EFFECT OF VERMICOMPOST ON THE YIELD AND QUALITY OF TOMATO (*Lycopersicon esculentum* Mill.)

By

PUSHPA S

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DECLARATION

I hereby declare that this thesis entitled Effect of vermicompost on the yield and quality of tomato (Lycopersicon esculentum Mill) 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

Vellayani

9-5-1996

PUSHPA S

CERTIFICATE

Certified that the thesis entitled **Effect of vermicompost on the yield and quality of tomato (Lycopersicon esculentum Mill)** is a record of research work done independently by Ms PUSHPA S under my guidance and supervision and that it has not previously formed the basis for the award of any degree fellowship or associateship

Dr (Mrs) PRABHAKUMARI P
Chairman Advisory Committee
Department of Soil Science and
Agricultural Chemistry,
College of Agriculture
Vellayani

Vellayani
9-05-1996

APPROVED BY

CHAIRMAN

Dr (Mrs) P PRABHAKUMARI

MEMBERS

1 Dr (Mrs) P PADMAJA

2 Dr (Mrs) ALICE ABRAHAM 7-8-96

3 Dr (Mrs) GEETHAKUMARI V L

EXTERNAL EXAMINER

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Introduction

INTRODUCTION

Downer Cow Syndrome is a clinical condition of world wide occurrence and importance Clinically it is dealt as a complication of hypocalcaemia in dairy cattle The term Downer Cow (synonym Creeper Cow) is used to describe dairy cows that vary from alert and normal but unable to get up Hallgren (1955) and Hemsley (1957) regarded Downers as cows that are normal in every respect but without the necessary muscular strength to regain feet Cows that had parturient paresis are considered as Downers when they do not get up within 24 to 48 hours after the initial treatment for milk fever Cox et al (1986) defined Downer Cow as one down for at least 24 hours without apparent reason for being recumbent

Downer Cow Syndrome may occur independently or follow apparent recovery after treatment for parturient paresis for the continued recumbency which in effect constitutes the disease Typical Downer Cow is bright and alert with reduced appetite and continues to eat and drink moderately There are no systemic disturbances apparent among the affected animal (Blood et al 1989)

A high incidence of Downer Cow Syndrome among the crossbred dairy cattle in Kerala is increasingly observed in the recent past Economic loss on account of loss of production incapacitation of the animals and the high cost for prolonged treatment which often fails to evoke a positive response noted to be substantial Lack of proper line of treatment and control regimen based on the proper understanding of the etio-pathogenesis warrant detailed investigation of this condition The present work was taken up to study the metabolic profile of Downer Cow Syndrome in cattle to throw more light on its etio pathogenesis

The investigations were carried out on the following lines The following parameters were selected as the main items of observation

1 Haematological changes

(i) Erythrocyte sedimentation rate

(ii) Packed-cell volume

(iii) Haemoglobin

(iv) Red blood cell

(v) White blood cell

(vi) Differential leukocytic count

2 Biochemical changes

(i)	Calcium	(v)	Blood urea nitrogen
(ii)	Phosphorus	(vi)	Total serum protein Albumin and Albumin/ Globulin Ratio
(iii)	Magnesium	(vii)	Plasma sodium
(iv)	Glucose	(viii)	Plasma potassium

3 Urinalysis for pathological constituents

(i)	Protein	(iv)	Blood
(ii)	Glucose	(v)	Bile pigments
(iii)	Ketone bodies	(vi)	Bile salts

Review of Literature

2. REVIEW OF LITERATURE

Adequate quantity of organic matter in the soils is a prerequisite for maintaining soil health and productivity. Among the means available to achieve sustainability in agricultural production organic matter plays a key role because it possesses many desirable properties and exerts beneficial effects on the physical, chemical and biological properties of the soil. The nature and quality of organic matter in combination with mineral constituents decide the soil physical properties. Apart from promoting soil aggregation leading to better water holding capacity in coarse textured soils and drainage in heavy soils, organic manures cause favourable changes in soil reaction and enrich the nutrient status of the soil. Humus, derived from the decomposition of organic manures, has chelating properties, as well as nutrient buffering capacity. By virtue of these properties, humus increases the availability of both the added and native nutrients. Effect of organic manures on soils and crops are reviewed here under.

2.1 Organic manures on soil physical properties

Kanwar and Prihar (1962) reported that continuous addition of farm yard manure decreased the hydraulic conductivity of soil in two out of the four permanent manurial trials conducted in Jalandhar. Das et al. (1966) also observed a

decrease in the hydraulic conductivity due to the continuous application of farm yard manure in sandy calcarious soils, in the Pusa Permanent Manurial Experiment at Pusa, Bihar.

Havanagi and Mann (1970) observed that continuous application of farm yard manure and use of green manure decreased the bulk density of the soil and increased the water holding aggregates in a long term manurial experiment under dry farming conditions in Delhi. Application of farm yard manure, groundnut cake and green manure in a rice fallow rotation for 10 years improved the water retention characteristics of an alluvial sandy loam soil. (Biswas et al., 1969).

Suneja et al. (1982) studied the effect of farm yard manure on hydraulic conductivity, dispersion percentage, and soil moisture availability of sodic soils and reported an increase in hydraulic conductivity and decrease in dispersion with farm yard manure addition.

Nambiar and Ghosh (1984) reported that there was a rise in hydraulic conductivity under continued farm yard manure treatment in alluvial soils and medium black soils and a slight decrease was seen in laterite soils. Farm yard manure has favourable effect on soil aggregation compared to fertilizers. (Rabindra et al., 1985). The structural index and organic carbon which were taken as a measure of soil physical conditions were

found to be positively correlated with other physical parameters viz. water holding capacity, porosity etc. The beneficial effect of farm yard manure in increasing the water stable aggregates was also reported by Kanwar and Prihar (1982) and Prasad and Singh (1980).

Mahimairaja et al. (1986) had found the highest values of hydraulic conductivity in plots receiving cattle manure or cattle manure residue in a long term fertilizer experiment at Coimbatore on maize and sorghum.

It is reported that continuous crop production with manuring and mulching had significantly increased moisture retention in soil at 0.1 bar tension from 10 to 12.1 per cent (Gupta, 1989).

Lal and Mathur (1989) in a study to evaluate the soil physical properties in an alfisol on maize by long term fertilization and manuring found that bulk density decreased with organic matter, either alone or in conjunction with inorganic. It was also observed that water holding capacity was significantly higher in soils receiving organics than inorganics.

From a long term field experiment in England, Rose (1990) reported that continuous application of farm yard manure increased the total porosity.

A decrease in bulk density by the addition of organic matter residue over a long time was observed by Rasmussen and Collins (1991).

Bhatnagar et al. (1992) reported that soil porosity was significantly higher in treatments receiving farm yard manures continuously in a long term experiment with soyabean wheat cropping sequence in Uttar Pradesh. It is also reported that the soils receiving continuous farm yard manure showed 22.1 - 27.5 per cent increase in water retention at 0.33 bar resulting in 25.17 and 34.26 per cent increase in plant available water content in the surface soil. Bulk density was found to be decreased with continuous manuring.

Joshi et al. (1994) reported that volumetric water content of saturated clay loam soil varied from 0.4 cm^3 in the sesbania treated plots to 0.425 cm^3 in plots receiving no green manure. In the unsaturated soils at rice harvest the corresponding values were 0.317 and 0.271 cm^3.

Hudson (1994) reported that organic matter is an important determinant of available water content as it is a significant soil component by volume and it increases the available water content in sandy textured soils only. As organic matter increased, the volume of water held at field capacity increased at a greater rate than that held at permanent wilting point.

2.2 Organic manures on soil chemical properties

Addition of organic matter primarily provides nitrogen to the crop. The organically bound form of nitrogen becomes available to the crop after undergoing the process of decomposition, followed by the mineralisation into inorganic forms such as NH_3, NH_4^+, NO_2^{--} and NO_3 and immobilisation of inorganic forms into organic forms. The magnitude of these two reactions control the available nitrogen status in the soil. (Jansson, 1963; Tusneem and Patrick, 1971).

Havanagi and Mann (1970) reported that farm yard manure application increased the organic carbon and the available P_2O_5 content of the soil but not the total nitrogen in a long term fertilizer experiment under dry farming conditions in Delhi.

Humus by virtue of its chelating properties, increase the availability of nitrogen, phosphorus, sulphur and other nutrients to plants growing in humus rich soils. The humus substances increase phosphorus availability as they have a very high exchange capacity (Eberhardt and Pipes, 1974 and Gaur, 1994).

Mukherjee et al. (1979) explained the importance of organic matter in providing phosphorus to the soil.

Gattani et al. (1976) reported that the continuous use of farm yard manure had increased the organic carbon level of the

soil to a good extent but the available nitrogen level had not increased to that extent in a permanant manurial experiment at Rajastan on wheat- bajra cropping sequence.

Prasad and Singh (1980) observed that available N, P_2O_5 and organic carbon content of the soil increased with continuous use of farm yard manure. Available Zn, Cu, Fe and Mn also increased considerably with continuous use of farm yard manure in a long term fertilizer experiment at Ranchi under wheat - maize rotation.

In a permanent manurial experiment with dwarf indica rice at Pattambi, pH was uninfluenced by the application of organic manure (Kurumthottical, 1982).

Subba Rao (1982) explained the utilization of farm waste and residue in agriculture as manure for composting and biogas production.

Fellaca et al. (1983) reported that humified organic matter can significantly reduce the amount of phosphates required to maintain a solution concentration necessary for crop growth. Sharma et al. (1984) reported that available K increased slightly with the addition of farm yard manures for long time.

Application of farm yard manure increased the availability of both native and applied micronutrient cation.

These ions form stable complexes with organic ligands which decrease their susceptibility to adsorption and fixation (Swarup, (1984).

Srivastava (1985) observed that increased use of nitrogenous fertilizers decreased organic carbon content, total N, available P and K status whereas, farm yard manure addition increased all the parameters in the soil.

The complexing property of organic matter influences the availability and mobility of micronutrients. The micronutrients and other heavy metals, designated as toxic elements, form water soluble as well as insoluble complexes with the soil organic matter. The stability of micro nutrients which determine the availability follow the order: for humic acid $Cu^{2+} > Fe^{2+} > Zn^{2+} > Mn^{2+}$ where as for fulvic acid the stability is $Cu^{2+} > Zn^{2+} > Fe^{2+} > Mn^{2+}$ (Relan et al. 1986).

Organic residue incorporation to the soil improves the overall physical, chemical and biological properties of the soil and regular return of crop residues to the soil contributes to the soil nutrient pool in a gradual manner, besides offering other indirect benefits (Srivastava 1988; Sidhu and Beri, 1989 and Bhat et al., 1991). Similar results were also reported by Palaniappan and Natarajan (1993). They further stressed the role of organic matter in the maintanance of fertility and productivity.

More (1994) reported that addition of farm wastes and organic manures increased the status of organic carbon available nitrogen phosphorus and potassium of the soil

Among nutrients the most significant role of organic matter is in supplying K (Bharadwaj 1995)

2 3 Effect of organic matter on the yield of crop

Garg et al (1971) reported an increase in the yield of rice wheat sugarcane and cotton due to the application of farm yard manure and compost

Krishnamoorthy and Ravikumar (1973) reported that in permanent manurial trial at Coimbatore cattle manure treatment gave the highest yield of ragi but was on par with NPK treatment

A significant increase in the yield of sorghum due to organic matter addition was reported by Vinodkumar (1974)

In maize application of cowdung slurry at 0 25 per cent and 0 5 per cent was comparable to 40 kg N ha ^{1} (Neelakantan et al 1978)

Gaur and Mukherjee (1979) reported that wheat straw applied at 5t ha ^{1} significantly increased the pod yield of groundnut by 95 5 per cent

Increase in corn response in a sandy loam soil with increasing rate of farm yard manure application was reported by Antoun et al (1985)

Ganguly (1988) reported the beneficial effects of farm yard manure on crop yield The yield increases were gradually due to favourable increase in grain number per ear and increased grain weight

Residue incorporation has resulted in higher agronomic efficiency and apparent recovery of nitrogen in both upland and low land rice condition (John et al 1989)

Dhillon and Dhillon (1991) obtained significant increase in wheat yield and contents of available phosphorus and potash of soil due to incorporation of groundnut residue

More (1994) found that application of farm waste and other organic manures to the soil enhanced significantly the grain and straw yield of rice and wheat

Arokiaraj and Kannappan (1995) studied the effect of organic wastes on yield and economics of rainfed sorghum (Co 25) and reported that higher straw yield and grain yield resulting in higher net return and B/C ratio can be obtained in Co 25 sorghum by application of FYM 5t ha ^{1} under rainfed condition

2 4 Effect of organic manure on the uptake of nutrients

A study conducted at Amori Prefactural Experiment Station showed that absorption of N P and K was found to be increased with increasing amounts of FYM alone Increase in K was highest followed by N and P (Yamashita 1964)

Terman and Mays (1973) noticed increased phosphorus content in sorghum plants with increased compost application Hartenstein and Rothwell (1973) observed an increase in uptake of all nutrients except Manganese by sorghum on compost application

Khan et al (1981) reported that city compost raised the zinc and iron contents of plants from deficiency to sufficiency level

Ahmed et al (1984) reported that organic matter promoted grain P uptake which was greater with flooding

Ganguly (1988) reported the beneficial effect of farm yard manure on the uptake of all nutrients in maize

Dhillon and Dhillon (1991) obtained increased N P and K uptake in wheat due to incorporation of groundnut residue

Minhas and Sood (1994) opined that FYM application was beneficial in enhancing the uptake of all three major nutrients by potato and maize

2 5 Effect of organic manure on the quality of produce

Addition of pressmud increases the juice quality in sugarcane (Mariappan et al 1983)

Increase in the grain protein content of rice due to the application of Karanja and Mahua seed cake was reported by Sahrawat and Mukherjee (1977) and Sahrawat (1981)

Kansal et al (1981) opined that application of 20t FYM ha^{-1} increased the ascrobic acid content in spinach leaves

Sabrah et al (1995) reported the beneficial effect of town refuse compost in enhancing the protein content in maize

2 6 Effect of integrated application of organic manure and inorganic fertilizers on soil physical properties

Manickam and Venkitaramanan (1972) observed that in the new permanent manurial experiment at Coimbatore plots which received NPK as inorganic fertilizers or cattle manure recorded favourable increase in the physical properties of the soil like pore space volume expansion etc

Continuous application of farm yard manure in combination with chemical fertilizers was proved to be beneficial in increasing the water holding capacity of soil (Manickam and Venkitaramanan 1972 Prasad and Singh 1980)

A decrease in bulk density was noticed by the application of lime and farm yard manure in combination with chemical fertilizers whereas continuous use of chemical fertilizers alone caused an increase in bulk density (Sinha et al 1980)

Porosity was improved by combined application of farm yard manure and chemical fertilizers (Mahmairaja et al 1986) Improvement in hydraulic conductivity of black soils due to continuous addition of organics in combination with inorganics as compared to inorganics alone was reported by Nambiar and Ghosh (1984) and Aravind (1987)

Patnaik et al (1989) reported an increase in available water content by the application NPK fertilizers together with compost or farm yard manure

Bhatnagar et al (1992) from the study on the effect of long term manuring and fertilization under soya bean and wheat cropping sequence in the Kumaron region of UP concluded that long term manuring has considerable beneficial influence on soil physical properties particularly water retention and release

2 7 Integrated application of organic manures and inorganic fertilizers on the availability of nutrients

Application of farm yard manure and phosphatic fertilizers improved the organic matter status of soil in

permanent manurial experiment at Ranchi (Biswas et al 1969) Combined application of organic manures and inorganic fertilizers also had resulted in higher organic carbon content of soil (Mathan et al 1978 Udayasooryan 1988)

In a permanent manurial experiment on dwarf indica at Pattambi significant variation was noticed in available nitrogen content of soil Highest value of 106 2 kg ha ^{1} was observed in treatments where 90 kg N ha ^{1} was supplemented through organic and inorganic sources together with P_2O_5 and K_2O (Kurumthottical 1982)

In a long term fertilizer cum manurial experiment on paddy wheat cropping sequence addition of higher doses of nitrogen showed more depletion of available P both in the absence and presence of farm yard manure (Kaushik et al 1984)

Phosphorus enrichment in soils with application of balanced or high dose of NPK and combined use of NPK and farm yard manures and phosphorus depletion in the absence of phosphorus fertilizers was quite evident in the long term fertilizer experiment with wetland rice conducted at various locations in India (Nambiar 1985 Patnaik et al 1989)

Combination of organic manures with inorganic fertilizers had a moderating effect on soil reaction particularly under acid soils improvement in sustained

availability of N P K S and the micro nutrients particularly zinc (Nambiar and Abrol 1989)

Review of research information from long term fertilizer experiments specific to wet land rice in India has revealed that there was an increase in available N content of soil at Hyderabad with intensive manuring and cropping The improvment in N status of soil at Barakpore was more pronounced in 100% NPK + farm yard manure and 150% NPK treatments in unfertilized controls (Patnaik et al 1989)

Studies on the effect of long term application of farm yard manure fertilizers and lime for 28 years on the status of total (6N HCl-K) non exchangeable IN HNO_3 K) exchangeable (IN ammonium acetate K) and water soluble potassium on the surface of soil revealed that non exchangeable K was found to be increased in the fertilized and manured plots (Lal et al 1990)

2 8 Effect of application of integrated application of organic manure and inorganic fertilizers on crop growth

A study on optimum level of poultry manure requirement for cauliflower by Singh et al (1970) revealed a progressive increase in growth and yield of cauliflower when the doses were increased from 0 to 169 6 q ha^{1}

Singh et al (1973) reported that in potato 160 kg N ha^{1} applied 50 per cent through poultry manure and

remaining 50 per cent through fertilizer gave maximum yield compared to 80 or 120 kg N ha ^{1} applied as FYM or poultry manure or in combination with fertilizers

Abusaleha (1981) reported early flowering and highest yield of 18 02 t ha ^{1} with the application of half nitrogen through $(NH_4)_2 SO_4$ and the remaining half through poultry manure in bhindi

In lettuce poultry manure applied at 0 20 and 40 m^3 ha ^{1} either as entire basal dose or in splits increased the yield from 0 66 to 0 88 and 0 90 kg plant ^{1} (Anez and Tavira 1984)

Rawankar et al (1984) revealed that application of farm yard manure produced significantly high seed cotton yield by 41 1 per cent over its no application Srivastava (1985) reported that economically higher wheat grain yield was obtained with 15 tonnes of farm yard manure in combination with 120 kg of fertilizer nitrogen ha ^{1}

Application of green manure and urea had been more effective than applying urea alone in increasing the rice yield (Saravanan et al 1987 Furoc et al (1988)

Jose et al (1988) observed that plants supplied with 50 kg N as poultry manure and 50 kg nitrogen as urea recorded the highest yield of brinjal fruits (51 t ha ^{1}) followed by plant supplied with 50 kg N as pig manure and 50 kg as urea

Lekha Sreekantan and Palaniappan (1989) reported that green manuring along with single super phosphate application increased the yield of the first crop of rice significantly in rice-rice green gram cropping system

Meena Nair and Peter (1990) reported highest yield in chilli with 15t FYM + 175 40 25 kg NPK ha ^{1} in the three seasons tried when compared to FYM alone or inorganic fertilizer alone

Studies conducted in KAU revealed that the organic and inorganic fertilizers and their combinations had significant influence on vegetable productivity and higher rate of N along with FYM induced earliness and enhanced the fruit yield in clustered chilli (Kerala Agricultural University 1991)

Subbiah and Sundararajan (1993) found that combined application of 12 5 t ha ^{1} FYM + recommended dose of macro nutrients + 25 kg $ZnSO_4$ ha ^{1} in bhindi was better than FYM alone or combinations of 25t ha ^{1} FYM with the recommended dose of fertilizers with or with out micronutrients

Minhas and Sood (1994) reported that farm yard manure application significantly increased the crop yield Super imposition of inorganic fertilizers over farm yard manure had a spectacular effect on crop yields The effect of farm yard manure was beneficial in enhancing the uptake of all the three major nutrients

Alokkumar and Yadav (1995) reported that farm yard manure and prickly sesban green manure can substitute about 60 kg fertilizer N ha ^{1} in rice grown in a sequence with wheat They also reported that green manuring with prickly sesban improves soil sodicity at faster rate than with farm yard manure and wheat straw

Prasad and Sinha (1995) opined that 50% NPK in combination with 10 t ha ^{1} of farm yard manure crop residue alone and farm yard manure along with crop residue increased grain yield of wheat to 26 per cent 11 7 per cent and 30 9 per cent respectively over the application of NPK alone Similarly 50% NPK in combination with farm yard manure crop residue alone farm yard manure along with crop residue increased the grain yield of rice to 24 3 per cent 7 3 per cent and 36 5 per cent respectively compared to no farm yard manure or crop residue

2 9 Effect of integrated application of organic manure and inorganic fertilizers on the uptake of nutrients

Ramaswami and Raj (1972) in a pot culture experiment with rice Co 32 strain as a test crop observed that phosphorus and potassium uptake by straw were enhanced by phosphorus and green manure application

In a long term fertilizer cum manurial experiment on paddy wheat cropping sequence application of nitrogen and farm yard manure increased the uptake of N P and K (Kaushik et al, 1984)

Singh and Brar (1985) found that K content in potato leaves was significantly influenced by applied K and farm yard manure But applied K decreased the leaf concentration of Mg and Ca

Lal and Mathur (1989) are of the opinion that application of lime or FYM along with fertilizers had significant effect on the uptake of N P K and Ca by maize and wheat in an arid red loam soil

Singh et al (1991) opined that both FYM and K application had a positive effect on the uptake of N Ca and Mg by wheat crop

Prasad and Sinha (1995) found that 50 per cent NPK in combination with farm yard manure increased the uptake of all the three major nutrients by wheat

2 10 Effect of integrated application of organic manure and inorganic fertilizers on the quality of produce

Luchnik (1975) is of the opinion that both organic and inorganic fertilization resulted in high sugar and Vitamin C content in cabbage

A combined application of farm yard manure and fertilizer nitrogen was found to significantly increase the protein content of grains in red gram (Muthuvel et al 1985)

ragi (Chellamuthu et al 1987) and in wheat (Patel et al 1993) than when applied alone

Lal and Mathur (1989) found that FYM along with fertilizer enhanced the protein content of grains in wheat and maize

2 11 Effect of organic manure on the growth and yield of tomato

Lin and Lee (1962) reported addition of fertilizer organo to tomato as basal dose at the rate of 1 kg m^2 gave significantly higher yield

Application of filter press cake at about 10 tonnes / acre was found to increase the yield of marketable tomatoes by 6 76 tonnes (Azzam and Samuels 1964) Use of commercial as well as prepared starter solutions along with filterpress cake led to further yield increase

Graifenberg and Linardakis (1983) found a significantly higher yield of tomato cv Etna when the plants were grown in pumice as compared to a 1 1 pumice peatmoss medium

Araki et al (1985) studied the effect of long term application of sawdust bark and peatmoss at the rate of 60 kg m^2 on continuous tomato cropping in a green house Average yield over 10 year period using a base index of 100 for rice

straw plot were assumed as 107 99 and 110 for saw dust bark and peat moss respectively

The efficiency of solid and liquid fractions obtained from lignite as an organic fertilizer for tomato was studied by Salas et al (1986) and reported that smaller addition of lignite produced similar yield to manure

Hilman and Suwandi (1989) found that sheep manure at 30 t ha ^{1} gave highest yield (1 05 kg) of class one (≥ 60) fruits in tomato cultivar Gondol

Elliot and Singer (1989) studied the effect of water treatment sludge on growth and elemental composition of tomato in a green house and concluded that sludge at 2 10 per cent dry weight raised the pH of silt loam soil from 5 3 to 8 0 which enhanced the growth

Murillo et al (1989) were of the opinion that successive application of city waste compost to tomato in a green house experiment resulted in increased yield

Ahmed (1993) opined that incorporation of composted coir pith along with farm yard manure (5 20 t ha ^{1}) into the soil one day prior to transplanting gave the highest fruit yield (19 t ha ^{1}) followed by 20 t ha ^{1} coir pith alone (16 t ha ^{1}) and lowest in control (11t ha ^{1}) which were treated with neither FYM nor coir pith

2 12 Effect of organic manures on the quality of tomato

Meier Ploeger and Lehri (1989) studied the quality of food plants grown with composts from biogenic waste Composts from biogenic wastes were applied at various levels to tomatoes NPK fertilizers composted FYM commercial organic fertilizers were used for comparison They found that storage quality contents of desirable nutrients (Vitamin C and Sugar) improved by compost treatments

Montegu and Gosh (1990) found that fruit colour of tomato was increased significantly on application of blood and bone meal

2 13 Effect of integrated application of organic manures and inorganic fertilizers on the growth and yield of tomato

Hodos S (1968) studied the effects of green manuring with rye on tomato Green manure along with mineral fertilizer gave approximately 25 per cent higher yield than fertilizer alone

Morelock and Hall (1980) compared the effects of broiler litter applied at different rates (0 8 t/acre) with a pre-planting application of commercial fertilizer ($N_{10}P_{20}K_{10}$) at 250 750 lb/acre on field grown tomato plants Marketable fruit yield was found to increase with broiler application

Khawari and Nejad (1986) observed that fertilized compost treated tomato plants produced bigger sized fruits than those treated with Hewitt culture solution

Zhang et al (1988) found that in comparison with the application of Nitrogen alone the combined use of nitrogen with soyabean meal resulted in better growth higher yield and better fruit quality

Almazov and Kholuyako (1990) reported that application of optimum dose of NPK along with peat increased drymatter production and yield of tomato compared to the application of NPK alone

2 14 Effect of integrated application of organic manure and inorganic fertilizers on the quality of tomato

Yoshida et al (1984) found that fertilization with bone and rape seed meals produced firm fruits with most cohesiveness chewingness and uniform firmness at top and bottom of fruits

Shanmugavelu (1989) pointed out that the application of a combination of FYM and inorganic mixture was the best for firmness storage life and keeping quality of tomatoes for a long time

Almazov and Kholuyako (1990) found increased sugar content in tomato due to the application of NPK along with peat compared to the application of NPK alone

2 15 Influence of Vermicompost/Vermiculture on nutrient uptake, growth and yield of crops

Yield increase in pasture production caused by earthworms was noted by Stockdill and Cossens (1966)

Van Rhee (1969) found that grass yields were increased upto four times and clover yields upto ten times after inoculation with earthworms

Sharpley and Syres (1977) found increased P availability to plants when vermicasts were used

The possibility of replacing the chemical fertilizers by the organic manure was established by the preliminary field trials conducted on the summer crop of paddy Var IR 20 (Kale and Bano 1983)

Atlavinyte and Zimkuviene (1985) observed improved growth and yield in barley crops by using worm activated soil

Grapelli *et al* (1985) had reported the initiation of rooting of layers and shoots when grown in worm cast

Lee (1985) reported that in temperate climate earthworms are capable of stimulating plant growth

The application of worm worked compost resulted in higher yields of paddy crop ranging from 95 per cent increase in grain and 128 per cent increase in straw and root production and 38 per cent decrease in weed growth Senapathi et al (1985)

Sacirage and Dzelilovic (1986) obtained higher dry matter yields for leek by growing in vermicompost than with the application of mineral fertilizers They also found that by application of 4 6 and 8 kg m^{2} of vermicompost the cabbage dry matter yield increased from 1 to 66 per cent

Bouche and Ferrierie (1986) reported that 15_N labelled nitrogen from earthworms was rapidly and almost entirely taken up by plants in the spring in undisturbed soils

Kale et al (1987) studied the influence of worm cast on the growth and mycorrhizal colonization of two ornamental plants (salvia and aster) and reported that the worm cast when used as a manure in place of farm yard manure significantly influenced both their vegetative and flowering characters and increased mycorrhizal root colonization

Curry and Boyle (1987) reported enhanced plant growth in the presence of earthworms which was attributed to an increased supply of readily available plant nutrients and to the physical effect of earthworms in improving soil structure and aeration and in providing channels for root growth in undisturbed profiles

Senapathi (1988) reported the effectiveness of earth worm cast as a substitute for gram powder in mushroom production

Considerable scientific data were generated recently to show that produce obtained from organic farming is nutritionally superior with good taste good lusture and better keeping qualities The better storage life of spinach grown with organic manure was found to be associated with lower free amino acid content lower level of nitrate accumulation and higher protein nitrogen to nitrate nitrogen (Lampkin 1990)

Shuxin et al (1991) observed 30 50 per cent increase in plant growth and N uptake and a 10 per cent increase in height and effective tillering and diameter of sugar cane They also reported a 20 25 per cent increase in height and 50 per cent increase in weight of soybean plants when vermicompost was applied

Reddell and Spain (1991) suggested that part of growth stimulation credited to earthworms may be due to more rapid and intensive infection by mycorrhizal propagules which almost is ubiguitous in earthworm casts in field situations

Spain et al (1992) found increased plant production related to earth worm biomass due to the addition of earthworms to the field

Kale et al (1992) found significantly higher levels of uptake of N and P in rice treated with vermicompost

Gunjal and Nikam (1992) reported earthworm inoculation in combination of heavy mulching of agricultural wastes all the year round as a successful practice of grape production without application of chemical fertilizers

Barve (1993) reported increase in the yield and improved quality both in taste and in attractive lusture on application of vermicompost to grape Reduction in cost of cultivation also indicated

Phule (1993) obtained more sugarcane yield from vermiculture treated plots and also the juice had 3 4 extra brix and lesser salts that chemical fertilizers applied

In watermelon vigorous growth and increased number of flowers and fruits were observed when treated with vermicompost (Ismail et al 1991)

By applying vermicompost Khamkar (1993) obtained healthier coccinia plants and better keeping quality of vegetables reduced cost of cultivation through low labour cost and reduced use of fertilizers and pesticides

Vadiraj et al (1993) reported that use of vermi compost as a component of potting mixture in cardmom nursery

helped better seedling growth and drymatter production in a shorter period of time

Ismail et al (1993a) studied the influence of vermicompost on the relative appearence height of plants number of branches and flowers of Zinnea and reported that vermicompost treated plants showed more number of brighter coloured flowers number of branches per plants compared to farm yard manure treated plants

Stephens et al (1994) studied the ability of earthworms to increase plant growth and foliar concentration of elements in wheat in sandy loam soil They observed a significant increase in the plant yield root and shoot weight and the foliar concentration of elements like Ca Na Mn Cu Fe and Al

Dharmalingam et al (1995) studied the effect of vermicompost pelleting in soyabean and reported 16 per cent increase in yield over non pelleted seeds

MATERIALS AND METHODS

MATERIALS AND METHODS

The study entitled Effect of vermicompost on the yield and quality of tomato (Lycopersicon esculentum Mill) has been carried out at the instructional farm attached to the College of Agriculture Vellayani during 1994 The main objective of the study was to investigate the potential of using vermicompost as an organic manure and as a partial substitute for inorganic fertilizers in tomato for increasing yield and to improve the quality of fruits

3 1 Soil

The soil of the experimental site is red loam non saline moderately acidic in reaction low in CEC medium in organic carbon low available nitrogen high phosphorus and medium potassium The physical and chemical properties of soil are presented in table 1

Table 1a Mechanical analysis of the soil of the experimental site

Fractions	Content in soil (%)	Method used
Coarse sand	13 60	
Fine sand	33 70	Bouyoucos
Silt	28 10	Hydrometer method
Clay	24 60	(Bouyoucos 1962)
Textural class	Loam	

Table 1b Physico chemical properties of the soil of the experimental site

Parameter	Content	Rating
Total N	0 03%	
Total P	0 04%	
Total K	0 095%	
Available N	264 4 kg ha ^{1}	Low
Available P_2O_5	30 8 kg ha ^{1}	High
Available K_2O	145 6 kg ha ^{1}	Medium
Exchangeable Ca	0 75 c mol kg ^{1}	
Exchangeable Mg	1 0 c mol kg ^{1}	
pH	5 1	Acidic
EC	< 0 05 d Sm ^{1}	
Organic carbon	0 68 %	Medium
CEC	4 5 c mol kg ^{1}	
Bulk density	1 51 Mg m^{-3}	
Water holding capacity	25 37%	

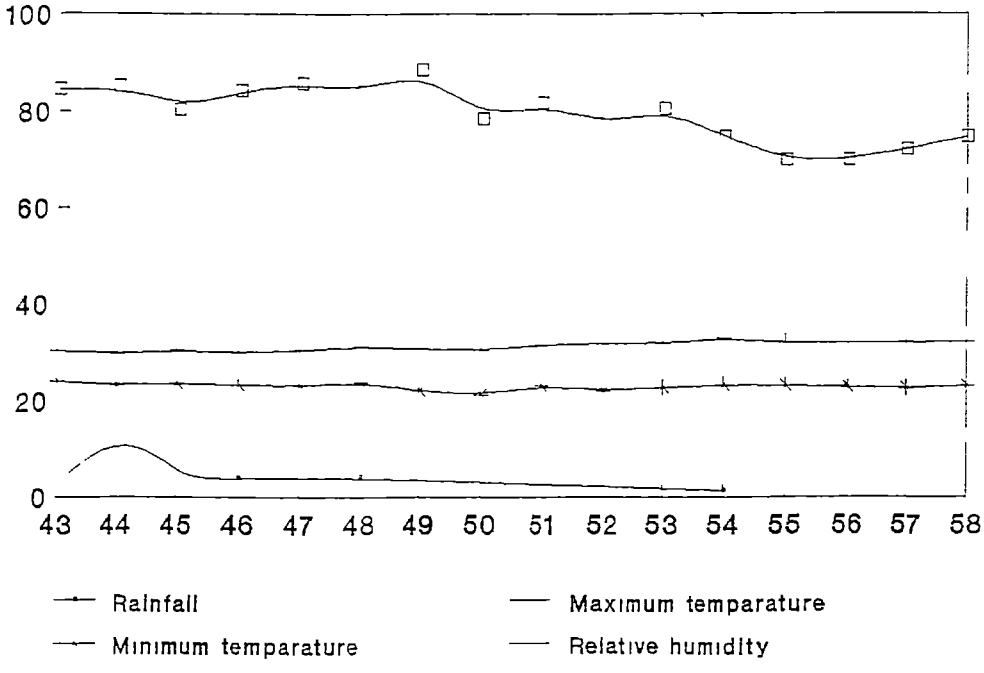
3 2 Season

The experiment was carried out during October to February of 1994 95 which received a total rainfall of 30 8 mm The range of maximum and minimum temperature during cropping period was 28 to 30°C and 22 to 25°C respectively

3 3 Variety Sakthi

Seeds of tomato variety Sakthi were obtained from the instructional farm of College of Agriculture Vellayani

Fig 1 Weather data during the cropping season (weakly averages) from 22-10-1994 to 11-02-1995



3 4 Fertilizers

The carrier fertilizers for NPK were Urea (46 5% N) Mussorie rock phosphate (20% P_2O_5) and Muriate of potash (59 81% K_2O) respectively

3 5 Manures

The nutrient status of the organic manures used in this study are furnished below

	% N	% P	% K
Cowdung	0 63	0 18	0 52
Vermicompost	1 69	0 78	1 90

3 6 METHODS

3 6 1 Layout and Design

The experiment was laid out in Randomised Block Design with ten treatments and three replications The lay out of the design is given in Fig 2

3 6 2 Spacing and plot size

A spacing of 60 x 60 cm was adopted

Gross plot size	3 0 x 3 0 m
Net plot size	2 4 x 2 4 m

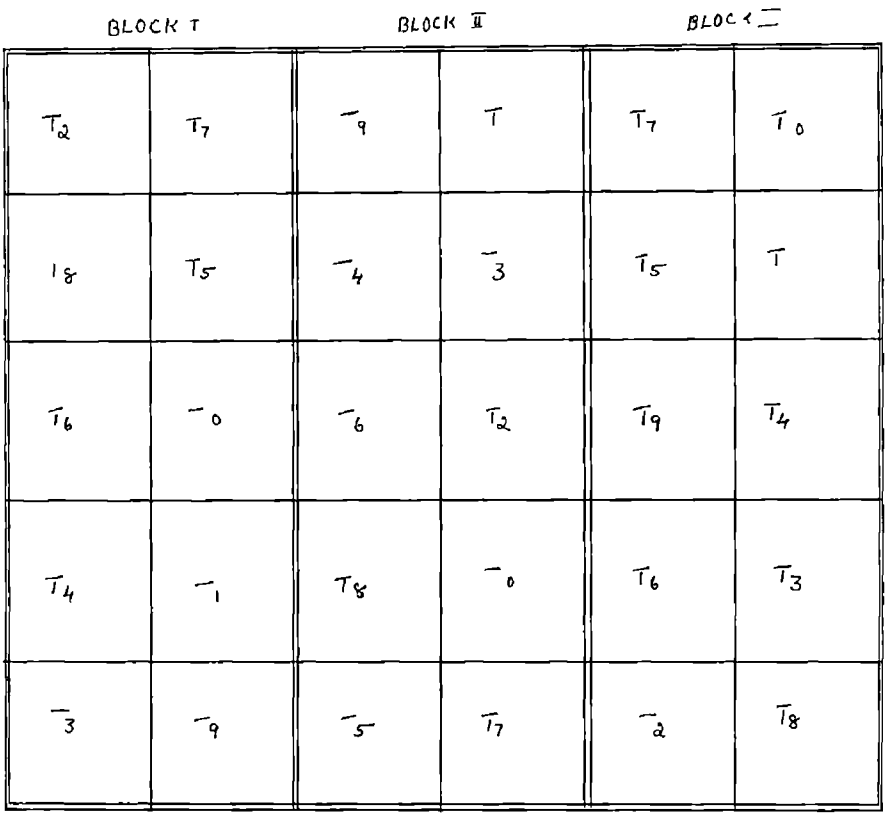


Fig 2 *LAYOUT OF THE EXPERIMENT*

3 6 3 Treatments

T_1 FYM @ 25t ha ^{1} + NPK in the ratio 75 40 25 as per Package of Practice Recommendations of KAU

T_2 FYM @ 25t ha ^{1}

T_3 Vermicompost @ 25t ha ^{1}

T_4 Vermicompost @ 37 5t ha ^{1}

T_5 Vermicompost @ 50t ha ^{1}

T_6 - Vermicompost @ 100t ha ^{1}

T_7 Vermiculture *in situ*

T_8 - Vermicompost @ 25t ha ^{1} + NPK in the ratio 75 40 25 as per Package of Practice Recommendations of KAU

T_9 Vermicompost @ 25t ha ^{1} + NPK in the ratio 56 25 30 18 75 (3/4th of recommended dose as per Package of Practice Recommendations of KAU)

T_{10} Vermicompost @ 25t ha ^{1} + NPK in the ratio 37 5 20 12 5 (1/2 the recommended dose as per Package of Practice Recommendations of KAU)

3 6 4 Vermiculture *in situ*

Basal dose of fertilizers was given to the crop Chopped banana leaves and pseudostem mixed with cowdung in the ratio 8 1 was applied at the rate of 10 50 kg per plot in two splits First application was done one week after

transplanting 250 worms were introduced into the net plot along with the waste Remaining quantity of wastes applied after 25 days of first application In order to maintain moisture sufficient irrigation was given

3 6 5 Details of cultivation

3 6 5 1 Planting

Tomato seedlings were raised in the nursery Twenty five days old seedlings were used for transplanting All cultivation practices as per Package of Practice Recommendations of KAU were followed

3 6 5 2 Application of fertilizers and manures

Entire quantity of phosphorus half of nitrogen and potash were given as basal dose before transplanting Remaining potash and 1/4th of nitrogen applied 25 days after transplanting Remaining 1/4th nitrogen was applied one month after first application Farm yard manure and vermicompost were applied to different plots in two splits as basal and one month after transplanting

3 6 6 Biometric observations

Four plants from the middle of each plot were tagged to record biometric observations viz plant height number of leaves date of flowering number of flowers and number of fruits at fortnightly intervals after transplanting

3 6 7 Harvest

Harvesting was done by picking ripe fruits and matured fruit yield of individual plots was recorded

3 7 Weight and girth of fruits

After harvest five random fruits were selected for taking individual fruit weight and girth of fruit and average worked out for each harvest

3 8 Number of seeds per fruit

Five random fruits from each plot were selected for extracting seeds and number of seeds per fruit were recorded separately

3 9 Seed quality

3 9 1 Fertility percentage of seeds

Fertility percentage of seeds was determined by placing 100 seeds uniformly on a moistened filter paper After twelve days germination count was taken on the basis of number of normal seedlings

3 9 2 Viability at fortnightly intervals

Conditioned the seeds overnight on the top of filter paper Bisected the seeds while still on the filter paper cutting laterally with a sharp blade above the embryo Then

placed the embryo in the tetrazoleum solution transferring the seeds with a forceps Viability is recorded by testing the red colour developed on the embryo Viability was tested for two consecutive fortnights

3 10 Plant analysis

Uprooted plants were chopped and dried to constant weight in an electric oven at 70°C ground and passed through 0 5 mm sieve The contents of N P K Ca Mg and micro nutrients Mn Cu Zn were determined following the procedure given below (Jackson 1973)

Parameter	Method
Nitrogen	Modified Micro Kjeldahl method
Phosphorus	Vanado molybdate yellow colour method using Klett Summerson photo electric colorimeter
Potassium Calcium	Flame photometer
Magnesium	Atomic absorption spectrophotometer
Manganese Copper Zinc	Atomic absorption spectro photometer

3 11 Uptake of nutrients

The total uptake of nutrients by the plants was calculated as the product of percentage of these nutrients in the plant samples and respective dry weights and expressed kg ha ^{1}

3 12 Fruit quality analysis

3 12 1 Protein

The total nitrogen content of the dried fruit was estimated by modified micro kjeldahl method as given by Jackson (1973) Protein content was calculated by multiplying the nitrogen content by the factor 6 25 (Simpson et al , 1965)

3 12 2 Carbohydrate

Total carbohydrate was estimated by anthrone method (Sadasivam and Manickam 1992) Five gram of the dried sample in a boiling tube was hydrolysed by keeping it in waterbath for 3 hours with 5 ml of 2 5 N HCl Cooled and neutralised with solid sodium carbonate and the volume was made upto 100 ml and centrifuged One ml of the aliquot was taken and added 4 ml of anthrone reagent (200 mg anthrone dissolved in 100 ml sulphuric acid) The standard curve was prepared by taking 0 0 2 0 4 0 6 0 8 and 1 ml of glucose Four ml of anthrone reagent was added to all tubes and heated for 8 minutes in a boiling water bath cooled rapidly and read the green colour at 530 nm in a Klett Summerson photoelectric colorimeter From the standard curve the amount of carbohydrate was calculated and expressed in percentage

3 12 3 Crude fibre

Five gram of the dried fruit was boiled with 200 ml of 1 25% sulphuric acid for 30 minutes and filtered through muslin cloth and washed with boiling water Then boiled with 200 ml of 1 5% NaOH solution for 30 minutes and filtered through muslin cloth again and washed with 25 ml of alcohol The residue was removed and transferred to a silica dish Dried the residue at 130°C for 2 hours cooled and weighed Then ignited for thirty minutes at 600°C cooled and reweighed The crude fibre content in the sample was expressed in percentage (Kanwar and Chopra 1976)

3 13 Soil analysis

After the harvest of the crop soil samples were taken from each plot separately and analysed for pH EC Organic carbon available nitrogen available phosphorus available potash exchangeable calcium and magnesium content and micro nutrients viz manganese copper zinc using standard analytical procedures as given below

Parameter	Method	
pH	Soil water ratio 1 2 5	Jackson 1973
EC	Soil water ratio 1 2 5	Jackson 1973
Organic carbon	Walkely and Black s rapid titration method	Jackson 1973
Available N	Alkaline permanganate method	Subbiah and Asija 1956
Available P_2O_5	Bray No 1 Chlorostannous reduced molybdo phosphoric blue colour method using Klett Summerson photo electric colorimeter	Bray and Kurtz, 1945
Available K_2O	Flame photometer Neutral normal ammonium acetate extract	Jackson 1973
Exchangeable Calcium and Magnesium	Flame photometer Neutral normal ammonium acetate extract	Jackson 1973
Available micro nutrients Mn, Cu Zn	Atomic absorption spectro photometer (Perkin Elmer model) DTPA extract	Lindsay and Norvell 1969

3 14 Statistical analysis

Data generated from the experiment were subjected to statistical analysis by applying analysis of variance technique and significance tested by F test (Snedecor and Cochran 1975)

Simple correlations were worked out between biometric observations nutrient uptake nutrient availability and yield

RESULTS AND DISCUSSION

4 RESULTS AND DISCUSSION

The results of the present study which consists of the effect of vermicompost on the growth nutrition, yield and quality of tomato are presented and discussed

4 1 Biometric observations

Biometric observations were recorded at five stages of growth of tomato viz 35 50 65 80 and 95 DAP

4 1 1 Plant height

Effect of different levels of vermicompost on plant height is given in table 2 Treatments had significant effect on plant height at all growth stages Maximum height was recorded by plants receiving 25 t vermicompost along with full dose of inorganic fertilizers At all stages except 35 DAP it was observed that the effect of 25 t vermicompost along with full dose of inorganic fertilizers 100t vermicompost and 25 t farm yard manure along with full dose of inorganic fertilizers was on par Plants with minimum height was observed in plots receiving 25 t farm yard manure (47 cm) while plants receiving 25t vermicompost recorded a comparatively higher value (53 cm) This was on par with the height recorded for the plants receiving 37 5 t vermicompost, plants under vermiculture *in situ* plants receiving 25t vermicompost along with 3/4th inorganic fertilizers and 25t vermicompost with 1/2 inorganic fertilizers was on par

Table 2 Height of plants at different stages of growth (cm)

Treatments	35 DAP	50 DAP	65 DAP	80 DAP	95 DAP
T_1 (Farm yard manure + Full inorganic fertilizer)	37	47	57	61	66
T_2 (25t Farm yard manure)	22	33	37	42	47
T_3 (25t vermicompost)	23	35	40	49	53
T_4 (37 5t vermicompost)	27	39	44	52	56
T_5 (50t vermicompost)	36	49	57	61	64
T_6 (100t vermicompost)	37	51	59	63	67
T_7 (Vermiculture in situ)	31	39	44	50	56
T_8 (25t vermicompost + full inorganic fertiliser)	40	58	65	72	77
T_9 (25t vermicompost + 3/4 inorganic fertiliser)	31	40	46	53	57
T_{10} (25t vermicompost + 1/2 inorganic fertiliser	31	38	45	50	55
CD	3 7	4 3	5 2	3 3	5 4

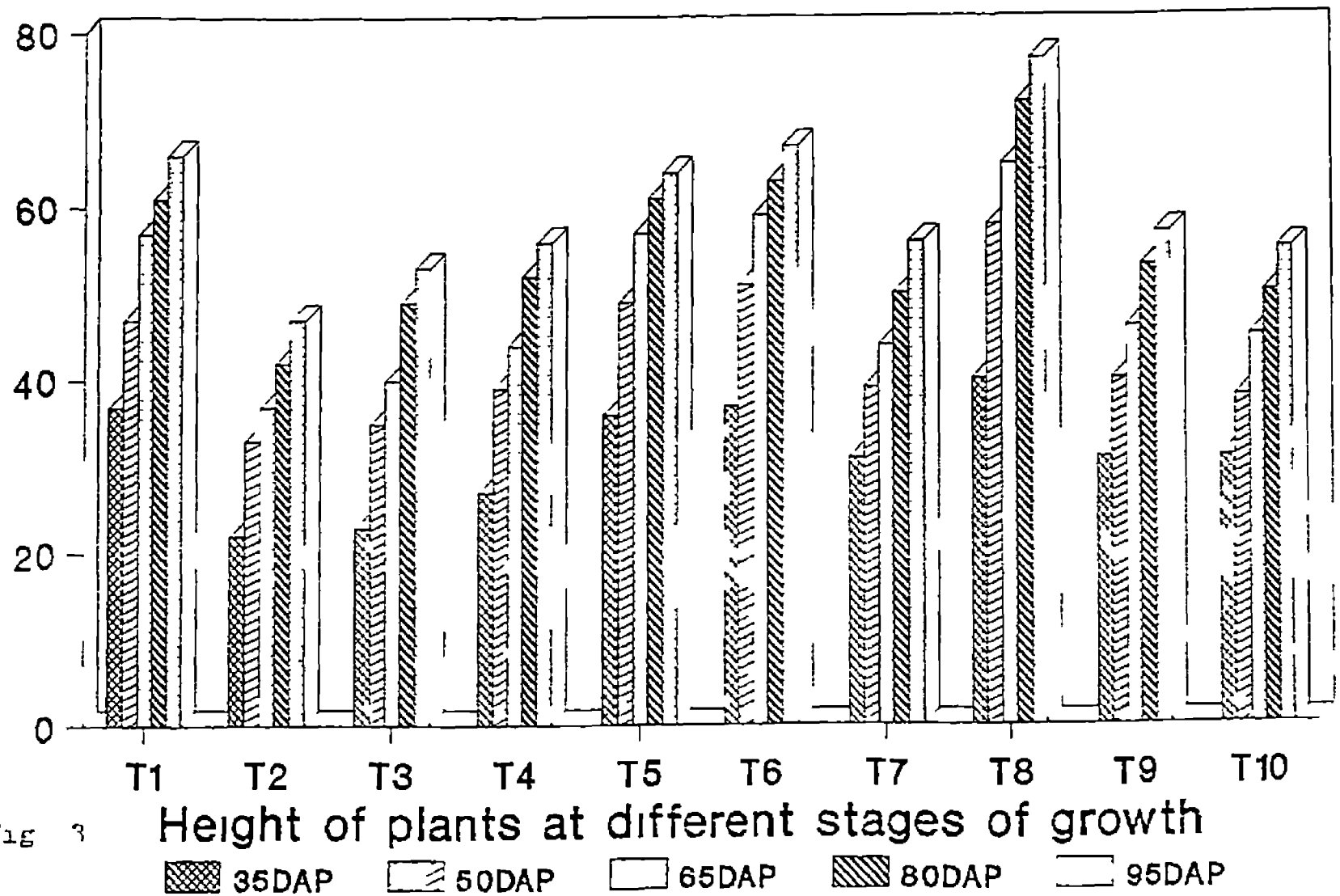

80
60
40
20
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
Height of plants at different stages of growth
35DAP
50DAP
65DAP
80DAP
95DAP

Fig 3

The height of plants in the above treatments at harvest were 56 59 and 57 cm respectively At all the stages of observations there was an increase in height with increase in the quantity of vermicompost Similar observation were made in sugarcane and soyabean by Shuxin et al (1991) The effect of vermicompost in increasing plant height was also reported by Ismail et al (1991) in Zinnea and Stephens et al (1994) in wheat The increase in plant height is attributed to the rapid meristematic activity due to the positive influence 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 confirmity with the results obtained by Joseph (1982) Paraminder 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 high uptake of nutrient and this might have resulted in increased utilization of N leading to increased vegetative growth James et al (1967) Mohammed Kunju (1968) Joseph (1982) and John et al (1989) obtained increased plant height due to higher levels of N and P application

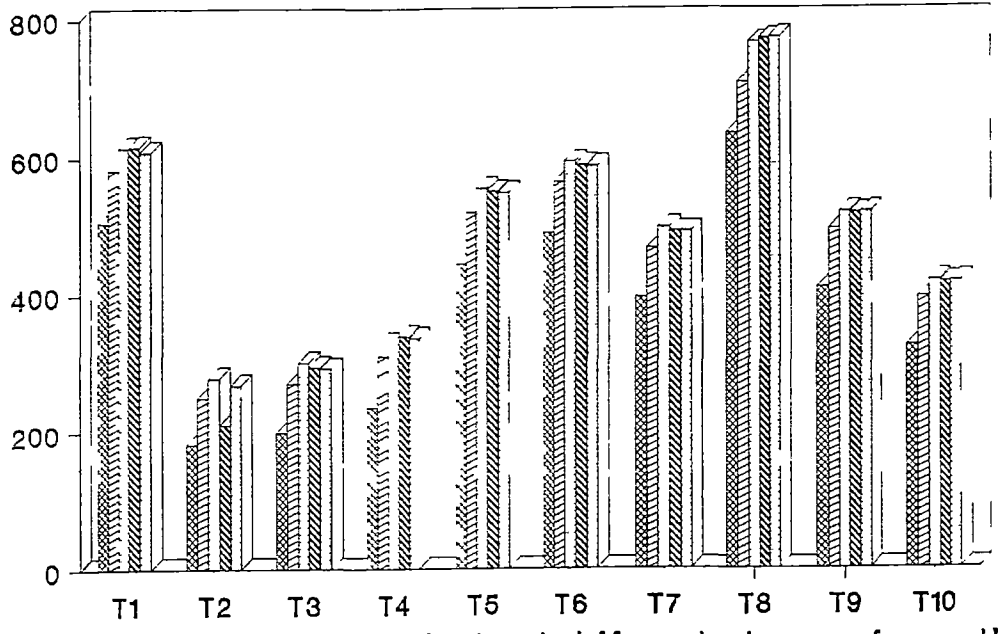
4 1 2 Number of leaves

Table 3 shows the number of leaves per plant at different stages of growth A significant variation in number of leaves per plant was observed in all treatments at various

Table 3 Numbers of leaves per tomato plant

Treatments	35 DAP	50 DAP	65 DAP	80 DAP	95 DAP
T_1 (Farm yard manure + Full inorganic fertilizer)	505	583	616	617	609
T_2 (25t Farm yard manure)	182	250	279	271	269
T_3 (25t vermicompost)	199	271	302	295	293
T_4 (37 5t vermicompost)	236	311	346	340	337
T_5 (50t vermicompost)	445	520	555	551	549
T_6 (100t vermicompost)	490	564	594	590	588
T_7 (Vermiculture in situ)	395	467	498	492	492
T_8 (25t vermicompost + full inorganic fertiliser)	635	708	767	772	774
T_9 (25t vermicompost + 3/4 inorganic fertiliser)	410	495	520	518	520
T_{10} (25t vermicompost + 1/2 inorganic fertiliser	325	395	419	416	418
CD	10 5	13	14 4	15	14 4

* DAP Days after planting



Number of leaves per plants at different stages of growth

stages of growth Since in some treatments leaf number got reduced due to leaf fall at 95 DAP leaf number at 80 DAP was taken for comparison Maximum number of leaves was recorded in plants receiving the combination of 25t vermicompost along with full dose of inorganic fertilizers At 80 DAP 25t farm yard manure along with full dose of inorganic fertilizers recorded 617 leaves whereas in treatment where vermicompost was used as the organic source, the plant recorded an average of 772 leaves Plants recorded the lowest number of leaves in plots receiving 25t farm yard manure alone (271) whereas plants receiving 25t vermicompost alone recorded 295 leaves per plant Here also the superiority of vermicompost in accelerating growth when compared to other organic sources is well brought out The results obtained here are in close agreement with the findings of Ramanujam and Singh (1956) Tabata and Takase (1968) and Singh et al (1993) who reported that foliage growth increased with increase in nitrogen and phosphorus level Influence of vermicompost in increasing the vegetative growth of plant is an accepted fact Worm cast when used as organic manure significantly influenced vegetative characters (Kale et al 1991)

4 1 3 Number of flowers

The number of flowers per plant was more in treatments receiving 25t vermicompost along with full dose of inorganic fertilizers followed by plants receiving 100t vermicompost and

Table 4 Number of flowers per tomato plant (Cumulative value)

Treatments	35 DAP	50 DAP	65 DAP	80 DAP	95 DAP	No of days to flower
T_1 (Farm yard manure + Full inorganic fertilizer)	40	43	49	53	54	26
T_2 (25t Farm yard manure)	13	17	22	26	27	30
T_3 (25t vermicompost)	15	21	27	30	32	26
T_4 (37 5t vermicompost)	22	26	33	37	39	27
T_5 (50t vermicompost)	36	39	44	48	50	22
T_6 (100t vermicompost)	44	48	51	55	56	20
T_7 (Vermiculture in situ)	27	32	36	40	42	27
T_8 (25t vermicompost + full inorganic fertiliser)	51	54	60	64	66	21
T_9 (25t vermicompost + 3/4 inorganic fertiliser)	29	33	38	42	42	25
T_{10} (25t vermicompost + 1/2 inorganic fertiliser	23	26	29	33	33	26
CD	4	3 1	3	3 6	3 2	

* DAP Days after planting

25t farm yard manure along with full dose of inorganic fertilizers The values are 66 56 and 54 respectively as seen from table 4 Lowest number of flowers (27) was produced by plants receiving 25t farm yard manure while those receiving the same dose as vermicompost produced 32 flowers per plant Number of days to flower by plants under different treatments are also given in table 4 Here also it could be noticed that very early flowering was observed in treatments where vermicompost was used as the organic source along with full dose of inorganic fertilizers Mehrotra et al (1968) found that nutrient deficiencies adversely affected flower production in chilli An adequate supply of nutrients in early stages of plant growth is important in the initiation of flower primordia (Tisdale and Nelson 1995) The presence of phytohormones enzymes antibiotics vitamins etc in vermicompost may be positively influencing the early flowering of plants Similar results of inducing earliness to flowering in chilli by the application of higher dose of nutrients have been reported by Khan and Suryanarayana (1977) and Joseph (1982)

4 1 4 Number of fruits per plant

Table 5 shows the number of fruits per plant at different stages of growth A significantly higher number of fruits per plant was observed in plots receiving 25t vermicompost along with full dose of inorganic fertilizers at all stages of

Table 5 Number of fruits per tomato plant (Cumulative value)

Treatments	35 DAP	50 DAP	65 DAP	80 DAP	95 DAP
T_1 (Farm yard manure + Full inorganic fertilizer)	22	41	46	49	50
T_2 (25t Farm yard manure)	6	16	20	23	24
T_3 (25t vermicompost)	8	20	25	28	30
T_4 (37 5t vermicompost	13	25	30	34	35
T_5 (50t vermicompost)	19	38	41	45	47
T_6 (100t vermicompost)	24	45	48	51	53
T_7 (Vermiculture in situ)	11	27	34	37	38
T_8 (25t vermicompost + full inorganic fertiliser)	33	51	58	60	61
T_9 (25t vermicompost + 3/4 inorganic fertiliser)	16	30	34	37	38
T_{10} (25t vermicompost + 1/2 inorganic fertiliser	13	23	26	28	31
CD	4 2	2 3	2 6	3 0	2 8

* DAP Days after planting

growth The total number of fruits produced was maximum for the plants receiving 25t vermicompost along with full inorganic fertilizers (61) Plants receiving 100t vermicompost and 25t farm yard manure along with full dose of inorganic fertilizers were on par the values being 53 and 50 respectively Lowest number of fruits per plant was observed in plants receiving 25t farm yard manure (24) No significant variation was observed in the number of fruits in the case of plants receiving vermiculture in situ and 25t vermicompost along with 3/4th inorganic fertilizers Also it was observed that there was no significant variation in the number of fruits in plants receiving 25t vermicompost and 25t vermicompost along with 1/2 inorganic fertilizers, the values being 30 and 31 respectively The results clearly indicate the role of vermicompost in enhancing the growth and yield of crops These results are in confirmity with the findings of Ismail et al (1993) who reported an increase in the number of fruits in chilli due to vermicompost application Increased number of of fruits per plant in vermicompost treated plots compared to farm yard manure application may be due to high level of N in vermicompost compared to farm yard manure Vermicompost is reported to contain about three times more nutrients than farm yard manure (Prabhakumari et al 1995) Increase in the number of fruits with increasing levels of N was reported by Sinha (1975) Joseph and Pillai (1985) and Singh and Srivastava (1988) Thus apart

from acting as a growth determinant vermicompost is acting as an yield determinant also The number of fruits per plant was significantly increased when vermicompost at the rate of 25t ha^{-1} was applied along with inorganic fertilizers The higher dose of vermicompost application alone could not give significant increase in number of fruits per plant suggesting the need for an integrated use of both organic and inorganic sources

4 1 5 Mean weight, girth and number of seeds per fruit

Table 6 shows the mean fruit weight girth and number of seeds per fruit

4 1 5 1 Mean fruit weight

Mean fruit weight was maximum for the plants receiving 25t vermicompost along with full dose of inorganic fertilizers (63 g) Plants receiving 100t vermicompost and 25t farm yard manure along with full dose of inorganic fertilizers did not show any signficant difference in mean fruit weight the values being 53 and 52 g respectively Plants treated with 25t farm yard manure produced fruits with lowest mean fruit weight (26 g)

4 1 5 2 Mean girth

Mean girth of fruit was significantly higher in plots receiving 25t vermicompost along with full dose of inorganic fertilizers followed by plants receiving 100t vermicompost, the

Table 6 Mean weight girth and number of seeds per fruit

Treatments	Mean weight (g)	Girth cm	No of seeds per fruit
T_1 (Farm yard manure + Full inorganic fertilizer)	52	11	90
T_2 (25t Farm yard manure)	26	9	70
T_3 (25t vermicompost)	32	13	74
T_4 (37 5t vermicompost	38	13	83
T_5 (50t vermicompost)	42	14	92
T_6 (100t vermicompost)	53	16	97
T_7 (Vermiculture in situ)	43	12	88
T_8 (25t vermicompost + full inorganic fertiliser)	63	18	105
T_9 (25t vermicompost + 3/4 inorganic fertiliser)	43	12	94
T_{10} (25t vermicompost + 1/2 inorganic fertiliser)	40	11	86
CD	4 2	1 6	4 3

values are 18 and 16 cm respectively However in plots receiving 25t farm yard manure along with full dose of inorganic fertilizers the mean girth of fruit was only 11 cm The factors contributing to the higher weight and girth of fruits may be due to the higher levels of plant available nutrients coupled with other growth promoting substances in the vermicompost Beneficial effect of phosphorus in increasing the girth of pods in chilli was reported by Joseph (1982) and Khan and Suryanarayana (1977)

4 1 5 3 Number of seeds per fruit

Number of seeds per fruit was highest in plants receiving 25t vermicompost along with full dose of inorganic fertilizers followed by plants receiving 100t vermicompost the values being 105 and 97 respectively Lowest number of seeds per fruit was recorded in plants receiving 25t farm yard manure The positive influence of nitrogen and phosphorus application on the seed yield of carrot is reported by Singh *et al* (1991) and in chilli by Singh *et al* (1988 1993) and Srinivas (1983) The superiority of vermicompost as an organic source is well understood The mean weight girth and number of seeds per fruit are positively influenced by vermicompost application thereby projecting the master role of vermicompost as an yield determinant

Table 7 Yield of tomato (var Sakthi)

Treatments	Tonnes ha ^{1}
T_1 (Farm yard manure + Full inorganic fertilizer)	8 5
T_2 (25t Farm yard manure)	4 4
T_3 (25t vermicompost)	5 4
T_4 (37 5t vermicompost	6 9
T_5 (50t vermicompost)	7 1
T_6 (100t vermicompost)	8 5
T_7 (Vermiculture *in situ*)	6 0
T_8 (25t vermicompost + full inorganic fertiliser)	10 8
T_9 (25t vermicompost + 3/4 inorganic fertiliser)	6 2
T_{10} (25t vermicompost + 1/2 inorganic fertilizer)	5 5
CD	1 7

4 2 Yield

Table 7 gives the yield of plants in tonnes ha ^{1} under different treatments Significantly higher yield was recorded with plants receiving 25t vermicompost along with full dose of inorganic fertilizers (10 8t ha ^{1}) Plants receiving 100t vermicompost and 25t farm yard manure along with full dose of fertilizers produced similar yield (8 5t ha ^{1}) The lowest yield of 4 4t ha ^{1} was recorded on plots receiving 25t farm yard manure It was observed that 25t vermicompost along with full dose of inorganic fertilizers recorded 27 per cent increase in yield over Package of Practice Recommendations of KAU for tomato where farm yard manure was used as the organic source From the results obtained it could be observed that 25t vermicompost along with inorganic fertilizer were giving the highest yield This was significantly higher than the yield obtained from Package of Practice Recommendations of KAU When vermicompost was applied in higher doses ie 37 5t 50t and 100t ha ^{1} the yield was comparatively lower Eventhough vermicompost contains many growth promoting hormones vitamins enzymes etc in addition to plant nutrients the superiority could not be reflected in yield when given without inorganic fertilizers The higher availability of N and P due to improved physical environment created by worms N fixing and P solubilizing organisms have contributed to highest yield (More 1994) Similar increase in yields due to application of worm worked composts have been

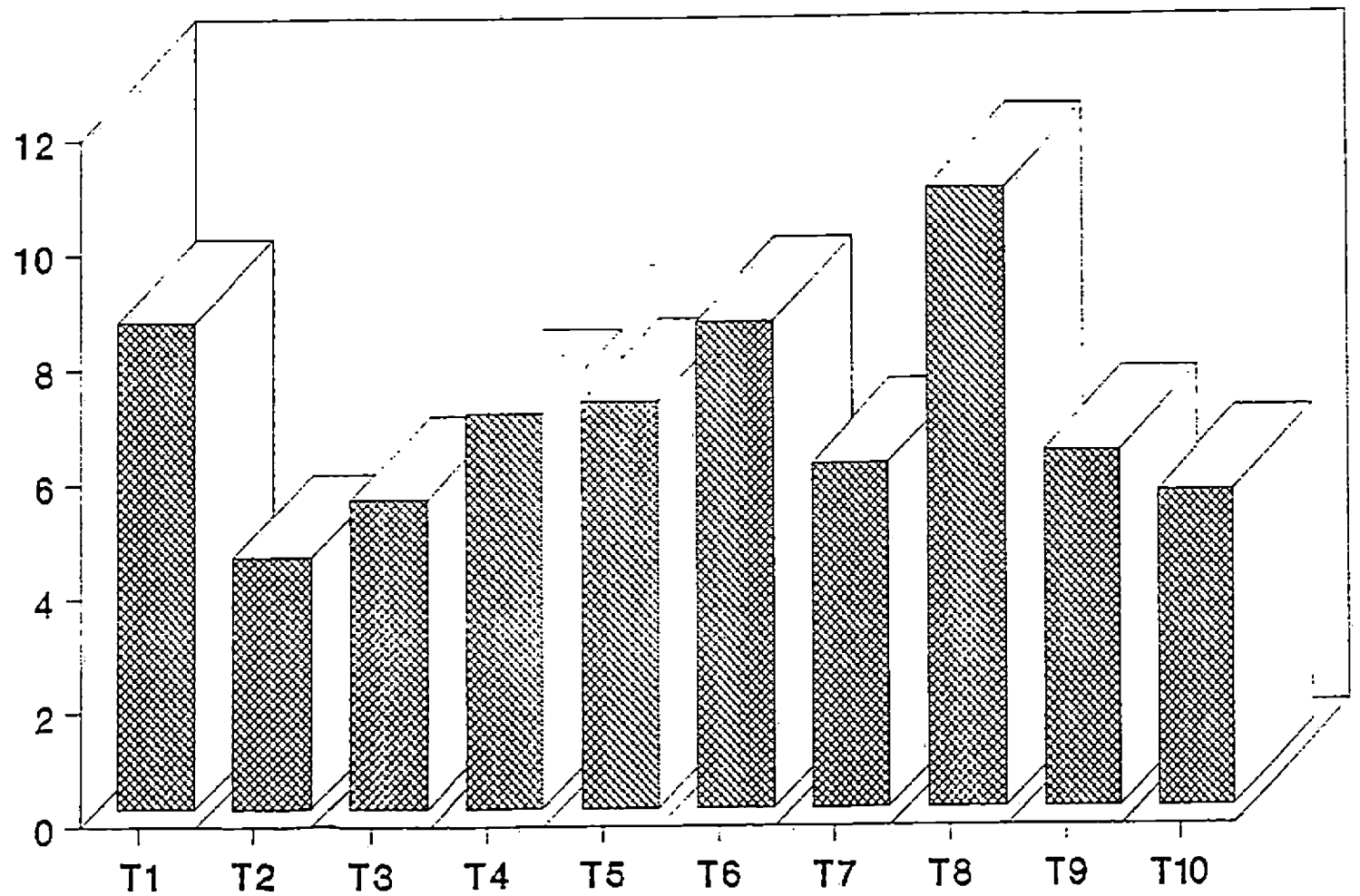


Fig. 5

PLATE I EXPERIMENTAL SITE AN OVERVIEW

PLATE - II

PLATE - III

PLATE IV

PLATE V

reported by Senapathi *et al* (1985) in rice Zachariah and Prabhakumari (1996) in chilli Shuxin *et al* (1991) in sugarcane and soyabean Barve (1993) in grapes Phule (1993) in sugarcane and Ismail *et al* (1993b) in chilli Noticeable increases in yields especially in vegetables were observed by organic manure application (Wani 1990 Subba Rao 1983) The primary factor governing the soil health is the organic matter content of soil and the concept of organic farming is widely accalimed now But the results of the present study reveal that the integration of organics and inorganics give the highest yield and this supports the concept of Integrated Plant Nutrient Management System But again when the organic source was vermicompost instead of farm yard manure the results are very much encouraging with respect to yield as well as other biometric characters

4 3 Quality of fruits

Protein, Carbohydrate and Crude fibre contents of fruits as influenced by the application of vermicompost are presented in table 8

4 3 1 Protein

In the case of protein a significant variation among treatments was observed Protein content was more in plants receiving 100t vermicompost (20 per cent) Plants under vermiculture *in situ* produced fruits with a protein content of 17 per cent followed by the plants receiving 50t vermicompost

Table 8 Tomato fruit quality

Treatments	Protein (%)	Carbohydrate (%)	Crude fibre (%)
T_1 (Farm yard manure + Full inorganic fertilizer)	15	31	1 4
T_2 (25t Farm yard manure)	8	19	2 9
T_3 (25t vermicompost)	10	20	2 6
T_4 (37 5t vermicompost	12	24	2 5
T_5 (50t vermicompost)	16	33	2 0
T_6 (100t vermicompost)	20	34	1 1
T_7 (Vermiculture in situ)	17	33	2 2
T_8 (25t vermicompost + full inorganic fertiliser)	15	38	1 6
T_9 (25t vermicompost + 3/4 inorganic fertiliser)	12	28	1 2
T_{10} (25t vermicompost + 1/2 inorganic fertilizer)	10	21	1 0
CD	3	3	0 6

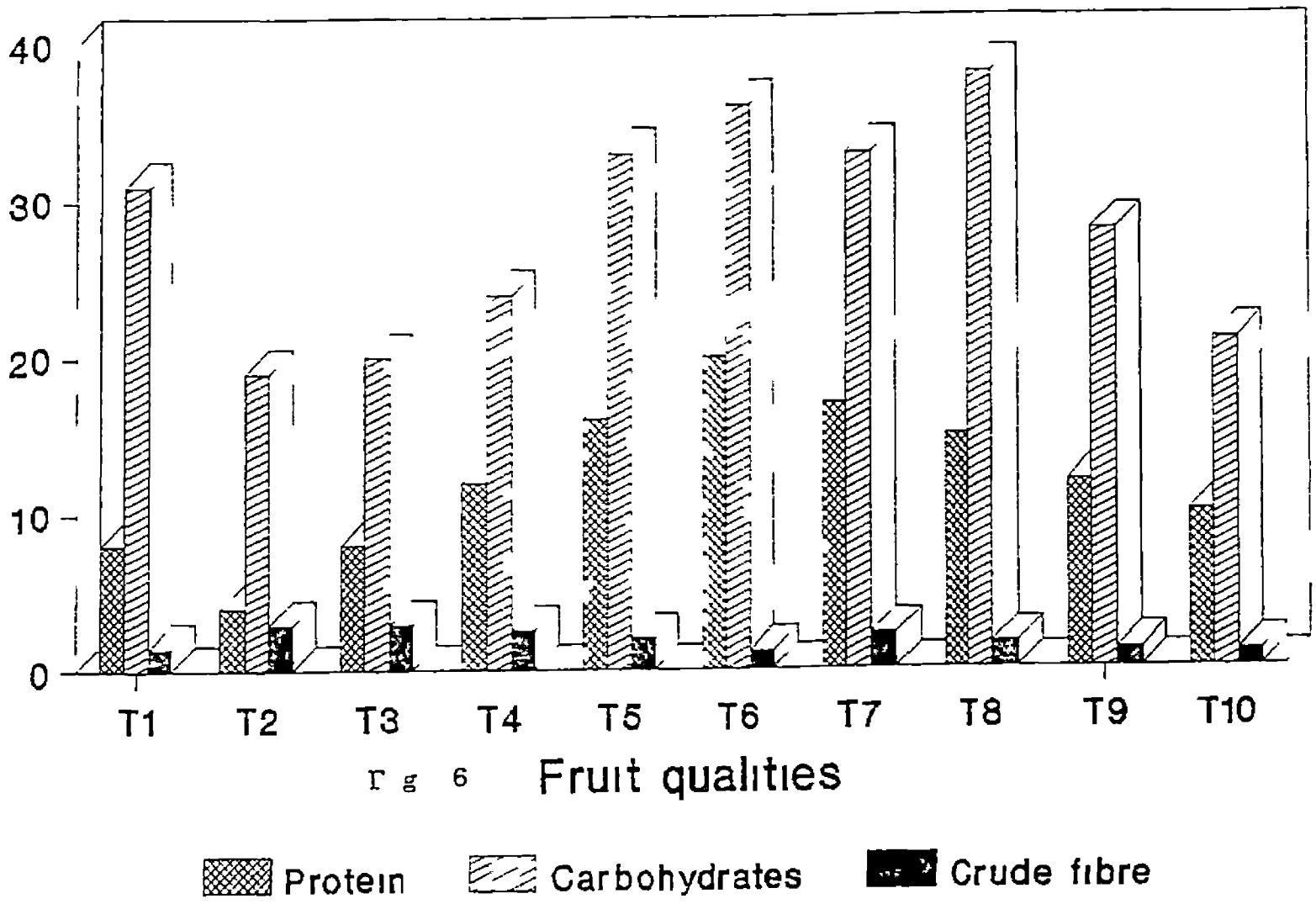

40
30
20
10
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
Fruit qualities
Protein
Carbohydrates
Crude fibre

Fig 6

(16 per cent) The lowest protein content was observed in plants receiving 25t farm yard manure (8 per cent) Application of nutrients exerted significant influence on fruit protein content This might be due to the favourable effect of nitrogen on protein synthesis These results are in confirmity with the findings of Thampan (1963) and Subramonian (1980) Increased crude protein content with phosphorus was reported by Punnoose and George (1974)

4 3 2 Carbohydrate

A significant difference in the carbohydrate content of fruits was observed Maximum carbohydrate content was found in plants receiving 25t vermicompost along with full dose of inorganic fertilizers (38 per cent) followed by the plants receiving 100t vermicompost (34 per cent) Fruits with least carbohydrate content was produced by the plants receiving 25t farm yard manure and 25t vermicompost alone the values being 19 and 20 per cent respectively Influence of organic manures in enhancing the quality of fruits is already recognised Increased carbohydrate content in potato due to the application of poultry manures along with inorganic fertilizers was reported by Singh et al (1993) Rasulov (1968) and Loginov and Klupezynski (1969)

4 3 3 Crude fibre

Crude fibre content of plants receiving 100t vermicompost 25t vermicompost along with full dose of inorganic fertilizers 25t farm yard manure along with full dose of

inorganic fertilizers and 25t vermicompost along with 3/4 inorganic fertilizers were on par the values being 1 1 per cent 1 6 per cent 1 4 per cent and 1 2 per cent respectively This is significantly lower than farm yard manure applied plots Plants receiving 25t farm yard manure recorded the highest crude fibre content of 2 9 per cent Decrease in crude fibre content due to the incremental dose of nitrogen was reported by Mani and Ramanathan (1982) and Irene Vethamoni (1988) The results obtained in this study is in agreement with the general belief that the application of organic manures especially vermicompost improve the quality of agricultural produce Improvement in the grain quality of barley due to organic manure addition was reported by Aldag and Graff (1975) and Kolhe and Ruikar (1986) in cabbage

4 4 Seed characters

4 4 1 Germination count

Table 9 shows the germination count in percentage of seeds under various treatments Plants in plots receiving 100t vermicompost showed the maximum germination (96) followed by the plants receiving 50t vermicompost 25t vermicompost along with full dose of inorganic fertilizers (92 8) Plants under vermiculture in situ had germination percentage of (91 3) From the table it is clear that vermicompost treated plots showed maximum germination compared to farm yard manure treated plots 25t farm yard manure applied plots showed germination count of 64

Table 9 Germination count and viability at fornightly intervals in percentage

Treatments	Germination count (%)	Viability (%) I		Viability (%) II	
T_1 (Farm yard manure + Full inorganic fertilizer)	83 6 (9 2)	82 6	(9 1)	79 6	(8 9)
T_2 (25t Farm yard manure)	64 0 (8 0)	64 3	(8 0)	63 6	(8 0)
T_3 (25t vermicompost)	89 0 (9 4)	92 8	(9 6)	90 1	(9 4)
T_4 (37 5t vermicompost)	91 0 (9 5)	93 3	(9 7)	90 6	(9 4)
T_5 (50t vermicompost)	92 8 (9 6)	94 0	(9 7)	90 6	(9 4)
T_6 (100t vermicompost)	96 0 (9 8)	93 6	(9 7)	91 5	(9 6)
T_7 (Vermiculture <u>in situ</u>)	91 3 (9 56)	93 0	(9 6)	91 1	(9 5)
T_8 (25t vermicompost + full inorganic fertiliser)	92 8 (9 6)	92 3	(9 6)	90 2	(9 4)
T_9 (25t vermicompost + 3/4 inorganic fertiliser)	90 0 (9 5)	88 0	(9 4)	87 3	(9 3)
T_{10} (25t vermicompost + 1/2 inorganic fertiliser)	89 0 (9 4)	85 0	(9 2)	83 0	(9 1)
CD	0 3	0 3		0 5	

( ) transformed values
square root transformation

and this was significantly lower than the rest of the treatments Plots receiving 25t vermicompost showed a germination count of 89 followed by 25t farm yard manure along with full dose of inorganic fertilizer treated plots (83 6) Here also it could be inferred that when vermicompost was used as organic source growth was accelerated Vermicompost is reported to contain many growth promoting substances such as enzymes vitamins plant growth hormones antibiotics etc in addition to nutrients The phytohormones such as cytokinins IAA gibberelic acid etc present in vermicompost may be positively influencing the germination and thereby increasing the count

4 4 2 Viability at fortnightly intervals

Table 9 shows the viability of the seeds at fort nightly intervals Viability was maximum for plots receiving 100t vermicompost (91 5) followed by plants under in situ vermiculturing (91 1) No significant difference was recorded for plots receiving 25t vermicompost 37 5t vermicompost 50t vermicompost and 25t vermicompost along with full dose of inorganic fertilizers the values being 90 1 90 6 90 6 and 90 2 respectively

4 5 Chemical properties of soil after the experiment

The chemical properties of the soil before the experiment is given in table (1) and after the experiment in

table (10) It could be observed that most of the chemical properties of soil are significantly influenced by the crop

4 5 1 pH

In the case of pH (table 10) a significant difference among treatments was observed The final pH was highest for the plots receiving 25t vermicompost along with full dose of inorganic fertilizers (6 1) followed by the plots under vermiculture *in situ* (5 9) Plots receiving 25t farm yard manure along with full dose of inorganic fertilizers recorded a pH of 5 8 Lowest pH was recorded in plots receiving 25t farm yard manure (5 2) The results indicate that when vermicompost was used as organic source the pH of soil was increased Wormcasts are closer to neutral pH range than the surrounding soil and the possible factors that act on pH may be NH_4^+ excretion and excretion from the calciferous glands as reported by Lee (1985) Conversion of organic N to NH_3 and further to NH_4^+ temporarily reduces the pool of H^+ in the soil Earthworms significantly raised the pH of humus and the effect of earthworms on the soil pH was probably due to an increase in the concentration of ammoniacal nitrogen (Binkly and Richter 1987 Haimi and Huhta 1990) Bhawalkar and Bhawalkar (1993) also reported that the pH of the intestinal content of earthworms is remarkably stable around neutral to slightly alkaline The calciferous glands in them fix $CaCO_3$ and prevent any fall in pH (Robertson 1936 Wallwork 1983 and Kale and Krishnamoorthy 1980)

Table 10 pH, organic carbon and available nutrient status of soil after the experiment

Treatments	pH	Organic carbon /	N kg ha $^{-1}$	P_2O_5 kg ha $^{-1}$	K_2O Kg ha $^{-1}$	Ca C mol kg $^{-1}$	Mg C mol kg $^{-1}$	Mn ppm	Cu ppm	Zn ppm
T_1 (Farm yard manure + full inorganic fertilizer)	5 8	1 3	343 2	50 6	248 6	1 2	2 0	17 4	0 6	2 4
T_2 (25t Farm yard manure)	5 2	1 0	284 5	34 9	215 3	0 9	1 0	13 0	0 4	2 1
T_3 (25t vermicompost)	5 5	1 2	298 1	34 2	221 7	1 1	1 1	18 7	0 5	2 3
T_4 (37 5t vermicompost)	5 5	1 3	319 0	37 2	235 1	1 2	1 9	24 1	0 6	2 5
T_5 (50t vermicompost)	5 7	1 5	360 8	42 9	247 9	1 4	2 8	26 7	0 6	2 7
T_6 (100t vermicompost)	5 7	1 6	380 4	46 5	252 3	1 6	3 2	28 5	0 7	2 9
T_7 (Vermiculture <u>in situ</u>)	5 9	1 3	338 8	40 4	266 7	1 2	1 8	20 9	0 5	2 6
T_8 (25t vermicompost + full inorganic fertiliser)	6 1	1 7	411 4	63 2	287 1	1 7	3 6	27 4	0 6	2 8
T_9 (25t vermicompost + 3/4 inorganic fertiliser)	5 7	1 2	325 1	44 1	228 2	1 2	2 2	22 9	0 4	2 6
T_{10} (25t vermicompost + 1/2 inorganic fertiliser)	5 5	1 1	307 1	33 5	224 7	1 1	1 8	18 2	0 4	2 4
CD	0 05	0 17	4 5	2 2	4 2	0 1	0 2	2 2	0 05	0 2

4 5 2 Organic carbon

The initial organic carbon content was 0 68 per cent and there was a significant increase in the organic carbon content of the soil after the experiment Organic carbon content was more in plots receiving 25t vermicompost along with full dose of inorganic fertilizers (1 7 per cent) followed by the plots receiving 100t vermicompost (1 6 per cent) as seen from table 10 25t farm yard manure along with full dose of inorganic fertilizers treated plots recorded an organic carbon content of 1 3 per cent Lowest organic carbon content was observed in plots receiving 25t farm yard manure (1 0 per cent) where as 25t vermicompost treated plots recorded an organic carbon content of 1 2 per cent These results clearly indicate that when vermicompost was used as the organic source the organic carbon content of the soil was significantly increased The vermicompost used in the present study was prepared from banana waste by using the earthworm species Eudrillus eugineae This Eudrillus compost contained about 18 86 per cent alkali soluble carbon (Zachariah and Prabhakumari 1996) The higher humifying capacity of worms is due to the accelerated humification process by the gut microflora especially the lignolytic microflora in the egesta while the organic wastes pass through the earthworm gut (Bhat et al 1960 Kale et al 1991)

4 5 3 Available nutrients

Nitrogen

Table 10 shows the available nitrogen content in the soil after the harvest of the crop A significant increase in the available nitrogen content was observed after the crop The initial available nitrogen content was only 264 4 kg ha ^{1} Available nitrogen content was highest for the plots receiving 25t vermicompost along with full dose of inorganic fertilizers (411 4 kg ha^{-1}) followed by the plots receiving 100t vermicompost (380 4 kg ha ^{1}) 50t vermicompost treated plots recorded an available nitrogen content of 360 8 kg ha ^{1} which was also higher than that of 25t FYM along with full dose of inorganic fertilizer treated plots the value being 343 2 kg ha ^{1} The lowest value for available nitrogen content was observed in plots receiving 25t farm yard manure 284 5 kg ha ^{1} whereas 25t vermicompost applied plots recorded available nitrogen content of 298 1 kg ha^{-1} From the results it is clear that when vermicompost was used as organic source the residual available nitrogen content of soil was significantly increased Increased availability of nitrogen in vermicompost treated plot may be due to the presence of relatively higher percentage of nitrogen in wormcasts when compared to farm yard manure Increase in available nitrogen content of soil and increased nitrogen recovery due to the use of organic source of nitrogen

has been reported by several workers (Muthuvel et al 1977 Srivastava 1985, Azam 1990) The higher degree of decomposition and mineralisation in vermicompost may be one of the reasons for high N content and this might have finally contributed to the available N status of the soil Haima and Huhta (1990) also observed an increased N content by earthworm activity and opined that it may be due to the earthworm carcasses The microbial activation by the earthworms and excretion by earthworms are more important in nitrogen cycling than the additional N brought into the soil in the earthworm biomass Microorganisms in the gut of some earthworm species using mucus secreted from the gut epithelium as an energy source may fix atmospheric nitrogen in significant quantities and this acts as a source of N for plant growth (Lee 1992)

4 5 4 Available phosphorus

Table 10 shows the available P_2O_5 content in the soil after the crop The initial P_2O_5 content was 30 8 kg ha^{-1} and there was a significant increase in the available P_2O_5 content after the crop P_2O_5 availability was highest for plots receiving 25t vermicompost along with full dose of inorganic fertilizers and this significantly varied from the remaining treatments (63 2 kg ha^{1}) Plots treated with 100t vermicompost and 50t vermicompost recorded available P_2O_5 content of 46 5 and 42 9 kg ha^{1} respectively It was also found that

there was no significant variation in the available P_2O_5 content of plots receiving 25t farm yard manure and 25t vermicompost after the crop the values being 34 9 and 34 3 kg ha ^{1} respectively No significant difference in the avaıalble P_2O_5 content was also noticed in plots receiving 50t vermicompost and plots under vermiculture *in situ*

Increased P_2O_5 availability in soil during crop growth by phosphorus fertilization and farm yard manure addition was reported by Shanmugam (1989) This is also in confirmity with the findings of Muthuvel *et al* (1987) Increase in total and available P_2O_5 content due to vermicompost application was reported by Gaur (1990) Increased P_2O_5 availability ın earthworm casts was reported by Lal (1974) Gupta and Sakal (1967) and Petal *et al* (1977) The higher P content of vermicompost might have reflected in the higher P status of soıl This may be because of the greater mineralısatıon of organic matter with the aid of microflora associated with earthworms Increased P_2O_5 availability may be due to the ıncreased phosphatase activity The organic matter and nutrients applied along with the vermicompost stimulate the phosphatase producing microorganisms The presence of P solubılizıng organisms ın vermicompost may be enhancing the biological solubilization of P there by increasing the available P_2O_5 status of the soıl

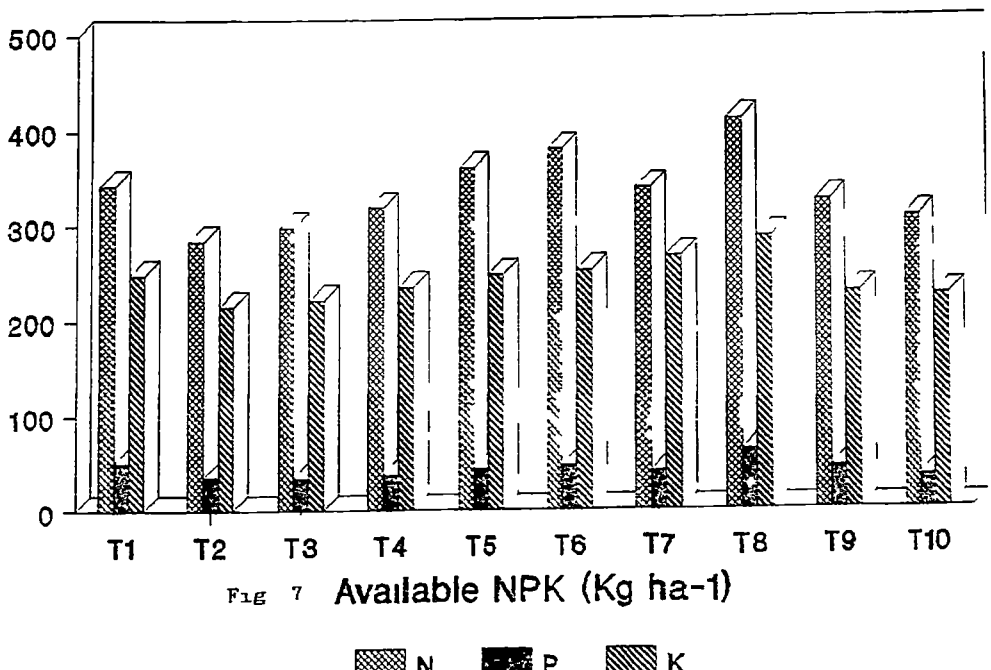

500
400
300
200
100
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
Available NPK (Kg ha-1)
N
P
K

Fig 7

4 5 5 Available potassium

Table 10 shows the available K_2O content in the soil under different treatments after the crop Significantly higher level of available K_2O was recorded in plots receiving 25t vermicompost along with full dose of inorganic fertilizers (287 1 kg ha^{-1}) followed by the plots under vermiculture *in situ* (266 7 kg ha^{-1}) No significant difference in the available K_2O content was observed in plots that had received 100t vermicompost 50t vermicompost and 25t farm yard manure along with full dose of inorganic fertilizers the values being 252 3 247 9 and 248 6 kg ha^{-1} respectively The lowest value for available K_2O was recorded in plots receiving 25t farm yard manure (215 3 kg ha^{-1}) The available K_2O content in the soil before the crop was only 145 6 kg ha^{-1} From this it is clear that the treatments significantly influenced the status of available K_2O in the soil after the crop Increased availability of potassium due to the addition of vermicomposts may be due to the increased concentration of available and exchangeable potassium contents in casts compared to surrounding soils Baskar *et al* (1992) inferred that earthworms increases the availability of potassium by shifting the equilibrium among the forms of K from relatively unavailable forms to more available forms

4 5 6 Available calcium

Table 10 shows the available calcium contents in the soil under different treatments The initial calcium content in

the soil was only 0 75 c mol kg ^{1} and there was a significant variation in the available calcium content of the soil after the crop Available calcium content was highest for plots receiving 25t vermicompost along with full dose of inorganic fertilizers followed by the plots receiving 100t vermicompost and 50t vermicompost, the values being 1 7 1 6 and 1 4 C mol kg ^{1} The lowest value for the available calcium was recorded in soil receiving 25t farm yard manure alone in two splits (0 9 C mol kg^{-1}) where as soil receiving 25t 37 5t vermicompost ha ^{1} recorded an available calcium content of 1 1 and 1 2 C mol kg ^{1} respectively From the results it is clear that available calcium content increases with respect to the quantity of vermicompost applied to the different plots

Calcium content of vermicompost was significantly higher than that of ordinary compost Higher calcium content of vermicomposts was reported by earlier workers (Nighawan and Kanwar 1958 Kale and Krishnamoorthy, 1980 and Shuxin et al, 1991) According to Pierce (1972) species with active calciferous glands absorb excess calcium from their diet and transfer it to calciferous glands from which it is excreted via the digestive tracts Stephens et al (1994) observed higher foliar concentration of calcium in wheat in sandy loam soil by earthworm activity Kale and Krishnamoorthy (1980) opined that considerable amount of total calcium in castings was due to the active feeding of calcium rich material by earthworm

4 5 7 Available magnesium

The available magnesium content of the soil under different treatments is given in table 10 In the case of available magnesium highest availability was recorded in plots receiving 25t vermicompost along with full dose of inorganic fertilizers (3 6 C mol kg ^{1}) and this significantly differed from the remaining treatments Plots receiving 100t vermicompost and 50t vermicompost recorded available magnesium content of 3 2 and 2 8 C mol kg ^{1} respectively Lowest magnesium availability was recorded in plots receiving 25t farm yard manure alone (1 0 C mol kg^{-1})

Increased accumulation of magnesium in the soil due to the application of town refuse compost was reported by Gaur *et al* (1991) Increased availability of magnesium due to vermicompost application may be due to the higher concentration of exchangeable magnesium in the worm cast than the surrounding soils Worm casts have higher concentration of exchangeable Ca and Mg than the underlying soil The increase in available cations are related to the higher content of plant tissue in casts than surrounding soil

4 5 8 Available micronutrients

Table 10 shows the available micro nutrient content in the soil in different plots under different treatments

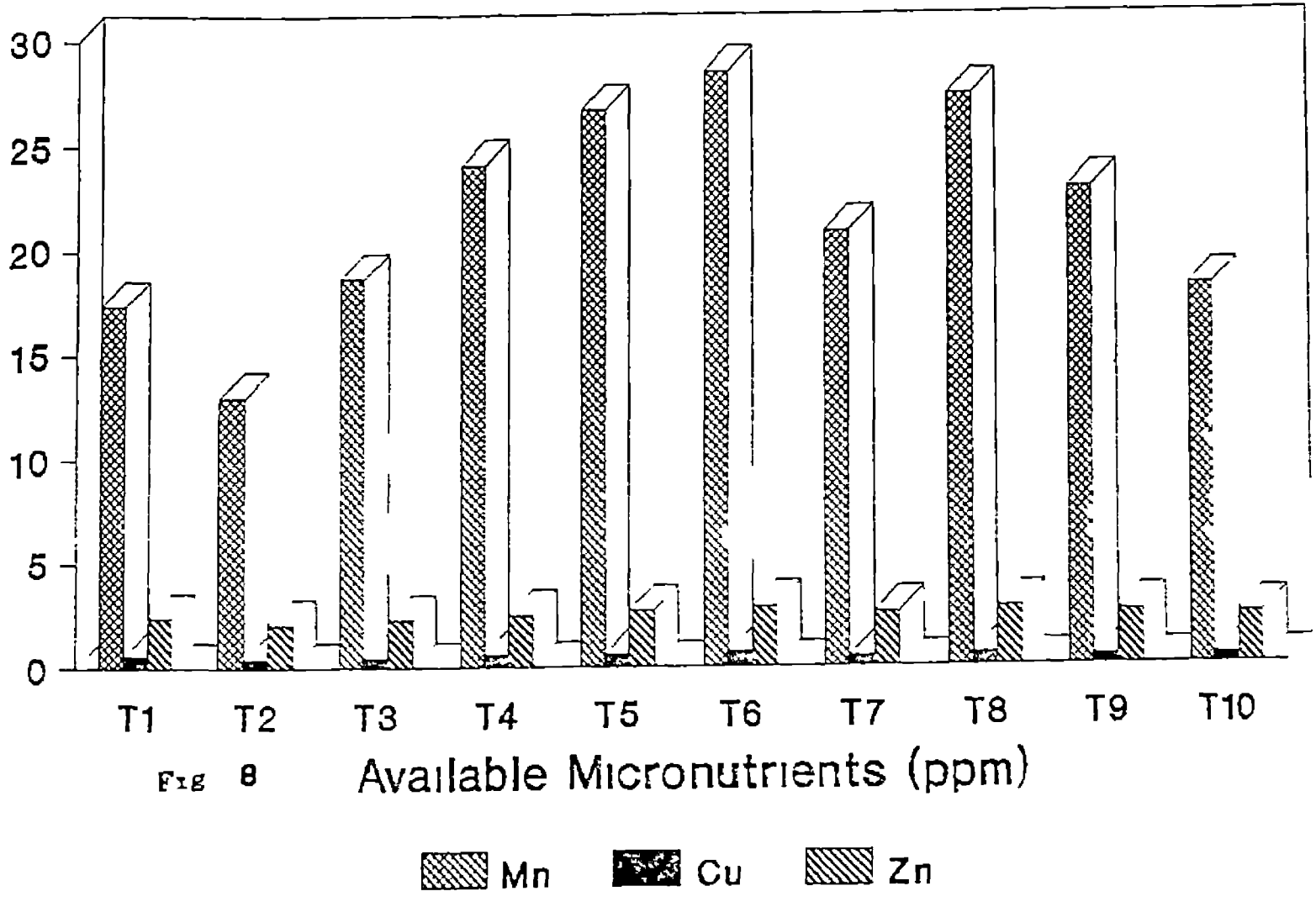

30
25
20
15
10
5
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
Available Micronutrients (ppm)
Mn
Cu
Zn

Fig 8

4 5 8 1 Manganese

The initial available manganese content in the soil was 10 ppm and there was a significant variation in the available manganese content after the crop From the table it is clear that vermicompost applied plots showed more residual Mn availability when compared to farm yard manure treated plots The maximum availability was recorded in plots receiving 100t vermicompost (28 5 ppm) followed by the plots receiving 25t vermicompost along with full dose of inorganic fertilizers (27 4 ppm) Soils receiving 25t farm yard manure recorded the lowest available manganese content of 13 ppm whereas plots receiving 25t vermicompost recorded an available manganese content of 18 7 ppm

4 5 8 2 Copper

No significant difference in the residual available copper content was observed between treatments Residual availability of Cu was highest for the plots receiving 100t vermicompost followed by 25t vermicompost along with full inorganic fertilizers and 50t vermicompost the values being 0 7 0 6 and 0 6 respectively Similar available copper content was recorded in plots receiving 25t farm yard manure 25t vermicompost along with 1/2 inorganic fertilizers and 25t vermicompost along with 3/4 inorganic fertilizers (0 4 ppm) whereas the initial available copper content was only 0 36 ppm Increased copper availability in vermicompost treated plots may

be due to the humic acid like components in vermicomposts which contain appreciable amount of Fe and Cu in the inner sphere complex (Senesi *et al* 1992)

4 5 8 3 Zinc

In the case of zinc also highest residual availability was recorded in plots receiving 100t vermicompost followed by the plots receiving 25t vermicompost along with full dose of inorganic fertilizers and 50t vermicompost the values being 2 9 2 8 and 2 7 ppm respectively The lowest residual availability was recorded in plots receiving 25t farm yard manure alone (2 1 ppm)

4 6 Nutrient uptake by plants

The increase in nutrient uptake following vermicompost application as the organic source is probably due to improvement in soil environment which encourages proliferation of roots which in turn derive more water and nutrients from larger volumes of soil

4 6 1 Nitrogen

The data on uptake of N by plants under different treatments are given in table 11 In general N uptake by plant was considerably increased when vermi compost was used as an organic source Here also it could be noticed that maximum N

Table 11 Uptake of nutrients in kg ha $^{-1}$

Treatments	N	P	K	Ca	Mg	Mn	Cu	Zn
T_1 (Farm yard manure + Full inorganic fertilizer)	50 1	7 8	23 3	1 6	3 9	0 08	0 08	0 09
T_2 (25t Farm yard manure)	18 3	3 9	16 1	1 0	2 7	0 03	0 03	0 03
T_3 (25t vermicompost)	19 5	4 7	17 5	1 3	4.4	0 05	0 06	0 08
T_4 (37 5t vermicompost)	46 4	6 4	19 2	1 5	4 6	0 06	0 06	0 08
T_5 (50t vermicompost)	47 2	6 7	23 2	1 6	4 6	0 07	0 07	0 08
T_6 (100t vermicompost)	50 3	7 2	26 7	1 7	4 7	0 09	0 09	0 09
T_7 (Vermiculture <u>in situ</u>)	28 3	6 1	40 0	1 5	2 8	0 08	0 09	0 07
T_8 (25t vermicompost + full inorganic fertiliser)	73 1	9 2	37 5	2 3	5 1	0 12	0 10	0 11
T_9 (25t vermicompost + 3/4 inorganic fertiliser)	36 1	6 4	22 8	1 5	3 8	0 07	0 08	0 06
T_{10} (25t vermicompost + 1/2 inorganic fertiliser)	22 5	5 6	19 5	1 2	2 8	0 06	0 07	0 06
CD	5 1	1 80	3 2	0 03	0 05	0 03	0 01	0 06

uptake was for plants receiving 25t vermicompost along with full dose of inorganic fertilizers (73 1 kg ha ^{1}) This is followed by the plants receiving 100t vermicompost in two splits and 25t FYM along with full dose of inorganic fertilizers the values being 50 3 and 50 kg ha^{-1} respectively It could be seen that N uptake was much less when FYM alone was applied in two splits (18 3 kg ha ^{1}) When 25t VC alone was used as organic source the N uptake was 19 5 kg ha ^{1}

The increase in N uptake may be 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 Also it can be attributed to small increase in N input from biological nitrogen fixation increased nitrate reductase activity with the enhancement in uptake of No_3 and NH_4^+ There are reports of increase in N uptake in sugarcane with the incorporation of trash along with fertilizer (Yadav and Verma 1988) The increase in nitrogen use efficiency due to residue incorporation was also reported by John et al (1989) Increased nitrogen availability by combined application of green manure and NPK green manure along with compost and farm yard manure along with NPK has been reported by (Joseph 1986) and Saravanan et al (1988) Zacharia (1995) has also reported the superiority of vermicompost in enhancing N uptake in chilli The higher rate of metabolic activity with rapid cell division brought about by vermicompost applications resulted in high uptake of nutrients

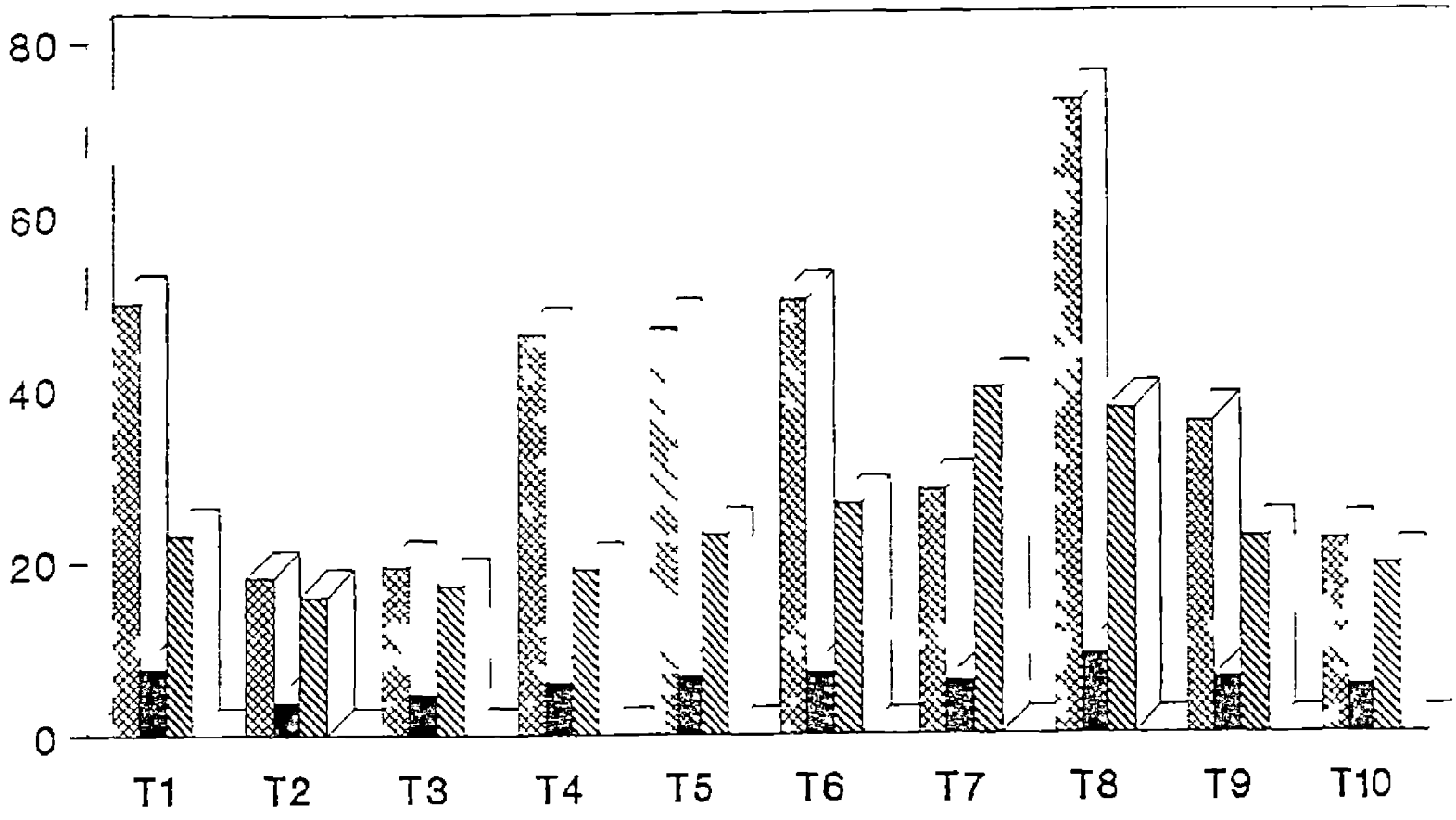


Fig 9 Macronutrient uptake by plants

and this might have resulted in increased utilization of N (James et al 1967)

4 6 2 Phosphorus

Data on phosphorus uptake by plants under different treatments are given in table 11 P uptake was also highest in plants treated with 25t vermicompost along with full dose of inorganic fertilizers (9 2 kg ha ^{1}) The P uptake by plants treated with farm yard manure along with full dose of inorganic fertilizers 100t and 50t vermicompost treated plants were found to be high when compared to other treatments the values being 7 8 7 2 and 6 7 kg ha ^{1} respectively

It was also noticed that there was no significant difference in P uptake between plants receiving 37 5t vermicompost (6 4 kg ha ^{1}) and vermiculture in situ (6 1 kg ha^{-1}) However significantly lower value was obtained when farm yard manure alone was applied

The earthworms stimulate P uptake by the redistribution of organic matter and by increasing the enzymatic activation of phosphatase (Mackay et al 1982) The increased mineralisation of soil P as a result of production of organic acids during decomposition of organic matter may also be one of the reasons for increased P uptake by the plants The solubilization of P by these micro organisms is attributed to excretion of organic acids

like citric acid glutamic acid succinic acid lactic acid oxalic acid glyoxillic acid maleic acid fumaric acid and tartaric acid (Gaur 1988 and 1990 Subba Rao 1988) In addition to phosphours solubilization these micro organisms can mineralise organic P into a soluble form The increased P availability by the increase in solubility of phosphorus by higher phosphatase activity by vermicompost application was noticed by Syres and Springett (1984) Shuxin et al (1991) observed an increase of 18 2 ppm available phosphorus over control by earthworm cast application

4 6 3 Potassium

Potassium uptake of plants under different treatments are given in table 11 The values ranged from 16 1 kg ha ^{1} for farm yard manure alone treated plots to 40 kg ha ^{1} for plants receiving in situ vermiculture A significant variation in potassium uptake by plants under different treatments was observed The increase in potassium uptake due to vermicompost application may be due to the increase in potassium availability consequent to shifting of the equilibrium among the forms of potassium from relatively unavailable forms to more available forms in the soil (Baskar et al , 1992) Little is known about the effect of vermicompost on potassium availability and this may be due to the fact that the content of potassium in plant debris is less than that of the soil and potassium is not strongly bound

in plant material The increased concentration of potassium in the cast under field condition could have resulted from the transport of potassium from the potassium rich horizon of subsoil by earthworm activity or may be due to a change in one or more of the fators affecting fixation and release of potassium in the soil (Baskar et al , 1992) Zacharia (1995) observed the superiority of vermicompost application in uptake of potassium by chilli

4 6 4 Calcium and Magnesium

The calcium and magnesium uptake by plants under different treatmentss is given table 11 A scan through the data revealed a significant difference among the treatments in the case of calcium Maximum calcium uptake (2 3 kg ha ^{1}) was recorded by plants treated with 25t vermicompost along with full dose of inorganic fertilizers and the lowest value 1 0 kg ha ^{1} for plants receiving 25t farm yard manure alone Plants receiving 25t farm yard manure along with full dose of inorganic fertilizers 50t vermicompost 100t vermicompost recorded an uptake of 1 6 1 7 and 1 6 kg ha ^{1} respectively

Similarly magnesium uptake by plants under different treatments are significantly different with 2 7 kg ha ^{1} and 2 8 kg ha ^{1} for 25t farm yard manure alone and plants under vermiculture in situ Magnesium uptake for the plants receiving 25t vermicompost along with full dose of inorganic

fertilizers was 5 1 kg ha ^{1} 25t farm yard manure along with full dose of inorganic fertilizers treated plants showed an uptake of 3 9 kg ha^{-1}

The increased calcium and magnesium in vermicomposts may be the reason for the increased uptake (Shuxin et al , 1991) The calciferous glands in earthworm contains carbonic anhydrase which catalyse the fixation of CO_2 as $CaCO_3$ thereby increasing the calcium availability Zacharia (1995) also found increased calcium and magnesium uptake in vermicompost treated plants

4 6 5 Micro nutrients

In the case of micro nutrients (Table 11) no significant variation was observed in the nutrient uptake by plants under different treatments

4 6 5 1 Manganese

The highest value for Mnuptake was noticed for plants receiving 25t vermicompost along with full dose of inorganic fertilizers (0 12 kg ha^{-1}) This is followed by the plants receiving 100t vermicompost Plants treated with farm yard manure along with full dose of inorganic fertilizers and plants under vermiculture insitu had similar value of manganese uptake of 0 08 kg ha^{-1} Manganese uptake by plants treated with 25t far yard manure alone was as low as 0 03 kg ha ^{1} Hortenstein an Rothwell (1973) when tried pelletised garbage composts as

source of nutrients observed an increase in the uptake of all nutrients except that of Mn But Zacharia (1995) found an increase in the Mn uptake in plants treated with vermicompost enriched with azospirillum and P solubilizing organisms Earthworms are reported to have the capacity to accumulate trace elements in some parts of their bodies there by decreasing final concentration in the compost Only if the earthworms die and decay these nutrients get fully incorporated into the compost

4 6 5 2 Copper

In the case of Cu uptake (Table 11) the highest value 0 1 kg ha ^{1} was for plants receiving 25t vermicompost along with full dose of inorganic fertilizers Similar uptake was recorded by plants receiving 100t vermicompost and the plants receiving in situ vermiculture 25t farm yard manure alone treated plots showed the lowest value of 0 03 kg ha ^{1}

A study for utilizing copper tailings in agriculture through vermicomposting using Eudrillus eugeniae showed the role of earthworms as a bioindicator for copper toxicity in the medium (Gangadhar and Kale 1993) Increased Cu uptake in vermicompost treated plants was also reported by Stephens et al (1994) and Zacharia (1995)

4 6 5 3 Zinc

The uptake of Zn by plants (Table 11) coming under different treatments ranged from 0 03 kg ha ^{1} for plants receiving

Table 12 Coefficient of correlation between height of plants number of leaves number of flowers and yield

Height 35 DAP	0 6976**
Height 50 DAP	0 7923**
Height 65 DAP	0 8015**
Height 80 DAP	0 8015**
Height 95 DAP	0 8089**
Leaves 35 DAP	0 7919**
Leaves 50 DAP	0 7877**
Leaves 65 DAPA	0 8022**
Leaves 80 DAP	0 8102**
Leaves 95 DAP	0 8081**
Flowers 35 DAP	0 8598**
Flowers 50 DAP	0 8593**
Flowers 65 DAP	0 8679**
Flowers 80 DAP	0 8508**
Flowers 95 DAP	0 8731**

** significant at 1% level

25t farm yard manure) to 0 1 kg ha ^{1} (25t vermicompost along with full dose of inorganic fertilizers) Plants receiving 25t farm yard manure along with full dose of inorganic fertilizers recorded an uptake of 0 09 kg ha ^{1} Plants receiving 25t vermicompost alone recorded an uptake of 0 08 kg ha ^{1} which is followed by plants receiving *in situ* vermiculture (0 07 kg ha ^{1})

4 7 Correlation studies

4 7 1 Correlation between yield and biometric characters

Yield was significantly and positively correlated with height of plants and number of leaves per plant at all stages of observation Number of leaves at 80 DAP showed the highest degree of correlation with yield (r 0 8102) There was also a significant correlation between yield and number of flowers Number of flowers at 95 DAP showed highest degree of correlation with yield (r = 0 8731) From this it could be seen that the vigour of the plant as determined by number of leaves per plant height of plant number of flowers per plant etc is reflected in the final fruit yield As explained earlier vermicompost as an organic source is positively influencing the growth nutrition as well as yield of tomato

4 7 2 Coefficient of correlation between nutrient uptake by plants and yield

Results of correlation studies clearly showed that correlation coefficients of yield attributing characters were highly significant

Nutrient uptake by plants was positively correlated with yield of plants Among them nitrogen uptake was highly correlated with yield (r 0 8730) From the strength of correlations it could be observed that nitrogen uptake was influencing the yield to the maximum followed by the uptake of phosphorus calcium and manganese the r values being 0 8686 0 8271 and 0 7919 respectively Inter correlation between the nutrients clearly brought out the nutrient antagonisms and nutrient synergism

The beneficial effects of phosphorus in increasing the uptake of nitrogen has been reported by James et al (1967) Joseph (1982) and John et al (1989) Increase in the uptake of nitrogen by increased potassium content was reported earlier by Ozaki and Hamilton (1954) Ivanic and Strelec (1976) Joseph (1982) and John et al (1989) which support the results of the present study

Table 13 Coefficient of correlation between yield and soil available nutrients

Available nutrients	Yield
N	0 8358**
P	0 8231**
K	0 7489**
Ca	0 7403**
Mg	0 7772**
Mn	0 6199**
Cu	0 7208**
Zn	0 6495**

** Significant at 1% level

Table 14 Coefficient of correlation between nutrient uptake and yield

Uptake	Yield
N	0 8730**
P	0 8686**
K	0 5125**
Ca	0 8271**
Mg	0 6401**
Mn	0 7919**
Cu	0 6688**
Zn	0 6182**

** Significant at 1% level

4 7 3 Coefficient of correlation between yield and soil available nutrients

Yield was positively correlated with soil available nutrients Significant positive correlations were obtained between yield and residual available nitrogen content (r 0 8358) Significant yield increases were obtained with higher levels of available nitrogen content in soil Yield increase due to increased levels of N application was reported by Subbiah (1983) Srinivas (1983) Narasappa et al (1985) Hegde (1986) Shukla et al (1987) Ramarao et al (1988) and John et al (1989)

A positive and significant correlation was also observed between yield and available phosphorus potassium calcium magnesium manganese copper and zinc the r values being 0 8231 0 7489 0 7403 0 7772 0 6199 0 7208 and 0 6495 respectively Increase in yield due to increased phosphorus content was reported by Khan and Sooryanarayana (1977) Joseph (1982) Prabhakar et al (1987) and John et al (1989) There was a positive increase in yield with high levels of potassium and potassium had its influence on uptake and utilization of N (Subbiah 1983 , Kadam et al , 1985 Ramarao et al 1988 John et al 1989) The available nutrient status in soil is increased by vermicompost application which inturn have a positive influence on yield

Table 15 Coefficient of correlation between nutrient uptake and soil available nutrients

Uptake	Available nutrients							
	N	P	K	Ca	Mg	Mn	Cu	Zn
N	0 8986**	0 8905**	0 7790**	0 8577**	0 8718**	0 7230**	0 7577**	0 7594**
P	0 9010**	0 9112**	0 8387**	0 8330**	0 8642**	0 6398**	0 6653**	0 7387**
K	0 7053**	0 6306**	0 9028**	0 5631**	0 5774**	0 4536**	0 4170**	0 5669**
Ca	0 8986**	0 8781**	0 8762**	0 8518**	0 8244**	0 7294**	0 6441**	0 7441**
Mg	0 6297**	0 5457**	0 4019*	0 7082**	0 6233**	0 7375**	0 6745**	0 5771**
Mn	0 9128**	0 8924**	0 8873**	0 8448**	0 8518**	0 6637**	0 6109**	0 7864**
Cu	0 8175**	0 7285**	0 8048**	0 7896**	0 7910**	0 6471**	0 5015**	0 7577**
Zn	0 5108**	0 5865**	0 2387**	0 5883**	0 5766**	0 4647**	0 3550**	0 4291**

** Significant a 1% level
* Significant at 5% level

4 7 4 Coefficient of correlation between soil available nutrients and nutrient uptake

Nutrient uptake by plant was positively correlated with soil available nutrients The available nitrogen content of soil has a synergestic effect on the uptake of phosphorus manganese and calcium which is evident from the correlation coefficient obtained (the r value being 0 9010 0 9128 and 0 8986) Similarly the phosphorus availability also enhances the uptake of manganese, calcium and nitrogen r values being 0 8924 0 8781 and 0 8905 respectively Potassium availability has got a synergestic effect on the uptake of phosphorus calcium manganese and copper r values being 0 8387 0 8762 0 8873 and 0 8048 respectively

The addition of vermicomposts to soil increases the availability of nutrients especially nitrogen and phosphorus by making available the biologically fixed nitrogen and solubilized phosphorus It provides a conducive environment for multiplication of microbes there by enhancing the mineralisation and increasing the available nutrient status of soil The fertility of a soil results from the maintenance of soil conditions such that the mineralisation process operate at a level adequate to release nutrients from the litter to sustain optimum plant growth In vermiculture <u>in situ</u> treatment the improved water infiltration resulting from the activity of

earthworms which is the most significant for better plant growth Apart from the various growth promoting substances vermicompost contain about three times more nutrients than farm yard manure when applied on equal weight basis Thus vermicompost is superior to farm yard manure and this is reflected in the growth and yield of tomato Application of vermicompost even at a lower level of 25t ha^{1} will leave considerable amount of residual nutrients in the soil since the nutrients and other growth promoting substances supplied through it may be much above the normal requirement of plants The capacity of vermicompost in improving the nutrient status of the soil after the main crop may be better utilized by raising a succeeding crop with lower nutrient input

SUMMARY

SUMMARY

The study entitled Effect of vermicompost on the yield and quality of tomato has been carried out at the Instructional farm attached to the College of Agriculture Vellayani during 1994 The main objective of the study was to investigate the potential of using vermicompost as an organic manure and as a partial substitute for inorganic fertilizers in tomato for increasing the yield and improving the quality of fruits

The experiment was laid out in Randomised Block Design with ten treatments and three replications The treatments consist of (T_1) 25t farm yard manure along with full dose of inorganic fertilizers (T_2) 25t farm yard manure (T_3) 25t vermicompost, (T_4) 37 5t vermicompost (T_5) 50t vermicompost (T_6) 100t vermicompost (T_7) vermiculture *in situ* (T_8) 25t vermicompost along with full dose of inorganic fertilizers (T_9) 25t vermicompost along with 3/4 inorganic fertilizers and (T_{10}) 25t vermicompost along with 1/2 inorganic fertilizers The data generated were statistically analysed presented and discussed in the foregoing chapters The findings of the study are summarised below

Biometric observations viz height of the plant number of leaves number of flowers and number of fruits were greatly influenced by the application of vermicompost compared to farm yard manure Maximum height (77 cm) number of leaves (774)

number of flowers (66) and number of fruits (61) were obtained when 25t vermicompost along with full dose of inorganic fertilizers was applied

Yield attributes like mean fruit weight and girth of fruits were found to be significantly influenced by vermicompost application Mean fruit weight (63 g) and mean girth (18 cm) was obtained when 25t vermicompost along with full dose of inorganic fertilizer was used Number of seeds per fruit was also higher in the plants receiving 25t vermicompost along with full dose of inorganic fertilizers

Highest yield (10 8t ha^{-1}) was obtained with plants receiving 25t vermicompost along with full dose of inorganic fertilizers Plants receiving 100t vermicompost and those treated with 25t farm yard manure along with full dose of inorganic fertilizers recorded the same yield (8 5t ha^{1})

Correlation studies showed that yield was positively and significantly correlated with plant height number of leaves number of flowers nutrient uptake and available nutrients

Germination count and viability was maximum when vermicompost was used as the organic source Maximum germination count was recorded in plots receiving 100t Vermicompost (96 per cent) Similar values were obtained for plots receiving 50t vermicompost and 25t vermicompost along with full dose of inorganic fertilizers and plants receiving in situ vermiculture (92 8)

Similarly viability of seeds was maximum for plots receiving 100t vermicompost (91 5) followed by plants receiving vermiculture in situ (91 1)

Fruit qualities like protein and carbohydrate content were more in vermicompost treated plots compared to farm yard manure application Highest protein (20 per cent) was found in plants receiving 100t vermicompost whereas maximum carbohydrate content was found in plants receiving 25t vermicompost along with full dose of inorganic fertilizers

pH and organic carbon content were significantly increased by vermicompost application

Availability of nutrients in soil was significantly influenced by the application of vermicompost Availability of N P_2O_5 K_2O Ca and Mg was highest when 25t vermicompost along with full dose of inorganic fertilizers was used However availability of micronutrients Mn Cu Zn was more in 100t vermicompost applied plots

Application of vermicompost increased the uptake of nutrients by plants Highest uptake of all rutrients viz N P K Ca Mg Mn Cu and Zn was found in plants treated with 25t vermicompost along with full dose of inorganic fertilizers Correlation studies showed that nutrient uptake was significantly and positively correlated with availability of nutrients

From the results it can be concluded that vermicompost which contains growth promoting hormones such as IAA gibberelic acid etc vitamins enzymes and antibiotics can be effectively utilized for increasing the yield and quality of fruits in tomato But an integrated use of organics and inorganics was found to give the highest yield especially when the organic source was vermicompost Integrated use of organic manures and fertilizers has been found to be promising not only in maintaining higher productivity but also for producing stability in crop production The superiority of integrated use of organic manures and chemical fertilisers in sustaining crop prouctivity is already established The effect has been more pronounced in the case of acidic soils than in normal soils

The effect of vermicompost application on succeeding crops has not been adequately studied and they need to be better defined More field information on in situ decomposition of crop residues in relation to soil properties and crop productivity are needed on short medium and long term basis

Long and medium term field trials using integrated concept of organic mineral and biofertilizers in relation to sustainable agriculture should be conducted to work out specific recommendation for different crops and agroclimatic conditions

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*Original not seen

APPENDIX

APPENDIX I

Weather data during the cropping period
22nd October 1994 to 14th February 1995

Standard week	Date	Rainfall (mm)	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity
43	Oct 22 Oct 28	2 1	30 3	23 9	84 3
44	Oct 29 Nov 04	15 7	29 7	23 2	85 2
45	Nov 05 Nov 11	3 3	30 5	23 5	80 5
46	Nov 12 Nov 18	3 8	29 9	23 2	84 2
47	Nov 19 Nov 25		30 4	23 0	85 7
48	Nov 26 Dec 02	4 1	31 2	23 8	84 1
49	Dec 03 Dec 09		30 8	22 1	88 4
50	Dec 10 Dec 16		30 5	21 1	78 5
51	Dec 17 Dec 23		31 5	23 1	81 5
52	Dec 24 Dec 31		31 8	22 0	77 2
53	Jan 01 Jan 07		31 8	22 6	80 4
54	Jan 08 Jan 14	1 2	32 0	23 2	74 7
55	Jan 15 Jan 21		31 9	23 1	69 8
56	Jan 22 Jan 28		31 9	22 7	69 8
57	Jan 29 Feb 04		32 0	22 5	72 1
58	Feb 05 Feb 11		32 1	23 1	74 7

ABSTRACT

EFFECT OF VERMICOMPOST ON THE YIELD AND QUALITY OF TOMATO (*Lycopersicon esculentum* Mill)

By

PUSHPA S

ABSTRACT OF THE THESIS

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ABSTRACT

An investigation was carried out at the Instructional farm, attached to the College of Agriculture Vellayani to evaluate the Effect of vermicompost on the yield and quality of tomato The experiment was laid out in Randomised Block Design with ten treatments and three replications

Biometric observations viz height of the plant number of leaves and number of flowers were greately influenced by the application of vermicompost compared to farm yard manure Yield attributes like mean fruit weight and girth of fruits were also found to be significantly influenced by the vermicompost application Vermicompost application has got a significant influence on the yield of tomato Plants receiving 25t vermicompost along with full dose of inorganic fertilizers produced maximum yield followed by the plants receiving 25t farm yard manure along with full dose of inorganic fertilizers

Germination count and viability was maximum when vermicompost was used as the organic source Maximum germination count and viability was observed when 100t ha ^{1} vermicompost was used Vermicompost application has also got a significant influence on fruit qualities Protein and carbohydrate content were more in vermicompost treated plants compared to farm yard manure application

Chemical properties of the soil was significantly influenced by the application of vermicompost. pH, organic carbon, available N, P_2O_5, K_2O, Ca and Mg was maximum when 25t vermicompost along with full dose of inorganic fertilizers was used. However availability of micronutrients Mn, Cu, Zn was more in 100t vermicompost applied plots.

Application of vermicompost increased the uptake of nutrients by plants. Maximum uptake of all nutrients viz. N, P, K, Ca, Mg, Mn, Cu and Zn was found in plants treated with 25t vermicompost along with full dose of inorganic fertilizers. Correlation studies showed that nutrient uptake was significantly and positively correlated with availability of nutrients.

Yield and nutrient uptake of plants were significantly and positively correlated with availability of nutrients and s vermicompost can be effectively used for increasing the frui yield and quality of fruits in tomato.