FIELD EVALUATION OF COMMERCIAL ORGANIC MANURES AND GROWTH PROMOTERS IN BUSH TYPE VEGETABLE COWPEA (*Vigna unguiculata* subsp. *sesquipedalis*)

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Dedicated to my parents-in-law

Sri. K. Chandrasekharan Nair

And

Smt. C. Vasanthakumari

DECLARATION

I hereby declare that this thesis entitled "**Field evaluation of commercial organic manures and growth promoters in bush type vegetable cowpea (*Vigna unguiculata* subsp. *sesquipedalis*)**" is a bonafide record of research work 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, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "**Field evaluation of commercial organic manures and growth promoters in bush type vegetable cowpea (*Vigna unguiculata* subsp. *sesquipedalis*)**" is a record of research work done independently by Mrs. Deepa. S (2003-11-20) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Deepa, S.

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LIST OF ABBREVIATIONS

%	–	Per cent
@	–	At the rate of
°C	–	Degree Celsius
°E	–	Degree East
°N	–	Degree North
BCR	–	Benefit-cost ratio
CD	–	Critical difference
cm	–	Centimetre
cv.	–	Cultivar
DAS	–	Days after sowing
DMP	–	Dry Matter Production
EC	–	Emulsifiable Concentrate
et al.	–	And others
Fig.	–	Figure
FYM		Farmyard manure
g	–	Gram
GA	–	Gibberellic acid
ha	–	Hectare
IAA	–	Indole Acetic Acid
K	–	Potassium
K_2O	–	Potash
kg	–	Kilogram
kg ha^{-1}	–	Kilogram per hectare
LAI	–	Leaf area index
m	–	Metre
mg	–	Milligram
mg 100^{-3}g	–	Milli gram per hundred gram
mm	–	Millimetre
N	–	Nitrogen
NS	–	Non significant
P	–	Phosphorus
P_2O_5	–	Phosphate
POP	–	Package of Practices Recommendations
ppm	–	Parts per million
RGR	–	Relative Growth Rate
RLWC	–	Relative leaf water content
Rs	–	Rupees
t ha^{-1}	–	Tonnes per hectare
WAS	–	Weeks After Sowing

Introduction

1. INTRODUCTION

Nutrient management in crop production assumes paramount importance in sustainable agriculture. With the advent of green revolution our farming community, with the sole aim of maximizing production and profit, had been moving away from integrated nutrient management towards inorganic fertilizer management. Stagnant crop yields in spite of high yielding varieties and advanced plant protection measures have made the farming community and policy makers convinced of the importance of organic manures in sustaining soil productivity and quality of agricultural produces. Organic farming is now being advocated globally as a panacea for all the present day problems in the agricultural front.

The paradigm shift towards organic farming is due to many reasons like concern for human health and environment, decreasing productivity of modern farms, increasing pests and diseases etc. The prime cause for all these is being attributed to repeated use of chemical fertilizers without the accompaniment of organic manures. This has become more serious in case of crops that do not return back organic residues in substantial quantities or in farming practices where all the residues are removed. Over dependence on chemical fertilizers due to unavailability of organic manures has slowly but definitely resulted in decline of soil organic matter, nutrient imbalance and consequent deterioration of physical, chemical and biological functioning of soils in many intensively cropped areas.

But sole dependence on organic sources to satisfy the full nutrient requirement of a crop warrants enormous quantity of organic manures. The viable alternative to this is a strategic shift from the present day chemical-based soil fertility management to organic-based integrated nutrient management.

In the Indian scenario the arable per capita land availability will be reduced to 0.087 ha if population is stabilised by 2050 (Jose, 2004). Then, the biggest challenge will be to produce more food with less land. To face such a situation we should get set by increasing the productivity of available land through the application of adequate organic manures in conjunction with chemical fertilizers. Realizing the underlying reason for the stagnant productivity of the crops, our farming community has started including organic manures in the input package. Application of organic manures along with inorganic fertilizers has become a standard practice by the farmers.

Organic manures contain high percentage of carbon and relatively small percentage of plant nutrients. They have a multifarious role in improving and maintaining soil productivity. Organic manures serve as a source of nutrients for the plant and a source of carbon for the soil microorganisms. They also improve the structure of soils either directly through their action as bulky diluents in compacted soils or indirectly when the waste products of animals or microorganisms thriving on organic matter act as cements to bind soil particles together. Structural improvements brought about in this manner enhance water holding capacity of the soil. They also improve soil aeration and drainage and encourage root growth by providing pores of appropriate size, in structures that do not become too rigid when dry or completely water logged when wet.

The best known organic manure and the one commonly used by farmers is the waste from mixed arable and livestock farming called Farm Yard Manure (FYM) which contains dung, urine and partially rotted straw. Till the mid nineties, this highly beneficial organic manure was a readily available resource to our farmers. But now due to the decreasing cattle population it has become a scarce resource. Although composting of bio-waste is an alternate source, our farmers are reluctant to practice it. Now they are depending on the commercially available ready–to-use organic manures in the market. Our markets are flooded with branded organic manures. These products were not subjected to field-testing for its effectiveness or suitability for crop production. Farmers are blindly applying these manures with out any scientific backing. As a mandatory agency to safe guard the interest of Kerala farmers it is the responsibility of Kerala Agricultural University to take up studies for evaluating these organic manures at the field level. Vegetables are crops in which substantial quantities of organic manures are still being used in the field. Therefore, bush type vegetable cowpea was selected as the test crop.

Traditional agricultural practices which are based on years of experience and careful observation have motivated Kerala farmers in using several products in crop production. Use of Panchagavyam in crop production is one among the traditional practices which has been gaining popularity in the recent times. Panchagavyam is a product of bovine origin, made out of cow's ghee, urine, dung, milk and curd. When suitably prepared and used it is said to have positive influence on living organisms. Panchagavyam is used in crop production as foliar spray, soil application or seed treatment. Panchagavyam contains growth regulators such as IAA, GA and cytokinins, essential plant nutrients and naturally occurring, beneficial, effective microorganisms (Somasundaram and Sankaran, 2004). Somasundaram *et al.* (2003) reported that it gives quick flowering, continuous flowering, high setting percentage besides giving resistance to pests and diseases. It has been prescribed in *Vrikshayurveda* for treating pests and diseases of plants and for better harvest.

Vermiwash is an aqueous extract of freshly formed vermicompost containing earthworms. It contains beneficial microorganisms, water soluble fractions of substances present in the vermicompost and body surface of earth worms, easily available form of major and micro nutrients along with plant growth promoting substances (Jasmin, 1999). Microbial analysis revealed that it contains microorganisms like bacteria, actinomycetes, fungi and nitrogen fixing organisms. Foliar application of vermiwash in bhindi, cowpea and tomato showed encouraging results in the studies conducted in Kerala Agricultural University. Hence the effect of vermiwash as a plant growth promoter on vegetable cowpea and its relative efficiency compared to Panchagavyam was included in this study.

The objectives of the study were:

1. To evaluate relative field efficiency of commercial organic manures *viz.*, Haritha Super, Poabs Green and Bharat Meal in comparison with FYM and Enriched Vermicompost.

2. To assess the effect of growth promoters such as Panchagavyam and Vermiwash on growth and yield of vegetable cowpea.

3. To study the interaction effect of organic manures and growth promoters in vegetable cowpea.

4. To assess the economic feasibility of commercial organic manures and growth promoters in vegetable cowpea cultivation.

Review of Literature

2. REVIEW OF LITERATURE

An experiment was conducted at the College of Agriculture, Vellayani to assess the comparative field efficiency of three commercial organic manures *viz.*, Haritha Super, Poabs Green and Bharat Meal, in comparison to Enriched Vermicompost (enriched with Rock phosphate, *Azospirillum* and *Pseudomonas* sp.) and FYM. Effect of two growth promoters *viz.*, Panchagavyam and Vermiwash were also studied in this experiment on bush type vegetable cowpea.

FYM is a proven and most popular organic manure used in crop production. It is a source of both macro and micronutrients. Even though it contains negligible quantity of plant nutrients, due to its multifarious role in improving soil fertility and productivity by improving the soil structure as well as the soil fauna it is an inevitable component of integrated nutrient management system as well as organic farming. Ever since, the availability of FYM has started declining, farmers started looking for alternate sources of organic matter. One such effective source is vermicompost. Vermicompost contains plant nutrients, plant growth regulating substances such as gibberellins, cytokinins, auxins etc. and microbial growth requirements such as vitamins, antibiotics, amino acids etc. Vermicompost is also a storehouse of microorganisms beneficial for plant growth. The nutritive value of vermicompost is increased on enrichment with rock phosphate and beneficial microorganisms like *Azospirillum* and *Pseudomonas*.

Use of Panchagavyam as a growth promoter and plant health tonic is an age old practice in India. Subsequent to the popular use of vermicompost, vermiwash, an aqueous extract of fresh vermicompost containing earthworms was tried as a growth promoter. Positive plant response to both Panchagavyam and Vermiwash were reported. Literature on the role of organic manures and growth regulators in crop production, soil productivity and their effect on yield and quality of vegetable crops are reviewed in this chapter.

2.1 ORGANIC MANURES AND CROP NUTRITION

2.1.1 Farm Yard Manure

Organic manures serve two purposes in life of the soil, they supply some nutrients for plants and the carbon containing compounds serve as food for small animals and micro organisms. Cooke (1972) opined that many wastes and residues of plant or animal life serve as organic manures. They contain large percentage of carbon and relatively small percentage of plant nutrients. Manures may improve the physical arrangement of soils, they may do this directly through their action as bulky diluents in compacted soils or indirectly when the waste products of animals or microorganisms act as cements to bind soil particles together. Structural improvements caused in these ways increase the amount of water that is useful to crops that soils can hold. They also improve aeration and drainage and encourage good root growth.

According to Cooke (1974) FYM supplies both major and minor plant nutrients, improves physical conditions in the soil and supplies substances that stimulates plant growth. Nitrogen in FYM is combined with organic substances and is only released when they decay. About a third of the nitrogen is released quite quickly, but much is very resistant and persists long in the soil. Phosphorous is also combined with the organic matter. Half of the total phosphorus present is quickly available to crops. Potassium in FYM is soluble in water and nearly all can be rated as available to crops. Chelating action of phenolic compounds formed from organic matter like salicylic acid had been referred as an additional effect of FYM. According to Gaur (1994) among the different organic sources, FYM is the best known and commonly used traditional organic manure in India. It consists of a mixture of animal shed wastes, containing dung, urine and some straw.

2.1.2 Vermicompost

Among the organisms which contribute to soil fertility the most important are the earth worms. They can consume practically all kinds of organic matter, as much as their own body weight per day, and release and recycle nutrients. Earthworms ingest and mix large amounts of soil and organic matter in the gut and deposit the material as casts or macroaggregates on the surface of the soil or in burrows depending on the species.. Graff (1971) reported a higher phosphorous content in the worm cast than in the surrounding soil. According to Sharpley and Syres (1977) phosphorous availability to plants increased when the casts of anaecic earthworms were used. Worm casts were rich in available nutrients required for plant growth (Tomati *et al.* 1983). According to Gaur and Sadasivan (1993) the excreta or casting of earthworms are rich in readily available form of plant nutrients (N, P, K, Ca and Mg), and also in bacterial and actinomycetes population. Increased availability of N in earthworm casts compared to non ingested soil had been reported by Packin and Berry, (1994) and Rao *et al.* (1996). Ismail (2004) reported that certain metabolites produced by earthworms may be responsible to stimulate plant growth.

The role of earthworms in composting organic residues is also well evidenced and documented. According to Gaur and Sadasivan (1993) composting of organic residues is a source of organic manure as well as a means of waste disposal. Composting organic residues using earthworms is termed vermicomposting. Vermicompost contains worm cast, partially decomposed organic residues and earthworms. The vermicompost obtained from degradation of organic matter by earthworms can be used as organic manure. Indira *et al.* (1996) noticed the presence of 10^6 bacteria, 10^5 fungi and 10^5 actinomycetes in vermicompost by dilution plate technique. Population of beneficial organisms like P solubilising bacteria, N fixing organisms and entomophagous fungi were in the range of 10^5 to 10^6. P solubilizing species, *Bacillus* and *Aspergillus* and N fixing species, *Acetobacter, Azospirullum* and *Rhizobium* were dominant. Jasmin (1999) opined that vermicompost contain growth regulators like gibberellins, cytokinins, auxins etc. which enhance growth of plants. According to Sailajakumari (1999) nutrient composition of ordinary vermicompost was 1.83 % N, 1.37 % P2O5, 2.66 % K_2O, 0.46 % Ca and 1.3 % Mg.

Shinde *et al.* (1992) studied the comparative performance of vermicompost and conventional farmyard manure and observed similar nutrient status in both the manures. According to Prabhakumari *et al.* (1995) vermicompost contains about 3 times more nutrients than FYM.

2.1.3 Effect of Organic Manures on Growth and Yield of Crops

FYM favourably influenced the vegetative mass dry weight, plant height and rate of dry matter increment per unit area in capsicum (Cerna, 1980) . Dikshit and Khatik (2002) reported that 50 per cent recommended dose of NPK + 10 t farmyard manure ha^{-1} enhanced the availability of NPK and sulphur in soil, increased the uptake of nutrients and grain and straw yield in soybean. Singh (2002) reported higher grain yield, higher protein and vitamin C content by the application of farmyard manure + dense organic manure in cowpea. Shelf life was also prolonged under ambient storage condition by this treatment. Balachandar *et al.* (2004) observed increased number and weight of nodules biomass production and grain yield in black gram by the application of press mud when compared to farmyard manure, biodigested slurry and compost.

Curry and Boyle (1987) reported enhanced plant growth in the presence of earthworms due to the increased supply of readily available plant nutrients and better soil physical conditions. Application of *Eudrillus* compost inoculated with *Azospirillum* and P solubilizing organisms recorded the highest plant height, number of leaves and shoot : root ratio (Zachariah, 1995). Ushakumari *et al.* (1997) observed that vermicompost when applied to substitute the recommended doses of inorganic nitrogen in banana recorded the highest bunch yield, number of hands per bunch, number of fingers per hand and mean weight of hands. Vermicompost as organic source improved the sweetness of fruit also. Use of vermicompost as an organic manure and also as a substitute for inorganic fertilizer enhanced vegetative growth in sweet potato. Significant treatment effect could be observed in total tuber yield and marketable tuber yield (Suresh Kumar, 1998). Sailajakumari (1999) reported that application of enriched vermicompost (Vermicompost enriched with RP) increased the plant height, number of branches, nodule number and yield in cowpea. Marimuthu *et al.* (2002) observed enhanced growth and yield of groundnut due to the application of vermicompost prepared out of organic wastes. Rajkhowa *et al.* (2002) evaluated the effect of vermicompost alone and in combination with fertilizer in greengram and observed a significant increase in growth characters, yield components and yield due to combined use of vermicompost and fertilizer. He also opined the possibility of saving 25–50 per cent of fertilizer through the addition of 2.5 t ha^{-1} vermicompost. Rajkhowa *et al.* (2003) observed increased N, P and K uptake and nodulation in green gram by the application of inorganic fertilizer and vermicompost. Soil organic carbon, available N, P and K status in soil were also improved by the application of vermicompost alone or in combination with fertilizer.

Shinde *et al.* (1992) studied the comparative performance of vermicompost and conventional farmyard manure and observed similar nutrient status in both the manures. Ismail *et al.* (1993) compared the effect of vermicompost, FYM and fertilizers on yield of bhindi and watermelon and observed an increase in yield due to vermicompost in both the crops. According to Prabhakumari *et al.* (1995) vermicompost contains about 3 times more nutrients than FYM. Reddy and Mahesh (1995) observed a significant increase in grain yield of green gram due to the application of vermicompost compared to FYM. Jiji *et al.* (1996) found that the requirement of chemical fertilizers in cowpea var. Malika and bitter gourd var. Preethi was significantly reduced when recommended dose of FYM was substituted by equal quantity of vermicompost. Vermicompost and phosphobacteria in combination with two inorganic phosphorous sources *viz.* single superphosphate and Tumis rock phosphate were verified in a calcarious black soil for their effect on yield parameters on black gram. The application of Tumis rock phosphate (100%) along with vermicompost and phosphobacteria recorded the highest grain yield and haulm yield (Thiyageswari and Perumal, 1998).

According to Arunkumar (2000) higher level of FYM and vermicompost (150% of POP) maintained their superiority at all growth stages regarding plant height, number of leaves, and number of branches in amaranthus. A study on the effect of different organic manures on growth, yield and quality of turmeric revealed that application of FYM and vermicompost resulted in higher CGR and RGR. Vermicompost recorded maximum NAR. Maximum DMP, LAI, LAD as well as root shoot ratio were obtained for FYM and coir pith compost treatment (Rakhee, 2002). Vasanthi and Subramanian (2004) evaluated the effect of organic manures such as vermicompost and farmyard manure, and fertilizer on the uptake of nutrients and crude protein content in blackgram and observed high crude protein, NPK concentration and uptake in the treatment that received vermicompost @ 2 t ha^{-1} along with 100 per cent recommended dose of NPK. Yadav and Malik (2005) reported increased plant height, dry matter accumulation, seeds per pod, pods per plant and yield per plant in cowpea by the application of vermicompost. Application of vermicompost @ 20 kg N ha^{-1} was found superior with respect to most of the yield attributes than farmyard manure.

Addition of organic matter enhanced the growth and biomass of the pepper vines (Sivakumar and Wahid, 1994). Thamburaj (1994) found that organically grown tomato plants were taller with more number of branches than inorganically grown ones. Manjaiah *et al.* (1995) observed a significant increase in nodule number in ground nut when treated with combination of organic amendments and P solubilizers plus Mussoorie Rock Phosphate. Srivastava and Ahlawat (1995) reported a significant increase in nodulation in pea by seed inoculation with rhizobium or P bacteria and phosphate fertilizers. There was overall improvement in growth of the crop. The beneficial effect of organic amendments in increasing the growth parameters were reported by Pushpa (1996) in tomato. Rekha (1999) reported highest LAI, RGR and CGR for brinjal plants treated with organic manure and chemical fertilizers in 1:1 ratio. Raj (1999) reported that growth characters such as plant height, LAI, dry matter production (DMP) and yield attributes such as fruit number per plant, fruit weight, fruit length and fruit yield were higher in organic manure treated bhindi crop. The influence of organic manures on leaf number, LAI, DMP in brinjal was superior over inorganic fertilizer application (Subbarao and Ravisankar, 2001).

Biofertilizers are ready to use living formulations of beneficial microorganisms which on application to seed, root or soil enhance the availability of nutrients by their biological activity and help to build up the microflora and inturn bring about soil nutrient enrichment. Krishnamoorthi and Rema (2004) reported that besides fixing nitrogen *Azospirillum* also helps in plant growth through its capability to produce plant growth promoting hormones. *Azospirillum* is suitable for upland and wetland conditions and fixes 15 to 20 kg nitrogen per has under ideal conditions and thereby effecting a reduction of 10 to 25 per cent nitrogeneous fertilizers. Phosphobacter helps in solubilising phosphorous that are immobilised and fixed in soil to utilizable form and help in easy uptake. P solubilizers help in increasing the yield by 15 to 20 %. It also improves the uptake of available K by the innoculated plants. They also opined that use of bio-fertilizers along with organic manures and fertilizers would enhance the productivity of various crops without compromising the quality of produce and polluting the environment.

2.1.4 Effect of Organic Manures on Uptake of Nutrients and Soil Nutrient Status

Lignin rich organic amendments like FYM were reported to be more recalcitrant to decomposition and resulted in higher soil carbon accumulation per unit carbon input than low lignin amendments. These effects were attributed to a direct stabilisation of lignin degradation products in the slow organic matter pool as opposed to the more complete metabolism of non-liginin residue fractions by soil microbial biomass (Carter and Stewart, 1972). Kanwar and Prihar (1982) reported that continuous application of FYM increased the organic carbon as well as nitrogen content of the soil. Srivastava (1985) observed that increased use of nitrogenous fertilizers decreased organic carbon content and total N in soil while FYM increased the above parameters. Increased availability of K due to the combined application of FYM with 100% recommended quantity of NPK in the long term fertilizer experiments was reported by Aravind (1987). Udayasoorian *et al.* (1988) reported that carbon content of soil increased from 0.91 to 1.58 per cent by the continuous application of organic manure, and among the organic manures FYM had a significant influence. Kabeerathumma *et al.*. (1990) observed in a long term manurial experiment after 13 years of continuous cropping, increased nutrients like N, P and K and organic carbon with the inclusion of FYM and application of respective nutrients to soil. Higher efficiency of FYM in producing higher yield and improving chemical properties of soil compared to castor oil cake and urea was reported by Gomes *et al.* (1993). Dhanokar *et al.* (1994) found that continuous use of FYM raised the available K content of soil by 1.3 to 5.4 folds over control. Minhas and Sood (1994) found that application of FYM was beneficial in enhancing the uptake of P by potato and maize. According to Raj (1999) available N, P_2O_5 and K status of the enriched FYM (enriched with neem cake) was high. She also reported that available nitrogen status of soil was improved with *Azospirillum* inoculation. Sharma *et al.* (2001) reported 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.

Tomati *et al.* (1983) observed that vermicompost improved soil aeration and also it contained higher concentration of exchangeable cations like Ca, Na, Mg, K etc., available phosphorus and manganese. Vasanthi and Kumara Swamy (1996) observed an increase in soil nutrient status due to the application of vermicompost. They reported highest concentration of micronutrients in the treatments that received vermicompost along with NPK fertilizer compared to the treatment that received NPK alone. According to Meera (1998) use of vermicompost coated seeds caused the maximum uptake of N, P and K at peak flowering stage and harvest. Soil application of vermicompost recorded the highest uptake of Ca, Mg, Cu and Mn during peak flowering stage . Soil analysis for available nutrients revealed that the different treatments had significant influence on the Ca, Mg, Zn, Cu and Mn content in soil. Sailajakumari (1999) reported that application of enriched vermicompost (enriched with rock phosphate) registered significant increase in soil available NPK and their uptake.

Enriched compost registered maximum mean value for the uptake of all the macro nutrients. Srikanth *et al.* (2000) studied the direct and residual effect of enriched compost, FYM, vermicompost and fertilizers on the properties of alfisol and reported that soil nutrient status was found to be high in enriched compost amended soil after the harvest of first and second crop. Sheeba (2004) reported an increase in microbial count of soil treated with vermicompost upto 45th day of incubation. Bacterial count g^{-1} of enriched vermicompost (enriched with bonemeal 2%) was found to be 60 x 10^6 and that of fungi 23 x 10^4.

Reddy and Mahesh (1995) reported an increased availability of N and K in soil by the application of vermicompost compared to FYM. According to Maheswarappa *et al.* (1998) organic carbon content was the highest in the vermicompost treated plot (0.39 per cent) compared to FYM, NPK alone and control plot. The initial value of organic carbon content was 0.21 per cent.

Increase in the available nitrogen content of soil and increased nitrogen recovery due to organic sources of nitrogen have been reported by Muthuvel *et al.* (1977). While studying the physico-chemical properties of soil in the permanent manurial experiments he had also observed the favourable influence of organic manures in enhancing available K content of soils. Organics serve d as a source of potassium. The soil organic matter because of its high absorptive capacity usually carries substantial amounts of exchangeable K. The beneficial effects of organic matter on the mobilization of soil phosphorous have been reported by Sivasamy (1982). He opined that phosphorous is present in the soil in both inorganic and organic forms. The inositol phosphates, which are the major constituents of organic phosphorous in the soil, have to undergo microbial decomposition before becoming available to crops. As in the case of nitrogen, the organic phosphates on appearance are also appropriated by the microbial population causing temporary immobilization of the nutrient. The most important contribution of organic matter in the phosphorous nutrition of plants is the release of phosphates from soil minerals. The organic acids and humus formed in the course of decomposition of organic substances form complexes with iron and aluminum compounds in the soil and consequently reduce inorganic phosphate fixation in the soil. Subramanian (1986) reported that available nitrogen, organic carbon and total nitrogen concentration were favourably influenced by organic sources of nitrogen. Damodaran (1987) stated that enzyme activity in soil was favourably influenced by organic sources of nitrogen. Carbon content of soil increased from 0.91 to 1.58 per cent by the continuous application of organic manures (Udayasoorian *et al.*, 1988). More (1994) reported that addition of farm waste and organic manure increased the status of organic carbon, available nitrogen, available phosphorous and available potassium of the soil.

2.1.5 Effect of Organic Manures on Quality of Vegetables

An increase in the ascorbic acid content of spinach leaves due to the application of FYM (20t ha^{-1}) was reported by Kansal *et al.* (1981). Abusaleha (1992) recommended equal quantity or more organic form of nitrogen for good quality okra fruits. Organic manures like FYM, compost, oil cakes, green leaf, poultry manure etc. improved the quality of vegetable crops like tomato, onion, gourd, chillies etc. Increase in ascorbic acid content in tomato, pyruvic acid in onion and minerals in gourds are the impact of application of organic manures to vegetable crops. FYM application as an organic amendment increased the DMP of bhindi crop (Senthilkumar and Sekar, 1998). Bhadoria *et al.* (2002) reported that protein and total mineral content of okra fruit was high when it was treated with the FYM. Rao *et al.* (2001) studied the effect of organic manures like FYM, neem leaf, vermicompost, neem cake, *Azopirillum* and *Phosphobacterium* on the growth and yield of brinjal. Effect of these organic manures on leaf number, LAI, DMP and other growth and yield characters were better than inorganic fertilizers.

Joseph (1998) observed that in snake gourd poultry manure treated plants recorded the highest crude protein and lowest crude fibre content as compared to that of FYM and vermicompost treatments and also reported that when vermicompost was used as a nutrient source in snake gourd field, it produced fruits with more shelf life, P and K content over FYM and poultry manure. Sailajakumari (1999) found the superiority of vermicompost enriched with rock phosphate on yield and quality of cowpea. Arunkumar (2000) reported that application of vermicompost to amaranthus crop recorded significantly high ascorbic acid content as compared to POP. Ascorbic acid content increased with increasing level of organic manures. Lower fibre content was also reported in vermicompost treated plants.

Protein content of cowpea seeds were more in vermicompost treated plot compared to FYM application (Sailajakumari and Ushakumari, 2001). Raj (1999) reported that crude protein content and ascorbic acid content were maximum for FYM + poultry manure and FYM + enriched compost respectively in bhindi.

Lampkin (1990) reported that better storage life of spinach grown with organic manures was found to be associated with lower free amino acid content, nitrate accumulation and higher protein nitrogen to nitrate nitrogen. Montogu and Ghosh (1990) found that fruit colour of tomato was significantly increased as a result of application of organic manures of animal origin. Anitha (1997) reported that chilli plants treated with poultry manure recorded the maximum ascorbic acid content in fruits as compared to vermicompost and control treatments. Omae *et al.* (2003) reported that cattle compost application increased freshness and vitamin C content in melon.

2.2 GROWTH PROMOTERS

Somasundaram and Sankaran (2004) opined that in the plight of material welfare the traditional knowledge developed by farmers, which has been subjected to a process of refinement through generations of experience, were given negligible importance and are now receiving recognition. They continued that the scientific basis for such indigenous technologies needs to be evaluated and perfected before large scale dissemination. At present the organic production system suffers for want of an input to replace foliar fertilization, growth promoting hormones and immunity boosters to maximize the efficiency of cultivated crops and co-ordinate the process leading to sustained higher productivity. At the same time our Indian traditional knowledge system, a treasure trove of information had been recommending Panchagavyam to safeguard plants and soil microorganisms from time immemorial. In Sanskrit, 'Panchagavya' means the blend of five products obtained from cow. It contains ghee, milk, curd, cowdung and urine.

Vermiwash, another liquid organic growth promoter is an aqueous extract of freshly formed vermicompost containing earthworms. According to Jasmin (1999) it contains surface washings of earthworms along with beneficial microorganisms and water soluble fractions of substances present in both vermicompost and body surface of earthworms. The nutrients present in vermiwash are in the water soluble and plant available form and the immediate requirement of a number of components can be met from the single source. Vermiwash is highly alkaline in nature, which suggests its potential for liming.

Only a few research works on vermiwash and panchagavyam has been reported and they are reviewed here under.

2.2.1 Effect of Growth Promoters on Growth and Yield of Crops

Growth substances have been found to play important role in the endogenous control of flowering. Auxins and gibberellins are considered as endogenous controlling entities in flowering processes. Auxins are thought to play a role in diverse growth processes such as cell extension, cell division and differentiation and flower induction. Gibberellin is considered as a component of the flowering hormone or flower promoter through its stimulation of stem growth and perhaps of some mobilization actions associated with growth. Auxins promote femaleness and gibberellins promote maleness. Cytokinins have been suggested to play a crucial role in several developmental processes in higher plants. It is well documented that increase in RNA, protein and chlorophyll levels can be observed upon treatment with cytokinins. Specific aspects of development that are affected by cytokinins include shoot formation, release of auxiliary buds, partial floral evocation and inhibition of root elongation (Leopold, 1964).

Devadasan (1965) reported that in *Capsicum frutescens* GA applied at 25 ppm or low concentration during flowering stage resulted in increased yield. Nanjappa (1965) studied the effect of GA, IAA and NAA at different concentrations in chilli and reported that foliar spraying of GA 50 ppm increased height of plant and reduced number of flowers produced subsequent to spraying. Maximum yield in chilli was obtained with 2 foliar sprays of NAA (10 ppm) one at 25 DAS and other 50 DAT (Chandra and Shivraj, 1972). Highest fruit yield was observed in chilli by foliar sprays of GA at 50 mg l^{-1} at fruit setting (Sinha, 1975) and foliar spray of NAA at 10 mg l^{-1} twice (at flowering and 5 weeks later) (Chandra *et al.* 1976). Kadhum *et al.* (1980) reported that, of the seven fertilizer treatments evaluated yield was highest and the root and shoot growth were best in plants which received 6 l m^{-2} of a liquid organic fertilizer containing 60 g NPK (18:18:5). Singh (1982) observed increase in plant growth with NAA (100 ppm) through increase in height and number of primary and secondary branches per plant in bell pepper. IAA and GA (10 mg l^{-1}) gave that best seed yields in pea when compared to the untreated control (Dawle, 1983). Mozarker *et al.* (1991) observed that highest fruit yield was obtained with Pusa Early Dwarf variety of tomato by seed treatment with NAA, GA, IAA and IBA. In tomato highest yield was obtained by foliar application of NAA at 20 ppm (Phookan *et al.* 1991). Upadhyay (1994) observed increased plant height, number of branches, number of flowers, vegetative growth and yield in chickpea by the application of NAA and kinetin. Tomar and Ramagiry (1997) observed that tomato seedlings soaked with GA_3 50 ppm for 30 minutes showed significantly greater plant height, number of branches per plant and number of fruits per plant than untreated control. Gedam *et al.* (1998) observed that in bitter gourd fruit maturity was earliest in plants treated with 50 ppm NAA or 4 ppm boron. Fruit and seed yield were also highest in these treatments. . Upadhyay (2002) observed higher number of buds, flowers, length and weight of pod, number of pods, biological yield and grain yield in chickpea by the application of NAA. The exogenous application of GA_3 and 2,4-D increased growth, dry matter production and yield in cowpea (Mohandoss and

Rajesh, 2003). Senthil *et al.* (2003) observed increased soluble protein, chlorophyll, reducing sugar, N, P and K content in greengram by the application of salicylic acid and NAA. Resmi and Gopalakrishnan (2004) observed increased fruit set and productivity by the foliar application of NAA.

Varshney and Gaur (1974) in a micro plot experiment on the sandy loam alluvium soils of Delhi treated soybean and the subsequent tomato crop were sprayed four times with 125 ml per plot of solution of sodium humate extracted from FYM. Sodium hum ate at 10 and 50 ppm increased the seed yield of soybean by 24 and 14.5 per cent respectively and also increased nitrogen uptake. Corresponding increases in tomato yield were 109 and 104 per cent. Sarr and Ganry (1985) found that rice husk compost + effluent (liquid produced during composting) at 7.5 t ha^{-1} gave tomato yields of 71.96 t ha^{-1} compared with 59.2 t ha^{-1} for control. He reported that any compost + effluent gave better yield than compost with out effluent.

In a comparative evaluation of carbendazim, neem cake and modified Panchagavyam Reddy and Padmodya (1996) found that modified Panchagavyam was superior to carbendazim in reducing plant disease index and increasing the vigour of plant and yield. They also found high microbial activity and low pathogen in the soil treated with modified Panchagavyam. Inhibition of pathogen *in vitro* was also recorded. They concluded that suppression of pathogen could have occurred by encouraging the local antagonist of the pathogen. Tests also revealed that modified Panchagavyam has inhibitory effect on *Fusarium oxysporoum*. f. sp. *cubens* which causes banana wilt. Vivekanandan (1999) reported that spraying two rounds of Panchagavyam one before flower initiation and another during pod setting phase gave quick flowering and high setting percentage. In jasmine it ensured continuous flowering and in annual morringa sprayings doubled the fruit yield besides giving resistance to pests and diseases.

In a study conducted by Somasundaram *et al.* (2003) to investigate the response of green gram to varied concentrations of foliar applications of Panchagavyam it was found that increasing or decreasing the levels of Panchagavyam from 3% level decreased the yield parameters and yield. At higher concentration scorching was observed resulting in reduced photosynthetic activity and yield. They also observed increased number of seeds per pod, higher grain weight and grain yield by the application of Panchagavyam. Additional revenue and higher BC ratio was also reported. Somasundaram and Sankaran (2004) reported that Panchagavyam contains growth regulators such as IAA, GA and cytokinin, essential plant nutrients, naturally occurring, beneficial, effective microorganisms (EMO) predemoninantly lactic acid bacteria, yeast, actinomycetes, photosynthetic bacteria and certain fungi besides *Acetobacter, Azospirillum* and *Phosphobacterium* and plant protection substances such as Pseudomonads and saprophytic yeasts. Optimum physiological efficiency, maximum partial factor productivity for N and radiation use efficiency were reported for foliar application of Panchagavyam. The total productivity of the system in terms of the total dry matter production, NPK uptake, maize grain equivalent yield and crude protein yield was higher for Panchagavyam treated plants.

Sundararaman (2004) observed that natural preparations like Panchagavyam will be of much help in the conversion from chemical farming to organic farming. Application of Panchagavyam through irrigation water promoted growth of beneficial soil microorganisms and plant health. This acts 75 per cent as manure and 25 per cent as pests controller. Panchagavyam stimulates plant growth, rectifies micro nutrient deficiencies, acts as a pest repellent and it helps plants to develop resistance against diseases. Reddy (2004) opined that promoting the use of Panchagavyam as a nutrient and a hormone can help to get better yield at very cheap cost. Manjunatha *et al.* (2004) evaluated Panchagavyam as foliar spray and soil drenching and found that soil drenching or foliar spray of 3 per cent Panchagavyam improved growth and yield.

Vermiwash was very effective for foliar application of nurseries, lawns and orchids (Ismail, 1995). The preliminary trials conducted in the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani using different concentrations of vermiwash for foliar application in bhindi and cowpea showed encouraging results and the dilution required was found to vary with crop. Jasmin (1999) reported that soil application of vermiwash along with inorganic fertilizers produced increased fruit yield in tomato. At higher concentrations (50 and 25%) of vermiwash, inorganic fertilizer could be reduced to half of the recommended dose without any yield reduction. Vermiwash applied through foliage along with full inorganic fertilizers increased plant uptake of major and micro nutrients (Jasmin, 1999) She found that soil application of vermiwash produced fruits with more shelf life. The different concentrations of vermiwash had positive influence on the lycopene content of tomato, but no influence on the ascorbic acid and crude fibre content. Nutrient content of plant and fruits were influenced by vermiwash application. In a study conducted by Thangavel *et al.* (2003) on the effect of vermiwash and vermicast extract on the growth and yield of paddy it was observed that both vermiwash and vermicast extracts increased growth and yield of paddy. Sivasubramanian and Ganeshkumar (2004) reported increased growth parameters such as plant height, number of leaves, leaf area and yield parameters such as number of days to flowering and number of flowers by the application of vermiwash in marigold . In a study conducted by Venkateswara *et al.* (2005) on the effect of organic fertilizers on yield of bhindi it was observed that vermiwash increased the growth by supplementing growth promoting substances such as IAA and IBA. It also improved the yield, quality, resistance to diseases and improved the soil health by conserving natural flora and fauna of soil.

Materials and Methods

3.1.3 Cropping History of the Field

A bulk crop of bitter gourd was grown in the experimental site in the previous season.

3.1.4 Season

The study was conducted during the period extending from the second fortnight of October to the second fortnight of January 2005.

3.1.5 Weather Data

Data on weekly averages of temperature, evaporation, relative humidity and weekly totals of rainfall during the cropping period were collected from the agro-meteorological observatory attached to the Department of Agronomy, College of Agriculture, Vellayani and are presented in Appendix I and Fig. 1.

3.1.6 Crop and Variety

Vegetable cowpea cv. Pusa Komal was selected for the study. This variety released from IARI, New Delhi was found suitable for cultivation in Kerala. The morphological characters of the variety are given in Table 3.2. Seeds for the experiment were obtained from the National Seeds Corporation, Karamana, Thiruvananthapuram.

Table 3. 2 Morphological characters of vegetable cowpea cv. Pusa Komal
(Source: IARI Vegetable Varieties and Crops, 2001)

Characteristics	Pusa Komal
Plant type	Bushy
Season	All seasons
Days to flowering	45-50 days
Bearing	Synchronous pod bearing
Length of pod	20-22 cm
Fibre content	Non-fibrous
Shape	Cylindrical
Colour	Light green
Pod attachment to peduncle	Pendant
Disease resistance	Resistant to bacterial wilt
First picking	60 days after sowing
Average yield	103 q ha^{-1}

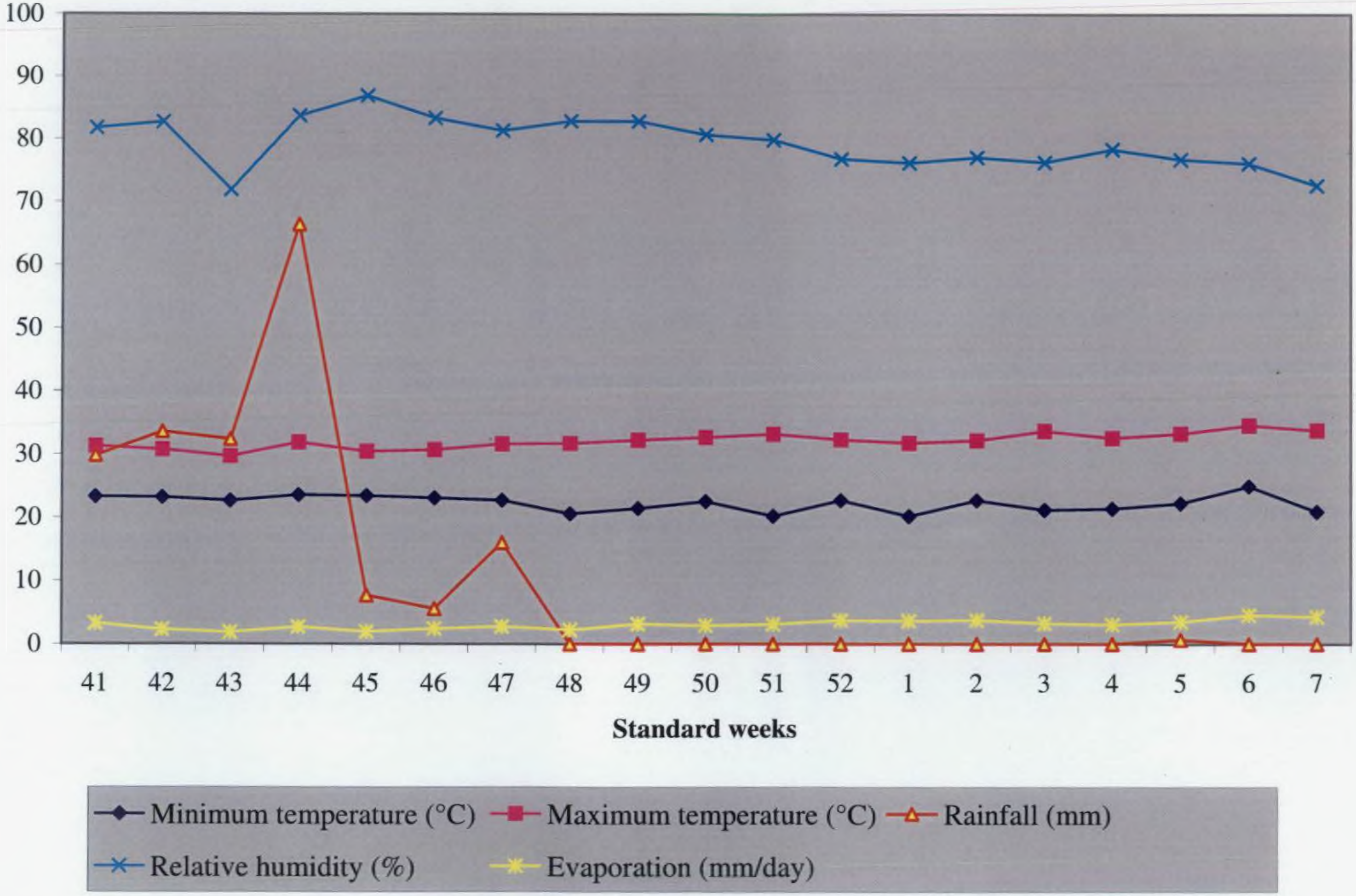


Fig. 1. Weather data for the cropping period (October 2004 to February 2005)

3.1.7 Manures and Fertilizers

Nutrient management as per the Package of Practices Recommendations 'Crops'(POP) of Kerala Agricultural University (KAU) was adopted. 20 tonnes of FYM + 20 : 30 : 10 kg NPK ha^{-1} is the POP recommendation for bush type vegetable cowpea. As per the technical programme, four different organic manures were tried as possible alternatives for FYM. Five organic manures viz. FYM, Enriched Vermicompost, 'Poabs Green', 'Haritha Super' and 'Bharat Meal' were used for the study. All the organic manures were applied on nitrogen equivalent basis. P and K contributed by the organic manures applied were also accounted for, while computing P and K fertilizer requirement in the various treatments.

Table 3.3 Nutrient composition of the organic manures used in the experiment

Organic Manures	NPK (per cent)	Organic carbon (per cent)	C : N (per cent)
FYM	1.0 : 0.4 : 0.5	52.50	52 .50:1
Haritha Super	4.0 : 4.4 : 2.0	27.40	6 .85:1
Poabs Green	2.7 : 1.2 : 2.0	70.11	25. 96:1
Bharat Meal	1.5 : 1.25 : 1.0	27.00	18. 00:1
Enriched Vermicompost	2.0 : 1.25 : 1.0	29. 00	14.50:1

3.1.8 Growth Promoters

Growth promoters viz. Panchagavyam and Vermiwash were prepared for the experiment. Panchagavyam is an organic liquid prepared out of five products of bovine origin viz. cow dung, cow's urine, milk, curd and ghee. To prepare 10 litres of Panchagavyam, the quantity of ingredients required were:

Cow dung	:	3 kg
Cow's urine	:	3 litres
Cow's milk	:	2 litres
Curd	:	2 litres
Ghee	:	660 g

Vermiwash is an aqueous extract of freshly formed vermicompost containing earthworms. It contains beneficial microorganisms and water soluble fractions of substances present in both vermicompost and body surface of earthworms.

3.2 METHODS

3.2.1 Design and Layout

The field experiment was laid out in Factorial Randomised Block Design, with three replications. The layout is presented in Fig 2.

Gross plot size: 4.7 x 3.9 m^2

Spacing : 30 x 15 cm^2

3.2.2 Treatment Details

Treatments included combinations of five Organic Manures and three Growth Promoters.

3.2.2.1 *Organic Manures*

M_1 - FYM

M_2 - Haritha Super

M_3 - Poabs Green

M_4 - Bharat Meal

M_5 - Enriched Vermicompost

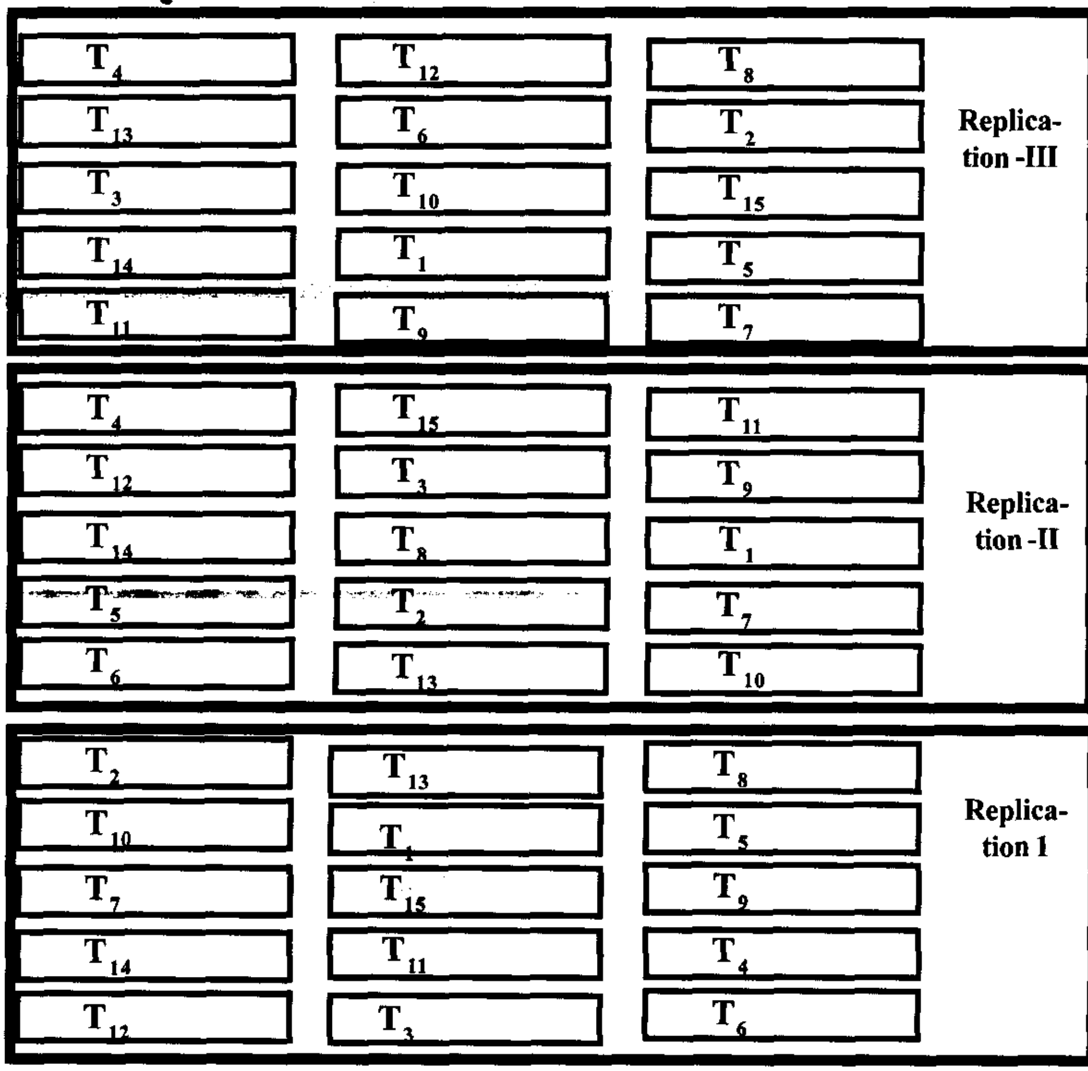
3.2.2.2 Growth Promoters

G_1 - Control (No growth promoter – water spray)

G_2 - 'Panchagavyam'

G_3 - Vermiwash

Fig. 2 Layout of the Experiment



T_1-FYM+Water spray(Control)
T_2-FYM +Panchagavyam(P)
T_3-FYM+Vermiwash(V)
T_4-Haritha Super(HS)+Control
T_5-HS+P
T_6-HS+V
T_7-Poabs Green (PG)+Control
T_8-PG+P
T_9-PG+V
T_{10}-Bharat Meal(BM)+Control
T_{11}-BM+P
T_{12}-BM+V
T_{13}-Enriched Vermicompost(EV)+Control
T_{14}-EV+P
T_{15}-EV+V

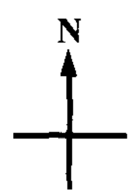


Plate 1. General view of the exerimental field

3.2.2.3 Treatments

1. $M_1 G_1$ – FYM + Water Spray
2. $M_1 G_2$ – FYM + Panchagavyam
3. $M_1 G_3$ – FYM + Vermiwash
4. $M_2 G_1$ – Haritha Super + Water Spray
5. $M_2 G_2$ – Haritha Super + Panchagavyam
6. $M_2 G_3$ – Haritha Super + Vermiwash
7. $M_3 G_1$ – Poabs Green + Water Spray
8. $M_3 G_2$ – Poabs Green + Panchagavyam
9. $M_3 G_3$ – Poabs Green + Vermiwash
10. $M_4 G_1$ – Bharat Meal + Water Spray
11. $M_4 G_2$ – Bharat Meal + Panchagavyam
12. $M_4 G_3$ – Bharat Meal + Vermiwash
13. $M_5 G_1$ – Enriched Vermicompost + Water Spray
14. $M_5 G_2$ – Enriched Vermicompost + Panchagavyam
15. $M_5 G_3$ – Enriched Vermicompost + Vermiwash

The nutrient scheduling and management in all the treatments was done as per POP recommendations of KAU (20 t ha^{-1} of FYM + 20:30:10 kg ha^{-1} NPK).

3.2.3 Preparation of Organic Manures and Growth Promoters

3.2.3.1 Preparation of Enriched Vermicompost

Preparation of Enriched Vermicompost was carried out in the composting yard. The bio wastes were collected and pretreated for two weeks by heaping it under shade and then mixed with rock phosphate @ 10 kilogram per tonne raw material. Earthworms were introduced @ 500 numbers per tonne of organic material. After two weeks the partially decomposed organic waste was mixed with *Azospirillum* and *Phosphobacter* (obtained from the Department of Plant

Pathology, College of Agriculture, Vellayani) @ one kilogram each per tonne of material. Inoculated materials were incubated for a period of two weeks at 30 per cent moisture. After incubation the compost was thoroughly mixed and air dried.

3.2.3.2 Preparation of Panchagavyam

Cow dung and ghee were mixed and kneaded well. To this mixture cow's urine, milk and curd were added. All the ingredients were thoroughly mixed and kept in an earthen pot. The mouth of earthen pot was closed airtight with a polythene sheet and kept for two weeks. During this period the mixture was stirred twice daily after removing the polythene sheet. After two weeks this mixture (Panchagavyam) was diluted ten times, strained through a muslin cloth and used for foliar application.

3.2.3.3 Preparation of Vermiwash

Vermiwash was prepared for the experiment following the method recommended by Kerala Agricultural University (KAU, 2002).

3.2.4 Field Culture

3.2.4.1 Land Preparation

The experimental plot was ploughed with a power tiller, stubbles were incorporated and levelled properly. The field was then laid out into blocks and plots. Liming was done @ 175 gram per plot.

3.2.4.2 Sowing

Seeds were sown in lines at a spacing of 30 x 15 cm @ three seeds per hole at a depth of five centimeters.

3.2.4.3 Application of Organic Manures and Fertilizers

Nutrient management was done as per POP recommendation of KAU (20t FYM + NPK @ 20 : 30 : 10 kg ha^{-1}) using the various sources according to treatments. All the organic manures and half N, full P and full K were applied as basal and the remaining N in two splits, on 20 and 30 DAS.

Table 3. 4 Quantity of organic manures and fertilizers applied as per treatment requirement

Organic manures	Quantity applied plot^{-1} (kg)	Inorganic fertilizers applied plot^{-1} (g)		
		Urea	Single super phosphate	Muriate of potash
FYM	37.44	43.48	187.5	16.66
Haritha Super	9.36	43.48	--	16.66
Poabs Green	13.87	43.48	133.1	--
Bharat Meal	24.96	43.48	--	--
Enriched Vermicompost	18.72	43.48	--	16.66

3.2.4.4 Application of Growth Promoters

The growth promoters were applied at fortnightly intervals starting from four leaf stage. Both the growth promoters were diluted ten times, filtered and sprayed on the leaves using a knapsac sprayer. Altogether six sprayings were given.

3.2.4.5 After Cultivation

Uniform germination was obtained in the field. One week after emergence thinning was done. Regular weeding was done through out the cropping period. Top dressing with half nitrogen was done at 20 and 30 DAS. After top dressing, earthing up was done.

3.2.4.6 Irrigation

Since there was sufficient rain during the early stages, irrigation was given only at later stages.

3.2.4.7 Plant Protection

Fenvalerate (cyano (3-phenoxy phenyl) methyl 4-chloro- alpha(1-methyl ethyl) benzene acetate) dust was applied at sowing to prevent the attack of ants and grass hoppers. Dusting was repeated 3 WAS. Rogor 30 EC @ 2.5 ml l^{-1} was applied to protect the crop from pod borer attack.

3.2.4.8 *Harvesting*

Picking of pods for vegetable purpose was commenced at 45 DAS. Subsequent harvests were done on alternate days, uniformly from all the treatments.

3.2.5 Biometric Observations

3.2.5.1 Height of Plant

Height of plant was taken from the base of the plant to the terminal leaf bud and expressed in centimeters. The mean value of the height of five randomly selected observational plants from each net plot was computed at 30, 60 and 90 DAS.

3.2.5.2 Number of Primary Branches Plant^{-1}

The mean value of number of primary branches was computed from five observational plants at 30, 60 and 90 DAS.

3.2.5.3 Number of Leaves Plant^{-1}

The mean value of number of leaves plant^{-1} was computed from five observational plants at 30, 60 and 90 DAS.

3.2.5.4 Leaf Area Index (LAI)

Leaf Area Index (LAI) was calculated using the formula

$$\text{Leaf Area Index} = \frac{\text{Leaf Area}}{\text{Land area}} \times \text{Constant (Watson, 1952)}$$

Leaf area was calculated by taking the mean of product of length and breadth of leaves of observation plants.

3.2.5.5 Dry Matter Production (DMP) and Partitioning

Dry matter production up to 60 DAS was recorded. Five plants were uprooted from the destructive row, at 60 DAS, carefully without damaging the roots and separated into roots, leaves and stems and pods. These were dried under shade separately and then oven dried at 65° C till two consecutive weights coincided. Dry weight of the components were recorded separately and dry matter was computed and expressed in kg ha^{-1}.

3.2.5.6 Days to 50 per cent Flowering

Date of 50 per cent flowering in individual treatments were recorded when fifty per cent of the net population flowered and based on it days to 50 per cent flowering was worked out.

3.2.5.7 Number of Pods Plant^{-1}

Average of the total number of pods collected in the crop period from five observation plants was worked out.

3.2.5.8 Number of Seeds Pod^{-1}

Number of seeds pod $^{-1}$ was found out by taking the mean of number of seeds in five pods from each observation plant.

3.2.5.9 Length of Pod

Average length of five pods from each observation plant was taken to get the mean length of pod.

3.2.5.10 Weight of Pod

Average weight of five pods from each observation plant was taken to get the mean weight of pod.

3.2.5.11 Total Pod Yield in t ha^{-1}

Total yield of tender pods, in the crop period, from net plot was recorded and yield per ha was worked out in tonne.

3.2.5.12 Marketable Pod Yield in t ha^{-1}

Marketable yield of tender pods from the net plot was worked out by deducting the weight of pest infested pods from total pod yield . Marketable yield per ha was then worked out in tonne.

3.2.6 Analytical Procedures

3.2.6.1 Soil Analysis

Composite soil sample was collected from the experimental site before the start of experiment. After the experiment soil samples were collected from individual plots. The air dried soil samples were analysed for available N, P_2O_5, K_2O and organic carbon. Available N content was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956), available P_2O_5 by Bray's colorimetric method (Jackson, 1973), available K_2O by ammonium acetate method (Jackson, 1973) and organic carbon by Walkley and Black method (Walkley and Black, 1935).

3.2.6.2 Plant Analysis

Plant samples collected at 60 DAS were analysed for N, P and K. Ascorbic acid, crude fibre, protein and total free amino acid content of the tender pods were also estimated. Samples were chopped and oven dried at 65 °C till constant weights were obtained. Samples were ground and sieved through 60 mesh sieve. The required quantity of samples were then weighed out accurately, in an electronic balance and used for chemical analysis.

3.2.6.2.1 Estimation of Total Free Amino Acids in Pods

500 mg fresh pod was ground using a pestle and mortar with acid washed sand. The ground sample was extracted thrice with 80 per cent ethanol and filtered. 0.1 ml of the filtrate was made up to 2 ml with distilled water after adding ninhydrin and heated in a boiling water bath for 20 minutes. To this diluent (equal volume of water and n-propanol) was added. The purple colour was read at 570 nm in a spectrophotometer after 15 minutes (Sadasivam and Manickam, 1992).

3.2.6.2.2 Estimation of Crude Fibre in Pods

Five gram dried pods was boiled with 200 ml 1.25 per cent H_2SO_4 for 30 minutes and was filtered through a muslin cloth and washed with boiling water. The residue was subsequently boiled with 200ml 1.5 per cent NaOH for 30 minutes and filtered through a muslin cloth again and washed with 25 ml alcohol.

The residue was transferred to a silica dish and dried at 130^0 C for 2 hours; cooled and weighed. Then it was ignited for 30 minutes at 600^0 C, cooled and reweighed. The difference in weight gave the fibre content which is expressed in percentage (Sadasivam and Manickam, 1992).

3.2.6.2.3 Estimation of Ascorbic Acid in Pods

Ascorbic acid content of the fresh pods were analysed by titrimetric method using 2, 6, dichlorophenol indophenol dye (Sadasivam and Manickam, 1992).

3.2.6.2.4 Estimation of Crude Protein in Pods

Crude protein in pods were calculated by multiplying percentage N content in pods by 6. 25

3.2.6.2.5 Uptake Studies

Total nutrient uptake (N, P and K) by the crop was computed based on the content of these nutrients in plants and the dry matter produced by the crop (Jackson, 1973).

3.2.6.3 Pest Scoring

Percentage infestation of pod borer was calculated using the formula,

$$\text{Percentage infestation} = \frac{\text{Weight of infested pods}}{\text{Total weight of pods}} \times 100$$

(Varghese,2003)

3.2.6.4 Economic Analysis

The economics of cultivation of the crop in the various treatments were worked out and the Benefit Cost Ratio (BCR) was calculated. Gross income was calculated based on marketable crop yield.

$$\text{BCR} = \frac{\text{Gross Income}}{\text{Total cost of cultivation}}$$

3.2.6.5 Statistical Analysis

Data pertaining to the experiment was analysed applying the Analysis of Variance Technique (ANOVA) (Panse and Sukhatme, 1985).

Results

4. RESULTS

A field experiment was conducted at the Instructional Farm of College of Agriculture, Vellayani, during the year 2004-2005 to study the relative field efficacy of three commercial organic manures (Haritha Super, Poabs Green and Bharat Meal) compared to FYM and Enriched Vermicompost, with and without two growth promoters (Panchagavyam and Vermiwash). The test crop selected was bush type vegetable cowpea. Results of the experiment are presented in this chapter.

4.1 GROWTH CHARACTERS

Observations were recorded from five randomly selected plants in each plot to compute height of plant, number of primary branches plant^{-1}, number of leaves plant^{-1}, leaf area index (LAI), dry matter accumulation and its partitioning.

4.1.1 Germination Percentage

Germination percentage in the treatments is presented in Tables 4.1.1.a and b. There was no significant difference between the treatments.

4.1.2 Height of Plant

Table 4.1.2 shows the effect of organic manures and growth promoters on height of plant at 30, 60 and 90 DAS.

Effect of organic manures on plant height was significant at 30 and 60 DAS. At both the stages highest mean values were recorded for Enriched Vermicompost (38.38 cm and 55.16 cm respectively) which were on par with Bharat Meal (34.51 cm and 51.86 cm respectively). Lowest values were obtained with Haritha Super (30.38 cm and 45.16 cm respectively) which were on par with Poabs Green (31.07 cm and 46.73 cm respectively) and FYM (33.58 cm and 47.89 cm respectively) and also with Bharat Meal at 30 DAS (34.51 cm).

Effect of growth promoters and the interaction effect of organic manures and growth promoters on plant height were not significant at any stage of growth.

Table 4.1.1.a Germination percentage in the treatments

Treatments	Germination %
M_1G_1 (FYM + Water Spray)	99.00
M_1G_2 (FYM + Panchagavyam)	98.66
M_1G_3 (FYM + Vermiwash)	97.66
M_2G_1 (Haritha Super + Water Spray)	98.00
M_2G_2 (Haritha Super + Panchagavyam)	98.33
M_2G_3 (Haritha Super + Vermiwash)	98.33
M_3G_1 (Poabs Green + Water Spray)	96.66
M_3G_2 (Poabs Green + Panchagavyam)	99.00
M_3G_3 (Poabs Green + Vermiwash)	97.66
M_4G_1 (Bharat Meal + Water Spray)	98.00
M_4G_2 (Bharat Meal + Panchagavyam)	98.00
M_4G_3 (Bharat Meal + Vermiwash)	98.66
M_5G_1 (Enriched Vermicompost + Water Spray)	99.00
M_5G_2 (Enriched Vermicompost + Panchagavym)	98.33
M_5G_3 (Enriched Vermicompost + Vermiwash)	98.00
F (8,28)	0.598^{NS}
SE ± m	0.930
CD (0.05)	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Plate 2. The experimental field at five days after sowing

Table 4.1.1.b Effect of organic manures and growth promoters on germination, %

Treatments	Germination
Organic Manures	
M_1 (FYM)	98.44
M_2 (Haritha Super)	98.22
M_3 (Poabs Green)	97.77
M_4 (Bharat Meal)	98.22
M_5 (Enriched Vermicompost)	98.44
F (4,28)	0.256^{NS}
SE ± m	0.536
CD (0.05)	-
Growth Promoters	
G_1 (Water Spray)	98.13
G_2 (Panchagavyam)	98.46
G_3 (Vermiwash)	98.06
F (2,28)	0.265^{NS}
SE±m	0.415
CD (0.05)	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.1.2 Effect of organic manures and growth promoters on height of plant, cm

Treatments	30 DAS	60 DAS	90 DAS
Organic Manures			
M_1 (FYM)	33.58	47.89	54.98
M_2 (Haritha Super)	30.38	45.16	49.76
M_3 (Poabs Green)	31.07	46.73	51.02
M_4 (Bharat Meal)	34.51	51.86	55.22
M_5 (Enriched Vermicompost)	38.38	55.16	55.91
F(4,28)	3.28*	4.196**	2.399^{NS}
SE±m	1.472	1.633	1.798
CD (0.05)	4.263	4.731	-
Growth Promoters			
G_1 (Water Spray)	33.89	47.84	51.02
G_2 (Panchagavyam)	34.61	51.81	55.59
G_3 (Vermiwash)	34.04	51.22	54.00
F(2,28)	0.111^{NS}	2.873^{NS}	2.686^{NS}
SE±m	1.140	1.265	1.393
CD (0.05)	-	-	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

4.1.3 Number of Primary Branches Plant^{-1}

Data on the effect of organic manures and growth promoters on the number of primary branches plant^{-1} is furnished in Table 4.1.3

The effect of organic manures on number of primary branches per plant was significant at 30, 60 and 90 DAS. At all the three stages Enriched Vermicompost showed maximum number of primary branches (3.02, 4.86 and 4.86 respectively) which were on par with that of Bharat Meal (2.84, 4.58 and 4.58 respectively) and FYM (2.56, 4.53 and 4.53 respectively). Least number of primary branches were obtained with Haritha Super (2.19, 3.58 and 3.58 respectively) which was on par with Poabs Green (2.36, 3.73 and 3.73 respectively) and also with FYM on 30 DAS (2.56).

The effects due to growth promoters and interaction were not significant on the number of primary branches plant^{--1}.

4.1.4 Number of Leaves Plant^{-1}

The results on number of leaves plant^{-1} as influenced by different organic manures and growth promoters at 30, 60 and 90 DAS are presented in Table 4.1.4.

There was no significant difference in the number of leaves, at any stage of the crop, among the different organic manures or growth promoters studied.

The treatment combinations of these organic manures and growth promoters were also not significantly different.

4.1.5 Leaf Area Index (LAI)

LAI was computed for 30, 60 and 90 DAS and the data is given in Table 4.1.5.

LAI was significantly influenced by different organic manures at 30 and 60 DAS. At 60 DAS the influence was highly significant. Both at 30 and 60 DAS maximum LAI was recorded for Enriched Vermicompost (1.28 and 2.88 respectively). At 30 DAS Enriched Vermicompost was on par with Poabs Green,

Table 4.1.3 Effect of organic manures and growth promoters on number of primary branches plant^{-1}, cm

Treatments	30 DAS	60 DAS	90 DAS
Organic Manures			
M_1 (FYM)	2.56	4.53	4.53
M_2 (Haritha Super)	2.19	3.58	3.58
M_3 (Poabs Green)	2.36	3.73	3.73
M_4 (Bharat Meal)	2.84	4.58	4.58
M_5 (Enriched Vermicompost)	3.02	4.86	4.86
F(4,28)	2.718*	7.421**	7.421**
SE±m	0.209	0.207	0.207
CD (0.05)	0.607	0.599	0.599
Growth Promoters			
G_1 (Water Spray)	2.39	4.13	4.13
G_2 (Panchagavyam)	2.61	4.16	4.16
G_3 (Vermiwash)	2.77	4.48	4.48
F(2,28)	1.432^{NS}	0.193^{NS}	0.193^{NS}
SE±m	0.162	0.160	0.160
CD (0.05)	-	-	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.1.4 Effect of organic manures and growth promoters on number of leaves plant^{-1}

Treatments	30 DAS	60 DAS	90 DAS
Organic Manures			
M_1 (FYM)	9.24	21.73	15.80
M_2 (Haritha Super)	9.09	16.93	15.24
M_3 (Poabs Green)	10.96	23.04	17.44
M_4 (Bharat Meal)	9.98	21.40	16.18
M_5 (Enriched Vermicompost)	11.33	22.36	19.64
F(4,28)	1.811^{NS}	1.475^{NS}	2.503^{NS}
SE±m	0.745	1.983	1.107
CD (0.05)	2.157	5.743	3.209
Growth Promoters			
G_1 (Water Spray)	9.84	20.99	15.96
G_2 (Panchagavyam)	10.04	21.03	16.97
G_3 (Vermiwash)	10.48	21.27	17.65
F(2,28)	0.322^{NS}	9.711^{NS}	0.986^{NS}
SE±m	0.577	1.536	0.858
CD (0.05)	-	-	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.1.5 Effect of organic manures and growth promoters on leaf area index at 30, 60 and 90 DAS

Treatments	30 DAS	60DAS	90DAS
Organic Manures			
M_1 (FYM)	1.16	2.27	1.67
M_2 (Haritha Super)	1.01	2.08	1.56
M_3 (Poabs Green)	1.19	2.40	1.71
M_4 (Bharat Meal)	1.17	2.31	1.67
M_5 (Enriched Vermicompost)	1.28	2.88	1.82
F(4,28)	3.233*	7.033**	1.008^{NS}
SE±m	5.675	0.111	9.569
CD (0.05)	0.164	0.324	-
Growth Promoters			
G_1 (Water Spray)	1.11	2.32	1.65
G_2 (Panchagavyam)	1.84	2.45	1.73
G_3 (Vermiwash)	1.22	2.39	1.67
F(2,28)	1.649^{NS}	0.594^{NS}	0.334^{NS}
SE±m	5.675	8.667	7.41
CD (0.05)	-	-	-

*	Significant at 5% level
**	Significant at 1% level
NS	Non significant

Bharat Meal and FYM. At 60 DAS LAI of Enriched Vermicompost was significantly superior to that in all the other organic manures. Both at 30 and 60 DAS Haritha Super recorded the lowest LAI (1.01 and 2.08 respectively) which were on par with FYM, Bharat Meal and Poabs Green.

The effect of growth promoters and the interaction effect were not significant.

4. 1. 6 Days to 50 per cent Flowering

Data on number of days to 50 per cent flowering as influenced by different organic manures and growth promoters is given in Table 4.1.6. The effect of the organic manures on days to 50 per cent flowering was not significant.

The effect due to growth promoters on days to 50 per cent flowering was highly significant. Least number of days for 50 per cent flowering (45 days) was observed in the Panchagavyam treated crop. Panchagavyam was significantly superior to Vermiwash (46.67 days) and Water Spray (49 days) which in turn differed significantly.

The interaction effect of organic manures and growth promoters was not significant.

4.1.7 Dry Matter Production (DMP)

Per hectare DMP at 60 DAS was calculated based on the dry weight of sample plants and the data is presented in Table 4.1.7.

Organic manures had significant influence on total DMP at 60 DAS. Enriched Vermicompost recorded the maximum DMP (2366.16 kg ha^{-1}) which was found to be significantly superior to all other organic manures. Bharat Meal recorded the second best value (2351.48 kg ha^{-1}) and it was on par with FYM (2347.59 kg ha^{-1}) which in turn was on par with Poabs Green (2342.86 kg ha^{-1}). The least DMP was obtained with Haritha Super (2312.70 kg ha^{-1}) which was significantly lower than all other organic manures.

Effect of growth promoters and interaction effects were not significant.

Table 4. 1. 6 Effect of organic manures and growth promoters on days to 50 per cent flowering

Treatments	No of days
Organic Manures	
M_1 (FYM)	46.67
M_2 (Haritha Super)	47.22
M_3 (Poabs Green)	47.00
M_4 (Bharat Meal)	47.00
M_5 (Enriched Vermicompost)	46.56
F(4,28)	1.286^{NS}
SE±m	0.239
CD (0.05)	-
Growth Promoters	
G_1 (Water Spray)	49.00
G_2 (Panchagavyam)	45.00
G_3 (Vermiwash)	46.67
F(2,28)	0.265**
SE±m	0.185
CD (0.05)	0.538

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.1.7 Effect of organic manures and growth promoters on dry matter production at 60 DAS, kg ha^{-1}

Treatments	Dry matter production
Organic Manures	
M_1 (FYM)	2347.59
M_2 (Haritha Super)	2312.70
M_3 (Poabs Green)	2342.86
M_4 (Bharat Meal)	2351.48
M_5 (Enriched Vermicompost)	2366.16
F(4,28)	114.377**
SE	1.834
CD (0.05)	5.313
Growth Promoters	
G_1 (Water Spray)	2342.32
G_2 (Panchagavyam)	2345.43
G_3 (Vermiwash)	2342.72
F(2,28)	1.433^{NS}
SE±m	1.421
CD (0.05)	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

4.1.9 Dry Matter Partitioning

Table 4.1.8 shows the effect of organic manures and growth promoters on shoot, root and pod dry matter. The organic manures and growth promoters had no significant influence on shoot, root and pod dry matter.

The interaction effect was also not significant.

4.2. YIELD AND YIELD PARAMETERS

4.2.1 Number of Flowers Plant $^{-1}$

Observations on number of flowers were taken at 30, 60 and 90 DAS. Number of flowers plant^{-1} as influenced by different organic manures, growth promoters and their interactions are presented in the Tables 4.2.1 and 4.2.2.

Among the three growth stages number of flowers plant^{-1} was maximum at 60 DAS. Number of flowers plant^{-1} was significantly influenced by organic manures as well as growth promoters at 30 and 60 DAS. The influence was not significant at 90 DAS. Both at 30 DAS and 60 DAS maximum number of flowers were produced by the plants which received Enriched Vermicompost (5.64 and 6.98 respectively) and was significantly higher than all other organic manures which in turn were on par. Haritha Super produced least number of flowers at 30 and 60 DAS (4.03 and 5.06 respectively) which was on par with FYM, Bharat Meal and Poabs Green.

Number of flowers plant^{-1} at 30 and 60 DAS were significantly influenced by growth promoters whereas the effect was not significant at 90 DAS. Maximum number of flowers per plant at 30 and 60 DAS were obtained with Panchagavyam (5.83 and 6.79 respectively) which was on par with that obtained with Vermiwash (4.25 and 5.96 respectively). At 30 and 60 DAS both Panchagavyam and Vermiwash were significantly superior to Water Spray (3.61 and 4.19 respectively).

Table 4.1.8 Effect of organic manures and growth promoters on dry matter partitioning plant $^{-1}$, g

Treatments	Shoot	Root	Pod
Organic Manures			
M_1 (FYM)	8.17	2.39	2.67
M_2 (Haritha Super)	8.24	2.18	2.57
M_3 (Poabs Green)	8.20	2.34	2.64
M_4 (Bharat Meal)	8.04	2.54	2.72
M_5 (Enriched Vermicompost)	8.38	2.27	2.79
F(4,28)	0.966^{NS}	1.375^{NS}	1.707^{NS}
SE±m	0.048	0.087	0.063
CD (0.05)	-	-	-
Growth Promoters			
G_1 (Water Spray)	8.15	2.40	2.60
G_2 (Panchagavyam)	8.31	2.25	2.76
G_3 (Vermiwash)	8.17	2.38	2.68
F(2,28)	0.926^{NS}	1.328^{NS}	2.446^{NS}
SE±m	0.037	0.067	0.049
CD (0.05)	-	-	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.2.1 Effect of organic manures and growth promoters on number of flowers plant^{-1}

Treatments	30 DAS	60 DAS	90 DAS
Organic Manures			
M_1 (FYM)	4.35	5.29	2.24
M_2 (Haritha Super)	4.03	5.06	2.22
M_3 (Poabs Green)	4.46	5.47	2.60
M_4 (Bharat Meal)	4.32	5.39	2.36
M_5 (Enriched Vermicompost)	5.64	6.98	2.76
F(4,28)	3.453*	2.931*	1.248^{NS}
SE±m	0.375	0.446	0.198
CD (0.05)	1.087	1.293	-
Growth Promoters			
G_1 (Water Spray)	3.61	4.19	2.12
G_2 (Panchagavyam)	5.83	6.79	2.74
G_3 (Vermiwash)	4.25	5.96	2.45
F(2,28)	3.778*	9.162**	0.395^{NS}
SE±m	0.290	0.346	0.153
CD (0.05)	0.842	1.002	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.2.2 Interaction effect of organic manures and growth promoters on number of flowers $plant^{-1}$

Treatments	30 DAS	60 DAS	90 DAS
M_1G_1 (FYM + Water Spray)	3.33	3.00	1.11
M_1G_2 (FYM + Panchagavyam)	6.06	6.67	2.61
M_1G_3 (FYM + Vermiwash)	3.67	6.2	3.01
M_2G_1 (Haritha Super + Water Spray)	3.01	3.80	1.87
M_2G_2 (Haritha Super + Panchagavyam)	5.74	6.03	2.80
M_2G_3 (Haritha Super + Vermiwash)	3.35	5.37	2.00
M_3G_1 (Poabs Green + Water Spray)	3.44	4.37	2.36
M_3G_2 (Poabs Green + Panchagavyam)	5.17	6.67	2.76
M_3G_3 (Poabs Green + Vermiwash)	4.78	5.36	2.69
M_4G_1 (Bharat Meal + Water Spray)	3.43	4.33	2.87
M_4G_2 (Bharat Meal + Panchagavyam)	5.16	6.37	2.33
M_4G_3 (Bharat Meal + Vermiwash)	4.38	5.47	1.87
M_5G_1 (Enriched Vermicompost + Water Spray)	4.86	5.47	2.40
M_5G_2 (Enriched Vermicompost + Panchagavym)	7.00	8.2	3.20
M_5G_3 (Enriched Vermicompost + Vermiwash)	5.06	7.27	2.67
F(8,28)	1.954^{NS}	3.319**	1.678^{NS}
SE±m	0.650	0.773	0.343
CD (0.05)	-	2.241	-

* Significant at 5% level

** Significant at 1% level

NS Non significant

The interaction effect was significant only at 60 DAS. The highest mean value (8.2) was obtained with the treatment combination M_5G_2 (Enriched Vermicompost + Panchagavyam) which was on par with M_5G_3 (Enriched Vermicompost + Vermiwash) (7.27), M_1G_2 (FYM + Panchagavyam) (6.67), M_3G_2 (Poabs Green + Panchagavyam) (6.67), M_4G_2 (Bharat Meal + Panchagavyam) (6.37), M_1G_3 (FYM + Vermiwash) (6.20) and M_2G_2 (Haritha Super + Panchagavyam) (6.03).

4.2.3 Number of Pods Plant^{-1}

The effect due to organic manures and growth promoters on number of tender pods (vegetable) plant^{-1} is given in Table 4.2.3.

The effect due to organic manures was significant on number of pods plant^{-1}. Enriched Vermicompost recorded the highest number of pods (16.99) which was on par with Poabs Green (16.44) and Bharat Meal (16.27). The least number of pods was obtained with Haritha Super (14.09) which was on par with FYM (14.73).

The effect due to growth promoters and the interaction effect were not significant.

4.2.4 Length of Pod

Length of pods as influenced by organic manures and growth promoters are presented in Table 4.2.4. The organic manures significantly influenced the length of pod. Pods with maximum length (18.51 cm) was produced by the crop which received Enriched Vermicompost which was on par with that received Poabs Green (18.44 cm) and Bharat meal (18.31 cm). Pods with minimum length was produced in treatment with Haritha Super (17.69 cm) which was on par with the pod length obtained with FYM.

Effect of growth promoters and interaction effect on length of pod were not significant.

Table 4.2.3 Effect of organic manures and growth promoters on number of pods plant^{-1}

Treatments	No of Pods
Organic Manures	
M_1 (FYM)	14.73
M_2 (Haritha Super)	14.09
M_3 (Poabs Green)	16.44
M_4 (Bharat Meal)	16.27
M_5 (Enriched Vermicompost)	16.99
F(4,28)	3.164**
SE±m	0.690
CD (0.05)	2.000
Growth Promoters	
G_1 (Water Spray)	15.88
G_2 (Panchagavyam)	15.33
G_3 (Vermiwash)	15.89
F(2,28)	0.356^{NS}
SE±m	0.53
CD (0.05)	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.2.4 Effect of organic manures and growth promoters on length of pod, cm

Treatments	Length of pod
Organic Manures	
M_1 (FYM)	17.89
M_2 (Haritha Super)	17.69
M_3 (Poabs Green)	18.44
M_4 (Bharat Meal)	18.31
M_5 (Enriched Vermicompost)	18.51
F(4,28)	10.722**
SE	0.110
CD (0.05)	0.319
Growth Promoters	
G_1 (Water Spray)	18.07
G_2 (Panchagavyam)	18.19
G_3 (Vermiwash)	18.25
F(2,28)	1.22^{NS}
SE±m	8.55
CD (0.05)	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

4.2.5 Fresh Weight of Single Pod

The data on fresh weight of single pod as influenced by different organic manures and growth promoters are given in Table 4.2.5.

Effect of organic manures on fresh weight of single pod was highly significant. Maximum mean weight of tender pod (5.27 g) was recorded for Enriched Vermicompost. It was significantly superior to all other treatments which in turn were on par. Haritha Super recorded the least weight of single pod (4.78 g).

The effect of different growth promoters and interaction effects were not significant.

4.2.6 Number of Seeds Pod^{-1}

Data on the number of seeds pod^{-1} is presented in Table 4.2.6. The number of seeds pod^{-1} was not significantly influenced by organic manures, growth promoters and their interaction.

4.2.7 Pod Yield

Data on total and marketable yield of tender pods is presented in Table 4.2.7 and 4.2.8

Total pod yield as well as marketable yield were significantly influenced by organic manures. Maximum total yield was obtained for Enriched Vermicompost (4.97 t ha^{-1}) which was significantly superior to all other organic manures. Poabs Green recorded the second highest value (4.36 t ha^{-1}) which was on par with Bharat Meal (4.26 t ha^{-1}) and FYM (3.97 t ha^{-1}). Haritha super recorded the least yield (3.68 t ha^{-1}) which was on par with FYM (3.97 t ha^{-1}).

Marketable yield of pods was also maximum (4.02 t ha^{-1}) in Enriched Vermicompost which was significantly superior to all other organic manures. Marketable yield of Bharat Meal (2.95 t ha^{-1}) and Poabs Green (2.72 t ha^{-1}) were

Table 4.2.5 Effect of organic manures and growth promoters on fresh weight of single pod, g

Treatments	Fresh weight of single pod
Organic Manures	
M_1 (FYM)	4.80
M_2 (Haritha Super)	4.78
M_3 (Poabs Green)	4.89
M_4 (Bharat Meal)	4.85
M_5 (Enriched Vermicompost)	5.27
$F(4,28)$	4.758**
SE±m	9.733
CD (0.05)	0.281
Growth Promoters	
G_1 (Water Spray)	4.80
G_2 (Panchagavyam)	4.93
G_3 (Vermiwash)	4.96
$F(2,28)$	1.292^{NS}
SE±m	7.539
CD (0.05)	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.2.6 Effect of organic manures and growth promoters on number of seeds pod^{-1}

Treatments	No. of seeds pod^{-1}
Organic Manures	
M_1 (FYM)	12.08
M_2 (Haritha Super)	12.06
M_3 (Poabs Green)	12.20
M_4 (Bharat Meal)	12.18
M_5 (EnrichedVermicompost)	12.77
F(4,28)	1.953^{NS}
SE±m	0.210
CD (0.05)	-
Growth Promoters	
G_1 (Water Spray)	12.01
G_2 (Panchagavyam)	12.56
G_3 (Vermiwash)	12.21
F(2,28)	2.886^{NS}
SE±m	0.162
CD (0.05)	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.2.7 Effect of organic manures and growth promoters on total and marketable pod yield, t ha^{-1}

Treatments	Total pod yield	Marketable pod yield
Organic Manures		
M_1 (FYM)	3.97	2.27
M_2 (Haritha Super)	3.68	1.82
M_3 (Poabs Green)	4.36	2.72
M_4 (Bharat Meal)	4.26	2.95
M_5 (Enriched Vermicompost)	4.97	4.02
F(4,28)	7.083**	7.083**
SE±m	0.18	0.138
CD (0.05)	0.52	0.399
Growth Promoters		
G_1 (Water Spray)	4.19	2.17
G_2 (Panchagavyam)	4.20	3.31
G_3 (Vermiwash)	4.33	2.79
F(2,28)	0.321^{NS}	28.780**
SE±m	0.140	0.107
CD (0.05)	-	0.309

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.2.8 Interaction effect of organic manures and growth promoters on marketable pod yield, t ha^{-1}

Treatments	Marketable pod yield
M_1G_1 (FYM + Water Spray)	1.35
M_1G_2 (FYM + Panchagavyam)	2.86
M_1G_3 (FYM + Vermiwash)	2.59
M_2G_1 (Haritha Super + Water Spray)	1.07
M_2G_2 (Haritha Super + Panchagavyam)	2.47
M_2G_3 (Haritha Super + Vermiwash)	1.92
M_3G_1 (Poabs Green + Water Spray)	2.54
M_3G_2 (Poabs Green + Panchagavyam)	3.18
M_3G_3 (Poabs Green + Vermiwash)	2.44
M_4G_1 (Bharat Meal + Water Spray)	2.51
M_4G_2 (Bharat Meal + Panchagavyam)	3.30
M_4G_3 (Bharat Meal + Vermiwash)	3.05
M_5G_1 (Enriched Vermicompost + Water Spray)	3.35
M_5G_2 (Enriched Vermicompost + Panchagavym)	4.73
M_5G_3 (Enriched Vermicompost + Vermiwash)	3.97
F(8,28)	1.333**
SE±m	0.238
CD (0.05)	0.690

* Significant at 5% level
** Significant at 1% level
NS Non significant

on par and significantly superior to the yields in FYM (2.27 t ha^{-1}) and Haritha Super (1.82 t ha^{-1}).

Effect of growth promoters on total yield was not significant whereas marketable yield of pods was significantly influenced by growth promoters. Maximum marketable yield was obtained with Panchagavyam (3.31 t ha^{-1}) which was significantly higher than that in Vermiwash (2.79 t ha^{-1}) and Water Spray (2.17 t ha^{-1}) which also differed significantly from each other.

Interaction effect of organic manures and growth promoters on total yield was not significant but it was significant with respect to marketable yield. Maximum marketable yield was produced by the treatment combination M_5G_2 (Enriched Vermicompost + Panchagavyam) (4.73 t ha^{-1}) which was significantly superior to all others. Least marketable yield was produced by the treatment combination M_2G_1 (Haritha Super + Water Spray) (1.07 t ha^{-1}) which was on par with M_1G_1 (FYM + Water Spray) (1.35 t ha^{-1}).

4.3 PEST INCIDENCE

4.3.1 Percentage Pest Incidence

Data on percentage pest incidence is furnished in Table 4.3.1 and 4.3.2.

Results indicate that effect of organic manures and growth promoters on percentage pest incidence was highly significant. Pods in all the treatments were affected by pod borers, *Lambydis* sp. and *Maruca testulans.* Maximum percentage of pest incidence (51.10 per cent) was noted in Haritha Super applied crop which was significantly higher than all other organic manures which in turn differed significantly from one another. The least percentage pest incidence was noted in the crop that received Enriched Vermicompost (19.45 per cent) which was significantly lower than the percentage pest incidence in all other organic manures.

The growth promoters also differed significantly from one another. Least percentage pest incidence (21.90 per cent) was noted in the crop sprayed with Panchagavyam which was significantly less than that in Vermiwash(36.37

Table 4.3.1 Effect of organic manures and growth promoters on percentage pest incidence

Treatments	Pest incidence
Organic Manures	
M_1 (FYM)	42.27
M_2 (Haritha Super)	51.10
M_3 (Poabs Green)	37.31
M_4 (Bharat Meal)	30.22
M_5 (Enriched Vermicompost)	19.45
$F(4,28)$	159.007**
SE	0.952
CD (0.05)	2.758
Growth Promoters	
G_1 (Water Spray)	49.95
G_2 (Panchagavyam)	21.90
G_3 (Vermiwash)	36.37
$F(2,28)$	361.900**
SE±m	0.737
CD (0.05)	2.135

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.3.2 Interaction effect of organic manures and growth promoters on percentage pest incidence

Treatments	Pest incidence
M_1G_1 (FYM + Water Spray)	64.96
M_1G_2 (FYM + Panchagavyam)	18.93
M_1G_3 (FYM + Vermiwash)	42.91
M_2G_1 (Haritha Super + Water Spray)	68.63
M_2G_2 (Haritha Super + Panchagavyam)	35.60
M_2G_3 (Haritha Super + Vermiwash)	49.07
M_3G_1 (Poabs Green + Water Spray)	45.84
M_3G_2 (Poabs Green + Panchagavyam)	25.12
M_3G_3 (Poabs Green + Vermiwash)	40.97
M_4G_1 (Bharat Meal + Water Spray)	40.51
M_4G_2 (Bharat Meal + Panchagavyam)	17.82
M_4G_3 (Bharat Meal + Vermiwash)	32.32
M_5G_1 (Enriched Vermicompost + Water Spray)	29.80
M_5G_2 (Enriched Vermicompost + Panchagavym)	11.99
M_5G_3 (Enriched Vermicompost + Vermiwash)	16.99
$F_{(8,28)}$	14.395**
SE±m	1.649
CD (0.05)	4.776

* Significant at 5% level
** Significant at 1% level
NS Non significant

per cent) which in turn was significantly less than the pest incidence in control (Water Spray) (49.95 per cent)

The interaction effect due to organic manures and growth promoters on percentage pest incidence was also highly significant. Maximum percentage of pest incidence (68.63 per cent) was recorded for M_2G_1 (Haritha Super + Water Spray) which was on par with M_1G_1 (FYM + Water Spray) (64.96 per cent). Least value (11.99 per cent) was recorded for M_5G_2 (Enriched Vermicompost + Panchagavyam) which was significantly superior to all other combinations.

4.4 QUALITY PARAMETERS

4.4.1 Crude Protein Content of Pod

The effect of organic manures and growth promoters on crude protein content of pod is depicted in Table 4.4.1

The effect of organic manures and growth promoters on crude protein content of pod was highly significant. Enriched Vermicompost produced pods with maximum crude protein content (21.30 per cent) and it was significantly superior to all the other organic manures. Poabs Green, FYM and Bharat Meal were on par. Least protein content was obtained with Haritha Super (18.67 per cent) which was significantly lower than all other organic manures.

Protein content of pod was the maximum (20. 28 per cent) in Vermiwash which was on par with Panchagavyam (20.14 per cent) and both were significantly higher than Water Spray. Water spray recorded the least crude protein content in pods (19.90 per cent).

The interaction effect was not significant.

4.4.2 Shelf Life of Pods

The results on shelf life of pods as influenced by different organic manures and growth promoters are given in Table 4.4.2.

Table 4.4.1 Effect of organic manures and growth promoters on crude protein content of pod, %

Treatments	Crude protein content
Organic Manures	
M_1 (FYM)	20.26
M_2 (Haritha Super)	18.67
M_3 (Poabs Green)	20.30
M_4 (Bharat Meal)	20.18
M_5 (Enriched Vermicompost)	21.30
$F(4,28)$	91.594**
SE	0.097
CD (0.05)	0.281
Growth Promoters	
G_1 (Water Spray)	19.90
G_2 (Panchagavyam)	20.14
G_3 (Vermiwash)	20.28
$F(2,28)$	3.776*
SE	7.525
CD (0.05)	0.218

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.4.2 Effect of organic manures and growth promoters on shelf life of pods, days

Treatments	Shelf life in days
Organic Manures	
M_1 (FYM)	7.2
M_2 (Haritha Super)	7.4
M_3 (Poabs Green)	7.5
M_4 (Bharat Meal)	8.2
M_5 (Enriched Vermicompost)	8.2
$F(4,28)$	3.255*
SE	0.256
CD (0.05)	0.742
Growth Promoters	
G_1 (Water Spray)	7.37
G_2 (Panchagavyam)	7.73
G_3 (Vermiwash)	7.80
$F(2,28)$	0.113^{NS}
SE	0.198
CD (0.05)	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Organic manures exerted significant influence on shelf life of pods whereas the growth promoters and interaction had no significant influence. Both Bharat Meal and Enriched Vermicompost recorded the highest shelf life of pods (8.2 days) which was on par with Poabs Green (7.5 days) and Haritha Super (7.4 days). Minimum shelf life was obtained for treatment with FYM (7.2 days) which was on par with Haritha Super and Poabs Green. Shelf life obtained with FYM was significantly lower than Bharat Meal and Enriched Vermicompost.

4.4.3 Fibre Content of Pod

Data on the effect of treatments on fibre content of pods is furnished in Table 4.4.3.

There was no significant difference in fibre content of pods due to various organic manures, growth promoters and their interaction. Fibre content of pods ranged from 2.97 to 3.28 percentage

4.4.4 Ascorbic Acid Content of Pod

The ascorbic acid content of green pod as influenced by different organic manures and growth promoters are given in Table 4.4.4.

Neither the individual nor the combined effect of organic manures and growth promoters was significant on the ascorbic acid content of pods. Ascorbic acid content of the pod ranged from 11.73 to 13.33 mg 100 g^{-1}

4.4.5 Total Free Amino Acid Content of Pod

Total free amino acid content of green pod (Table 4.4.5) ranged from 0.111 to 0.133 mg 100^{-1} g. Maximum free amino acid content of green pod was obtained in Haritha Super followed by FYM, Poabs Green, Bharat Meal and Enriched Vermicompost.

Table 4.4.3 Effect of organic manures and growth promoters on fibre content of green pod,%

Treatments	Fibre content
Organic Manures	
M_1 (FYM)	3.03
M_2 (Haritha Super)	3.02
M_3 (Poabs Green)	3.24
M_4 (Bharat Meal)	3.28
M_5 (Enriched Vermicompost)	2.97
F(4,28)	0.613^{NS}
SE	0.185
CD (0.05)	-
Growth Promoters	
G_1 (Water Spray)	3.18
G_2 (Panchagavyam)	3.02
G_3 (Vermiwash)	3.12
F(2,28)	0.346^{NS}
SE	0.143
CD (0.05)	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.4.4 Effect of organic manures and growth promoters on ascorbic acid content of green pod, mg 100 g^{-1}

Treatments	Ascorbic acid content
Organic Manures	
M_1 (FYM)	12.00
M_2 (Haritha Super)	12.11
M_3 (Poabs Green)	12.44
M_4 (Bharat Meal)	12.00
M_5 (Enriched Vermicompost)	13.33
F(4,28)	0.605^{NS}
SE	0.725
CD (0.05)	-
Growth Promoters	
G_1 (Water Spray)	11.73
G_2 (Panchagavyam)	12.93
G_3 (Vermiwash)	12.47
F(2,28)	1.158^{NS}
SE	0.562
CD (0.05)	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.4.5 Effect of organic manures and growth promoters on total free amino acid content of green pod, mg 100 g^{-1}

Organic manures	Growth promoters			Mean
	G_1 (Water spray)	G_2 (Panchagavyam)	G_3 (Vermiwash)	
M_1 (FYM)	0.125	0.127	0.129	0.127
M_2 (Haritha Super)	0.133	0.131	0.129	0.131
M_3 (Poabs Green)	0.126	0.124	0.127	0.125
M_4 (Bharat Meal)	0.115	0.115	0.113	0.114
M_5 (Enriched Vermicompost)	0.111	0.112	0.115	0.113
Mean	0.122	0.122	0.123	

Not statistically analysed

4.5 NUTRIENT UPTAKE BY THE CROP

4.5.1 Uptake of N

Effect of organic manures and growth promoters on uptake of N is given in Table 4.5.1. The result indicated that effect of organic manures on uptake of N was highly significant. Among the organic manures maximum quantity of N (74.93 kg ha^{-1}) was taken up by the crop which received Enriched Vermicompost which was significantly higher than all other organic manures. Least value of N uptake (63.73 kg ha^{-1}) was obtained for the treatment with Haritha Super which was significantly less than FYM, Poabs Green and Bharat Meal which in turn were on par.

The growth promoters significantly increased the uptake of nitrogen by the plants when compared to Water Spray (control). N uptakes in Vermiwash and Panchagavyam were on par.

The interaction effect of organic manure and growth promoters were found to be not significant.

4.5.2 Uptake of P

Data on uptake of P as influenced by different organic manures is presented in Table 4.5.2. Organic manures exerted highly significant influence on uptake of P. Application of Enriched Vermicompost resulted in significantly higher uptake (9.44 kg ha^{-1}) compared to other organic manures. Uptake of P in Bharat Meal (8.23 kg ha^{-1}), Poabs Green (7.75 kg ha^{-1}) and Haritha Super (7.73 kg ha^{-1}) were on par.

The growth promoters and the interaction exerted no significant influence on uptake of P.

4.5.3 Uptake of K

Effect of organic manures and growth promoters on uptake of K by the crop is presented in Table 4.5.3. Effect of organic manures and growth promoters on uptake of K was highly significant. Uptake of K was highest (76.44 kg ha^{-1}) in

Table 4.5.1 Effect of organic manures and growth promoters on uptake of nitrogen, kg ha^{-1}

Treatments	Uptake of N
Organic Manures	
M_1 (FYM)	70.81
M_2 (Haritha Super)	63.73
M_3 (Poabs Green)	70.81
M_4 (Bharat Meal)	70.95
M_5 (Enriched Vermicompost)	74.93
F(4,28)	115.55**
SE±m	0.376
CD (0.05)	1.090
Growth Promoters	
G_1 (Water Spray)	69.68
G_2 (Panchagavyam)	70.29
G_3 (Vermiwash)	70.76
F(2,28)	3.478*
SE±m	0.291
CD (0.05)	0.844

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.5.2 Effect of organic manures and growth promoters on uptake of P, kg ha^{-1}

Treatments	Uptake of P
Organic Manures	
M_1 (FYM)	7.75
M_2 (Haritha Super)	7.73
M_3 (Poabs Green)	7.77
M_4 (Bharat Meal)	8.23
M_5 (Enriched Vermicompost)	9.44
F(4,28)	16.378**
SE±m	0.301
CD (0.05)	0.873
Growth Promoters	
G_1 (Water Spray)	8.147
G_2 (Panchagavyam)	8.412
G_3 (Vermiwash)	8.537
F(2,28)	0.729^{NS}
SE±m	0.233
CD (0.05)	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.5.3 Effect of organic manures and growth promoters on uptake of K, kg ha^{-1}

Treatments	Uptake of K
Organic Manures	
M_1 (FYM)	62.32
M_2 (Haritha Super)	59.87
M_3 (Poabs Green)	66.44
M_4 (Bharat Meal)	71.50
M_5 (Enriched Vermicompost)	76.44
F(4,28)	6.66**
SE±m	2.617
CD (0.05)	7.579
Growth Promoters	
G_1 (Water Spray)	60.49
G_2 (Panchagavyam)	70.09
G_3 (Vermiwash)	71.15
F(2,28)	8.398**
SE±m	2.027
CD (0.05)	5.871

* Significant at 5% level
** Significant at 1% level
NS Non significant

plants which received Enriched Vermicompost which was on par with that in Bharat Meal (71.50 kg ha^{-1}) but was significantly higher than the other three organic manures which in turn were on par.

K uptake was highest in Vermiwash (71.15 kg ha^{-1}) which was on par with that in Panchagavyam (70.09 kg ha^{-1}) and both were significantly higher than the uptake in Water Spray (60.49 kg ha^{-1}).

The interaction effect was not significant.

4.6 SOIL NUTRIENT STATUS

4.6.1 Available N

The N status of soil was analysed after the experiment and the results are presented in Table 4.6.1

The different organic manures and growth promoters had highly significant influence on post harvest available N status of the soil. Application of Haritha Super resulted in the highest available N level (452.37 kg ha^{-1}) which was significantly superior to other organic manures. This was followed by Enriched Vermicompost (446.06 kg ha^{-1}) and FYM (440.05 kg ha^{-1}) which differed significantly from each other. Plots that received Poabs Green recorded the least available N status of soil (437.28 kg ha^{-1}) which was on par with that in Bharat Meal (437.90 kg ha^{-1}) and FYM (440.05 kg ha^{-1}).

Maximum available soil N status was recorded in the plots which received Panchagavyam (445.85 kg ha^{-1}) which was significantly higher than Vermiwash and Water Spray which in turn were on par.

The interaction effect was found to be not significant.

4.6.2 Available P_2O_5

The data on available phosphorous status of the soil after harvest of the crop is presented in Table 4.6.1. Effect of organic manures on post harvest available P_2O_5 status of the soil was highly significant. Plots treated with Haritha

Table 4.6.1 Effect of organic manures and growth promoters on soil nutrient status after the experiment

Treatments	N (kg/ha)	P (kg/ha)	K (kg/ha)
Organic Manures			
M_1 (FYM)	440.05	61.51	231.08
M_2 (Haritha Super)	452.37	74.09	236.27
M_3 (Poabs Green)	437.28	58.79	256.09
M_4 (Bharat Meal)	437.90	66.86	239.71
M_5 (EnrichedVermicompost)	446.06	59.90	207.06
F(4,28)	35.19**	17.312**	217.30**
SE±m	1.080	1.520	1.949
CD (0.05)	3.128	4.403	5.645
Growth Promoters			
G_1 (Water Spray)	441.28	63.28	242.76
G_2 (Panchagavyam)	445.85	66.46	239.04
G_3 (Vermiwash)	441.09	62.95	238.33
F(2,28)	10.38**	2.701^{NS}	2.485^{NS}
SE±m	0.837	1.777	1.509
CD (0.05)	2.423	-	-

* Significant at 5% level
** Significant at 1% level
NS Non significant

Super resulted in highest soil P_2O_5 level (74.09 kg ha^{-1}) which was significantly higher than all other organic manures. Bharat Meal which recorded the second highest value (66.86 kg ha^{-1}) was significantly higher than the remaining three organic manures which in turn were on par. Least value of available P_2O_5 in soil was recorded by Poabs Green (58.79 kg ha^{-1}).

The growth promoters exerted no significant influence on available P_2O_5 in soil.

4.6.3 Available K_2O

Table 4.6.1 depicts the post harvest available K_2O content of soil.

Effect of organic manures on available K_2O content in the soil after the experiment was found to be highly significant. Poabs Green exerted highly significant influence on the residual K_2O content, with a maximum value of 256.09 kg ha^{-1} which was significantly higher than all other organic manures. Available K_2O content in the soil was least in plots which received Enriched Vermicompost (207.06 kg ha^{-1}) which was significantly lower than all other organic manures.

The growth promoters and the interaction exerted no significant influence on residual K_2O status.

The interaction effect was not significant.

4.6.2 Organic Carbon Content

The data on organic carbon content of the soil after harvest of the crop is presented in Table 4.6.2.a. and 4.6.2.b.

The different organic manures and growth promoters had highly significant influence in improving soil organic carbon content. All the organic manures differed significantly from one another. Maximum organic carbon content resulted by the treatment with Poabs Green (2.72 per cent) which was

Table 4.6.2.a Effect of organic manures and growth promoters on soil organic carbon content, %

Treatments	Soil organic carbon
Organic Manures	
M_1 (FYM)	2.62
M_2 (Haritha Super)	1.58
M_3 (Poabs Green)	2.72
M_4 (Bharat Meal)	1.95
M_5 (Enriched Vermicompost)	1.70
F (4,28)	746.06**
SE±m	0.019
CD (0.05)	0.058
Growth Promoters	
G_1 (Water Spray)	2.60
G_2 (Panchagavyam)	1.91
G_3 (Vermiwash)	1.83
F(2,28)	685.906**
SE±m	0.015
CD (0.05)	0.044

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.6.2.b Interaction effect of organic manures and growth promoters on organic carbon content of soil, %

Treatments	Soil organic carbon
M_1G_1 (FYM + Water Spray)	3.86
M_1G_2 (FYM + Panchagavyam)	1.94
M_1G_3 (FYM + Vermiwash)	2.06
M_2G_1 (Haritha Super + Water Spray)	1.84
M_2G_2 (Haritha Super + Panchagavyam)	1.52
M_2G_3 (Haritha Super + Vermiwash)	1.38
M_3G_1 (Poabs Green + Water Spray)	2.74
M_3G_2 (Poabs Green + Panchagavyam)	2.60
M_3G_3 (Poabs Green + Vermiwash)	2.82
M_4G_1 (Bharat Meal + Water Spray)	2.08
M_4G_2 (Bharat Meal + Panchagavyam)	1.94
M_4G_3 (Bharat Meal + Vermiwash)	1.82
M_5G_1 (Enriched Vermicompost + Water Spray)	2.50
M_5G_2 (Enriched Vermicompost + Panchagavym)	1.54
M_5G_3 (Enriched Vermicompost + Vermiwash)	1.06
F (8,28)	194.599**
SE ±m	0.344
CD (0.05)	0.099

* Significant at 5% level
** Significant at 1% level
NS Non significant

significantly higher than that in other organic manures treated soil. Least organic carbon content was obtained in the treatment with Haritha Super (1.58 per cent).

The growth promoters also differed significantly from one another. The control treatment (Water Spray) recorded the highest soil organic carbon level (2.60 per cent). Soil organic carbon content with Panchagavyam was 1.91 per cent and that with Vermiwash was 1. 83 per cent .

The interaction effect of organic manures and growth promoters was also significant (Table 4.6.2.b). The treatment combination M_1G_1 (FYM + Water Spray) resulted in maximum residual soil organic carbon (3.86 per cent) where as M_2G_1 (Haritha Super + Vermiwash) resulted in the least (1.38 per cent).

4.7 ECONOMICS OF CULTIVATION

Effect of organic manures and growth promoters on economics of cultivation is given in Table 4.7.1. and 4.7.2

Organic manures, growth promoters and their interactions had significant influence on economics of cultivation. BCR in Enriched Vermicompost was the highest (1.43) which was on par with that in FYM (1.31). BCR in both Enriched Vermicompost and FYM were significantly higher than that in Poabs Green (0.64), Haritha Super (0.58) and Bharat Meal (0.47). BCR in Poabs Green and Haritha Super were on par and significantly higher than that in Bharat Meal.

BCR of Panchagavyam was maximum (1.04) which was significantly higher than that in Vermiwash (0.94) and Water Spray (0.71). Vermiwash and Water Spray also differed significantly from each other.

Maximum B:C was recorded in the treatment combination M_5G_2 (Enriched Vermicompost + Panchagavyam) (1.68) which was on par with M_5G_3 (Enriched Vermicompost + Vermiwash) (1.48), M_1G_2 (FYM + Panchagavyam) (1.56) and M_1G_3 (FYM + Vermiwash) (1.51). The treatment combination M_2G_1 (Haritha Super + Water Spray) recorded the least B:C (0.39)

Table 4.7.1 Effect of organic manures and growth promoters on economics of cultivation

Treatments	BCR
Organic Manures	
M_1 (FYM)	1.31
M_2 (Haritha Super)	0.58
M_3 (Poabs Green)	0.64
M_4 (Bharat Meal)	0.47
M_5 (Enriched Vermicompost)	1.48
$F_{(4,28)}$	45.382**
SE	0.040
CD (0.05)	0.116
Growth Promoters	
G_1 (Water Spray)	0.71
G_2 (Panchagavyam)	1.04
G_3 (Vermiwash)	0.94
$F_{(2,28)}$	29.904**
SE	0.031
CD (0.05)	0.089

* Significant at 5% level
** Significant at 1% level
NS Non significant

Table 4.7.2. Interaction effect of organic manures and growth promoters on economics of cultivation

Treatments	BCR
M_1G_1 (FYM + Water Spray)	0.85
M_1G_2 (FYM + Panchagavyam)	1.56
M_1G_3 (FYM + Vermiwash)	1.51
M_2G_1 (Haritha Super + Water Spray)	0.39
M_2G_2 (Haritha Super + Panchagavyam)	0.73
M_2G_3 (Haritha Super + Vermiwash)	0.61
M_3G_1 (Poabs Green + Water Spray)	0.61
M_3G_2 (Poabs Green + Panchagavyam)	0.72
M_3G_3 (Poabs Green + Vermiwash)	0.59
M_4G_1 (Bharat Meal + Water Spray)	0.42
M_4G_2 (Bharat Meal + Panchagavyam)	0.51
M_4G_3 (Bharat Meal + Vermiwash)	0.48
M_5G_1 (Enriched Vermicompost + Water Spray)	1.28
M_5G_2 (Enriched Vermicompost + Panchagavym)	1.68
M_5G_3 (Enriched Vermicompost + Vermiwash)	1.48
F (8,28)	4.809**
SE ±m	0.069
CD (0.05)	0.201

* Significant at 5% level
** Significant at 1% level
NS Non significant

Discussion

5. DISCUSSION

In a field study conducted in the college of Agriculture, Vellayani, three commercial organic manures viz., Haritha Super (4.0 : 4.4 : 2.0 NPK), Poabs Green (2.7 : 1.2 : 2.0 NPK) and Bharath Meal (1.5 : 2.2 : 2.5 NPK) were compared with FYM (1.0 : 0.4 : 0.5 NPK) and Enriched Vermicompost (2.0 : 1.25 : 1.0 NPK) as the organic component of integrated nutrient management in bush type vegetable cowpea in combination with and without two growth promoters viz., Panchagavyam and Vermiwash. Feasibility of using the commercial organic manures as an alternative for FYM was also looked into. Results of the experiment are discussed in this chapter.

Organic manures tested in the field experiment were FYM, Haritha Super, Poabs Green, Bharath Meal and Enriched Vermicompost. All the organic manures were applied on nitrogen equivalent basis in accordance with the Package of Practices Recommendations 'Crops' (POP) of Kerala Agricultural University (KAU). The POP recommendation for bush type vegetable cowpea is 20 t FYM + 20 : 30 : 10 kg NPK ha^{-1}. This is equivalent to 220 kg N, 110 kg P_2O_5 and 110 kg K_2O ha^{-1}. When FYM was substituted with other organic manures on nitrogen equivalent basis P and K supplied by these organic manures were accounted for while calculating the quantity of inorganic phosphatic and potassium fertilizers to be applied in each treatment. The P and K received by the treatments showed some variations as presented in Table 5.1.

Table 5.1 Nutrient schedule in the treatments

Organic Manures		Quantity applied (t ha^{-1})	Quantity of inorganic fertilizers applied (kg ha^{-1})			Nutrients supplied (kg ha^{-1})		
Notation	Name		Urea	SSP	MoP	N	P_2O_5	K_2O
M_1	FYM	20.0	43.48	187.50	16.66	220	110	110
M_2	Haritha Super	5.0	43.48	-	16.66	220	220	110
M_3	Poabs Green	7.4	43.48	133.31	-	220	110	148
M_4	Bharat Meal	13.3	43.48	-	-	220	166.67	133
M_5	Enriched Vermicompost	10.0	43.48	-	16.66	220	125	110

5.1 ORGANIC MANURES

5.1.1 Effect of Organic Manures on Growth and Yield of Bush Type Vegetable Cowpea

Germination percentage in the various treatments ranged between 97.66 to 99 per cent and it did not vary significantly (Tables 4.1.1. a and b). Growth parameters such as height of plant, number of primary branches per plant, LAI and dry matter production were significantly influenced by the different organic manures. Effect of organic manures on number of leaves per plant, days to 50% flowering and dry matter partitioning were not significant. All the significantly influenced growth characters recorded maximum values in Enriched Vermicompost applied crop and least values in Haritha Super applied crop.

Enriched Vermicompost realized maximum plant height of 38.38 cm and 55.16 cm at 30 and 60 DAS respectively which were on par with Bharath Meal (Table 4.1.2). Enriched Vermicompost was significantly superior to FYM, Poabs Green and Haritha Super with respect to height of plants. All the commercial

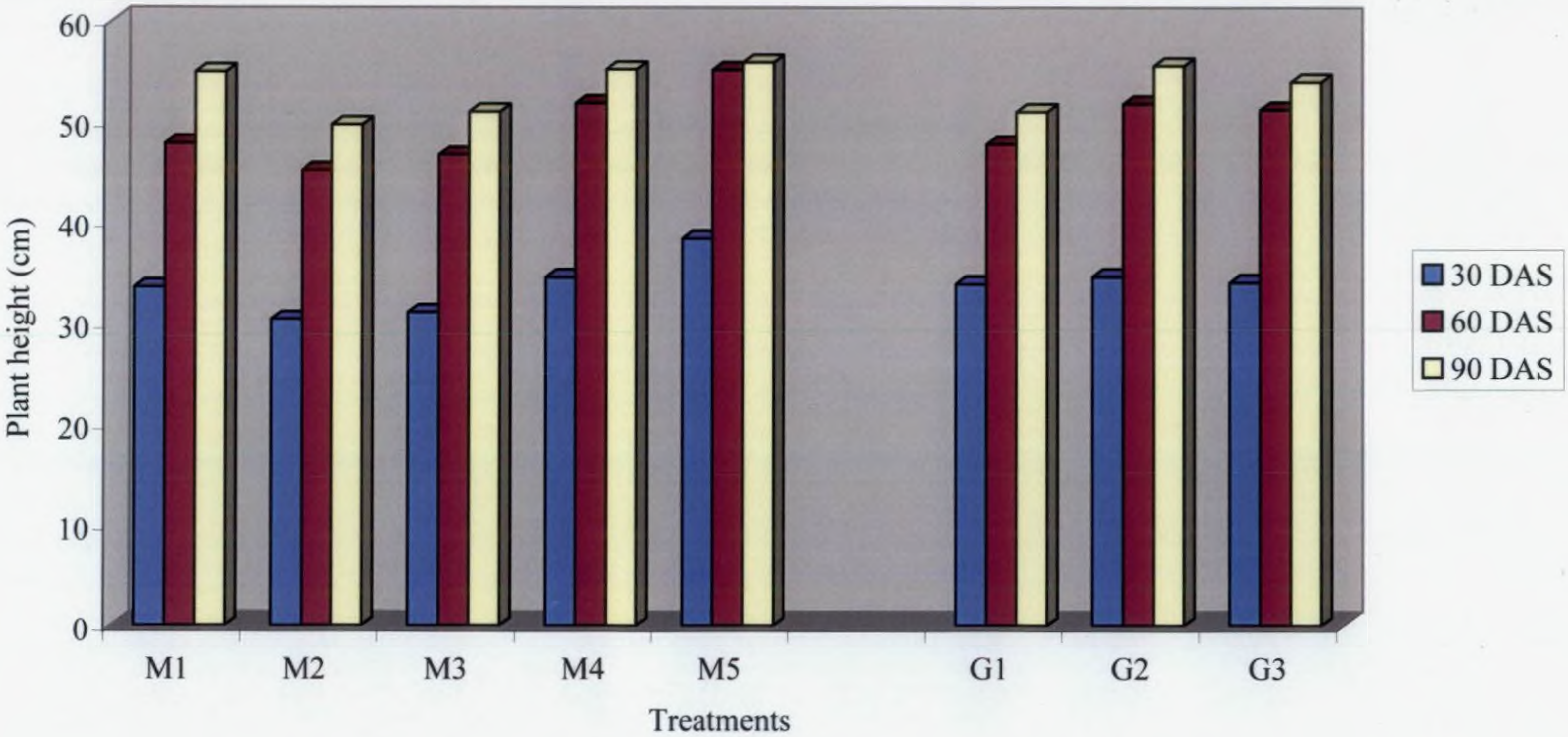


Fig. 3. Effect of organic manures and growth promoters on height of plant

organic manures were on par with FYM regarding plant height. The least plant height of 30.38 cm on 30 DAS and 45.16 cm on 60 DAS were recorded in Haritha Super. At 90 DAS the plant height was not significant.

Enriched Vermicompost produced maximum primary branches per plant (3.02 at 30 DAS and 4.86 at 60 DAS) which were on par with Bharath Meal and FYM (Table 4.1.3). At 30 DAS the commercial organic manures were on par with FYM but by 60th day primary branch production in Enriched Vermicompost, Bharath Meal and FYM became significantly higher than Poabs Green and Haritha Super which remained on par. Haritha Super produced the least number of primary branches (2.19 and 3.58 branches per plant at 30 and 60 DAS respectively). There was no increase in primary branches after 60 days of sowing.

LAI was significant at 30 and 60 DAS and non-significant at 90 DAS (Table 4.1.5). Maximum LAI was recorded by Enriched Vermicompost (1.28 at 30 DAS and 2.88 at 60 DAS) which was followed by Poabs Green, Bharath Meal, FYM and Haritha Super. Haritha Super recorded the least LAI of 1.01 at 30 DAS and 2.08 at 60 DAS. At both stages all the three commercial organic manures were on par with FYM. At 30 DAS Enriched Vermicompost was on par with the other organic manures except Haritha Super. At 60 DAS LAI in Enriched Vermicompost differed significantly from that of other organic manures.

Increase in dry matter production (Table 4.1.7) due to organic manures was significant. Dry matter production hectare^{-1} was maximum (2366.16 kg ha^{-1}) in Enriched Vermicompost which was significantly higher than the dry matter production in all other organic manures. Dry matter production was in the order Enriched Vermicompost followed by Bharath Meal, FYM, Poabs Green and Haritha Super respectively. Bharath Meal and Poabs Green were on par with FYM but Haritha Super produced significantly lower dry matter (2312.70 kg ha^{-1}) than all other organic manures.

A well developed photosynthetic system is the prerequisite for realizing good crop yield. Among the five organic manures subjected to field testing Enriched Vermicompost recorded the maximum values for height of plant,

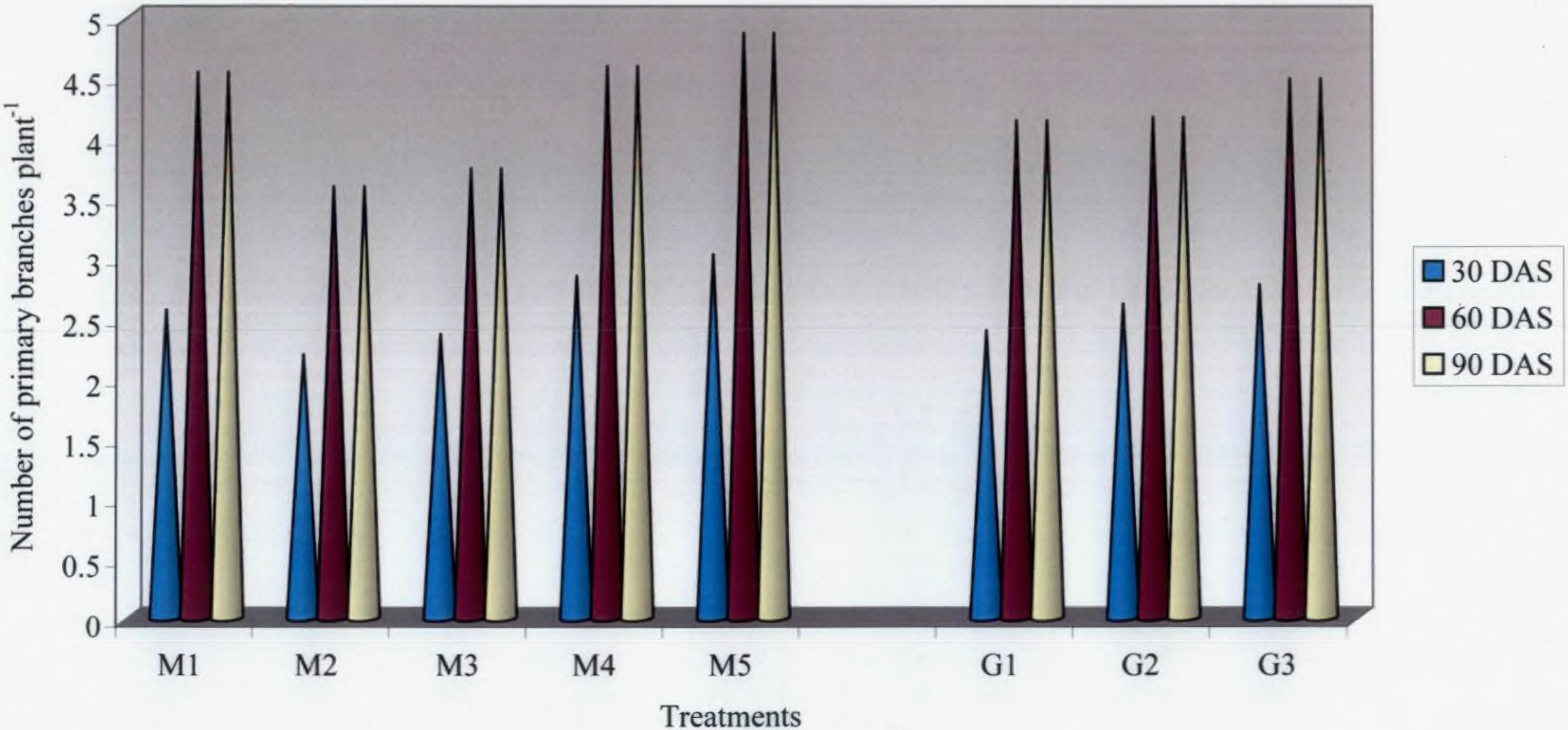


Fig. 4. Effect of organic manures and growth promoters on number of primary branches plant^{-1}

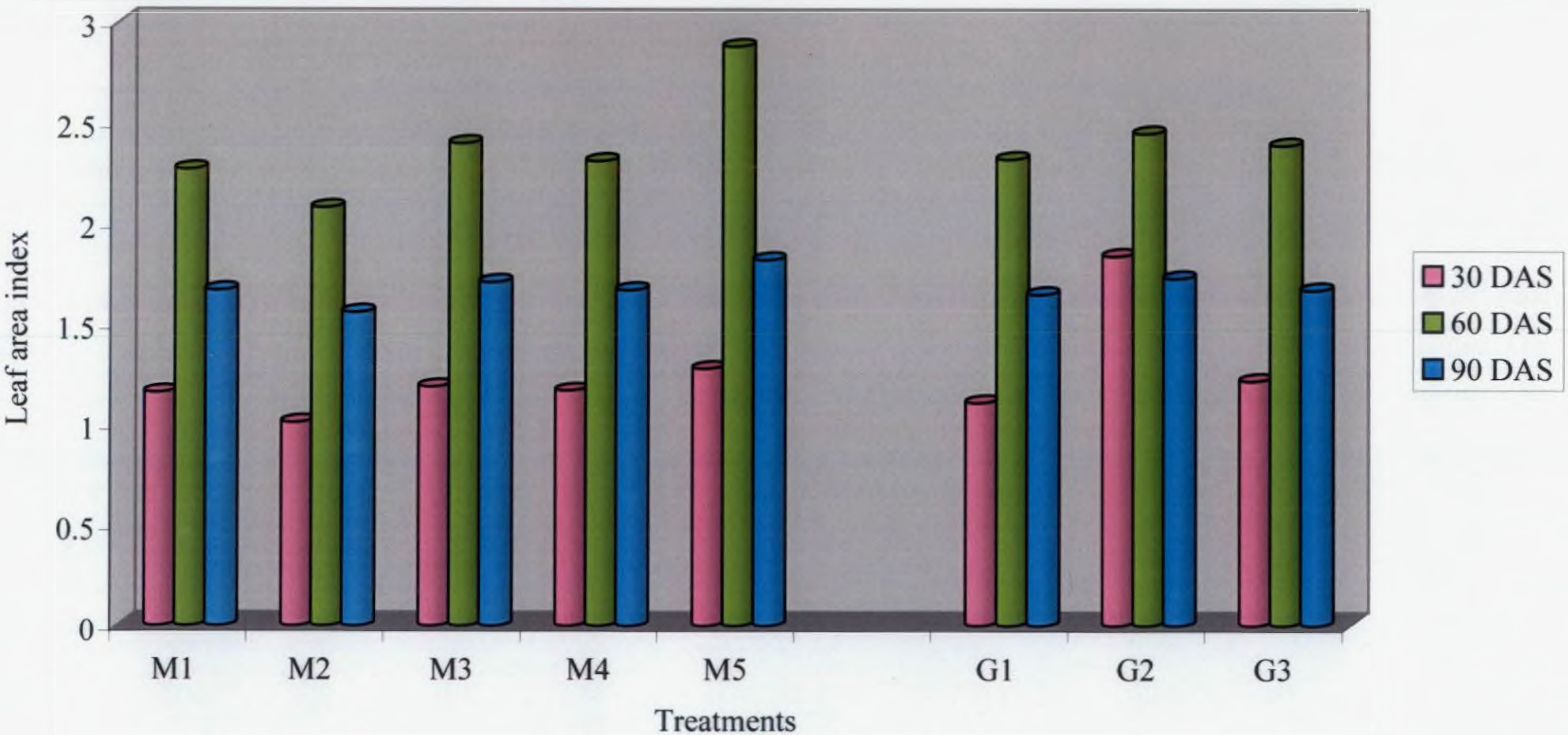


Fig. 5. Effect of organic manures and growth promoters on leaf area index at 30, 60 and 90 DAS

number of primary branches, LAI and dry matter production which may be attributed to the high nutrient uptake (NPK) in this treatment (Table 4.5.1). The NPK uptake in Enriched Vermicompost applied treatments were 74.93, 9.44 and 76.44 kg per ha respectively. All these might have contributed positively towards better development of growth parameters and dry matter accumulation.

Vermicompost is a rich source of plant nutrients such as N, P, K, Ca, Mg, Fe, Zn, Mn and Cu. It also contains growth regulators such as gibberellins, auxins, and microbial requirements like vitamins, antibiotics and amino acids (Sailajakumari, 1999). Nutritive value of vermicompost was increased when it was enriched with Rock Phosphate and beneficial microorganisms such as *Azospirillum* and *Pseudomonas fluorescens. Azospirillum* might have increased the nitrogen availability in the rhizosphere by nitrogen fixation and Pseudomonas being P solubilising microorganism might have increased P availability in the rhizosphere. The higher availability of nutrients might have resulted in the higher uptake. Meenakumari and Sivaprasad (2004) reported that in addition to N fixation *Azospirillum* produce considerable quantities of growth hormones, which enhance seedling growth, root development and vigor. Plants showed increase in latetal roots and dense root hairs, root volume and root dry weight. According to Krishnamoorthy and Rema, (2004) phosphobacter helps solubilizing P that are immobilized and fixed in soil to utilizable form and helps in easy uptake. P solubilizers helped in increasing the yield by 15-20 per cent. It also improved the uptake of available K by the inoculated plants. Use of biofertilizers along with organic manures and fertilizers would enhance the productivity of various crops, without compromising the quality of produce.

Sacirage and Dzelilovic (1986) reported an increase in DMP in cabbage from 1 to 66 per cent by the application of 4, 6 and 8 kg ha^{-1} of vermicompost.

Fayez (1990) reported that combined inoculation of *Azospirillum* and *Pseudomonas* resulted in significant increase in growth and dry matter production. Vadiraj et al. (1993) reported that use of vermicompost as a component of potting mixture in cardamom nursery helped better seedling growth and DMP in a shorter

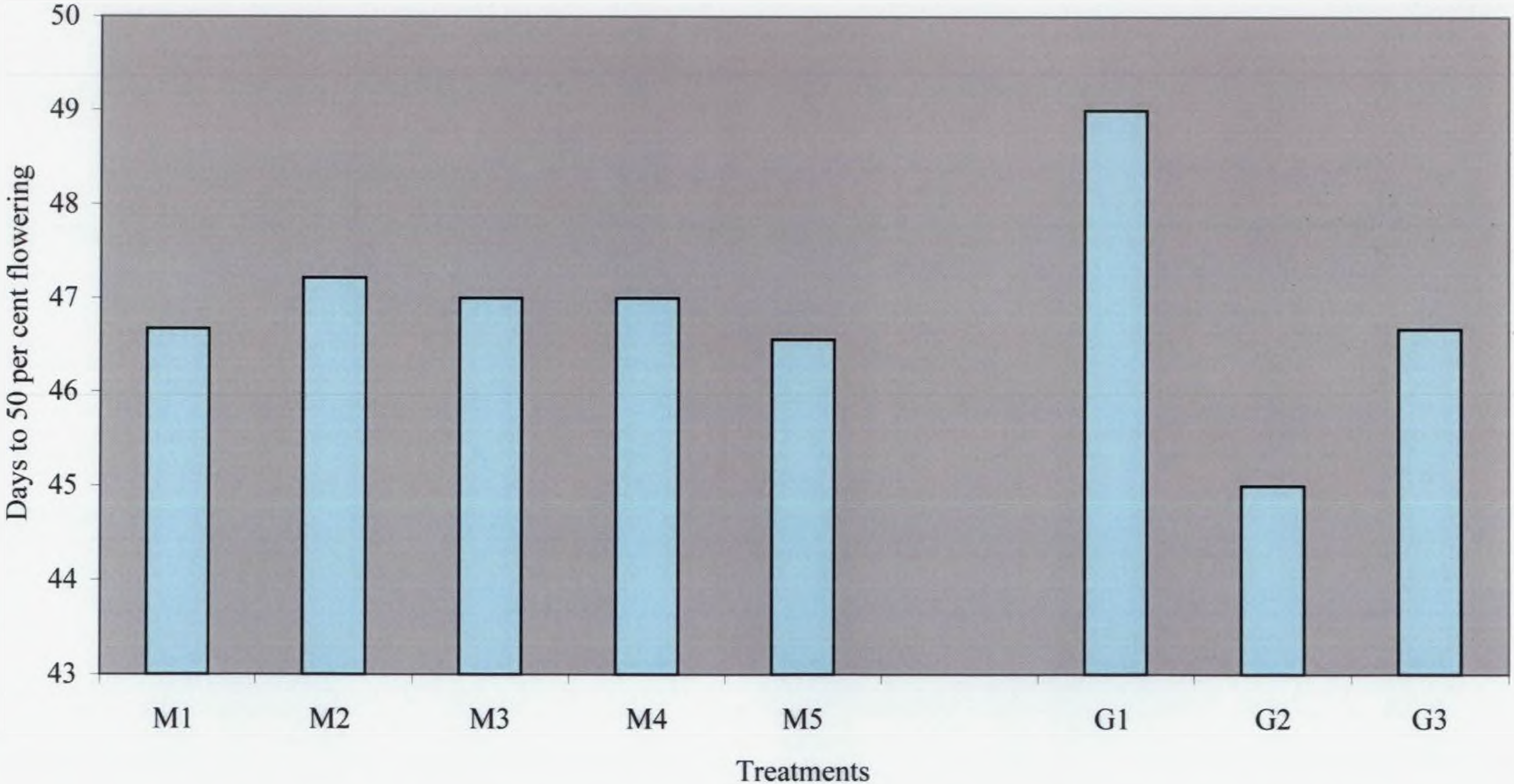


Fig. 6. Effect of organic manures and growth promoters on days to 50 per cent flowering

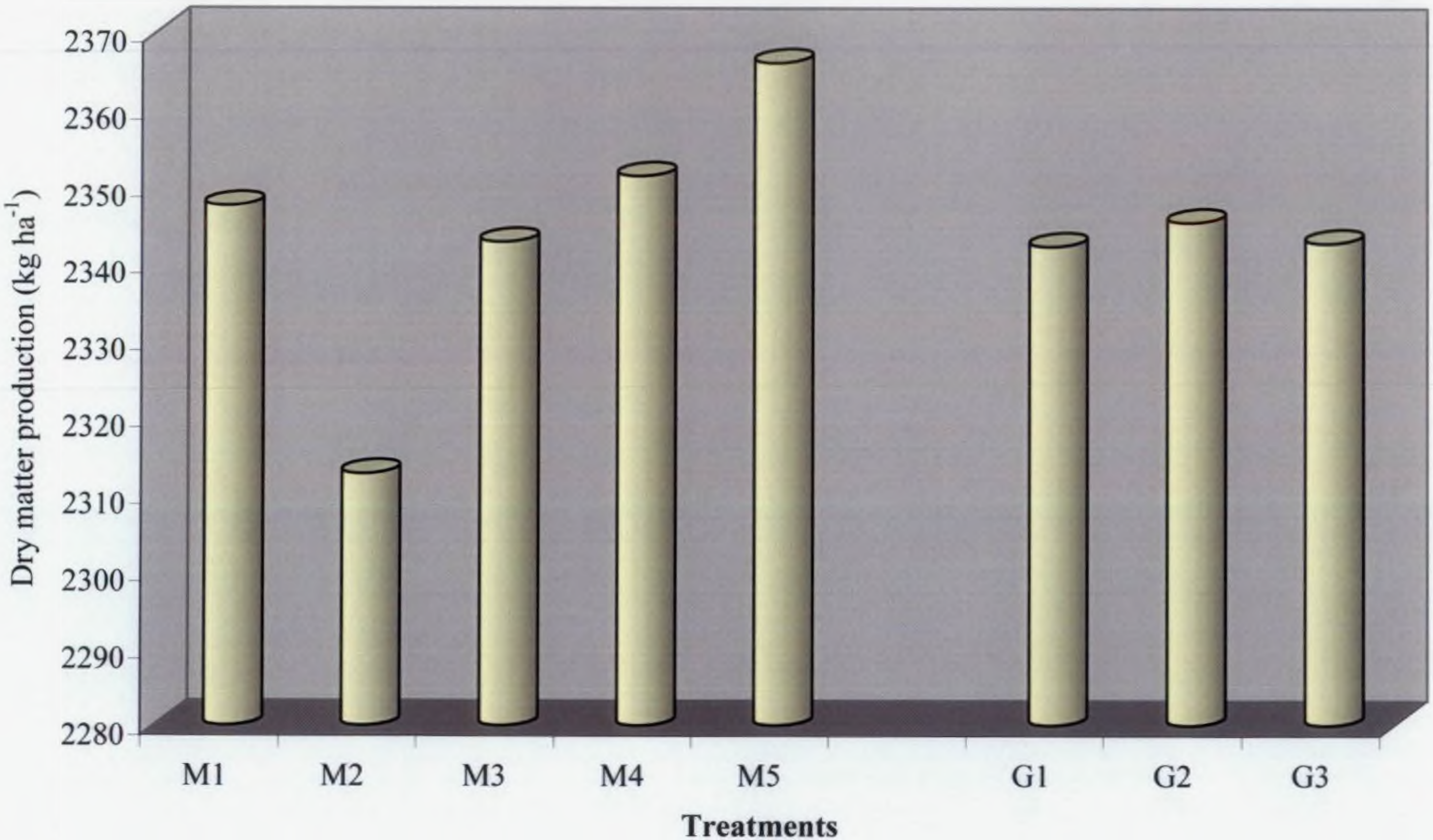


Fig. 7. Effect of organic manures and growth promoters on dry matter production at 60 DAS

period of time. Application of compost inoculated with *Azospirillum* and P solubilising organisms had the highest plant height, number of leaves and shoot root ratio in chilly (Zachariah, 1995). Vadiraj et al. (1996) found that vermicompost application resulted in increased leaf area of turmeric over control. Sailajakumari (1999) also reported that application of vermicompost enriched with rock phosphate increased plant height and number of branches in cowpea. Similar favourable influence of vermicompost were reported by Rajkhowa et al. (2002) in green gram and Yadav and Malik (2005) in cowpea.

All the other organic manures (Haritha Super, Poabs Green, Bharat Meal and FYM) were on par with respect to significantly important growth parameters such as height of plant, number of primary branches plant^{-1} and LAI. This may be due to the fact that the nutrients supplied in all the treatments were more or less equal with very slight variations such as slightly high potassium in Poabs Green, slightly high K and P in Bharat Meal and reasonably high P in Haritha Super as a result of the nutrient composition of these organic manures. All the growth parameters as well as dry matter production were least in Haritha Super. DMP in Haritha Super was significantly lower than the other organic manures. This may be attributed to the imbalance in nutrient uptake (63.73:10.33:66.09 kg ha^{-1}). Haritha Super applied plots received 220 kg P per hectare whereas POP recommendation is 110 kg per ha. NPK content of Haritha Super was 4.0 : 4.4 : 2.0. Reduced vegetative growth of the crop due to higher application of P had been reported earlier. Geethakumari (1981) reported a significant reduction in number of leaves per plant and LAI when P was supplied at a rate more than 50 kg ha^{-1}. Jain and Trivedi (2005) reported that excessive application of P have depressing effect on yield probably by imbalancing and limiting the availability of other nutrients.

Yield attributing characters which were significantly influenced by organic manures include number of flowers and number of pods per plant, length of pod and fresh weight of pod. Crop yield (yield of tender pods for vegetable purpose) was also significantly influenced by the organic manures. All the significantly

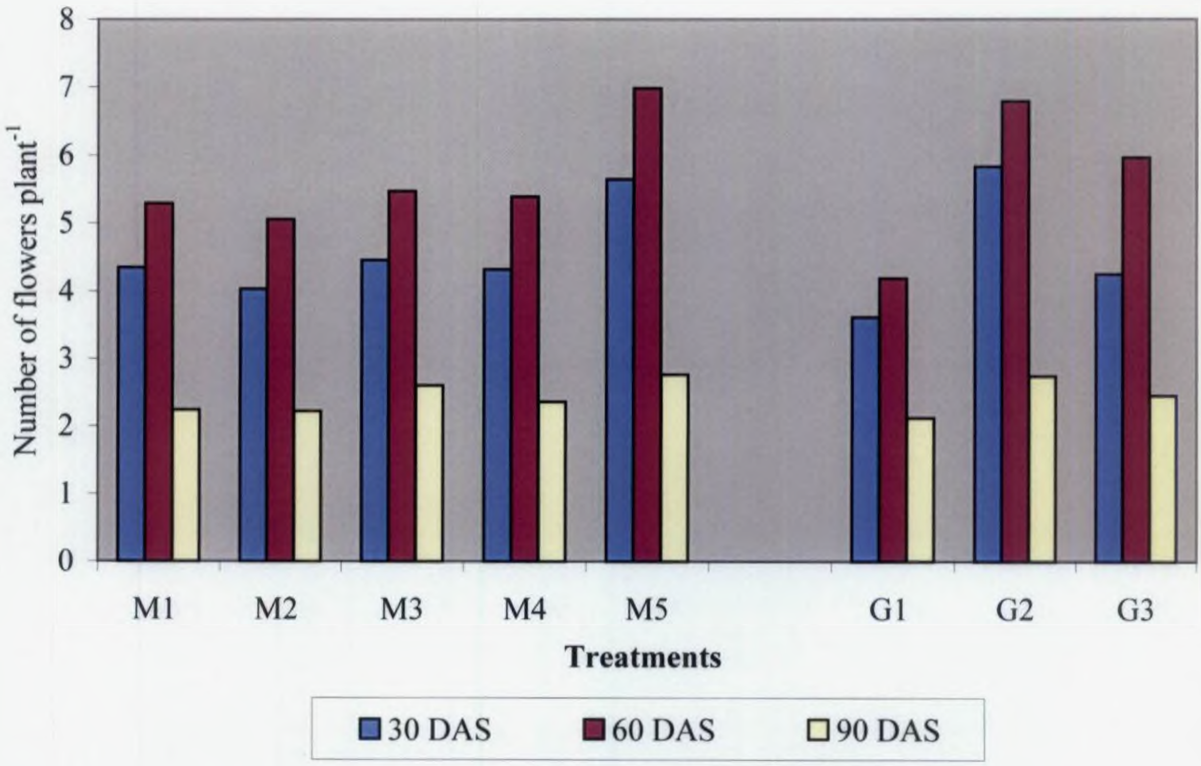


Fig. 8. Effect of organic manures and growth promoters on number of flowers plant^{-1}

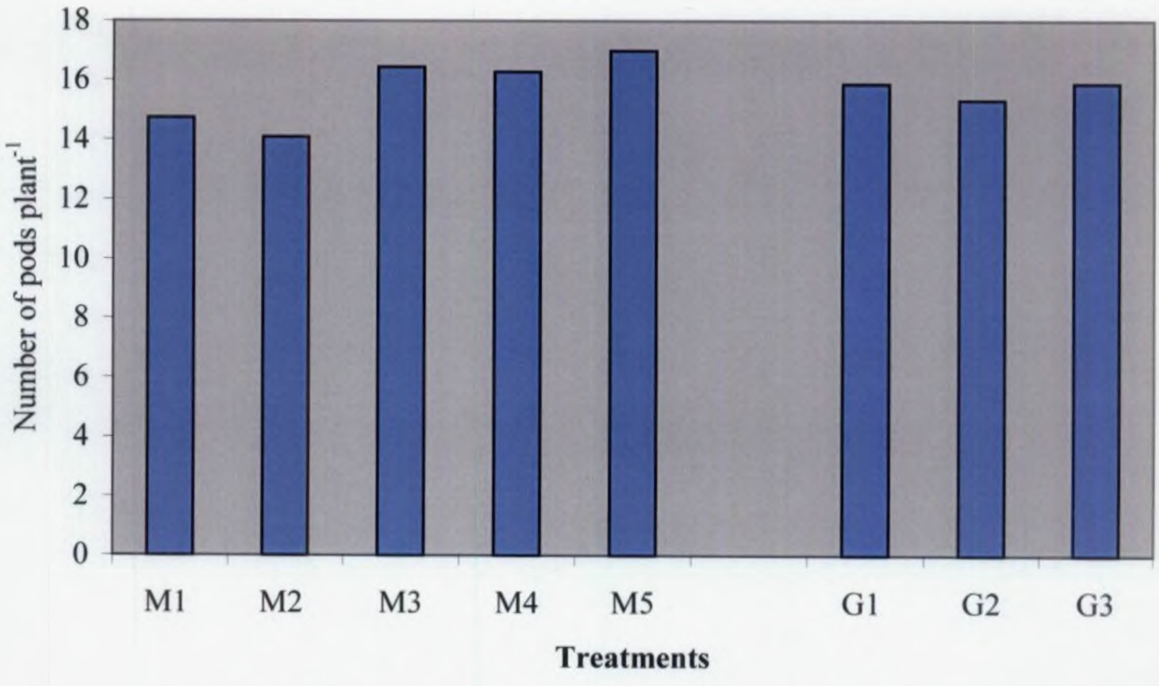


Fig. 9 Effect of organic manures and growth promoters on number of pods plant^{-1}

influenced yield attributing characters recorded maximum value in Enriched Vermicompost followed by Poabs Green, Bharath Meal, FYM and Haritha Super respectively. Difference in number of flowers at 30 and 60 DAS were significant (Table 4.2.1). Among the three growth stages of 30, 60 and 90 DAS number of flowers were maximum at 60 DAS. Maximum number of flowers per plant at 30 DAS (5.64) and at 60 DAS (6.98) were recorded in Enriched Vermicompost which was significantly higher than all other organic manures which in turn were on par. All the three commercial organic manures were on par with FYM. Number of pods per plant (Table 4.2.3) was maximum in Enriched Vermicompost (16.99) which was on par with Poabs Green and Bharath Meal. Least number of pods (14.09) was produced in Haritha Super which was on par with FYM. Length of pod was maximum (18.51 cm) in Enriched Vermicompost which was on par with Poabs Green and Bharath Meal which were significantly higher than FYM and Haritha Super. Haritha Super produced the shortest pods of length 17.69 cm. Fresh weight of single pod (Table 4.2.5) was maximum (5.27 g) in Enriched Vermicompost which was significantly superior to all the other four organic manures which in turn were on par. Fresh weight of pod ranged from 4.78 to 5.27 g.

The superiority of Enriched Vermicompost on growth characters was seen repeated in the yield parameters also. All the yield parameters realized maximum values in Enriched Vermicompost treated crops which may be attributed to the essential plant nutrient supplying capacity of the manure, the growth promoting substances present in the manure and the nutrient availability enhancement by the beneficial microorganisms such as *Azospirillum* and *Pseudomonas* present in the manure. The highest nutrient (NPK) uptake realized in Enriched Vermicompost applied plots and the better photosynthetic system resulted from the enhanced uptake also manifested in significantly higher yield parameters.

Application of 100% N and P_2O_5 + *Azospirillum* and *Phosphobacteria* favourably influenced the yield components such as number of capsules per plant, number of seeds per capsule and 1000 seed weight of sesamum (Wahab and Kadiresan, 1995). Yadav and Malik (2005) reported increased seeds per pod, pods

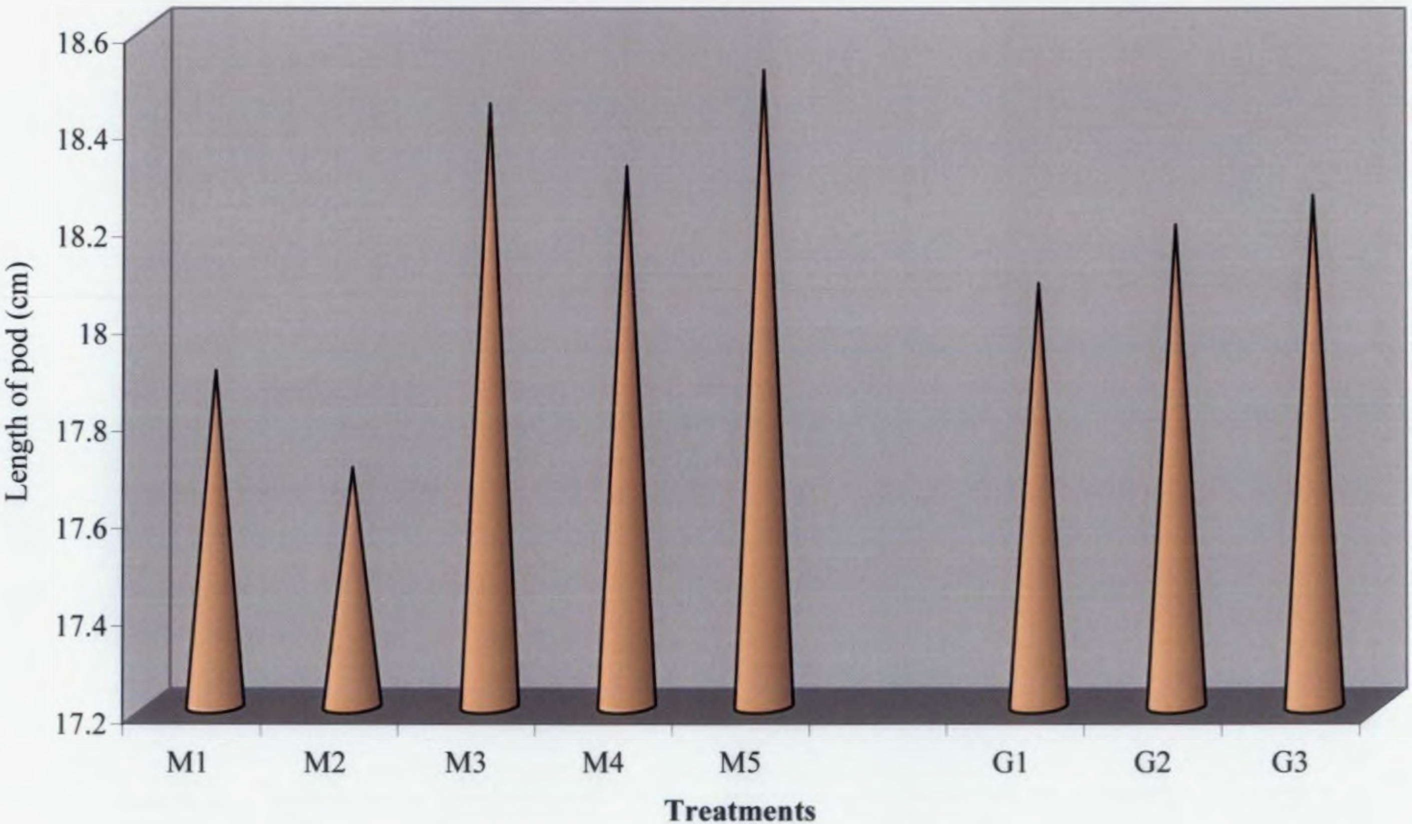


Fig. 10. Effect of organic manures and growth promoters on length of pod

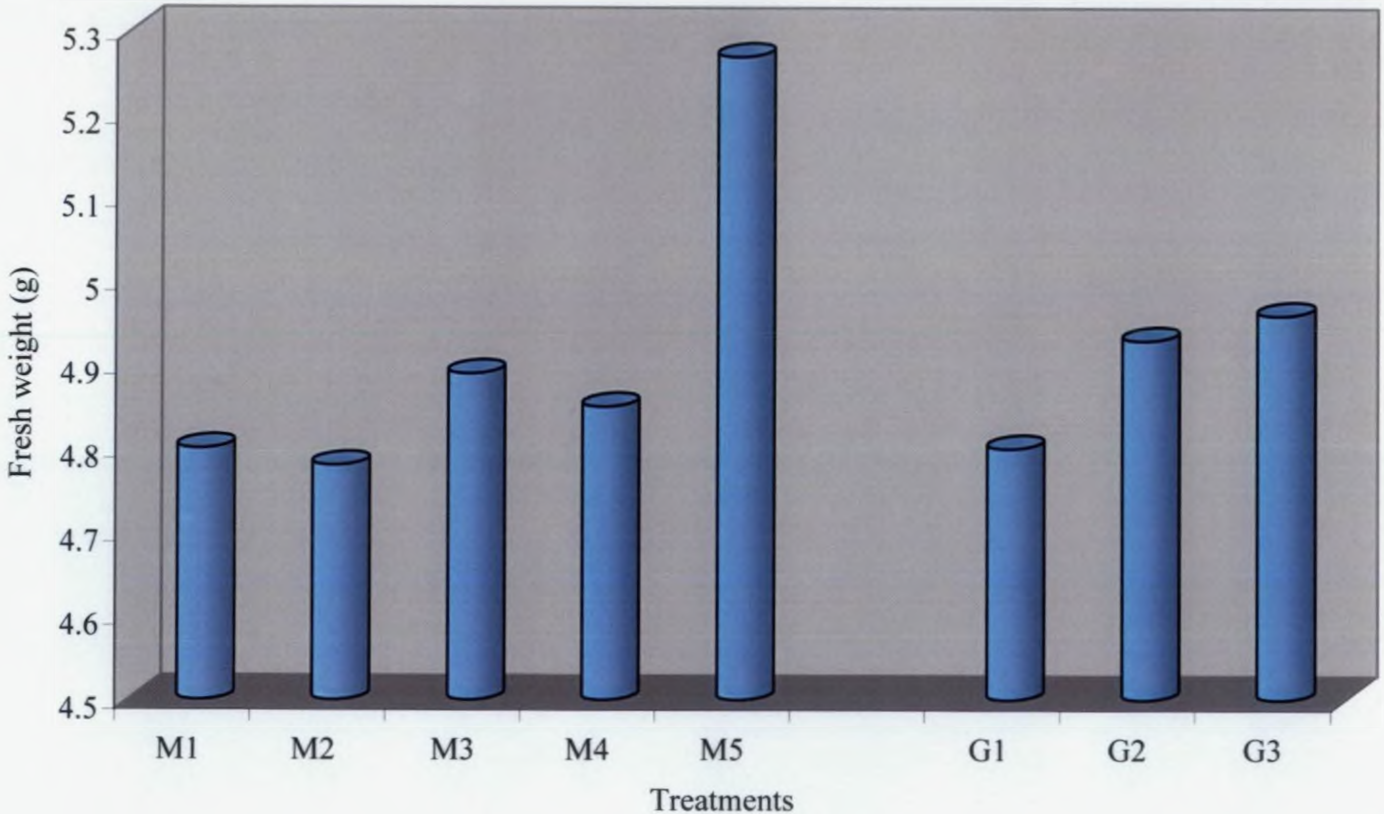


Fig. 11. Effect of organic manures and growth promoters on fresh weight of single pod

per plant and yield per plant by the application of vermicompost in green gram. According to them Vermicompost at the rate of 20 kg nitrogen per ha was found superior with respect to most of the yield attributes than FYM.

The commercial organic manures were on par with FYM with respect to most of the yield parameters. This might be attributed to the uniform quantity of the nutrients supplied by these organic manures and the same degree of their favourable impact on soil structure and soil fauna beneficial for crop growth.

Least pod number observed for Haritha Super can be due to the negative influence of P on pod formation, when given in excess. Geethakumari (1981) also observed a decline in pod number in bush type vegetable cowpea when the phosphorous level was increased from 50.0 to 62.5 kg P_2O_5 ha^{-1}. The excessive application of P has a depressing effect on yield, probably by imbalancing and limiting the availability of other nutrients (Jain and Trivedi, 2005).

Per ha total pod yield (Table 4.2.7) was maximum (4.97 t ha^{-1}) in Enriched Vermicompost which was significantly higher than the yields realized in all other organic manure treatments. The sequence of yield realization was in the order Enriched Vermicompost, Poabs Green, Bharath Meal, FYM and Haritha super. Enriched Vermicompost increased total pod yield by 25% compared to FYM. Yield increase in Poabs Green, Bharath Meal and Haritha Super compared to FYM were 9.8, 7.3 and –7.3 per cent respectively. Haritha Super obtained lowest total pod yield (3.68 t ha^{-1}) which was on par with that in FYM (3.97 t ha^{-1}). All the three commercial organic manures were on par with FYM with respect to total yield realization

Marketable yield of pods was also maximum (4.02 t ha^{-1}) in Enriched Vermicompost which was significantly superior to all other organic manures (Table 4.2.7). Marketable yield of Bharat Meal (2.95 t ha^{-1}) and Poabs Green (2.72 t ha^{-1}) were on par and significantly superior to the yields in FYM (2.27 t ha^{-1}) and Haritha Super (1.82 t ha^{-1})

Enriched Vermicompost was found to be significantly superior with

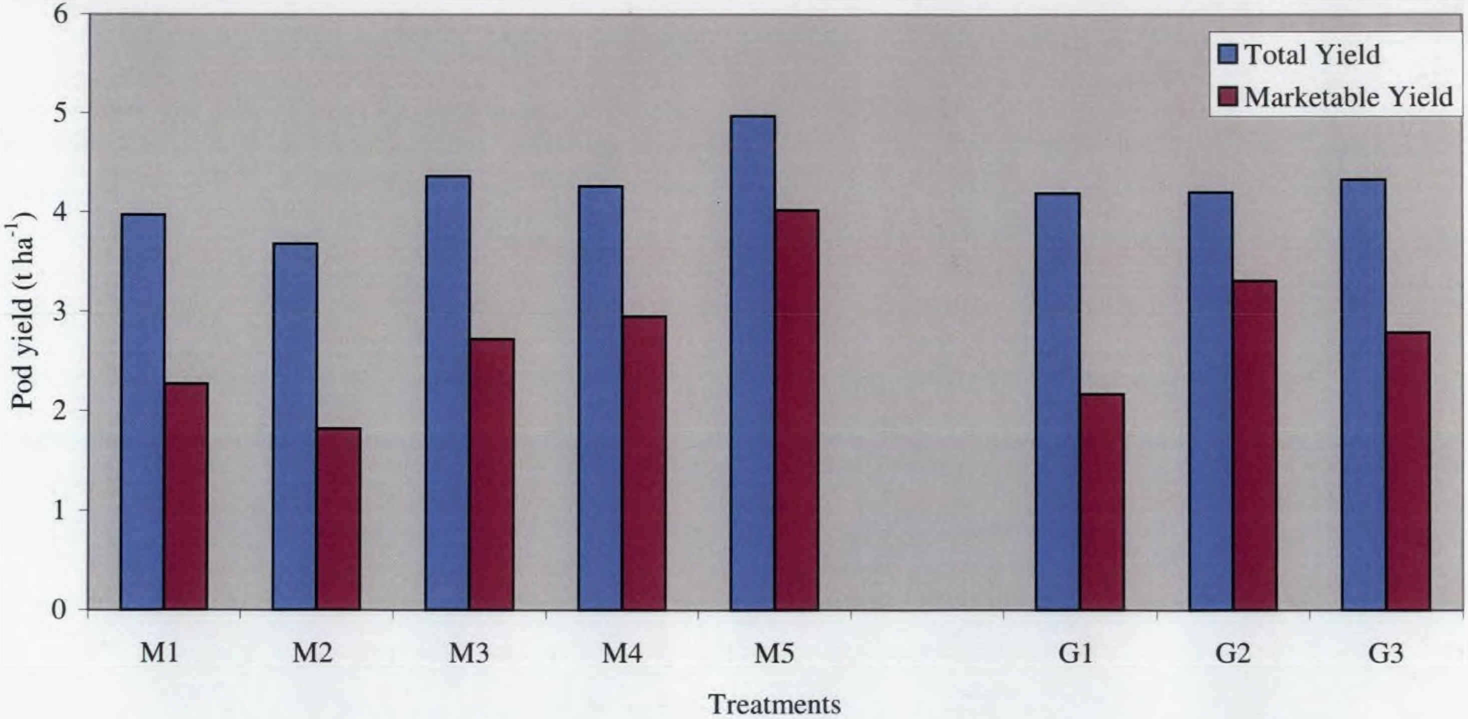
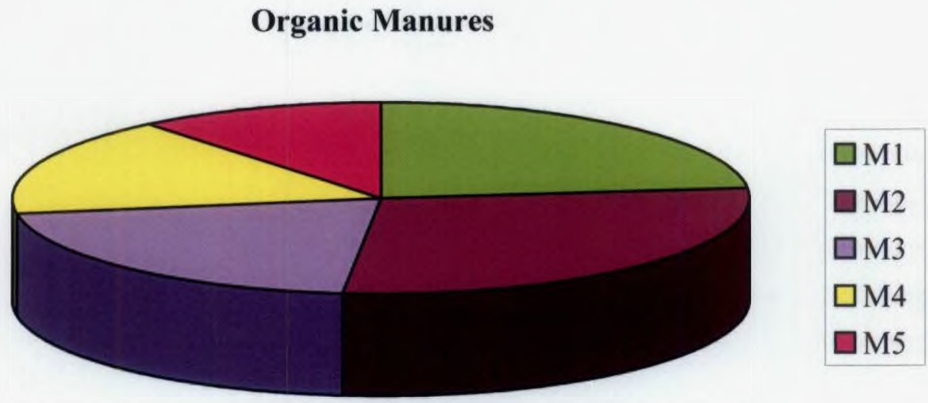


Fig. 12. Effect of organic manures and growth promoters on total and marketable pod yield

respect to total and marketable pod yield ha^{-1}. Highest total pod yield in Enriched Vermicompost could be due to abundant quantities of available essential nutrients and microbial population and biologically active metabolites present in the Enriched Vermicompost which accelerate growth and reproductive ability of the plant. Maximum and significantly higher yield in Enriched Vermicompost was the cumulative expression of significantly superior yield attributes realized in this treatment. The better yield attributes were a manifestation of the significantly efficient vegetative system as indicated by height of plant, number of primary branches and LAI. Significantly high N (74.93 kg ha^{-1}) P (9.44 kg ha^{-1}) and K (76.44 kg ha^{-1}) uptake might have also contributed to higher crop yield. The lowest percentage pest incidence observed in Enriched Vermicompost has resulted in the highest marketable yield. Increased yield due to application of vermicompost was earlier reported in bhindi (Ismail et al.,1993), green gram (Reddy and Mahesh,1995) and cowpea (Sailajakumari,1999). Jiji (1997) observed lesser infestation of pod borer in cowpea treated with vermicompost.

Total crop yield in all the three commercial organic manures were on par with that in FYM which may be attributed to the same extend of multifarious effect of these organic manures in terms of soil structure improvement, nutrient supplying capacity and influence on beneficial soil fauna. Yield and yield parameters in these organic manures were in the same order of Poabs Green, Bharath Meal, FYM and Haritha super respectively.

Pest incidence in the organic manures differed significantly (Table 4.3.2) with the minimum pest incidence of 19.45 percent in Enriched Vermicompost. All the organic manures differed significantly from one another in the case of pest incidence. The magnitude of pest incidence was in the order Enriched Vermicompost < Bharat Meal < Poabs Green < FYM < Haritha Super. The least incidence of pest recorded in Enriched Vermicompost may be attributed to the better developed vegetative



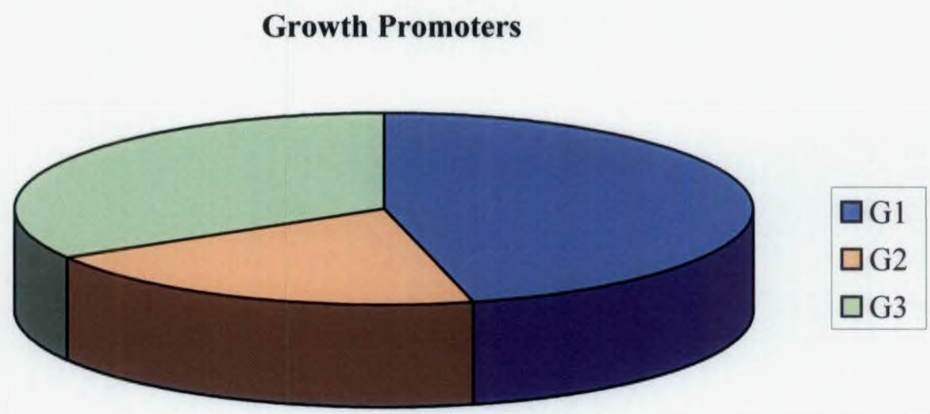


Fig. 13. Effect of organic manures and growth promoters on percentage pest incidence

system as indicated by the significantly superior growth parameters which might have resisted the pest attack more effectively compared to the plants supplied with other organic manures. This result is in conformity with the finding of Jiji (1997), who observed non-significant decrease in pod borer and aphid attack in cowpea which was treated with vermicompost.

5.1.2 Effect of Organic Manures on Quality of Tender Pods

Among the quality parameters crude protein content of pods (Table 4 4.1) and shelf life of pods (Table 4.4.2) were significantly influenced by organic manures. Protein content of pod was maximum in Enriched Vermicompost (21.30 per cent) which was significantly higher than all other organic manures. Protein content of pods in Poabs Green, FYM and Bharath Meal were on par but that in Haritha Super was significantly less than the protein content of pods in FYM. Haritha Super produced pods of lowest protein content (18.67 per cent). The trend in percentage protein content of pods reflects the trend in N uptake. Enriched Vermicompost with the maximum N uptake produced pods of maximum protein content. Similar results of increased N uptake and consequent increase in protein production with Enriched Vermicompost had been reported by Sailajakumari (1999) in cowpea and Vasanthi and Subramaniam (2004) in black gram.

Shelf life of pods ranged from 7.22 (FYM) to 8.20 days (Enriched Vermicompost and Bharat Meal). Shelf life of pods in Enriched Vermicompost and Bharat Meal were the same and 14 per cent higher than that in FYM and was significantly higher than the other three organic manures. Shelf life of pods in Poabs Green and Haritha Super were on par with FYM. Increased shelf life of pods in Enriched Vermicompost and Bharath Meal may be associated with low total free amino acid content of the pod (0.113 and 114 mg 100 g^{-1}respectively) (Table 4.4.5). Lampkin (1990) reported that better storage life of spinach grown with organic manures was found to be associated with lower free amino acid content. Joseph (1998) reported better shelf life in snake gourd treated with vermicompost when compared to FYM and poultry manure.

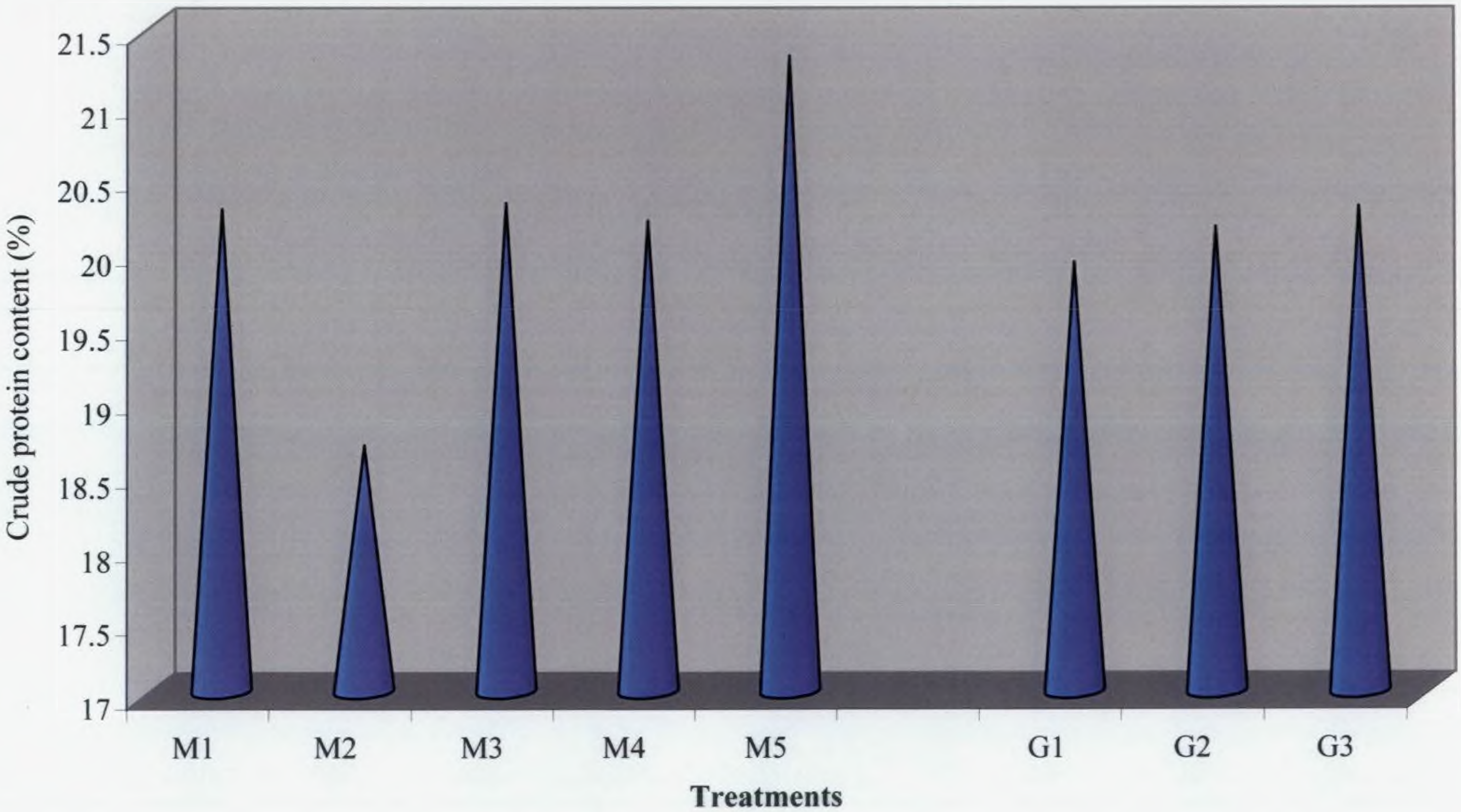


Fig. 14. Effect of organic manures and growth promoters on crude protein content of pod

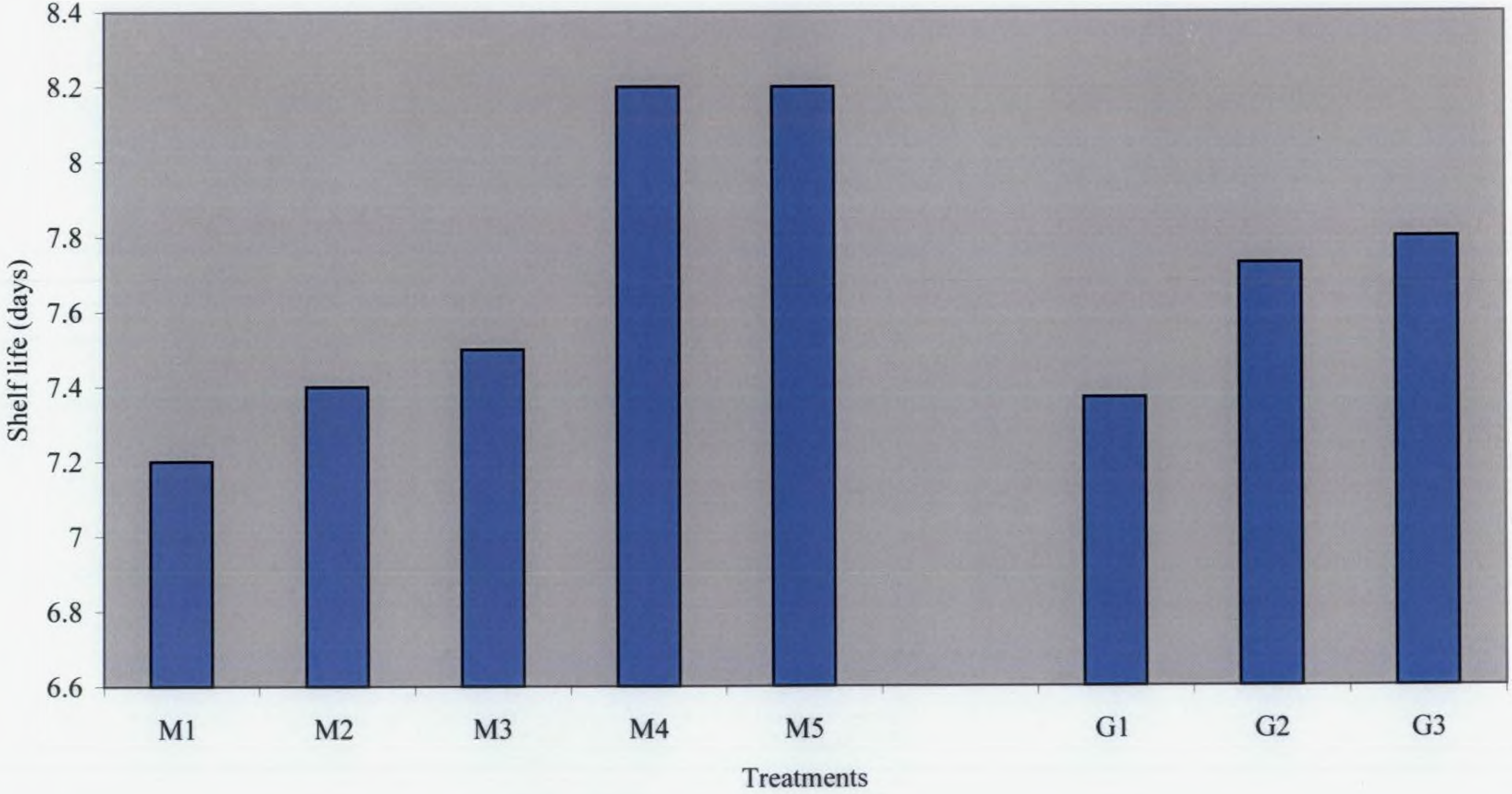


Fig. 15. Effect of organic manures and growth promoters on shelf life of pods

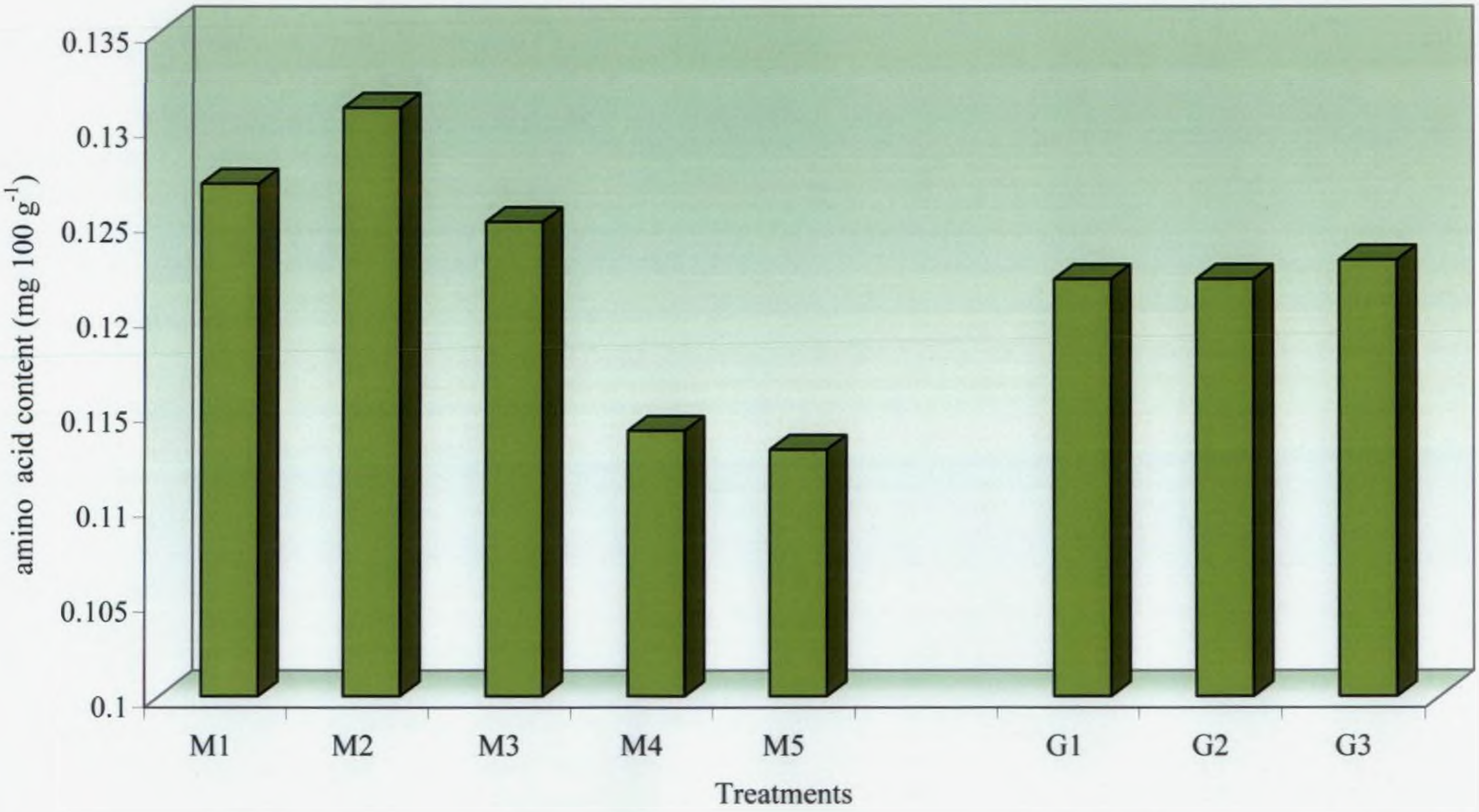


Fig. 16. Effect of organic manures and growth promoters on total free amino acid content of green pod

Fibre content of tender pods did not show significant variation. It ranged from 2.97 (Enriched Vermicompost) to 3.28 (Bharat Meal) percent. Arunkumar (2000) reported lower fibre content in vermicompost treated amaranthus. Total free amino acid content of green pod (Table 4.4.5) ranged from 0.111 to 0.133 mg 100^{-1}g. Maximum free amino acid content of green pod was obtained in Haritha Super followed by FYM, Poabs Green, Bharat Meal and Enriched Vermicompost respectively.

5.1.3 Effect of Organic Manures on Nutrient Uptake by the Crop

Nutrient uptake by the crop (NPK) was significantly influenced by organic manures. NPK uptakes were maximum in Enriched Vermicompost (74.93 kg ha^{-1} N, 9.44 kg ha^{-1} P and 76.44 kg ha^{-1} K) and minimum in Haritha Super (63.73 kg ha^{-1} N, 7.73 kg ha^{-1} P and 59.87 kg ha^{-1} K). N uptake in Enriched Vermicompost was significantly higher than that in the other four organic manures and that in Haritha Super was significantly less than the uptake in the other four organic manures. N uptake in Bharat Meal and Poabs Green were on par with FYM.

Increased N uptake in Enriched Vermicompost might be due to increased availability of N. Enriched Vermicompost itself is a good source of available N. *Azospirillum* enriched vermicompost also might have increased the nitrogen fixation in the rhizosphere. Better plant growth as observed from DMP (Table 4.1.7) realized in the enriched vermicompost plot would have facilitated higher symbiotic N fixation by Rhizobium in the crop. Higher availability of P and K from the Enriched Vermicompost might have also facilitated higher N uptake. Sailajakumari (1999), Vasanthi and Subramanian (2004) and Rajkhowa et al. (2002) reported corroborative results in cowpea, black gram and green gram respectively.

P uptake in Enriched Vermicompost (9.44 kg ha^{-1}) was significantly higher than that in all other organic manures which in turn were on par. This might be due to higher P availability to plants due to the action of P solubilizer, *Pseudomonas* used for enriching the vermicompost. P solubilizer mediated increased availability of P in soil might be due to increased solubilisation of the

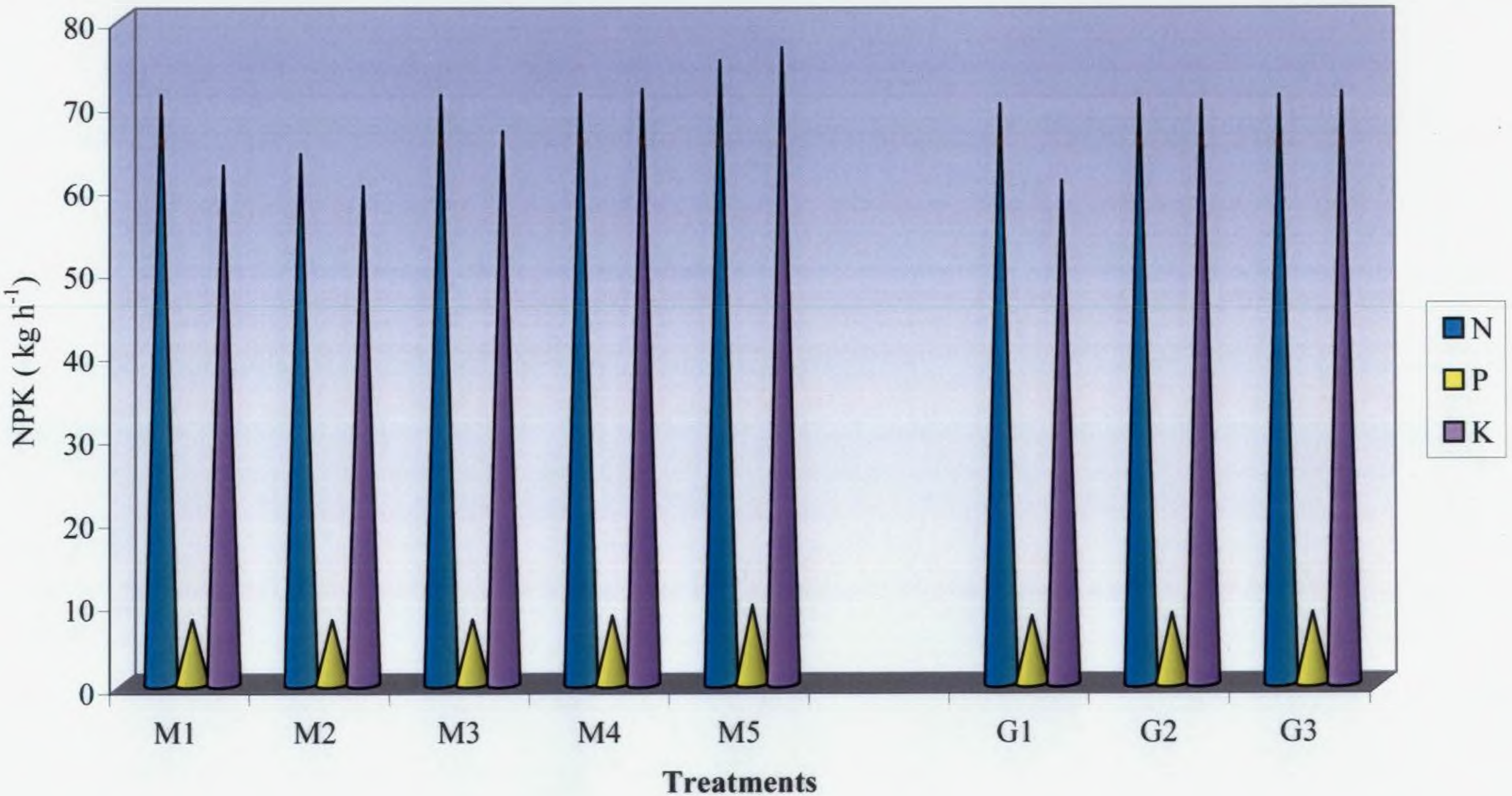


Fig. 17. Effect of organic manures and growth promoters on uptake of N, P and K

applied P, increased use efficiency of applied P, increased mineralisation of organic sources of P in the soil. P solubilizers brought about solubilisation of P through different mechanisms like production of organic and inorganic acids, formation of chelates etc. The organic acids and humus formed in the course of decomposition of organic substances form complexes with Fe and Al compounds in the soil and thus reduce inorganic phosphate fixation in the soil and increase P nutrition of plants. Due to occurrence of microbial lysis towards crop maturity metabolically bound P might have also been rendered available for plants. (Sivasamy, 1982). Vasanthi and Subramoniam (2004) observed highest NPK uptake in black gram in the treatment that received vermicompost + NPK. In general organic manure application improves P nutrition of pulses.

K uptake in Enriched Vermicompost (76.44 kg ha^{-1}) and Bharat Meal (71.50 kg ha^{-1}) were on par and the uptake in Haritha Super, FYM and Poabs Green were also on par. Enriched Vermicompost contains K in the easily available form as reported by Sailajakumari (1999) which might have increased the uptake. Supply of higher quantity of P than POP by Bharat Meal (133 kg ha^{-1} vs 110 kg ha^{-1}) may be attributed to the higher uptake.

5.1.4 Effect of Organic Manures on Available Nutrient Status in the Soil

Post harvest analysis of the soil showed that organic manures differed significantly in their influence on post harvest available nutrient (NPK) status of the soil (Table 4.6.1). Available N and P_2O_5 content of soil was highest (452.37 and 74.09 kg ha^{-1} respectively) in Haritha Super treated plots which was significantly higher than all other organic manures. Since the rate of N application was the same for all the treatments higher post harvest soil N in Haritha Super may be attributed to the lowest crop uptake (63.73 kg ha^{-1}) in the plot. Highest level of P_2O_5 in the soil in this treatment might have been the result of higher rate of P supplied (220 kg ha^{-1}) when the manure was applied on N equivalent basis by virtue of very high P content (4.4 per cent) of Haritha Super(Table 5.1). In the Haritha Super plots no inorganic phosphatic fertilizer was applied since the quantity of Haritha Super applied (5t ha^{-1}) supplied 220 kg P_2O_5

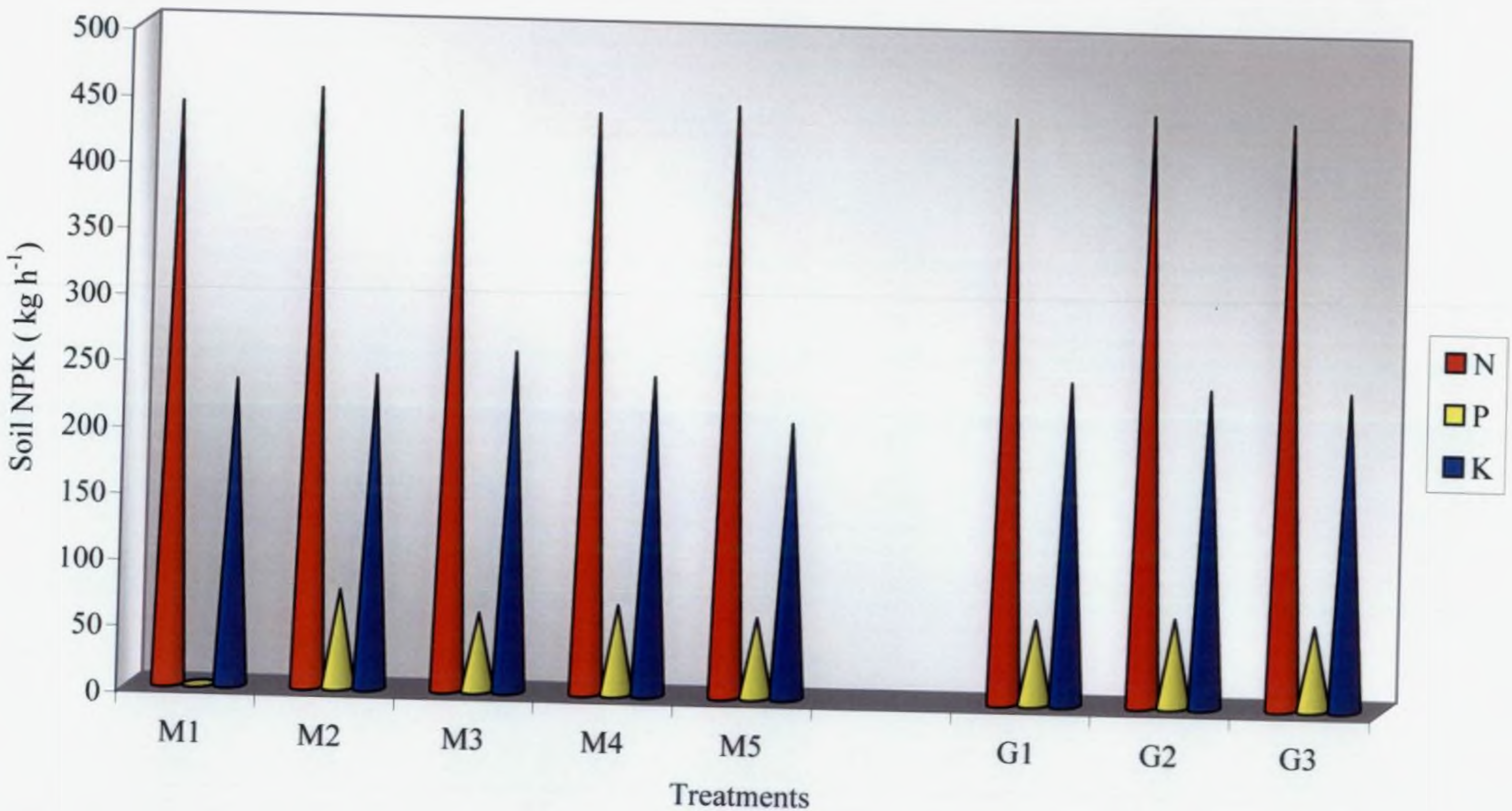


Fig. 18. Effect of organic manures and growth promoters on soil nutrient status after the experiment

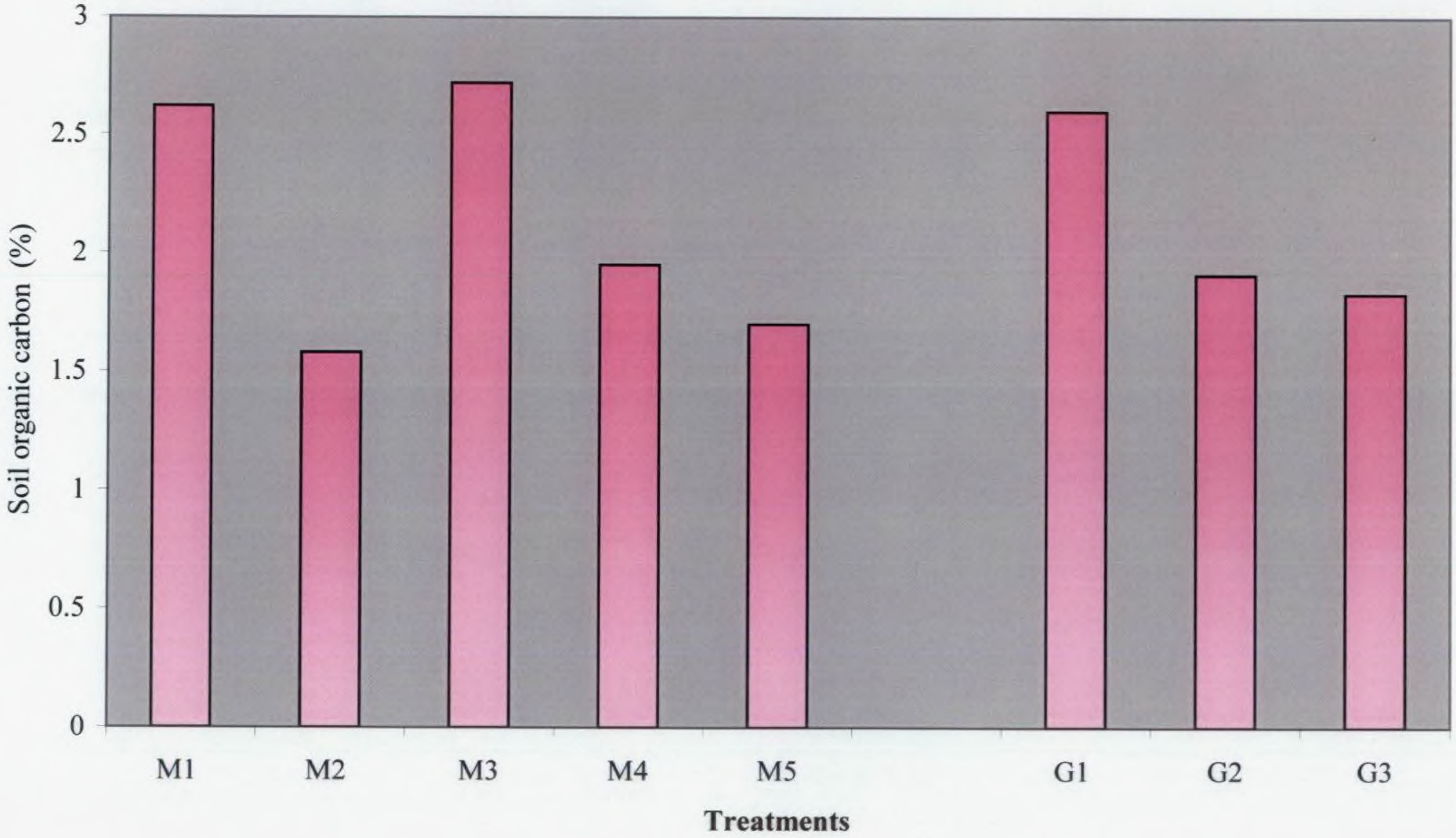


Fig. 19. Effect of organic manures and growth promoters on soil organic carbon content

ha^{-1} whereas the POP recommendation was 110 kg P_2O_5 ha^{-1}. Available N was next highest in Enriched Vermicompost (446.06 kg ha^{-1}) which was significantly higher than FYM (440.05 kg ha^{-1}), Bharat Meal (437.90 kg ha^{-1}) and Poabs Green (437.28 kg/ha). Significantly higher availability of N in Enriched Vermicompost may be attributed to the higher biological N fixation in the rhizosphere by the *Azospirillum* present in the manure, which might have become available on autolysis of the microbes. Higher N uptake by the crop in Bharat Meal (70.95 kg ha^{-1}) and FYM (70.81 kg ha^{-1}) and Poabs Green (70.81 kg ha^{-1}) might have resulted in the lower post harvest N status in the soil.

Available P_2O_5 status in the soil was in the order Haritha Super > Bharat Meal > Enriched Vermicompost > Poabs Green > FYM. This may be explained on the basis of rate of P application and crop uptake in the treatments. Rate of P application in the various treatments (Table 5.1) were in the order Haritha Super (220 kg ha^{-1}) > Bharat Meal (167 kg ha^{-1}) > Enriched Vermicompost (125 kg ha^{-1}) > Poabs Green (110 kg ha^{-1}) and FYM (110 kg ha^{-1}). The crop uptake of P was in the order Enriched Vermicompost (9.44 kg ha^{-1}) > Bharat Meal (8.23 kg/ha) > Poabs Green (7.77 kg/ha) > FYM (7.75 kg ha^{-1}) > Haritha Super (7.73 kg ha^{1}). Increase in available phosphorous by the application of incremental doses of phosphorous fertilizers was reported by Geethakumari (1981).

Post harvest available K_2O status was the highest in Poabs Green (256.09 kg ha^{-1}) which was significantly higher than K_2O status in all other organic manures. Post harvest level of K_2O in soil was in the order Poabs Green > Bharat Meal > Haritha Super > FYM > Enriched Vermicompost. Rate of K_2O application was in the order Poabs Green (148 kg ha^{-1}) > Bharat Meal(133 kg ha^{-1}) > Enriched Vermicompost > FYM and Haritha Super(110 kg ha^{-1} each). Uptake was in the order Enriched Vermicompost > Bharat Meal > Poabs Green > FYM > Haritha Super. Higher K_2O supply than POP (110 kg ha^{-1}) in Poabs Green (148.18 kg ha^{-1}) and Bharat Meal (133 kg ha^{-1}) due to the higher K_2O content in the products might have resulted in higher post harvest available K_2O in the soil. Higher K_2O uptake in Enriched Vermicompost might have resulted in lower K_2O status of the soil after the experiment.

The different organic manures exerted significant influence on organic carbon content in soil (Table 4.6.2.a and 4.6.2.b). Initial soil organic carbon was 0.69 per cent. All the five organic manures increased the organic carbon content of the soil and they differed significantly with respect to post harvest organic carbon level in the soil. Poabs Green and FYM were found to cause about 3 fold increase in carbon content of soil (2.72 and 2.62 per cent respectively). This may be due to the wide C : N ratio of these materials. C:N ratio of FYM and Poabs Green were 52.5: 1 and 25.96: 1 respectively. According to Carter and Stewart (1972) high lignin organic amendments like FYM which were more recalcitrant to decomposition, resulted in higher soil carbon accumulation per unit carbon input than low lignin amendments. These effects were attributed to a direct stabilization of lignin degradation products in the slow organic matter pool as opposed to the more complete metabolism of nonlignin residue fractions by soil microbial biomass. Similar spectacular ncrease in organic carbon content of soil following addition of FYM was also reported by Rajkhowa et al. (2002) in green gram. Post harvest organic carbon content of soil was least in Haritha Super (1.58 per cent) which may be attributed to the initial low C : N ratio of the manure (7.35:1)

5.2 GROWTH PROMOTERS

5.2.1 Effect of Growth Promoters on Growth, Yield and Quality of Bush Type Vegetable Cowpea

Effect of two growth promoters viz. Panchagavyam and Vermiwash on bush type vegetable cowpea in conjunction with five organic manures was studied in the field experiment. Effect of the foliarly applied growth promoters was compared with Water Spray as control. Individual effect of the growth promoters on growth, yield and quality of bush type vegetable cowpea is discussed here.

Only a few growth and yield parameters were significantly influenced by growth promoters. Number of days to 50 per cent flowering, number of flowers plant^{-1} at 30 and 60 DAS, marketable yield, percentage pest incidence, N and K uptake by crop, post harvest N and organic carbon status of soil were significantly influenced by growth promoters. Even though some of the yield parameters, N and K uptake by crop and marketable yield were significantly influenced by growth promoters, total yield difference between the growth promoters were not significant.

Panchagavyam was significantly superior to Vermiwash with respect to characters such as days to 50 per cent flowering (45 vs. 46.67 days), marketable yield (3.31 vs. 2.79 days), percentage pest incidence (21.9 vs. 36.37) post harvest N (445.85 vs. 441.09 kg ha^{-1}) and post harvest organic carbon content (1.91 vs. 1.83 per cent) of soil.

Panchagavayam and Vermiwash were on par with respect to number of flowers per plant at 30 and 60 DAS, protein content (20.28 vs. 20.14 per cent), crop uptake of N (70.76 vs. 70.29 kg ha^{-1}) and K (71.15 vs. 70.09 kg ha^{-1}). Both the growth promoters were significantly superior to water spray in their influence on days to 50 per cent flowering, number of flowers per plant at 30 and 60 DAS, percentage pest incidence, protein content of pods, N and K uptake and post harvest soil organic carbon content.

The positive influence of Panchagavayam and Vermiwash may be attributed to the growth regulating substances such as IAA, GA and cytokinins, essential plant nutrients and naturally occurring beneficial, effective microorganisms present in them (Jasmin, 1999 and Somasundaram and Sankaran, 2004). Vermiwash also contains microbial growth requirements like vitamins, antibiotics,, aminoacids etc. The results are in conformation with the finding of Somasundaram et al. (2003) that Panchagavayam gave quick flowering, continuous flowering and resistance to pest and diseases. Significant influence of GA on number of flowers was also reported by Upadhyay (2002).

Both Panchagavyam and Vermiwash increased crop uptake of N and K which may be attributed to the presence of growth hormones like GA, cytokinins, IAA etc. in these growth promoters. The growth promoting substances in the growth promoters might have improved root growth which in turn might have increased uptake of N and K. Moreover, foliar application of Panchagavyam and Vermiwash which contain N and K (Somasundaram and Sankaran (2004) and Jasmine (1999)) also would have contributed towards crop uptake of these nutrients. Somasundaram and Sankaran (2004) and Jasmin (1999) observed significant increase in the uptake of N and K by the application of Panchagavyam in green gram and Vermiwash in cowpea respectively.

Significantly superior post harvest soil nitrogen status in Panchagavyam applied plots may be attributed to the increased biological nitrogen fixation in the rhizosphere and the nitrogen fixing microorganisms contained in Panchagavam (Somasundaram and Sankaran, 2004)

Post harvest organic carbon content of control plot (Water Spray) (2.6 per cent) was significantly higher than that in the growth promoters applied plots (1.91 and 1.83 per cent in Panchagavyam and Vermiwash respectively). This may be attributed to the enhanced organic matter decomposition in the growth promoter applied plots brought about by the microbial population present in these growth promoters.

Growth characters such as height of plant, number of primary branches and leaves per plant, LAI and DMP plant^{-1}, yield attributes such as number of pods, length of pods, weight of pods, number of seeds per pod and dry matter distribution in plants were not significantly influenced by growth promoters. Total crop yield as well as quality parameters such as crude fibre and ascorbic acid content of pods were also not significantly influenced by growth promoters. Post harvest P_2O_5 and K_2O status of soil remained unaffected by growth promoters.

5.3 INTERACTION EFFECTS

5.3.1 Interaction Effect of Organic Manures and Growth Promoters on Growth, Yield, Quality, Nutrient Uptake and Post Harvest Soil Nutrient Status

Treatments of the field experiment conducted in factorial RBD were combinations of five organic manures and three growth promoters. Most of the interaction effects on growth, nutrient uptake and quality parameters and post harvest soil nutrient status were non significant. Significant interaction effects were obtained in the case of number of flowers per plant at 60 DAS, marketable pod yield, percentage pest incidence, organic carbon content of soil after the experiment.

Number of flowers per plant at 60 DAS was maximum in Enriched Vermi compost + Panchagavyam (8.20) and the least was in FYM + Water Spray (3.00). Enriched Vermicompost + Vermiwash was on par with Enriched Vermicompost + Panchagavyam and all other organic manures with Panchagavyam. Combinations of organic manures and Water Spray produced significantly less number of flowers (3.00 to 5.47).

Maximum marketable yield was produced by the treatment combination M_5G_2 (Enriched Vermicompost + Panchagavyam) (4.73 t ha^{-1}) which was significantly superior to all others. Least marketable yield was produced by the treatment combination M_2G_1 (Haritha Super + Water Spray) (1.07 t ha^{-1}) which was on par with M_1G_1 (FYM + Water Spray) (1.35 t ha^{-1})

Interaction effect on percentage pest incidence was highly significant. Percentage pest incidence was the least (11.99 per cent) in Enriched Vermicompost + Panchagavyam which was significantly lower than all other treatments. The highest percentage of pest incidence (68.63 per cent) was in Haritha Super + Water Spray). Enriched Vermicompost +Vermiwash (16.99 per cent), Bharat Meal + Panchagavyam (17.82 per cent) and FYM + Panchagavyam (18.93 per cent) were on par. Percentage pest incidence in the combination of organic manures and water spray were relatively high (29.80 to 68.63 per cent).

Total free amino acid content of tender pods was maximum (0.133 mg 100 g^{-1}) in Haritha Super + Water Spray and the least value (0.111mg 100 g^{-1}) was obtained in Enriched Vermicompost + Water Spray.

Interaction effect on post harvest organic carbon status of soil was highly significant. Maximum soil organic carbon content (3.86 per cent) was obtained in FYM + Water Spray and the least soil organic carbon content (1.38 per cent) was in Haritha Super + Vermiwash. Post harvest organic carbon content of soil bears a relation with the C:N ratio of the organic manure supplied and the nature of the growth promoter component. The highest residual soil organic carbon in FYM + Water Spray treatment is in tune with the widest C : N ratio (52.5:1) of the applied FYM. The C : N ratio of Haritha Super was 6.85:1 and the micro organisms present in vermiwash would have accelerated further decomposition of the added organic matter bringing about the least level of post harvest soil organic carbon.

5.4 EFFECT OF ORGANIC MANURES AND GROWTH PROMOTERS ON BENEFIT COST RATIO IN BUSH TYPE VEGETABLE COWPEA

All the organic manures, growth promoters and their interactions had significant influence on Benefit Cost Ratio (B: C). Among the organic manures B: C in Enriched Vermicompost was the maximum. Only the B: C in Enriched Vermicompost (1.48) and FYM (1.31) were more than one. B: C in Poabs Green, Haritha Super and Bharat Meal were 0.64, 0.58 and 0.47 respectively. Among the growth promoters B: C in Panchagavyam (1.04) was significantly higher than that in Vermiwash (0.94) and Water Spray (0.71). Maximum B:C was recorded in the treatment combination M_5G_2 (Enriched Vermicompost + Panchagavyam) (1.68) which was on par with M_5G_3 (Enriched Vermicompost + Vermiwash) (1.48), M_1G_2 (FYM + Panchagavyam) (1.56) and M_1G_3 (FYM + Vermiwash) (1.51). The treatment combination M_2G_1 (Haritha Super + Water Spray) recorded the least B:C (0.39)

From the growth and yield point FYM can be substituted with the commercial manures such as Haritha Super, Poabs Green and Bharath Meal. But FYM is more desirable from the economic point. Among the five

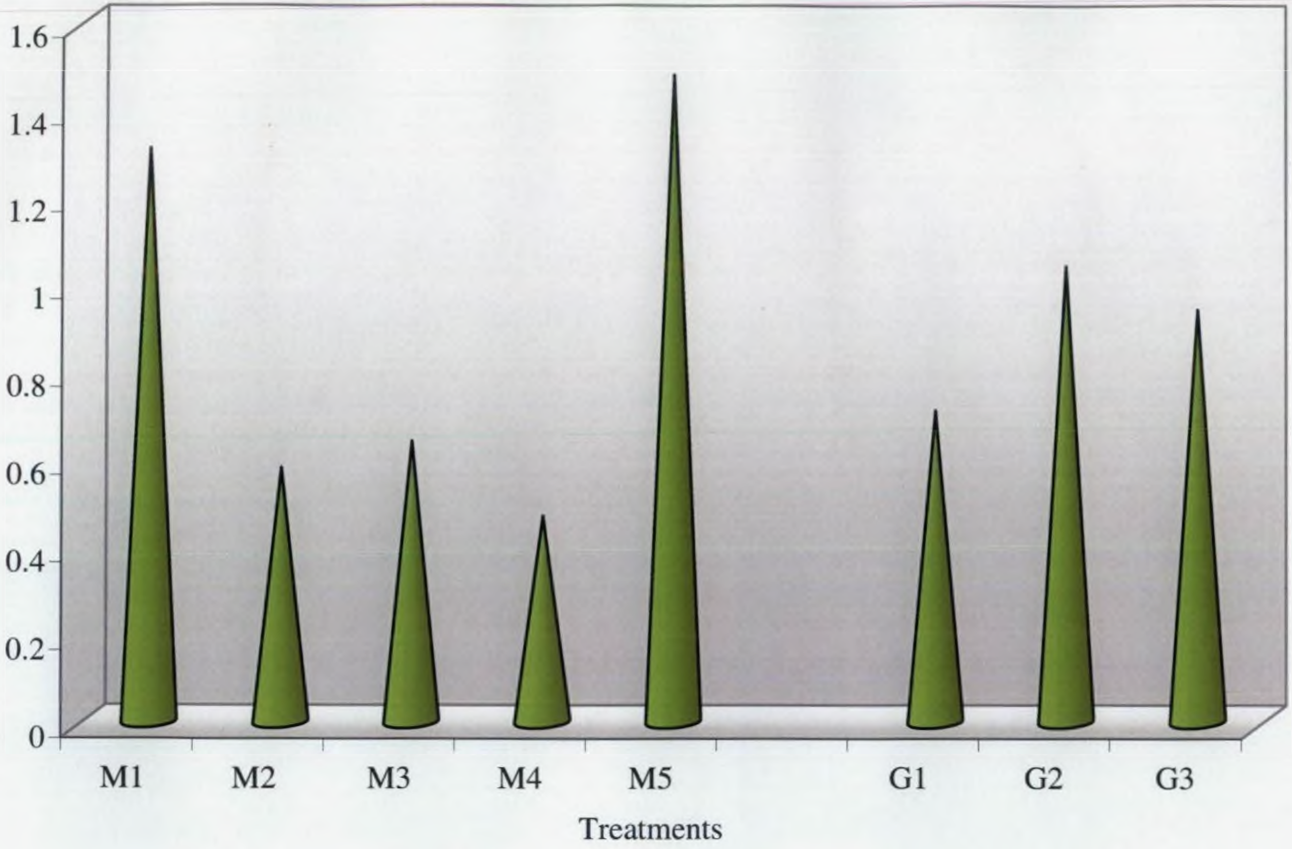


Fig. 20. Effect of organic manures and growth promoters on economics of cultivation

organic sources tested Enriched Vermicompost was the best organic component of integrated nutrient management both in terms of yield and economics of production. The higher BCR of Enriched Vermicompost is attributed to the low cost of production of Enriched Vermicompost (Rs.2.00 kg $^{-1}$) and its significantly better effect on growth and yield of the crop. Even though the commercial organic manures were on par with FYM with respect to crop yield, due to the very high market price of the commercial organic manures the cost of production was very high in the treatments where FYM was substituted with these organic manures. Cost of one kg FYM was only Rs. 0.33 whereas that of Haritha Super, Poabs Green and Bharat Meal were Rs 6.00 each. Spraying vegetable cowpea with Panchagavyam reduced pest infestation significantly compared to Vermiwash and Water Spray. This resulted in higher B : C in Panchagavyam

Summary

6. SUMMARY

In a field study conducted in the college of Agriculture, Vellayani, three commercial organic manures viz. Haritha Super (4.0 : 4.4 : 2.0 NPK), Poabs Green (2.7 : 1.2 : 2.0 NPK), and Bharath Meal (1.5 : 2.2 : 2.5 NPK) were compared with FYM (1.0 : 0.4 : 0.5 NPK) and Enriched Vermicompost (2.0 : 1.25 : 1.0 NPK) as the organic component of integrated nutrient management in bush type vegetable cowpea in combination with and without two growth promoters viz. Panchagavyam and Vermiwash. Feasibility of using the commercial organic manures as an alternative for FYM was also looked into.

All the organic manures were applied on nitrogen equivalent basis in accordance with Package of Practices (POP) of Kerala Agricultural University (KAU). The POP recommendation for bush type vegetable cowpea is 20 t FYM + 20 : 30 : 10 kg NPK ha^{-1}. This is equivalent to 220 kg N, 110 kg P_2O_5 and 110 kg K_2O ha^{-1}. When FYM was substituted with other organic manures on nitrogen equivalent basis P and K supplied by these organic manures were accounted for while calculating the quantity of inorganic phosphatic and potassium fertilizers to be applied in each treatment. The results of the experiment are summarised below:

1. Germination percentage in the various treatments ranged between 97.66 to 99 per cent and it did not vary significantly.
2. Growth parameters such as height of plant, number of primary branches per plant, LAI and dry matter production were significantly influenced by the different organic manures. Effect of organic manures on number of leaves per plant, days to 50% flowering and dry matter partitioning were not significant.
3. All the significantly influenced growth characters recorded maximum values in Enriched Vermicompost applied crop and least values in Haritha Super applied crop. All the other organic manures (Haritha Super,

Poabs Green, Bharat Meal and FYM) were on par with respect to significantly important growth parameters such as height of plant, number of primary branches $plant^{-1}$ and LAI.

4. Dry matter production $hectare^{-1}$ was maximum (2366.16 kg ha^{-1}) in Enriched Vermicompost which was significantly higher than the dry matter production in all other organic manures. Dry matter production was in the order of Enriched Vermicompost followed by Bharath Meal, FYM, Poabs Green and Haritha Super respectively.

5. Yield attributing characters in vegetable cowpea significantly influenced by organic manures include number of flowers and number of pods per plant, fresh weight of pod and length of pod.

6. In the case of significantly differing yield parameters, maximum values were recorded by Enriched Vermicompost followed by Poabs Green, Bharat Meal, FYM and Haritha Super respectively.

7. Total pod yield and marketable pod yield were also significantly influenced by the organic manures. Enriched Vermicompost was found to be significantly superior to all other organic manures with respect to these parameters.

8. Pest incidence was least in Enriched Vermicompost followed by Bharat Meal, FYM, Poabs Green and Haritha Super respectively.

9. Among the quality parameters crude protien content of pod and shelf life of pods were significantly influenced by organic manures. Protein content of pod was maximum in Enriched Vermicompost (21.30%) which was significantly higher than all other organic manures. Haritha Super produced pods of lowest protein content. Shelf life of pods in Enriched Vermicompost and Bharat Meal were the same and 14 per cent higher than that in FYM and was significantly higher than the other three organic manures.

10. N uptake in Enriched Vermicompost was significantly higher than that in the other four organic manures and that in Haritha Super was significantly less than the uptake in the other four organic manures. N uptake in Bharat Meal and Poabs Green were on par with FYM.

11. P uptake in Enriched Vermicompost was significantly higher than that in all other organic manures which in turn were on par.

12. K uptake in Enriched Vermicompost and Bharat Meal were on par and the uptake in Haritha Super, FYM and Poabs Green were on par.

13. Post harvest analysis of the soil showed that organic manures differed significantly in their influence on post harvest available nutrient (NPK) status of the soil. Available N and P_2O_5 content of soil was highest in Haritha Super treated plots which was significantly higher than all other organic manures. Available P_2O_5 status in the soil was in the order of Haritha Super > Bharat Meal > Enriched Vermicompost > Poabs Green > FYM. Post harvest available K_2O status was the highest in Poabs Green which was significantly higher than K_2O status in all other organic manures. Post harvest level of K_2O in soil was in the order of Poabs Green > Bharat Meal > Haritha Super > FYM > Enriched Vermicompost. All the five organic manures increased the organic carbon content of the soil and they differed significantly with respect to post harvest organic carbon level in the soil. Poabs Green and FYM were found to cause about three fold increase in carbon content of soil .

14. Only a few growth and yield parameters were significantly influenced by growth promoters (Panchagavyam and Vermiwash). Number of days to 50 per cent flowering, number of flowers plant^{-1} at 30 and 60 DAS, marketable yield, percentage pest incidence, nutrient uptake (N and K) by crop, post harvest N and organic carbon status of soil were significantly influenced by growth promoters. Panchagavyam was significantly superior to Vermiwash with respect to characters such as days to 50 per cent flowering, marketable yield, percentage pest incidence, post harvest N

and organic carbon content of soil. Panchagavayam and Vermiwash were on par with respect to number of flowers per plant at 30 and 60 DAS, protein content of pods (20.28 vs. 20.14 per cent), crop uptake of N (70.76 vs. 70.29 kg. ha^{-1}) and K (71.15 vs. 70.09 kg ha^{-1}).

15. Both the growth promoters were significantly superior to water spray in their influence on days to 50 per cent flowering, number of flowers per plant at 30 and 60 DAS, percentage pest incidence, protein content of pods, N and K uptake and post harvest soil organic carbon content.

16. Most of the interaction effects on growth, nutrient uptake and quality parameters and post harvest soil nutrient status were non significant. Significant interaction effects were obtained in the case of number of flowers per plant at 60 DAS, marketable yield, percentage pest incidence, organic carbon content of soil after the experiment.

17. All the organic manures, growth promoters and their interactions had significant influence on Benefit Cost Ratio (B: C). Among the organic manures B: C in Enriched Vermicompost was the maximum. Among the growth promoters B: C in Panchagavyam (1.04) was the maximum. Maximum B:C was recorded in the treatment combination M_5G_2 (Enriched Vermicompost + Panchagavyam) (1.68) which was on par with M_5G_3 (Enriched Vermicompost + Vermiwash) (1.48), M_1G_2 (FYM + Panchagavyam) (1.56) and M_1G_3 (FYM + Vermiwash) (1.51). The treatment combination M_2G_1 (Haritha Super + Water Spray) recorded the least B:C (0.39)

18. From the growth and yield point FYM can be substituted with the commercial manures such as Haritha Super, Poabs Green and Bharath Meal. But FYM is more desirable from the economic point. Among the five organic sources tested Enriched Vermicompost is the best organic component of integrated nutrient management both in terms of yield and economics of production. Panchagavyam is a better growth promoter than Vermiwash in regulating marketable yield of vegetable cowpea.

Future Line of Work

Effect of organic manures in crop production is slow and cumulative in nature. Hence, long term experiments are to be conducted to find out the impact of these organic manures on the biological and physico-chemical properties of soil which have direct and indirect bearing on crop production.

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* Original not seen

FIELD EVALUATION OF COMMERCIAL ORGANIC MANURES AND GROWTH PROMOTERS IN BUSH TYPE VEGETABLE COWPEA (*Vigna unguiculata* subsp. *sesquipedalis*)

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ABSTRACT

In a field study conducted in the college of Agriculture, Vellayani, three commercial organic manures viz. Haritha Super (4.0: 4.4 : 2.0 NPK), Poabs Green (2.7 : 1.2 : 2.0 NPK) and Bharath Meal (1.5 : 2.2 : 2.5 NPK) were compared with FYM (1.0 : 0.4 : 0.5 NPK) and Enriched Vermicompost (2.0 : 1.25 : 1.0 NPK) as the organic component of integrated nutrient management in bush type vegetable cowpea in combination with and without two growth promoters viz. Panchagavyam and Vermiwash. Feasibility of using the commercial organic manures as an alternative for FYM was also looked into.

All the organic manures tested in the field experiment (FYM, Haritha super, Poabs Green, Bharath Meal and Enriched Vermicompost) were applied on Nitrogen equivalent basis in accordance with Package of Practices (POP) recommendation of Kerala Agricultural University (KAU). The POP recommendation for bush type vegetable cowpea is 20 t FYM + 20 : 30 : 10 kg NPK ha^{-1}. When FYM was substituted with other organic manures on nitrogen equivalent basis P and K supplied by these organic manures were accounted for while calculating the quantity of inorganic phosphatic and potassium fertilizers to be applied in each treatment.

Germination percentage in the various treatments ranged between 97.66 to 99 per cent and it did not vary significantly. All the significantly influenced growth characters such as height of plant, number of primary branches per plant, LAI and dry matter production recorded maximum values in Enriched Vermicompost applied crop and least values in Haritha Super applied crop.

Yield attributing characters in vegetable cowpea significantly influenced by organic manures include number of flowers and number of pods per plant, fresh weight of pod and length of pod. All the significantly influenced yield attributing characters recorded superior value for Enriched Vermicompost. Enriched Vermicompost was found to be significantly superior with respect to total and marketable crop yield.

Among the quality parameters crude protein content of pod was significantly superior for Enriched Vermicompost. Haritha Super produced pods of lowest protein content. Shelf life of pods in Enriched Vermicompost and Bharat Meal were the same and was 14 per cent higher than that in FYM. N and P uptake were superior for Enriched Vermicompost where as K uptake in Enriched Vermicompost and Bharat Meal were on par and superior to other organic manure treatments.

Post harvest available N and P_2O_5 content of soil was highest in Haritha Super treated plots which was significantly higher than all other organic manures. Post harvest available K_2O status was the highest in Poabs Green compared to all other organic manures.

Among the growth promoters, Panchagavyam was significantly superior to Vermiwash with respect to characters such as days to 50 per cent flowering, marketable yield, percentage pest incidence, post harvest N and organic carbon content of soil. Panchagavayam and Vermiwash were on par with respect to number of flowers per plant at 30 and 60 DAS, protein content of pods, crop uptake of N and K. Both the growth promoters were significantly superior to water spray in their influence on days to 50 per cent flowering, number of flowers per plant at 30 and 60 DAS, percentage pest incidence, protein content of pods, N and K uptake and post harvest soil organic carbon content.

Significant interaction effects were obtained in the case of number of flowers per plant at 60 DAS, marketable yield, percentage pest incidence and organic carbon content of soil after the experiment

All the organic manures, growth promoters and their interactions had significant influence on Benefit Cost Ratio (B: C). Among the organic manures B: C in Enriched Vermicompost was the maximum. Among the growth promoters B: C in Panchagavyam (1.04) was the maximum. Maximum B:C was recorded in the treatment combination M_5G_2 (Enriched Vermicompost + Panchagavyam) (1.68) which was on par with M_5G_3 (Enriched Vermicompost + Vermiwash) (1.48), M_1G_2 (FYM + Panchagavyam) (1.56) and M_1G_3 (FYM + Vermiwash)

(1.51). The treatment combination M_2G_1 (Haritha Super + Water Spray) recorded the least B:C (0.39)

From the growth and yield point, FYM can be substituted with the commercial manures such as Haritha Super, Poabs Green and Bharath Meal. But FYM is more desirable from the economic point. Among the five organic sources tested Enriched Vermicompost is the best organic component of integrated nutrient management both in terms of yield and economics of production. Panchagavyam is a better growth promoter than Vermiwash in regulating marketable yield of vegetable cowpea.

Appendix

APPENDIX – I

Weather data for the cropping period (October 2004 to February 2005)

Standard week	Temperature (°C)		Rainfall (mm)	Relative humidity (%)	Evaporation (mm/day)
	Minimum	Maximum			
41	23.25	31.28	29.8	81.74	3.27
42	23.18	30.75	33.6	82.71	2.25
43	22.63	29.7	32.4	71.92	1.82
44	23.52	31.87	66.4	83.71	2.68
45	23.38	30.43	7.63	86.92	1.92
46	23.05	30.72	5.53	83.33	2.41
47	22.70	31.65	16.0	81.34	2.76
48	20.56	31.71	0	82.83	2.23
49	21.42	32.25	0	82.83	3.18
50	22.53	32.71	0	80.71	2.93
51	20.21	33.25	0	79.91	3.15
52	22.72	32.36	0	76.87	3.76
1	20.21	31.85	0	76.25	3.67
2	22.72	32.24	0	77.14	3.81
3	21.21	33.75	0	76.35	3.28
4	21.41	32.63	0	78.41	3.09
5	22.25	33.32	0.67	76.78	3.54
6	24.95	34.63	0	76.14	4.60
7	20.91	33.85	0	72.64	4.31