IMPACT OF ORGANIC FARMING PRACTICES ON SOIL HEALTH, YIELD AND QUALITY OF COWPEA

[*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcort]

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I hereby declare that this thesis entitled "**Impact of organic farming practices on soil health, yield and quality of cowpea [*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcort]**" 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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Certified that this thesis entitled "**Impact of organic farming practices on soil health, yield and quality of cowpea [*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcort]**" is a record of research work done independently by Mrs. Devi Krishna (2003-11-25) 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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LIST OF ABBREVIATIONS

%	–	Per cent
μ	–	Micro
°C	–	Degree Celsius
μg	–	Micro gram
@	–	At the rate of
AR_0^k	–	Equilibrium activity ratio for potassium
CD	–	Critical difference
CEC	–	Cation exchange capacity
cm	–	Centimetre
cmol	–	Centimol
et al.	–	And others
Fig.	–	Figure
g	–	Gram
ha^{-1}	–	Per hectare
HI	–	Harvest index
I	–	Intensity factor
K_0	–	Non specific potassium site
KAU	–	Kerala Agricultural University
kg	–	Kilogram
kg^{-1}	–	Per kilogram
$KMnO_4$	–	Potassium permanganate
K_S	–	Specific potassium site
LAI	–	Leaf area index
m	–	Metre
meq	–	Milli equivalents
mg	–	Milligram
Mg	–	Mega gram
Mg m^{-3}	–	Mega gram per cubic metre
MSL	–	Mean sea level
nm	–	Nanometre
NS	–	Non significant

LIST OF ABBREVIATIONS CONTINUED

p^+	–	Proton
PBC_k	–	Linear potential buffering capacity for potassium
POP	–	Package of Practices
PSB	–	Phosphorus solubilising bacteria
PSM	–	Phosphorus solubilising microorganism
Q	–	Quantity factor
q	–	Quintal
SE	–	Standard error
subsp.	–	Sub species
t	–	Tonne
TPF	–	Triphenyl formazan
TTC	–	Triphenyl tetrazolium chloride
var.	–	Variety
viz.	–	Namely

Introduction

1. INTRODUCTION

Global awareness on health and environmental issues are spreading fast in the recent years. Sustainability in production has become the prime concern in agriculture development. Organic method of farming is the best option to ensure food, air, water and soil around us unpolluted leaving the environment safe for the present and future generation.

The agricultural model promoted during the green revolution period was based on the use of high yielding varieties and high dose of chemical fertilizers and pesticides. Long term field experiments have made clear the negative impact of continuous use of chemical fertilizers on soil health (Yadav, 2003). The occurrence of multinutrient deficiencies and overall decline in the productivity of soil under intensive fertilizer use has widely reported (Chhonkar, 2003). Recognizing soil as a Dynamic Living Entity, which promotes beneficial biological activities in soil and root zone of plant is central to the theme of organic agriculture.

Meeting the domestic food requirement has been the foremost social priority before India, since independence. Vegetables play a vital role in the health and nutrition of people. The food experts and nutritionists have realized and appreciated the food value of vegetable because of its low calorific value, high content of proteins, vitamins and minerals. Hence vegetable is the most essential topic currently in terms of organic farming.

Organic farming is today's answer not only for higher and sustained productivity but also for safe nutritious food and it is increasingly demanded by enlightened consumers around the world. Organically grown agricultural produces fetch a premium in the market.

India has vast potential of manurial resources. Farm yard manure and poultry manure are the most commonly used organic manures by the farmers of Kerala. Poultry manure is a rich source of nutrients especially for vegetable production (Jose *et al.*, 1988). Vermicompost which is produced by chemical disintegration of organic matter by earthworm contain higher amount of nutrients, hormones and enzymes and has stimulatory effect on plant growth.

Among various vegetable crops grown in Kerala, cowpea occupies a prime position because it is an important protein source and hence its yield and quality are important. It can be cultivated either as an upland crop during rainy season or as an irrigated crop in the summer rice fallows. Being a leguminous crop, the phosphorus requirement is high in cowpea. Further it is well documented that phosphorus is a limiting nutrient in productivity of legumes. Eventhough our tropical soils are rich in phosphorus, its availability to plants is less due to fixation by various factors. One approach is to increase the phosphorus use efficiency by incorporating phosphorus solubilising microorganisms to soil.

In the light of recent literature on organic farming, the present investigation was carried out at College of Agriculture, Vellayani. The main objectives of the study were:

1) To monitor the changes in physico-chemical and microbiological properties of soil under organic farming.

2) To study the effect of organic farming on the yield of cowpea.

3) To assess the influence of organic farming on quality of the crop.

Review of Literature

2. REVIEW OF LITERATURE

The use of organic manures as alternatives to the environment polluting inorganics in agriculture is gaining importance in the present decade. These can effectively act as slow release fertilizers and restore ecological balance. Regular addition of organic manures in sufficient quantities, lead to the maintenance of organic matter content at optimum levels (Thampan, 1993).

An investigation was carried out at the College of Agriculture, Vellayani during the period from October 2004 to February 2005 to study the impact of organic farming practices on soil health, yield and quality of cowpea. The literature collected pertaining to the above subjects is reviewed, hereunder.

2.1 EFFECT OF ORGANIC FARMING PRACTICES ON SOIL HEALTH

Since soil is known as the soul of infinite life, continued maintenance of good soil health is vital to agricultural production and nation's economy. Amongst the various attributes, organic matter content is the most important determinant of soil quality including its fertility and productivity, since it serves as a primary source and temporary sink for plant nutrients, influences water air regime, minimises degradation process and aids in sustaining soil health.

2.1.1 Physical Properties

In his experiment, Mbagwu (1989) reported that application of organic wastes like poultry manure, compost, sawdust, rice shavings and cashew leaves improved the soil structure, water retention property, total porosity, macroporosity and saturated hydraulic conductivity, but it decreased the bulk density of a tropical Ultisol. A decrease in bulk density by the addition of organic matter residues over long time was observed by Rasmussen and Collins (1991) in temperate and semi-arid regions.

According to Hudson (1994), organic matter is an important determinant of available water content and it increased the available water content in sandy texture soils only. As the organic matter increased, the volume of water held at field capacity increased at a greater rate than held at permanent wilting point. Organic matter addition increased the ability of soils to hold moisture, expanded the available water capacity and decreased the modulus of rupture of compacted soils (Nidal, 2003).

Vijayalekshmi (1993) reported that soil properties such as porosity, soil aggregation, soil water transmission and conductivity of worm cast treated soil were improved when compared with no worm cast amended soil. The study condueted by Mayunkusi *et al.* (1994) on Typic Hapludalf soil showed that macropores were more and continuous to a greater depth (>5 cm layer) in the plots receiving liquid dairy sludge, than in the fertilized plots due to the presence of earthworms. In another experiment to study the water retention characteristics under soybean-wheat cropping sequence, it was observed that in farmyard manure treated plots, soil water retention was significantly higher in all the depths compared to fertilized plots. This is because water retention at lower tension depends primarily upon the pore size distribution (Ranjan *et al.*, 2004).

Organic matter have a specific heat of 1.9 J kg^{-1} $°C^{-1}$ compared to soil minerals with 0.7 – 0.8 kg^{-1} $°C^{-1}$. This is the reason why organic manured plots are cooler. This was reported by Tripathi and Tomar (2002).

Banerjee (1998) reported that organic manures contain more or less of all nutrient elements required for plant growth. When it was applied to soil, it improved soil aeration, permeability, aggregation, water and nutrient holding capacity. According to Senthilkumar and Surendran

(2002), vermicompost influenced the physical, chemical and biological properties of the soil. They also opined that it improved the water holding capacity of soil and acted as a mine for various plant essential nutrients such as N, P, K, S and trace elements.

2.1.2 Chemical Properties

Lee (1985) observed that the application of vermicompost raised the pH of the soil. Worm casts have a pH near to neutral range than the surrounding soil and the possible factors that act on soil pH may be excretion of NH_4^+ ions from calciferous glands of the earthworms. In their experiment, Lal and Mathur (1988) reported that application of N, P and K fertilizers reduced the pH from 5.5 to 3.8, but farmyard manure application maintained or increased the pH of the acid soil under study, while combination of fertilizer and manures decreased the pH. According to Banerjee (1988), the organic acids like tartaric acid, citric acid etc trapped the toxic elements like Fe and Al through chelation and removed them from root environment by forming insoluble precipitates. It also acts as a buffer and keeps the soil pH within a desired range. Farmyard manure application resulted in lowest acidity due to decrease in exchangeable and soluble Al in the soil (Patiram, 1996).

Shuxin *et al.* (1991) reported that by manure application, the organic C in the red arid soil increased from 0.5 to 0.6 per cent. Organic C content and pH increased significantly by vermicompost application (Pushpa, 1996). Tolanur and Badanur (2003) observed a significant increase in organic C content due to organic manure addition. This was due to better root growth and the subsequent decomposition of roots which resulted in increased organic C content of soil.

Singh *et al.* (1973) attributed the higher efficiency of poultry manure to its narrow C : N ratio and comparatively higher content of readily mineralisable N. Gaur and Sadasivam (1993) opined that C : N ratio of composted materials narrowed down with the advancement of the period of decomposition. It was reported that the C : N ratio narrows down as N remains in the system, while some of the C is released as CO_2. Bijulal (1997) studied the effect of organic matter on C : N ratio on the variable charge soils of Vellayani, Thiruvananthapuram district and reported a lower value of 13 for vermicompost applied plots against 17 and 15 for ordinary compost and farmyard manure treated plots respectively. In an experiment conducted by Marimuthu *et al.* (2002) it was revealed that enhanced yield attributes of vermicompost was due to higher nutrient availability, uptake of plant nutrients, release of growth substances throughout the crop period favouring narrowing down the C : N ratio coupled with more available P, total N and nitrate N.

Poonia and Niederbudde (1990) observed that increase in organic matter resulted in increase of internal : external surface area / exchange sites. This increased the preference of exchanger for those monovalent cations like K^+ and NH_4^+. According to Miller and Donahue (1992), application of organic matter increased the CEC of soils. Tisdale *et al.* (1997) reported that total acidities of isolated fractions of humus range from 300 to 1400 meq 100 g^{-1}. This will increase the soil CEC. From 20 to 70 per cent of the CEC of many soils (eg. Mollisols) is due to organic matter. In the experiment Joseph (1998) could observe an increase in CEC in vermiculture applied plots compared to farmyard manure and poultry manure. The humic colloidal substances have a typical value of CEC which is pH dependent may be in the order of 200-250 cmol (p^+) kg^{-1} or even higher (Sanyal, 2002).

2.1.3 Nutrient Availability

2.1.3.1 N, P and K

Srivastava (1985) observed that increased use of nitrogenous fertilizers decreased organic C and total N, while farmyard manure increased the above parameters. Sharu (2000) reported that poultry manure recorded higher levels of soil N compared to vermicompost, neem cake and POP recommendation (KAU, 1996). Poultry manure with its low C : N ratio and good nutrient value suits well for all crops especially vegetables. Its higher efficiency is due to large quantities of easily mineralisable N (Meerabai and Raj, 2001).

Increase in total and available P_2O_5 content in soil due to vermicompost application was reported by Gaur (1990). This was due to greater mineralisation of organic matter with the aid of microflora associated with earthworms. Increased P_2O_5 content was due to high phosphatase activity. Jones and Darrah (1994), showed that phosphate dissolution rates can be greatly accelerated in soil in presence of organic acids such as malate, citrate and oxalate leading to 10-1000 fold higher soil solution P concentration depending on soil type and concentration of organic acids. According to Bijulal (1997), the major effect of vermicompost application in soil was a reduction in P fixation and thus increasing the P availability in acid soils.

Basker *et al.* (1992) observed increased concentration of available and exchangeable K by vermicompost application. Application of poultry manure (15 t ha^{-1}) as source of N increased the exchangeable K and available K content of soil in a tomato field (Julia *et al.*, 1993). Dhanokar *et al.* (1994) reported that continuous use of farmyard manure raised available K_2O by 1.3 to 5.4 fold over no manure application in Vertisol. Long term effects of applying crop residues, green manure and farmyard manure on the quantity-intensity (Q/I) relation of K were studied by Pannu *et al.* (2002). They observed that application of organic materials increased the potential buffering capacity (PBC_k) and the intensity parameter (AR_0^k) values of the soils. Amount of K adsorbed on the specific (K_s) as well as on the non-specific sites (K_0) was also increased with organic matter addition. From the results of the effect of long term application of organic material and inorganic N fertilizers conducted by

Pannu *et al.* (2003), it was observed that all organic materials showed less K fixation as compared to inorganic N fertilizer.

Channabasavanna and Biradar (2002) opined that as the nutrient present in poultry manure is easily available, its effect can be noticed directly on the crop and residual effect can also be seen. Due to high content of NPK, it has been proven that one tonne of poultry manure is equivalent to seven tonnes of farmyard manure. Patidar and Mali (2002) found that available N and P in soil after sorghum harvest with 10 tonnes ha^{-1} farmyard manure application was higher by 9 and 16 per cent respectively over no farmyard manure application. The increase in N and P in soil was due to the release of N and P on decomposition of farmyard manure. According to Singh (2002), green manure and farmyard manure get mineralized rapidly and maintain adequate N status of soil. Application of green manure or farmyard manure reduced the capacity of soil minerals to fix P and increased its availability through release of organic acids. Application of this also supplied K and solublised K from K bearing minerals by the organic acids and hence increased its availability in soil. Patidar and Mali (2004) studied the effect of farmyard manure and biofertilizer on N and P content of soil after harvest of sorghum crop and found significant increase in these parameters over no manure and biofertilizer addition.

2.1.3.2 Ca, Mg, S

Olsen *et al.* (1970) inferred that application of manures increased the exchangeable Ca and Mg particularly at higher rates of their application. Kurumthottical (1982) revealed that exchangeable Ca and Mg were higher in the treatments which received organic manure either alone or in combination with phosphatic fertilizers in the Permanent Manurial Experiment (PME) on paddy at Pattambi and Kayamkulam. Udayasoorian *et al.* (1988) noticed that continuous application of compost improved the status of exchangeable Ca, but lowered the exchangeable Mg content in the permanent manurial experiment conducted in TNAU, Coimbatore.

Singh and Tomar (1995) reported that the contents of exchangeable Ca and Mg in soil decreased with applied K and increased with farmyard manure application. Rajalekshmi (1996) in her experiment found that application of organic manure in the form of vermicompost recorded the highest value for all available nutrients: According to Meera (1998), use of vermicompost coated seeds produced the maximum uptake of all nutrients. Soil analysis of available nutrients revealed that the treatments receiving vermicompost had significant influence on the Ca, Mg, Zn, Cu and Mn content in soil compared to inorganic fertilizers.

Akbari *et al.* (2002) observed that application of farmyard manure @ 10 t ha^{-1} significantly improved organic C, available P, K and S status in soil after harvesting of groundnut to the tune of 12.94, 37.47, 33.76 and 20.82 per cent as compared to their respective control (without manure). This was due to the addition of nutrients through application of farmyard manure, prevention of nutrient fixation and release from fixed forms by organic acids. It was proved by Rao and Shaktawat (2002) that S content of soil after harvest of mustard crop was found to be significantly higher for farmyard manure and poultry manure treated plots over control. Two tonnes of farmyard manure was found to be equivalent to one tonne of poultry manure. After 20 years of continuous intensive cropping under various fertilizer and manurial treatments, Tiwari *et al.* (2002) observed that the differences in the values of S in soil at 0-15 cm depth and crop productivity were found to be very marked. The inclusion of farmyard manure in the treatment schedule improved S in soil (Vertisol).

2.1.3.3 Micronutrients

Available Zn, Cu, Mn and Fe content increased considerably with the continuous use of farmyard manure in a long term fertilizer experiment at Ranchi under wheat-maize rotation (Prasad and Singh, 1980). Swarup

(1984) reported that application of farmyard manure increased the availability of both native and applied micronutrient cations. These ions formed stable complexes with organic ligands which decreased their susceptibility to adsorption and fixation. According to Relan *et al.* (1986), the complexing property of organic matter influenced the availability and mobility of micronutrients. The stability of micronutrients which determine the availability follows the order, for humic acid Cu^{2+} > Fe^{2+} > Zu^{2+} > Mn^{2+}, whereas a for fulvic acid the stability is like Cu^{2+}> Zn^{2+} > Fe^{2+} > Mn^{2+}.

Bitzer and Sims (1988) opined that long term increase in soil levels of nutrients like B, Ca, Mg, Cu and Zn could be expected with poultry manure application. From the permanent manurial experiments conducted at Coimbatore, it has been observed by Kurumthottical (1995) that continuous addition of cattle manure for 68 years resulted in substantial build up of Zn, Mn, Cu and Cd in soil. Das (2000) reported that the application of compost, crop residues, other organic wastes etc. increased the water soluble plus exchangeable and easily reducible fractions of Mn, increased availability of Cu in soil due to the formation of complexing agents resulting reduced fixation. It modified the soil reaction as well as increased the activity of microorganisms which may affect the transformation of native as well as applied Zn in soil. Fuhua *et al.* (2002) observed that application of sewage sludge improved physico-chemical properties of soil. The content of Fe and Mn had improved, but heavy metal content did not vary significantly.

2.1.4 Biological Properties

Soil enzymes

Soil enzymes which catalyse reactions in soils that are important in the transformation of nutrients such as C, N, P and S are primarily of microbial origin, but may also originate from plant and animal residues (Kiss *et al.*, 1975). The study of microbial biomass, dehydrogenase and alkaline phosphatase activity to obtain a more complete and precise definition of soil fertility was suggested by Beyer *et al.* (1992). Monreal *et al.* (1998) reported that elevated enzyme activities appear to be associated with conditions promoting microbial synthesis of enzymes and such sensitivity would make soil enzyme activities as effective indicators of changes in soil quality.

2.1.4.1 Phosphatase

Soil phosphatase enzymes have been accorded a major role in the minearlization process namely the catalysis of hydrolytic cleavage of ester phosphate bond. Phosphatase perform an important function in soil by transforming organic P to inorganic phosphate (Skujins *et al.*, 1962).

Harrison (1983),Chhonkar and Tarafdar (1994) suggested a positive relationship between phosphatase and organic matter content since the enzyme was seen bound to humic protein complex. Studies on kinetic parameters by Ginafreda and Bollag (1994) reported higher Km values for acid phosphatase in several investigations with humic acids or other organic constituents.

Jose *et al.* (1997) found out that factors like organic matter and moisture served to be important in determining the distribution of phosphatase in moderately well and some what poorly drained soils. Zacharia and Chhonkar (2004) reported that both urease and phosphatase activity of the compost increased significantly due to earthworm activity, while there was no significant increase in microbial biomass and cellulase activity.

2.1.4.2 Dehydrogenase

Studies on the effect of compost addition by Martin and Marinissen (1993) revealed that the activity of dehydrogenase increased to the range of 2101 μg TPF hydrolysed 24 hr^{-1} with the application of vermicompost. According to Cooper and Warman (1997),application of compost showed significant increase in dehydrogenase activity in silty clay soil than the application of manures and fertilizers.

Tateno (1998) observed increased activity of dehydrogenase due to the application of poultry manure in a clay loam soil. Fraser *et al.* (1998) opined that the dehydrogenase activity was linked with the levels of available organic C substrates in the soil in a sandy loam soil.

2.2 EFFECT OF ORGANIC FARMING PRACTICES ON GROWTH AND YIELD OF CROPS

2.2.1 Growth Characters

Many research works showed that addition of organic manures increased the yield of several crops by enhancing the growth characters.

2.2.1.1 Height and Leaf Area

Thamburaj (1994) found that organically grown tomato plants were taller with more number of branches. They yielded 28.18 t ha^{-1} which was on par with the recommended dose of farmyard manure and NPK (20 : 100 : 100). Arunkumar (1997) reported that in amaranthus, farmyard manure application was found to be superior to vermicompost in increasing plant height, root biomass production, leaf area index and yield. According to Sailajakumari and Ushakumari (2001), vermicompost application improved the growth characters and yield of cowpea.

Rao and Sankar (2001) studied the effect of organic manures like farmyard manure, neem leaf, vermicompost, neem cake, *Azospirillum* and Phosphobacterium on the growth and yield of brinjal and found that leaf area index, dry matter production and other growth characters were increased when compared to inorganic fertilizer.

Patidar and Mali (2004) observed that with the application of farmyard manure, *Azospirillum* and PSB alone or in combination increased leaf area index, chlorophyll content, plant height, dry matter g $plant^{-1}$, grain yield (q ha^{-1}), protein content etc. and reduced days to 50 per cent bloom in sorghum.

2.2.1.2 Number and Weight of Effective Nodules

Srivastava and Ahlawat (1995) reported a significant increase in nodulation in cowpea by seed inoculation with *Rhizobium* or Phosphobacteria. There was overall improvement in growth of the crop.

The effect of organic amendments (farmyard manure, compost) on nodulation and yield of blackgram was studied by Balachandar *et al.* (2003) and observed significant improvement in these parameters. The slow release of nutrients from the decomposed organic matter application might be the reason for maximum nodulation and yield. Similar results were shown in greengram by Rajkhowa *et al.* (2003).

Results of the field experiment on vegetable cowpea by Chattopadhyay and Dutta (2003) showed that single or dual inoculation with biofertilizer resulted in conspicuous increase in nodule number and weight, leg-haemoglobin content and nitrogenase activity.

2.2.2 Yield and Yield Attributes

Cerena (1980) reported that farmyard manure favourably influenced the rate of dry matter increment per unit leaf area of capsicum. Senthilkumar and Sekar (1998) observed that fruit yield $plant^{-1}$ in bhindi was increased markedly by farmyard manure application. Joseph (1998) revealed that yield attributing characters like length of the fruit, weight of the fruit and number of fruits per plant (snake gourd) were highest in plots applied with farmyard manure to substitute NPK chemical fertilizers. Growth characters *viz.*, weight of root $plant^{-1}$ and dry matter production ha^{-1} were also higher in farmyard manure alone applied plots. Purushottam kumar and Puri (2002) in their experiment reported that farmyard manure application recorded 25.9 and 19.6 per cent more seed and straw yields in french bean respectively over no manure addition. The increase in yields due to farmyard manure application was due to its favourable effect on growth and yield attributes of the plant. In terms of economics, farmyard manure application also recorded higher net returns.

Jiji *et al.* (1996) found that the requirement for chemical fertilizers in cowpea var. Malika and bittergourd var. Preethi was significantly reduced,when recommended dose of farmyard manure was substituted by an equal quantity of vermicompost. Ushakumari *et al.* (1996) conducted an experiment to study the response of bhindi to vermicompost and the results showed that when cattle manure was substituted by vermicompost in POP recommendation of Kerala Agricultural University for bhindi, the yield of green vegetable was enhanced by 105 per cent.

According to Meera (1998), the coating of seeds with vermicompost significantly influenced grain yield of cowpea and also number of pods reported. Rajkhowa *et al.* (2003) reported that application of vermicompost showed significant positive effect on yield and dry matter production of greengram. Highest dry matter production and seed per plant were obtained with the application of 75 per cent N as urea along with 5 t ha^{-1} vermicompost and it was found to be on par with N as vermicompost alone.

Anitha (1997) remarked that in chilli various growth attributes like plant height, yield, dry matter production etc. were better with poultry manure application as compared to farmyard manure and vermicompost. Rekha (1999) reported that poultry manure treated plots showed maximum number of flowers and fruits leading to maximum fruit set percentage in brinjal. Harvest index was also found to be higher than POP. Julia *et al.* (1993) pointed out the beneficial effect of N nutrition through poultry manure,wherein an increase in the number of large and medium size fruits by applying 15 t ha^{-1} of poultry manure was noticed in tomato.

2.2 EFFECT OF ORGANIC FARMING PRACTICES ON QUALITY OF CROPS

Quality improvement occurs when nutrients are supplied through organic manures than fertilizer alone. This is because of the supply of enzymes, hormones, growth regulators etc beside supply of necessary elements through the manures. This will encourage, enhances and regulate metabolic function within the plant system resulting in the better synthesis of proximate constituents in desired proportions, thereby improving the quality of the produce.

2.3.1 Nutrient Uptake

Studies on soil nutrients alone will not give any inference on the influence of various nutrients on plant growth and development. For that, the uptake of nutrients by plant has to be studied. Uptake of nutrients is influenced by several soil and plant factors. Organic manures greatly influence the uptake of major and minor nutrients and are revised hereunder.

Application of farmyard manure and K had a positive effect on the uptake of Ca and Mg by wheat crop (Singh and Tomar, 1995). Raju *et al.* (1991) observed farmyard manure to be more effective in increasing N uptake in chickpea. Abusaleha (1992) noticed an increased uptake of N, P, K, Ca and Mg in bhindi when 40 kg N was supplied through poultry manure,when compared to application of same quantity through farmyard manure or ammonium sulphate on equivalent N basis. Kale *et al.* (1992) found that vermicompost application enhanced the activity of beneficial microbes like N fixers and mycorrhizal fungi. It played a significant role in N fixation and phosphate mobilization, leading to higher nutrient uptake by plants.

According to Zacharia (1995), application of *Eudrillus* compost increased the uptake nutrients by plants. Meera (1998) reported that use of vermicompost coated seeds produced 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.

In brinjal, the uptake and content of plant K were highest when nutrients were applied as 100 per cent organic manure (Rekha, 1999). Plant analysis at harvest indicated significant response to macronutrients, while none of the micronutrients showed significant response. Maximum mean value for all macronutrients except Mg was registered by enriched vermicompost treatment. Uptake of nutrients at harvest was also studied. Significant increase in the uptake of nutrients like N, P, K, Ca and Mg was registered by enriched vermicompost.

Dikshit and Khatik (2002) studied the influence of organic manures in combination with chemical fertilizers on nutrient uptake in soybean and found that maximum plant removal of S uptake *i.e.*, 17.41 kg ha^{-1} was noted in treatments where only organic source of 10 t compost ha^{-1} was added independently.

2.3.2 Protein Content, Fibre Content and Shelf Life

Vermicompost contains significant quantities of available nutrients, a large beneficial microbial population and biological active metabolites, particularly gibberellins, cytokinins, auxins and group B vitamins. It can be applied alone or in combination with organic or inorganic fertilizer, so as to get better yield and quality of diverse crops (Bano *et al.*, 1987).

Montogu and Ghosh (1990) found that fruit colour of tomato was significantly increased as a result of application of organic manures of animal origin. Organic manures like farmyard manure, compost, oil cakes, green leaf, poultry manure etc. improved the yield as well as quality of vegetable crops like tomato, onion, gourds, chillies etc. According to Rani *et al.* (1997), increase in ascorbic acid content in tomatoes, pyruvic acid in onion and minerals in gourds are the impact of application of organic manures to vegetable crops. Anitha (1997) reported that chilli plants treated with poultry manure recorded the maximum ascorbic acid content in fruits as compared to vermicompost and control (without manure) treatments. Omar *et al.* (2003) found that application of cattle compost increased freshness and vitamin C content in melon.

Joseph (1998) observed that in snake gourd, poultry manure treated plots recorded the highest crude protein content and lowest crude fibre content as compared to that of farmyard manure and vermicompost treatments. She also reported that when vermicompost was used as nutrient source,it produced fruits with more shelf life over farmyard manure and poultry manure. Jasmin (1999) in her experiment found that soil application of vermiwash produced fruits with more shelf life. The different concentration of vermiwash produced positive influence on the lycopene content of tomato, but no influence on the ascorbic acid and crude fibre content.

Application of vermicompost to amaranthus crop recorded significantly high ascorbic acid content as compared to POP (KAU, 1996). Lower fibre content was also reported in vermicompost plants (Arun Kumar, 2000). Bhadoria *et al.* (2002) reported that protein and total mineral content of okra fruit was high, when treated with farmyard manure. According to Sharu (2000), poultry manure application registered maximum keeping quality of fruits compared to vermicompost, neem cake and POP recommendation. An experiment comprising of organic and inorganic fertilizer and pesticide sources revealed that the treatment combination of farmyard manure + dense organic manure + Neemax (biopesticide) gave higher yield, protein, vitamin C content with prolonged shelf life in french beans (Singh, 2002).

Renu (2003) in her work on bittergourd regarding the effect of vermicompost on some quality aspects observed that texture, odour and keeping quality was well pronounced in organically treated plots (farmyard manure, vermicompost, poultry manure) than those with integrated and fully inorganic plots. Sheeba (2004) showed that treatments with organic sources of plant nutrients recorded the highest value for β-carotene content, protein content and the lowest fibre content in amaranthus.

Significantly higher crude protein content of 18.5 per cent was recorded in the treatments that received vermicompost followed by farmyard manure with 17.8 per cent as against crude protein content of 14.7 per cent in the non-manured control plots in blackgram (Vasanthi and Subramanian, 2004).

2.3 ROLE OF PHOSPHATE SOLUBILISING MICROBES (PSM) IN ORGANIC FARMING

In general PSM include different groups of microorganisms such as bacteria and fungi which convert insoluble organic and inorganic phosphatic compounds into soluble form. In India, a high volume of research has been carried out on the usefulness of PSM in boosting P use efficiency in various crops.

Srivastava and Ahlawat (1995) confirmed that seed inoculation with *Rhizobium* or phosphate solubilising bacteria (PSB) alone or in combination resulted in considerable increase in nodulation, nitrogenase activity, growth, yield and nutrient uptake by cowpea over uninoculated control. Vaishya *et al.* (1996) has observed that the use of PSM along with rock phosphate for bengal gram in Vertisol resulted in a significantly higher P uptake. Meena *et al.* (2003) reported that inoculation with phosphobacteria significantly increased the grain yield, straw yield and harvest index in chickpea. This was mainly due to the growth promoting substances by PSB as well as increase in availability of native soil P.

Tanwar *et al.* (2003) reported that seed inoculation with bacterial culture (P solubliser) significantly improved yield, N, P content and uptake in both seed and straw in black gram. Inoculation of soybean seed with rhizobium significantly improved seed yield parameters *viz.*, pods plant^{-1}, number of seeds pod^{-1}, seed index and seed yield plant^{-1}. Greater availability of nutrients in the soil and better nodulation under the influence of inoculation resulted in better growth and development of plants (Menaria and Singh, 2004).

Materials and Methods

3. MATERIALS AND METHODS

A field experiment to evaluate the impact of organic farming practices on soil health, yield and quality of cowpea [*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcort] was carried out during 2003-2005 at the Instructional Farm, College of Agriculture, Vellayani. The details of the experimental site, season and weather conditions, materials used and methods adopted are presented in this chapter.

3.1 LOCATION

The experiment was carried out at College of Agriculture, Vellayani. The site is situated at 8^0 30' N latitude and 76^0 54' E longitudes and at an altitude of 29 m above MSL.

3.2 SEASON

The experiment was conducted during the period October 2004 to February 2005.

3.3 WEATHER CONDITIONS

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.

3.4 SOIL

The soil of the experimental site belongs to the family of Loamy skeletal Kaolinitic Isohyperthermic Rhodic Haplustult. The physical and chemical characteristics of the soil, where the experiment was conducted are given in Table 1.

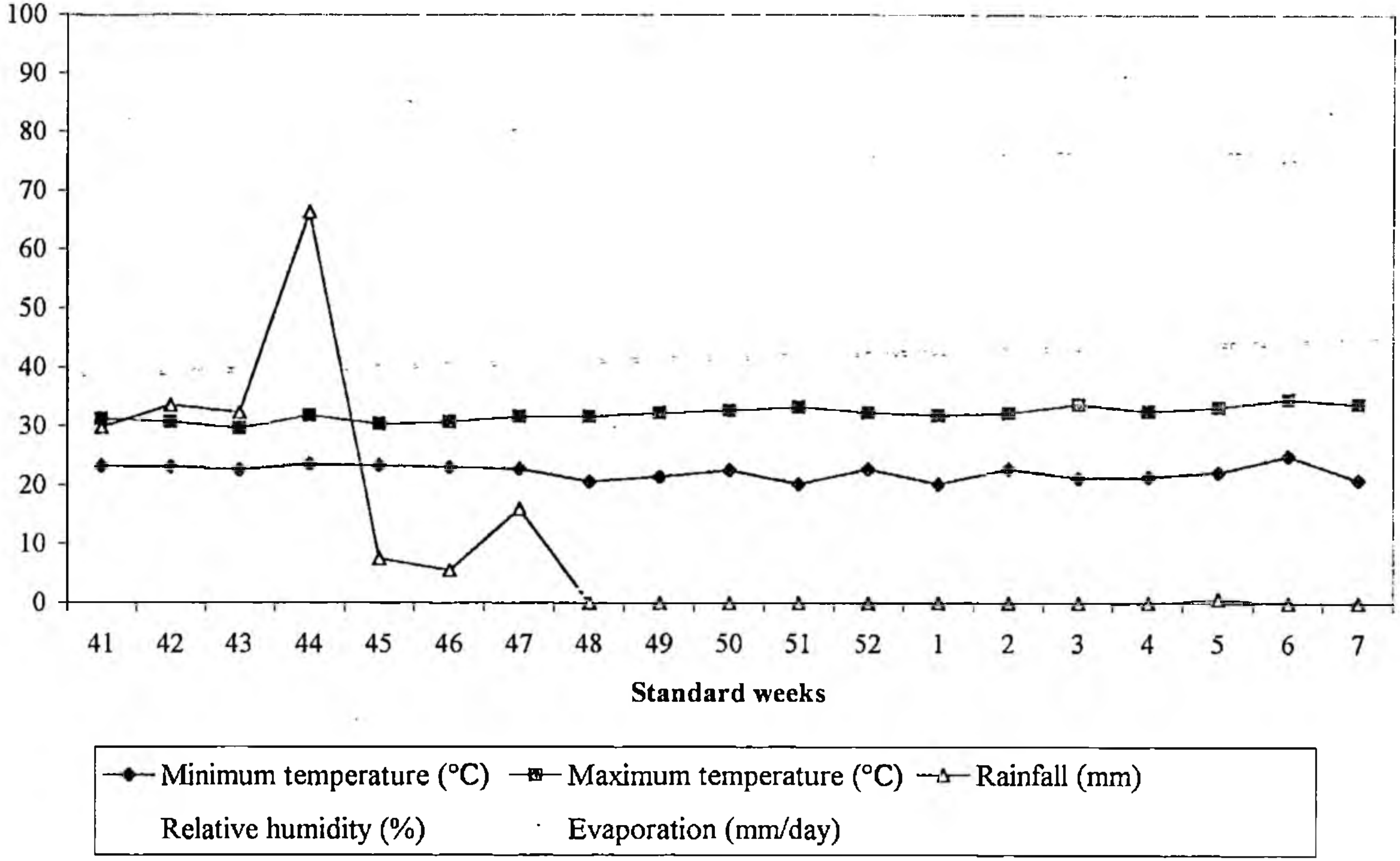


Fig. 1. Weather data for the cropping period (October 2004 to February 2005)

Table 1. Physico-chemical properties of soil of the experimental site

Sl. No.	Parameter	Content
1	Mechanical composition	
	Coarse sand	49.15 (%)
	Fine sand	14.4 (%)
	Silt	6.25 (%)
	Clay	27.5 (%)
2	Texture	Sandy clay loam
3	Bulk density	1.52 Mg m^{-3}
4	Water holding capacity	26 %
5	Porosity	38.5 %
6	Soil temperature	32.4°C
7	pH (soil: water) (1:2.5)	5.2
8	Organic Carbon	0.53 %
9	C:N ratio	10.5
10	CEC	2.52 cmol(p^+)kg^1
11	Available N ($KMnO_4$-N)	220 kg ha^{-1}
12	Available P – Bray Extraction (Ascorbic acid blue colour method)	22.3 kg ha^{-1}
13	Available K	120 kg ha^{-1}
14	Available Ca	0.8 cmol ha^{-1}
15	Available Mg	1.2 cmol ha^{-1}
17	Available S	11 kg ha^{-1}
18	DTPA extractable micronutrients	
	Fe	34 ppm
	Mn	2.8 ppm
	Zn	1.5 ppm
	Cu	0.18 ppm

3.5 MATERIALS

3.5.1 Planting Material and Variety

The planting material of the cowpea variety Sharika was obtained from the Instructional Farm, Vellayani. It is a trailing vegetable type variety with duration of 100 days.

3.5.2 Manures and Fertilizers

3.5.2.1 Manures

Different organic sources used for the field experiment were farm yard manure, vermicompost and poultry manure. Nutrient composition of these organic sources is given in Table 2.

Table 2. Nutrient composition of organic manures

Source	Nutrient composition		
	N (%)	P (%)	K (%)
Farmyard manure	1.12	0.46	0.24
Vermicompost	1.53	0.9	0.93
Poultry manure	2.1	0.86	0.75

3.5.2.2 Biofertilizers

PSM – Phosphorus solubilising microorganisms consisting of a mixture of *Pseudomonas, Aspergillus* and *Azospirillum* obtained from the Department of Plant Pathology, KAU, Vellayani was used.

3.5.2.3 Fertilizers

Fertilizers of the following analysis were used as source of N, P and K respectively.

Urea	-	46 % N
Rock phosphate	-	20 % P_2O_5
Muriate of potash	-	60 % K_2O

3.6 DESIGN AND LAYOUT OF THE EXPERIMENT

Design	-	Randomised block design
Treatments	-	8
Replications	-	3
Gross plot size	-	5 x 4 m
Spacing	-	2 x 2 m

Treatments

T_1 – Recommended as per POP

T_2 – Full recommended dose as Farmyard manure

T_3 – Full recommended dose as Farmyard manure + PSM

T_4 – Full recommended dose as Vermicompost

T_5 – Full recommended dose as Vermicompost + PSM

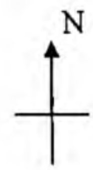
T_6 – Full recommended dose as Poultry manure

T_7 – Full recommended dose as Poultry manure + PSM

T_8 – Inorganic alone

The POP recommendation for cowpea is 20 kg N ha^{-1}, 30 kg P_2O_5 ha^{-1} and 10 kg K_2O ha^{-1} along with 20 t farm yard manure ha^{-1}. Lime application was also done @ 250 kg ha^{-1}. Cultural operations were done as per POP (KAU, 2002).

The layout of the experiment is given in Figure 2.



	R3T7	**R3T5**	**R3T3**	**R3T1**
R1T1	**R1T2**	**R2T8**	**R2T7**	**R3T8**
R1T3	**R1T4**	**R2T6**	**R2T5**	**R3T2**
R1T5	**R1T6**	**R2T4**	**R2T3**	**R3T6**
R1T7	**R1T8**	**R2T2**	**R2T1**	**R3T4**

Design: Randomised Block Design, Treatments: 8, Replication: 3

Fig. 2. Layout of field experiment

3.7 FIELD CULTURE

3.7.1 Land Preparation

The experimental field was dug twice, stubbles removed, clods broken and laid out into blocks and plots.

3.7.2 Manure and Fertilizer Application

Farmyard manure, vermicompost and poultry manure were applied on the N content basis and requirements of P and K were met through addition of rock phosphate and ash according to treatments. PSM @ 1 g $plant^{-1}$ was applied in T_3, T_5 and T_7 treatments. Entire P and K were applied basally and half the recommended N as basal and rest after two weeks of planting for all the treatments.

3.7.3 Sowing

Plots were taken and seeds were dibbled at the rate of three $hole^{-1}$ at a depth of 5 cm.

3.7.4 After Cultivation

Uniform germination was observed in the field. Gap filling was done four days after sowing. The crop was thinned to two plants pit^{-1} one week after emergence and the plants were trailed on standards. The crop was given regular weeding throughout the cropping period. Earthing up was also done along with top dressing of N.

3.7.5 Plant Protection

Azadiractin @ 2.5 ml l^{-1} and tobacco decoction were applied against bug attack at weekly intervals. As a prophylactic measure against wilt, *Pseudomonas fluorescence* (10 g l^{-1}) @ 200 ml pit^{-1} was drenched three weeks after sowing.

3.7.6 Harvesting

Pods were harvested for vegetable purpose from 55 days after sowing onwards. Subsequent harvests of green immature pods were done in alternate days from all the treatments up to 100 days after sowing onwards and fresh weight recorded. After the crop period, when the vegetable yield had fallen well below the economic level, the plants were pulled out, sundried and bhusa yield recorded. After that the same was oven dried and dry weight was recorded. General view of the experimental field is given in Plate 1.

3.8 BIOMETRIC OBSERVATIONS

3.8.1 Height of Plant

Length was measured from base of the plant to the terminal leaf bud at 50 per cent flowering stage and expressed in centimetres.

3.8.2 Number of Effective Nodules

Plants were uprooted from each plot at random without disturbing the root system and nodules were separated at flowering stage. The nodules with pink or reddish colour were counted to get the number of effective nodules.

3.8.3 Weight of Nodules

The collected nodules were cleaned of dirt and washed with water, drained well and weight was taken.

3.8.4 Leaf Area Index (LAI)

LAI was measured using leaf area metre at 50 per cent flowering stage. LAI was worked out using the following equation.

$$LAI = \frac{\text{Total leaf area}}{\text{Land area}}$$ (Watson, 1962)

Plate 1. General view of the experimental field

3.8.5 Days to 50 per cent Flowering

The days for flowering of 50 per cent of the net population was recorded for each treatment and the period was calculated from the day of sowing.

3.9 YIELD AND YIELD ATTRIBUTES

3.9.1 Pod Yield

Yield of vegetable pod obtained from each net plot was recorded separately and totalled up at the end of the cropping period and expressed in kg ha^{-1}.

3.9.2 Bhusa Yield

After the pods were picked from each net plot, the plants were uprooted, sundried uniformly and weighed. The weight was expressed in kg ha^{-1}.

3.9.3 Total Dry Matter Production (TDM)

The total dry weight of pods and bhusa were added to get the TDM production.

3.9.4 Harvest Index (HI)

Harvest index of each net plot calculated as

$$\frac{\text{Economic yield}}{\text{Biological yield}}$$

3.10 ANALYTICAL PROCEDURES

3.10.1 Soil Analysis

Soil samples were taken from the experimental area before the start of the experiment, at 50 per cent flowering time and after the experiment. The air dried samples passed through 2 mm sieve were used for the analysis of physical, chemical and biological properties using standard procedures given in Table 3.

Table 3. Analytical methods followed in soil analysis

Sl. No.	Parameters	Methods	Reference
I	**Physical properties**		
1.	Bulk density	Undisturbed core sample	Black *et al.* (1965)
2.	Water holding capacity	Undisturbed core sample	Black *et al.* (1965)
3.	Porosity	Undisturbed core sample	Black *et al.* (1965)
4.	Soil temperature	Soil thermometer	Kohnke (1968)
II	**Chemical properties**		
1.	pH (soil : water) (1 : 2.5)	pH meter with glass-calomel electrode	Jackson (1973)
2.	Organic C	Walkley and Black chromic acid wet digestion	Walkley and Black (1934)
3.	CEC	Ammonium saturation using neutral normal ammonium acetate	Jackson (1973)
4.	Available N ($KMnO_4$ – N)	Alkaline permanganate method	Subbiah and Asija (1956)
5.	Available P	Bray No. 1 extraction and photoelectric colorimetry	Jackson (1973)
6.	Available K	Neutral normal ammonium acetate extraction and flame photometry	Jackson (1973)
7.	Exchangeable Ca and Mg	Neutral normal ammonium acetate extraction and titration with EDTA	Hesse (1971)
8.	S	Turbidimetry	Chesnin and Yein (1951)
9.	Fe, Mn, Zn, Cu	DTPA extraction and AAS	Lindsay and Norvell (1978)

II Biological Properties (Enzyme analysis)

1. Dehydrogenase

It involves colorimetric determination of 2, 3, 5-Triphenyl Tetrazolium Chloride (TTS).

Mixed 5 g air dried soil and 0.05 g $CaCO_3$. Added 1 ml TTC and 2.5 ml distilled water. Mixed well and plugged with cotton. Incubated at 37° C for 24 hours. Removed stopper and added 10 ml methanol. Plugged cotton. Shaked for one minute. Filtered through glass funnel plugged with absorbent cotton until red colour of cotton disappeared (with methanol). Made upto 100 ml with methanol. Measured the red colour at 485 nm in spectrophotometer. Calculated from caliberation graph using Triphenyl formazan (Page *et al.*, 1982).

2. Phosphatase

This involved colorimetric estimation of P-nitrophenol released by phosphatase activity when soil was incubated with buffered sodium-para-nitrophenyl phosphate solution and toluene.

Took 1 g soil in conical flask and added 0.2 ml toluene, 4 ml modified universal buffer pH 6.5, and 1 ml p-nitro-phenyl phosphate. Swirled the flask. Incubated at 37° C for one hour. Removed stopper and added 1 ml 0.5 M $CaCl_2$ and 4 ml 0.5 M NaOH. Again swirlled the flask. Filtered it and read yellow colour. Calibrated from graph using p-nitrophenol solution (Page *et al.*, 1982).

3.10.2 Plant Analysis

Leaf samples at 50 per cent flowering stage, harvesting stage and pod samples were collected. The samples were oven dried at 70° C, powdered and used for estimation of N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu. Standard procedures adopted are given in Table 4.

Table 4. Analytical methods followed in plant analysis

Sl. No.	Element	Method	Reference
1	N	Microkjeldahl distillation after digestion in H_2SO_4	Jackson (1973)
2	P	Nitric-perchloric acid (9 : 4) digestion and colorimetry using Vanado-molybdo phosphoric yellow colour method	Jackson (1973)
3	K	Nitric-perchloric acid (9 : 4) digestion and flame photometry	Jackson (1973)
4	Ca and Mg	Nitric-perchloric acid (9 : 4) digestion and versenate titration with standard EDTA	Tandon (1993)
5	S	Nitric-perchloric acid (9 : 4) digestion and turbidimetry	Tabatabai and Bremner (1970)
6	Fe, Mn, Zn, Cu	Nitric-perchloric (9 : 4) digestionand AAS	Jackson (1973)

3.10.3 Quality Aspects

3.10.3.1 Protein Content

The pod N values were multiplied by the factor 6.25 to obtain the protein content of pods and the values were expressed as per cent (Simpson *et al.*, 1965).

3.10.3.2 Fibre Content

The crude fibre content in the pods was expressed in per cent (Kanwar and Chopra, 1976).

3.10.3.3 Shelf Life

The number of days after which the harvested pods lose its appearance and starts decaying

3.10.3.4 Organoleptic evaluation

Scoring test was used for quality evaluation as suggested by Swaminathan (1974). A four point rating scale was applied for each quality. The quality attributes studied include appearance, colour, texture and taste. Details of score card are presented in Appendix II.

3.10.4 Statistical Analysis

Data generated from the experiment were subjected to statistical analysis applying analysis of variance technique and significance tested by t test (Cochran and Cox, 1969). In cases were the effects were found to be significant, CD was calculated using standard techniques.

Results

4. RESULTS

An investigation was carried out at the Instructional Farm, College of Agriculture, Vellayani to find out the impact of organic farming practices on soil health, yield and quality of vegetable cowpea. The data on various characters were statistically analysed and are presented in this chapter.

4.1 EFFECT OF ORGANIC FARMING PRACTICES ON SOIL PROPERTIES

4.1.1 Physical Properties

The physical properties of the soil at 50 per cent flowering stage and at harvest stage are presented in Table 5. It could be observed that all the physical properties were significantly influenced by organic matter addition.

4.1.1.1 Bulk Density

Bulk density was found to be significantly influenced by organic treatments at 50 per cent flowering stage and at harvest stage. It recorded a lowest value of 1.32 Mg m^{-3} for the treatment T_5 (vermicompost + PSM) which was found to be on par with T_2, T_3, T_4, T_6 and T_7 *i.e.*, all other treatments receiving organic manures alone. The highest value of 1.49 Mg m^{-3} was recorded by T_8 (Inorganic alone) followed by T_1 (POP recommendation).

At harvest stage, T_5 recorded the lowest mean value of 1.3 Mg m^{-3} which showed significant difference with other treatments. The highest value being 1.48 Mg m^{-3} was for T_8, and the next being for treatment receiving POP recommendation.

4.1.1.2 Water Holding Capacity

From the experiment, it can be observed that the different treatments had a significant influence on water holding capacity of soil. The treatments, T_4 (vermicompost) and T_5 (vermicompost + PSM) recorded higher values of 36.3 per cent and 36.07 per cent respectively at 50 per cent flowering stage which was significantly higher than the other treatments. The lowest value was obtained for the treatment without any organic matter addition (29.2 %). All other treatments were on par. At harvest stage also the results showed similar trend. Higher values were noticed in T_5 (41.93 %) and T_4 (41.7 %) treatments. This was due to improvement in porosity and soil aggregation.

4.1.1.3 Soil Temperature

Observations on soil temperature revealed that it was significantly influenced by different treatments at 50 per cent flowering and at harvest stages.

The treatments T_4 (vermicompost) and T_5 (vermicompost + PSM) was found to have significantly lower values of 28.23° C and 28.2° C at 50 per cent flowering stage and 29.4° C and 29.13° C at harvest stage respectively. In both cases T_8 registered the highest value followed by T_1. All other treatments were found to be on par.

4.1.1.4 Porosity

It was clear from the analytical data that organic manure addition produced a significant effect on soil porosity. At 50 per cent flowering stage, the highest value was given by T_5 (vermicompost + PSM), 46.13 per cent, which was on par with vermicompost alone treatment (46 %). At harvest stage, the highest value was for T_4 (48 %) followed by T_5 (47.97 %). In both the cases treatment receiving inorganic fertilizer alone recorded the lowest values.

Table 5 Effect of organic farming practices on soil physical properties

Treatments	BD (Mg m^{-3}) (50 % flowering)	BD (Mg m^{-3}) (Harvest)	WHC (%) (50 % flowering)	WHC (%) (Harvest)	Temperature (°C) (50 % flowering)	Temperature (°C) (Harvest)	Porosity (%) (50 % flowering)	Porosity (%) (Harvest)
T_1	1.43	1.41	32.63	35.84	30.13	31.26	42.20	44.00
T_2	1.36	1.35	33.43	36.54	29.20	30.13	42.57	44.70
T_3	1.35	1.34	34.13	35.83	29.13	30.33	42.90	44.87
T_4	1.33	1.32	36.30	41.70	28.23	29.40	46.00	48.00
T_5	1.32	1.30	36.07	41.93	28.20	29.13	46.13	47.97
T_6	1.36	1.34	34.47	37.30	29.70	30.53	43.30	45.30
T_7	1.35	1.33	34.47	37.43	29.53	30.43	43.07	44.97
T_8	1.49	1.48	29.20	30.13	31.90	32.73	39.57	41.13
SE	0.01	0.01	0.54	0.59	0.13	0.15	0.30	0.32
CD (0.05)	0.03	0.03	1.64	1.79	0.38	0.47	0.90	0.98

4.1.2 Chemical Properties

The data regarding chemical properties of soil is given in Table 6. It indicated the importance of organic nutrition on various chemical aspects of soil.

4.1.2.1 pH

The different treatments significantly influenced pH of soil. At both stages *i.e.,* at 50 per cent flowering and at harvest stage, T_5 (vermicompost + PSM) recorded the highest values of 5.69 and 6.33 respectively which was on par with T_4 (vermicompost). Treatment having only inorganic nutrition recorded the lowest value (5.3).

4.1.2.2 Organic C

This character also was significantly influenced by the different treatments. Vermicompost applied plot got significantly higher values of 0.87 per cent and 0.78 per cent at 50 per cent flowering stage and harvest stage respectively which was on par with the treatment receiving combination of vermicompost and PSM. T_8 (inorganic fertilizer alone) got the lowest value of 0.59 per cent and 0.50 per cent at 50 per cent flowering and harvest stage respectively.

4.1.2.3 C : N Ratio

From the data, it could be observed that the different treatments had a significant influence on C : N ratio. At 50 per cent flowering stage, T_8 (inorganic fertilizer alone) recorded the lowest value of 10.9 followed by T_1 (POP) *i.e.,* 13.9. T_2 (farmyard manure) and T_3 (farmyard manure + PSM) were on par and recorded higher values, the highest being 17.06 for farmyard manure alone application. At harvest stage also T_2 got the highest value of 12.2 which was on par with T_3. All other treatments were found on par. The lowest value was for T_5 (vermicompost + PSM) and T_4 (vermicompost) *i.e.,* 9.97.

4.1.2.4 CEC

Organic manure application could significantly influence CEC of soil as shown in the table. At 50 per cent flowering stage, the highest value of 5.39 c mol (p+) kg^{-1} soil was recorded by T_5 (vermicompost + PSM) followed by T_4 (vermicompost). Treatment receiving inorganic alone registered the lowest value followed by the treatment with POP recommendation. At harvest stage also the trend was similar with significantly higher values for T_5 and T_4, the highest being 5.02 c mol (p+) kg^{-1} soil for T_5 and the lowest for T_8. Organic matter addition resulted in increased humic colloidal compounds which contributed to the higher CEC in those treatments receiving organic manures.

4.1.3 Soil Nutrient Availability

The effect of organic farming on available soil nutrients is presented in Table 7. It showed the nutrient status of soil at 50 per cent flowering and at harvest stage of the crop.

4.1.3.1 Available N

The data showed significant difference in available N content among the treatments at 50 per cent flowering stage and at harvest stage. Significantly higher values was recorded by T_5 (vermicompost + PSM) with a value of 338 kg ha^{-1} at 50 per cent flowering stage and 307.67 kg ha^{-1} at harvest stage. This was found on par with treatment having vermicompost alone. The higher values for vermicompost treatments were due to easily mineralisable N present in it. The lowest value was registered by T_8 (inorganic fertilizer alone).

4.1.3.2 Available P

The amount of available P at both the stages (50 per cent flowering and at harvest stage) was significantly influenced by the treatments. The highest value was shown by T_5 (vermicompost + PSM) *i.e.*, 46.1 kg ha^{-1} at 50 per cent flowering stage and 39.27 kg ha^{-1} at harvest. Here all the treatments having PSM combinations (T_3, T_5, T_7) recorded significantly

Table 6 Effect of organic farming practices on soil chemical properties

Treatments	pH (50 % flowering)	pH (Harvest)	Organic C (%) (50 % flowering)	Organic C (%) (Harvest)	C : N ratio (50 % flowering)	C : N Ratio (Harvest)	CEC (c mol (p+) kg^{-1}) (50 % flowering)	CEC(c mol (p+) kg^{-1}) (Harvest)
T_1	5.39	5.53	0.71	0.61	13.90	10.17	3.21	2.94
T_2	5.49	5.57	0.76	0.66	17.06	12.20	3.82	3.51
T_3	5.49	5.57	0.73	0.67	16.90	12.03	3.65	3.37
T_4	5.68	6.31	0.87	0.78	15.93	9.97	5.32	4.97
T_5	5.69	6.33	0.86	0.78	15.93	9.97	5.39	5.02
T_6	5.55	5.62	0.69	0.56	15.67	10.03	4.18	3.78
T_7	5.55	5.62	0.69	0.58	15.50	10.00	4.23	3.70
T_8	5.20	5.30	0.59	0.50	10.90	10.13	2.52	2.45
SE	0.03	0.04	0.02	0.02	0.28	0.25	0.06	0.06
CD (0.05)	0.10	0.13	0.05	0.05	0.86	0.76	0.17	0.18

higher values when compared with the treatment with organic manure alone (T_2, T_4, T_6) respectively. This difference was due to the greater dissolution of native P by P solubilising organisms. Here also T_8 got the lowest value.

4.1.3.3 Available K

There was a significant influence of different treatments on the available K status of soil. At 50 per cent flowering stage,all the treatments showed significantly higher values compared to the treatment without organic matter addition (138.67 kg ha^{-1}). T_5 (vermicompost + PSM) recorded the highest value of 191.67 kg ha^{-1} which was on par with T_4, T_6, T_7 and T_2. At harvest stage also treatment with NPK alone got the lowest value (121.67 kg ha^{-1}), while T_4 (vermicompost) was found to be superior with a value of 174.67 kg ha^{-1}. T_5 and T_6 were on par with T_4.

4.1.3.4 Exchangeable Ca

From the data it was evident that there was a significant variation in exchangeable Ca content in soil. T_5 (vermicompost + PSM) recorded the highest value of 1.54 c mol kg^{-1}, which was found on par with T_4.While T_8 (inorganic alone) recorded the lowest value at 50 per cent flowering time. Similar results were obtained at harvest stage, the highest value being 1.33 c mol kg^{-1} for T_5 and were on par with T_4, the reason was that castings of earthworms are rich in soluble forms of Ca.

4.1.3.5 Exchangeable Mg

Exchangeable Mg content at 50 per cent flowering and harvest stage showed significant variation with the treatments. In both cases, T_5 (vermicompost + PSM) and T_4 (vermicompost) was found to be superior. The values recorded at 50 per cent flowering stage was 1.92 and 1.90 c mol kg^{-1} respectively, while at harvest stages the values obtained were 1.61 c mol $kg^{-1}$and 1.6 c mol kg^{-1} respectively. T_8 (inorganic alone) was found inferior to all other treatments (1.17 c mol kg^{-1} at 50 per cent flowering and 0.87 c mol kg^{-1} at harvest), followed by treatment with POP recommendation.

4.1.3.6 Available S

Available S was also significantly influenced by the different treatments. At both the stages T_7 (poultry manure + PSM) recorded the highest value of 20.37 kg ha^{-1} and 17.9 kg ha^{-1} at 50 per cent flowering and at harvest stages respectively. This was on par with T_6 (poultry manure) in both the cases. The lowest value was noticed for inorganic fertilizer application alone followed by POP recommendation.

4.1.3.7 Available Fe

It was evident from the data that all the treatments receiving organic manure showed significant difference with T_8 (inorganic alone). The highest value was for T_8 (32.3 ppm) followed by T_1 (POP). The least value was recorded for T_5 (vermicompost + PSM) (25.37 ppm). This is the case with 50 per cent flowering stage. Harvest stage values also showed similar trend. The highest value was for T_8 *i.e.*, 27.27 ppm, followed by T_1 and the lowest was for T_5 (16.27 ppm). The other treatments were seen on par with T_5.

4.1.3.8 Available Mn

Significant variation was shown by the different treatments. At 50 per cent flowering stage, the highest value was with T_5 (vermicompost + PSM) *i.e.*, 3.87 ppm which was on par with T_4, T_6, T_7, T_3 and T_2. T_8 got the lowest value of 2.6 ppm which was on par with POP recommendation (T_1) and farmyard manure application plot (T_2). At harvest stage, all the treatments with organic nutrition were on par and differed significantly from the treatment where inorganic fertilizer alone was applied (T_8). The highest value was recorded by T_5 *i.e.*, 3.07 ppm.

4.1.3.9 Available Zn

The treatments showed significant variation. T_5 (vermicompost + PSM) registered the highest Zn content at 50 per cent flowering stage (7.47 ppm). At harvest stage, T_4 got the highest value of 9.53 ppm. For both cases, T_5 and T_4 were found to be on par. The lowest mean value was for T_8.

4.1.3.10 Available Cu

As in the table, available Cu content significantly varied among the different treatments. The highest Cu content of 0.6 ppm was recorded by T_4 (vermicompost) at 50 per cent flowering stage which was on par with T_5 (vermicompost + PSM). At harvest stage, the highest value was contributed by T_5 *i.e.*, 0.68 ppm and found on par with T_4. In both cases, treatment receiving inorganic fertilizer alone was inferior (0.14 ppm at 50 per cent flowering and 0.06 ppm at harvest stage) followed by POP recommendation. The higher micronutrient status (Mn, Zn, Cu) with organic matter addition was due to the formation of stable complexes with organic ligands which decreased their susceptibility to adsorption and fixation.

4.1.4 Soil Biological Properties

Studies concerning soil biological properties, especially soil enzymes are important to obtain a complete picture of soil fertility. The data in Table 8 revealed the significance of organic farming on soil enzymes.

4.1.4.1 Dehydrogenase

Values showed that the treatments varied significantly. T_5 (vermicompost + PSM) was found superior with value of 310.67 μg TPF g soil^{-1} 24 hr^{-1} and it was found to be on par with T_4 (vermicompost). The lowest mean value was with T_8 (inorganic alone), which was on par with the treatments having POP recommendation and farmyard manure + PSM

Table 7 Effect of organic farming practices on soil available nutrients

Treatments	Available N (50 % flowering)	Available N (Harvest)	Available P (50 % flowering)	Available P (Harvest)	Available K (50 % flowering)	Available K (Harvest)
	kg ha^{-1}					
T_1	254	238	36	25	163	141
T_2	261	241	36	30	174	144
T_3	279	261	39	33	161	149
T_4	332	296	41	37	191	175
T_5	338	308	46	39	192	171
T_6	265	237	35	32	186	163
T_7	273	254	38	34	183	160
T_8	216	188	26	22	139	122
SE	5.07	7.86	1.18	0.59	6.24	3.88
CD (0.05)	15.38	23.85	3.60	1.80	18.93	11.76

Table 7 Continued

Treatments	Exchangeable Ca (50 % flowering)	Exchangeable Ca (Harvest)	Exchangeable Mg (50 % flowering)	Exchangeable Mg (Harvest)	Available S (50 % flowering)	Available S (Harvest)
	cmol kg^{-1}				kg ha^{-1}	
T_1	1.17	0.90	1.49	1.23	12.60	11.23
T_2	1.32	0.96	1.61	1.40	13.43	12.23
T_3	1.34	0.97	1.63	1.40	13.03	12.37
T_4	1.52	1.30	1.90	1.60	16.47	12.67
T_5	1.54	1.33	1.92	1.61	15.33	12.53
T_6	1.37	1.04	1.68	1.43	19.23	16.93
T_7	1.39	1.05	1.69	1.44	20.37	17.90
T_8	0.85	0.69	1.17	0.87	10.80	9.57
SE	0.02	0.03	0.02	0.02	0.80	0.32
CD (0.05)	0.06	0.08	0.06	0.06	2.44	0.96

Table 7 Continued

Treatments	Available Fe (50 % flowering)	Available Fe (Harvest)	Available Mn (50 % flowering)	Available Mn (Harvest)	Available Zn (50 % flowering)	Available Zn (Harvest)	Available Cu (50 % flowering)	Available Cu (Harvest)
	ppm							
T_1	28.47	18.20	3.10	2.57	3.53	5.50	0.23	0.34
T_2	26.87	17.63	3.50	2.80	4.43	6.30	0.34	0.44
T_3	26.23	17.37	3.60	2.83	4.37	6.47	0.36	0.43
T_4	25.43	16.33	3.82	3.00	7.32	9.53	0.60	0.68
T_5	25.37	16.27	3.87	3.07	7.47	9.47	0.59	0.68
T_6	26.10	16.90	3.77	2.93	4.73	6.53	0.36	0.47
T_7	25.63	16.67	3.76	2.90	4.63	6.43	0.37	0.44
T_8	32.30	27.27	2.60	1.50	1.34	1.05	0.14	0.06
SE	0.70	0.83	0.19	0.19	0.21	0.19	0.01	0.03
CD (0.05)	2.11	2.52	0.57	0.57	0.64	0.56	0.04	0.08

application (T_3). The data showed that dehydrogenase activity was linked with the presence of organic matter in soil.

4.1.4.2 Phosphatase

Phosphatase activity also was significantly influenced by the different treatments. Vermicompost + PSM (T_5) got the highest value of 135.7 μg P-nitrophenol g soil^{-1} hr^{-1} followed by T_4 (vermicompost). The lowest value was observed in T_8 (inorganic fertilizer alone), 39.07 μg P-nitrophenol g soil^{-1} hr^{-1}. A positive correlation between soil organic matter content and phosphatase activity was clear from the data.

4.2 EFFECT OF ORGANIC FARMING PRACTICES ON GROWTH AND YIELD CHARACTERS

4.2.1 Growth Characters

Data relating to growth characters of the crop was presented in table 9. It showed the influence of different organic manures on the different growth aspects of cowpea.

4.2.1.1 Height of Plant

Plant height was noted to be significantly enhanced by organic manure addition. T_5 (vermicompost + PSM) recorded a height of 293.6 cm which was the highest among all the treatments and was found on par with T_4 (vermicompost). Inorganic fertilizer alone application was found inferior to the other treatments with a value of 225 cm. In addition to this, there was also a significant increase in value for the treatments with PSM compared to those without it. This was due to the growth promoting substances contributed by PSM as well as increase in native P.

4.2.1.2 Number and Weight of Nodules

Observations revealed that, it was significantly influenced by the treatments. For both aspects, vermicompost + PSM (T_5) recorded the highest values. This was found on par with T_4. Treatments with inorganic

Table 8 Effect of organic farming practices on soil enzymes

Treatments	Dehydrogenase (μg TPF g $soil^{-1}$ 24 hr^{-1})	Phosphatase (μg P-nitrophenol g $soil^{-1}$ hr^{-1})
T_1	204.67	76.33
T_2	236.67	81.93
T_3	231.00	91.00
T_4	301.00	115.83
T_5	310.67	135.70
T_6	238.30	76.07
T_7	244.30	81.13
T_8	150.00	39.07
SE	10.12	3.19
CD (0.05)	30.71	9.68

fertilizer alone got the lowest value followed by T_1 (POP recommendation). Here also due to addition of PSM, significantly higher values were recorded.

4.2.1.3 Leaf Area Index

Data on leaf area index showed significant difference among the treatments. T_5 (vermicompost + PSM) got the highest value of 2.23 and was found on par with T_4 (vermicompost). The lowest value was for T_8 (inorganic NPK alone) (1.23). The treatments, T_5, T_3 and T_7 which got PSM addition obtained significantly higher values than T_4, T_2 and T_6 respectively, where no PSM was included.

4.2.1.4 Days to 50 per cent Flowering

The data showed that T_1 (POP recommendation) got the lowest value of 41.67 days and T_8 (inorganic NPK alone) got the highest value of 47 days. T_8 differed significantly from all other treatments except T_2 which was found to be on par.

4.2.2 Yield and Yield Attributes

From Table 10, the relation between yield and yield attributes and the different treatments could be understood.

4.2.2.1 Pod Yield

On scrutinizing the results, it was noted that pod yield showed significant variation with the treatments. Treatment with POP recommendation (T_1) was found superior with 3708 kg ha^{-1} which was on par with T_4 and T_5 (vermicompost treatments). T_8 got the lowest yield of 2866 kg ha^{-1}. The data made clear that inorganic fertilizer alone was ineffective in enhancing yield of the crop.

4.2.2.2 Bhusa Yield

As from the data, it could be inferred that bhusa yield varied significantly among the treatments. T_5 (vermicompost + PSM) obtained

Table 9 Effect of organic farming practices on growth characters of cowpea

Treatments	Height of plant (cm)	Number of nodules plant^{-1}	Weight of nodules (g)	Leaf area index	Days to 50 per cent flowering
T_1	243.33	20.00	0.50	1.50	41.67
T_2	265.33	24.00	0.52	1.77	43.67
T_3	274.40	28.30	0.56	1.80	45.33
T_4	284.20	31.07	0.58	2.03	42.00
T_5	293.60	33.30	0.61	2.23	42.00
T_6	269.60	24.00	0.52	1.73	43.00
T_7	275.00	27.07	0.55	1.80	43.00
T_8	225.00	12.30	0.22	1.23	47.00
SE	3.47	1.30	0.02	0.07	0.57
CD (0.05)	10.52	3.94	0.05	0.22	1.73

the highest bhusa yield of 9600 kg ha^{-1}. This was followed by T_4 which was on par with T_7, T_6 and T_5. The lowest bhusa yield of 8090 kg ha^{-1} was recorded by T_8 (inorganic NPK alone), then came T_1 (POP recommendation).

4.2.2.3 Total Dry Matter Production

Data pertaining to the total dry matter production showed significant variation. Vermicompost + PSM (T_5) got value of 5283 kg ha^{-1} and was found superior, which was on par with T_7. The lowest mean value obtained for T_8, followed by T_1. This showed the influence of organic matter addition on dry matter increment.

4.2.2.4 Harvest Index

It was noticed that there exists significant influence on harvest index of plants by various treatments. The treatment with POP recommendation (T_1) registered the highest mean value of 0.301 and lowest by T_8 (0.261). All other treatments were found to be on par.

4.3 EFFECT OF ORGANIC FARMING PRACTICES ON QUALITY OF COWPEA

4.3.1 Nutrient Content in Bhusa

Plant nutrient content at 50 per cent flowering and harvest stages were shown in Table 11.

4.3.1.1 Plant N

There was significant difference in N content of plants. A higher value for N at 50 per cent flowering stage and at harvest stage was observed for the treatment T_5 (vermicompost + PSM) (4.07 % and 3.7 % respectively) which was on par with T_4 and the lowest value was recorded by T_8 (2.43 %) followed by T_6 at 50 per cent flowering stage and T_8 followed by T_1 at harvest stage. The higher plant N content was due to higher soil N in vermicompost treatments.

Table 10 Effect of organic farming practices on yield and yield attributes of cowpea

Treatments	Pod yield (kg ha^{-1})	Bhusa yield (kg ha^{-1})	Total dry matter (kg ha^{-1})	Harvest index
T_1	3708	8580	4976	0..301
T_2	3403	9236	5058	0.269
T_3	3476	9376	5170	0.270
T_4	3590	9450	5198	0.274
T_5	3606	9600	5283	0.273
T_6	3450	9400	5140	0.268
T_7	3496	9413	5205	0.268
T_8	2866	8090	4382	0.261
SE	38.78	60.10	26.93	0.003
CD (0.05)	118	182	82	0.009

4.3.1.2 Plant P

The details of plant P showed that at 50 per cent flowering stage, T_5 (vermicompost + PSM) registered a significantly higher value of 0.84 per cent which was on par with T_4. The treatment with inorganic NPK alone got the lowest value (0.53 %). At harvest stage, T_5 recorded superior value of 0.76 per cent. T_8 got the least value of 0.42 per cent. At harvest time T_5, T_3 and T_7 (PSM application) got significantly higher values than T_4, T_2 and T_6 (organic manure alone) respectively. This was due to the influence of PSM on soil P.

4.3.1.3 Plant K

Significant difference in K contents between the treatments can be viewed. Here at both stages, *i.e.*, 50 per cent flowering and harvest stage, T_5 got the highest value (2.58 % and 2.29 % respectively) followed by T_4. T_8 got the lowest value which was on par with T_1. From the data, it can be inferred that organic nutrition enhanced K status in the plant.

4.3.1.4 Plant Ca

Plant Ca showed significant variation between the treatments. At 50 per cent flowering stage, T_5 recorded the highest value of 1.28 per cent followed by T_4. T_8 was found inferior to all the other treatments followed by T_1. Similarly at harvest stage, vermicompost + PSM treatment was found best among the treatments and recorded 1.25 per cent value. This was found on par with T_4. Here also T_8 registered the lowest value followed by T_1. The higher Ca content in T_5 and T_4 can be related to higher uptake of Ca from soil applied with vermicompost.

4.3.1.5 Plant Mg

Significant difference was noticed in Mg content of the plants with different treatments. The highest value of 0.97 per cent was obtained for T_5 followed by T_4. At harvest stage, T_5 and T_4 was seen on par and T_5 got the highest value of 0.76 per cent. In both cases, T_8 was found inferior to all other treatments.

4.3.1.6 Plant S

The values from the table clearly showed the significance of various treatments on plant S. Here at 50 per cent flowering stage and at harvest stage, poultry manure treated plots registered higher values (0.064 for T_7 at 50 per cent flowering and 0.083 per cent at harvest). In both cases the treatment with inorganic NPK alone got the lowest mean value followed by POP recommendation.

4.3.1.7 Plant Fe

Values from the data makes clear that Fe content in plants showed no significant difference among the treatments. However the highest value was obtained by T_3 (953 ppm) at 50 per cent flowering stage and T_4 (449.7 ppm) at harvest stage.

4.3.1.8 Plant Mn

There was significant difference on the Mn content by the different treatments. T_4 got the highest mean value of 693.3, which was on par with T_5 at 50 per cent flowering stage. At harvest time, T_5 got higher value of 369.7 ppm and was on par with T_4. In both cases T_8 got the lowest value and then T_1.

4.3.1.9 Plant Zn

Plant Zn content was studied at both stages and found significant difference between treatments. In both cases T_4 registered the highest value. At 50 per cent flowering, it got 45 ppm and 39 ppm at harvest. It was seen on par with T_5.Inorganic NPK alone treatment was found inferior followed by T_1.

4.3.1.10 Plant Cu

Table 11 indicated significant difference for plant Cu content with the treatments. T_4 got the highest value of 20.3 ppm which was found on par with T_5, T_6 and T_7. The lowest value was for T_8, followed by T_1. Similarly at harvest stage, T_4 registered the highest value of 17.3 ppm which was on par with T_5. The lowest mean value obtained for T_8 and then T_1.

4.3.2 Nutrient Content in Pods

Tables 12 gives idea about the nutrient content in pods. The data showed that almost all the nutrients were significantly varied by the different treatments.

4.3.2.1 Pod N

N content of pods showed significant variation. The highest value was recorded by the treatment T_5 (vermicompost + PSM) *i.e.*, 4.43 per cent. This was found on par with T_4 (vermicompost) and T_1 (POP). The lowest value being for inorganic NPK alone application *i.e.*, 2.73 per cent.

4.3.2.2 Pod P

The table indicated that pod P content was significantly varied by different treatments. T_5 (vermicompost + PSM) got a value of 1.2 per cent which was the highest among the treatments. This was followed by T_4 and T_1 which was found on par. The lowest value was obtained for T_8 (inorganic NPK alone) (0.63 %). Here also PSM applications (T_5, T_3 and T_7) showed significant variation with T_4, T_2 and T_6, indicating the influence of PSM in increasing P content in pods.

4.3.2.3 Pod K

The different treatments showed significant influence on K content of pods. T_5 and T_4 (vermicompost treatments) registered the highest contents followed by T_1. The highest value being 1.91 per cent for T_5. The higher values in all the treatments except T_8 (inorganic NPK alone) can be attributed to organic nutrition.

Table 11 Effect of organic farming practices on nutrient content in plants at 50 per cent flowering and harvest

Treatments	N (50 per cent flowering)	N (Harvest)	P (50 per cent flowering)	P (Harvest)	K (50 per cent flowering)	K (Harvest)
	Percentage					
T_1	3.57	2.63	0.68	0.47	2.02	1.36
T_2	3.40	3.03	0.67	0.52	2.12	1.73
T_3	3.60	3.13	0.71	0.58	2.13	1.71
T_4	3.93	3.60	0.81	0.70	2.52	2.28
T_5	4.07	3.70	0.85	0.76	2.58	2.29
T_6	3.40	3.67	0.64	0.48	2.10	1.72
T_7	3.50	3.30	0.67	0.53	2.08	1.71
T_8	2.43	2.13	0.54	0.42	1.82	1.30
SE	0.10	0.10	0.02	0.01	0.03	0.03
CD (0.05)	0.31	0.32	0.07	0.04	0.08	0.08

Table 11 Continued

Treatments	Ca (50% flowering)	Ca (harvest)	Mg (50% flowering)	Mg (harvest)	S (50% flowering)	S (harvest)
	Percentage					
T_1	1.07	0.88	0.82	0.56	0.051	0.070
T_2	1.09	0.96	0.81	0.63	0.055	0.074
T_3	1.16	0.99	0.86	0.66	0.054	0.073
T_4	1.24	1.19	0.90	0.73	0.056	0.075
T_5	1.28	1.25	0.97	0.76	0.055	0.075
T_6	1.08	0.97	0.82	0.61	0.062	0.082
T_7	1.16	1.02	0.85	0.64	0.064	0.083
T_8	0.80	0.68	0.67	0.43	0.039	0.048
SE	0.01	0.02	0.01	0.02	0.001	0.001
CD (0.05)	0.03	0.07	0.03	0.05	0.003	0.004

Table 11 Continued

Treatments	Fe (50% F)	Fe (Har)	Mn (50% F)	Mn (Har)	Zn (50% F)	Zn (Har)	Cu (50% F)	Cu (Har)
	ppm							
T_1	945.6	441.3	613.7	315.7	31.0	24.6	11.0	8.33
T_2	932.3	433.7	620.0	344.7	32.7	29.0	13.0	10.0
T_3	953.0	444.3	619.3	337.3	34.7	28.0	15.7	12.3
T_4	948.3	449.7	693.3	363.3	45.0	39.0	20.3	17.3
T_5	943.6	432.3	689.3	369.7	45.0	37.7	20.0	17.0
T_6	935.7	425.0	629.0	334.3	35.7	32.3	17.7	14.7
T_7	925.0	439.0	634.7	338.3	36.7	31.3	17.7	15.3
T_8	946.0	426.3	544.0	273.3	23.0	18.0	7.0	4.3
SE	11.5	15.8	13.5	16.7	1.63	0.78	0.88	0.57
CD (0.05)	NS	NS	41	50.8	4.94	2.36	2.67	1.71

F – Flowering Har – Harvest

4.3.2.4 Pod Ca

Effect of organic manure addition was significant in influencing Ca content in pods. Among the different treatments, T_5 (vermicompost + PSM) got a value of 0.69 per cent, which was found the highest and was on par with T_4. Here also the treatment with only inorganic fertilizer registered the lowest value of 0.45 per cent.

4.3.2.5 Pod Mg

The different sources of organic manures could make significant difference in Mg content in pods. The highest value for pod Mg was registered by T_5 (vermicompost + PSM) (1.48 %) followed by T_4 (vermicompost). The lowest value obtained for T_8 (inorganic NPK alone) (0.763 %). The higher soil and plant Mg in vermicompost treatments, can be attributed as the reason for higher Mg in pods.

4.3.2.6 Pod S

Observations on pod S content revealed that significant variation existed among the different treatments. The highest value of 0.27 per cent was obtained for T_6 (poultry manure) followed by T_7 treatment (poultry manure + PSM). Both are on par. Inorganic NPK alone application (T_8) got the lowest value of 0.21 per cent.

4.3.2.7 Pod Fe

It was noticed that there existed no significant difference in pod Fe between the different treatments. Among the treatments, T_5 (vermicompost + PSM) application recorded the value of 859.7 ppm which was found the highest.

4.3.2.8 Pod Mn

Organic nutrition could produce significant influence on pod Mn. Treatment T_4 (vermicompost) recorded the highest value of 670 ppm. This was on par with the other treatments T_5, T_7 and T_2. Treatment with no manure addition (T_8) was found inferior to all other treatments with value of 603.3 ppm.

4.3.2.9 Pod Zn

Organic matter application showed marked influence on Zn content in pods. The highest value was for T_4 *i.e.*, 58.3 ppm and was on par with T_5, T_6 and T_7, the lowest being for T_8.

4.3.2.10 Pod Cu

The different treatments significantly influenced pod Cu content. Treatments receiving vermicompost *i.e.*, T_5 (vermicompost + PSM) got value of 28.7 ppm (the highest) and found on par with T_4 (vermicompost alone) (28 ppm). The treatment with inorganic NPK alone got the lowest value (7ppm). The significantly higher micronutrient content in the treatments having organic nutrition compared to inorganic alone treatment (T_8), could be due to the chelation effects of organic matter, which supplied those nutrients, otherwise had been lost.

4.3.3 Quality Aspects of Pod

The various quality aspects of pod like fibre content, protein content, shelf life and organoleptic studies were presented in Table 13.

4.3.3.1 Crude Fibre Content

Crude fibre content of pods at harvest indicated that inorganic NPK application (T_8) resulted in the highest fibre content of 15.67 %. This was followed by T_1 (POP recommendation) which was found on par with all other treatments. The higher value indicates low quality of the produce. The lowest value was with T_5 (8.5%) which was on par with T_4

4.3.3.2 Crude Protein Content

The table showed the level of crude protein content by the different treatments. An increased value compared to inorganic fertilizer application was noticed with the different sources of manures. Vermicompost application (T_4 and T_5) resulted the highest value of 26.7 per cent and was on par with T_1. T_8 got the lowest value of 17.1 per cent.

Table 12 Effect of organic farming practices on nutrient composition of pod

Treatments	N	P	K	Ca	Mg	S
	Percentage					
T_1	4.13	1.03	1.85	0.59	1.28	0.219
T_2	3.70	0.78	1.77	0.57	1.32	0.223
T_3	3.83	0.83	1.75	0.61	1.38	0.224
T_4	4.27	1.05	1.90	0.65	1.43	0.223
T_5	4.43	1.20	1.91	0.69	1.48	0.224
T_6	3.83	0.82	1.75	0.59	1.32	0.271
T_7	3.83	0.89	1.73	0.62	1.38	0.265
T_8	2.73	0.63	1.58	0.45	0.76	0.205
SE	0.11	0.01	0.02	0.01	0.01	0.004
CD (0.05)	0.35	0.04	0.05	0.04	0.04	0.013

Table 12 Continued

Treatments	Fe	Mn	Zn	Cu
	ppm			
T_1	838.7	628.7	42.0	11.0
T_2	822.0	639.7	47.0	15.6
T_3	842.3	629.0	46.7	15.3
T_4	836.0	670.0	58.3	28.0
T_5	859.7	669.7	57.0	28.7
T_6	847.7	637.0	53.7	23.0
T_7	820.0	642.3	53.7	21.0
T_8	835.7	603.3	26.0	7.0
SE	10.42	10.48	2.09	1.66
CD (0.05)	NS	31.8	6.36	5.03

4.3.3.3 Shelf Life

Shelf life of pods were studied. The data showed T_5, T_4 and T_2 got significantly higher values, the highest being 6.3 for T_5 and T_4. T_8 (inorganic NPK alone) got the lowest value.

4.3.3.4 Organoleptic Evaluation

The score mean values proved that organic nutrition showed significant influence on various characters like appearance, texture and palatability. Vermicompost and farmyard manure treated plots (T_4, T_5, T_6 and T_7) got the highest value for appearance *i.e.,* 3.7. T_3 and T_2 were found to be on par. In case of texture, T_6 got the highest value of 4, and found on par with T_5, T_4 and T_7. In case of palatability also, the results were found similar. In all the case, it could be observed that organic manure application enhanced the quality. T_8 (NPK alone) was found inferior followed by T_1 (POP recommendation).

4.3.4 Uptake of Nutrients

Uptake of nutrients by the crop was worked out. The bhusa uptake, pod uptake and total uptake at harvest were shown separately.

4.3.4.1 Bhusa Uptake

Bhusa uptake recorded at harvest stage was given in Tables 14. It was observed that the different treatments showed significant influence on the uptake of nutrients by bhusa.

Among the different treatments, the highest value for N, P, K, Ca, and Mg was recorded by the combined application of vermicompost and PSM and was found on par with T_4 in case of all the nutrients except N and P. For N, T_5 showed significant difference from T_4, T_7 from T_6 and a higher value for T_3 compared to T_2 which makes importance of nodulation on N fixation. In the treatments with T_7, T_5 and T_3, in addition to the different organic manures, there was supplementation with PSM, which increased nodulation and subsequently N fixation and N uptake. For P

Table 13 Effect of organic farming practices on quality aspects of pod

Treatments	Fibre Content (%)	Protein Content (%)	Shelf Life (days)	Appearance (score)	Texture (score)	Palatability (score)
T_1	11.6	25.9	4.7	2.3	2.3	2.3
T_2	10.2	23.1	5.7	3.3	2.7	2.7
T_3	10.0	23.1	5.3	3.3	2.7	2.7
T_4	8.7	26.7	6.3	3.7	3.7	3.3
T_5	8.5	26.7	6.3	3.7	3.7	3.7
T_6	9.4	24.0	4.3	3.7	4.0	4.0
T_7	9.3	22.5	5.3	3.7	3.7	3.7
T_8	15.67	17.1	4.3	1.3	1.3	1.7
SE	1.04	0.72	0.27	0.32	0.31	0.31
CD (0.05)	3.15	2.2	0.81	0.97	0.93	0.93

uptake also similar results were observed. It could be viewed that in all cases, inorganic NPK application alone resulted the lowest uptake followed by T_1. Values of T_5 are N- 142.1 kg ha^{-1}, P- 29.2 kg ha^{-1}, K- 87.93 kg ha^{-1}, Ca- 48 kg ha^{-1} and Mg with 29.2 kg ha^{-1}.

S uptake of plants showed marked influence. Poultry manure application was found superior, whereas T_8 (inorganic NPK alone) registered the lowest value. The highest value was for T_7 *i.e.*, 3.13 kg ha^{-1}.

No significant difference was shown by the different treatments regarding Fe uptake by bhusa. However, the highest value was for T_4 (449.7 mg kg^{-1}).

All the treatments with vermicompost *i.e.*, T_4 and T_5 got significantly higher values for Mn, Zn and Cu uptake, when compared to the other treatments. T_8 was found inferior in all cases.

4.3.4.2 Pod Uptake

The uptake of different nutrients by pods was significantly influenced by the different treatments given in Table 15.

The data showed that, the highest mean value for N, P and K uptake was recorded by vermicompost + PSM (T_5) application. This was seen on par with POP recommendation (T_1) and T_4 (vermicompost). The highest values being 63.45 kg ha^{-1} for N, 17.2 kg ha^{-1} for P and 27.54 kg ha^{-1} for K. For the three nutrients, the inferior treatment found was T_8 (inorganic NPK alone). As in the case of bhusa uptake, P uptake by pods also showed significantly higher values for PSM application.

Organic matter application significantly increased Ca and Mg uptake by pod. Vermicompost application resulted better uptake, the highest value being T_5 *i.e.*, 9.43 kg ha^{-1} for Ca and 21.19 kg ha^{-1} for Mg. T_4 was on par with T_5. In both cases T_8 was found to be the lowest.

Poultry manure application (T_6 and T_4) markedly influenced the S uptake by pods. It was seen that the treatment without manure addition

Table 14 Effect of organic farming practices on uptake of nutrients by bhusa

Treatments	N	P	K	Ca	Mg	S
	kg ha^{-1}					
T_1	89.23	16.23	46.70	30.20	19.20	2.40
T_2	111.80	19.10	63.80	35.42	22.87	2.70
T_3	117.38	21.75	64.10	36.75	24.37	2.73
T_4	137.00	26.60	86.40	45.30	27.80	2.85
T_5	142.01	29.20	87.93	48.00	29.20	2.88
T_6	115.01	18.00	64.40	36.47	21.30	3.07
T_7	124.7	19.70	64.60	38.60	24.17	3.13
T_8	68.93	13.60	42.10	22.00	13.90	1.61
SE	1.81	1.18	1.32	1.39	1.00	6.73
CD (0.05)	5.50	3.60	4.00	4.21	3.00	0.20

Table 14 Continued

Treatments	Fe	Mn	Zn	Cu
	mg kg^{-1}			
T_1	441.3	315.7	24.6	8.33
T_2	433.7	344.7	29.0	10.0
T_3	444.3	337.3	28.0	12.3
T_4	449.7	363.3	39.0	17.3
T_5	432.3	369.7	37.7	17.0
T_6	425.0	334.3	32.3	14.7
T_7	439.0	338.3	31.3	15.3
T_8	426.3	273.3	18.0	4.3
SE	15.8	16.7	0.78	0.57
CD (0.05)	NS	50.8	2.36	1.71

was having the lowest value. All other treatments were on par. The highest value was recorded by T_6 *i.e.,* 3.7 kg ha^{-1}.

The different treatments showed no significant influence on Fe uptake by pods. The highest value was for T_5 and the lowest for T_7.

Significant difference was shown by the different treatments for Mn uptake. T_4 got the highest value of 670 mg kg^{-1}. It was found on par with T_5, T_7 and T_2. The lowest being 603.3 mg kg^{-1} for T_8.

For Zn uptake, vermicompost and poultry manure application got significantly higher values compared to treatments with farmyard manure, POP recommendation and inorganic alone application. T_4, T_5, T_6 and T_7 were found on par, T_4 got the highest value of 58.3 mg kg^{-1} and the lowest was for T_8.

Significant variation was observed for Cu uptake for organic nutrition. All the treatments where organic matter alone was added,got significantly higher values, the highest registered by T_5 (28.7 mg kg^{-1}). T_8 got the lowest value which was found on par with POP recommendation.

4.3.4.3 Total Uptake

It was seen from Table 16 that the total uptake values for almost all the nutrients showed marked variation with the different treatments.

In the case N, P, K, Ca and Mg uptake, T_5 got the highest value and was found to be on par with T_4. In the case of P and Ca uptake, T_5 significantly differed from T_4. The highest value obtained were 205.5 kg ha^{-1} (N), 46.5 kg ha^{-1} (P), 115.47 kg ha^{-1} (K), 57.9 kg ha^{-1} (Ca) and 50.37 kg ha^{-1} (Mg). For N and P uptake, the pronounced effect of PSM was noticed. T_5, T_3 and T_7 treatments got significantly higher values than the treatments having organic manures alone (T_4, T_2 and T_6) respectively. In all the cases inorganic NPK application registered the the lowest values.

T_6 and T_7 got significantly higher values for total S uptake. Inorganic alone treatment got the least value. All other treatments in between were found to be on par.

Table 15 Effect of organic farming practices on uptake of nutrients by pod

Treatments	N	P	K	Ca	Mg	S
	kg ha^{-1}					
T_1	62.94	15.69	27.20	8.99	19.50	3.35
T_2	50.35	10.61	24.08	7.75	17.96	2.97
T_3	52.80	11.53	24.32	8.97	19.18	3.03
T_4	60.88	14.86	26.90	9.20	20.24	3.10
T_5	63.45	17.20	27.54	9.43	21.19	3.17
T_6	52.44	11.31	24.15	8.13	18.21	3.70
T_7	53.12	12.44	24.18	8.63	19.29	3.60
T_8	30.94	7.20	18.10	5.13	8.70	2.27
SE	1.01	0.55	0.85	0.30	0.97	0.10
CD (0.05)	3.05	1.68	2.59	0.91	2.96	0.31

Table 15 Continued

Treatments	Fe	Mn	Zn	Cu
	mg kg^{-1}			
T_1	838.7	628.7	42.0	11.0
T_2	822.0	639.7	47.0	15.6
T_3	842.3	629.0	46.7	15.3
T_4	836.0	670.0	58.3	28.0
T_5	859.7	669.7	57.0	28.7
T_6	847.7	637.0	53.7	23.0
T_7	820.0	642.3	53.7	21.0
T_8	835.7	603.3	26.0	7.0
SE	10.42	10.48	2.09	1.66
CD (0.05)	NS	31.8	6.36	5.03

No significant difference was noted by the different treatments for total Fe uptake. But the highest value (129.7 mg kg^{-1}) was obtained for T_5 and the lowest for T_2.

The data from Table 16 makes clear the importance of organic nutrition on uptake of Mn, Zn and Cu. Vermicompost was found superior to all the treatments. T_5 got the highest value of 1040 mg kg^{-1} for Mn. T_4 and T_2 found on par. In the case of Zn, T_4 got value of 97 mg kg^{-1} and found on par with T_5. For Cu, T_5 and T_4 found on par and the highest being 46 mg kg^{-1} was registered to T_5. In all case inorganic NPK alone was found inferior, followed by POP recommendation (T_1).

4.4 CORRELATION STUDIES

Correlation between yield and soil and plant characters were studied and the results were presented hereunder

4.4.1 Yield and Soil Properties

The physical properties *viz.*, water holding capacity and porosity were significantly and positively correlated with pod yield (Table 17), but bulk density and temperature showed significant negative correlation. Among the chemical properties pH and organic C showed significant positive correlation with yield.

At harvest stage, a positive and significant correlation with yield was shown by available soil nutrients(N, K, Ca, Mg, Mn, Zn and Cu).

Soil enzyme studies showed that both dehydrogenase and phosphatase showed significant positive correlation with yield.

4.4.2 Yield and Growth Characters

It was revealed from the data presented in Table18 that yield was significantly and positively correlated with height of plant, leaf area index, number and weight of nodules. Maximum r value was obtained for weight of nodule (0.772*).

Table 16 Effect of organic farming practices on total uptake of nutrients

Treatments	N	P	K	Ca	Mg	S
	kg ha^{-1}					
T_1	152.12	31.90	74.25	39.19	38.70	5.75
T_2	162.16	29.57	87.90	43.17	40.83	5.70
T_3	170.20	33.27	88.40	45.20	43.57	5.77
T_4	197.90	41.50	113.30	54.29	48.00	5.96
T_5	205.50	46.50	115.47	57.90	50.37	6.03
T_6	167.30	29.35	88.67	44.40	41.13	6.76
T_7	177.90	32.30	88.80	47.20	43.17	6.73
T_8	99.90	20.80	60.13	27.13	22.60	3.90
SE	3.18	1.58	2.19	1.49	1.78	0.15
CD (0.05)	9.66	4.78	6.66	4.54	5.39	0.47

Table 16 Continued

Treatments	Fe	Mn	Zn	Cu
	mg kg^{-1}			
T_1	1280.0	945	66	19.3
T_2	1256.0	985	76	26.0
T_3	1288.3	966	75	27.0
T_4	1286.0	1033	97	45.0
T_5	1291.7	1040	94	46.0
T_6	1272.0	971	83	37.0
T_7	1259.0	980	85	36.3
T_8	1261.0	876	44	11.3
SE	60.90	21.9	1.85	1.34
CD (0.05)	NS	66.6	5.60	4.08

4.4.3 Yield and Yield Attributes

All the yield attributes were significantly influenced (Table 18). Bhusa yield, total dry matter production and harvest index showed positive and significant correlation with yield. Maximum r value seen with harvest index (0.743*).

4.4.4 Yield and Nutrient Composition of Crop

At harvest stage, N, P, K, Ca, Mg, Zn and Cu content of pods showed significant positive correlation (Table19), the highest value being 0.829 for N.

4.4.5 Yield and Quality Aspects

From Table 20, it can be viewed that among the different quality attributes, protein content showed significant positive correlation, whereas fibre content showed significant negative correlation.

4.4.6 Yield and Nutrient Uptake

Total uptake of N, P, K, Ca, Mg, S, Mn and Zn was found to be significant and positively correlated with pod yield (Table 21). Highest correlation was shown with N (0.654).

Thus from the results it could be observed that organic matter addition significantly influenced the soil physical, chemical and biological properties. Among the different manures, vermicompost addition showed significantly higher values. Regarding the growth characters also organic nutrition played significant role, especially vermicompost. But concerning yield of the crop, integrated nutrient management (POP) and vermicompost addition were found to be on par. The role of PSM in enhancing soil nutrient P could be clearly understood from the results.

Table 17 Correlation between yield and soil properties

i. Soil physical properties at harvest stage

	Yield
Bulk density	-0.542*
Water holding capacity	0.627*
Temperature	-0.578*
Porosity	0.568*

ii. Soil chemical properties at harvest stage

pH	0.526*
Organic C	0.504*
C : N ratio	-0.066
CEC	0.405

iii. Soil nutrient status at harvest stage

N	0.573*
P	0.427
K	0.508*
Ca	0.504*
Mg	0.606*
Mn	0.672*
Zn	0.598*
Cu	0.592*

iv. Soil enzyme activity at harvest stage

Dehydrogenase	0.524*
Phosphatase	0.592*

Table 18 Correlation between growth characters and yield attributes on yield

i. Growth characters	**Yield**
Height of plant	0.464*
Leaf area index	0.499*
Number of nodule	0.556*
Weight of nodule	0.772*
ii. Yield attributes	
Bhusa yield	0.461*
Total dry matter	0.733*
Harvest index	0.743*

Table 19 Correlation between yield and nutrient composition of pod

Nutrient status of pod	Yield
N	0.829*
P	0.757*
K	0.737*
Ca	0.733*
Mg	0.785*
S	0.211
Fe	0.115
Mn	0.455
Zn	0.606*
Cu	0.380

Table 20 Correlation between yield and quality aspects of pod

Quality aspects	Yield
Fiber content	-0.577*
Protein content	0.810*
Shelf life	0.216
Appearance	0.403*
Texture	0.394
Palatability	0.367

Table 21 Correlation between yield and total nutrient uptake

Total nutrient uptake	Yield
N	0.654*
P	0.593*
K	0.466*
Ca	0.574*
Mg	0.71*
S	0.633*
Mn	0.982*
Zn	0.547*
Cu	0.427

Discussion

5. DISCUSSION

A field experiment was conducted during October 2004 to February 2005 at the Instructional Farm, College of Agriculture, Vellayani to study the effect of organic farming on soil health, yield and quality of vegetable cowpea. A critical analysis of the results of the experiment revealed marked response of the crop to organic nutrition. The results generated from the present study are discussed in the light of published information and fundamental theoretical knowledge.

5.1 EFFECT OF ORGANIC FARMING PRACTICES ON SOIL PROPERTIES

The details pertaining to the difference in organic, integrated and inorganic nutrition on the physical, chemical and biological properties of the soil collected at 50 per cent flowering stage and harvest stage is discussed hereunder.

5.1.1 Physical Properties

Observations showed that bulk density was significantly influenced by the addition of organic manures (Fig. 3). At 50 per cent flowering and harvest stage, vermicompost treated plots showed significantly lower values, the lowest was for T_5 (vermicompost + PSM). All other treatments receiving organic nutrition also recorded lower values compared to treatments receiving inorganic fertilizer alone. The next higher value was for POP recommendation. The decrease in bulk density was noted to be 11 per cent for T_5 compared to T_8 at 50 per cent flowering stage and 12 per cent decrease at harvest stage. The organic matter present in the surface soil, either by addition of farmyard manure, vermicompost or poultry manure reduced the surface bulk density. The findings of Khaleel *et al.* (1981) corroborate with the present result. According to Brady (1996), organic matter was a major agent that stimulated the formation and stabilization of granular and crumb type aggregates. As organic residues decompose, jells and other viscous microbial products are evolved which along with associated fungi and bacteria encourage the crumb formation and net effect of these activities would decrease bulk density and increase porosity as reported by Helkiah *et al.* (1981) and Loganathan (1990). Higher bulk density indicates soil compactness and is unfavourable for crop growth. An increase in organic matter decreased the bulk density of soil which is optimum for plant growth (Das and Agarwal, 2002).

As in Fig.3, the different treatments significantly influenced the water holding capacity. It was noted that water holding capacity increased by 24 per cent for T_4 (vermicompost) at 50 per cent flowering stage and 39 per cent for T_5 (vermicompost + PSM) at harvest as compared to T_8 (inorganic alone). T_5 and T_4 was found to be on par in both the cases. These findings were in support of the view of Khaleel *et al.* (1981) who stated that higher organic matter addition could increase the organic carbon content of the soil which resulted in an increased water holding capacity of the soil. In this study, it could be inferred that addition of organic manures had significant influence on water holding capacity over inorganic fertilizers. Application of chemical fertilizers reduced the aggregate stability of the soil and resulted in poor water holding capacity of the soil. This is in conformity with the findings of Sarkar *et al.* (1989). The greater water holding capacity of all organic treatments was due to the fact that humus can absorb water from two to six times its own weight (Kohnke, 1968). The water retention capacity is more pronounced with high organic matter content, basically due to its qualitatively higher net negative charges and the dipolar nature of water molecules. Besides, the greatest influence of organic matter on water retention is attributed to the structural changes brought about by the organic matter, through the changes in pore size both within and between the soil aggregates (Larson and Clap, 1989). Also humic materials play significant role in lowering the surface tension of water and so increase wettability. Humic acids and fulvic acids are predominantly hydrophilic.

Regarding porosity (Fig.3), manure in the form of vermicompost showed a significant increase of 16 per cent for T_5 (vermicompost + PSM) at 50 per cent flowering stage and 16 per cent for T_4 (vermicompost) at harvest when compared to the treatment where no organic matter was added. Soil organic matter is responsible to very great extent, directly or indirectly for making the physical environment of the soil suitable for the growth of crops. It exerted this benefit largely through its effect on improving soil aggregation and porosity which inturn influenced soil structure, water infiltration, moisture conservation, drainage, tilth, aeration, temperature, microbial activities etc. The beneficial effects of organic amendments on various soil properties was reported by Aravind (1987). Similar results obtained by Rajalekshmi (1996).

The data from Fig.3 showed the influence of different organic manures on soil temperatures. For both stages of soil analysis, T_8 got the highest value and the treatments T_4 and T_5 (vermicompost treatments) registered the lowest values. The lower values for the organic addition were due to the higher specific heat capacity of organic matter and may also be due to the higher water holding capacity. Since vermicompost is a completely decomposed organic manure, no further heat expulsion is there. Because of more moisture retention in vermicompost treatments, temperature recorded was less. This was due to the high specific heat capacity and evaporative cooling of water.

5.1.2 Chemical Properties

As a key factor in deciding the availability of various nutrients, the data on changes in pH under various treatment conditions was discussed hereunder (Fig. 4). The initial pH of the soil under study was determined to be 5.2. There was slight increase in pH for all the treatments receiving organic nutrition. Among all the manures, vermicompost was found

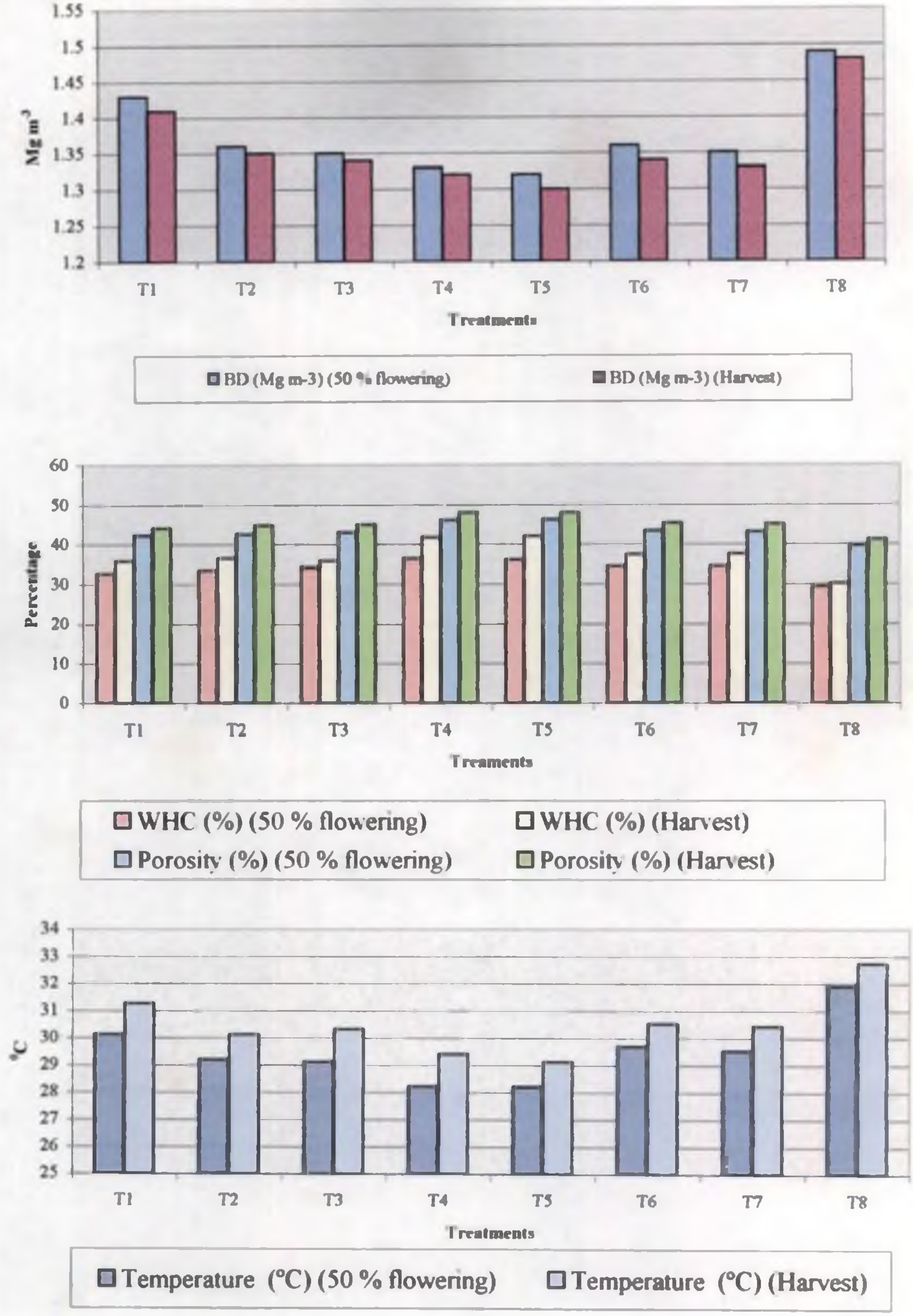


Fig. 3. Effect of organic farming practices on soil physical properties

superior. The values showed increase from 50 per cent flowering to harvest stage also.

The observed enhancement of pH was due to the suppression of the activity of Fe and Al oxides and hydroxides,which played a vital role in protonation–deprotonation mechanism,controlling the H^+ ion concentration in soil solution. Thus the proton source sites were temporarily blocked and the exchange complex was modified by the degradation products of organic manure. This process considerably reduced the proton concentration in soil solution by suppressing the step-wise hydrolysis of Fe and Al compounds (Wiklander, 1964). Hence a substantial portion of potential acidity was rendered inactive which resulted in a relative environment of soil solution with OH^- ions. Further, sudden release of bases by the active degradation of organic matter also contributed to the observed increase in pH. The higher value of vermicompost treated plots was due to the fact that because of the excretion of NH_4^+ ions from calciferous glands of earthworms, the wormcasts had a pH near to neutral range (Basker *et al.*, 1994). The calciferous glands in earthworm contain carbonic anhydrase which catalyse the fixation of CO_2 as calcium carbonate and prevent any fall in pH.

The mean values of organic C expressed in percentage were presented in Fig.4. The data showed significantly lower values for the treatments which did not receive any organic manures (T_8) during 50 per cent flowering and harvest stages. Among the various treatments receiving organic manure, T_5 (vermicompost + PSM) and T_4 (vermicompost) recorded top most values *i.e.*, an increase of 46 per cent and 57 per cent at 50 per cent flowering and at harvest stage respectively for T_4 over T_8. Similar results were showed by Bijulal (1997) and Sheeba (2004). There was a decrease in organic C content in all the treatments at harvest time compared to the content at 50 per cent flowering stage. The observed decrease in organic C content with time after a peak was due to active mineralisation and loss of carbon as CO_2. Thus a substantial amount of C is oxidised and lost through metabolic activities of microbial proliferation. Halvorson *et al.* (1999) reported that, by organic matter addition, there was increased root biomass production, which resulted in increased C content in soil.

Being an index to determine the optimum availability of N, the C : N ratio had an important role in plant nutrition. A close scrutiny of the results presented in Fig.4 on C : N ratio showed a decreasing trend with advancement of time. Farmyard manure treatments got higher values at 50 per cent flowering stage. But at harvest, the lowest value was for the treatments receiving vermicompost, showing desirable rate of mineralisation and faster decomposition. The general decrease in C : N ratio observed in samples treated with organic amendments with time was theoretically sound, as decomposition of bulky organic matter always registered a decrease in C : N ratio (Gaur, 1994). The enhanced effects of vermicompost was due to higher nutrient availability and the narrowing down of C : N ratio during the crop period. N fixing bacteria present in vermicompost also indirectly helped in decreasing C : N ratio by making available more N from added organic matter (Lee, 1985 and Shinde *et al.*, 1992).

The change in CEC as shown in Fig.4 indicated the significance of organic manures on ion exchange capacities of soil. It was clear that among the different treatments, T_5 got the highest value followed by T_4 (both are treatments receiving vermicompost). CEC of treatments getting organic amendments registered higher values than other treatments without organics. The degradation products of organic matter with high CEC and surface area had directly contributed to this observed increase (Wiklander, 1964; Thompson *et al.*, 1989). Vermicompost with higher amounts of active humic fraction having high CEC had thus resulted in maximum enhancement of this parameter. A decline in CEC values were observed at harvest stage for all the treatments. This might be due to the interaction of the active organic fraction with the inorganic constituents of the soil blocking some of the exchange sites. A typical value of CEC of soil humic colloids is of the order of 200-250 cmol (p^+) kg^{-1} or even higher (Sanyal, 2002). One gram organic carbon has got a CEC of 3.36 cmol (p^+) kg^{-1}.

5.1.3 Soil Nutrient Availability

5.1.3.1 Available Nitrogen

Being the most important nutrient in plant nutrition, the data (Fig.5) on available N need a thorough study and interpretation. From this observation it was clear that both the treatments receiving vermicompost *i.e.*, T_5 and T_4 are significantly superior in providing available N compared to the other treatments, at 50 per cent flowering and at harvest stage. An increase of 56 per cent available N for T_5 over T_8 was noticed at 50 per cent flowering stage. In general, the higher values for available N at 50 per cent flowering stage compared to the nutrient content at harvest stage can be attributed to the crop removal. At harvest stage, T_5 (vermicompost + PSM) registered 63 per cent increase for available N when compared to T_8 treatment.

The higher degree of decomposition and mineralisation in vermicompost was one of the reasons for high N status in T_5 and T_4 (Shuxin *et al.*, 1991). This was also supported by the view of Bhawalkar (1993) that incorporation of wormcasts enriched in N also increased the N content in vermicompost. Beneficial microorganisms like N fixing, cellulose decomposing and P solubilising organisms are present in vermicompost which also contributed to the higher N status.

It was reported that vermicompost had a high urease activity than soil and other compost materials (Bremner and Mulvaney, 1978). The process of aminisation, ammonification and oxiditave deamination, all

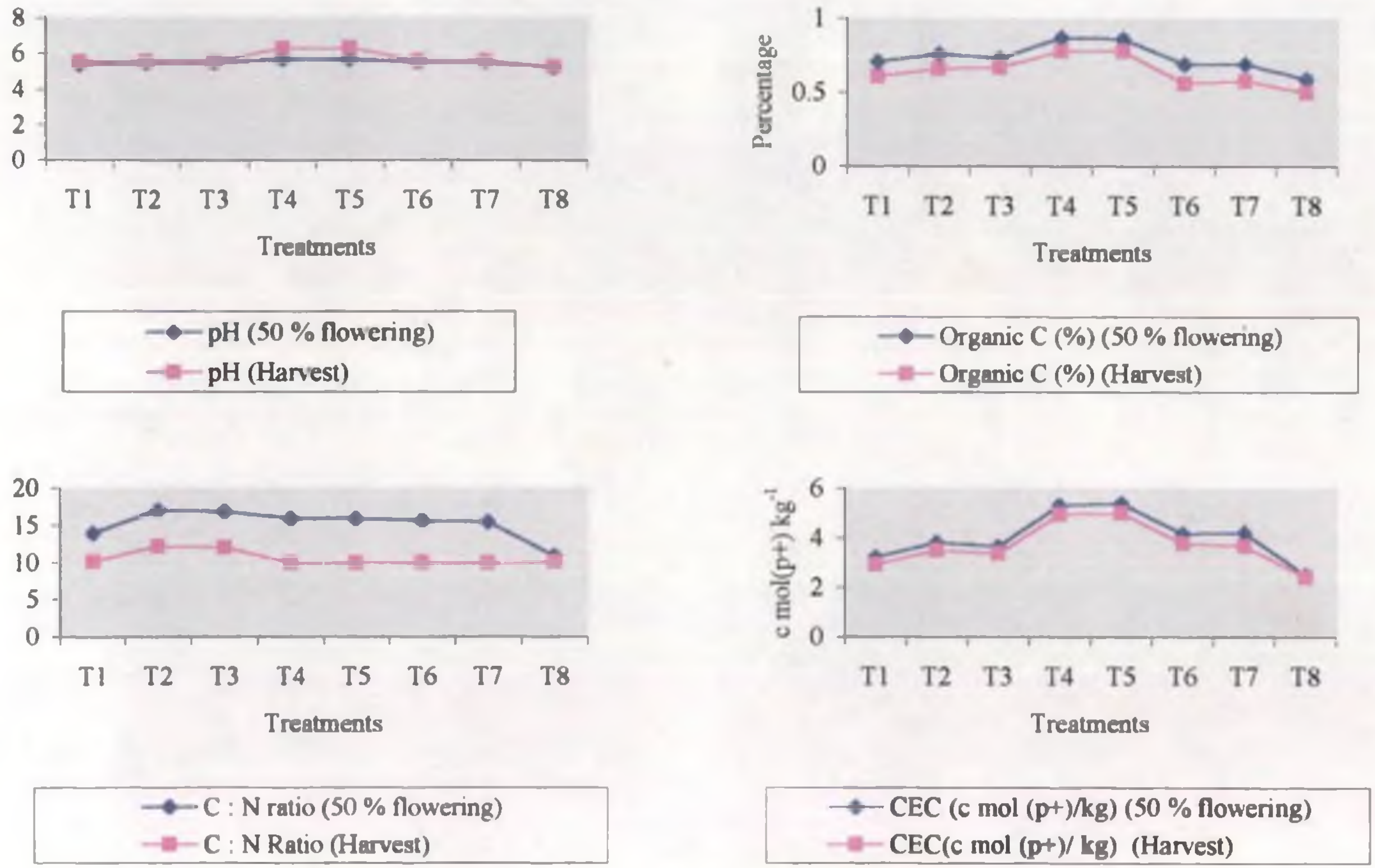


Fig. 4. Effect of organic farming practices on soil chemical properties

brought about by microbially mediated enzyme systems are active in vermicompost and other organic amendments, thus contributing more of soluble N to the soil N economy. In addition to this, soluble N compounds excreted, secreted and synthesized by microbial population was also more in soils treated with organic amendments. The beneficial microflora present in the alimentary system of earthworms also contributed to enhance the N levels in the case of vermicompost.

5.1.3.2 Available P

The quantity of available P_2O_5 is considered to be very important, since it directly reflected the immediate P nutrition to plants. Application of any of the organic amendments (vermicompost, farmyard manure or poultry manure) showed significantly higher values when compared to T_8 (inorganic alone) at both the stages of soil analysis. An increase of 63 per cent in available P was noticed at 50 per cent flowering stage and 79 per cent at harvest, when compared to control (T_8). In addition to this, the influence of PSM in enhancing the P solublisation of native P could be understood clearly. The treatments, T_3, T_5 and T_7 in which PSM was included in addition to the organic manures got values significantly higher from the corresponding treatments which excluded PSM (*i.e.*, T_2, T_4 and T_6).

The high microbial activity and enhanced mineralisation of soil P coupled with high phosphatase activity are some of the reasons for high Bray extractable P obtained (Alexander, 1978; Sharpley and Syres, 1977). Though the same mechanism is applicable to all treatments with organics, the effectiveness of vermicompost was more pronounced in the process than other organic amendments. The liberation of P by decomposition of organic matter is also one of the mechanism contributing available P. Hence the easily decomposable vermicompost could build up a high phosphate labile pool in soil than farmyard manure and poultry manure application. The chances of P released by ligand exchange and by anion exchange with silicates, humates, citrates and OH^- ions cannot be ruled out in any soil system treated with large dose of organic manure (Alexander, 1978). The use of P solubilising culture (PSM) increased available P content in soils, by converting insoluble organic and inorganic phosphatic compounds into soluble form (Mohod *et al.*, 1989).

5.1.3.3 Available K

The details relating to the changes in available K_2O due to the effect of various treatments are presented in Fig. 5. Among the treatments, those receiving vermicompost (T_5 and T_4) registered the highest values at 50 per cent flowering stage and also at harvest stage. A decline in value was observed at the second stage compared to 50 per cent flowering stage which corresponds to the nutrient uptake by the crop. The percentage increase recorded for T_5 compared to T_8 (inorganic alone) were 38 per cent at 50 per cent flowering and 43per cent at harvest stage.

Bano *et al.* (1987) observed considerable variation in the K_2O content of compost when earthworms were used as biological agents for degradation of wastes. Since vermicompost is neutral to alkaline in reaction, much of NH_3 in organic matter was converted to NH^+ ions by accepting protons. According to Aldag and Graff (1975), K^+ ions form edge, wedge or interlayer sites within clay minerals, could possibly be replaced by NH_4^+ ions of similar ionic radius, the concentration of which was increased in the presence of vermicompost. Results of the present study involving available K support this preposition. Basker *et al.* (1994) also reported that the total contribution of K to the soil K pool, which varies with organic source, was also one of the factors affecting the K availability. As the microbial and enzyme activity was reported to be more in vermicompost, the K build up in the soil solution was also more.

5.1.3.4 Exchangeable Ca

As seen from Fig. 5, the exchangeable Ca content of soil was the highest in the treatments with vermicompost (T_5 and T_4). In all the treatments, there was a general trend of decline in values at harvest stage from 50 per cent flowering stage. A percentage increase of 80 was observed for T_5 at 50 per cent flowering stage and 91 at harvest stage from the treatment which received only inorganic nutrition.

The high Ca content of vermicompost was reported by Kale and Krishnamoorthy (1980) and Shuxin *et al.* (1991). Kale and Krishnamoorthy also reasoned the decline in Ca content at harvest as due to the microbial immobilization and reaction with soil components leading to temporary fixation of Ca. The superiority of vermicompost over other treatments was due to a higher Ca content of 0.35 per cent in it (Bijulal, 1997). As per the report of Pierce (1972) species with active calciferous glands absorb excess Ca from their diet and transferred it to calciferous glands from which it was excreted via the digestive tract, thereby increasing the exchangeable Ca content in the soil.

5.1.3.5 Exchangeable Mg

The dynamics of Mg closely follows the trend of Ca with increased concentration at 50 per cent flowering stage than at harvest stage (Fig.5). As in the case of Ca, here also treatments receiving vermicompost (T_4 and T_5) obtained significantly higher values. The treatment maintained their superiority at both stages. The increase in content of exchangeable Mg calculated were 64 per cent at 50 per cent flowering stage and 85 per cent at harvest from T_8 values.

The results obtained were similar to the findings of Rajalekshmi (1996). From the nutrient analysis of vermicompost, done by her the Mg percentage obtained was 1.34 which was higher than the content in farmyard manure and poultry manure. This increased the exchangeable Mg content in soils treated with vermicompost. The higher values in organic treated plots compared to inorganic NPK application alone was mainly due to decomposition of organic amendment,chiefly by enhanced microbial proliferation. Subsequent decline at harvest stage was due to various reactions with inorganic soil components, organic fractions, microbial immobilization and plant uptake.

5.1.3.6 Available S

The Fig. 5 presents data of available S status of the soil, by the different treatments. The initial S content in the soil before the various treatment application was 11 kg ha^{-1}, which increased to the tone of 82 per cent at 50 per cent flowering stage and 87 per cent at harvest for the treatment with poultry manure and PSM (T_7). This was closely followed by T_6, both of which were on par. Besides this, a general increase for available S was noticed in all the treatments receiving organic nutrition when compared to T_8 (inorganic alone). The superiority of treatments receiving organic amendments in augmenting mineralisation was explained earlier.

Sulphate is the primary source of S taken up by most of the crops. Soil solution sulphate level determines the amount of S accessible to a plant. Since S is a constituent of organic matter, its contents in Indian soils have been shown to be governed by the amount and nature of organic matter (Takkar, 1988). The increase in S content in soil for organic treatments was also reported by Bijulal (1997).

5.1.3.7 DTPA Extractable Fe

Fig. 5 presents data on DTPA extractable Fe, the values showing decreasing content of DTPA extractable Fe in soil for all the organic treatments compared to T_8 (inorganic alone) which got the highest value at both the stages, *i.e.*, 50 per cent flowering and harvest stages. The treatment which received vermicompost as the organic source recorded 21 per cent decrease at 50 per cent flowering stage and 40 per cent decrease at harvest from T_8

The observed decrease in DTPA extractable Fe in treatments receiving organic manures could be explained by chelation process leading to specific metal complex formation (Schnitzer and Khan, 1978). Humic colloids form very stable compounds with Fe which reduced the available Fe concentration in soils. This effect was clearly manifested in all treatments receiving organic manures. As the humic acid fraction was more in vermicompost, more of active Fe is locked up through chelation in soils receiving vermicompost. The same mechanism was operative in the case of other treatments also. Similar findings were reported by Bijulal (1997).

5.1.3.8 DTPA Extractable Mn

From the data presented in Fig. 5 on DTPA extractable Mn, it was evident that, the treatments which received vermicompost (T_4 and T_5) showed significantly higher values. The increase in per cent was 48 and 104 for T_5 from the lowest (T_8) at 50 per cent flowering and harvest stages respectively.

The observed increase in DTPA extractable Mn in treatments receiving organic manures could be explained by the direct contribution of this element from the incorporated organic matter (Debnath and Hajra, 1972). Further, chelation by the humic colloidal fractions of native soil Mn also contributed to this effect. Unlike DTPA – Fe, Mn doesn't form stable chelation complexes with organic fractions, thus registering a higher concentration in the DTPA extract. This was due to preferential chelation of Fe compounds present in large concentrations by the organic colloidal fraction which formed comparatively stable Fe – organic – metal complexes, which survived DTPA extraction (Schnitzer and Khan, 1978). Further, metal-organic complexes of Mn appeared to be less stable and amenable to DTPA extraction. This effect was manifested in all the treatments receiving organic manures. As the soluble humic fractions are more in vermicompost, more of Mn-humate fractions formed were available for DTPA extraction. A preferential interaction of the humic fractions from vermicompost with Fe also would have restricted the reaction of Mn with the less soluble fractions of vermicompost forming complexes with Mn.

5.1.3.9 *DTPA Extractable Zn*

Data on DTPA extractable Zn presented in Fig. 5 revealed that there was significant variation due to treatments. A close scrutiny of the mean value indicated an increase in available Zn content of all the samples receiving organic amendments. A decline in values at harvest stage was due to the crop uptake. Vermicompost treatments recorded significantly higher values at 50 per cent flowering stage and at harvest.

The observed increase in DTPA extractable Zn content for treatments receiving organic manures was attributed to a direct contribution from the decomposing organic sources and release of soluble chelates from the soil inorganic mineral sources (Debnath and Hajra, 1972). It was presumed from the observation that the chelated forms of Zn formed with organic fractions was soluble in DTPA extract, which resulted in an increase in DTPA – Zn for all the samples receiving organic manures (Schnitzer and Khan, 1978). The higher efficiency of vermicompost in releasing Zn in this context could be explained by the higher absolute content of Zn in it when compared to other organic sources. This may also be due to the higher solubility of Zn – organic complexes formed from vermicompost in DTPA compared to those formed from other organic sources.

5.1.3.10 *DTPA Extractable Cu*

By examining the Fig.5, it was clear that Cu also showed the trend similar to Zn, once again emphasizing the superiority of vermicompost. All other organic sources also showed significant increase in values compared to inorganic fertilizer application at 50 percent flowering stage and at harvest. The observations indirectly indicated the very low DTPA – Cu status in the inorganic mineral fraction of the soil used for the study.

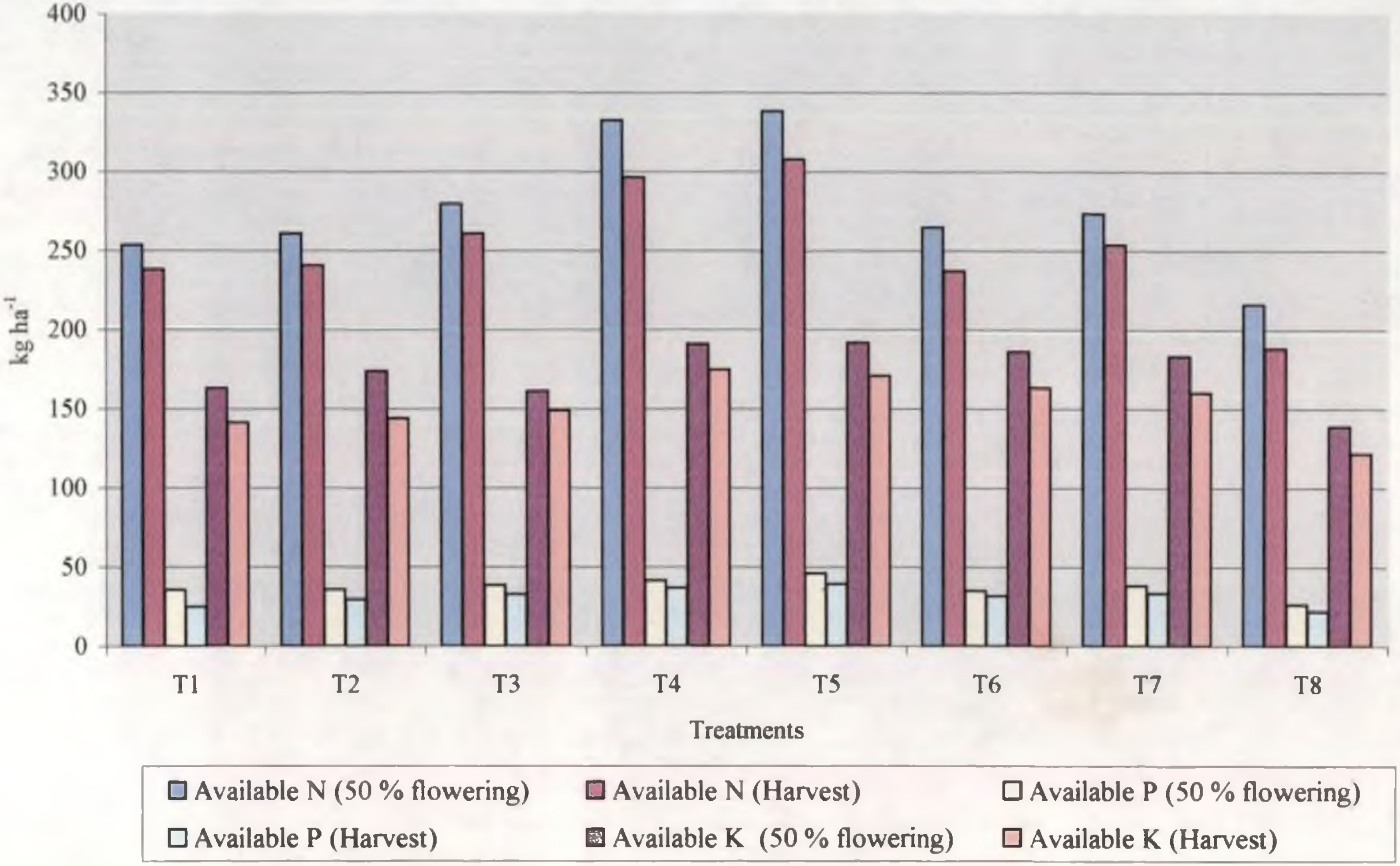
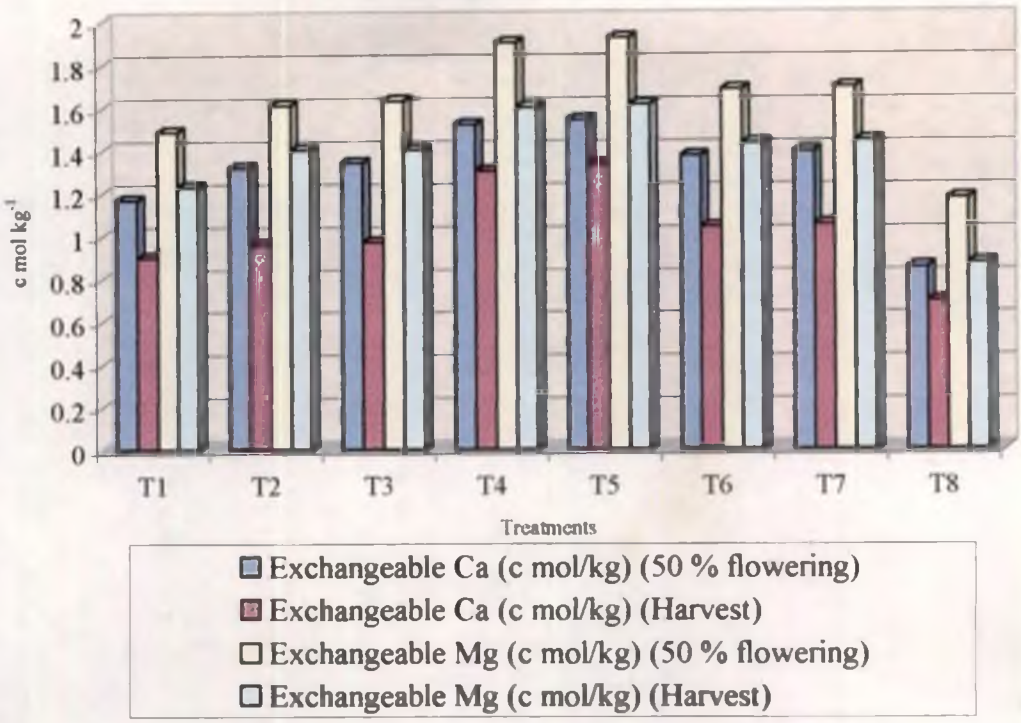
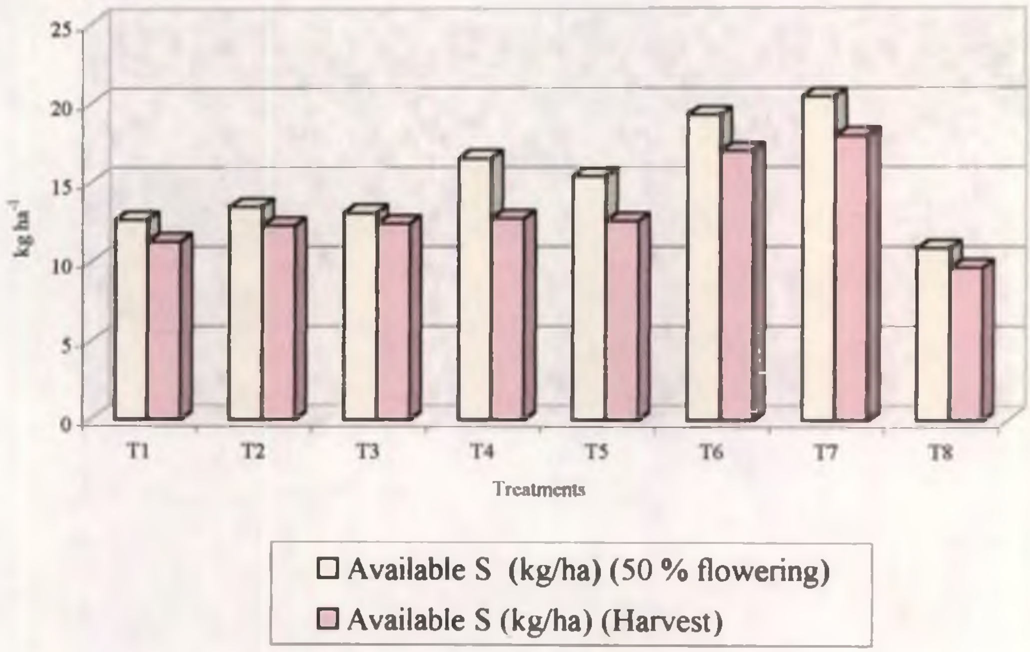


Fig. 5. Effect of organic farming practices on soil available nutrients





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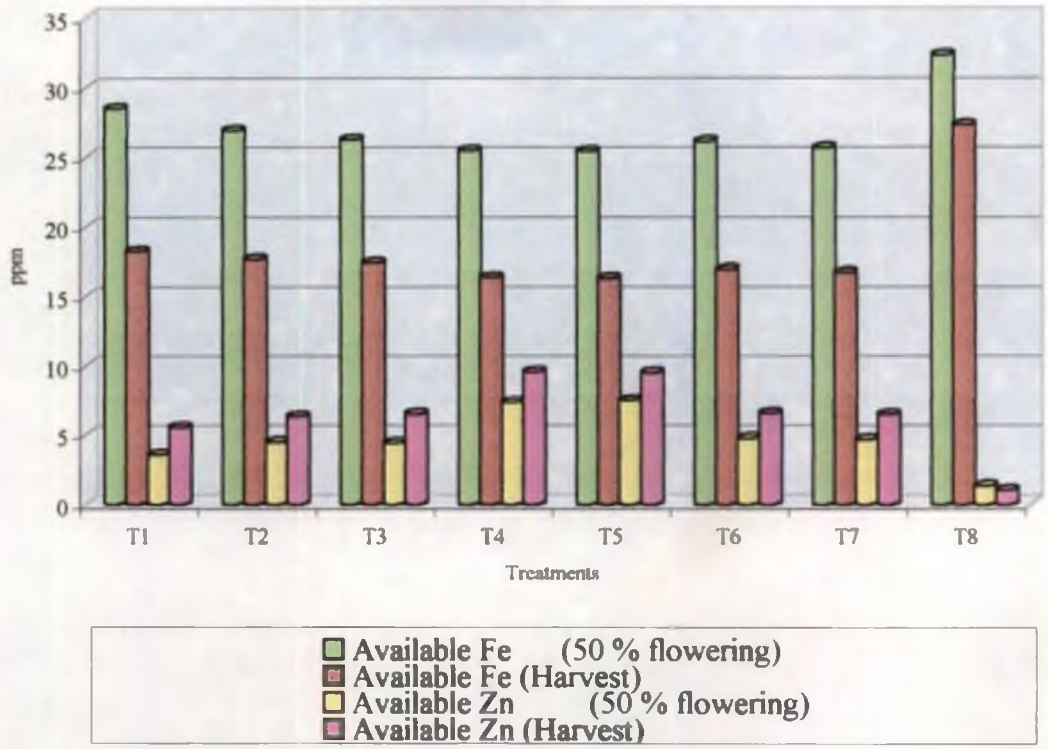


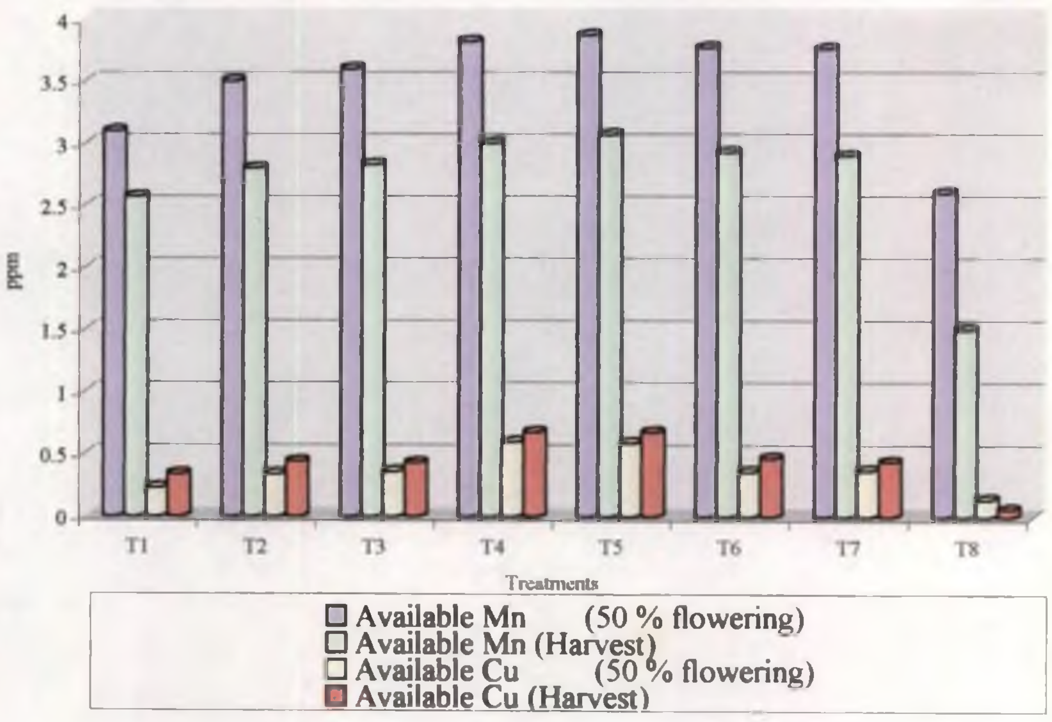


Fig. 5 Continued

Micronutrients especially Cu is associated more with organic matter. Small organic acid molecules solubilize Cu^{2+} by chelation and complexation, resulting in more dissolution of Cu in the soil solution as compared to soils devoid of organic matter. The Cu^{2+} is directly bonded to two or more functional groups of organic matter *viz.*, carboxyl and phenolic. Humic and fulvic acids contain multiple binding sites for Cu, with COO^- carboxyl groups playing a prominent role (Das, 2000).

5.1.4 Soil Enzymes

The role of soil enzymes in improving soil health is discussed here

5.1.4.1 Dehydrogenase

The enzyme assay (Fig.6) indicated the significance of organic nutrition over inorganic. There was an increase of 107 per cent for T_5 (vermicompost + PSM) when compared to T_8. All other treatments showed significantly higher values from T_8.

Dehydrogenase activity had been commonly used as indicators of biological activity in soils because of its occurrence only within living cells, unlike other enzymes which can occur in an extra cellular state.

A significant and positive correlation between dehydrogenase activity and available P, K and N at RRS, Kayamkulam indicated the importance of organic nutrition in relation to dehydrogenase activity. Similarly a significant positive correlation for the permanent manurial experiment at Pattambi, between dehydrogenase activity and available N and P again confirm the above findings (Aparna, 2000). The change in dehydrogenase activity corresponds more closely to microbial biomass generated through an enhanced microbial activity rather than direct nutritional or amendment effect. Hence, dehydrogenase activity will be a more representative index of the soil management practices, manuring. This view was in accordance with the findings of Burns (1982).

5.1.4.2 Phosphatase

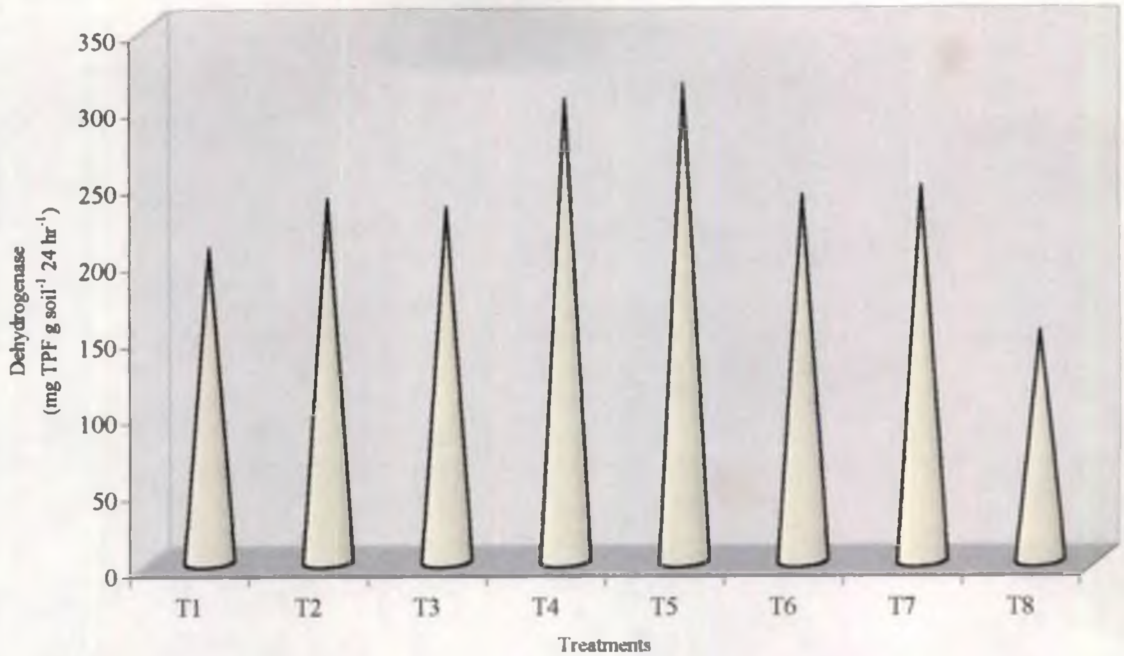
Fig. 6 showed that the trend was similar to dehydrogenase activity. This was due to the variation in the amount of this endoenzyme in the viable microbial population and variation in the levels of accumulated phosphatase in the soil matrix. As the phosphatase activity had shown to be highly correlated with both microbial respiration and total biomass in soil (Frankenberger and Dick, 1983), it was logical to observe greater activity in samples treated with organic amendments. The soil without any organic matter addition (T_8) had shown the lowest value.

A significant positive relationship reported between enzyme activities and soil organic C by Bremner and Mulvaney (1978) was in conformity with the observations obtained in the present study. Addition of organic manure stimulated microbial activity and therefore phosphatase production and accumulation. Further, higher organic C levels in soils also provided substrate for the production of these enzymes in the soil matrix, since soil organic constituents are thought to be important in forming stable complexes with free enzyme. The superiority of vermicompost from other organic amendments in exhibiting a higher phosphatase activity was due to the higher microbial load that vermicompost supports.

5.2 EFFECT OF ORGANIC FARMING PRACTICES ON GROWTH AND YIELD CHARACTERS

5.2.1 Growth Characters

Effect of different treatments on plant height was given in Fig.7. The organic treatments had significant effect on plant height. The maximum value was recorded by T_5 (vermicompost + PSM) *i.e.*, an increase of 30 per cent over T_8 (inorganic alone). The effect of vermicompost in increasing plant height was also reported by Ismail *et al.* (1991) and Stephens *et al.* (1994). The increase in plant height was attributed to the rapid meristematic activity due to the positive influence



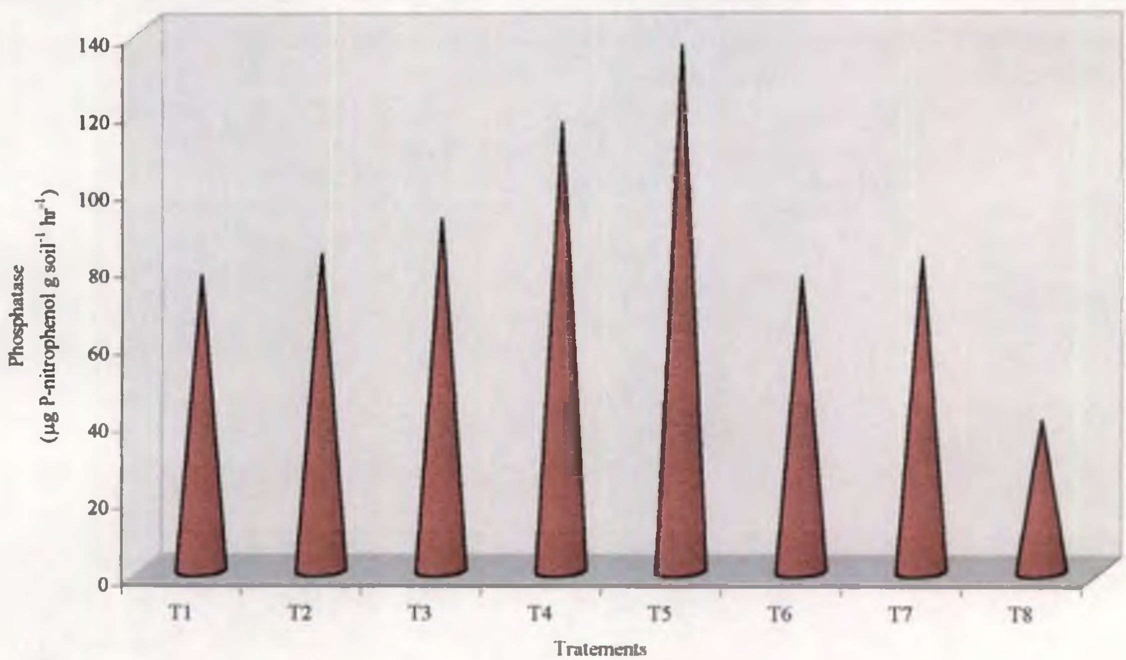


Fig. 6. Effect of organic farming practices on soil enzymes

of vermicompost in increasing the vegetative growth of plant. Significant increase in plant height due to incremental dose of nitrogen by giving vermicompost as an organic source is in conformity with the results obtained by Joseph (1982), Singh *et al.* (1986) and John *et al.* (1989). The higher rate of metabolic activity with rapid cell division brought about by vermicompost application resulted in increased utilization of N, leading to increased vegetative growth. All the other treatments including POP recommendation got significantly higher values from T_8. Significantly higher values were recorded in T_3, T_5 and T_7 treatments (receiving PSM) compared to T_2, T_4 and T_6 treatments respectively. This was due to the influence of growth promoting substances produced by these organisms as suggested by Gaur (1985). An increased plant height due to PSM inoculation in groundnut was reported by Detroja *et al.* (1997).

The data (Fig.7) revealed that organic nutrition had significant influence on nodule formation. Among the various treatments, T_5 (vermicompost + PSM) was found superior. The increase noticed over T_8 was 162 percent. In addition to this fact, PSM application in T_3, T_5 and T_7 significantly affected nodulation compared to T_2, T_4 and T_6 respectively. Vermicompost and other organic manures had contributed significantly for the multiplication of *Rhizobium* indirectly through the better plant growth accrued consequent to their application. Thus, the rhizobial population was able to derive large amounts of metabolic fuel from the actively growing cowpea plants which resulted in better nodulation. The root exudates helped in the build up of microbial population by vermicompost into the rhizosphere of the plant. Thus, the microenvironment created by the interaction between chemicals secreted by living roots and micro-organisms in the rhizosphere, positively influenced root growth and thereby nodulation. The flavanoids in root exudates also induced the transportation of an important set of nodulation genes (Peters *et al.*, 1986 and Kosslak *et al.*, 1987). Increased nodulation in vermicompost treated plants was not only due to the increased supply of nutrients to plants, but also due to the direct effect on nodule bacteria. It stimulated the multiplication of nodule forming bacteria and was found conducive to the development of motile forms which are essentially required to migrate through the soil towards the root system (Madhok, 1961).The enhanced activity of PSM in increasing nodulation was due to more available soil P which increased nodulation on account of properly developed rooting system (Srivastava and Sharma,1985).

It was observed from Fig.7 that the highest leaf area was recorded by the plants treated with vermicompost and PSM. All organically treated plants got significantly higher values from inorganic nutrition. As in the case of plant height and nodulation, here also PSM application have got significant influence. Leaf area index is a function of leaf number and size. Obviously higher levels of N present in the soils treated with organic manures favoured the above two aspects and thereby increased the leaf area. Naturally, under lower levels of N, the leaf production rate and leaf expansion was less. Russel (1973) reported that as the nitrogen supply increased, the extra protein content produced allowed the plant leaves to grow larger and hence to have more surface area available for photosynthesis. Thus the increased leaf area might be due to enhanced production of leaves and its increased longevity. The higher levels of N released from vermicompost had resulted in higher leaf area index. Similar results were obtained in solanaceous crops by Joshi and Nankar (1992). The increase in leaf as noticed in PSM application was due to the fungistatic and growth promoting substances which increased the general health of the plant (Mishustin and Naumova, 1962).

The data regarding days to 50 per cent flowering was presented in Fig.7. It was noticed that the plants with inorganic nutrition initiated flowering at a later stage compared to the other treatments. Early flowering among the treatments was observed for integrated nutrient management (POP recommendation). In other treatments receiving

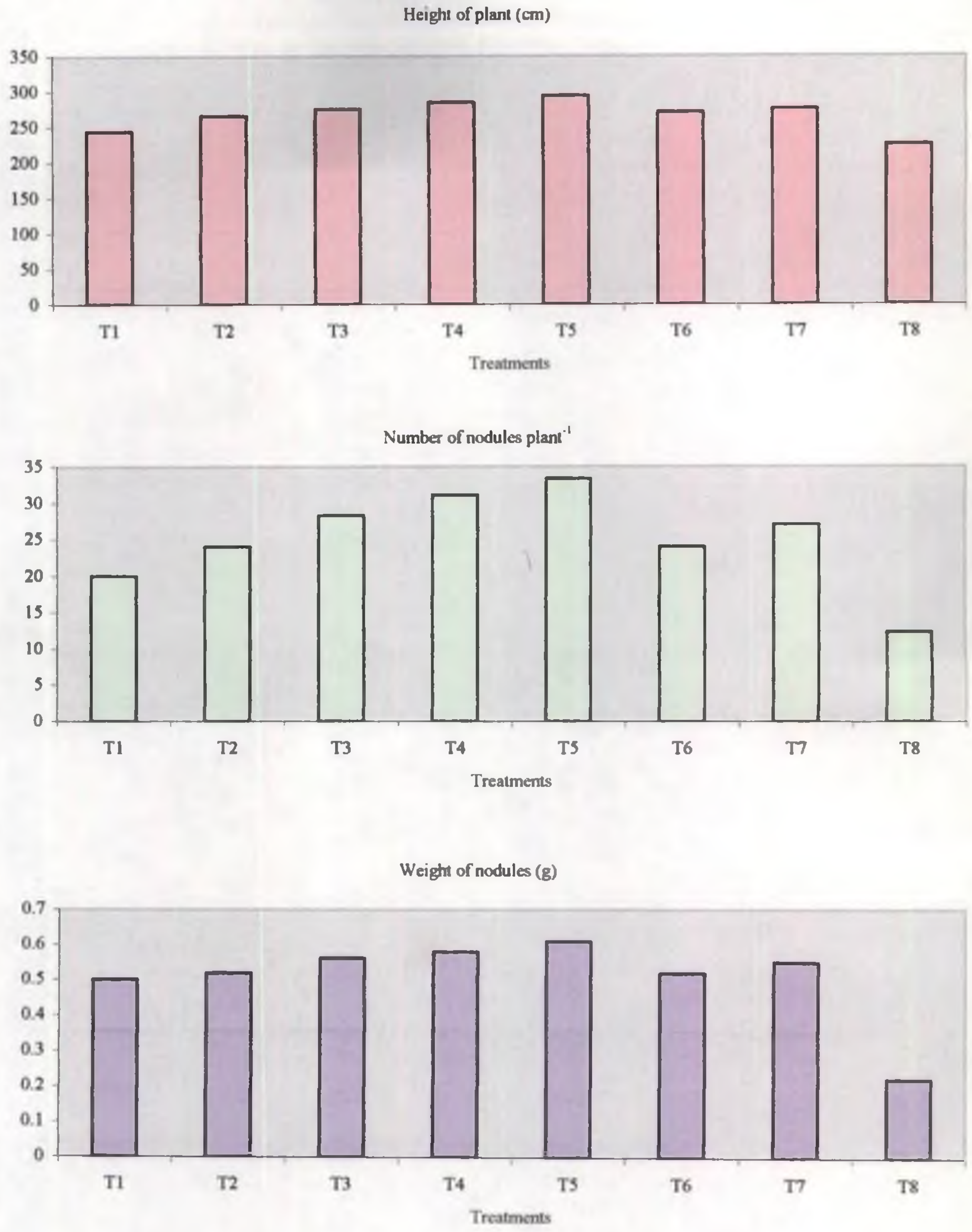
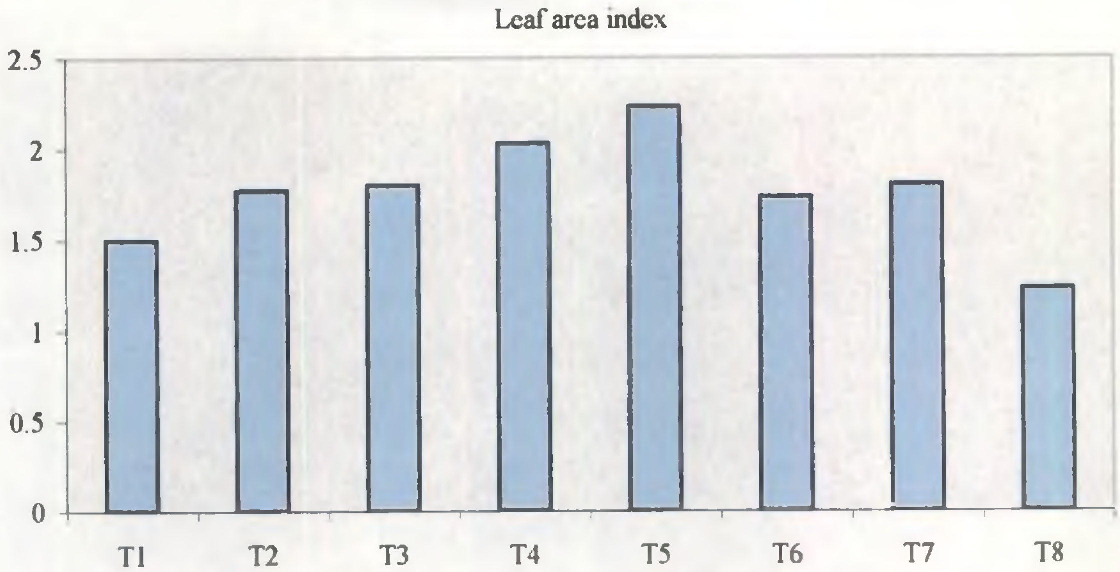


Fig. 7. Effect of organic farming practices on growth characters of cowpea



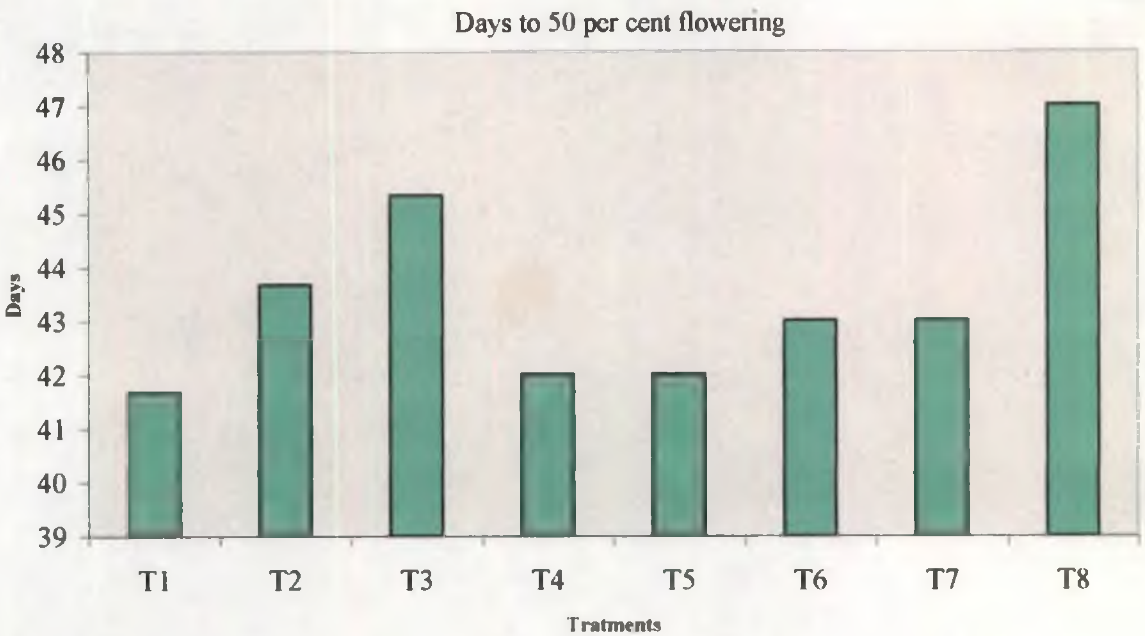


Fig. 7. Continued

organic nutrition alone vegetative growth was more pronounced and flowered a little bit later than T_1 treated plots. The higher nitrogen status at later stages in soil in the pure organic plots, caused an increase in N uptake which delayed maturity by diverting carbohydrate into vegetative growth and by decreasing the concentration of other nutrients in vegetative tissue

5.2.2 Yield and Yield Attributes

The results of pod yield (Fig.8) showed that the treatments with integrated nutrient application (T_1) and vermicompost treatments (T_4 and T_5) were found superior to all other treatments. The treatment with POP recommendation got the highest value and was found to be on par with T_4 and T_5. The data also showed the significance of organic nutrition (pure or integrated approach) and made clear that inorganic fertilizer alone was ineffective in enhancing yield of the crop.

Eventhough organic manures contain many growth promoting hormones, vitamins etc. in addition to plant nutrients, its superiority could not be reflected in yield (except in case of vermicompost) when given without inorganic fertilizers. The primary factor governing the soil health is the organic matter content of soil and the concept of organic farming is widely acclaimed now. But the results of the present study revealed that the integration of organics and inorganics and vermicompost treatment recorded significantly superior values, the highest was for T_1.

The failure of the increment in N to cause an increase in yield was not due to a lack of vegetative response to the N, but resulted from failure of the vegetative response to be translocated into yield response. A relative high N status of the crop is desired in the early growing season and a relative low N status in the later part of the growing season favours high yield. The release of N from bulky organic manures throughout the growing period might have contributed to considerable vegetative growth of the crop. The partitioning of assimilates to reproductive part might have been hindered because of inappropriate N:P:K ratio. This opens up the way for reducing the quantity of organic manures to crops.

As the supply of N to plants increased, the tendency is for the carbohydrate content to decrease. The effect of N supply was explained on the basis that N promotes growth of additional tissue, in which the carbohydrates produced by photosynthesis were used. With a growing season of given length, the time available for development of the storage organ decreased with increase in length of time the carbohydrate supply was used primarily for vegetative growth. Thus organic manures behaved as slow releasing nitrogenous fertilizer and checked the leaching, denitrification and runoff losses of N throughout the growth period.

The plant leaf analysis at 50 per cent flowering stage and harvest stage (Table 13) showed that the concentration of almost all the major nutrients decreased drastically from 50 per cent flowering stage to harvest stage for T_1 compared to the other treatments. This pronounced effect was due to the better partitioning of photosyntheates to the pods as is evident from the pod nutrient status (Table 16).

The higher yield for vermicompost compared to the other organic treatments was due to better soil properties, enhanced nutrient availability and better proportionate uptake of nutrients.

As from Fig.8, it was clear that bhusa yield varied significantly among the treatments. The highest value was obtained by T_5 (vermicompost + PSM) *i.e.*, 18 per cent increase from the lowest T_8 (inorganic alone). All the other treatments got higher bhusa yield compared to T_8. Here also the superiority of vermicompost in accelerating growth when compared to other organic source is well brought out. The results obtained here were in close agreement with the findings of Ramanujan and Singh (1956), Tabata and Takase (1968) and Singh *et al.* (1993) who reported that foliage growth increased with increase in N and P level. Influence of vermicompost in increasing the vegetative growth of plant was an accepted fact. Worm cast when used as organic manure significantly influenced vegetative characters (Kale *et al.*, 1991) because of the presence of growth promoting substances. It could also be viewed that plant height and leaf area index was also highest for vermicompost treatments which in turn increased the bhusa yield.

The data pertaining to the dry matter production were presented in Fig.8. As in the case of bhusa yield, T_5 (vermicompost + PSM) got the highest value (an increase 20 per cent over T_8 was noticed). The increase in dry weight of plants as a result of manure addition was due to the production of humus substances which improved the physical and chemical properties of soil, as well as to the increased nutrient release and hence their ability to enhance the growing parts (Sakr, 1985). These results were in agreement with the findings of the present study. The increase in plant height and other growth characters due to better assimilation of nutrients by the addition of organic manures helped to increase the dry matter production. Pandey *et al.* (1992) got similar results.

Fig. 8 showed the significance of organic nutrition on harvest index of crops. The data from the other yield parameters showed that bhusa yield was lower for POP recommendation compared to other organic treatments, but was significantly higher than inorganic nutrition alone. Because of the difference in partitioning of nutrients, pod yield was found maximum for POP recommendation and so recorded the highest harvest index. Since both pod yield and bhusa yield was low in the case of T_8, harvest index obtained for that treatment was the lowest.

5.3 EFFECT OF ORGANIC FARMING PRACTICES ON QUALITY OF COWPEA

5.3.1 Nutrient Content in Bhusa

As in the case of available N content present in the soil, the content of N in the plant parts (Fig. 9) was the highest for the treatments with

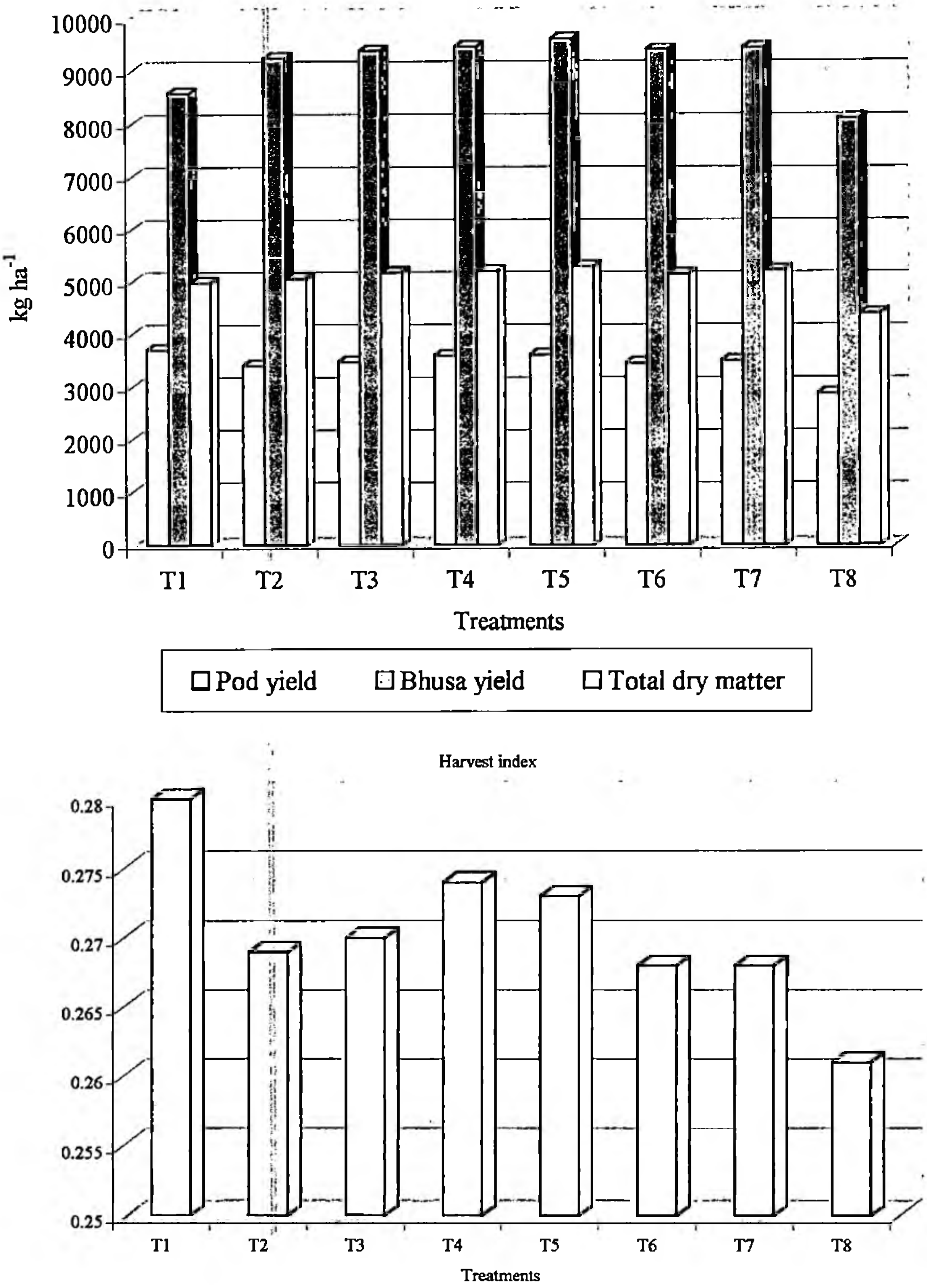


Fig. 8. Effect of organic farming practices on yield and yield attributes of cowpea

vermicompost (T_5 and T_4). The N content increased by 67 per cent at 50 per cent flowering and 73 per cent at harvest stage for T_5 when compared to T_8 (inorganic alone). The mineralisation of N was supposed to be faster in the presence of vermicompost as reported by Shuxin *et al.* (1991). This had led to the increased biomass production. The results of the present study was supported by the findings of Aldag and Graff (1975) and Grapelli *et al.* (1987).

The P content of plant parts due to various treatments was presented in Fig.9. The maximum P content was in T_5 followed by T_4. The least was for inorganic nutrition alone. T_5 treated plants showed an increase of 57 per cent at 50 per cent flowering stage and 80 per cent at harvest over T_8. The increased production of organic acids during decomposition of organic matter was the reason for increased P content of the plant parts. The solubilisation of P by the microorganisms was attributed to the excretion of organic acids like citric, fumaric, tartaric and keto butyric acids (Rao, 1983). The microorganisms present in vermicompost helped in mineralisation of organic phosphorus to the soluble form (Syres and Springett, 1984). There also observed a higher P content in those plants where PSM addition was made *i.e,* T_3, T_5 and T_7, when compared to T_2, T_4 and T_6 respectively. This was due to the solubilisation of native P by P solubilising microorganism. The increased P availability can also be attributed to a higher phosphatase activity in the presence of vermicompost application. Similar findings were reported by Shuxin (1991) as well.

The nutrients analysis showed that (Fig. 9) the K content was highest in the treatment T_5, followed by T_4, both of which had vermicompost as the organic nutrient source. The treatment T_8 (inorganic alone) could not bring any significant influence on K content of plants. The increase noticed from T_8 for T_5 was 41 per cent at 50 per cent flowering stage and 76 percent at harvest. The increase in K content due to vermicompost application was due to the increase in K availability, by shifting the equilibrium forms of K from relatively unavailable forms to more available forms in the soil. This finding of Basker *et al.* (1992) was in consonance with the present result obtained. In the presence of vermicompost, the K leaching might have reduced thereby more K in the soil. The enhanced proliferation of roots by organic matter addition also helped in the increased uptake of K. Release of occluded and co-precipitated forms of K in the soil by organic acids also resulted in the higher K availability.

The superiority of vermicompost in supplying Ca and Mg to the crops was well documented (Fig. 9). For both the nutrients, the treatment receiving only inorganic nutrition was found inferior. At 50 per cent flowering stage 59 per cent increase for Ca and 45 per cent increase for Mg was noticed in T_5 over T_8. Similarly at harvest stage the percentage increase registered were 83 and 76 for Ca and Mg respectively. The higher values for exchangeable Ca and Mg in soil enhanced the content of these nutrients in the plant parts. The higher amounts of Ca and other bases present in wormcast, vermicompost and vermiwash had been reported by many workers. Thus the higher content of these two cations in plants treated with vermicompost was due to the increased uptake through enhanced availability from soil. Similar results obtained by Rajalekshmi (1996) and Sheeba (2004).

The importance of organic nutrition on the S content in plants was clear from Fig.9. All the treatments receiving organic manures, got significantly higher values when compared to T_8 at both 50 per cent flowering and at harvest stage. Poultry manure treated plot, T_7 got the highest value, 64 per cent increase at 50 per cent flowering stage and 73 present increase at harvest. T_6 comes next. Sulphur present in the soil by the agency of certain autotrophic organisms undergo a series of oxidative reactions which terminated in sulphate. The fully oxidized form was available to the plant so that the normal oxidative biological reactions that occur in soil in presence of organic matter are advantageous so far as the availability of this element was concerned. This is in accordance with the findings of Takkar (1988). Besides this, the presence of S in appreciable quantities in the organic matter also contributed to available S and subsequently higher content in plants receiving organic nutrition.

The data presented in Fig.9 showed the pronounced effect of organic matter addition on the micronutrient availability in the soil and the increased nutrient content in the plant parts. It was observed that vermicompost treated plots, T_5 and T_4 got significantly higher values for Mn, Zn and Cu at both stages of plant analysis. For Mn, the increase in percentage was 27 and 35 at 50 per cent flowering and harvest respectively from T_8. Similarly 96 per cent and 116 per cent for Zn, 190 per cent and 302 per cent for Cu at both stages respectively. The ability of soil organic matter to hold micronutrient cations in stable combinations was well established. Some of the organic ligands can keep the micronutrient cations as soluble chelates and these are plant available. Microorganisms also assimilate these metal ions for many microbial transformation reactions and temporarily immobilize the micronutrients in their body which however are released after the death of the microorganisms through mineralisation process and are made available to plants (Deb and Sakal, 2002). The results made by them were in support of the present findings.

The results presented with respect to the nutrient content of plants at 50 per cent flowering and harvest stage clearly brought out an increase in the nutrient content up to the flowering stage and then a decline to lower values towards senescence. Though the latter part of the observation could be substantiated by nutrient immobilization and translocation to the storage organs, namely pods, through destructive senescence, the initial increase in the nutrient may be attributed to their enhanced availability

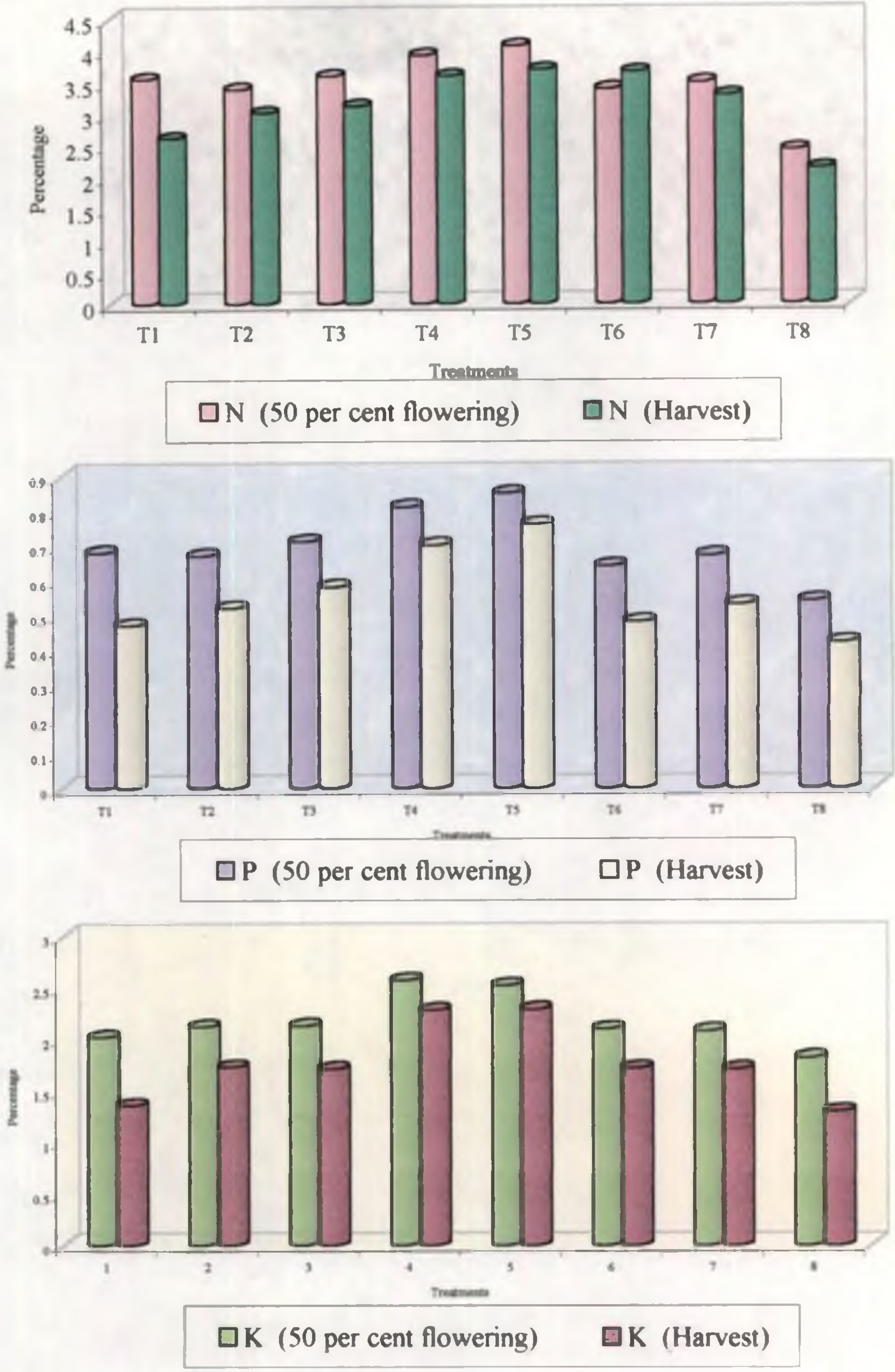


Fig. 9. Effect of organic farming practices on nutrient content in plants at 50 per cent flowering and harvest

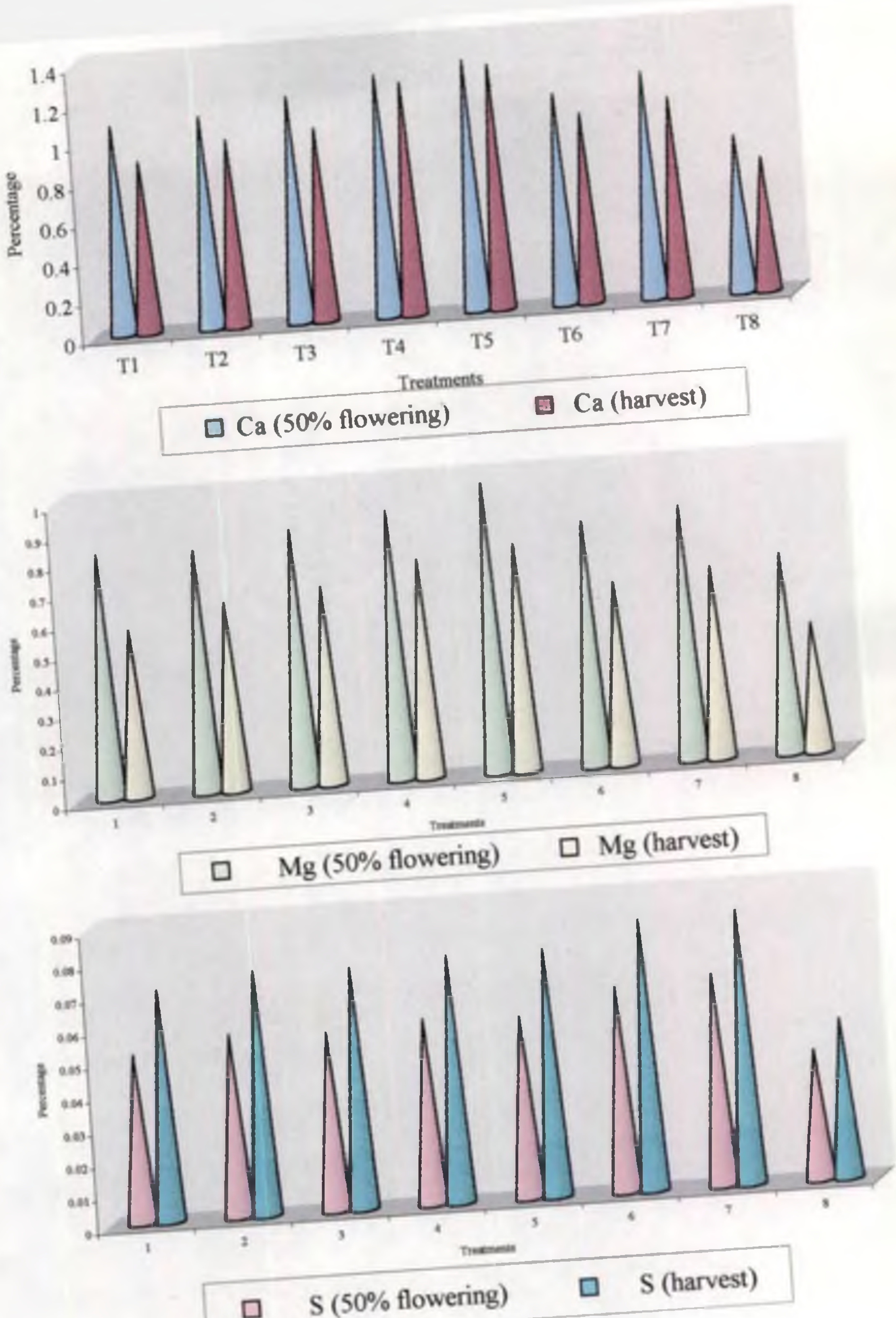


Fig. 9. Continued

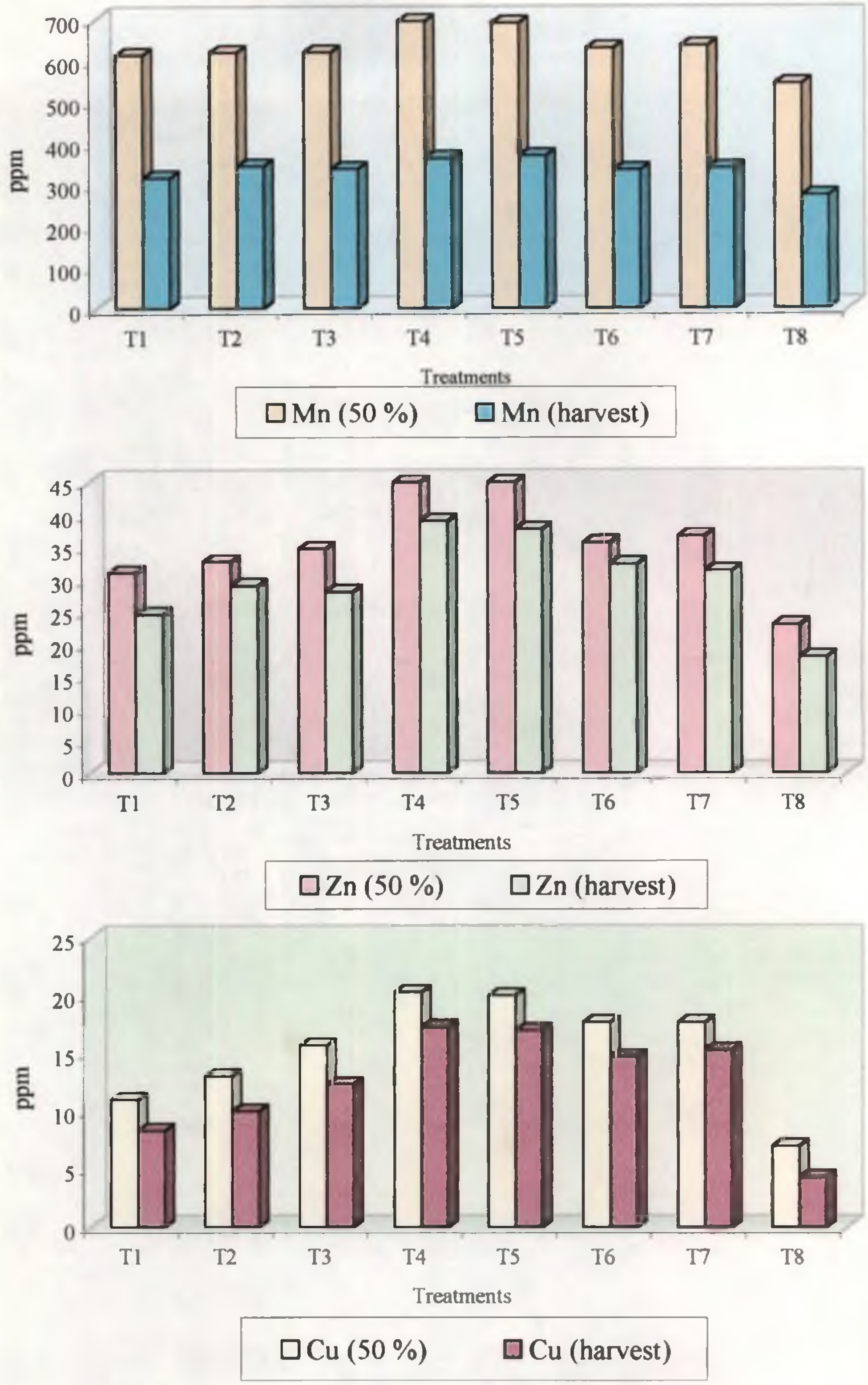


Fig. 9. Continued

through faster mineralisation especially in an environment dominated by vermicompost (Stephens *et al.*, 1994). Similar results got by Vasanthi and Kumaraswamy (1996) and Pushpa (1996) in rice and tomato respectively.

5.3.2 Nutrient Content in Pods

N content of pod was significantly influenced by the different treatments (Fig.10). Application of vermicompost produced the highest values which were on par with the POP recommendation. The treatment which excluded organic manures got significantly lower value. The percentage increase of the highest value from the lowest, T_8 was 62. The superiority of vermicompost application was due to the high available nutrient status in soil as well as by better nutrient composition in plants. Even though the nutrient composition in plants was better, there was a slight hindrance in partitioning of assimilates to pods (storage organs) because of profuse vegetative growth. T_1 also got results on par with vermicompost because of the better partitioning of photosynthates.

P content of pods also showed similar trend (Fig. 10). The highest value obtained was for T_5, which was followed by T_4 and T_1. Here also nutrition with inorganic fertilizers was found inferior. T_5 got 90 per cent increase in pod P content value over T_8. There were also significantly higher values for those treatments receiving PSM *i.e.*, T_3, T_5 and T_7 from the corresponding T_2, T_4 and T_6 treated plots. This was because of the increased available P in soil by their solubilization effect.

Fig.10 showed that the K content in pods was also significantly influenced by the different treatments. T_5 (vermicompost + PSM) got the highest value which showed an increase of 21 per cent over T_8 (inorganic alone). T_1 was found to be on par with T_5.

The Ca and Mg content in pods also showed similar results. For both the nutrients, the highest value was for T_5, which was followed by T_4. Inorganic fertilizer application got the lowest values in the case of both nutrients. For Ca the percentage increase for T_5 from T_8 was 52 per cent and for Mg it was 93 per cent.

The data from Fig. 10 indicated the significance of applying organic manures in enhancing the S content in pods. The highest value obtained was for the treatments receiving poultry manure (T_6 and T_7). The reason being, higher S content in poultry manure compared to the other two manures. An increase of 32 per cent was noticed in T_6 compared to T_8 (lowest value).

The results of micronutrient analysis of pods (Fig.10) revealed that the higher micronutrient contents (Mn, Zn and Cu) in pods of those plants receiving vermicompost was due to the increased availability of these nutrients and subsequent uptake by plants. The other treatments receiving organic manures also got significantly higher values from T_8 (inorganic alone).

Thus it could be genaralised that the increased pod nutrient status in vermicompost treated plots was due to greater mineralization of the manure, increased availability of nutrients and enhanced uptake of the plant available nutrients.

5.3.3 Quality Aspects

Fig. 11 indicated that crude fibre content of the pods were significantly influenced by the different treatments. The lowest fibre content, which was found as a desirable quality was for the treatment T_5 (vermicompost + PSM). All other treatments receiving organic nutrition was found on par including the treatment having POP recommendation. The percentage decrease for T_5 from T_8 (inorganic fertilizer alone) was 45 per cent. The production of growth hormones might have decreased the crude fibre content in organic plots, especially treatments receiving vermicompost. Increased N uptake also should have resulted in increasing the succulence and thereby decreasing crude fibre content. The findings

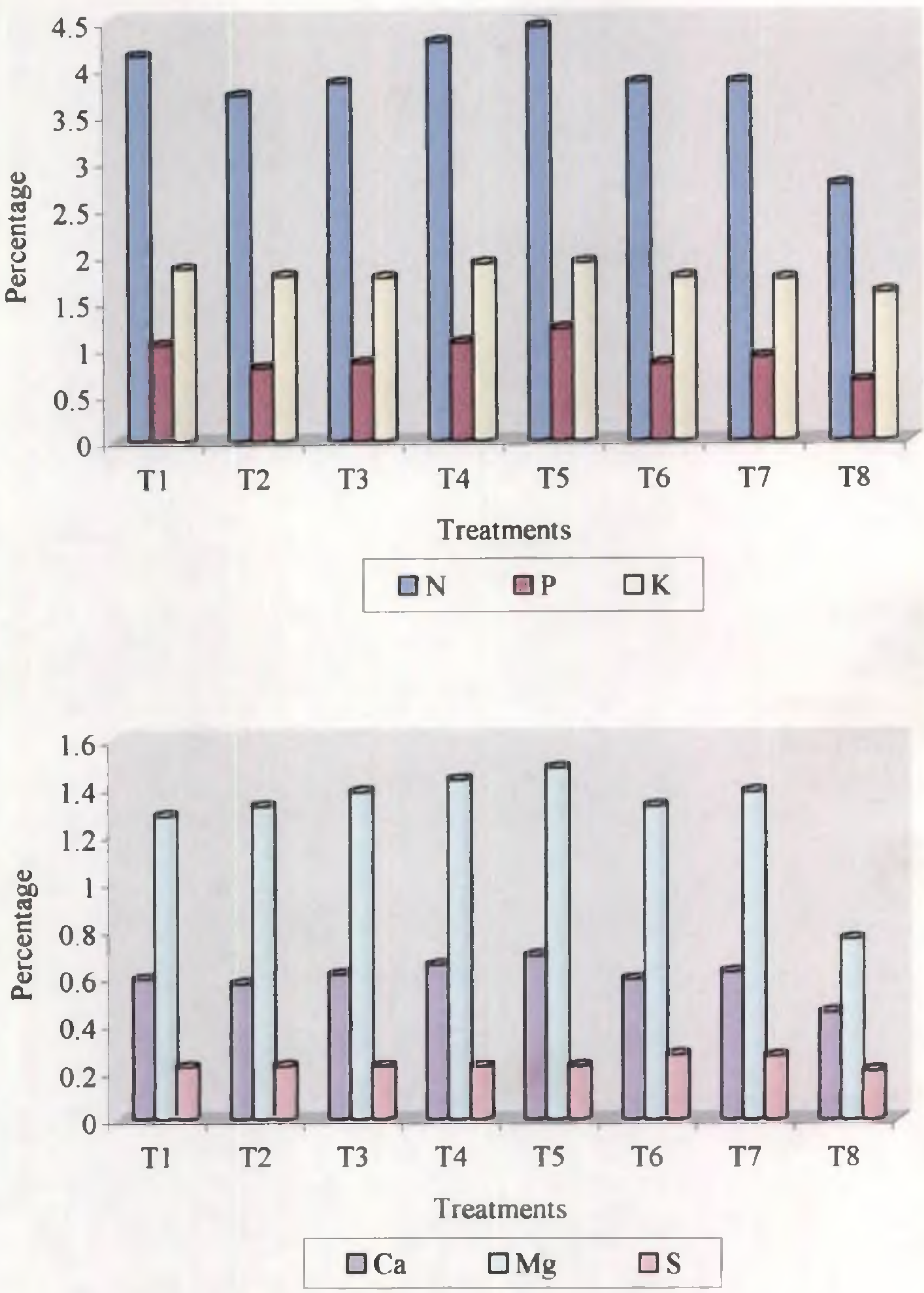


Fig. 10. Effect of organic farming practices on nutrient composition in pod

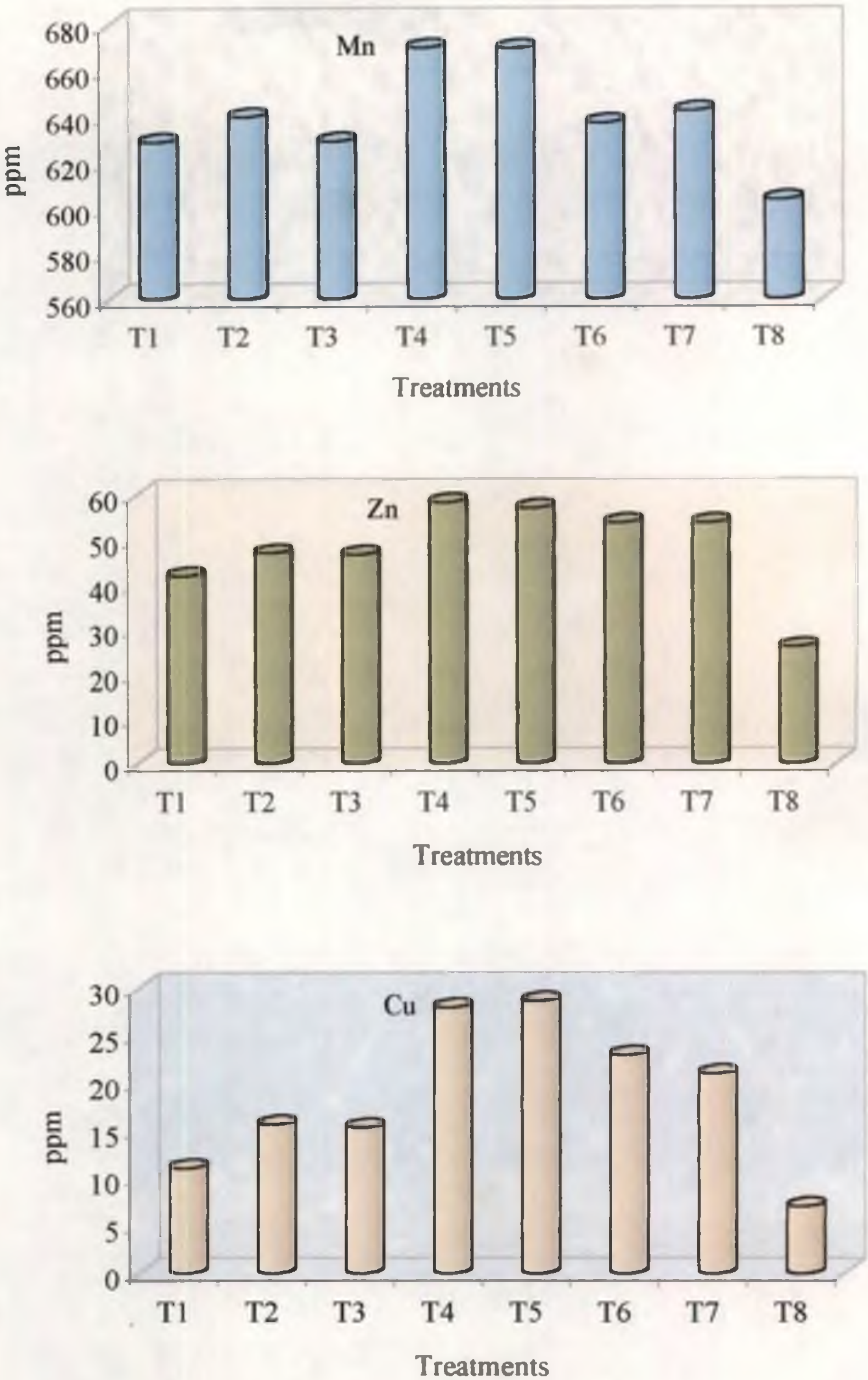


Fig. 10. Continued

were similar to the results obtained by Raj (1999). It could be viewed that higher levels of N improved the quality of pods. Tiwana *et al.* (1975) observed decreased crude fibre content in Napier bajra hybrid fodder due to N application. Raj (1999) also observed that crude fibre content of okra fruits increased with the advancement in the days after harvest. This might be due to the reduced succulence resulting from the cell wall thickness. Mani and Ramanathan (1981) found that bhindi fruits had lower fibre content due to addition of more N. A decrease in fibre content with increased levels of N was reported by Pillai (1986) in guinea grass.

The data from (Fig. 11) showed the influence of organic matter addition on crude protein content of pods. The highest values were with vermicompost treated and POP recommended plants. The better translocation of N to the pods at the reproductive stage resulted in higher crude protein content in T_5, T_4 and T_1. It was observed that there was an increase of 56.14 per cent for vermicompost treated pods compared to the treatment which excluded organic manures. The increase in N content in pods by organic manure addition especially vermicompost compared to the inorganic fertilizer, where there was much leaching loss could be attributed to the decreased N availability to plants. Nitrogen thus obtained was metabolized via ammonia into alpha keto-glutamic acid. Carbon skelton provided by photosynthesis were incorporated in the process of amino acid synthesis which were stored as proteins (Tisdale *et al.*, 1997). Similar results were obtained by Sheeba (2004).

Shelf life of the pods was also significantly influenced by the different sources of nutrition. The highest keeping quality was observed in T_5 and T_4 treatments which were on par with T_2. As in the case of other two quality aspects, here also T_8 registered the lowest value. An increase of 46 per cent was noticed for T_5 and T_4 treatments compared to T_8. Application of higher levels of N through organic manures resulted in increased ascorbic acid content and reduced crude fibre content (Raj, 1999). The increased shelf life of pods was due to the high K content. Fritz and Habben (1972) reported that K fertilizers increased the durability of the pods by lowering the activity of enzymes which breakdown carbohydrate.Khamkar (1993) also reported the better keeping quality of vegetables in vermicompost applied plots compared to fertilizer application. The significant quantities of available nutrients, biologically active metabolites particularly giberellines, cytokinins, auxins and group B vitamins might have contributed to better quality of vermicompost treatment. Similar results of increased quality with vermicompost treatment was reported by Bano *et al.* (1987) and Meerabai and Raj (2001). The enhanced availability of micronutrients also have enhanced the shelf life of vermicompost treated plots (Tisdale *et al.*, 1997).

Organoleptic evaluation was studied for the pods. The data from Fig. 11 showed the effect of organic nutrition. The different attributes studied were appearance, texture and palatability. In all cases the treatment T_8 (inorganic alone) got the lowest value. Vermicompost and poultry manure application got significantly higher value from other treatments. For palatability and texture, a slightly higher value was obtained for T_6 treatment. Similar results obtained by Renu (2003).

During decomposition bulky organic manures yield many organic compounds as well as antibiotic substances as intermediate products. These products on absorption by plants increased their resistance to disease and improved quality of the harvested produce (Thampan,1993).

5.3.4 Nutrient Uptake

The uptake of nutrients by bhusa, pod and total uptake were discussed separately.

5.3.4.1 Bhusa Uptake

The uptake of nutrients N, P, K, Ca and Mg (Fig.12) showed that the treatments receiving vermicompost had got significant influence on the

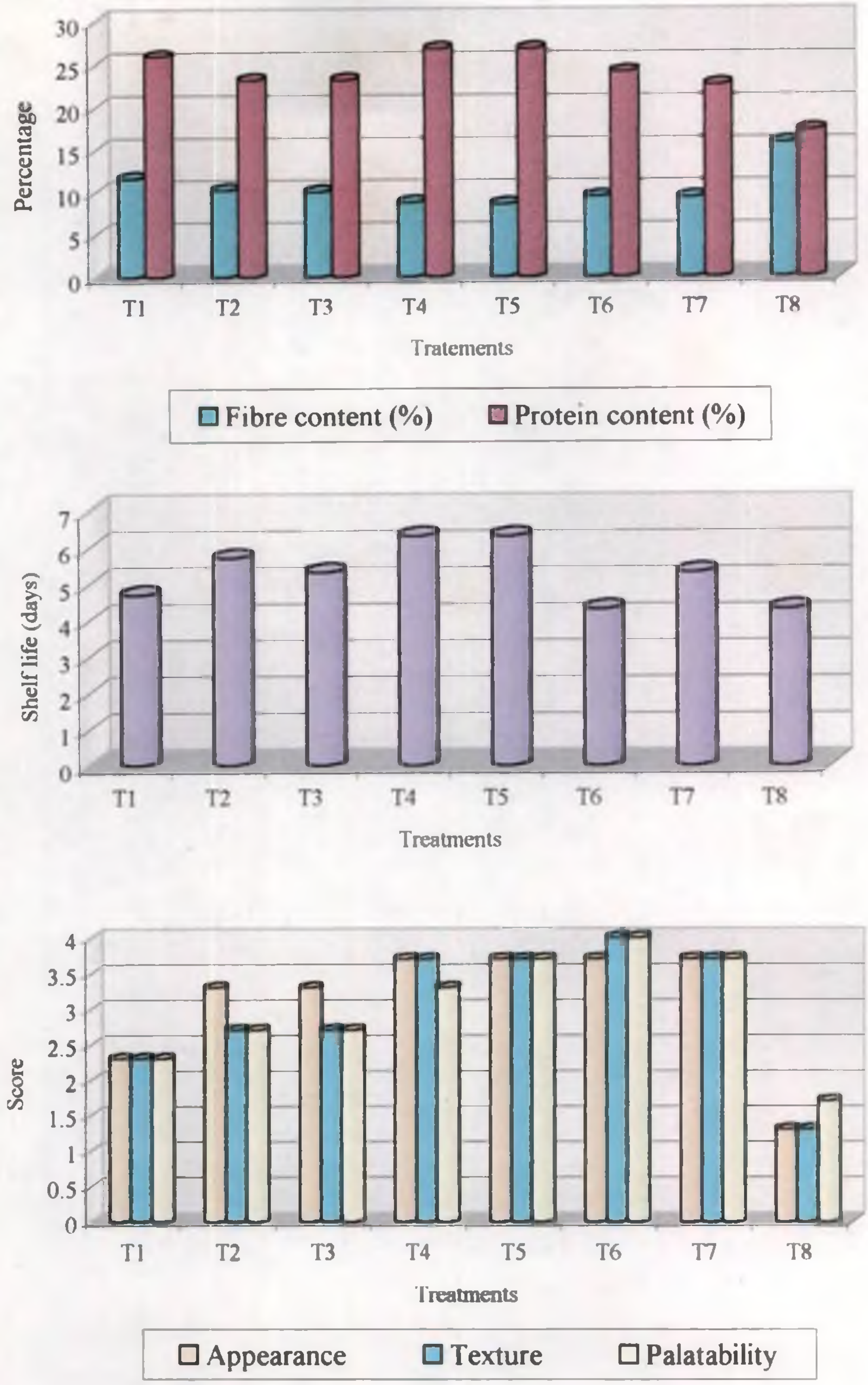
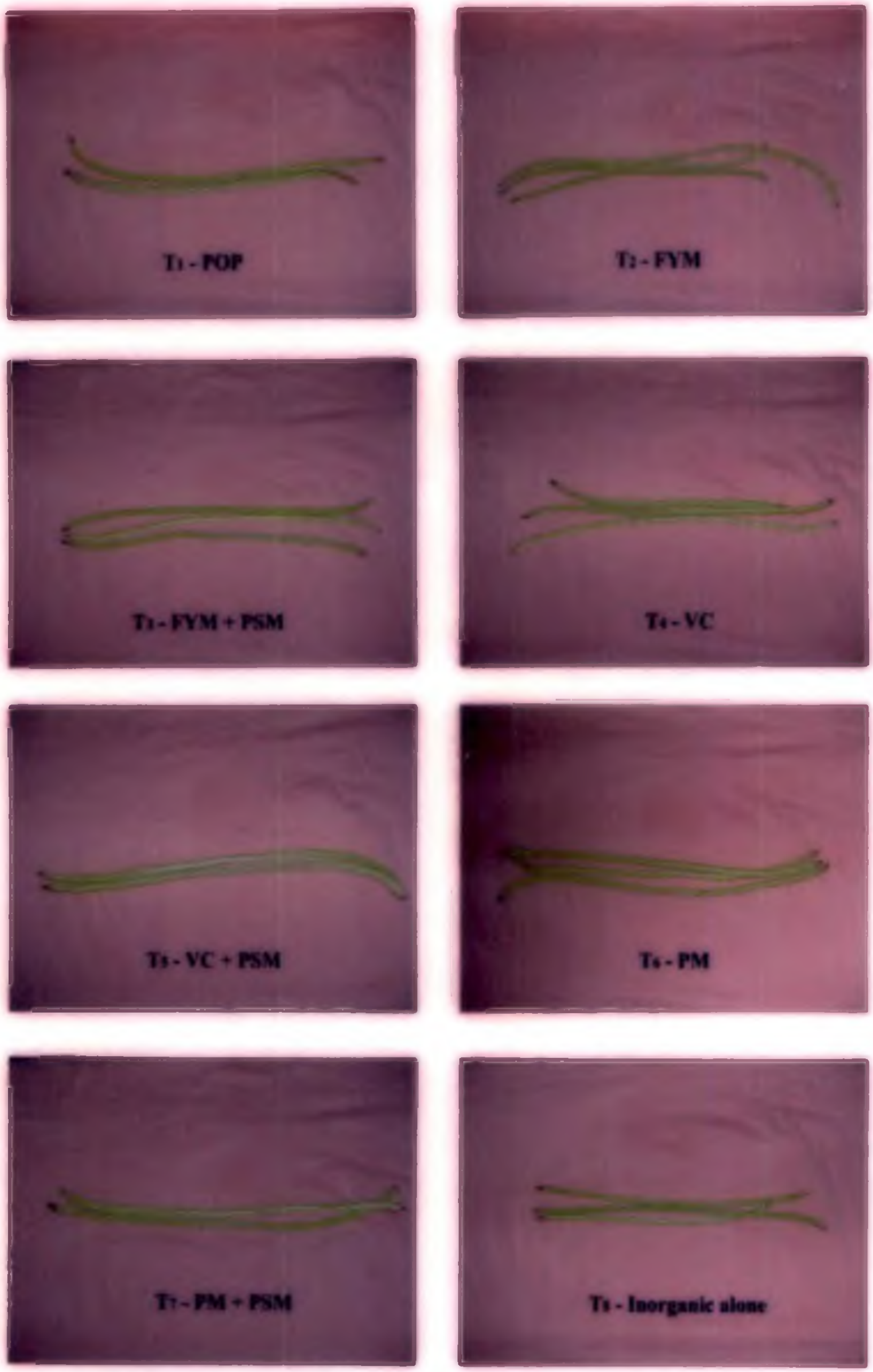


Fig. 11. Effect of organic farming practices on quality aspects of pod



POP - Package of practices **FYM - Farmyard manure** **PM - Poultry manure**
VC - Vermicompost **PSM - Phosphorus solubilising microorganism**

Plate 2. Effect of treatments on pod appearance

other treatments. The increase in N uptake was due to the fact that vast portion of non-oxidisable N present in organic matter could be made available to plants through vermicomposting and microbial activity. The higher rate of metabolic activity with rapid cell division brought about by vermicompost application resulted in higher nutrient uptake (James *et al.*, 1967).

The increased P uptake could be attributed to various factors. P solubilising microorganisms present in vermicompost enhanced phosphatase activity and increased the availability of soluble P. The higher P uptake in PSM applied plots was due to the release of organic acids like citric acid, glutamic acid, succinic acid, lactic acid, glyoxalic acid, maleic acid, fumaric acid and tartaric acid (Gaur, 1988; Rao, 1988).

Uptake of K by plants at harvest stage was significantly influenced by the different treatments. Several workers have reported the effect of organic manures in enhancing the K content of plant parts (Dhanokar *et al.*, 1994; Mather, 1994). The increase in K uptake due to increased K availability consequent to shifting of the equilibrium among the forms of K from relatively unavailable forms to more available forms in soil.

The increased Ca and Mg in vermicompost was the reason for increased uptake by plants (Shuxin *et al.*, 1991). The calciferous glands in earthworms contain carbonic anhydrase which catalyse the fixation of CO_2 as $CaCO_3$, thereby increasing the Ca availability. Zachariah (1995) also found increased Ca and Mg uptake in vermicompost treated chilli plants.

The increased S uptake by organic treatments especially by the application of poultry manure was due to the increased S content in the manure and subsequently more available forms in soil receiving the organic treatments.

Use of vermicompost as organic source resulted in higher uptake of Mn, Zn and Cu by the plants. Humic substances in vermicompost formed stable complexes with micronutrients which are readily absorbed by plants. The chelating action of humic acid and fulvic acid had been attributed to the high amount of functional groups.

5.3.4.2 Pod Uptake

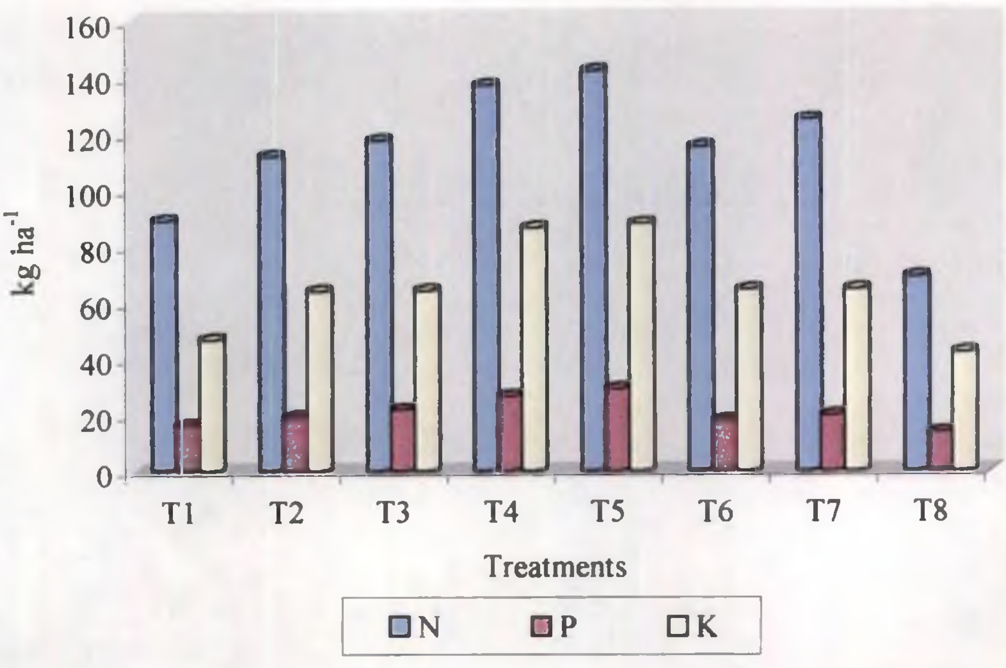
The uptake of different nutrients by pods was significantly influenced by the different treatment as shown in Fig.13.

The highest pod uptake values for N, P and K were recorded by vermicompost applications which were found to be on par with the treatment receiving POP recommendations. The higher uptake values for vermicompost was due to the greater soil nutrient availability and for POP recommendation. It was due to the efficient translocation of nutrients to the sink compared to the other organic treatments. As in the case of bhusa uptake, PSM application made significant contribution to P uptake of pods.

Organic matter application significantly increased Ca and Mg uptake by pods. Among the various treatments, vermicompost application ranked first because of the greater nutrient content (Ca and Mg) in it compared to the other manures.

Poultry manure application markedly influenced the S uptake by pods. It was seen that the treatment without any manure addition was having the lowest value. This was due to the greater S availability from poultry manure.

Significant difference was shown by the different treatments in the case of Mn, Zn and Cu uptake. The superiority of vermicompost was once again emphasized. From the values of other treatments with organic addition, the chelating effect of organic acids which increased the micronutrients availability was clearly understood.



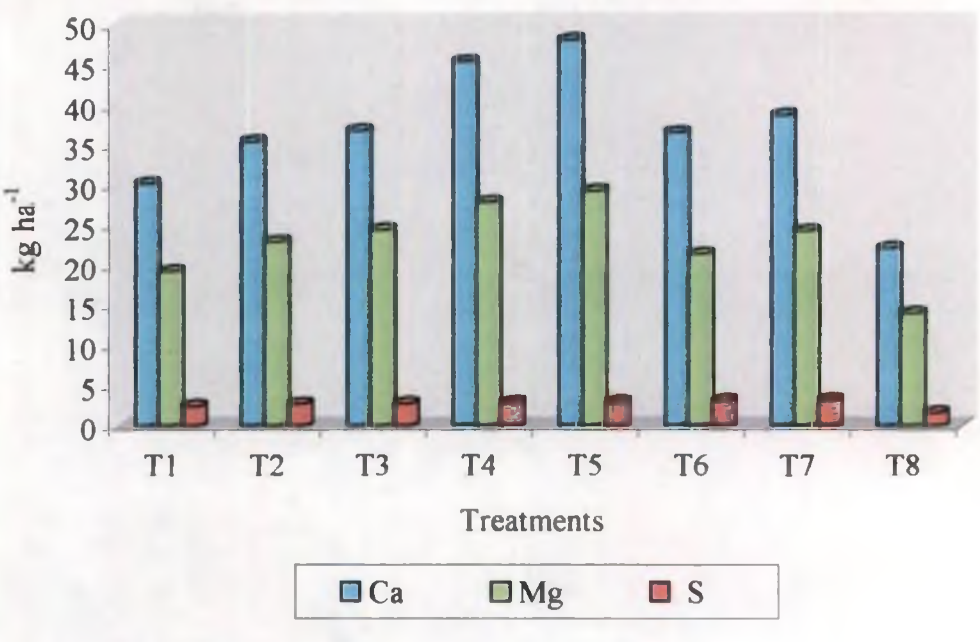


Fig. 12. Effect of organic farming practices on uptake of nutrients by bhusa

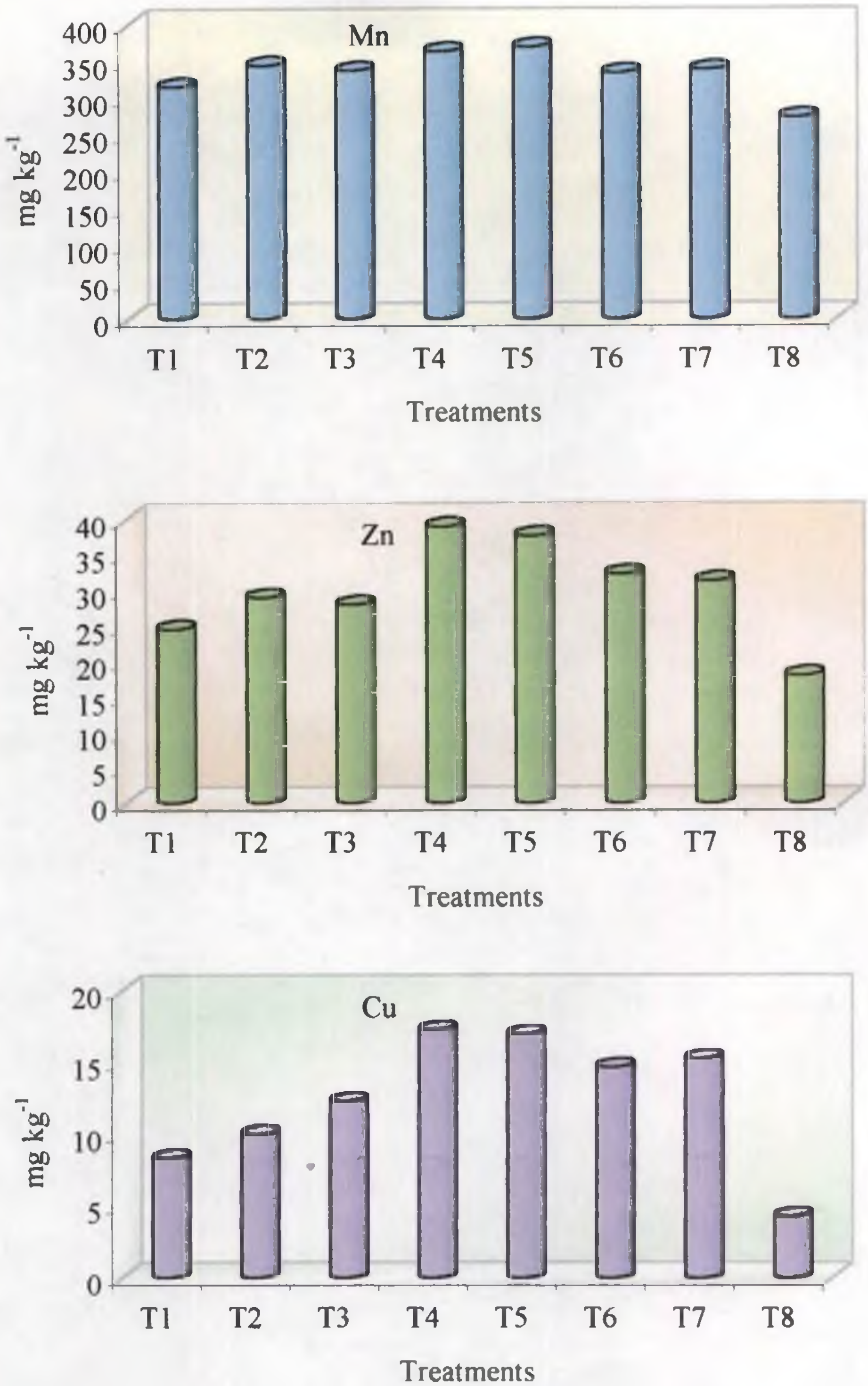


Fig. 12. Continued

5.3.4.3 Total uptake

The total uptake values for almost all the nutrients showed marked variation with the different treatments (Fig.14).

Among the different treatments, vermicompost application recorded significantly higher values for N, P, K, Ca and Mg uptake. This was due to the greater availability of soil nutrients and due to the enhanced dry matter production. A stimulated growth under higher levels of nutrient application resulted in better proliferation of root system and increased the uptake efficiency of plants. Also the beneficial effect of higher levels of nutrients in increasing the uptake of N had been reported by Hedge (1988), John (1989) and Sajitharani (1993).

Due to the increased N availability, the P uptake had improved which might have increased the P content in plants. Synergistic influence of N nutrition on P content was reported by Singh et al., (1970).

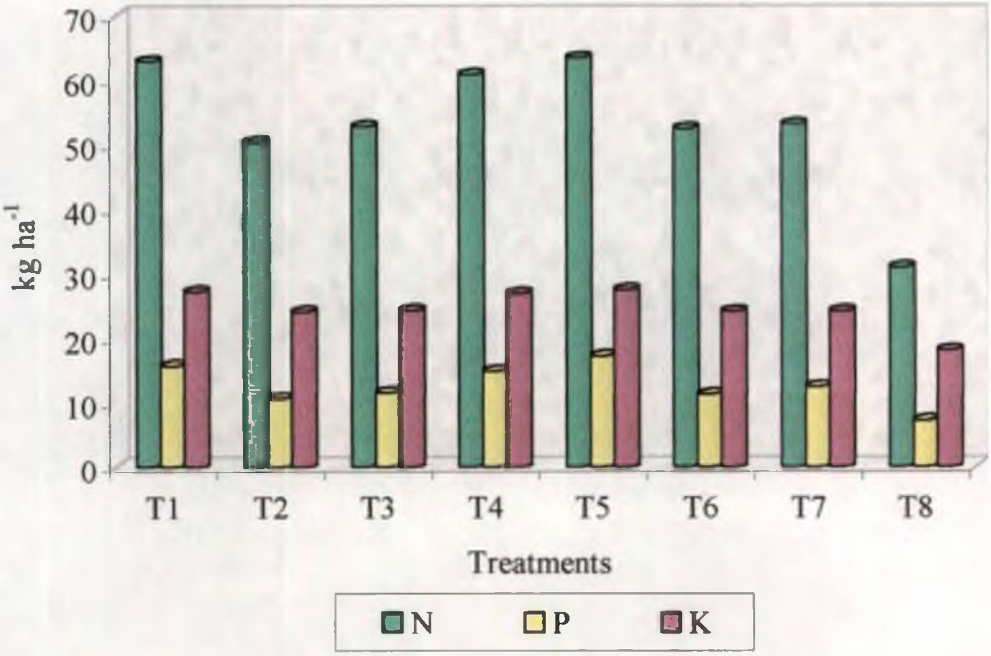
Organic matter application in higher proportion resulted vigorous root growth which might have increased P and K content in plants .As uptake of K is mostly through root interception, better the root system, the more is K uptake. This agrees with the findings of Niranjana (1998).

The higher soil nutrient status of Ca and Mg in vermicompost treated soils was reflected in the uptake values of those nutrients.

Poultry manure application got significantly higher values for total S uptake, due to higher bhusa and pod uptake of S by T_6 and T_7 treatments.

The data made clear the importance of organic nutrition on the uptake Mn, Zn and Cu. Vermicompost application registered significantly higher values.

Thus in the light of the aforementioned discussion, it was proved beyond doubt that organic nutrition is a must in improving the physical, chemical and biological properties of soil, thus restoring the soil health.



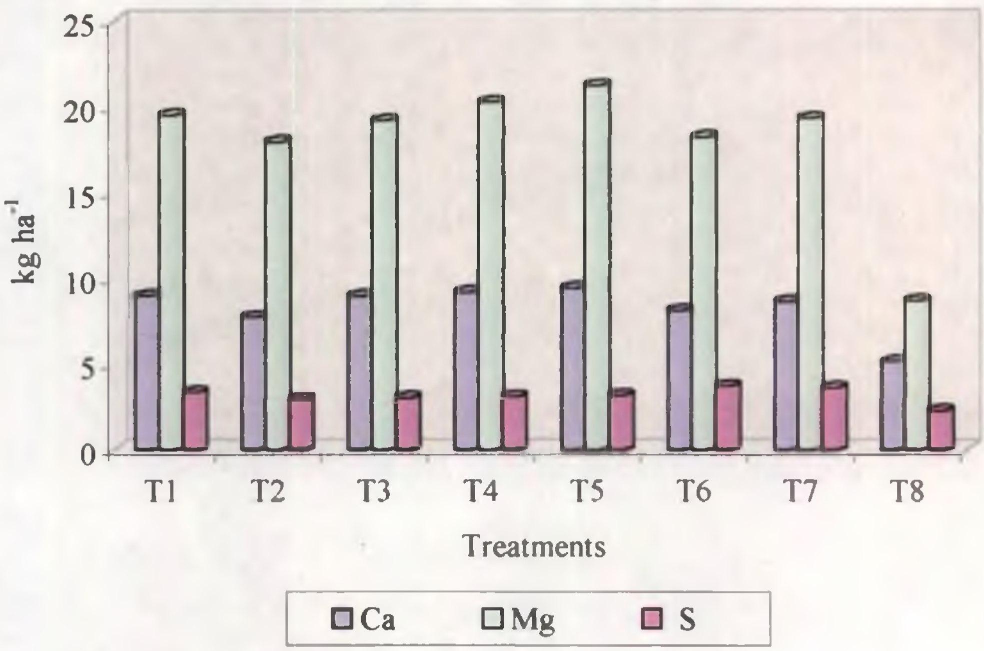


Fig. 13. Effect of organic farming practices on uptake of nutrients by pod

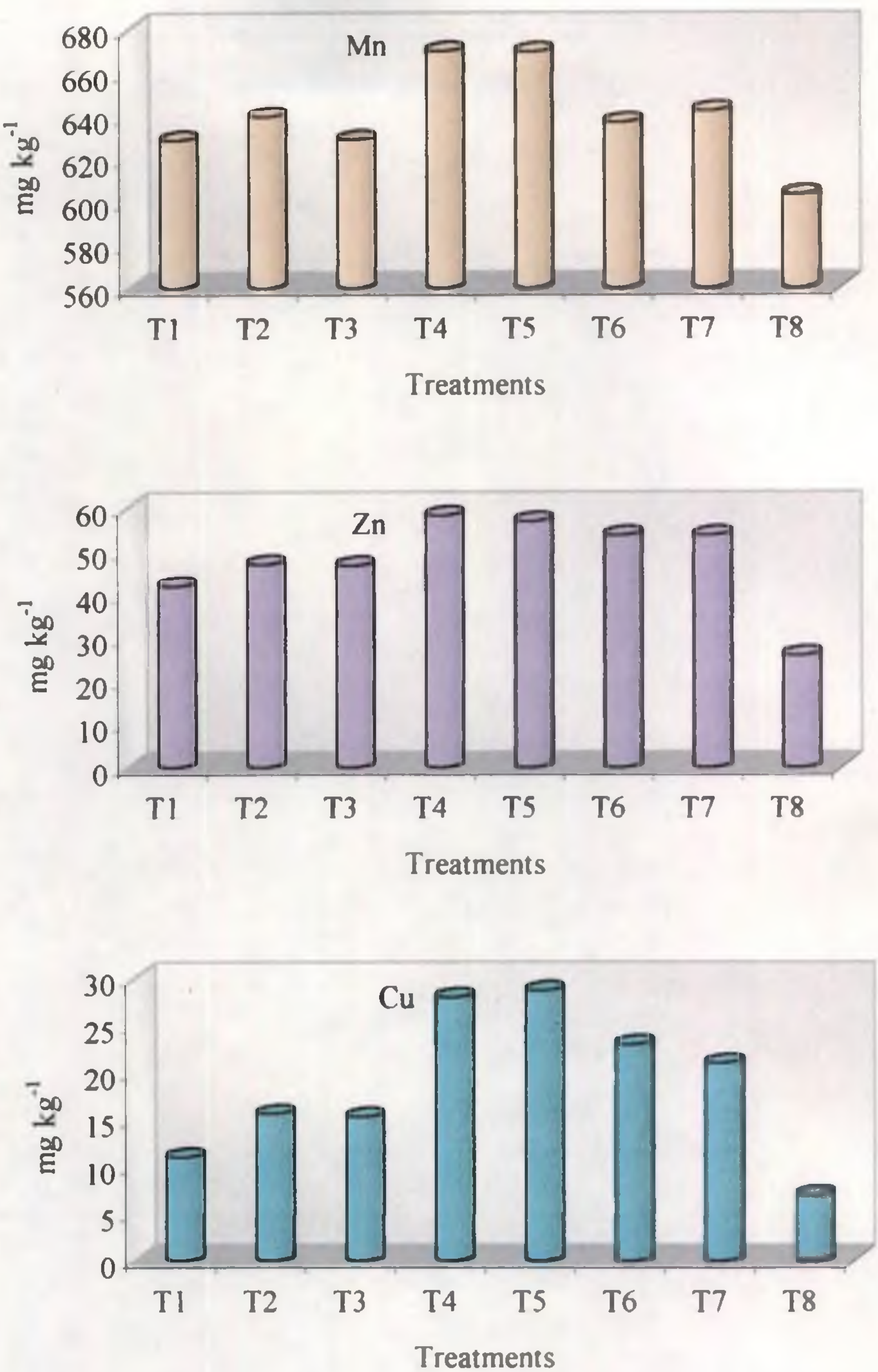
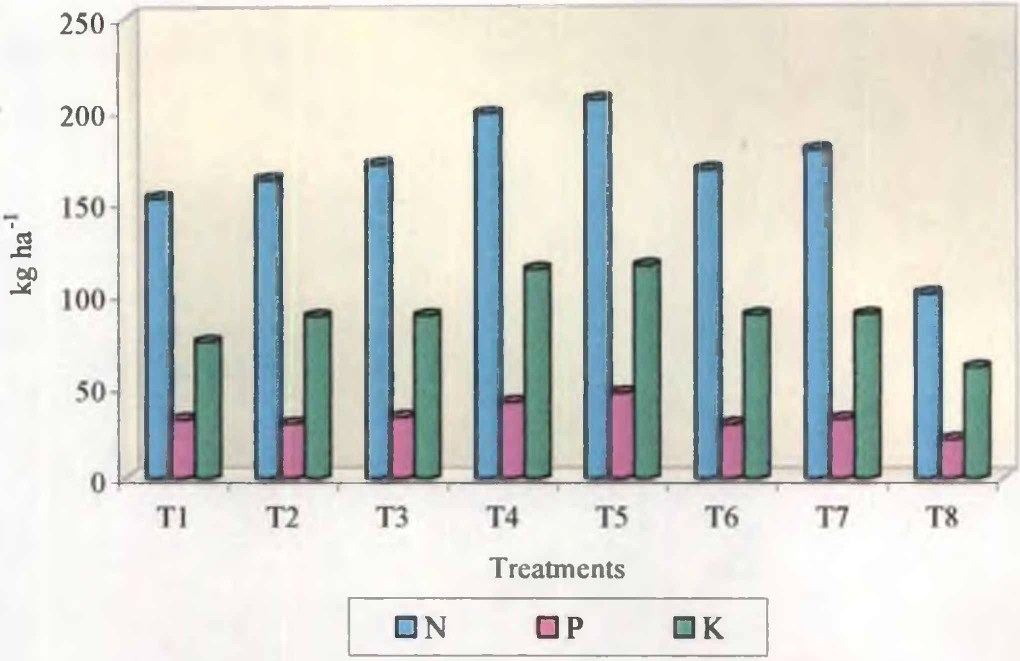


Fig. 13. Continued

To cope up with increasing need of the expanding population, we successfully implemented green revolution. But all the progress made since then was at the expense of finite natural resources and irreversible damage to soil health and environment.

A sudden change to pure organic practices from the existing trend could not significantly add to the yield. In this study it was concluded that even though production level was on par with integrated approach, organic practice has produced substantial benefits for soil and on the quality aspects of the crop. One more thing to be added in this context, from the results obtained was that organic nutrition might be best for leafy vegetables, since vegetative growth was enhanced.

Among the different organic treatments in the present study, the unchallengeable superiority of vermicompost over other organics in releasing nutrients, modifying the soil environment, enhancing plant growth and quality of the crop was made clear.



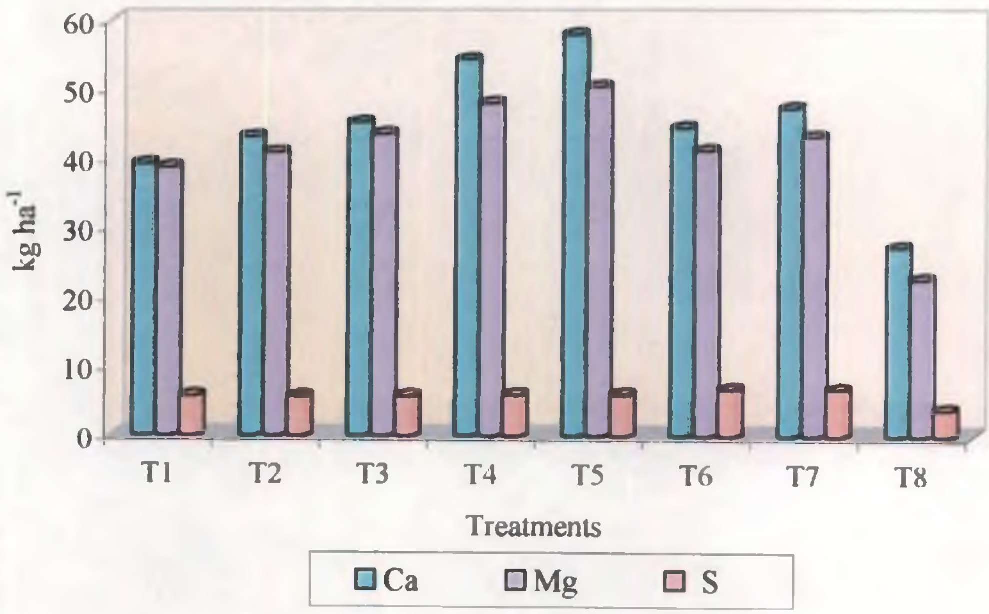
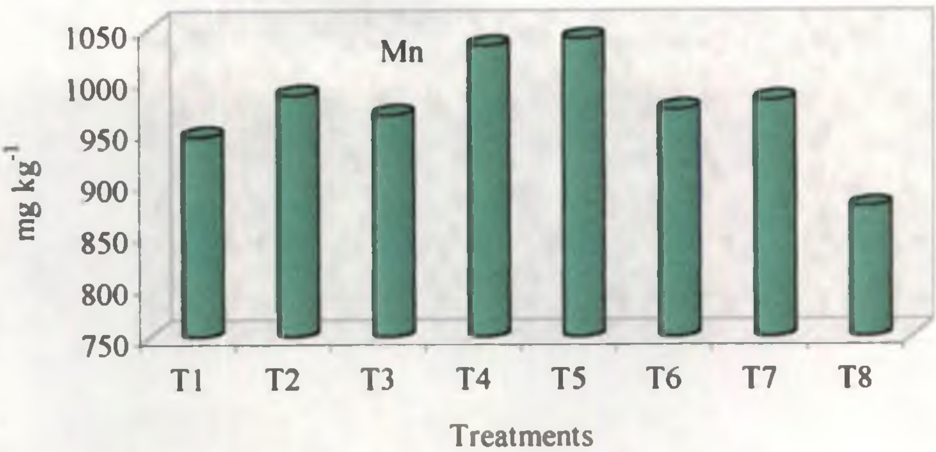
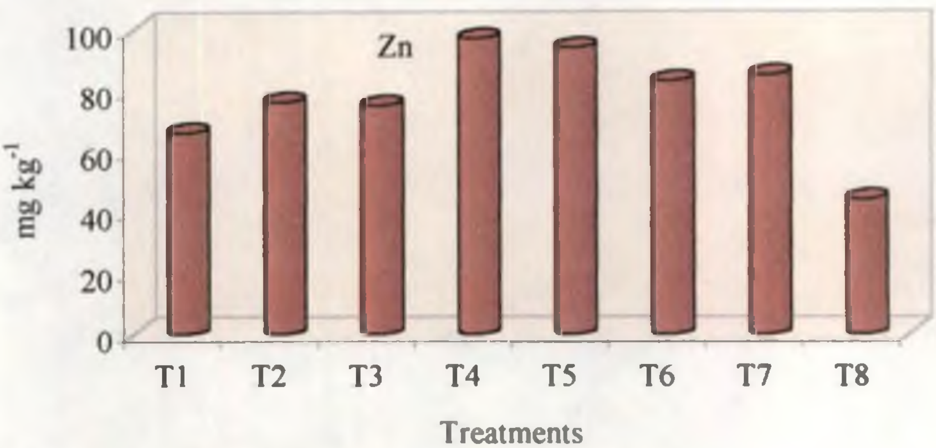


Fig. 14. Effect of organic farming practices on total uptake of nutrients





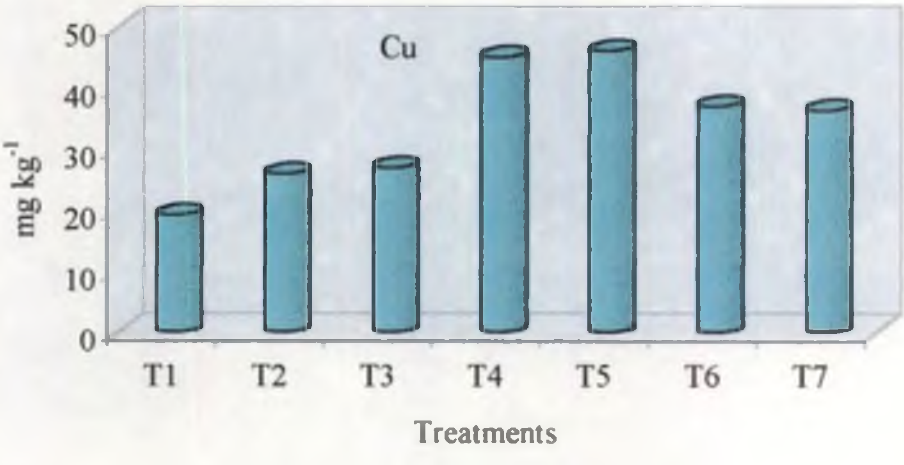


Fig. 14. Continued

Summary

6. SUMMARY

An investigation was carried out to study the impact of organic farming practices on soil health, yield and quality of cowpea (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcort) at the Instructional Farm, College of Agriculture, Vellayani from October 2004 to February 2005.

The experiment was laid out in RBD with eight treatments and three replications. The treatments consisted of T_1 –POP recommendation, T_2 – Farmyard manure, T_3 – Farmyard manure + PSM, T_4 – Vermicompost, T_5 – Vermicompost + PSM, T_6 – Poultry manure, T_7 – Poultry manure + PSM and T_8 – NPK alone. The POP recommendation for cowpea is 20 kg N ha^{-1}, 30 kg P_2O_5 ha^{-1} and 10 kg K_2O ha^{-1} along with 20 t farmyard manure ha^{-1}. Lime application was also done @ 250 kg ha^{-1}. Cultural operations were done as per POP recommendation of Kerala Agricultural University (KAU, 2002).

Summarized below are the salient findings, which were generated out of detailed investigations, carried out in field and laboratory in studying the impact of organic nutrition on soil and plant characters.

1. All the soil physical characters like bulk density (1.32 Mg m^{-3} at 50 per cent flowering and 1.30 Mg m^{-3} at harvest for T_5), water holding capacity (36.3 per cent at 50 per cent flowering for T_4 and 41.93 per cent for T_5 at harvest), porosity (46.13 per cent for T_5 at 50 per cent flowering and 48 per cent at harvest for T_4) and soil temperature (28.20 ^{0}C and 29.13 ^{0}C for T_5 at both stages respectively) were found to be significantly influenced by organic nutrition. In all the cases vermicompost application (T_4 and T_5) was found to be superior. No significant difference was observed between these two treatments.

2. The treatment T_5 (vermicompost + PSM) and T_4 (vermicompost) were found to have significantly superior values for all the soil chemical properties studied. pH (5.69 at 50 per cent flowering and 6.33 at harvest) and CEC (5.39 cmol $p^{(+)}$ kg^{-1} and 5.02 cmol $p^{(+)}$ kg^{-1} at both stages respectively) values were highest for T_5 treatment which was on par with T_4. Regarding C: N ratio, a significant reduction was noticed in T_5 (9.97) and T_4 (9.97) treated plots. T_4 (0.87 at 50 per cent flowering and 0.78 at harvest) registered higher values for organic C, the next value being for T_5.

3. The soil nutrient availability was studied at 50 per cent flowering stage and at harvest. Perusal of the data indicated that organic matter addition has got significant role in enhancing the nutrient availability of soil. Available N, P and K got significantly higher values for the treatment, T_5 compared to the other treatments. Regarding available soil P, T_3, T_5 and T_1 got significantly higher values from T_2, T_4 and T_6 respectively. The treatment T_4 was found to be on par with T_5. Vermicompost + PSM application registered the highest value for exchangeable Ca and Mg. Here also T_4 was found to be on par. In the case of available S, poultry manure application was found superior, with the highest value for T_7 followed by T_6. The highest value for Fe was observed in T_8 plot receiving inorganic fertilizer alone. For Mn and Zn, the highest value was with T_5, followed by T_4. In the case of Cu, at 50 per cent flowering stage, T_4 got the highest value and at harvest time, T_5 was found superior.

4. The soil analysis data indicated the influence of organic nutrition in enhancing dehydrogenase and phosphatase activity of the soil. For both the enzymes T_5 and T_4 got significantly higher values, the highest was for T_5.

5. The growth characters like height of plant, number and weight of nodules and leaf area index were found to be significantly boosted up by organic matter addition and PSM application. In all the cases T_5 registered the highest value, followed by T_4. The treatments receiving PSM application (T_3, T_5 and T_7) got significantly higher values compared to the corresponding treatment without it (T_2, T_4 and T_6). The least number of days for 50 per cent bloom was registered by POP recommended crop and the maximum days were taken by the treatment T_8.

6. From the data concerning yield and yield attributes, it was observed that pod yield (8580 kg ha^{-1}) and harvest index (0.301) was highest for the treatment T_1, the next highest value being for T_5 and then T_4. But these treatments were statistically on par. The other treatments receiving organic nutrition also showed differential response compared to inorganic nutrition. Vermicompost + PSM application showed pronounced effect on bhusa yield and total dry matter production, followed by treatment with application of vermicompost alone.

7. Plant analysis (bhusa) of the crop at 50 per cent flowering stage and harvest stage showed that organic nutrition had got significant influence in enhancing the nutrient content in bhusa. The nutrients N, P, K, Ca and Mg was found to be highest for the treatment T_5 followed by T_4. Plant P showed significantly higher values in PSM treatments. Regarding S, poultry manure application was found superior. The highest value being for T_7 followed by T_6. The values showed a declining trend towards harvest due to crop uptake.

8. Pod nutrient composition as obtained from chemical analysis projected the role of organic manures in enhancing the pod nutrient content N (4.43 per cent), P (1.20 per cent) and K (1.91 per cent) values were higher for T_5 followed by T_4 and T_1. As in the case of

plant P, PSM application showed its significance on pod P values. Regarding Ca and Mg, T_5 got values of 0.69 per cent and 1.48 per cent respectively and T_4 was found on par. S content was highest in T_6 (0.271 per cent) which was on par with T_7. Vermicompost application (T_4 and T_5) got significantly higher values for Mn, Zn and Cu.

9. The influence of organic manure addition over inorganic nutrition was clearly highlighted in quality studies of pod. All the manures showed significant role in enhancing the quality of the produce. T_5 registered the lowest value of crude fibre followed by T_4. Regarding protein content and shelf life superior values were recorded by T_5 and T_4 treatments. Organoleptic evaluation showed the superiority of organic treatments over inorganic alone and integrated application, with particular reference to poultry manure and vermicompost applied.

10. From the bhusa uptake studies, it could be inferred that the highest values for N, P, K, Ca and Mg uptake were recorded by the combined application of vermicompost and PSM and was found on par with T_4 for K, Ca and Mg. Regarding N and P, significantly higher values were obtained with PSM application corresponding to the treatments receiving organic manure addition only. Poultry manure addition (T_6 and T_7) was found having significantly higher values for S uptake from other treatments. Mn, Zn and Cu uptake values showed the superiority of T_5 and T_4 over other treatments.

11. The uptake of different nutrients by pods was significantly influenced by the different treatments. The data showed that the highest mean value for N, P and K uptake by pods was recorded by T_5. This was found to be on par with T_1 and T_4. As in the case of bhusa uptake, P uptake by pods also showed significantly higher values for PSM application. Vermicompost application resulted

better uptake of Ca and Mg, the highest value being for T_5. Poultry manure application markedly influenced the S uptake by pods. It was seen that the treatment without manure addition was having the lowest value. No significant influence was shown on Fe uptake by pods. Vermicompost application was significant in enhancing Mn, Zn and Cu uptake.

12. The total uptake values for almost all nutrients showed marked variation with the different treatments. For N, P, K, Ca and Mg the total uptake was highest in T_5 followed by T_4. For N and P uptake the pronounced effect of PSM was noticed. T_6 and T_7 got significantly higher values for total S uptake. Fe uptake values showed little significance. Regarding Mn, Zn and Cu uptake, T_5 and T_4 was found superior.

13. Correlation studies revealed positive correlation between yield and soil characters like water holding capacity, porosity, pH and organic content. Bulk density and temperature showed significant negative correlation. A positive and significant correlation with yield was shown by available soil nutrients (N, K, Ca, Mg, Mn, Zn and Cu). Soil enzyme studies showed that both dehydrogenase and phosphatase showed significant positive correlation with yield.

14. Regarding growth characters, yield was significantly and positively correlated with height of plant, leaf area index, number and weight of nodules. All the yield attributes were significantly influenced. Bhusa yield, total dry matter production and harvest index showed positive and significant correlation with yield.

15. The nutrient composition of pods revealed that N, P, K, Ca, Mg, Zn and Cu content of pods showed significant positive correlation. Among the different quality attributes, protein content showed significant positive correlation, whereas fibre content showed significant negative correlation.

The study revealed the favourable effect of organic nutrition in enhancing the quality aspects of cowpea pod in comparison with inorganic and integrated nutrition, with pronounced effect on VC + PSM application. But regarding yield POP recommendation was found to be the highest, but it was on par with vermicompost + PSM and vermicompost alone application.

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*Original not seen

IMPACT OF ORGANIC FARMING PRACTICES ON SOIL HEALTH, YIELD AND QUALITY OF COWPEA

[*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcort]

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Abstract of the
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ABSTRACT

The research work entitled "Impact of organic farming practices on soil health, yield and quality of cowpea [*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcort]" was conducted at the Instructional Farm, College of Agriculture, Vellayani. The study was undertaken to evaluate the effect of different nutrient sources (organic, inorganic and integrated) on soil health, yield and quality of cowpea using the variety Sharika.

The experiment was laid out in RBD with three replications. Vermicompost, poultry manure, farmyard manure, their combinations with PSM, POP recommendation and NPK alone application as inorganic fertilizer constituted the eight treatments. The nutrient application was according to the POP (KAU, 2002) recommendation @ 20 : 30 : 10 kg ha^{-1} along with 20 t farmyard manure in all the treatments except the treatment receiving only inorganic fertilizer.

Soil characters like porosity, water holding capacity, pH, CEC, organic C content, available nutrients (N, P, K, Ca, Mg, Mn, Zn and Cu), enzyme activities (dehydrogenase and phosphatase) were significantly enhanced with vermicompost application either alone or in combination with PSM, but bulk density, soil temperature and C : N ratio get decreased with it. S status was improved by poultry manure addition. Available soil P significantly increased with PSM application.

The growth characters including height of plant, number and weight of effective nodules, leaf area index recorded the highest values with vermicompost + PSM application (T_5). Regarding yield, the treatment with POP recommendation (T_1) was found to have higher pod yield and harvest index. Bhusa yield and total dry matter production got the highest values with vermicompost + PSM application. Statistically pod yield was found to be on par in (T_1),(T_5) and (T_4) treatments.

Concerning the quality attributes vermicompost + PSM application got superior values. The highest protein content, shelf life and the lowest fibre content were with vermicompost + PSM application. Organoleptic result showed superiority of poultry manure and vermicompost application.

The nutrient content (N, P, K, Ca, Mg, Mn, Zn and Cu) in bhusa at 50 per cent flowering stage and at harvest stage was the highest with vermicompost + PSM application (T_5) except Mn and Cu which got slightly higher values with vermicompost application alone. P values were higher with PSM application for the three manures. S got higher values with poultry manure + PSM application. Regarding N, P, K, Ca and Mg, the treatment with POP recommendation showed a greater difference in values between the two stages of analysis.

Pod nutrient status also showed the same trend, except the fact that the highest value for pod Mn was with the treatment receiving vermicompost alone. The bhusa, pod and total uptake values for N, P, K, Ca, Mg, Mn, Zn and Cu was with vermicompost + PSM application except Zn which got higher values with vermicompost alone application. S uptake was highest with poultry manure + PSM application.

All the soil characters, plant growth characters and yield attributes were best correlated with yield. Uptake of all nutrients and quality attributes showed positive and significant correlation.

From the above points, it can be concluded that POP recommendation registered the highest pod yield, even though statistically it was on par with T_5 and T_4. While concerning environmental safety and quality of products, vermicompost + PSM application stands supreme.

Appendices

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

APPENDIX – II

Score card for the assessment of organoleptic qualities of cowpea pod (vegetable)

	1	2	3	4	5	6	7	8	9	10
Appearance										
Very Good 4										
Good 3										
Fair 2										
Poor 1										
Colour										
Very Good 4										
Good 3										
Fair 2										
Poor 1										
Texture										
Very Good 4										
Good 3										
Fair 2										
Poor 1										
Taste										
Very Good 4										
Good 3										
Fair 2										
Poor 1										