the vegetative mass dry weight, plant height and rate of dry matter increment per unit area in capsicum. In potato plant height and number of leaves per plant were increased by the application of FYM (Sahota, 1993). Arunkumar (1997) found that FYM application was superior to vermicompost in increasing plant height, root biomass production, leaf area index and leaf yield in amaranthus. Joseph (1998) reported that in snakegourd growth characters viz., weight of the root per plant and dry matter production per ha were highest in FYM treated plants as compared to poultry manure or vermicompost treated plants. Senthilkumar and Sekar (1998) observed increased DMP of bhindi crop with FYM application as an organic amendment. Veena (2000) confirmed that the application of FYM at 20 t ha^{-1} resulted in increased plant height, leaves per plant and dry matter production. In tomato application of FYM (10 and 20 t ha^{-1}) significantly increased plant height and number of branches per plant over control (Sharma and Sharma, 2004). According to Sharma and Abraham (2010) a significant difference in plant height and dry matter production was recorded with 10 t FYM ha^{-1} over control at maturity in blackgram.

The results of the above studies indicate that application of FYM stimulates the growth characters in different crops.

2.2.2 Effect of FYM on yield and yield attributes

Gomes *et al.* (1993) reported higher efficiency of FYM in producing higher yield and improving chemical properties of soil compared to castor oil cake and urea. Senthilkumar and Sekhar (1998) observed that the fruit yield per plant in bhindi was increased markedly by farmyard manure. According to Joseph (1998) in snakegourd yield attributing characters like length, weight and number of fruits per plant were highest in FYM treated plants. The combined inoculation of *Azospirillum*, Phosphobacteria and AMF each at 2kg ha^{-1} with FYM 30 t ha^{-1} increased fruit size, number of fruits and tender fruit yield in cucumber (Nirmala *et al.,* 1999). FYM application recorded 25.9 and 19.6% more seed and straw yield in french bean respectively over no manure addition. The increase in yields due to FYM application was due to its favourable effect on growth and yield attributes of the plant. In terms of economics FYM application also recorded higher net returns (Purushottam kumar and Puri, 2002).

The results presented above reveal that FYM application increased the yield and yield attributing characters in various crops.

2.2.3 Effect of FYM on quality characters

Increased shelf life of spinach leaves due to application of 20t FYM/ha was reported by Kansal *et al.* (1981). Bhadoria *et al.* (2002) found that protein and total mineral content of okra fruit was high when treated with the FYM. Singh (2002) obtained high grain yield, high protein and vitamin C content by the application of FYM+ dense organic manure in french bean. Majumdar *et al.* (2005) reported that application of FYM significantly increased the crude protein and oleoresin content of ginger. Shelf life was also prolonged under ambient storage condition by this treatment. The lowest crude fibre content in bhindi was recorded by the treatment receiving 20 t ha^{-1} FYM compared to the lower levels (Sekhar and Rajasree, 2009).

These reviews indicate that FYM helps to improve the quality attributes in crops.

2.2.4 Effect of FYM on soil properties

According to Kanwar and Prihar (1982) continuous use of FYM increased the organic carbon as well as the nitrogen content of the soil. According to Badanur *et al.* (1990) available phosphorus content of soil was significantly increased with the incorporation of subabul, sunhemp loppings and farmyard manure. Krishnaswami *et al.* (1984) reported that application of FYM or compost (15 t ha^{-1}) had a significant effect on increasing the available P from the native and applied source. Gupta *et al.* (1992) found FYM as a good source of P and attributed increased levels of enzyme acivities and microbial biomass due to the decomposition products of the manure. Goyal *et al.* (1993) reported that the application of FYM increased the microbial biomass, C and also the enzyme activities. According to Dhanokar *et al.* (1994) continuous use of FYM raised available K_2O by 1.3 to 5.4 fold over no manure application in vertisol. Issac (1995) noted that available N, P_2O_5 and K_2O contents in the soil after the harvest were highest with the application of 12 t of FYM along with vermicompost as a source of nitrogen in bhindi. Singh and Tomar (1991) reported that application of FYM and K had a positive effect on the uptake of Ca and Mg by wheat crop. A decrease in soil bulkdensity value from 1.55g cc^{-1} to 1.38g cc^{-1} with the application of FYM @ 32 t ha^{-1} was reported by Maheswarappa *et al.* (1999). Application of FYM significantly brought down the bulk density of both surface and subsurface soil in comparison with the control. However application of different levels of fertilizer did not affect the bulk density. Singh *et al.* (2000) noticed an increase in total porosity from 42.6 to 44.0% when the rate of application of FYM was raised from 2.5 to 5 t ha^{-1}. Sreekala (2004) observed that soil physical characters viz., bulk density, particle density, WHC and soil aggregate index were superior for FYM+ green leaf treatment as compared to that of vermicompost and neemcake. Increased organic carbon content due to FYM application as compared to that of poultry manure and neemcake was also reported by Sreekala (2004).

From the above reviews it can be concluded that FYM has a favourable effect on physical and chemical properties of soil.

2.2.5 Effect of FYM on pest and disease incidence

Kumar *et al.* (1996) observed the least incidence of stem fly in soybean with FYM alone (6.45%) and highest with inorganic fertiliser alone (14.87%). According to Prakash *et al.* (2002) the incidence of fruit borer infestation in bhindi was lowest when the plants were treated with FYM and vermicompost.

2.3 COMBINED APPLICATION OF ORGANIC MANURES AND CHEMICAL FERTILIZERS

According to Singh (2001) organic sources when applied with mineral fertilizer improved the efficiency of later due to their favourable effect on physical and biological properties of soil.

2.3.1 Effect of combined application of organic manures and chemical fertilizers on growth characters

Dry matter production was increased in brinjal with the application of 50 kg N as poultry manure combined with 50 kg N as urea (Jose *et al.,* 1988). Increased dry matter accumulation in okra was observed by Abusaleha (1992) with the combined application of nitrogen in the form of poultry manure and ammonium sulphate. Integrated application of organic and inorganic sources recorded significantly higher values for all the growth characters in brinjal (Rekha,1999). Combined application of vermicompost and inorganic fertilizer increased plant height and number of leaves per plant in okra (Ushakumari *et al.* 1999). Sharu (2000) observed that plant height was highest in chilli with the integrated application of chemical fertilizer and poultry manure in the ratio 3:1. The plant height, number of trifoliates plant^{-1}, plant dry matter and leaf area index were significantly increased by the use of 50 kg N+ 1 tonne neemcake ha^{-1} (Saxena *et al.,* 2001).

Different studies reveals that combined application of organic manures and inorganic fertilisers helps in improving the growth characters of crops.

2.3.2 Effect of combined application of organic manures and chemical fertilizers on yield and yield attributes

Abusaleha (1992) observed the highest uptake of nutrients with the combined application of poultry manure and ammonium sulphate which is attributed to the increased dry matter accumulation in plants. According to Pushpa (1996) the yield attributes like mean fruit weight, girth of fruit and yield were highest in tomato for the treatment receiving 25 t ha^{-1} vermicompost along with full dose of inorganic fertilizer. Bijulal (1997) observed that in cowpea the treatment vermicompost (20 t ha^{-1})+ lime+ fertilizer was found to be superior with a mean grain weight of 10.91g $plot^{-1}$. Jiji and Dale (1999) reported that vermicompost with full dose of inorganic fertilizer increased the yield of bittergourd and cowpea by 21% and 19% respectively. According to Rekha (1999) time to 50% flowering was lowered when the nutrients are applied 100% as organic source especially poultry manure. When organic and inorganic sources were supplied in 1:1 ratio the content and uptake of N, P & K were higher. According to Ushakumari *et al.* (1999) vermicompost+ inorganic fertilizer increased the number of fruits per plant and gave more yield in okra. Sharu (2000) observed highest fruit length in chilli when vermicompost was applied along with chemical fertilisers in the ratio 1:1. Dikshit and Khalik (2002) observed greater availability of NPK and S in soil, higher uptake of nutrients, higher grain and straw yield in soybean when FYM @ 10 t ha^{-1} and 50% of the RDF was applied.

From the studies it is clear that integrated nutrient application has a positive influence on yield attributing characters.

2.3.3 Effect of combined application of organic manures and chemical fertilizers on quality characters

According to Shanmughavelu (1989) the application of a mixture of FYM and inorganic fertilizer was found to be the best for firmness, storage life and keeping quality of tomato for a long time. Pushpa (1996) reported highest protein content in tomato plants receiving 100 t ha^{-1} vermicompost whereas maximum carbohydrate content was found in tomato plants receiving 25 t ha-1 vermicompost along with full dose of inorganic fertilisers. Rajasree (1999) observed that the shelf life of bittergourd fruits under room temperature was more (4 days) when nitrogen nutrition was given through 2:1 ratio of organic chemical nitrogen using poultry manure as organic source in nitrogen equivalent basis. She also observed higher iron content in bittergourd when poultry manure and chemical fertilizers were used in the ratio 1:2 .

2.3.4 Effect of combined application of organic manures and chemical fertilizers on soil properties

Increased post harvest nutrient status of soil NPK was observed with the application of 5 t ha^{-1} of poultry manure along with 100 percent recommended fertilizer (Budhar *et al.,* 1991) According to Singh and Tomar (1991) organic manure applied in conjunction with optimal NPK dose resulted in highest potassium uptake by crops. When FYM or poultry manure as organic source was used in equal or higher proportion with chemical N source, it showed moderating effect on soil acidity (Rajasree, 1999). Integrated nutrient management had significantly increased the organic carbon, available nitrogen, phosphorus, potassium and sulphur content in soil as compared to control (Arbad and Ismail, 2011).

2.3.5 Effect of combined application of organic manures and chemical fertilizers on pest and disease incidence

Balasubramanian and Muralibaskaran (2000) observed that application of organic amendments along with 75% dose of nitrogen was found to be better in reducing the population of sucking pests of cotton than with full dose of nitrogen.

2.4 FYM AND CHEMICAL FERTILIZERS

According to Subbiah and Sundarajan (1993) combined application of 12.5t FYM + recommended dose of NPK along with 25 kg Zinc sulphate was superior to FYM alone in bhindi.

2.4.1 Effect of FYM and chemical fertilizers on growth characters

According to Nanthakumar and Veeraragavathatham (2000) combined application of organic manure through 12.5 t FYM ha^{-1}, 2 kg each of Azospirillum and Phosphobacteria with inorganic fertilisers favourably influenced the growth parameters like plant height, root length, number of primary branches and leaf area index in brinjal than recommended dose of inorganic fertiliser alone. Krishna and Krishnappa (2002) reported that the combined application of inorganic fertilizer and FYM recorded the highest values for plant height, branches per plant and clusters per plant in tomato crop during rabi season. All the growth characters like plant height, number of branches, number of leaves and leaf area index in soybean was increased with the application of 40 : 80 : 25 kg NPK per ha and 5 t FYM ha^{-1} (Maheshbabu *et al.,* 2008).

It can be concluded from the above review that combined application of FYM and chemical fertilizer has a favourable effect on growth characters of crops.

2.4.2 Effect of FYM and chemical fertilizers on yield and yield attributes

Nair and Peter (1990) observed that highest yield in chilli was obtained with 15 t FYM+ inorganic fertiliser when compared with farm yard manure alone or inorganic fertilizer alone. Studies conducted in KAU revealed that the organic and inorganic fertilizers and their combinations had significant influence on vegetable productivity. Higher rate of nitrogen alone with FYM induced earliness and enhanced fruit yield in clustered chilli (KAU, 1991). In an experiment conducted by Dixit (1997) it was found that integrated application of nitrogen @ 120 kg ha^{-1} and FYM @ 20 t ha^{-1} increased the yield characters such as head length, girth, number of non-wrapper leaves per head and head weight in cabbage. Issac *et al.* (1998) observed that weight of green fruits per plant, weight of mature fruits per plant and total fruit yield per plant were significantly higher in combined application of 12 t FYM with chemical fertilizer. Integrated use of farm yard manure and chemical fertilisers has considerable impact in enhancing the yield of vegetables (Parmar and Sharma, 2001). Application of optimum dose of fertilizer in combination with FYM @15 t ha^{-1} recorded highest pod yield and haulm yield in groundnut (Laxminarayana and Patiram, 2005). A study conducted by Singh and Mukherjee (2008) revealed that fruit yield increased with the application of 20 t ha^{-1} of FYM and 100% recommended fertilizer dose in brinjal. According to Sutaria *et al.* (2010) maximum pod yield in soybean was recorded due to application of 50% nitrogen through urea and 50% through farmyard manure.

From the review, it is clear that combined application of organic and inorganic fertilizer greatly influenced the yield compared to inorganic fertilizer alone in crops.

2.4.3 Effect of FYM and chemical fertilizers on quality characters

According to Sujatha and Krishnappa (1995) highest reducing sugars was found in treatments with inorganic fertiliser and 50 t ha^{-1} of FYM in potato. Nanthakumar and Veeraragavathatham (1999) remarked that combined application of organic fertilizers through 12.5 t ha^{-1} of FYM, 2kg each of *Azospirillum*, Phosphobacteria and inorganic fertilisers favourably influenced the keeping quality in brinjal. Maheshbabu *et al.* (2008) observed higher protein content (38.95) in soybean with application of FYM and recommended dose of fertiliser (40:80:25 kg NPK ha^{-1}).

2.4.4 Effect of FYM and chemical fertilizers on soil properties

According to Rajasree (1999) moderating effect on soil acidity was noticed when FYM or poultry manure was used in equal or higher proportion with chemical N source. Sharma *et al.* (2001) found that conjoint use of N along with FYM markedly influenced the NPK uptake which might be due to the supply of these nutrients and improvement of soil physical properties for better plant growth. According to Majumdar *et al.* (2005) exchangable K in soil increased significantly at every dose of applied K with FYM. The beneficial effect of FYM on exchangeable K build up in the soil may be due to the reduction of potassium fixation and release of potassium due to the interaction of organic matter with clay besides the direct potassium addition to the potassium pool. Sharma and Verma (2011) observed build up of available N, P and K in soil due to inoculation of rajmash with Rhizobium and application of FYM (5 t ha^{-1}) and chemical fertilizers.

The reviews reveals that combined application of FYM and chemical fertilisers significantly influenced the soil properties.

2.4.5 Effect of FYM and chemical fertilizers on pest and disease incidence

When farmyard manure was applied along with inorganic fertilizer, the population of pigeon pea pod borers were lower than that under the use of straight inorganic fertilizer alone (Dayakar *et al.,*1995).

2.5 BIOINOCULANTS

Geethakumari *et al.,* (1994) reported the possibility of saving phosphorus fertilizers using VAM in grain cowpea.

2.5.1 Effect of bioinoculants on growth characters

According to Varma (1995) *Azospirillum* inoculated bush pepper recorded significantly higher production of new leaves, branches, fresh and dry weight of shoot. Kumaran *et al.* (1998) reported that plant height and branches in tomato were best with organic plus inorganic fertilizers, *Azospirillum* and Phosphobacteria. Seed inoculation with rhizobium culture significantly increased the values of growth characters, yield attributes and yield of pigeonpea along with all the levels of nitrogen (Singh *et al.,* 1998). Nair *et al.* (2001) reported a depression effect of biofertilizer on the growth of sweet potato. According to Sreekala (2004) combined application of FYM + AMF and Trichoderma significantly improved the growth, yield and quality characters in ginger compared to the recommended dose of fertilizers. Besides nitrogen fixation *Azospirillum* also helps in plant growth promotion through its capability to produce plant growth promoting hormones (Krishnamoorthy and Rama, 2004).

From the above results it was observed that different bioinoculants have a positive influence on growth characters of crops.

2.5.2 Effect of bioinoculants on yield and yield attributes

When *Azosprillum* was given as seed and soil treatment along with 30 kg N ha^{-1}, bhindi gave highest yield compared to control (Balasubrahmani and Pappiah, 1995). Bhindi gave better yield when plants were treated with *Azospirillum*, FYM and inorganic fertilizers (Rajasekhar *et al.,* 1995). According to Srivastava and Ahlawat (1995) seed inoculation with Rhizobium or PSB alone or in combination resulted in considerable increase in growth, yield and nutrient uptake by cowpea over uninoculated control. Chilli plants inoculated with AMF produced more number of fruits and fruit yield as compared to uninoculated one (Kanaujia and Narayan, 2003). Seed inoculation of soyabean with bacterial culture (P solubilisers) significantly improved yield, N and P content and uptake in blackgram. Meena *et al.* (2003) confirmed that in chickpea the grain yield and straw yield were significantly increased by the inoculation of phosphobacteria. According to Ramana *et al.* (2010) the yield characters like number of clusters per plant, number of pods per cluster, number of seeds per pod, 100 seed weight and pod yield per plant were significantly increased by the application of 75% RDF+ VAM @ 2kg ha^{-1} + PSB @ 2.5 kg ha^{-1} in french bean.

Different studies reveal that inoculation of biofertilisers helps in improving the yield attributes of crops. However Dhanya (2011) reported that the highest number of tuber was noticed with treatment without microbial consortium.

2.5.3 Effect of bioinoculants on quality characters

Kumaraswami and Madalageri (1990) observed that *Azospirillum* treated plants gave tomato fruits with high TSS (8.86 percent) and ascorbic acid content (32.91 mg 100 g^{-1} fresh fruit). Sundaram and Arangarasan (1995) reported increased quality attributes of tomato namely vitamin C content and TSS over control by application of AMF. Higher P uptake was observed with the use of PSM and rock phosphate for bengal gram in vertisol (Vaishya *et al.,* 1996). According to Sreekala (2004) combined application of FYM, AMF and Trichoderma reduced the fibre content and improved the volatile oil content in ginger as compared to that of recommended dose of fertilizers. Niranjana (1998) reported maximum mineral and protein content and least fibre content in amaranthus by *Azospirillum* inoculation along with 75% RDF. Application of *Rhizobium*, *Azotobacter*, PSB and FYM @ 5 t ha^{-1} recorded maximum oil and protein content in soybean (Singh *et al.,* 2009).

The results presented above reveals that bioinoculant application helps to improve the quality attributes in crops.

Materials and methods

3. MATERIALS AND METHODS

The present investigation entitled Nutrient management in yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* L.) was undertaken to study the growth, productivity and quality of yard long bean under organic and integrated nutrient management system and to study the economics of production. The materials used and the methodology followed for the experiment is presented in this chapter.

3.1 MATERIALS

3.1.1 Location

The experiment was laid out at the Instructional Farm attached to College of Agriculture, Vellayani in an area with facilities for irrigation. The farm is located at 8^0 5' N latitude and 76^0 9'E longitude at an altitude of 29m above MSL.

3.1.2 Soil

The soil of the experiment site is red sandy clay loam (oxysol, Vellayani series). The important physico-chemical properties of the soil are presented in table 1.

3.1.3 Cropping history of the field

The experimental area was kept fallow before the experiment.

3.1.4 Season

The experiment was conducted from January 2012 to April 2012.

3.1.5 Variety

The variety used was Vellayani Jyothika, a high yielding variety of vegetable cowpea evolved by Kerala Agricultural University. It is a selection from Sreekaryam local.

The seed material was obtained from Department of Olericulture, College of Agriculture, Vellayani.

Table 1. Physico-chemical properties of soil

Sl. No.	Parameter	Content	Methods adopted
A.	Chemical composition		
1.	P^H	4.69	P^H meter with glass electrode (Jackson,1973)
2.	Available N ($kg\ ha^{-1}$)	268	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
3.	Available P ($kg\ ha^{-1}$)	17.17	Bray colorimeter method (Jackson ,1973)
4.	Available K ($kg\ ha^{-1}$)	168	Neutral normal ammonium acetate method(Jackson,1973)
B.	Mechanical composition (%)		
1.	Coarse sand	49.15	International pipette method (Piper, 1966)
2.	Fine sand	14.4	
3.	Silt	6.25	
4.	Clay	27.5	
	Texture	Sandy loam soil	

3.1.6 Weather conditions

The data on various weather parameters like rainfall, minimum and maximum temperature and relative humidity during the cropping period are given in Appendix I and graphically presented in Fig.1.

3.1.7 Manures and Fertilisers

Farmyard manure was applied as organic source. PGPR mix I was applied along with farmyard manure @ 2%.

Urea, mussoriephos and muriate of potash were used as inorganic sources for N, P and K respectively.

3.2 METHODS

3.2.1 Design and layout

Design	: Factorial RBD
Replication	: 3
Treatments	: 10
Spacing	: 2mx2 m
Number of plants per treatment	: 4
Gross plot size	: 3.7x3.7 m^2

The layout plan of the experiment is given in Fig.2.

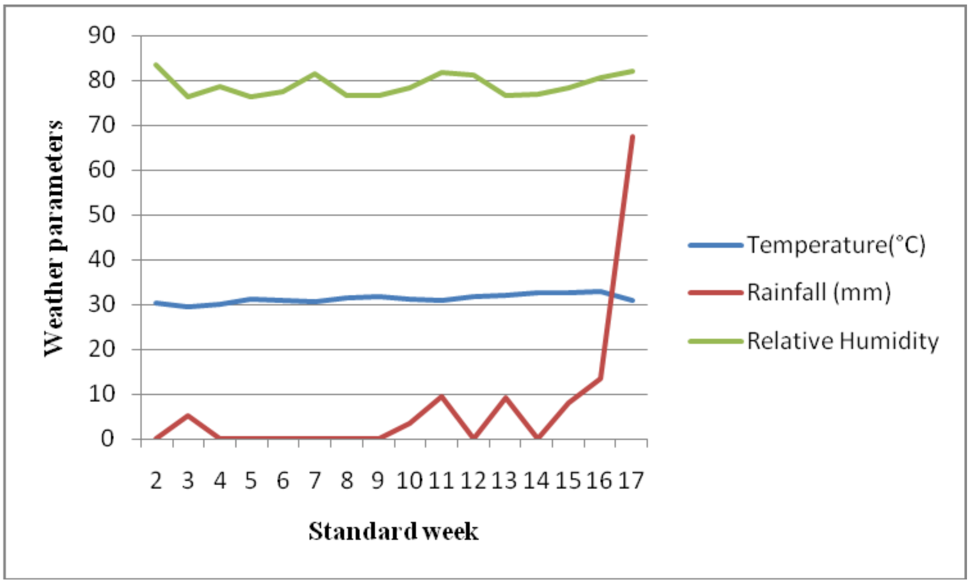
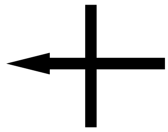


Fig.1 Weather parameters during the crop growth period

Fig.2 Lay out plan of the experiment



R I	R II	R III
T_{10}	T_4	T_9
T_9	T_8	T_2
T_8	T_5	T_7
T_7	T_9	T_3
T_6	T_3	T_8
T_5	T_7	T_4
T_4	T_2	T_1
T_3	T_{10}	T_6
T_2	T_1	T_{10}
T_1	T_6	T_5

Plate 1. Layout of the experimental plot

3.2.2 Treatments

I. Nutrient levels -5

1. 20t FYM/ha +20:30:10 kg NPK ha^{-1} (100% RDF)
2. 20t FYM/ha + 10:15:5 kg NPK ha^{-1} (50% RDF)
3. 20t FYM alone
4. 30t FYM alone
5. 40t FYM alone

II. Bioinoculant -2

1. With PGPR (mix I+II)
2. Without PGPR

3.2.3 Treatment combination – 10

1. 20t FYM/ha +20:30:10 kg NPK ha^{-1} (100% RDF)+ PGPR
2. 20t FYM/ha + 10:15:5 kg NPK ha^{-1} (50% RDF)+PGPR
3. 20t FYM alone + PGPR
4. 30t FYM alone+ PGPR
5. 40t FYM alone+ PGPR
6. 20t FYM/ha +20:30:10 kg NPK ha^{-1} (100% RDF)
7. 20t FYM/ha + 10:15:5 kg NPK ha^{-1} (50% RDF)
8. 20t FYM alone
9. 30t FYM alone
10. 40t FYM alone

Recommended Dose of Fertilizer (RDF) – 20:30:10 kg NPK ha^{-1}

Plate 2. Crop at vegetative stage

Plate 3. Crop at flowering stage

3.3 FIELD CULTURE

3.3.1 Land Preparation

The experimental area was first cleaned of weeds, ploughed and laid out as per the design. Initial soil samples were taken for analysis. The individual plots were dug thoroughly and pits were taken at 2mx2m spacing for sowing of cowpea seeds.

3.3.2 Sowing

Cowpea seeds were soaked overnight and 4 seeds were sown per pit. Two healthy seedlings were retained after 3 weeks.

3.3.3 Application of manures and fertilizers

FYM was applied as basal dose to respective plots as per the treatments and incorporated well in to the soil before sowing. N, P_2O_5 and K_2O were applied in the form of urea, mussoriephos and muriate of potash respectively as basal according to the treatments.

3.3.4 Biofertilizer application

The microbial consortium (PGPR mix I) received from the department of Microbiology, College of Agriculture, Vellayani was used for the experiment. It is the combination of different biofertilisers like *Azospirillum*, *Azotobacter* and phosphorus solubilising bacteria. The consortium was applied to the plots as per treatment after mixing with FYM at the rate of 2 %.

3.3.5 After cultivation

Uniform germination was observed in the field. The crop was thinned three weeks after emergence and the plants were allowed to trail on pandals. The crop was given regular hand weeding and irrigation throughout the cropping season. Earthing up was also done. Two plants were selected randomly from the net plot area and tagged as observational plants.

Plate 4. Crop at harvesting stage

Plate 5. Cowpea pods

3.3.6 Plant protection

As a prophylactic measure against basal rot Copper Oxychloride was drenched before sowing. To prevent pod borer attack which was found in the field Ekalux 0.2% was sprayed.

3.3.7 Harvest

Vegetable picking started from 55 DAS onwards. Subsequent harvests of green pods as vegetables were done in alternate days from all the treatments upto 105 DAS and fresh weight recorded separately.

3.4 OBSERVATIONS

3.4.1 Biometric observations

3.4.1.1 Vine length (cm)

Length of the vine was measured from the base of the plant to the tip of the growing point at the time of harvest and expressed in cm.

3.4.1.2 Leaves per plant

Number of functional leaves at the time of observation were counted and the average value recorded.

3.4.1.3 Branches per plant

Number of branches per plant were counted and the average value recorded.

3.4.1.4 Dry matter production (g plant^{-1})

At harvest stage, sample plants were uprooted from each plot, first dried in shade and then dried in an hot air oven at 70^0C. The dry matter content was obtained by summing up the dry weight of all plant parts including stem, leaves and fruit and expressed as g plant^{-1}.

3.4.2 Yield and yield attributes

3.4.2.1 Days to first harvest

Days taken for the first harvest was noted in the observational plants in each plot and mean values worked out.

3.4.2.2 Days to final harvest

Days taken for the final harvest was noted in the observational plants in each plot and mean values worked out.

3.4.2.3 Pods per plant

The total number of pods from observational plants were recorded and the mean was calculated.

3.4.2.4 Pod yield per plant

Pod yield per plant was calculated by adding the weight of fruits from the observational plants in each harvest and the mean values worked out and expressed in g $plant^{-1}$.

3.4.2.5 Pod yield in kg ha^{-1}

The total pod yield was calculated by summing up the weight of pods from observational plants from total harvest. The mean values were worked out and expressed in kg ha^{-1}.

3.4.2.6 Number of pickings

Number of vegetable picking from each net plot during the total crop period was recorded treatment wise.

Plate 6. General view of the field

3.4.2.7 Crop duration

The duration of crop from sowing up to the end of the cropping period ie, till the vegetable yield reached below the economic level, was recorded as number of days.

3.4.3 Quality characters

3.4.3.1 Keeping quality of pods in ambient condition

To determine the number of days the fruits can be stored without damage for culinary purpose, 100 g of sample having uniform maturity representing each plot was kept at room temperature. Keeping quality of each plot was assessed by visual observation like change in colour, weight, drying, decay etc.

3.4.3.2 Organoleptic test

The pod samples were drawn from different treatments, cooked uniformly and subjected to organoleptic evaluation in which colour, taste, texture and odour were scored by the 10 panellists and overall acceptability was recorded. The data were subjected to statistical analysis.

3.4.4 Soil analysis

Soil samples were taken from the experimental area before and after the experiment. The composite samples from the experimental area prior to the experiment was analysed for mechanical composition and chemical composition. After the experiment, composite samples were collected from each plot, air dried, powdered and passed through a 2 mm sieve and analysed for available N, P and K using the standard procedures. The air dried samples were analysed for available nitrogen by the alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus by Bray's colorimeter method and available potassium by ammonium acetate method (Jackson, 1973).

3.4.5 Plant analysis

Plant samples collected from each plot at harvest were analysed for nitrogen, phosphorus and potassium. The plants were chopped, sun dried and oven dried at 70^0 c to a constant weight. Samples were ground to pass through a 0.5 mm mesh in a Willey Mill and the required quantity of samples were digested and used for nutrient content analysis.

The nitrogen content in plant samples was estimated by the modified microkjeldhal method (Jackson, 1973) and the uptake of nitrogen was calculated by multiplying the nitrogen content of plant sample with the total dry weight of plants. The phosphorus content in plant samples was colorimetrically determined by wet digestion of the sample, developing colour by ascorbic acid method (Jackson, 1973) and read in a Spectrophotometer. The uptake of phosphorus was calculated by multiplying the phosphorus content of plant sample with the total dry weight of plants. The potassium content in plant sample was determined by flame photometer method and the uptake of potassium was calculated by multiplying the potassium content of plant sample with the total dry weight of plants. The uptake values were expressed in kg ha^{-1}.

3.4.6 Scoring for pest and diseases

The incidence of the important pests and the diseases throughout the crop period was monitored. The severity of incidence of pod borer attack was scored using an index scale.

Incidence of pests and diseases.

0	No incidence
Below 50%	Mild incidence
Above 50%	Severe incidence

3.4.7 Economic analysis

The economics of cultivation using the treatments was worked out considering the total cost of cultivation and the prevailing market price of the produce. The net returns and benefit :cost ratio were computed as follows.

Net returns = Gross income – Cost of cultivation

$$\text{B:C ratio} = \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

3.4.8 Statistical analysis

Data relating to different characters were analysed statistically by applying the technique of analysis of variance for factorial experiment in Randomised Block Design (Panse and Sukhatme, 1978) and the significance was tested by F test (Snedecor and Cochran, 1967). Wherever the F value was found significant, critical difference were worked out at five percent and one percent probability level.

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Results

4. RESULTS

An experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani during the period from January 2012 to April 2012 to study the growth, productivity and quality of yard long bean under organic and integrated nutrient management and to work out the economics of production. The study was laid out in factorial RBD with 10 treatments and three replications. The experimental data were subjected to statistical analysis and the results are presented hereunder with an approach to bring out the best and economic nutrient schedule for yard long bean.

4.1 GROWTH CHARACTERS OF COWPEA

Observations on growth characters of cowpea viz. vine length, number of leaves and number of branches plant^{-1} were recorded at vegetative, flowering and harvesting stages and the mean values are presented in table 2 to 4.

4.1.1 Vine length (cm)

Data presents in the table 2 indicated the variation in vine length due to various nutrient levels. At vegetative stage N_2 (20 t FYM + 10:15:5 kg NPK ha^{-1}) recorded longest vine (186.83cm) which was on par with N_1 (20 t FYM +20:30:10 kg NPK ha^{-1}) and N_3 (20 t FYM). At flowering stage N_3 (20 t FYM) recorded the longest vine (312.50 cm) which was on par with N_2 (20 t FYM + 10:15:5 kg NPK ha^{-1}). At harvesting stage also N_3 recorded the highest vine length (520.83 cm) which was on par with N_2 and N_4 (517.83 cm and 516.17 cm respectively).

Difference in vine length due to bioinoculant was not significant. Interaction effect of nutrient levels and bioinoculants had no significant influence on vine length.

Table 2. Vine length (cm) as influenced by nutrient levels, bioinoculants and interaction at different growth stages.

Nutrient level	Vegetative stage	Flowering stage	Harvesting stage
N_1	180.33	301.83	472.33
N_2	186.83	306.50	517.83
N_3	182.33	312.50	520.83
N_4	178.00	296.67	516.17
N_5	176.33	299.17	494.83
SE CD(0.05)	2.218 6.590	3.29 9.79	7.529 22.372
Bioinoculants			
B_1	182.00	303.93	500.07
B_2	178.73	302.73	508.73
SE CD(0.05)	1.40 NS	2.09 NS	4.76 NS

NS – Non significant

4.1.2 Leaves per plant

Data given in table 3 revealed that nutrient levels had significant influence on number of leaves only at flowering stage. At vegetative stage N_2 (20 t FYM + 10:15:5 kg NPK ha^{-1}) recorded the maximum number of leaves (38.33). At flowering stage N_2 recorded the highest number of leaves (72) and was on par with N_5 (69.83). At harvesting stage also N_2 recorded the highest number of leaves (222) though the difference was not significant.

Bioinoculant significantly influenced the number of leaves at all the growth stages. B_1 (with biofertilizer) recorded the highest number of leaves at all the growth stages (37.53, 65.73 and 195.93 respectively) which were significantly superior to B_2.

The interaction effect was significant at flowering stage only and was not significant at vegetative and harvesting stages. At flowering stage T_2 (20 t FYM +10:15:5 kg NPK ha^{-1}+ PGPR) recorded the maximum number of leaves (76.33) which was significantly superior to all other treatment combinations except T_{10} (40 t FYM alone).

4.1.3 Branches per plant

Nutrient levels, bioinoculant levels and their interaction did not show any significant difference in number of branches $plant^{-1}$ during the different growth stages.

N_3 recorded highest number of branches $plant^{-1}$ at all growth stages though it was not significant (Table 4).

4.1.4 Dry matter production (kg ha^{-1})

The data on dry matter production at final harvest is given in table 5. Among the various nutrient levels N_2 (20 t FYM + 10:15:5 kg NPK ha^{-1}) recorded highest dry matter production (3461.23 kg ha^{-1}) which was significantly superior to all other nutrient levels. The treatment N_3 (20 t FYM) was found as the next best treatment in dry matter production (3337.29 kg ha^{-1})

Table 3. Number of leaves as influenced by nutrient levels, bioinoculants and interaction at different growth stages

Nutrient level	Vegetative stage	Flowering stage	Harvesting stage
N_1	34.83	65.00	213.17
N_2	38.33	72.00	222.00
N_3	36.00	61.67	202.83
N_4	34.00	53.00	206.67
N_5	35.17	69.83	209.17
SE CD(0.05)	1.22 NS	1.29 3.831	7.09 NS
Bioinoculants			
B_1	37.533	65.73	225.60
B_2	33.800	62.86	195.93
SE CD(0.05)	0 .77 2.284	0.82 2.423	4.48 13.323
Treatments			
T_1	39.00	65.00	216.33
T_2	38.67	76.33	232.67
T_3	35.33	65.33	213.33
T_4	36.00	53.33	225.33
T_5	38.67	68.67	240.33
T_6	30.67	65.00	210.00
T_7	38.00	67.67	185.67
T_8	36.67	58.00	192.33
T_9	32.00	52.67	188.00
T_{10}	31.67	71.00	203.67
SE CD(0.05)	1.72 NS	1.82 5.419	10.03 NS

NS- Non significant

Table 4. No. of branches as influenced by nutrient levels and bioinoculants at different growth stages.

Nutrient level	Vegetative stage	Flowering stage	Harvesting stage
N_1	3.83	8.83	14.00
N_2	4.17	9.50	16.50
N_3	4.50	9.83	17.50
N_4	4.17	8.50	15.83
N_5	3.83	8.50	14.67
SE CD(0.05)	0.43 NS	0.58 NS	1.03 NS
Bioinoculants			
B_1	4.20	8.80	15.27
B_2	4.00	9.27	16.13
SE CD(0.05)	0.27 NS	0.36 NS	0.65 NS

NS – Non significant

and was significantly superior to all other treatments. Dry matter production was lowest for the treatment N_5 (2356.90 kg ha^{-1}).

Considering the two bioinoculant levels, B_2 recorded the highest dry matter production compared to B_1 (3313.82 kg ha^{-1})

The interaction effect of nutrient levels and bioinoculants had significant influence on dry matter production. The treatment T_7 (20 t FYM + 10:15:5 kg NPK ha^{-1}) recorded the highest dry matter production (3807.58 kg ha^{-1}) which was significantly superior to all other treatment combinations followed by T_9 (3613.49 kg ha^{-1}) and T_3 (3402.94 kg ha^{-1}). The lowest dry matter production of 2121.93 kg ha^{-1} was recorded by T_1 (20 t FYM +20:30:10 kg NPK ha^{-1}).

4.2 YIELD AND YIELD ATTRIBUTES OF COWPEA

Observations on yield characters of cowpea viz. days to first harvest , days to final harvest, number of pickings, number of pods $plant^{-1}$, pod yield $plant^{-1}$, pod yield in kg ha^{-1}, pod length , pod width and mean pod weight were recorded and the mean values are presented in tables 6 to 8.

4.2.1 Days to first harvest

Data presented in table 6 revealed that nutrient levels and bioinoculants had no significant influence on the number of days to first harvest. The crop took 54-55 days for getting the first harvest irrespective of the treatments.

4.2.2 Days to final harvest

From the data presented in table 6 it was found that either nutrient levels or bioinoculant levels did not show any significant difference in the number of days to final harvest. It was understood that vegetable cowpea could be harvested up to 104-105 days from the sowing date at all nutrient levels and bioinoculant levels tried in this experiment.

Table 5. Drymatter production (kg ha^{-1}) at final harvest as influenced by nutrient levels, bioinoculants and interaction.

Nutrient level	Dry matter production (kg ha^{-1})
N_1	2743.18
N_2	3461.23
N_3	3337.29
N_4	3005.64
N_5	2356.90
SE CD(0.05)	29.27 86.977
Bioinoculants	
B_1	2647.875
B_2	3313.823
SE CD(0.05)	18.51 55.008
Interactions	
T_1	2121.93
T_2	3114.88
T_3	3402.94
T_4	2397.79
T_5	2201.83
T_6	3364.42
T_7	3807.58
T_8	3271.65
T_9	3613.49
T_{10}	2511.98
SE CD(0.05)	41.39 123.004

Table 6. Days to first harvest, final harvest and number of pickings as influenced by nutrient levels and bioinoculants.

Nutrient level	Days to Ist harvest	Days to final harvest	No. of pickings
N_1	54.83	104.50	23.33
N_2	54.33	104.67	23.67
N_3	54.17	104.83	24.17
N_4	54.17	104.67	23.33
N_5	55.00	104.50	23.17
SE CD(0.05)	0.57 NS	0.18 NS	0.35 NS
Bioinoculants			
B_1	54.20	104.67	23.67
B_2	54.80	104.60	23.40
SE CD(0.05)	0.36 NS	0.11 NS	0.22 NS

NS – Non significant

4.2.3 Number of pickings

Number of pickings was not significantly influenced by various nutrient levels and bioinoculant levels. In vegetable cowpea whatever be the nutrient level, the number of pickings varied between 23-24.

4.2.4 Pods per plant

The data presented in table 7 reveals that number of pods per plant varied significantly due to nutrient levels and bioinoculants. Number of pods per plant was high (95.60) in the treatment N_3 (20 t FYM) and was on par with N_2 (94.40) and N_4 (94.16) and was significantly superior to N_1 and N_5.

In case of the two bioinoculant levels, B_2 recorded a higher number of pods per plant (93.30) compared to B_1 (82.15).

Interaction effect of nutrient levels and bioinoculants was significant in increasing the number of pods per plant. The treatment T_9 (30 t FYM ha^{-1} alone) recorded the highest number of pods per plant (108.16) which was superior to all other treatments except T_7 (106.44) which were on par.

4.2.5 Pod yield per plant

The data summarized in table 7 revealed that pod yield per plant was significantly influenced by nutrient levels. Nutrient level N_3 (20 t FYM) produced the highest pod yield per plant (2.39 kg) which was on par with N_2 (2.36 kg) and was significantly superior to all other nutrient levels. These nutrient levels were closely followed by N_4 (2.35 kg). The treatments N_2 and N_4 were on par.

Considering the two bioinoculant levels, B_2 recorded the highest pod yield per plant (2.33 kg) which was significantly superior to B_1 (2.05 kg).

Interaction effect was also significant in increasing the pod yield per plant. T_9 (30 t FYM alone) recorded the highest pod yield per plant (2.70 kg) which was significantly superior to all other treatments. The treatment T_9 was closely followed by T_7 (2.64 kg). Next to T_9 and T_7, pod yield was highest for T_8 (2.39 kg) and T_3 (2.38 kg) and these two treatments were on par though it was not significant. Pod yield per plant was lowest in treatment T_1.

4.2.6 Pod yield in kg ha^{-1}

Significant difference in pod yield was noticed with different nutrient levels. It was clearly evident from the data presented in table 7 that nutrient level N_3 (20 t FYM) recorded the highest pod yield (8386.83 kg ha^{-1}) which was significantly superior to all other nutrient levels. N_3 was closely followed by N_2 (8281.21 kg ha^{-1}) and N_4 (8258.93 kg ha^{-1}) which were on par. The lowest pod yield of 6391.85 kg ha^{-1} was recorded by N_1 (20 t FYM + 20:30:10 kg NPK ha^{-1}) and was significantly inferior to all other nutrient levels.

Among the two bioinoculant levels, highest pod yield in kg/ha was recorded in B_2 (8187.55 kg ha^{-1}) compared to B_1 (7208.26 kg ha^{-1}).

Interaction effect was also found significant in influencing the pod yield. Treatment T_9 (30 t FYM alone) recorded highest pod yield in kg ha^{-1} (9484.98 kg ha^{-1}) which was significantly superior to all other treatments. Next to the treatment T_9 was T_7 (9334.93 kg ha^{-1}) and was significantly superior to all other treatment except T_9. Treatments T_9 and T_7 were followed by T_8 and T_3 (8403.82 and 8369.84 kg ha^{-1} respectively) which were on par.

4.2.7 Pod length (cm)

Nutrient level and bioinoculants did not influence the pod length. Interaction effect also had little influence on pod length in vegetable cowpea (Table 8).

Table 7. Number of pods plant^{-1}, Pod yield plant^{-1}, Pod yield in kg ha^{-1} as influenced by nutrient levels, bioinoculants and interaction.

Nutrient level	Number of pods plant^{-1}	Pod yield(kg plant^{-1})	Pod yield in kg ha^{-1}
N_1	72.80	1.82	6391.85
N_2	94.40	2.36	8281.21
N_3	95.60	2.39	8386.83
N_4	94.16	2.35	8258.93
N_5	81.72	2.04	7170.71
SE CD(0.05)	2.08 6.169	0.01 0.030	30.95 91.947
Bioinoculants			
B_1	82.15	2.05	7208.26
B_2	93.30	2.33	8187.55
SE CD(0.05)	1.31 3.901	0.01 0.019	19.57 58.153
Interactions			
T_1	74.27	1.86	6518.08
T_2	82.39	2.06	7227.99
T_3	95.38	2.38	8369.84
T_4	80.16	2.00	7032.87
T_5	78.55	1.96	6892.48
T6	71.39	1.78	6265.61
T7	106.44	2.64	9334.43
T8	95.77	2.39	8403.82
T9	108.16	2.70	9484.98
T10	84.88	2.12	7448.93
SE CD(0.05)	2.94 8.724	0.01 0.043	43.76 130.033

4.2.8 Pod girth (cm)

It is clearly evident from the table 8 that there was no significant difference among nutrient levels and bioinoculants in influencing the pod girth.

Interaction effect was also not significant between nutrient levels and bioinoculants.

4.2.9 Mean pod weight (g)

Nutrient levels, bioinoculants and their interaction did not show any significant influence on mean pod weight. Whatever be the nutrient level, mean weight of pod varied between 24-25 g pod^{-1}.

4.2.10 Crop duration

It was found that duration of the crop was not influenced by nutrient levels, bioinoculants and their interaction.

4.3 QUALITY CHARACTERS

Quality characters like keeping quality of pods in ambient condition and organoleptic test are studied in detail and the data are presented in tables 9and 10.

4.3.1 Keeping quality of pods in ambient condition

Keeping quality of fruits was not significantly influenced by various nutrient levels and bioinoculants (Table 9). But in general it was observed that the organic treatments showed higher keeping quality compared to fertilizer treatments. Interaction effect of nutrient levels and bioinoculants was also not significant.

4.3.2 Organoleptic test

The results given in table 10 revealed that in the case of appearance and overall acceptability of pods and taste the highest score was shown by the treatment T_5 (40 t FYM) followed by T_3 (20 t FYM).

Table 8. Pod length (cm), girth (cm) and mean pod weight (g) as influenced by nutrient levels and bioinoculants.

Nutrient levels	Pod length(cm)	Pod girth(cm)	Mean pod weight(g)
N_1	52.58	2.97	24.85
N_2	51.75	2.93	24.83
N_3	52.25	3.07	24.83
N_4	50.00	3.03	24.76
N_5	49.83	2.98	24.41
SE	1.88	0.09	0.76
CD(0.05)	NS	NS	NS
Bioinoculants			
B_1	50.97	2.96	24.77
B_2	51.60	3.03	24.69
SE	1.19	0.06	0.48
CD(0.05)	NS	NS	NS

NS – Non significant

Table 9. Keeping quality of pods as influenced by nutrient level and bio inoculants

Nutrient level	Number of days
N_1	3.67
N_2	4.17
N_3	4.33
N_4	4.33
N_5	4.17
SE CD(0.05)	0.23 NS
B_1	4.00
B_2	4.27
SE CD(0.05)	0.14 NS

NS – Non significant

Table 10. Organoleptic test

Treatments	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability
T_1	74	74	70	70	73	71
T_2	76	75	72	73	75	74
T_3	77	72	72	77	74	76
T_4	73	72	75	74	74	74
T_5	79	73	73	77	73	77

In the case of colour and texture treatment T_2 (20 t FYM +10:15:5 kg NPK ha^{-1}) obtained highest score. For flavour the highest rank value was shown by the treatment T_4 (30 t FYM) followed by T_5 (40 t FYM).

4.4 PLANT ANLYSIS

Plant and pod samples were analysed for nitrogen, phosphorus and potassium content. Uptake of nutrients also calculated and the data are presented in tables 11, 12 and 13.

4.4.1 Content of N, P and K

4.4.1.1 Nitrogen content of plants (%)

Nutrient levels, bioinoculants and their interaction significantly influenced the percentage nitrogen content of plants. The highest plant nitrogen content was recorded by the nutrient level N_3 (2.89%) which was significantly superior to all other treatments. The next higher plant nitrogen content was recorded by N_4 (2.79%) and N_2 (2.63%).

Bioinoculant level had significant influence on plant nitrogen content. Highest nitrogen content was observed in treatment B_2 (without biofertilizer) (2.81%) and was significantly superior to B_1(2.35%).

Among the treatment combinations, highest nitrogen content (3.24%) was recorded by the treatment T_9 (30 t FYM alone) and was significantly superior to all other treatments. This was closely followed by T_7 (3.09%) and was significantly superior to all other treatments except T_9 .

4.4.1.2 Phosphorus content of plants (%)

From the data presented in table 11 it was found that nutrient levels, bioinoculant levels and their interaction did not show any significant variation in % phosphorus content of plants.

4.4.1.3 Potassium content of plants (%)

Data furnished in table 11 revealed that highest potassium content (2.26%) was recorded by the nutrient level N_4 (30 t FYM) which was on par with N_3 (2.22 %).

Of the two bioinoculant levels, B_2 recorded the highest potassium content in plant (2.24%).

Interaction effect between nutrient level and bioinoculants was found significant. Treatment T_7 (20 t FYM +10:15:5 kg NPK ha^{-1} alone) recorded the highest potassium content in plant (2.38 %) and was significantly superior to all other treatments except T_9 (2.36%) which were on par.

4.4.1.4 Nitrogen content of pods (%)

The results depicted in table 12 revealed that N_4 (30 t FYM) registered highest nitrogen content in pod (4.40%) which was on par with N_3 (4.35%).

Of the two bioinoculant levels, B_2 (without biofertilizer) recorded highest nitrogen content in pod (4.33%).

Interaction effect between nutrient levels and bioinoculants was also significant. Treatment T_9 recorded highest nitrogen content (4.70%) which was significantly superior to all other treatments. T_9 was closely followed by T_7 (4.42%), T_8 (4.35%) and T_3 (4.35%) and these three treatments were on par.

Table 11. Nutrient content in plants as influenced by nutrient levels, bioinoculants and interaction.

Nutrient level	N (%)	P (%)	K (%)
N_1	2.18	0.33	1.92
N_2	2.63	0.48	2.14
N_3	2.89	0.42	2.22
N_4	2.79	0.41	2.26
N_5	2.42	0.37	2.14
SE CD(0.05)	0.01 0.039	0.22 NS	0.03 0.077
Bioinoculants			
B_1	2.35	0.55	2.03
B_2	2.81	0.41	2.24
SE CD(0.05)	0.01 0.025	0.14 NS	0.02 0.049
Interactions			
T_1	2.13	0.31	1.81
T_2	2.16	0.48	1.89
T_3	2.87	0.42	2.25
T_4	2.34	0.36	2.16
T_5	2.23	0.35	2.05
T_6	2.22	0.35	2.03
T_7	3.09	0.44	2.38
T_8	2.90	0.42	2.19
T_9	3.24	0.45	2.36
T_{10}	2.61	0.39	2.23
SE CD(0.05)	0.02 0.056	0.32 NS	0.04 0.109

NS – Non significant

4.4.1.5 Phosphorus content of pods (%)

From the data presented in table 12, it was found that there was significant difference among the nutrient levels in influencing the phosphorus content of pods. The highest value was recorded for N_3 (0.83%) which was closely followed by N_2 (0.81%) and N_4 (0.80%).

In case of two bioinoculant levels B_2 recorded the highest phosphorus content in pod (0.81%). Among the different treatment combinations T_9 recorded the highest phosphorus content in pod (0.87 %) and was on par with T_7 (0.86 %) and was significantly superior to all other treatments. These two treatments were followed by treatments T_8 (0.83%) and T_3 (0.82%) which were on par.

4.4.1.6 Potassium content of pods (%)

From the data summarized in table 12 it was found that nutrient level N_3 recorded highest potassium content of pods (3.10%) which was significantly superior to all other treatments and was closely followed by N_4 (2.88%) and N_2 (2.87%). Of the two bioinoculant levels B_2 recorded the highest K content (2.91%).

Interaction effect of nutrient levels and bioinoculants in influencing the potassium content of plants were found to be significant. The highest K content was registered by the treatment T_9 (3.22%) which was significantly superior to all other treatments and T_9 was closely followed by T_7, T_3 and T_8.

4.4.2 Uptake of N, P and K

The data on uptake of N, P and K are presented in the table 13.

4.4.2.1 Nitrogen uptake

Nitrogen uptake by plants was significantly influenced by various nutrient levels. Highest N uptake was noticed for the treatment N_3 (148.67 kg ha^{-1}) which was on par with N_2 (147.33 kg ha^{-1}). These two treatments were closely followed

Table 12. Nutrient content in pod (%) as influenced by nutrient levels, bioinoculants and interaction

Nutrient level	N(%)	P(%)	K(%)
N_1	3.89	0.67	2.33
N_2	4.14	0.81	2.87
N_3	4.35	0.83	3.10
N_4	4.40	0.80	2.88
N_5	4.06	0.76	2.56
SE CD(0.05)	0.02 0.064	0.01 0.017	0.01 0.031
Bioinoculants			
B1	4.01	0.74	2.58
B2	4.33	0.81	2.91
SE CD(0.05)	0.01 0.041	0.004 0.011	0.01 0.019
Interactions			
T_1	3.80	0.65	2.23
T_2	3.86	0.76	2.62
T_3	4.35	0.82	3.11
T_4	4.10	0.73	2.53
T_5	3.94	0.71	2.41
T_6	3.97	0.69	2.43
T_7	4.42	0.86	3.11
T_8	4.35	0.83	3.09
T_9	4.70	0.87	3.22
T_{10}	4.18	0.80	2.70
SE CD(0.05)	0.03 0.091	0.01 0.024	0.02 0.043

by N_4 (146.17 kg ha^{-1}) . Of the two bioinoculant level, B_2 (without biofertilizer) recorded highest nitrogen uptake (146.77 kg ha^{-1}).

Interaction effect of treatments was significant in nitrogen uptake. Treatment T_9 (30 t FYM alone) recorded the highest N uptake (168.00 kg ha^{-1}) which was on par with T_7 (165.67 kg ha^{-1}) and were significantly superior to all other treatments. Treatments T_8 and T_3 were also recorded higher N uptake (149.33 kg ha^{-1} and 148.00 kg ha^{-1} respectively) and were on par.

4.4.2.2 Phosphorus uptake

Data presented in table 13 revealed that phosphorus uptake by plants was significantly influenced by various nutrient levels. It was noted that nutrient level N_3 recorded highest phosphorus uptake by plant (32.84 kg ha^{-1}) which was on par with N_4 and N_2 (31.06 and 30.64 kg ha^{-1}) respectively.

The difference in phosphorus uptake was significant due to bioinoculant. B_2 (without biofertilizer) recorded higher phosphorus uptake (31.27 kg ha^{-1}) compared to B_1. Among the various treatments T_9 recorded highest P uptake (39.28 kg ha^{-1}) which was on par with T_7 and T_8 (37.16 and 33.64 kg ha^{-1} respectively).

4.4.2.3 Potassium uptake

Nutrient levels had significant influence on potassium uptake of plants. Nutrient level N_3 recorded maximum potassium uptake in plants (90.66 kg ha^{-1}) which was on par with N_4 and N_2 (90.19 and 90.05 kg ha^{-1}). Between two bioinoculant level there was significant difference with regard to K uptake. The highest K uptake was noted with bioinoculant level B_2 (89.58 kg ha^{-1}).

Interaction effect of nutrient level and bioinoculants in influencing the potassium uptake was found to be significant. Treatment T_9 recorded highest K uptake (99.41 kg ha^{-1}) which was significantly superior to all other treatments. The treatment T_9 was followed by T_7 (96.42 kg ha^{-1}).

Table 13. Uptake of nutrients as influenced by nutrient level, bioinoculants and interaction

Nutrient level	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
N_1	110.17	18.82	70.68
N_2	147.33	30.64	90.05
N_3	148.67	32.84	90.66
N_4	146.17	31.06	90.19
N_5	129.17	20.51	82.19
SE CD(0.05)	0.59 1.778	1.51 4.485	0.23 0.685
Bioinoculants			
B_1	125.83	22.27	79.92
B_2	146.77	31.27	89.58
SE CD(0.05)	0.38 1.125	0.96 2.870	0.15 0.433
Interactions			
T_1	107.83	18.27	69.07
T_2	129.00	24.12	83.68
T_3	148.00	32.03	89.22
T_4	124.33	22.84	80.97
T_5	120.00	14.09	76.67
T_6	112.50	19.37	72.29
T_7	165.67	37.16	96.42
T_8	149.33	33.64	92.09
T_9	168.00	39.28	99.41
T_{10}	138.33	26.93	87.70
SE CD(0.05)	0.85 2.515	2.14 6.343	0.33 0.968

4.5 SOIL NUTRIENT STATUS AFTER THE EXPERIMNT

4.5.1 Available nitrogen

Data on available nutrient status of soil is given in Table 14. Available nitrogen in soil was highest for the nutrient level N_1 (20 t FYM + 20:30:10 kg NPK ha^{-1}) (347.07 kg ha^{-1}) which was significantly superior to all other nutrient levels. In case of bioinoculant levels, B_1 (with biofertilizer) recorded highest available nitrogen in soil (307.87 kg ha^{-1}).

Interaction effect of nutrient level and bioinoculants had significant effect on nitrogen status of soil. Highest nitrogen content in soil (355.45 kg ha^{-1}) was recorded in the treatment T_1 (20 t FYM + 20:30:10 kg NPK ha^{-1} with biofertilizer) which was found significantly superior to all other treatments. This treatment T_1 was followed by T_6 (338.69 kg ha^{-1}).

4.5.2 Available Phosphorus

With regard to available P status of soil, highest value (21.24 kg ha^{-1}) was obtained for the nutrient level N_1 (20 t FYM + 20:30:10 kg NPK ha^{-1}) which was significantly superior to all other nutrient levels. In case of bioinoculant levels, B_1 (with biofertilizer) recorded highest P in soil (19.13 kg ha^{-1}) .

Interaction effect of nutrient levels and bioinoculants had significant influence on phosphorus status of soil. Highest phosphorus content in soil was recorded in the treatment T_1 (21.65 kg ha^{-1}) which was found superior to all other treatments.

4.5.3 Available Potassium

Available K in soil was highest for the nutrient level N_1 (176.00 kg ha^{-1}) which was significantly superior to all other nutrient levels. Highest K in soil (161.73 kg ha^{-1}) was obtained for the bioinoculant level B_1 (with biofertilizer). Among the different treatment combinations T_1 (20 t FYM + 20:30:10 kg NPK ha^{-1}+ biofertilizer) registered the highest K status of soil (185.53 kg ha^{-1}) which was

Table 14. Soil NPK status as influenced by nutrient levels, bioinoculants and interaction

Nutrient levels	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
N_1	347.07	21.24	176.00
N_2	276.04	17.28	138.00
N_3	267.60	16.89	140.61
N_4	280.30	17.48	141.16
N_5	299.04	18.72	156.44
SE CD(0.05)	3.73 11.078	0.19 0.550	0.54 1.590
Bioinoculants			
B_1	307.87	19.13	161.73
B_2	280.15	17.51	139.55
SE CD(0.05)	2.36 7.006	0.12 0.348	0.34 1.006
Interactions			
T_1	355.45	21.65	185.53
T_2	292.84	18.36	147.39
T_3	271.78	17.09	142.26
T_4	305.53	18.85	156.92
T_5	313.75	19.71	176.49
T_6	338.69	20.82	166.46
T_7	259.24	16.20	130.53
T_8	263.42	16.68	138.96
T_9	255.06	16.12	125.39
T_{10}	284.32	17.73	136.40
SE CD(0.05)	5.27 15.666	0.26 0.778	0.76 2.249

was significantly superior to all other treatments. The lowest K status of soil was registered by the treatment T_9 (125.39 kg ha^{-1}) which was on par with T_7 (130.53 kg ha^{-1}) and significantly inferior to all other treatments.

4.6 INCIDENCE OF POD BORER

The data on incidence of pod borer showed that there was no significant difference among different nutrient levels, bioinoculants and their interaction.

4.7 ECONOMIC ANALYSIS

4.7.1 Net return

The data on economics of cultivation furnished in Table 15 showed that among the various nutrient levels, N_3 i.e., application of 20 t FYM alone resulted in maximum net profit of Rs. 86962.60 ha^{-1} and was significantly superior to all other nutrient levels. This treatment was closely followed by N_2 (Rs.83.203.40 ha^{-1})

Bioinoculant levels had a significant influence on the net return from the system. Without biofertilizer treatments (B_2) gave significantly higher net returns (Rs. 92,599.00 ha^{-1}) compared to biofertilizer applied treatments.

Interaction effect of nutrient levels with bioinoculants had significant effect on net returns from the system. Treatment T_9 (30 t FYM alone) recorded highest net return (Rs.1,18,265.60 ha^{-1}) which was on par with the treatment T_7 (20 t FYM + 10:15:5 kg NPK ha^{-1} alone) with a net profit of Rs. 1,16,867.70 ha^{-1}.

4.7.2 B:C ratio

With respect to B:C ratio, N_3 (application of 20 t FYM) recorded the highest benefit- cost ratio (2.13) and was on par with N_2 (20 t FYM + 10:15:5 kg NPK ha^{-1}).

Of the two bioinoculant level, treatments without biofertilizer application (B_2) gave a higher B: C ratio of 2.30 and was significantly superior to B_1.

Table 15. Net returns and benefit: cost ratio as influenced by nutrient level bioinoculants and interaction.

Nutrient level	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
N_1	127836.90	43769.28	1.55
N_2	165624.30	83203.40	2.10
N_3	167736.60	86962.60	2.13
N_4	165178.50	75894.50	1.98
N_5	143414.10	44575.14	1.55
SE CD(0.05)	618.30 1837.128	618.97 1839.132	0.01 0.023
Bioinoculants			
B_1	144165.10	41162.97	1.42
B_2	163751.10	92599.00	2.30
SE CD(0.05)	391.05 1161.902	391.47 1163.169	0.01 0.015
Interactions			
T_1	130361.70	33693.92	1.34
T_2	144559.90	49539.07	1.52
T_3	167396.90	74022.87	1.79
T_4	140657.40	33523.40	1.31
T_5	137849.60	15035.60	1.12
T_6	125312.10	53844.64	1.74
T_7	186688.60	116867.70	2.66
T_8	168076.30	99902.34	2.46
T_9	189699.60	118265.60	2.65
T_{10}	148978.70	74114.66	1.98
SE CD(0.05)	874.41 2598.091	875.36 2600.925	0.01 0.033

The interaction effect of nutrient levels and bioinoculants had significant influence on B:C ratio of the system. Treatment T_7 (20 t FYM + 10:15:5 kg NPK ha^{-1}) recorded the highest benefit-cost ratio (2.66) which was on par with T_9 (2.65) and were significantly superior to all other treatments.

Discussion

5. DISCUSSION

The result of the experiment Nutrient management in yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* L.) conducted to study the growth, productivity and quality of yard long bean under organic and integrated nutrient management system and to study the economics of cultivation are discussed in this chapter.

5.1 EFFECT OF NUTRIENT LEVELS AND BIOINOCULANTS ON GROWTH AND PRODUCTIVITY OF COWPEA

The results of the study indicated that nutrient levels had significant influence on the growth characters of cowpea like vine length, leaves plant^{-1} and dry matter production. The longest vine was recorded with the application of 20 t FYM+10:15:5 kg NPK ha^{-1} at vegetative stage. At flowering and harvesting stages N_3 (20 t FYM ha^{-1}) recorded highest vine length. Interaction effect of nutrient levels and bioinoculants had no significant influence on vine length at vegetative stage. Sharma and Abraham (2010) also reported a significant difference in plant height and dry matter production with 10 t FYM ha^{-1} over control at maturity in blackgram. Veena (2000) confirmed that application of 20 t FYM ha^{-1} resulted in increased plant height. Increase in plant height might be due to the improvement in soil physical condition provided for plant growth.

Branches per plant was not significantly influenced by different nutrient levels and bioinoculant levels. Interaction effect was also found not influencing the number on branches per plant.

Maximum leaves per plant was observed with the nutrient level 20 t FYM+ 10:15:5 kg NPK ha^{-1} at all the growth stages even though the effect was significant only at flowering stage. Bioinoculants significantly influenced the number of leaves per plant. Application of 2% PGPR resulted in higher number of leaves at all the growth stages. The interaction effect was significant only at flowering stage. At flowering stage 20 t FYM + 10:15:5 kg NPK ha^{-1}+ PGPR

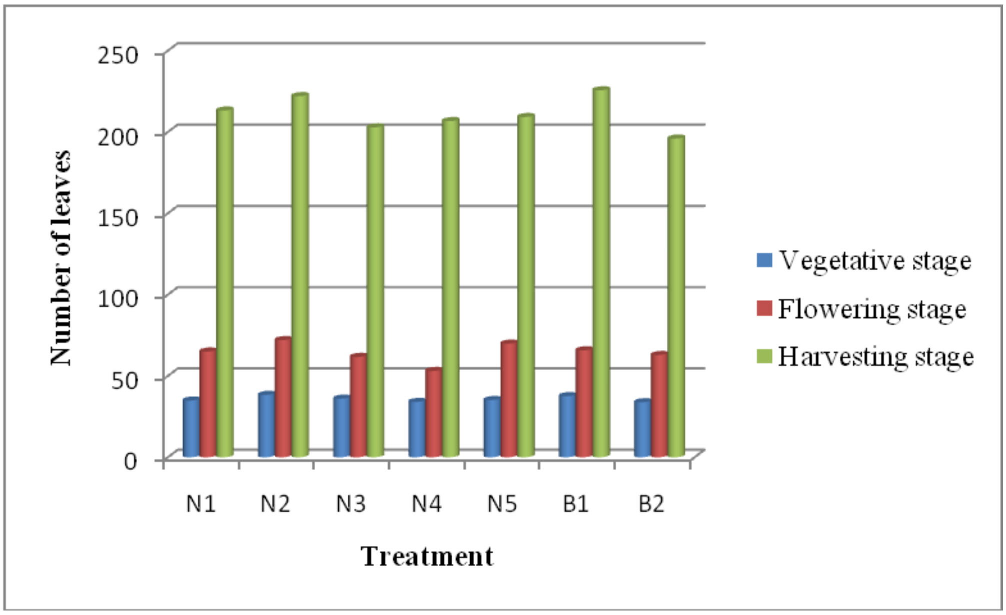

Fig.3 Number of leaves as influenced by main effect of nutrient levels and bioinoculants

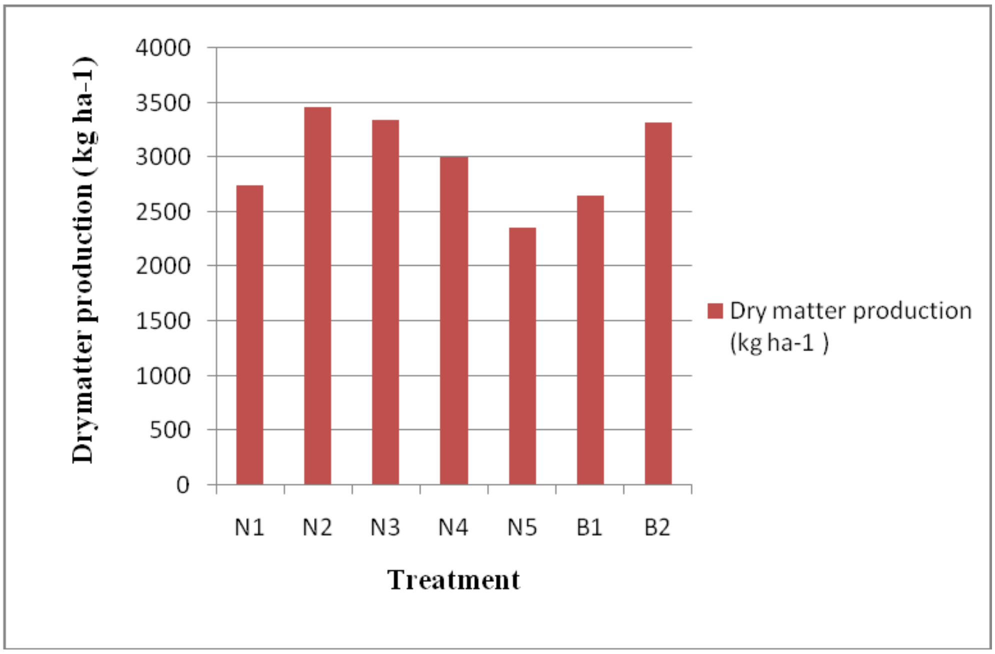

Fig.4 Dry matter production as influenced by main effect of nutrient levels and bioinoculants

recorded the maximum number of leaves. But this significant response of PGPR was confined mainly during the initial stages of crop growth. This significant response was not reflected in harvest stage. Nutrient levels and bioinoculants exerted significant influence on dry matter production. Application of nutrient level 20 t FYM+ 10:15:5 kg NPK ha^{-1} resulted in higher dry matter production. This may be due to increased plant height, number of leaves and increased vegetative growth for this treatment. Renu (2003) also opined that combined application of poultry manure and chemical fertilizer gave maximum dry matter production. Inoculation with microbial consortium produced lesser dry matter than inoculation without microbial consortium. This may be due to the very slow release of nutrients especially nitrogen from FYM in microbial consortium applied treatments. The small quantities of nutrients released might have utilized by microorganisms for their growth and reproduction and thus the plants might have deprived of adequate nutrients during the period of peak vegetative growth and resulted in reduced growth.

Regarding the yield attributes levels of organic manures and bioinoculant did not cause any significant influence on yield parameters like days to first harvest, days for final harvest and number of pickings. It was observed that vegetable cowpea took about 54-55 days for first harvest and could be harvested up to 104-105 days from the date of sowing. It could be inferred from the table 7 that pods per plant, pod yield per plant and pod yield in kg ha^{-1} were significantly varied due to different nutrient levels. These three parameters were highest with the application of nutrient level 20 t FYM ha^{-1}. The highest yield with application of 20 t FYM ha^{-1} might be due to increased uptake of nutrients with this treatment. This may probably be due to adequate nutrient availability from farm yard manure through mineralization process (Reddy and Swamy, 2000). This is in conformity with the findings of Senthilkumar and Sekar (1998). Farm yard manure acts as nutrient reservoir and upon decomposition produces organic acids, thereby absorbed ions are released slowly during entire growth period leading to higher yield and yield components. Farm yard manure registered highest number of tubers in sweet potato (Dhanya, 2011). Deepa (2005) also

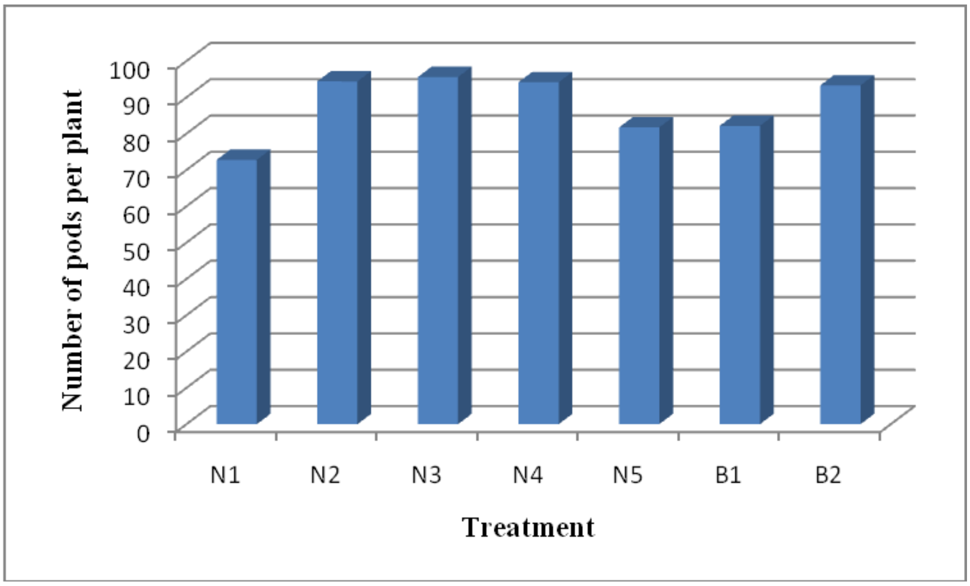

Fig. 5 Number of pods per plant as influenced by main effect of nutrient levels and bioinoculants

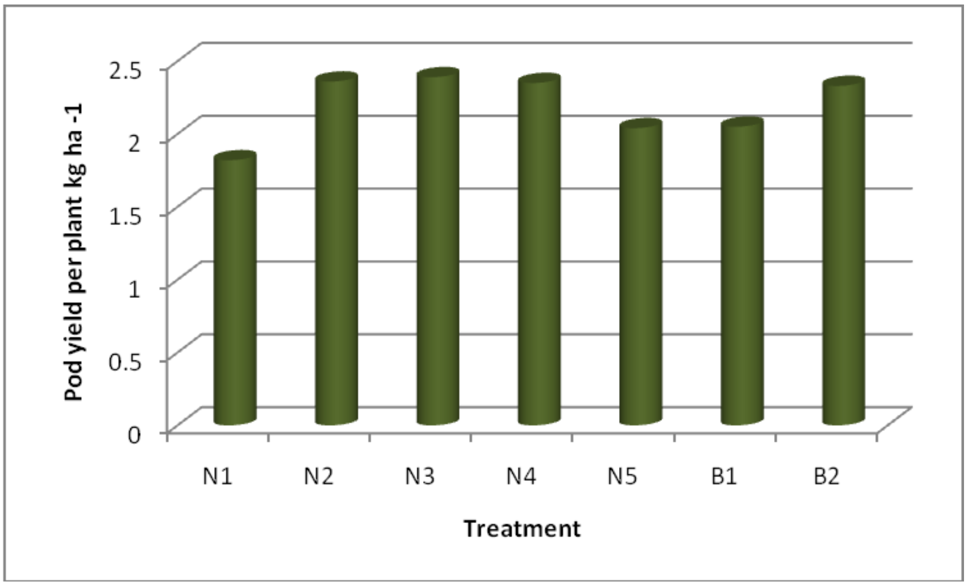

Fig.6 Pod yield per plant in kg ha^{-1} as influenced by main effect of nutrient levels and bioinoculants.

reported that yield attributing characters like number of flowers, number of pods per plant, total pod yield and marketable pod yield in vegetable cowpea was significantly influenced by organic manures. Among the different treatment combinations, application of 30 t FYM ha^{-1} resulted in highest number of pods per plant, pod yield per plant and pod yield in kg ha^{-1} followed by the application of 20 t FYM + 10:15:5 kg NPK ha^{-1}. The higher yield might be due to higher number of pods per plant and pod yield per plant. Application of FYM might have brought about a decrease in bulk density. A decrease in bulk density makes easier for plant roots to proliferate and as a consequence, the potential for plants to extract water and nutrient greatly increases. The beneficial effect of FYM on yield and yield attributes might be due to additional supply of plant nutrients as well as improvement in physical and biological properties of soil (Dutt *et al.* 2003). It could also be attributed to the fact that after decomposition and mineralization, the FYM supplied available nutrients directly to plants and also had solubilising effect on fixed form of nutrients (Sinha *et al*. 1981). This may be due to highest uptake and efficient utilization of nutrients.

Inoculation of microbial consortium didnot have any significant influence on yield and yield attributes of vegetable cowpea. Dhanya (2011) also reported that bioinoculants did not show any significant influence on tuber yield in sweet potato. Other yield attributes like pod length, pod width and mean pod weight were not influenced by various nutrient levels, bioinoculants and their interaction.

5.3 QUALITY CHARACTERS

Different nutrient levels and bioinoculants tested in the experiment did not show any significant influence on the keeping quality of fruits. The shelf life of cowpea pods were not influenced by organic and conventional cultivation practices (Agey, 2011). In the case of colour and texture application of 20 t FYM + 10:15:5 kg NPK ha^{-1} obtained highest score. For flavour the highest rank value was shown by the 30 t FYM alone followed by 40 t FYM ha^{-1}. Application of FYM alone registered more taste compared to integrated nutrient management. Renu (2003) also reported the texture, odour and keeping quality of bittergourd was well pronounced in organically treated plots (FYM, vermicompost, poultry manure) than those with integrated and fully inorganic plots. The organoleptic test revealed that the fruits obtained by application of FYM alone were highly acceptable since they recorded good taste and overall acceptability.

5.4 NUTRIENT CONTENT AND NUTRIENT UPTAKE

A perusal of the data shown in table 11 revealed that among the various nutrient levels, application of 20 t FYM ha^{-1} recorded the highest N content in plants. The highest K content of plants was recorded for the application of 30 t FYM ha^{-1}. Among the interaction effects, application of 30 t FYM without biofertilizer recorded maximum N content. P content was not significantly influenced by nutrient levels, bioinoculants and interaction. K content was higher with the application of 20 t FYM + 10:15:5 kg NPK ha^{-1} without biofertilizer. Nutrient content in pods were also influenced by various nutrient levels. Highest N content was recorded by 30 t FYM ha^{-1}. Maximum P and K content in pod was shown by the application of 20 t FYM ha^{-1}. Among the different treatment combinations application of 30 t FYM alone recorded in maximum content of N, P and K.

It can be noted from the table 13 that among the nutrient levels, application of 20 t FYM ha^{-1} registered the highest N uptake. The same trend was followed for P and K uptake which were on par with 20 t FYM + 10:15:5 kg NPK $ha^{-1}$and 30 t FYM ha^{-1}. The increased mineralisation of soil P as result of production of organic acids during decomposition of organic matter may be one of the reasons for increased P uptake. The vigorous root growth due to FYM application may also be one of the reason for increased P uptake and P content in plants. Increased moisture content and retention due to organic manure application may have accelerated K+ diffusion to roots (Tisdale *et al.,* 1995). Nutrient uptake was lesser in microbial consortium inoculated plots. Combination effect revealed that 30 t FYM ha^{-1} alone resulted in higher nutrient uptake. Rakshit and Sen (2008) reported the efficiency of FYM in enhancing the uptake of major nutrients. Raju

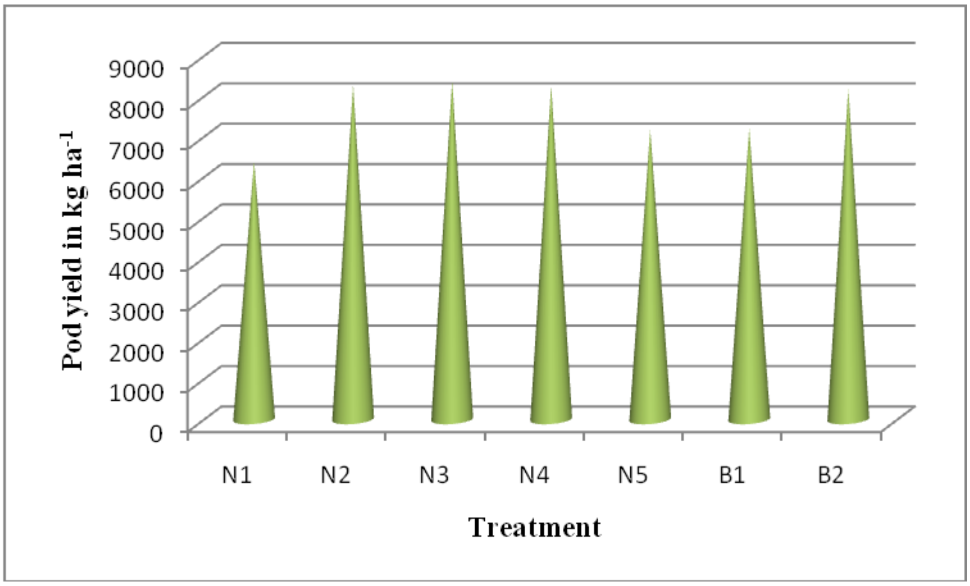

Fig.7 Pod yield in kg ha^{-1} as influenced by nutrient levels and bioinoculants

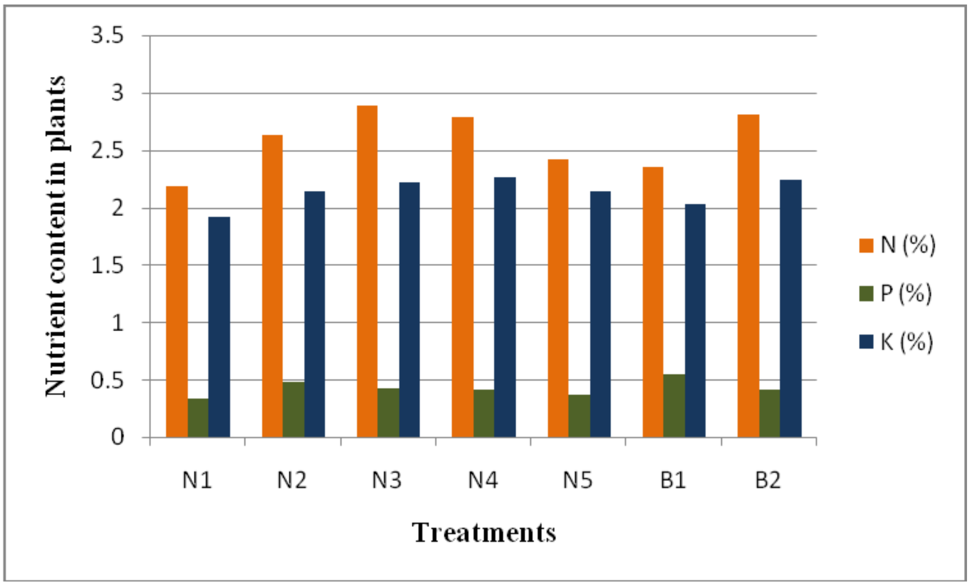

Fig.8 NPK content in plants as influenced by main effect of nutrient levels and bioinoculants

et al. (1991) also observed the effectiveness of FYM in increasing the N uptake in chickpea. This better uptake of nutrients by crop might have resulted in better expression of yield attributes and finally the yield.

5.5 SOIL NUTRIENT STATUS AFTER THE EXPERIMENT

Significant variation in available N status of soil was observed due to nutrient levels. Available N status of the soil after the experiment was highest for the nutrient level 20 t FYM+ 100% RDF. Available P and K status of the soil was also recorded highest for the same nutrient level. This might be due to the reduced uptake of nutrients by the crop. Parmer and Sharma (2001) reported that the application of 100% of RDF+ 30 t FYM per ha significantly improved the availability of N, P and K in soil.

Available N, P and K status of soil increased with inoculation of PGPR @ 2%. Interaction effect of nutrient level and bioinoculant were significant for available N, P and K status of soil. 20 t FYM+ 100% RDF with bioinoculant registered the highest value of available N ha^{-1} which was significantly superior to all other treatments. Available P and K status of soil also was highest with the treatment 20 t FYM+ 100% RDF with bioinoculant. Significant build up of soil available nitrogen under this treatment could be attributed to the direct addition of N through FYM and N fertilizers to the available pool of soil. The increase in available P content of soil might be due to the incorporation of organic manure, chemical fertilizers and direct addition of P as well as solubilisation of native P through various organic acids (Singh *et al.* 2009). Higher soil nutrient status might also be due to lower utilization of nutrients by the crop from applied source, which resulted in building up of higher N,P and K status of soil.

5.6 ECONOMIC ANALYSIS

A scanning of the data presented in table 15 revealed that among various nutrient levels, 20 t FYM ha^{-1} resulted in maximum net return (Rs.86962.60 ha^{-1}). Purushottam kumar and Puri (2002) also reported that FYM application recorded higher net returns. Considering the interactions, the treatment receiving 30 t FYM

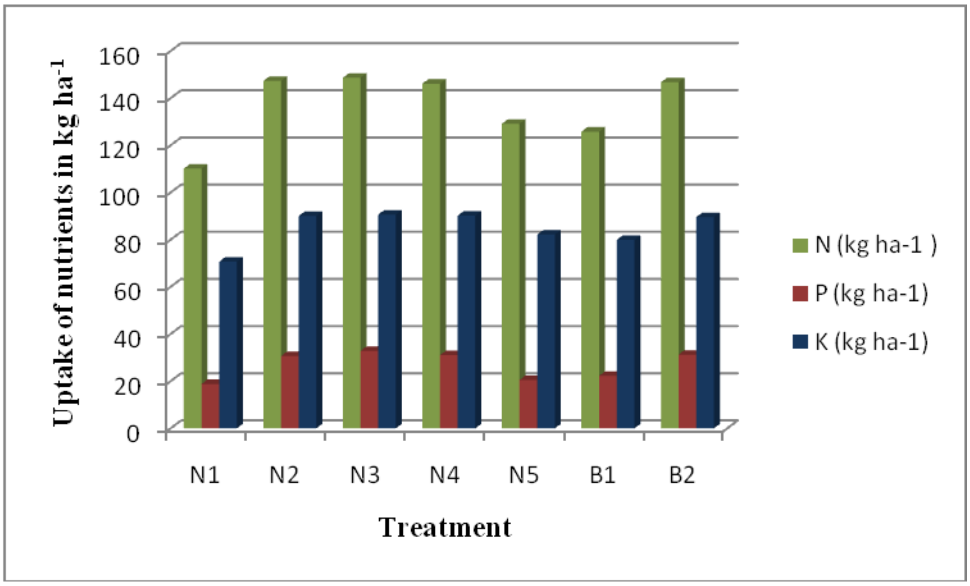

Fig.9 Uptake of N, P and K as influenced by main effect of nutrient levels and bioinoculants.

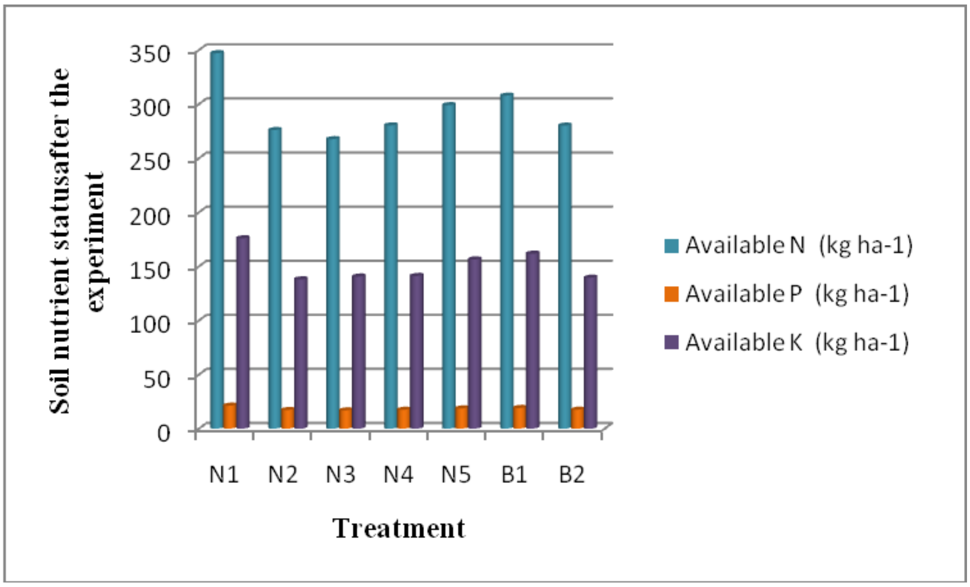

Fig.10 Soil NPK status as influenced by main effect of nutrient levels and bioinoculants

ha^{-1} recorded the highest net returns (Rs.1,18,265.60 ha^{-1}) followed by the treatment receiving 20 t FYM+ 10:15:5 kg NPK ha^{-1} (Rs.1,16,867.70 ha^{-1}). The higher returns may be due to the better performance of crop with respect to yield.

With regard to B: C ratio, application of 20 t FYM ha^{-1} (N_3) recorded the highest benefit- cost ratio (2.13) and was on par with N_2 (20 t FYM+ 10:15:5 kg NPK ha^{-1}). Among the interaction effects, 20 t FYM+ 10:15:5 kg NPK ha^{-1} without bioinoculant gave the highest B:C ratio (2.66) which was on par with 30 t FYM without bioinoculant (2.65). Dhanya (2011) also obtained higher B:C ratio with full dose of poultry manure without bioinoculant. Net return from brinjal was highest when organic manure was applied along with chemical fertilizer (Rekha, 1999). Even though maximum yield was obtained for the treatment 30 t FYM ha^{-1} alone, the increase in input cost for this treatment than T_2 ie,0.97% had resulted in a slight decrease of B:C ratio. Integrated application of FYM and chemical fertilizer resulted in highest B:C ratio. In vegetable cowpea, either 20 t FYM + 10:15:5 kg NPK ha^{-1} or 30 t FYM alone (organic) was found as best economically feasible nutrient schedule.

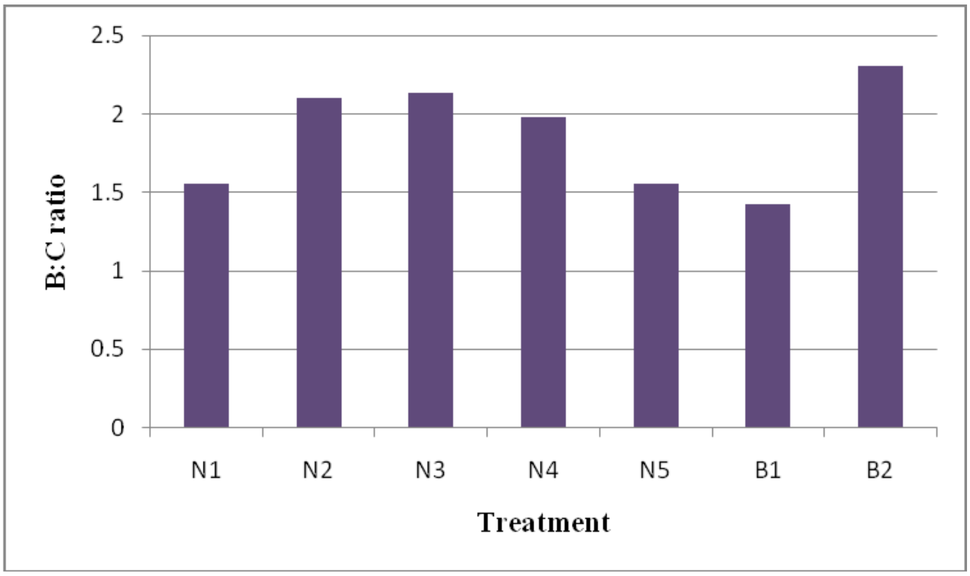

Fig.11 B:C ratio as influenced by main effect of nutrient levels and bioinoculants

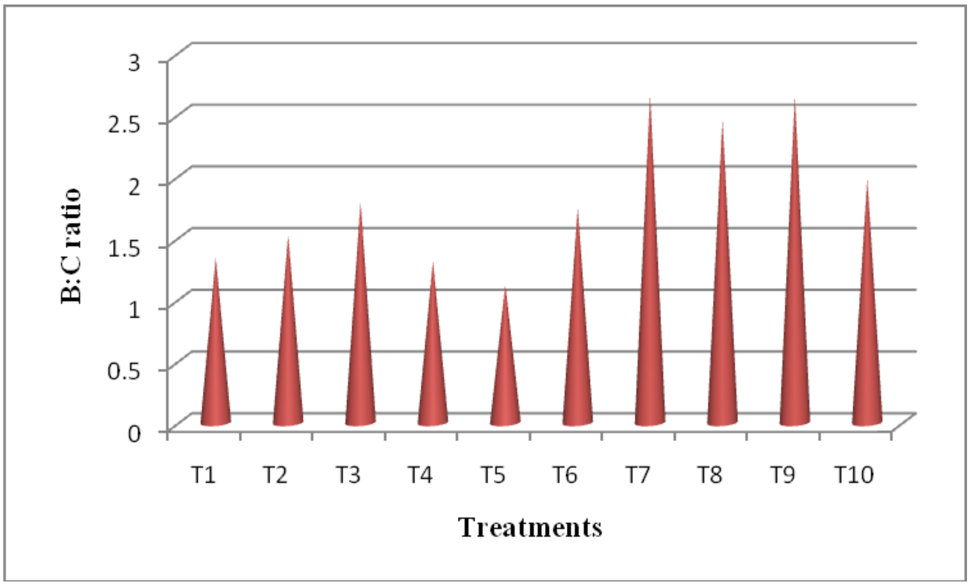

Fig.12 B:C ratio as influenced by interaction effect of nutrient levels and bioinoculants.

Summary

6. SUMMARY

The investigation entitled Nutrient management in yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* L.) was carried out at the Instructional Farm, College of Agriculture, Vellayani during the period from January 2012 to April 2012. The main objectives of the experiment were to study the growth, productivity and quality of yard long bean under organic and integrated nutrient management system and to study the economics of production.

The experiment consisted of five nutrient levels and two bioinoculant levels. There were altogether ten treatment combinations. The experiment was laid out in factorial Randomised Block Design with three replications. The salient findings of the experiment are summarised below.

Different nutrient levels showed significant influence on vine length at different growth stages. Application of 20 t FYM along with 10:15:5 kg NPK ha^{-1} recorded the longest vines at vegetative stage. At flowering and harvesting stage the longest plants were observed with the application of 20 t FYM alone. At all growth stages combined application of microbial consortium and 20 t FYM recorded highest vine length.

Different nutrient levels had significant influence on number of leaves only at flowering stage. Application of 20 t FYM and 10:15:5 kg NPK ha^{-1} recorded the maximum number of leaves. Inoculation of microbial consortium influenced number of leaves at all the growth stages significantly. At flowering stage combined application of 20 t FYM and 10:15:5 kg NPK ha^{-1} + PGPR recorded maximum number of leaves.

The individual and interaction effect of nutrient levels, bioinoculant levels a were not significant on number of branches per plant.

Dry matter production was significantly influenced by nutrient levels, bioinoculants and their interaction. The maximum dry matter was obtained for the treatment receiving 20 t FYM and 10:15:5 kg NPK ha^{-1}.

Yield parameters like days to first harvest, days to final harvest and number of pickings were not influenced by different nutrient levels, bioinoculant levels and their interaction.

Pods per plant varied significantly due to nutrient levels and bioinoculants. Application of 30 t FYM alone gave maximum number of pods per plant. The same trend was followed for pod yield per plant and pod yield in kg ha^{-1}.

Pod yield per plant and pod yield in kg ha^{-1}were also significantly influenced by nutrient levels, bioinoculants and their interaction. These parameters gave best result with the application of 30 t FYM alone.

Various nutrient levels, bioinoculant levels and their interaction did not exert any significant influence on pod length, pod width and mean pod weight of vegetable cowpea.

Keeping quality of fruits was not significantly influenced by various nutrient levels and bioinoculants. But in general it was observed that the organic treatments had better keeping quality compared to fertilizer treatments.

For appearance, overall acceptability and taste of pods the highest score was for the treatment 40 t FYM followed by the application of 20 t FYM ha^{-1}. For colour and texture, application of 20 t FYM + 10:15:5 kg NPK ha^{-1} obtained highest score. For flavour, application of 40 t FYM was best.

Various treatments revealed significant influence on nutrient content of plant parts. The highest plant nitrogen content was recorded by the application of nutrient level 20 t FYM. Highest nitrogen content was observed in treatment without bioinoculants. Comparing various interaction effects, nitrogen content was higher for the application of 30 t FYM alone. Phosphorus content in plant was unaffected by nutrient levels, bioinoculants and their interaction. Potassium content was found higher with the application of 30 t FYM. Among the various treatment combinations, application of 20 t FYM + 10:15:5 kg NPK ha^{-1} without biofertilizer recorded highest value for potassium.

Nitrogen content in pod was highest with the application of 30 t FYM alone. Among various interactions 30 t FYM alone recorded highest pod nitrogen content. P and K content in pod were significantly improved by the application of nutrient level 20 t FYM. Comparing various interaction effects, P and K content was higher for the treatment 30 t FYM alone.

Nutrient uptake by plants varied significantly with respect to various treatments. Plants applied with 20 t FYM recorded the maximum N, P and K uptake. Uptakes of nutrients were not influenced by inoculation of microbial consortium. Comparing various interaction effects, application of 30 t FYM alone registered high uptake for N, P and K.

With regard to available nutrient status of soil, application of 20 t FYM and 20:30:10 kg NPK ha^{-1} showed higher availability of N, P and K. Soil treated with bioinoculant recorded higher N, P and K content than without bioinoculant. Among various treatments, combinations of 20 t FYM and 20:30:10 kg NPK ha^{-1} and PGPR recorded higher availability of N, P and K content in soil after the experiment.

The incidence of pod borer was not influenced by nutrient levels, bioinoculant and their interaction.

Economic analysis of various nutrient level in vegetable cowpea revealed that application of 20 t FYM maintained higher net returns and B:C ratio as compared to other nutrient levels. Without biofertilizer treatments (B_2) gave significantly higher net returns and B:C ratio compared to biofertilizer applied treatments. Among various treatment combinations, application of treatment 30 t FYM alone recorded highest net return which was closely followed by application of 20 t FYM + 10:15:5 kg NPK ha^{-1} alone. However B: C ratio was highest for 20 t FYM + 10:15:5 kg NPK ha^{-1} alone which was closely followed by the treatment treatment 30 t FYM alone.

The current research brings out the suitability of farm yard manure as promising organic manure for vegetable cowpea. The effect of bioinoculant at the present rate had no significant influence in growth and yield of vegetable cowpea. It can be concluded that integrated application of 20 t FYM + 10:15:5 kg NPK ha^{-1} or organic cultivation with 30 t FYM ha^{-1} was found as the best economically feasible nutrient schedule.

Future line of work

From the results of the present investigation we could conclude that in vegetable cowpea 20 t FYM ha^{-1}+ 10:15:5 kg NPK ha^{-1} or 30 t FYM ha^{-1} alone was found as the best economic schedule. Application of microbial consortium at the present rate (2%) has no significant effect on vegetable cowpea. Hence higher rate of PGPR at regular interval can be studied.

Studies with other easily mineralisable organic manures and their split application can be tried.

A detailed study of organic manure-PGPR interaction may also be conducted.

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NUTRIENT MANAGEMENT IN YARD LONG BEAN

(*Vigna unguiculata* subsp. s*esquipedalis* L.)

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ABSTRACT

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8. ABSTRACT

A field experiment entitled Nutrient management in yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* L.) was conducted at the Instructional Farm attached to the College of Agriculture, Vellayani during 2011-2012 to study the growth, productivity and quality of yard long bean under organic and integrated nutrient management (INM) system and to study the economics of production . The treatments consisted of five nutrient levels and two biofertilizer levels. The experiment was laid out in factorial RBD with three replications.

Different nutrient levels showed significant influence on vine length at different growth stages. Application of 20 t FYM along with 10:15:5 kg NPK ha^{-1} recorded the longest vines at vegetative stage. At flowering and harvesting stage the longest plants were observed with the application of 20 t FYM. Different nutrient levels had significant influence on number of leaves only at flowering stage. Application of 20 t FYM and 10:15:5 kg NPK ha^{-1} recorded the maximum number of leaves. Inoculation of microbial consortium influenced number of leaves at all the growth stages significantly. At flowering stage combined application of 20 t FYM and 10:15:5 kg NPK ha^{-1} + PGPR recorded maximum number of leaves.

The individual and interaction effect of nutrient levels and bioinoculants were not significant on number of branches per plant.

The maximum dry matter was obtained for the treatment receiving 20 t FYM and 10:15:5 kg NPK ha^{-1}.

Yield parameters like days to first harvest, days to final harvest and number of pickings were not influenced by different nutrient levels, bioinoculant levels and their interaction. Pods per plant varied significantly due to nutrient levels and bioinoculants. Application of 30 t FYM alone gave maximum number of pods per plant. The same trend was followed for pod yield per plant and pod yield in kg ha^{-1}.

Keeping quality of fruits was not significantly influenced by various nutrient levels and bioinoculants. For appearance, overall acceptability and taste of pods the highest score was for the treatment 40 t FYM followed by the application of 20 t FYM ha^{-1}. For colour and texture, application of 20 t FYM + 10:15:5 kg NPK ha^{-1} obtained highest score.

The highest plant nitrogen content was recorded by the application of nutrient level 20 t FYM. Comparing various interaction effects, nitrogen content was higher for the application of 30 t FYM alone. Phosphorus content was unaffected by nutrient levels, bioinoculants and their interaction. Potassium content was found higher with the application of 30 t FYM. Among the various treatment combinations, application of 20 t FYM + 10:15:5 kg NPK ha^{-1} without biofertilizer recorded highest value for potassium.

Nitrogen content in pod was highest with the application of 30 t FYM alone. P and K content in pod were significantly improved by the application of nutrient level 20 t FYM. Comparing various interaction effects, N, P and K content was higher for the treatment 30 t FYM alone.

Nutrient uptake by plants varied significantly with respect to various treatments. Plants applied with 20 t FYM recorded the maximum N, P and K uptake. Comparing various interaction effects, application of 30 t FYM alone registered high uptake for N, P and K.

With regard to available nutrient status of soil, application of 20 t FYM and 20:30:10 kg NPK ha^{-1} showed higher availability of N, P and K. Soil treated with bioinoculant recorded higher N, P and K content than without bioinoculant.

Economic analysis revealed that among various treatment combinations, application of 30 t FYM alone recorded highest net return which was closely followed by application of 20 t FYM + 10:15:5 kg NPK ha^{-1} alone. However B: C ratio was highest for 20 t FYM + 10:15:5 kg NPK ha^{-1} alone which was closely followed by the treatment 30 t FYM alone.

Appendices

Appendix - I

Weather parameters during the crop growth period

Standard week	Temperature(^{0}C)		Rainfall (mm)	Relative Humidity (%)
	Maximum	Minimum		
2	30.3	23	-	83.42
3	29.5	19.3	5	76.2
4	30	19.9	-	78.6
5	31.1	21	-	76.2
6	30.8	23.2	-	77.4
7	30.6	22.8	-	81.5
8	31.4	21.9	-	76.4
9	31.8	22.4	-	76.5
10	31.3	24.8	3.5	78.2
11	31	24.2	9.5	81.7
12	31.9	24.3	-	81.2
13	32.1	23	9	76.5
14	32.7	24.5	-	76.9
15	32.7	24.8	8	78.1
16	32.9	22.1	13.5	80.45
17	30.8	25.4	67.4	82

Appendix - II

Average input cost and market price of produce

Sl.No.	Items	Cost(Rs.)
	INPUTS	
A	Cowpea seeds	1200 kg^{-1}
B	Labour	
1.	Men labourer	350
2.	Women labourer	175
C	Cost of manures and fertilisers	
1.	FYM	400 t^{-1}
2.	Urea	6 kg^{-1}
3.	Rajphos	4 kg^{-1}
4.	Muriate of potash	5.5 kg^{-1}
5.	PGPR mix-I	70 kg^{-1}
6.	PGPR mix-II	70 kg^{-1}
	OUTPUT	
1.	Market price of vegetable cowpea	20 kg^{-1}