VERMICOMPOST AS A POTENTIAL ORGANIC SOURCE AND PARTIAL SUBSTITUTE FOR INORGANIC FERTILIZERS IN SWEET POTATO (*Ipomoea batatas* (L.) Lam.)

By

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DECLARATION

I hereby declare that this thesis entitled "Vermicompost as a potential organic source and partial substitute for inorganic fertilizers in sweet potato (*Ipomoea batatas* (L.) Lam.)" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis "Vermicompost as a potential organic source and partial substitute for inorganic fertilizers in sweet potato (*Ipomoea batatas* (L.) Lam.)" is a record of research work done independently by Mr. Suresh Kumar. S. N. (94-11-48) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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INTRODUCTION

1. INTRODUCTION

Organic matter content of soil is the primary factor having influence on soil health. The use of chemical and off farm inputs in intensive agriculture is fast increasing and this has resulted in deterioration of soil health and increased environmental pollution. The intensive cultivation without using sufficient organic manure affects physical, chemical and biological properties of soils adversely. Indiscriminate use of inorganic fertilizers without organic manures also leads to soil acidity and increased pest and disease incidence. Soil acidity is harmful for the beneficial microorganisms. Increased pest and disease incidence leads to the use of toxic insecticides and pesticides which leave harmful residues in soil. The environmental hazard caused by prolonged or heavy rates of mineral fertilization can be easily mitigated by optimising the fertilizers with judicious application of organics. The complementary use of organics and inorganics helps not only in increasing nutrient use efficiency but also sustaining high yields of crops.

Maintenance of organic matter in soil is difficult in a state like Kerala with humid tropical climate. But for sustaining production, organic matter of the soil is to be maintained. Organic farming is gaining considerable momentum today. Increase in the use of organic source of nutrients is important in the context of organic farming and sustainable agriculture. At present the main problem faced by farmers is the limited availability of commonly used organic manures like cattle manure and green manure. The continuous use of costly inorganic fertilizers alone will affect the physical, chemical and biological properties of soil adversely which in turn affect the soil productivity. Recycling of biowaste is a major alternative to meet the growing demands for the organic manures.

Recently the vermiculture biotechnology has emerged as an effective biological route of soil fertility management system for sustainable agriculture. Large quantities of biowastes are accumulating in our surrounding areas causing environmental pollution and health hazards. Safe disposal of these waste is very important for abating environmental pollution. Vermicomposting is a cost-effective, feasible, eco-friendly technology which can be adopted to recycle biowastes, besides achieving their hygienic disposal. Many workers had suggested vermi technology as an ideal option for organic waste management in India (Ismail *et al.*, 1991 and Kale, 1991).

Epigeic earthworms are now regarded as efficient bioconverters of organic wastes. Vermicompost is a potential organic manure which enhances the uptake of macro and micronutrients by plants, harbours rich amount of microbes, degrade and mobilise the nutrients to available forms. These microorganisms are also found to fix atmospheric nitrogen into available nitrogen and increase availability of insoluble phosphorus. Vermicompost is also reported to contain growth enhancing substances like hormones, auxins, vitamins etc. which may influence the growth and yield of crops and quality of produce. Vermicompost also enhances the soil structure and improves the water holding capacity and porosity and facilitates the root penetration and growth (Lee, 1985).

Sweet potato (*Ipomoea batatus (L) Lam.*) is an important tuber crop of tropical and subtropical countries. Because of its high quantity of starch it is valued as a good supplement for major cereals like rice and wheat. Among the root and tuber crops cultivated in India sweet potato ranks third after potato and cassava. It is grown in over 1.38 lakh hectares with a production of 1.17 million tonnes (FAO, 1996). Among the states in India, Kerala enjoys seventh and sixth position in area and production respectively. In Kerala, it is grown in over 4000 hectares with a production of 33850 tonnes. The average productivity of the crop is 8.46 t ha^{-1}. In Kerala sweet potato is cultivated in low lands during summer fallows where irrigation facilities are available and in uplands during the south west and north east monsoon periods as an intercrop and also as a pure crop. It is mainly cultivated in Palakkad, Malappuram, Kasaragode, Thrissur, Kollam and Thiruvananthapuram districts.

The sweet potato tubers are well recognised as a source of food and industrial starch. Certain varieties having yellow flesh are rich in carotene, the precursor of vitamin A. The leafy tops are rich in proteins, minerals like Fe, Ca, P and vitamins like A and C (Gopalan *et al.*, 1987). The vines and low grade tubers of sweet potato are also utilised as animal feed.

As a pure crop, sweet potato can survive in Kerala only if the per hectare yield is increased and input cost is reduced. Recently the use of vermicompost in place of farmyard manure and the possibility of reducing costly inorganic fertilizers using vermicompost as organic manure has become a subject of active research.

It is in this background, the present study was undertaken with the following objectives:

1. To evaluate the potential of using vermicompost as a source of organic manure on yield and quality of sweet potato.
2. To find out the extent to which the inorganic fertilizers can be reduced when vermicompost is used as source of organic manure.
3. To study the feasibility of reducing the dose of vermicompost as an organic source.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The present investigation entitled "Vermicompost as a potential organic source and partial substitute for inorganic fertilizer in sweet potato (*Ipomoea batatas* L. lam.)" deals with the potential of using vermicompost as an organic source and extent to which the inorganic fertilizer and organic manure can be reduced when vermicompost is used as a source of organic manure for sweet potato. The available literature on the effect of various organic manures and inorganic fertilizers on soil properties, growth, yield and quality of crop plants including tuber crops are reviewed below.

2.1. Effect on soil properties

Organic materials are valuable byproducts of farming and allied industries, derived from plant and animal sources. It can be recycled in soil by different methods like *in situ* incorporation, organic mulches or as composts. Organic residue incorporation to the soil improves the overall physical, chemical and biological properties of the soil and the regular return of crop residue to the soil contribute to the soil nutrient pool in a gradual manner, besides offering other indirect benefits (Srivastava, 1988).

2.1.1. Effect on physical properties

Das *et al.* (1966) reported that a decrease in the hydraulic conductivity due to continuous application of manures in sandy calcareous soils, in the Pusa permanent manurial experiment at Pusa, Bihar. Biswas *et al.* (1969) reported that application of farmyard manure, groundnut cake and green manure in a rice fallow rotation for ten years improved the water retention characteristics of an alluvial sandy loam soil.

Havanagi and Mann (1970) reported that a continuous application of farmyard manure and use of green manure decreased the bulk density of soil.

Prasad and Singh (1980) observed that continuous application of farmyard manure in combination with chemical fertilizers was found to be beneficial in increasing the water holding capacity of soil.

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

Farm yard manure is beneficial in increasing the water stable aggregates in the soil (Kanwar and Prihar, 1982). Suneja *et al.* (1982) found an increase in hydraulic conductivity and decrease in dispersion percentage with farmyard manure application.

There was a rise in hydraulic conductivity under continued farmyard manure treatment in alluvial soils and medium black soils and a slight decrease was seen in laterite soils (Nambiar and Ghosh, 1984).

Rabindra *et al.* (1985) found that farmyard manure has a favourable effect on the soil aggregation compared to chemical fertilizers.

Mahimairaja *et al.* (1986) observed that the porosity of soil was improved by combined application of farmyard manure and chemical fertilizers. Highest values of hydraulic conductivity in plots receiving cattle manure or cattle manure residue were observed in a long term fertilizer experiment at Coimbatore on maize and sorghum (Mahimairaja *et al.*, 1986).

Aravind (1987) observed a continuous improvement in hydraulic conductivity of black soils due to continuous addition of organics in combination with inorganics.

Edward (1988) succeeded in converting the animal and other organic wastes into useful materials that could be added to agricultural land to improve soil structure and fertility which also would have considerable potential as a plant growth medium or commercial potting composts for horticultural plants.

Patnaik *et al.* (1989) reported an increase in available water content by the application of NPK fertilizers together with compost. A continuous crop production with manuring and mulching had significantly increased moisture retention in soil at 0.1 bar tension from 10.0 - 12.1 per cent (Gupta, 1989).

Rose (1990) observed that continuous application of farmyard manure increased the total porosity in a long term field experiment in England. The soil porosity was significantly higher in treatments receiving farmyard manure continuously in a long term experiment with soyabean - wheat cropping sequence in Utter Pradesh (Bhatnagar *et al.*, 1992). Similar results were reported by and Rasmussen and Collins (1991) and Bhatnagar *et al.* (1992).

Farmyard manure has considerable influence on water retention and release in soyabean - wheat cropping sequence (Bhatnagar *et al.*, 1992).

Vijayalakshmi (1993) reported that soil physical properties such as porosity, soil aggregation, soil transmission, conductivity and dispersive power of wormcast fertilized soil were improved when compared with no wormcast amended soil as reflected in the pot experiment of paddy.

The 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. As organic matter level increased, the volume of water held at field capacity increased at a greater rate than that held at permanent wilting point (Hudson, 1994).

2.1.2. Effect on chemical properties

A number of chemical properties are improved by the addition of organic manures in to the soil.

The seat of most of the ion exchange in soil is the finer portions of the soil which include the organic and inorganic colloidal fractions. The organic colloids, possess negative charges on their surfaces. The charges arise due to the presence of carboxyl, phenolic, hydroxyl, enolic hydroxyl, imide and possibly other groups. These negative charges adsorb nutrient cations for plant's use. The Cation Exchange Capacity (CEC) of organic colloids is very high compared to inorganic colloids. It ranges from 150 to 300 m.eq. $100g^{-1}$ of soil (Allison, 1973).

Humus buffers the soil against rapid changes in acidity, alkalinity and salinity and also against damage by pesticide and toxic heavy metals (Allison, 1973).

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

The combination of organic manures with inorganic fertilizers had a moderating effect on soil reaction, particularly in acid soils (Nambiar and Abrol, 1989).

Gaur (1990) reported that humus by virtue of its chelating properties, increases the availability of N, P, S and other nutrients to plants growing in humus rich soils.

Green manuring with prickly sesban improves soil acidity at a faster rate than with farmyard manure and wheat bran (Alokkumar and Yadav, 1995).

2.1.3. Effect on biological properties

The living phase of the soil is greatly stimulated by the addition of organic materials in soil. The augmented microbial population helps in organic matter decomposition, nitrogen fixation, phosphorus solubilisation, and increases the availability of plant nutrients (Allison, 1973).

Significantly higher levels of beneficial microbial population in rice treated with vermicompost was observed (Kale *et al.*, 1992).

2.2. Effect of organic manures on the availability of nutrients

A study conducted at Amori prefactural experiment station, showed that N, P and K increased with increasing amount of farmyard manure alone. Increase in K was highest followed by N and P (Yamashita, 1964).

Biswas *et al.* (1969) found that application of farmyard manure and phosphatic fertilizers improved the organic matter status of the soil in a permanent manurial experiment at Ranchi.

The combined application of organic manures and inorganic fertilizers had resulted in higher organic carbon content of soil (Mathan *et al.*, 1978).

Farmyard manure application was beneficial in enhancing the uptake of all the three major nutrients in wheat - maize rotation in a long term fertilizer experiment at Ranchi (Prasad and Singh, 1980).

The possibility of replacing chemical fertilizers by the organic manure was established by the preliminary field trials conducted on the summer crops of paddy variety IR -20 (Kale and Bano, 1983). They opined that it is not only economical but also helps in improving the physico-chemical and biological properties of the soil.

Kale *et al.* (1987) reported that the material ingested by earthworm undergo biochemical changes and the ejected cast contains the plant nutrients and growth substainces in plant assimilate forms. The fertility is contributed by both enzymatic and microbial activity that is associated with earthworms.

Bhawalkar and Bhawalkar (1992) considered the vermicasts produced from wastes as a resource for LEISA (Low External Input Sustainable Agriculture) and indicated that biocycling of these residues through vermicluture biology obviates the use of agrochemicals derived from non - renewable resources.

More (1994) reported that addition of farm wastes and organic manures increased the status of organic carbon, available N, P, and K of the soil.

Minhas and Sood (1994) observed that farmyard manure application benefited the uptake of all the three major nutrients by potato and maize.

Manindrapal (1994) found that the vermicomposted cow dung has more nutrient value for crops than cow dung as a composted manure.

2.2.1. Effect on nitrogen availability

Patnaik *et al.* (1989) noticed an increased available nitrogen content with intensive manuring and cropping. It was found that farmyard manure and prickly sesban green manure can substitute about 60 kg nitrogen ha^{-1} in rice grown in a sequence with wheat.

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

In a permanent manurial experiment with dwarf indica rice at Pattambi, significant variation was noticed in available N content of soil. Highest value of 106.2 kg ha^{-1} was observed in treatment where 90 kg nitrogen ha^{-1} was supplemented through organic and inorganic sources together with P_2O_5 and K_2O (Kurumthottical, 1982).

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 mineralisation into inorganic ions such as NH_3, NH_4^+, NO_2^- and NO_3^-. The magnitude of these reactions control the available N status in the soil.

2.2.2. Effect on phosphorus availability

An increased P content was observed in rice CO - 32 strain by compost application (Ramaswami and Raj, 1972). Similar result of increased P content with increased compost application was reported by Terman and Mays (1973). Sharpley and Syres (1977) found an increased P availability to plants when vermicasts were used.

Phosphorus enrichment was noticed in soils with application of balanced or high dose of NPK and combined use of NPK and farmyard manure, in a long term fertilizer experiment with wet land rice conducted at various locations in India (Nambiar, 1985).

The content of available phosphorus of soil was increased due to the incorporation of groundnut residue (Dhillon and Dhillon, 1991).

Significantly higher levels of uptake of P in rice treated with vermicompost was observed by Kale *et al.* (1992).

2.2.3. Effect on potassium availability

Available potassium increased slightly with the addition of farmyard manure for long time (Sharma *et al.*, 1984).

It was found that content of available P and K of soil was increased due to the incorporation of groundnut residue (Dhillon and Dhillon, 1991). Among the nutrients, the most significant role of organic matter is supplying K (Bharadwaj, 1995).

2.2.4. Effect on micronutrient availability

The availability of Zn, Cu, Fe and Mn in soil was increased considerably with continuous use of farmyard manure in a long term fertilizer experiment at Ranchi under wheat - maize rotation (Prasad and Singh, 1980). The application of farmyard manure increased the availability of both native and applied micronutrient cations (Swarup, 1984).

The chelating property of organic matter influences the availability and the mobility of micronutrients. The micronutrients form water soluble complexes with the soil organic matter. The stability of micronutrient humus complex which determine the availability follow the order : for humic acid $Cu^{2+} > Fe^{2+} > Zn^{2+} > Mn^{2+}$ whereas for fulvic acid the stability is $Cu^{2+} > Zn^{2+} > Fe^{2+} > Mn^{2+}$ (Relan *et al.*, 1986).

Khan *et al.* (1981) reported that city compost raised the Zn and Fe contents of plants from deficiency to sufficiency level.

2.3 Effect on growth and yield of crops

2.3.1 Effect on tuber crops

Increasing rates of farmyard manure and nitrogen fertilizer increased plant height but had an inconsistent effect on the number of main stem per hill in potato cultivar katela at Sumberbrantas (Wildjajanto and Widodo, 1982).

Sahota (1983) found out that farmyard manure application increased the plant height, number of leaves per plant, tuber weight and tuber number per plant in potato cultivar kufri jyothi at Shillong.

According to Poolperm (1987) when the fertilizer had much nitrogen, the development of vines was more than roots and yielded few tubers only.

2.3.2 Effect on yield of tuber crops

Numerous experiments had been carried out to study the response of various tuber crops to organic manures. Some experiments conducted in Karnataka to find out the response of sweet potato to farmyard manure and compost showed a 30.6% increase over control. Similarly tapioca gave 11.8% increase over control (Gaur *et al.*, 1970).

Morita (1970), in his study on the effects of combination of nitrogenous fertilizers on tuber formation and tuber thickening found that maximum reduction in tuber yield was in treatments with excess growth of vines during tuber formation. He also observed that this was compensated by increased photosynthetic activity during tuber thickening.

Austin and Lang(1972) observed linear increase in dry matter distribution in leaves, stems and roots with time. Wilson and Lowe (1973) suggested that early tuber growth in sweet potato is the slow stage of tuber development which precedes rapid tuber bulking.

Mohankumar *et al.* (1973) observed that mulching was significantly superior to non-mulched plot for the production of bigger sized corm and corm yield ha^{-1} in amorphophalus. Maximum yield was recorded at 75 X 75 cm spacing with mulching.

Mohankumar and Hrishi (1973) found that farmyard manure (12.5 t ha^{-1}) + NPK (100 kg ha^{-1}) gave a significant increase in yield in cassava.

Nitrogen level upto 60 kg ha^{-1} had a significant influence on the tuber yield and quality constituents of *Dioscorea alata*. The application of farmyard manure alone or in combination with P and K enhanced tuber yield over control (Singh *et al.*, 1973). Increased yield was obtained in *Dioscorea alata* when top portion of the tuber was used as planting material along with 20 t ha^{-1} of farmyard manure (Mohankumar and Nair, 1979).

Wildjajanto and Widodo (1982) obtained maximum marketable tuber yield of 20.58 kg $plot^{-1}$ with application of 20 t farmyard manure + 180 kg N ha^{-1} for potato crop. High rates of farmyard manure or nitrogen increased total tuber production in potato.

Ashokan *et al.* (1984) studied the influence of seed corm weight and supplementary manures on the growth and yield of amorphophallus. They found that the highest corm yield was obtained by planting 1000 g seed corm. The disadvantage of planting small sized seed corms could be eliminated by supplemental manuring.

Bourke(1985) from a series of experiments conducted in Papua New Guinea observed an increase in leaf area duration by nitrogen which could influence the mean tuber weight.

The cuttings of sweet potato cultivar BNAS - 51 were planted in ridges at the rate of one cutting per hill with incorporation of *Vigna mungo* and soyabean as green manure. The stage of green manure decomposition affected vine length and leaf area index during the second and third months of sweet potato growth including tuber length and diameter, weight and number of marketable tubers per hectare, total tuber yield and harvest index (Sevenorio and Escalada, 1985).

Thashkhodzhaev (1985) observed that increased rates of farmyard manure and NPK increased tuber yields, starch, vitamin C, nitrate nitrogen, dry matter contents and economic returns per tonne of organic fertilizer applied with no fertilizer application in potato. Highest yields and nitrate nitrogen contents were observed with 60 tonne farmyard manure + 150 kg N + 100 kg P_2O_5 + 60 kg K_2O ha^{-1}.

Potato yields were significantly increased by application of potassium and farmyard manure in an alluvial loamy sand (Singh and Brar, 1985).

In sweet potato, farmyard manure is essential for higher tuber production. A combination of 10 t ha^{-1} farmyard manure + 75 : 50 : 75 kg ha^{-1} NPK recorded maximum yield (Ravindran and Nambisan, 1987). Farmyard manure at higher dose did not produce any marked increase in yield which indicated that such a high dose was not required for sweet potato.

Mulching had significant effect on the production of corms and cormels per plant in taro. Maximum number of cormels per plant was produced by leaf mulch. This might be a result of better availability of nutrients and favourable physical condition of the soil for better growth and development of the cormel (Mohankumar and Sadanandan, 1988).

For a long duration crop like cassava, mussoorie rock phosphate was a better source of phosphatic fertilizer than single super phosphate in acid laterite soil when used along with farmyard manure (Kabeerathumma and Mohankumar, 1990). The inclusion of farmyard manure improved tuber yield significantly.

An increase in length and a corresponding decrease in girth of tubers was observed in sweet potato by enhanced nitrogen supply. The girth of tuber was maximum at 75 kg ha^{-1} potash while it did not exert any influence on the length of tuber (Nair, 1994).

2.3.3 Effect on growth of other crops

NPK application in absence of farmyard manure retarded the formation of vegetative organs and subsequently reproductive organs in chilli (Cerna, 1980).

Increasing ratio of farmyard manure and N fertilizer increased plant height but had an inconsistent effect on the number of main stem per hill in potato cv. Katela at Sumberbrantas (Wildjajanto and Widodo, 1982).

Valskova and Ivanic (1982) reported that farmyard manure favourably affected vegetative mass, dry weight, plant weight, photosynthetic potential and consequently fruit yield in chilli.

Grappelli *et al.* (1985) had reported the initiation of rooting of layers and shoots when grown in wormcast.

Kale and Bano (1986) reported the possibility of replacing chemical fertilizers by the organic fertilizers in field experiments conducted with summer crop of paddy variety IR -20 (medium). The seedlings showed significant increase in growth in plots treated with vermicompost. It was also found that the vegetative growth was influenced by the wormcast in a better way than chemical fertilizer whereas the grain yield remained the same without any significant difference.

Kale *et al.* (1987) observed the influence of wormcasts on the growth and mycorrhizal colonisation of two ornamental plants viz. salvia and aster. The wormcast when used as a manure in place of farmyard manure significantly influenced both their vegetative and flowering characters and increased mycorrhizal root colonisation.

The enhanced plant growth in presence of earthworms 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 (Curry and Boyle, 1987).

Bano *et al.* (1984) suggested that earthworms can be successfully employed in the biodegredation / vermicomposting technology and found that wormcast produced by African right crawler *Eudrillus eugeniae* can replace compost and to some extent the costly chemical fertilizers in the field.

Darley Jose *et al.* (1988) reported that highest plant height (75.15 cm) was observed in brinjal cv. MDU-1 which received 50 kg N as urea and 50 kg N as poultry manure. It was attributed that poultry manure contained growth promoting substances, which induced better plant growth.

Farmyard manure had beneficial effects on maize crop yield. The yield increase was generally due to favourable increase in grain number per ear and increased grain weight (Ganguly, 1988).

The application of optimum dose of NPK along with peat increased dry matter production and yield of tomato compared to the application of NPK alone (Almazov and Kholuyako, 1990).

Shuxin *et al.* (1991) observed 30 - 50 per cent increase in plant growth and nitrogen uptake and 10 per cent increase in height and effective tillering and diameter of sugarcane when vermicompost was applied. 20 - 25 per cent increase in height and 50 per cent increase in weight of soyabean plants were also obtained.

In water melon, vigorous growth and increased number of flowers were observed when treated with vermicompost (Ismail *et al.*, 1991).

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 ubiquitous in earthwormcasts in field situations.

Galbiatti *et al.* (1992) found out that organic manure in the form of bio-degraded cattle slurry at 60 m^3 ha^{-1} increased the number of leaves per plant and plant height in onion cultivar. Ferriere and Cruze (1992) observed higher dry matter yield in maize plants by the application of vermicompost.

Ismail *et al.* (1993) studied the influence of vermicompost on the relative appearance, height of plants, number of branches and flowers of Zinnia and reported that vermicompost treated plants showed maximum number of brighter coloured flowers, number of branches per plant compared to farmyard manure treated plants. Vadiraj *et al.* (1993) reported that use of vermicompost as a component of potting mixture in cardamom nursery helped better seedling growth and dry matter production in a shorter period of time.

Stephens *et al.* (1994) studied the ability of earthworms to increase the plant growth and foliar concentration of elements in wheat in sandy loam soil.

They observed a significant increase in plant yield, root and shoot weight and foliar concentration of elements like Ca, Na, Mn, Cu, Fe and Al.

Arokiaraj and Kannappan (1995) reported that higher straw yield and grain yield resulting in higher net return can be obtained in CO-25 sorghum by application of farmyard manure 5 t ha^{-1} under rainfed condition.

The height of the plants, number of leaves and number of flowers were greatly influenced by the application of vermicompost compared to farmyard manure in tomato (Pushpa, 1996).

2.3.4 Effect on yield of other crops

Stockdill and Cossens (1966) noted an yield increase in pasture production caused by earthworms.

Green manuring along with mineral fertilizers gave approximately 25 per cent higher yield than fertilizer alone (Hodoss, 1968).

Grass yield was increased upto four times and clover yield increased upto ten times, after inoculation with earthworms (Van Rhee, 1969).

Garg *et al.* (1971) reported that an increase in yield of rice, wheat, sugarcane and cotton was due to the application of farmyard manure.

In the permanent manurial experiment in Coimbatore, cattle manure treatment gave the highest yield of ragi but on par with NPK treatment (Krishnamoorthy and Ravikumar, 1973).

The yield of brinjal fruits was significantly influenced by the levels of farmyard manure but not by the levels of inorganic fertilizers and interaction due to farmyard manure and inorganic fertilizers. Application of 12.5 t ha^{-1}

farmyard manure recorded the highest yield of 54.28 t ha^{-1}. Among the levels of inorganic fertilizers, application of 50 per cent of the recommended fertilizers recorded the highest fruit yield (50.89 t ha^{-1}) followed by 150 per cent of the doses of inorganic fertilizers (45.99 t ha^{-1}). Application of 12.5 t ha^{-1} farmyard manure and 50 per cent of the recommended fertilizers improved the fruit yield (Subbiah *et al.*, 1983).

Application of farmyard manure produced significantly increased seed cotton yield by 41.1 per cent over its no application (Rawankar *et al.*, 1984).

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

Altavinyte and Zimkuviene (1985) observed that the growth and yield in barley crops improved by using worm activated soil. Higher dry matter yields of cabbage was obtained by growing with vermicompost than with the application of mineral fertilizers. By the application of 4, 6 and 8 kg m^{-2} of vermicompost, cabbage dry matter yield increased from 1 to 66 per cent (Sacirage and Dzelilovic, 1986).

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

Earthworm cast was found to be very effective substitute for gram powder in production (Senapathi, 1988).

Green manure along with single super phosphate application increased the yield of the first crop rice in the rice - rice -greengram cropping system (Lekha Sreekantan and Palaniappan, 1989).

Successive application of city waste compost to tomato in a green house experiment, resulted in increased yield (Murillo *et al.*, 1989).

The application of optimum dose of NPK along with peat increased dry matter production and yield of tomato compared to the application of NPK alone (Almazov and Kholuyako, 1990).

Nair and Peter (1990) obtained highest yield in chilli with 15 tonnes farmyard manure + 175 : 40 : 25 kg NPK ha^{-1} in the three seasons tried when compared to farmyard manure alone or inorganic fertilizer alone.

The organic and inorganic fertilizers and their combinations had significant influence on vegetable productivity and higher rate of N along with farmyard manure induced earliness and increased fruit yield in clustered chilli (KAU, 1991).

Significant increase in yield was obtained by the incorporation of groundnut residue to wheat crop (Dhillon and Dhillon, 1991).

Galbiatti *et al.* (1992) observed that organic manure applied as biodigested cattle slurry at 60 m^3 ha^{-1} improved the bulb diameter in onion and suggested that mineral fertilizer can be replaced successfully by organic fertilizer.

Earthworm inoculation in combination with heavy mulching of agricultural wastes all the year round was found to be a successful practice of grape production without the application of chemical fertilizers (Gunjal and Nikam, 1992).

Barve (1993) observed an increase in yield on application of vermicompost to grapes.

Phule (1993) studied the effect of vermiculture in sugarcane and reported that treatment with vermicompost yielded 125 t ha^{-1}, while control treatment with chemical fertilizers and farmyard manure yielded 100 and 75 t ha^{-1} respectively.

It was found that 50 per cent NPK in combination with 10 t ha^{-1} of farmyard manure, crop residue and farmyard manure + 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 per cent NPK in combination with farmyard manure, crop residue, farmyard manure + 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 farmyard manure or crop residue. 50 per cent NPK in combination with farmyard manure increased the uptake of all three major nutrients by wheat (Prasad and Sinha, 1995).

In the case of raddish, spinach and green peas, yield were better with 50 per cent dose of NPK through chemical fertilizers and the rest through vermicompost (Jambhakar, 1996). Highest yield of chilli (8.5 t ha^{-1}) was obtained for treatment with vermicompost 25 t ha^{-1} and NPK fertilizers at 75 : 40 : 25 kg ha^{-1} (Rajalekshmi , 1996). The same combination in tomato gave 10.8 t ha^{-1} of fruits (Pushpa, 1996).

Ushakumari *et al.* (1996) conducted an experiment to study the seasonal response of bhindi to vermicompost. The result showed that when farmyard manure was substituted by vermicompost in package of practices of Kerala Agricultural University for bhindi, the yield of green vegetable obtained was 105 per cent more. Vermicompost along with package of practices recommendations of inorganic fertilizers increased yield by 21.2 per cent and 16 per cent in bitter gourd and cowpea respectively (Jiji *et al.*, 1996).

2.4 Effect of organic manures on quality

Tsuno and Fujise (1968) reported that for producing tubers of high starch content N application should be moderate.

In amorphophallus, mulching was significantly superior to non-mulched plants for the production of bigger sized corms (Mohankumar *et al.*, 1973). But there was not much difference observed regarding the protein and dry matter contents of corms, but an increasing trend of carbohydrate was observed with decreasing plant population.

Mohankumar and Hrishi (1973) conducted a study to determine the response of cassava to farmyard manure and NPK alone and in combination on growth, yield and quality. They found that the HCN content of the tubers increased in treatments with farmyard manure, N and farmyard manure + N, whereas starch content of tubers showed an increasing trend with application of potash. The N content considerably affected the cooking quality, particularly taste.

Sahrawat and Mukherjee (1977) observed an increase in the grain protein content of rice due to the application of karanja and mahua seed cake.

Kansal *et al.* (1981) found that application of 20 t farmyard manure ha^{-1} increased the ascorbic acid content of spinach leaves.

Singh *et al.* (1973) observed that the sugar content of tubers was found to increased with application of N upto 80 kg ha^{-1}.

Mariappan *et al.* (1983) found out that the addition of pressmud increases the juice quality in sugarcane.

Ashokan *et al.* (1984) found out that the sugar content of the tuber was highest at the lowest levels of nitrogen and potash in sweet potato. With increasing levels of these nutrients the sugar content decreased. But the differences were not statistically significant. Similar to this, the non significant influence of nitrogenous fertilizers in sugar content sweet potato was reported by Stino (1956) and Anon (1978-79). The starch content of the tuber was increased by higher levels of N and K.

Ravindran and Balanambisan (1987) observed that the quality of tubers in sweet potato was not much affected by different doses of farmyard manure and NPK. The starch and sugar contents of tubers were not much affected.

A combined application of farmyard manure and fertilizer N was significantly increased the protein content of grains in ragi than when they were either applied alone (Chellamuthu *et al.*, 1987). Similar result was obtained by Muthuvel *et al.* (1985) in redgram.

Application of a combination of farmyard manure and inorganic fertilizers was found to be the best for increasing firmness, storage life and keeping quality of tomatoes for long time (Shanmugavelu, 1989).

The produce obtained from organic farming is nutritionally superior with good taste, good luster and better keeping quality. The better storage life of spinach grown with organic manure was found to be associated with low free aminoacid content, lower level of nitrate accumulation and higher ratio of protein nitrogen to nitrate nitrogen (Lampkin, 1990).

Earthworm castings increased protein yield by 24 per cent in lettuce and 32 per cent in radish (Tomati *et al.*, 1990).

Barve (1993) obtained an improvement in quality both in taste and attractiveness on application of vermicompost to grape.

Phule (1993) obtained more sugar cane yield from vermiculture treated plots and also the juice had 3 - 4 extra brix and lesser salts than chemical fertilizer applied crop. By applying vermicompost, Khamkar (1993) obtained healthier coccinia plants and better keeping quality, reduced cost of cultivation through low labour cost and reduced use of fertilizers and pesticides (Desai, 1993).

2.5. Pest incidence

In field experiments on the control of *Cylas formicarius*, the sweet potato weevil using different organic materials, calophyllum cake at 2500 kg ha^{-1} and lemon grass at 5000 kg ha^{-1} applied on the mounts before planting of the vines gave the effective control of the pest. Mahwa cake also gave good control. Neem cake and cahsew shell powder were in effective (Johnson *et al.*, 1979).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The field experiment was conducted in the wet lands of Instructional Farm, College of Agriculture, Vellayani during the period 1995-96. The details of the materials used and methods adopted for the study are described in this chapter.

3.1. MATERIALS

3.1.1. Location of the experimental field

The field experiment was laid out in the II block of Instructional Farm, College of Agriculture, Vellayani. Geographically the area is situated at 8^0 30' North latitude and $76^0$54' East longitude at an altitude of 29m above MSL.

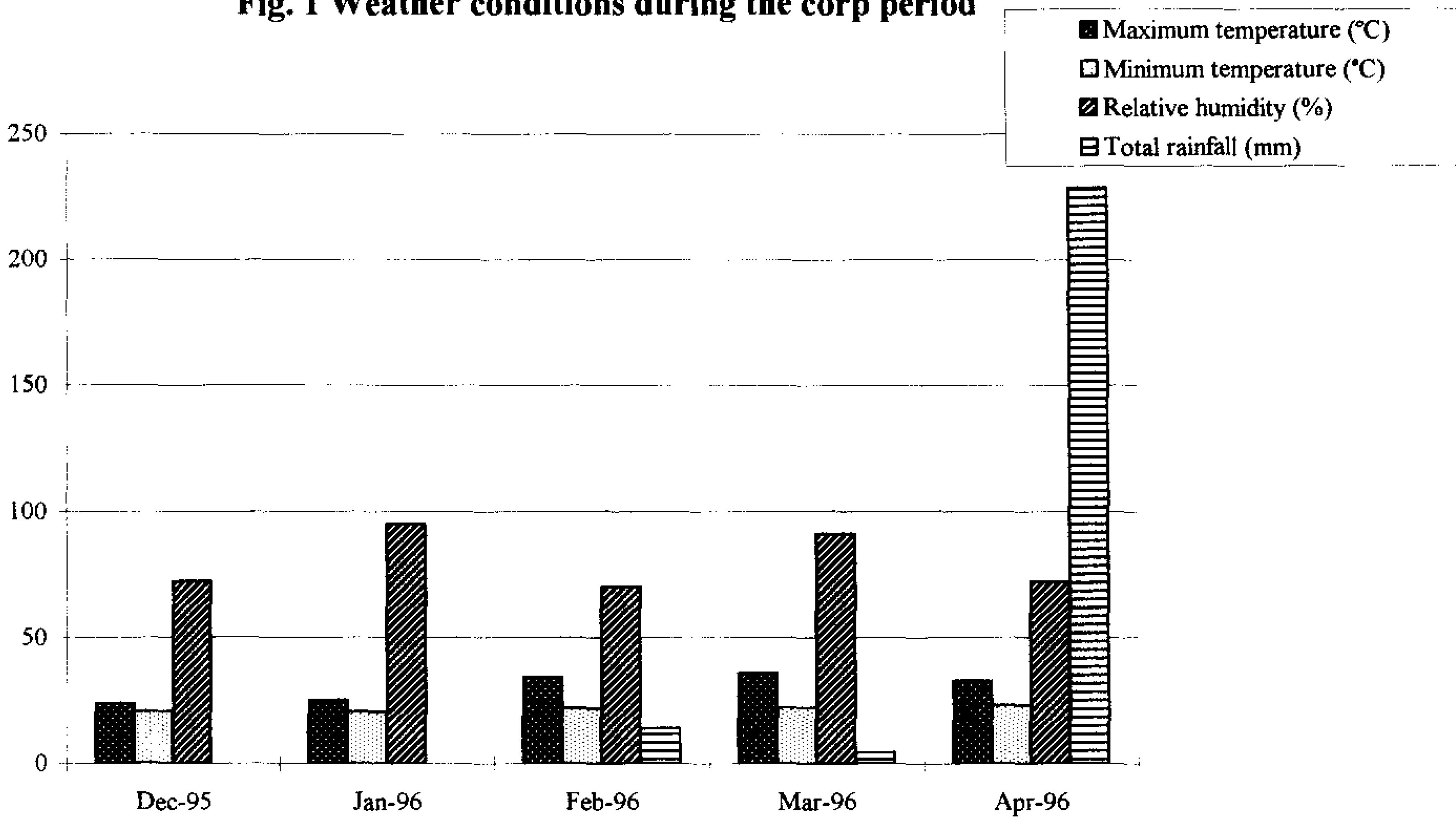
3.1.2. Season

The period of crop growth was from December 1995 to April 1996.

3.1.3. Weather and climate

The major weather parameters recorded during the crop growth period are given in Appendix-I and Fig. 1. The mean maximum and mean minimum temperatures during the period were 30.18^{0}C and 21.58^{0}C respectively. The average relative humidity was 80 per cent and the total rainfall received during the growth period was 246.9 mm.

Fig. 1 Weather conditions during the corp period



3.1.4. Soil

Soil of the experimental site is commonly named as brown hydromorphic soil and belongs to the taxonomic class of fine kaolinitic isohyperthermic Tropic Fluvaquent. The important physical and chemical characteristics of the soil are given in Table 1.

Table 1. Soil characteristics of the experimental field

Sl. No.	Characteristics	Value
A	Physical properties	
	I Mechanical composition	
	1. Clay	27.8 per cent
	2. Silt	21.4 per cent
	3. Fine sand	19.2 per cent
	4. Coarse sand	31.6 per cent
	II Textural class	Sandy clay loam
	III Bulk density	1.2 g cm^{-3}
B	Chemical properties	
	1. Available N	247.74 kg ha^{-1}
	2. Available P	32.76 kg ha^{-1}
	3. Available K	98.39 kg ha^{-1}
	4. pH (1:2.5 soil water suspension)	4.38
	5. E.C.	<0.05 dS m^{-1}
	6. Organic carbon	0.81 per cent
	7. Cation Exchange Capacity	4.5 c mol (+) kg^{-1}
	8. Exchangeable Ca	1.9 c mol (+) kg^{-1}
	9. Exchangeable Mg	1.3 c mol (+) kg^{-1}

3.1.5. Crop

Sweet potato variety *Kanjangad local* having a duration of 115 - 120 days, the most popular variety grown in Kerala, was used for the experiment. The material was obtained from the Central Tuber Crops Research Institute, Sreekaryam, Trivandrum. It was planted in the nursery for multiplication.

3.1.6. Manures

Cattle manure analysing 1.6 per cent N, 0.3 per cent P_2O_5 and 0.18 per cent K_2O was applied as per Package of Practices Recommendations of Kerala Agricultural University (Kerala Agricultural University, 1993) and vermicompost containing 1.6 per cent N, 0.7 per cent of P_2O_5 and 1.9 per cent K_2O was applied as per treatments.

3.1.7. Fertilizers

Urea analysing 46 per cent N, Rajphos with 20 per cent P_2O_5 and Muriate of potash analysing 60 per cent K_2O were used for the experiment.

3.1.8. Nursery

The planting material obtained from the Central Tuber Crops Research Institute, was planted in a well prepared nursery area of 50 m^2. The cuttings were planted on raised beds at a spacing of 60 x 20 cm. Regular irrigation and fertilizer application were given for better branching and vine growth. Cuttings were taken from the nursery on the 40^{th} day and used for planting in the experimental field.

3.2. METHODS

The different methods used for the analysis of soil and plant samples, details of field experiment and statistical analysis of data are presented below.

3.2.1. Design and lay out of the experiment (Fig. 2)

Design	- Randomised Block Design
Replications	- 4
Treatments	- 7
Plot size	- 3.6 x 3.6 m (Gross)
	2.4 x 2.8 m (Net)
Spacing	- 60 x 20 cm

One row on each side and two plants each on opposite sides were left out for eliminating border effect.

Treatments

The experiment was conducted by adopting the following treatments.

T_1 - Inorganic fertilizers + organic manure as cattle manure (Package of Practices Recommendations of Kerala Agricultural University)

T_2 - Inorganic fertilizers + organic manure as vermicompost.

T_3 - $3/4^{th}$ inorganic fertilizers + organic manure as vermicompost.

T_4 - 1/2 inorganic fertilizers + organic manure as vermicompost.

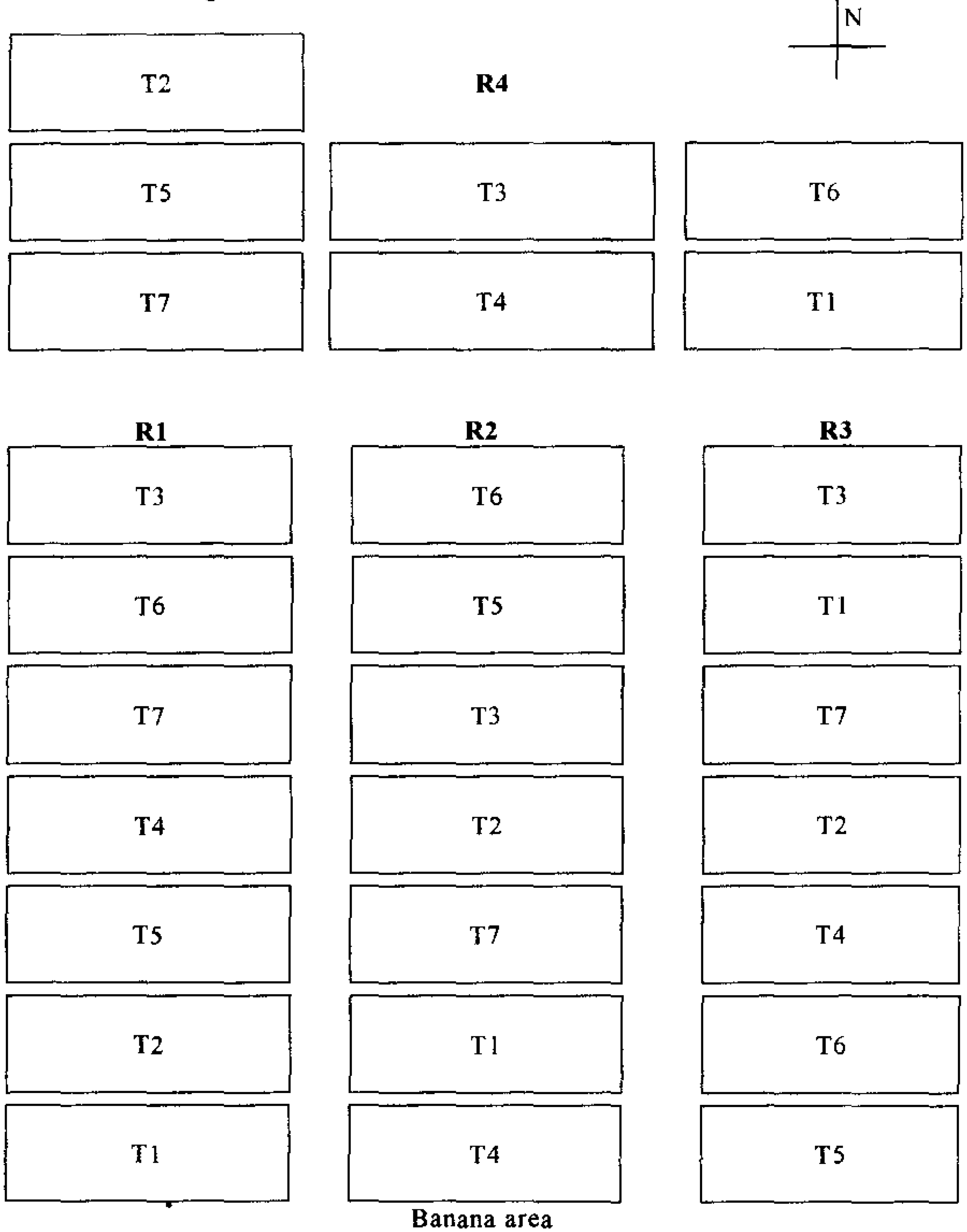
T_5 - Inorganic fertilizers + $3/4^{th}$ of organic manure as vermicompost.

T_6 - Inorganic fertilizers + 1/2 of organic manure as vermicompost

T_7 - Nitrogen as vermicompost + organic manure as vermicompost.

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

Fig. 2 LAY OUT PLAN OF THE EXPERIMENT



Design	: RBD
Replications	: 4
Number of treatmens	: 7
Number of experimental plots	: 28

3.3. Land preparation

All the cultural operations were done according to the Package of Practices Recommendations of Kerala Agricultural University (Kerala Agricultural University, 1993).

The field was worked to a fine tilth by digging to a depth of 15-25 cm. The plots were laidout according to the design of the experiment. The plot area was levelled and made ridges 60 cm apart having 25-30 cm height.

3.4. Planting

The cuttings obtained from the apical and near apical portions of the vines were used for planting. The sweet potato vines collected from the nursery were cut into pieces of 25 cm length having three or four nodes each. These cuttings were planted with the middle portion buried deep in the soil and the two cut ends each exposed to the surface.

3.5. Application of manures and fertilizers

Cattle manure / vermicompost was applied as per treatments at the time of preparation of ridges.

Chemical fertilizers were also applied as per treatments. Nitrogen was applied in the form of urea in two equal split doses, first at the time of planting and second four weeks after planting. Full dose of phosphorus as Rajphos and potassium as Muriate of potash were applied at the time of planting.

3.6. Gap filling

Gap filling was done on the seventh day to secure uniform stand of the crop.

3.7. After cultivation

Two weedings and earthing up operations were conducted at two weeks and five weeks after planting. The second dose of fertilizers were applied after second weeding. To prevent the development of small slender tubers at the nodes, turning up of vines was done during the active growth phase.

3.8. Irrigation

The vines were irrigated once in two days for a period of 10 days after planting and thereafter once in 10 days. The irrigation was stopped three weeks before harvest.

3.9. Plant protection

There was no serious attack of pest or disease during the growth period. As a precautionary measure, the vines were dipped in 0.05 per cent monocrotophos suspension for 5-10 minutes prior to planting for the control of sweet potato weevil. Spraying with the same chemical was done one month after planting and subsequently two more times at tri-weekly intervals.

3.10. Harvesting

The crop was harvested 115 days after planting, when the leaves turned yellow indicating tuber maturity.

The plants selected for biometric observations in the net plot area were uprooted a day prior to harvest and necessary observations were recorded.

3.11. Biometric observations

3.11.1. Observations before harvest

Four plants were selected from each net plot at random and were tagged. The following observations were recorded and mean values worked out before the harvest of the crop.

3.11.1.1. Length of vine

The length of vine was measured from the base to the tip of the longest vine of each plant.

3.11.1.2. Number of branches

The total number of branches present in each observational plant were recorded.

3.11.1.3. Incidence of pests and diseases

No serious pest / disease attack was observed except a minor incidence of sweet potato weevil.

3.11.1.4. Tuber bulking rate (BR)

It is the rate of increase in tuber weight per unit time and is an important measure of tuber growth.

It is expressed in g day^{-1} plant^{-1} (dry weight).

$$BR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where W_2 - Dry weight of tuber at time t_2

W_1 - Dry weight of tuber at time t_1

Replication I was used for observing tuber bulking rate.

3.11.2. Observations after harvest

3.11.2.1. Vine yield (Haulm yield)

The total fresh weight of vine from net plot was recorded immediately after harvest.

3.11.2.2. Incidence of pests / diseases

The total number of weevil affected tubers from each net plot was recorded. No other serious pest or disease was noticed.

3.11.2.3. Number of tubers per vine

All the tubers harvested from each observational plant were accounted separately and the mean value was recorded.

3.11.2.4. Length of tuber

The length of tuber was measured as the distance from point of attachment of tuber to the vine upto its tip.

3.11.2.5. Girth of tuber

Girth measurements were recorded from those tubers which were used for length measurement. It was taken from the widest part of tuber and the mean value was recorded.

3.11.2.6. Weight of tuber

The mean tuber weight in grams was worked out by dividing fresh tuber weight in net plot by total number of tubers.

3.11.2.7. Total tuber yield

Total weight of tubers obtained from each net plot were accounted separately.

3.11.2.8. Marketable tuber yield

The weevil affected non marketable tubers were separated from total tuber yield from each net plot. Rest of the tubers which can be marketed were weighed and recorded as marketable tuber yield.

3.11.3. Quality attributes

3.11.3.1. Starch content

The starch content of the tuber was estimated colorimetrically by potassium ferricyanide method (Aminoff *et al.*, 1970). The values were expressed on percentage fresh weight basis.

3.11.3.2. Sugar content

It was estimated colorimetrically using alkaline copper reagent (Nelson and Somogyi, 1952) and the values were expressed in percentage fresh weight basis.

3.11.3.3. Crude protein content

The nitrogen content of tuber was determined by the modified microkjeldhahl method (Jackson, 1973) and the crude protein estimated by multiplying the nitrogen values by the factor 6.25 (AOAC, 1969) on dry weight basis.

3.11.3.4. Crude fibre content

It was estimated by ashing and weight loss method (AOAC, 1975).

3.11.3.5. Carotene content

The total carotenoids are extracted and partitioned in organic solvence on the basis of their solubility (Sadasivam and Manickam, 1992).

3.12. Chemical analysis

3.12.1. Plant analysis

The individual plant parts such as leaf, vine and tuber collected at the time of harvest were finely chopped, air dried and then oven dried at a temperature of 65 to 70 ^{0}C in a hot air oven. The dried material was powdered uniformly and stored in air tight containers for chemical analysis. Nitrogen, phosphorus, potassium, calcium, magnesium and micronutrient contents (Cu, Zn, Fe, Mn) of different plant parts were analysed.

3.12.1.1. Nitrogen

Nitrogen of the plant samples was determined by the modified microkjeldhahl method (Jackson, 1973).

3.12.1.2. Phosphorus

The phosphorus content in the diacid extract was estimated by Vanadomolybdo-phosphoric yellow colour method in a klett summerson photo-electric colorimeter (Jackson, 1973).

3.12.1.3. Potassium

Potassium in the diacid extract was determined flame-photometrically using a flame photometer (Jackson, 1973).

3.12.1.4 Calcium

Calcium in the diacid extract was estimated by an Atomic Absorption Spectrophotometer (Jackson, 1973).

3.12.1.5 Magnesium

Magnesium in the diacid extract was determined by an Atomic Absorption Spectrophotometer (Jackson, 1973).

3.12.1.6. Micronutrients

Zn, Cu, Fe and Mn were determined by Atomic Absorption Spectrophotometer method (Jackson, 1973).

3.12.1.7. Uptake studies

Different plant parts like leaves, vines and tubers were analysed separately for nitrogen, phosphorus and potassium and total uptake was calculated based on their contents in the parts and their corresponding dry matter weight.

3.13. Soil analysis

Soil samples were taken before the experiment and after harvest of the crop. A representative soil sample of the field obtained by mixing the soil samples collected from the different parts of the field was used for initial analyses. Initial analysis was done for mechanical composition, organic carbon, available nitrogen, available phosphorus, available potassium, pH, EC, CEC, exchangeable calcium and magnesium. Plotwise analysis of soil samples for available N, P and K were done soon after the harvest of the crop.

3.13.1. Analytical methods

The methods used for the analysis of soil physical and chemical properties are given below.

3.13.1.1. Mechanical analysis

The international pipette method (Piper, 1966) was used for mechanical analysis of initial soil sample.

3.13.1.2. Organic carbon

The organic carbon content of the soil samples was estimated by Walkley and Black's wet oxidation method as described by Jackson (1973).

3.13.1.3. Available nitrogen

The available nitrogen content was estimated by the alkaline permanganate method described by Subbiah and Asija (1956).

3.13.1.4. Available phosphorus

Phosphorus in the soil sample was extracted with Bray No. I extractant and phosphate in the extracts was determined colorimetrically using ascorbic acid as reductant as per the procedure by Murphy and Riley (1962).

3.13.1.5. Available potassium

Available potassium was extracted by neutral normal ammonium acetate method and determined in a flame photometer (Jackson, 1973).

3.13.1.6. Soil pH

The pH was determined in a pH meter using 1:2.5 soil water suspension (Jackson, 1973).

3.13.1.7. Electrical conductivity

It was measured conductometrically by using 1:2.5 soil water suspension (Jackson, 1973).

3.13.1.8. Cation Exchange Capacity (CEC)

CEC was estimated by using neutral normal ammonium acetate and potassium chloride method (Piper, 1966).

3.13.1.9. Exchangeable Calcium

Exchangeable calcium content of soil was estimated by Flame photometer method using neutral normal ammonium acetate extract (Jackson, 1973).

3.13.1.10. Exchangeable Magnesium

Exchangeable magnesium content of soil was estimated by Atomic Absorption Spectrophotometer model PE-3030 using neutral normal ammonium acetate extract (Jackson, 1973).

3.14. Analysis of vermicompost

3.14.1. Nitrogen

Total nitrogen content of the vermicompost samples were determined by the modified microkjeldhahl method (Jackson, 1973).

3.14.2. Phosphorus

The phosphorus content in vermicompost samples were estimated by Vanadomolybdo phosphoric yellow colour method (Jackson, 1973).

3.14.3. Potassium

Potassium was determined flame-photometrically using a flame photometer (Jackson, 1973).

3.15. Economic analysis

Economics of cultivation was worked out for the field experiment after taking into account the cost of cultivation and prevailing market price of sweet potato. The net income and benefit cost ratio were calculated as follows.

Net income (Rs ha^{-1}) = Gross income - Total expenditure

$$\text{Benefit : Cost ratio} = \frac{\text{Gross income}}{\text{Total expenditure}}$$

3.16. Statistical analysis

Statistical methods of analysis such as analysis of variance and important correlation were carried out to find out the relationship between variables to draw definite conclusions (Panse and Sukhatme, 1967).

RESULTS

4. RESULTS

The various observations recorded were statistically analysed and the salient features of the results are presented below:

4.1. Growth characters

Results of the growth characters like length of vine, number of branches and vine yield are presented below:

4.1.1. Length of vine

The mean length of vine of treated plants at different growth stages are presented in Table 2. The length of vine did not vary significantly at any of the growth stages of sweet potato. The longest vines were produced by T_7 (N as vermicompost + o.m. as vermicompost at all growth stages. The shortest vines were produced by the treatment T_1 (inorganic fertilizers + organic manure as cattle manure). The different treatments did not exert any significant influence on the vine length of sweet potato.

Table 2. Effect of various treatments on vine length (cm) at different growth stages

Treatments	45 DAP	75 DAP	At harvest
T_1 (inorganic fertilizers + o.m as cattle manure)	78.07	126.07	155.17
T_2 (inorganic fertilizers + o.m. as vermicompost)	78.21	127.37	163.50
T_3 ($3/4^{th}$ inorganic fertilizers + o.m. as vermicompost)	97.07	155.30	185.25
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	90.87	144.03	189.00
T_5 (inorganic fertilizers + $3/4^{th}$ of o.m. as vermicompost)	96.73	149.33	190.02
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	82.30	134.03	194.92
T_7 (N as vermicompost + o.m. as vermicompost)	112.93	165.77	247.58
CD	NS	NS	NS

4.1.2. Number of branches per plant

The results presented in Table 3 show that the different treatments did not show any significant influence in the number of branches per plant. The highest number of branches were produced by T_7 (N as vermicompost + o.m. as vermicompost). The lowest number of branches were produced by the treatment T_5 (inorganic fertilizers + 3/4th organic manure as vermicompost).

Table 3. Effect of various treatments on the number of branches per plant

Treatments	Number of branches per plant
T_1 (inorganic fertilizers + o.m as cattle manure)	7.00
T_2 (inorganic fertilizers + o.m. as vermicompost)	7.58
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	6.92
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	7.50
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	6.42
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	7.17
T_7 (N as vermicompost + o.m. as vermicompost)	8.90
CD	NS

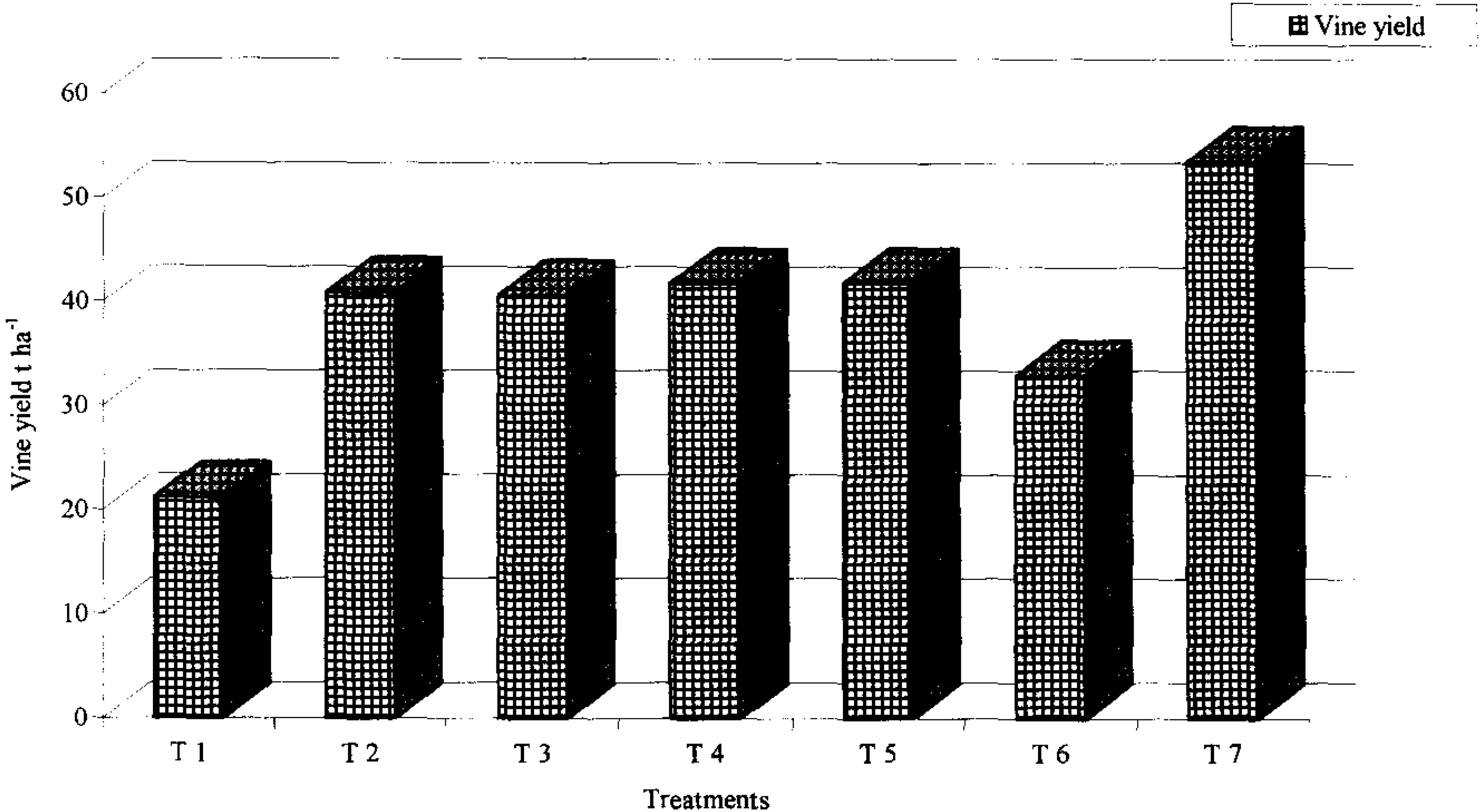
4.1.3. Vine yield

The data on vine yield (t ha^{-1}) shown in the Table 4. There was significant variation among various treatments. The highest vine yield was shown by T_7 (53.55 t ha^{-1}) which was on par with T_2, T_3, T_4 and T_5. The lowest vine yield (21.24 t ha^{-1}) was shown by the treatment T_1.

Table 4. Effect of various treatments on vine yield (t ha^{-1})

Treatments	Vine yield
T_1 (inorganic fertilizers + o.m as cattle manure)	21.24
T_2 (inorganic fertilizers + o.m. as vermicompost)	40.93
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	40.63
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	41.79
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	41.84
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	32.95
T_7 (N as vermicompost + o.m. as vermicompost)	53.55
CD	15.96

Fig. 3 Effect of various treatments on vine yield (t ha^{-1})



4.2. Yield components and yield

4.2.1. Number of tubers per plant

Efficiency of various treatments in the production of tubers per plant is given in Table 5. Different treatments had no significant influence on the number of tubers per plant. The highest number of tubers per plant was produced by applying the treatment T_7 (Nitrogen as vermicompost + organic manure as vermicompost).The lowest number of tubers per plant was recorded by the treatments T_1, T_2 and T_3.

Table 5. Effect of various treatments on the number of tubers per plant

Treatments	Number of tubers per plant
T_1 (inorganic fertilizers + o.m as cattle manure)	1.08
T_2 (inorganic fertilizers + o.m. as vermicompost)	1.08
T_3 ($3/4^{th}$ inorganic fertilizers + o.m. as vermicompost)	1.08
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	1.25
T_5 (inorganic fertilizers + $3/4^{th}$ of o.m. as vermicompost)	1.33
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	1.25
T_7 (N as vermicompost + o.m. as vermicompost)	1.50
CD	NS

4.2.2. Tuber weight

The Table 6 shows the data on the average tuber weight of the observational plants from different plots by applying various treatments. It is evident from the Table 6 that there is significant difference among various treatments regarding tuber weight. The tuber weight was maximum (257.47 g) when the treatment T_4 was given. It is found to be on par with T_2 , T_3 and T_6.

. The tuber weight was minimum (146.39 g) when T_1 was applied and was on par with T_5 and T_7 .

Table 6 Effect of various treatments on tuber weight (g)

Treatments	Tuber weight (g)
T_1 (inorganic fertilizers + o.m as cattle manure)	146.39
T_2 (inorganic fertilizers + o.m. as vermicompost)	247.42
T_3 ($3/4^{th}$ inorganic fertilizers + o.m. as vermicompost)	248.53
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	257.47
T_5 (inorganic fertilizers + $3/4^{th}$ of o.m. as vermicompost)	149.25
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	230.13
T_7 (N as vermicompost + o.m. as vermicompost)	184.61
CD	82.42

4.2.3. Number of tubers per net plot

Table 7 shows the number of tubers per net plot for various treatments. It reveals that there is no significant difference among various treatments in the case of number of tubers per net plot. Maximum number of tubers were produced by applying the treatment T_1 (Inorganic fertilizers + organic manure as cattle manure). The minimum number of tubers were recorded in the treatment T_4 (1/2 inorganic fertilizers + organic manureas vermicompost).

Table 7. Effect of various treatments on number of tubers per net plot and mean tuber weight.

Treatments	Number of tubers per net plot	Mean tuber weight (g)
T_1 (inorganic fertilizers + o.m as cattle manure)	89.67	127.11
T_2 (inorganic fertilizers + o.m. as vermicompost)	84.33	153.51
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	79.00	173.24
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	78.00	190.10
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	90.00	135.60
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	92.00	115.74
T_7 (N as vermicompost + o.m. as vermicompost)	89.00	127.69
CD	N S	47.78

4.2.4. Mean tuber weight

The data on mean tuber weight obtained for different treatments are represented in the Table 7. The mean tuber weight was maximum when the treatment T_4 was applied. It is on par with T_3 . The treatments T_3 and T_4 recorded mean tuber weights of 173.24 g and 190.1 g respectively. The lowest mean tuber weight is obtained from plots in which the treatment T_6 was given (115.74 g). But this is on par with T_1 , T_2 , T_5 and T_7 .

4.2.5. Length of tuber

The data pertaining to the length of tuber at harvest is shown in the Table 8. There is no significant difference among various treatments regarding the length of tuber. However, T_2 (inorganic fertilizers + organic manure as vermicompost), produced the longest tuber (23.31 cm) and T_1 produced the shortest one (17.79 cm).

4.2.6. Girth of tuber

Regarding the girth of tuber (Table 8) there is no significant difference among various treatment means. The highest mean was shown by T_4 (17.28 cm) and the lowest by T_5 (13.10 cm).

Table 8. Effect of various treatments on tuber length (cm) and tuber girth (cm) at harvest

Treatments	Tuber length (cm)	Tuber girth (cm)
T_1 (inorganic fertilizers + o.m as cattle manure)	17.79	13.20
T_2 (inorganic fertilizers + o.m. as vermicompost)	23.31	14.19
T_3 ($3/4^{th}$ inorganic fertilizers + o.m. as vermicompost)	22.36	16.76
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	20.26	17.28
T_5 (inorganic fertilizers + $3/4^{th}$ of o.m. as vermicompost)	19.55	13.10
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	21.47	15.45
T_7 (N as vermicompost + o.m. as vermicompost)	22.80	13.52
CD	NS	NS

4.2.7. Total tuber yield

The Table 9 shows the data on total tuber yield (t ha^{-1}). The different treatments showed highly significant difference in total tuber yield. T_4 gave the maximum total tuber yield (21.39 t ha^{-1}) and it was on par with T_2 and T_3. The treatments T_1, T_5, T_6 and T_7 were found to be on par. The lowest mean was observed for the treatment T_6 (15.31 t ha^{-1}) and the highest for the treatment T_4.

4.2.8. Marketable tuber yield

Significant differences were observed between the treatments for marketable tuber yield (Table 9). The highest marketable tuber yield was given by the treatment T_4 (17.36 t ha^{-1}) while the lowest by the treatment T_6 (11.83 t ha^{-1}). The treatment means for marketable tuber yield were showing similar trends to that of total tuber yield with respect to different treatments.

Table 9. Effect of various treatments on tuber yield (t ha^{-1})

Treatments	Total tuber yield	Marketable tuber yield
T_1 (inorganic fertilizers + o.m as cattle manure)	15.93	12.38
T_2 (inorganic fertilizers + o.m. as vermicompost)	19.28	16.01
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	20.53	17.25
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	21.39	17.34
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	17.80	15.31
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	15.31	11.83
T_7 (N as vermicompost + o.m. as vermicompost)	17.50	14.41
CD	2.70	3.55

4.2.9. Tuber bulking rate

The data (Table 10) showed that there is significant difference among various treatments regarding the tuber bulking rate. The tuber bulking rate was maximum in T_4 (1.93 g day^{-1} $plant^{-1}$) which was on par with T_2 and T_3. The lowest tuber bulking rate was shown by the treatment T_6 (1.37 g day^{-1} $plant^{-1}$) and which was on par with T_1, T_5 and T_7.

Table 10. Effect of various treatments on tuber bulking rate (g day^{-1} $plant^{-1}$)

Treatments	Tuber bulking rate
T_1 (inorganic fertilizers + o.m as cattle manure)	1.41
T_2 (inorganic fertilizers + o.m. as vermicompost)	1.80
T_3 ($3/4^{th}$ inorganic fertilizers + o.m. as vermicompost)	1.90
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	1.93
T_5 (inorganic fertilizers + $3/4^{th}$ of o.m. as vermicompost)	1.68
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	1.37
T_7 (N as vermicompost + o.m. as vermicompost)	1.64
CD	0.371

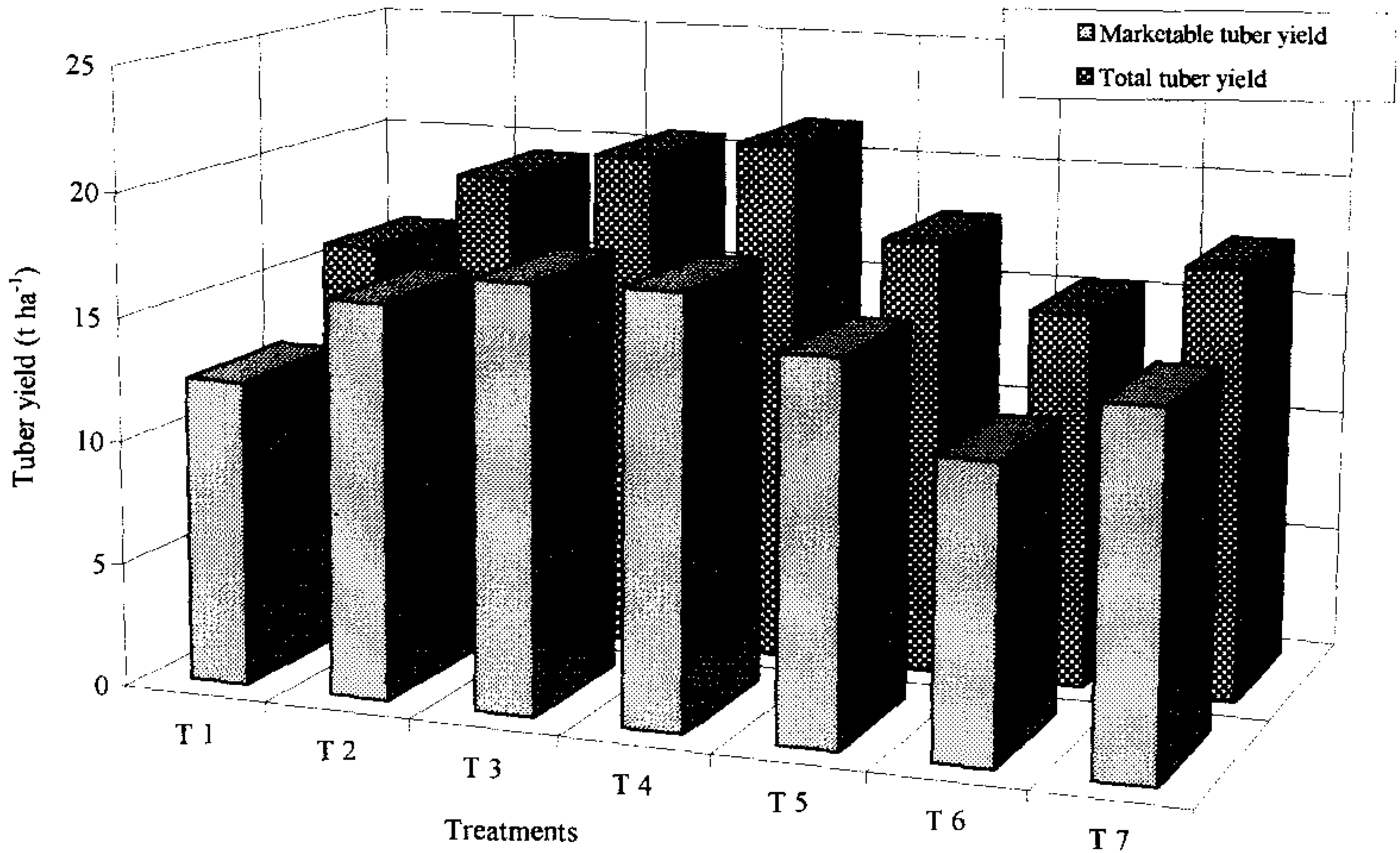
4.3. Number of weevil affected tubers per plot

It is seen from the Table 11 that there is no significant difference among various treatments regarding weevil affected tubers per plot. Minimum number of weevil affected tubers was recorded the the treatment T_3 ($3/4^{th}$ inorganic fertilizers + organic manure as vermicompost) . Maximum number was reported in the treatment T_6 (inorganic fertilizers + 1/2 organic manure as vermicompost).

Table 11 Effect of various treatments on number of weevil affected tubers per net plot.

Treatments	Number of weevil affected tubers
T_1 (inorganic fertilizers + o.m as cattle manure)	11.33
T_2 (inorganic fertilizers + o.m. as vermicompost)	10.33
T_3 ($3/4^{th}$ inorganic fertilizers + o.m. as vermicompost)	4.00
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	10.33
T_5 (inorganic fertilizers + $3/4^{th}$ of o.m. as vermicompost)	11.67
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	14.33
T_7 (N as vermicompost + o.m. as vermicompost)	9.00
CD	N S

Fig. 4 Effect of various treatments on total tuber yeild and marketable tuber yield ($t\ ha^{-1}$)



4.4. Plant nutrient content

4.4.1. Nitrogen

The effect of various treatments on nitrogen content in leaves, vines and tubers are presented in the Table 12. The treatments had no significant influence on nitrogen content in the case of leaf and vine while highly significant difference was observed for tuber. The nitrogen content was maximum in leaves when the treatment T_4 was applied (0.84 %) while it was minimum when treatment T_7 was given (0.67 %).

In the case of vines, the plants which were supplied with T_4 recorded maximum nitrogen content (0.69 %) while the minimum was recorded in plants supplied with T_7 (0.54 %).

The nitrogen content in tubers differed significantly for different treatments and the maximum was recorded in the case where T_4 was given (0.52 %). The tubers were having low nitrogen content in T_2 and T_7 (0.36 %) and these treatments were on par with T_1. The N content in treatment T_4 differed significantly from the rest.

Table 12. Effect of various treatments on plant nitrogen content (%)

Treatments	Leaf	Vine	Tuber
T_1 (inorganic fertilizers + o.m as cattle manure)	0.69	0.64	0.37
T_2 (inorganic fertilizers + o.m. as vermicompost)	0.73	0.62	0.36
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	0.76	0.62	0.43
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	0.84	0.69	0.52
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	0.74	0.62	0.43
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	0.72	0.62	0.43
T_7 (N as vermicompost + o.m. as vermicompost)	0.67	0.54	0.36
CD	NS	NS	0.065

4.4.2. Phosphorus

The data on plant phosphorus content (Table 13) revealed no significant difference among various treatments as for as leaves and vines were concerned while highly significant differences were observed for tubers. The minimum phosphorus content was recorded in leaves which were obtained from the plants with treatments T_1, T_2, T_3, T_4 and T_6 (0.10 %) while maximum was recorded in treatment T_7 (0.11 %).

Minimum phosphorus was observed in vines of plants which were given the treatment T_4 (0.589 %) while the maximum was recorded for treatments T_1, T_2 and T_6 (0.494 %). The data were showing a similar trend to that of plant nitrogen content.

The plants accumulated maximum phosphorus in tubers when they were supplied with T_1 (0.123 %) which differed significantly from the rest. The minimum phosphorus content was observed in tuber in plants which were subjected to the treatment T_7 (0.103 %) which also differs significantly.

Table 13. Effect of various treatments on plant phosphorus content (%)

Treatments	Leaf	Vine	Tuber
T_1 (inorganic fertilizers + o.m as cattle manure)	0.100	0.494	0.123
T_2 (inorganic fertilizers + o.m. as vermicompost)	0.100	0.494	0.113
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	0.100	0.492	0.120
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	0.100	0.589	0.113
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	0.103	0.491	0.117
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	0.100	0.494	0.113
T_7 (N as vermicompost + o.m. as vermicompost)	0.110	0.491	0.103
CD	NS	NS	0.008

4.4.3. Potassium

Table 14 depicts the effect of various treatments on potassium content in leaf, vine and tuber. Unlike that of nitrogen and phosphorus, the potassium content in plant differed significantly with various treatments for leaf, vine and tuber.

Highly significant differences were observed among treatments for potassium content in leaf. Maximum accumulation was observed in leaves when the treatment T_2 was given (2.12 %) which was on par with T_3 (2.05 %) and T_4 (1.98 %) while the minimum was recorded in leaves of plants when treatments T_6 and T_7 were given (1.62 %).

In the case of vines also T_6 and T_7 were recorded the minimum level and were found to be on par (2.22 % and 2.25 % respectively). Maximum was recorded when plants were given the treatment T_2 (1.807 %) which differed significantly from the rest.

In tubers also T_6 and T_7 were found to be on par (2. 13 % and 2.12 %) and recorded the lowest potassium content. The maximum potassium content was observed In tuber when T_2 was given (2.48 %) and it was on par with T_3 and T_4.

Table 14. Effect of various treatments on plant potassium content (%)

Treatments	Leaf	Vine	Tuber
T_1 (inorganic fertilizers + o.m as cattle manure)	1.80	2.43	2.37
T_2 (inorganic fertilizers + o.m. as vermicompost)	2.12	2.81	2.48
T_3 ($3/4^{th}$ inorganic fertilizers + o.m. as vermicompost)	2.05	2.65	2.47
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	1.99	2.62	2.38
T_5 (inorganic fertilizers + $3/4^{th}$ of o.m. as vermicompost)	1.80	2.37	2.23
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	1.62	2.22	2.13
T_7 (N as vermicompost + o.m. as vermicompost)	1.62	2.25	2.12
CD	0.136	0.143	0.106

4.4.4. Calcium and Magnesium

Table 15 shows the data on the effect of various treatments on plant calcium and magnesium contents. The treatments did not show any significant difference in these nutrient contents in leaf, vine and tuber. Tubers recorded minimum calcium and magnesium contents while the leaves recorded the maximum values.

Leaves recorded minimum calcium and magnesium percentages when the treatment T_1 was given (0.21 % and 0.21 % respectively). Maximum calcium content was observed in leaves obtained which was given T_5 treatment (0.36 %) while T_3 recorded maximum magnesium content (0.25 %).

T_1 recorded maximum calcium content in vines (0.19 %) while T_5 recorded the minimum (0.15 %). But in the case of magnesium, T_2 recorded the minimum value (0.15 %) and T_7 the maximum value (0.16 %).

In the case of tubers, T_4 obtained the minimum level for calcium (0.004 %) and T_5 for magnesium (0.04 %). The maximum levels were obtained when the plants were given the treatment T_6, 0.006 % for calcium and 0.07 % for magnesium. The treatment T_4 also recorded the same level for magnesium.

Table 15 a . Effect of various treatments on plant calcium content (%)

Treatments	Leaf	Vine	Tuber
T_1 (inorganic fertilizers + o.m as cattle manure)	0.21	0.19	0.005
T_2 (inorganic fertilizers + o.m. as vermicompost)	0.24	0.19	0.005
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	0.30	0.15	0.005
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	0.303	0.16	0.004
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	0.36	0.15	0.004
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	0.28	0.16	0.006
T_7 (N as vermicompost + o.m. as vermicompost)	0.27	0.16	0.005
CD	NS	NS	NS

Table 15 b. Effect of various treatments on plant magnesium content (%)

Treatments	Leaf	Vine	Tuber
T_1 (inorganic fertilizers + o.m as cattle manure)	0.21	0.16	0.07
T_2 (inorganic fertilizers + o.m. as vermicompost)	0.22	0.15	0.06
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	0.25	0.16	0.07
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	0.24	0.16	0.07
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	0.22	0.15	0.04
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	0.24	0.16	0.07
T_7 (N as vermicompost + o.m. as vermicompost)	0.23	0.16	0.07
CD	NS	NS	NS

4.4.5. Iron

The data (Table 16) revealed no significant difference among treatments as far as plant iron content is concerned. Leaves, vines and tubers did not show any significant difference in iron concentration for various treatments.

T_7 recorded the maximum concentration in leaves (981.33 ppm), T_1 in vines (543.33 ppm) and T_2 in tubers (345 ppm). The minimum levels were recorded for the treatments T_4 in leaves (883.67 ppm) and tubers (258.33 ppm) and T_3 in vines (461.67 ppm).

Table 16. Effect of various treatments on plant iron content (ppm)

Treatments	Leaf	Vine	Tuber
T_1 (inorganic fertilizers + o.m as cattle manure)	922.67	544.33	341.67
T_2 (inorganic fertilizers + o.m. as vermicompost)	918.67	540.00	345.00
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	889.00	461.67	316.67
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	883.67	488.67	258.33
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	976.00	521.67	300.00
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	942.67	522.00	275.00
T_7 (N as vermicompost + o.m. as vermicompost)	981.33	539.00	316.67
CD	NS	NS	NS

4.4.6. Manganese

As far as manganese was concerned, no significant difference was observed in vines, while significant difference was observed in leaves and highly significant difference was observed in tubers for different treatments. The treatment T_2 recorded the maximum concentration (180.33 ppm) in leaves and was on par with T_3 (158.33 ppm). The minimum level was noticed T_5 (120 ppm).

Regarding vines, the highest value was noticed by treatment T_3 (77.67 ppm) and lowest by T_5 (63.67 ppm). Similar trend was noticed in tubers also. T_4 recorded minimum Mn concentration (19.67 ppm) in tubers while maximum was recorded by T_2 (30 ppm). The treatments T_2, T_5 and T_6 were found to be on par for manganese level in tuber was concerned.

Table 17. Effect of various treatments on plant manganese content (ppm)

Treatments	Leaf	Vine	Tuber
T_1 (inorganic fertilizers + o.m as cattle manure)	153.67	66.00	27.67
T_2 (inorganic fertilizers + o.m. as vermicompost)	180.33	67.67	30.00
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	158.33	77.67	28.67
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	120.67	65.00	19.67
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	120.00	63.67	23.00
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	152.00	69.00	23.00
T_7 (N as vermicompost + o.m. as vermicompost)	148.33	71.33	26.67
CD	148.33	NS	3.774

4.4.7. Zinc

Table 18 reveals the zinc content in different parts of plant. Zinc concentration in vines and tubers differed significantly with respect to different treatments. The leaves did not have any significant difference in zinc concentration for different treatments.

The treatment T_1 recorded the minimum level in leaves (21.33 ppm) while T_6 recorded maximum (37.67 ppm). T_4 accumulated maximum zinc content in tubers (36 ppm) but in vines it had the least level (20.33 ppm). In vines T_1 recorded the maximum value (31.33 ppm) and it differed significantly. Minimum level was recorded in T_7 for tubers (14.67 ppm).

Table 18. Effect of various treatments on plant zinc content (ppm)

Treatments	Leaf	Vine	Tuber
T_1 (inorganic fertilizers + o.m as cattle manure)	21.33	31.33	22.00
T_2 (inorganic fertilizers + o.m. as vermicompost)	23.33	26.67	20.00
T_3 ($3/4^{th}$ inorganic fertilizers + o.m. as vermicompost)	32.33	21.67	28.33
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	23.67	20.33	36.00
T_5 (inorganic fertilizers + $3/4^{th}$ of o.m. as vermicompost)	32.00	21.33	31.67
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	37.67	24.67	19.67
T_7 (N as vermicompost + o.m. as vermicompost)	24.67	23.67	14.67
CD	NS	4.235	12.40

4.4.8. Copper

The Table 19 shows the copper content in different plant parts. Leaves and tubers did not show any significant difference in copper content as far as different treatments were concerned but vines showed significant differences. The copper level was maximum in leaves when the plants were subjected to the treatment T_1 (25.33 ppm) and the level was minimum when T_6 applied (20.33 ppm). The treatment T_7 recorded the minimum value in vines and tubers (14.67 ppm and 18 ppm respectively). The maximum level was recorded in vines (25.33 ppm) and was on par with T_1, T_3 and T_6. The maximum level was observed in tuber for T_3 (26.32 ppm).

Table 19. Effect of various treatments on plant copper content (ppm)

Treatments	Leaf	Vine	Tuber
T_1 (inorganic fertilizers + o.m as cattle manure)	25.33	24.00	18.33
T_2 (inorganic fertilizers + o.m. as vermicompost)	21.67	17.67	17.67
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	24.33	22.67	26.33
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	23.67	25.33	19.00
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	22.33	27.00	21.67
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	20.33	23.00	18.67
T_7 (N as vermicompost + o.m. as vermicompost)	20.67	14.67	18.00
CD	NS	7.105	NS

4.5. Quality characteristics

4.5.1. Starch

The treatment means for starch content in tubers are presented in the Table 20. It ranged from 12.45 % (T_4) to 18.84 % (T_7) on fresh weight basis. Highly significant differences were observed among the means for different treatments. The treatments T_4 (12.45 %) and T_3 (14.28 %) were found to be on par.

4.4.2. Reducing sugar

In the case of reducing sugar (Table 20), treatments were found to have significant differences on mean values. The values ranged between 3.16 % (T_5 and T_2) to 3.54 % (T_3 and T_4). The treatments T_3 and T_4 were found to be on par with T_7 (3.45 %).

Table 20. Effect of various treatments on starch and reducing sugar contents of tubers (on percentage fresh weight basis)

Treatments	Starch %	Reducing sugar %
T_1 (inorganic fertilizers + o.m as cattle manure)	17.72	3.30
T_2 (inorganic fertilizers + o.m. as vermicompost)	15.93	3.16
T_3 ($3/4^{th}$ inorganic fertilizers + o.m. as vermicompost)	14.28	3.54
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	12.45	3.54
T_5 (inorganic fertilizers + $3/4^{th}$ of o.m. as vermicompost)	18.44	3.16
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	15.95	3.19
T_7 (N as vermicompost + o.m. as vermicompost)	18.84	3.45
CD	3.162	0.25

4.5.3. Crude protein

The treatment means for crude protein content of the tubers on dry weight basis are presented in the Table 21. The crude protein content of tubers was significantly influenced by different treatments. The tubers obtained from the plants where 1/2 inorganic fertilizers + organic manure as vermicompost (T_4) was given, were having very high protein content (3.27 %), while low protein content was observed in the case of plants which were given T_2 (2.22 %) and T_7 (2.22 %).

4.5.4. Crude fibre

The Table 21 shows the crude fibre content of sweet potato tubers by the application of various treatments. It is seen that there is significant differences among various treatments regarding crude fibre content. It was maximum in tubers obtained from the plots which was given the treatments T_4. It recorded a value of 0.86 per cent and is on par with T_3 and T_7. The lowest content of crude fibre (0.79 per cent) was shown by applying the treatment T_2. But it is on par with T_1, T_5 and T_6.

Table 21. Effect of various treatments on crude protein and crude fibre contents of tubers (on percentage dry weight basis)

Treatments	Crude protein (%)	Crude fibre (%)
T_1 (inorganic fertilizers + o.m as cattle manure)	2.33	0.80
T_2 (inorganic fertilizers + o.m. as vermicompost)	2.22	0.79
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	2.68	0.85
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	3.27	0.86
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	2.68	0.81
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	2.68	0.80
T_7 (N as vermicompost + o.m. as vermicompost)	2.22	0.83
CD	0.408	0.036

4.5.5. Carotene

The treatment means for the carotene content of tubers on fresh weight basis is presented in the Table 22. Highly significant differences among the treatment means were observed for carotene content of tubers. Maximum carotene content was observed in tubers where treatment T_4 was given (1728.89 IU 100 g^{-1}) while the lowest carotene content was observed in tubers obtained from the plots where T_7 was given (1058.687 IU 100 g^{-1}). The treatments T_2, T_3 and T_4 were found to be on par.

Table 22. Effect of various treatments on carotene content of tubers (on IU 100g^{-1} fresh weight basis)

Treatment	Carotene
T_1 (inorganic fertilizers + o.m as cattle manure)	1302.220
T_2 (inorganic fertilizers + o.m. as vermicompost)	1621.777
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	1640.000
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	1728.890
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	1167.110
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	1212.000
T_7 (N as vermicompost + o.m. as vermicompost)	1058.667
CD	257.403

4.6. Nutrient uptake

4.6.1. Nitrogen uptake

The mean data on the total uptake of nitrogen by sweet potato plants by applying different treatments are given in the Table 23. The highest uptake of 127.33 kg ha^{-1} of nitrogen was recorded in the treatment T_4 (1/2 inorganic fertilizers + organic manure as vermicompost). It is on par with T_3 which recorded about 123 kg ha^{-1}. The lowest nitrogen uptake was observed in T_6 which showed a value of 88.6 kg ha^{-1}. The treatments T_1, T_2, T_5 and T_7 are found to be on par.

4.5.2. Phosphorus uptake

The Table 23 reveals that there is no significant difference among various treatments regarding phosphorus uptake. The highest value of phosphorus uptake (20.28 kg ha^{-1}) was recorded in the treatment T_4 and the lowest (11.77 kg ha^{-1}) in the treatment T_5 .

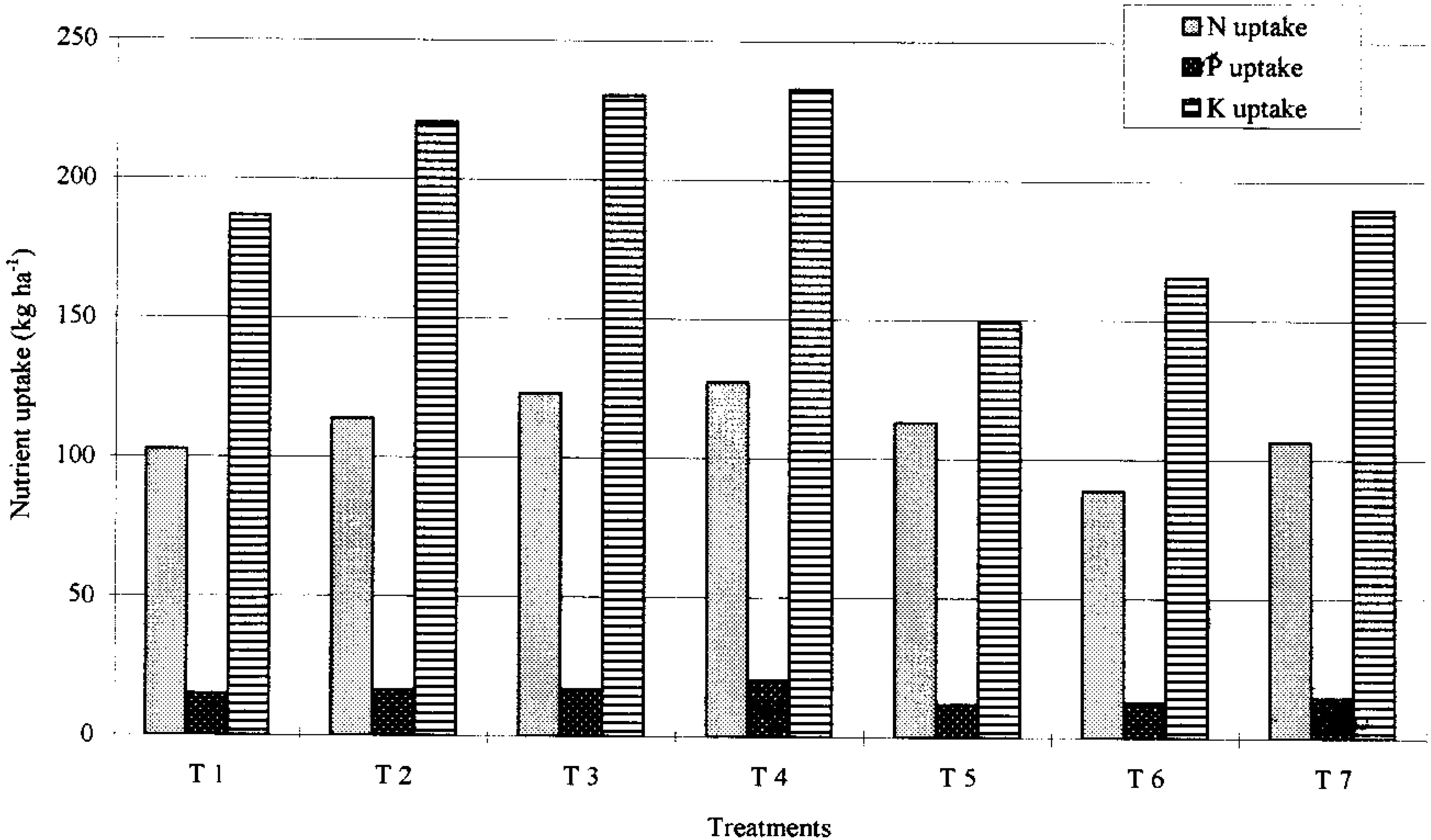
4.5.3. Potassium uptake

Potassium uptake of sweet potato plants by applying different treatments are given in the Table 23 . It shows that there is significant difference among various treatments regarding potassium uptake. Maximum uptke (232.7 kg ha^{-1}) was shown by the plants obtained from the plots which were supplied with the treatment T_4 . It is found to be on par with T_2 and T_3. The lowest uptake was shown by the treatment T_5 and is on par with T_6 . The treatment T_1 and T_7 showed similar values.

Table 23 Effect of various treatments on the uptake of nitrogen, phosphorus and potassium (kg ha^{-1})

Treatments	N uptake	P uptake	K uptake
T_1 (inorganic fertilizers + o.m as cattle manure)	102.57	14.78	186.71
T_2 (inorganic fertilizers + o.m. as vermicompost)	113.70	16.16	220.40
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	123.00	16.78	230.33
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	127.33	20.28	232.70
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	113.05	11.77	149.1
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	88.60	12.87	165.27
T_7 (N as vermicompost + o.m. as vermicompost)	106.31	14.62	189.79
CD	13.73	N S	27.06

Fig. 5 Effect of various treatments on nutrient uptake (kg ha^{-1})



4.7. Soil properties

4.7.1. Available Nitrogen

The effect of various treatments on the available N content of the soil after the crop is presented in the Table 24.

The nitrotgen content was significantly influenced by different treatments. The maximum value of 252.2 kg ha^{-1} was recorded in plots which received the treatment T_1 ; but this was found to be on par with T_6 and T_7. The lowest value was obtained from the plot which was given the treatment T_4 (248.91 kg ha^{-1}) and is on par with T_2, T_3 and T_5.

4.7.2. Available Phosphorus

The data pertaining to the effect of various treatmetns on the available phosphorus content of the soil after the crop is presented in the Table 22.

It ranges from 31.62 to 34.20 kg ha^{-1}. It is seen that there is no significant difference among various treatments regarding the phosphorus content of the soil. The lowest value was recorded in T_4 and the highest in the treatment T_6.

4.7.3. Available Potassium

Highly significant differences among the treatment means were observed for the available K content of the soil after the crop (Table 22). The potassium content was maximum (85.44 kg ha^{-1}) in plots which received the treatment T_5 , that is on par with the treatment T_7 (84.59 kg ha^{-1}); and the minimum content was shown by the treatment T_2 (78.33 kg ha^{-1}) which is on par with T_1 , T_3 , T_4 and T_6.

Table 24 Effect of various treatments on available nitrogen, phosphorus and potassium contents (kg ha^{-1}) of soil after the crop.

Treatments	N	P	K
T_1 (inorganic fertilizers + o.m as cattle manure)	252.20	32.89	79.66
T_2 (inorganic fertilizers + o.m. as vermicompost)	249.19	32.72	78.33
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	249.08	31.62	78.95
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	248.91	31.62	78.93
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	250.34	33.13	85.44
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	251.13	34.20	82.88
T_7 (N as vermicompost + o.m. as vermicompost)	251.07	33.23	84.59
CD	1..515	N S	4.89

4.7.4. Exchangeable Calcium

The calcium content of the soil after the crop differed significantly for different treatments (Table 25) and the maximum was recorded in the case were T_1 was given (1.92 c mol (+) kg^{-1}) and which is on par with T_2 . The lowest value was recorded in the treatment T_5 (1.69 c mol (+) kg^{-1}) and found to be on par with T_3. The treatments T_4 , T_6 and T_7 showed medium values which are found to be on par.

4.7.5. Exchangeable Magnesium

The mean magnesium content of the treated plots after the harvest of the crop are presented in the Table 25. There is significant variartion among different treatments regarding magnesium content. Maximum value (1.34 c mol (+) kg^{-1}) was recorded in plots received the treatment T_5 and the minimum value was recorded by T_3.

Table 25 Effect of various treatments on exchangeable calcium and magnesium contents of the soil after the crop (c mol (+) kg^{-1})

Treatments	Exchangeable Calcium	Exchangeable Magnesium
T_1 (inorganic fertilizers + o.m as cattle manure)	1.92	1.25
T_2 (inorganic fertilizers + o.m. as vermicompost)	1.87	1.20
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	1.72	1.05
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	1.79	1.17
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	1.69	1.34
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	1.84	1.14
T_7 (N as vermicompost + o.m. as vermicompost)	1.83	1.21
CD	0.056	0.056

4.7.6. Organic carbon

The results presented in Table 26 shows significant variations among different treatments with respect to the organic carbon content of the soil after the harvest of the crop. The maximum value of 0.96 per cent was observed in plots which has received nitrogen as vermicompost + organic manure as vermicompost (T_7) which is on par with T_2 with an organic carbon per cent of 0.91. The lowest value was reported by T_5 (0.79 per cent) which is on par with T_6. The rest of the treatments (T_1, T_3 and T_4)showed medium values and are found to on par.

4.7.7. pH

The Table 26 shows that there is significant differences among various treatments regarding the pH of the soil after the crop. The maximum value was recorded in the treatment T_5 (4.43) and is on par with T_3 and T_4. The minimum value was recorded by applying the treatment T_7 .

4.7.8. Cation exchange capacity

The Table 26 shows the data on the effect of various treatments on the cation exchange caapcity of the soil after the crop. The maximum value was shown by the treatment T_7 (4.91 c mol (+) kg^{-1}). It is much higher than the rest of the treatments. All other treatments are found to be on par.

Table 26 Effect of various treatments on organic carbon, pH and cation exchange capacity of the soil after the crop

Treatments	Organic carbon (%)	pH	Cation exchange capacity (c mol (+) kg^{-1})
T_1 (inorganic fertilizers + o.m as cattle manure)	0.85	4.32	4.64
T_2 (inorganic fertilizers + o.m. as vermicompost)	0.91	4.33	4.80
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	0.90	4.40	4.75
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	0.86	4.39	4.54
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	0.79	4.43	4.54
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	0.81	4.35	4.57
T_7 (N as vermicompost + o.m. as vermicompost)	0.96	4.31	4.91
CD	0.056	0.056	0.263

Correlation studies

4.8.1. Correlation between yield, yield components and nutrient uptake

Simple correlations were worked out between yield and yield components like number of tubers per plant, tuber weight as well as uptake of nitrogen, phosphorus and potassium and grwoth characters like vine yield and number of branches. The correltion matrices are presented in Table 27.

It may be seen from the data that the growth charcters like vine yield and number of branches were negatively correlated with the yield. The yield components like number of tubers per plant, tuber weight, uptake of nitogen, phosphorus and potassium were showing positive correltions with the tuber yield. The weight of tuber is showing the positive correltion with the uptake of nitrogen, phosphorus and potassium.

4.9. Economics of various treatments

Economics was worked out for different treatments and presented in Table 28. It is seen from the Table that the cost of cultivation is maximum (Rs. 26111.25 ha^{-1}) for the treatment T_2 (inorganic fertilizers + organic manure as vermicompost). But it recorded a tuber yield of 19.28 t ha^{-1} only. The treatment T_6 (inorganic fertilizers + 1/2 organic manure as vermicompst) showed minimum cost of cultivation, but its tuber yield was very low (15.31 t ha^{-1}).

The Table also reveals that the gross return is maximum (Rs. 64161.00 ha^{-1}) in the treatment T_4 (1/2 inorganic fertilizers + organic manure as vermicompst). It also showed highest net returns (Rs. 38830.37 ha^{-1}) and B-C ratio of 2.53. The lowest values for gross returns and net returns were shown by the treatment T_6 (inorganic fertilizers + 1/2 organic manure as vermicompst). It also showed the

Table 27 Correlation matrix - simple correlation among tuber yield, yield components and nutrient uptake

	Total tuber yield	Vine yield	Number of branches	Number of tubers per plant	Tuber weight	Total N uptake	Total P uptake	Total K uptake
Total tuber yield	1.000							
Vine yield	-0.334	1.000						
Number of branches	-0.325	0.779 *	1.000					
Number of tubers per plant	-0.181	0.420 *	-0.037	1.000				
Tuber weight	0.625 *	0.328	0.502 *	-0.296	1.000			
Total N uptake	0.956 *	0.551 *	0.577 *	-0.172	0.377	1.000		
Total P uptake	0.797 *	-0.319	0.010	-0.285	0.670 *	0.716 *	1.000	
Total K uptake	0.802 *	-0.331	-0.021	-0.439 *	0.738 *	0.698	0.921 *	1.000

* Significant at 5 % level

Table28 Effect of treatments on net income and benefit cost ratio

Treatments	Cost of cultivation (Rs. ha^{-1})	Yield (t ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B C ratio
T_1 (inorganic fertilizers + o.m as cattle manure)	24111.25	15.93	47781.00	23669.75	1.98
T_2 (inorganic fertilizers + o.m. as vermicompost)	26111.25	19.28	57843.00	31731.75	2.22
T_3 (3/4th inorganic fertilizers + o.m. as vermicompost)	25720.94	20.53	61584.00	35863.06	2.39
T_4 (1\2 inorganic fertilizers + o.m. as vermicompost)	25330.63	21.39	64161.00	38830.37	2.53
T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost)	24861.25	17.80	53403.00	28541.75	2.15
T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost)	23611.25	15.31	45918.00	22306.75	1.94
T_7 (N as vermicompost + o.m. as vermicompost)	25800.00	17.50	52506.00	26706.00	2.04

DISCUSSION

5. DISCUSSION

The experimental findings detailed in the previous chapter have been briefly disucussed here.

5.1. Growth characters

5.1.1. Length of vine

The results showed that (Table 2) the treatments did not show any significant difference at any of the growth stages with respect to vine length. The longest vines were produced in the treatment T_7 (N as vermicompost + o.m. as vermicompost) at all the growth stages. This shows the superiority of this treatment over the rest of the treatments. Similar results showing increase in plant height in crops like sugar cane and soyabean with vermicompost application has been reported by Shuxin *et al.* (1991). Ismail *et al.* (1993) obtained an increase in height of zinnia plants when vermicompost was applied. Compared to farmyard manure, vermicompost application increased plant height in tomato (Pushpa, 1996). The increase in vine length of sweet potato obtained in the presented study by application of N as vermicompost + o.m. as vermicompost may be due to the presence of the growth promoting substances as well as its high nutrient content along with favorable effect on soil physico-chemical properties.

5.1.2. Number of branches

The data presented in Table 3 shows that there is no significant difference among various treatments regarding number of branches. The highest number of branches were produced by applying N as vermicompost + o.m. as vermicompost (T_7). Similar result of increase in number of branches in Zinnia by applicaton of vermicompost was reported by Ismail *et al.* (1993). Venkatesh *et al.* (1997) obtained increased number of branches in grapes by vermicompost application. The better performance of vermicompost in increasing the number of branches was attributed to the presence of growth substances, group B vitamins, mucous deposit of epidermal cells and coelomic fluid produced by worms which contain plant hormones and chemical exudates. So the increase in number of branches due to the application of treatment T_7 can be attributed to the presence of growth promoting substances present in vermicompost.

5.1.3. Vine yield

Results of vine yield (Table 4) reveal that there is significant difference among various treatments. The highest vine yield was produced in plots which received the treatment T_7 (N as vermicompost + o.m. as vermicompost) which is on par with treatments T_2 , T_3, T_4 and T_5 . So it is evident that higher doses of vermicompost significantly increased the vine yield. In line with this finding, Kale *et al.* (1987) obtained increased vegetative growth in two ornamental plants viz. Salvia and Aster by the application of wormcast in place of farmyard manure. A similar result of increase in dry matter yield of cabbage was obtained by growing in vermicompost than with the application of mineral fertilizers (Sacirage and Dzelilovic, 1986). By the application of 4, 6 and 8 kg m^{-2} of vermicompost, the dry matter yield of cabbage increased from 1 to 66 per cent.

Kale and Bano (1988) obtained a significant increase in growth of paddy seedlings when applied with vermicompost. He also found that the vegetative growth was influenced by the wormcast in better way than with chemical fertilizers whereas the grain yield remained the same without any significant difference. Similarly a 30 to 50 per cent increase in plant growth was obtained in sugar cane by applying vermicompost (Shuxin *et al.*, 1991). So in sweet potato, the treatment T_7 (N as vermicompost + o.m. as vermicompost) contributed better growth of vines and number of branches. This might have contributed to higher vine yield by the application of N as vermicompost + o.m. as vermicompost to sweet potato.

5.2. Yield components

5.2.1. Number of tubers per plant

The data presented in Table 5 revealed that there is no significant influence of various treatments on the number of tubers per plant. The highest number of tubers per plant was produced by applying the treatment T_7 (N as vermicompost + o.m. as vermicompost). The treatment which has got highest vegetative growth produced maximum number of tubers per plant (T_7). This may be due to the effect of growth hormones which initiated production of more number of tubers per plant. The lowest vegetative growth observed in the treatment T_1 (inorganic fertilizers + o.m as cattle manure) has recorded the lowest number of tubers. This is in accordance with the findings of Oommen (1989).

5.2.2. Tuber weight

The data in the Table 6 clearly show that there is significant difference among various treatments regarding the weight of tubers. Highest tuber weight (257.47 g) was recorded by applying 50 per cent of the recommended dosage of inorganic fertilizers + organic manure as vermicompost (T_4). But it is on par with treatments T_2 (inorganic fertilizers + o.m. as vermicompost), T_3 (3/4th inorganic fertilizers + o.m. as vermicompost) and T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost). Higher doses of vermicompost in combination with inorganic fertilizers increased the tuber weight. Similarly increase in tuber weight in sweet potato Cv. BNAS - 51 was observed by the application of *Vigna mungo* and soybean as green manures (Sevenorio and Escalada, 1985).

Ganguly (1988) obtained increase grain weight in maize crop by farmyard manure application. Sansamma (1996) reported that the growth stimulating effect of vermicompost @ 5 t ha^{-1} was on par with farmyard manure @ 10 t ha^{-1} when applied alone as well as with a booster dose 25 per cent NPK. Nutrients in the vermicompost was in a more readily available form (Albanell *et al.*, 1988). So in the present study, the increase in tuber weight may be due to the higher availability of nutrients by providing the combination of vermicompost with inorganic fertilizers. The vermicompost application might have also helped in providing in a better physical condition for tuber growth. So the combination of 50 per cent or recommended dosage of inorganic fertilizers + organic manure as vermicompost is the best combination for increasing tuber weight in sweet potato.

5.2.3. Number of tubers per net plot

The Table 7 shows the number of tubers per net plots obtained by applying different treatments. There is no significant difference exists between various treatments. Highest numbre of tubers per net plot was recorded by applying the treatment T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost). The lowest number of tubers were produced by the treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost). It revealed that lowering the dose of vermicompost produced higher number of tubers when applied along wtih inorganic fertilizers.

5.2.4. Mean tuber weight

The mean tuber weight obtained by the application of different treatments are presented in the Table 7. It shows that there is significant difference among various treatments regarding mean tuber weight. The highest mean tuber weight was recorded by applying the treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost). It observed a mean tuber weight of 190.1g . It was on par with T_2 (inorganic fertilizers + o.m. as vermicompost). All other treatments are on par. It is evident from the Table 6 that higher doses of vermicompost in combination with inorganic fertilizers increased the mean tuber weight. Sevenorio and Escalada (1985) observed incresed tuber weight in sweet potato Cv. BNAS - 51 by the application of *Vigna mungo* and Soyabean as green manures. So higher value of mean tuber weight in T_4 may be due to higher availability of nutrients and better physical conditon for tuber growth. The combination of 50 per cent of recommend dosage of inorganic fertilizers + organic manure as vermicompost is a best combination for getting higher mean tuber weight in sweet potato.

5.2.5. Length of tuber

The data on Table 8 shows that the length of tuber was not much influenced by applying various treatments. Longest tubers (23.31 cm) were produced by applying full dose of inorganic fertilizers + organic manure as vermicompost (T_2). The lowest tuber length (17.79 cm) was recorded by the application of T_1 (inorganic fertilizers + o.m as cattle manure). It is evident from the table that the combinations of inorganic fertilizers with vermicompost and nitrogen as vermicompost + organic manure as vermicompost recorded higher vales.

5.2.6. Girth of the tuber

The data in Table 8 show that there is no significant difference among various treatments regarding the girth of the tubers. Maximum tuber girth was observed in the treatment that received 50 per cent of the recommended dose of inorganic fertilizers + organic manure as vermicompost (T_4).

From the Table 8, it is clear that when the recommended dose of inorganic fertilizers is gradually reduced in the presence of an organic source, the girth of the tuber increased. An increase in length and a corresponding decrease in girth were noticed at enhanced rate of nitrogen supply (Nair, 1994). Since sweet potato is a tuber crop, the soil structural conditons influenced tuber girth. The vermicompost has a positive effect in improving the soil structural properties. This poroperty along with reduced nitrogen might have contributed to the increased girth in the treatment T_4 . So the combination of 50 per cent of the recommended dose of NPK + organic manure as vermicompost may have a positive influence in increasing tuber girth in sweet potato.

5.2.7. Total tuber yield

The data presented in Table 9 shows that there is significant difference among various treatments regarding total tuber yield as well as marketable tuber yield.

The total tuber yield was maximum in plots which received 50 per cent of recommended inorganic fertilizers and organic manrure as vermicompost (T_4). The highest tuber yield of 21.387 t ha^{-1} was recorded when this treatment was given. The plots which received 75 per cent of the recommended dose of inorganic fertilizers + organic manure as vermicompost (T_3) and full dose of inorganic fertilizers + organic manrue as vermicompost (T_2) recorded 20.528 t ha^{-1} and 19.281 t ha^{-1} respectively. Eventhough the yields are comparatively lower, they are found to be on par with that of treatment T_4 .

Application of 12.5 t ha^{-1} farmyard manure and 50 per cent of recommended fertilizers improved the fruit yield in Brinjal (Subbiah *et al.*, 1983). They found that yield was significantly influenced by the levels of farmyard manure but not by the effect of inorganic fertilizers. Barve (1993) also observed an increase in yield on application of vermicompost to grape. Earthworm inoculation in combination with heavy mulching of agricultural wastes all round the year was found to be a successful practice of grape production without the application of chemical fertilizers (Gunjal and Nikam, 1992). Similarly 50 per cent NPK in combinaiton with farmyard manure, crop residue, farmyard manure + crop residue increased the grain yield of rice to 24.3 per cent, 7.3 per cent and 36.5 per cent respectively to no farmyard manure or crop residue.

Recently the use of vermicompost in place of farmyard manure and the potential for reducing chemical fertilizers using vermicompost as an organic fertilizer (Kale and Bano, 1986) has become a subject of active research. The posibility of replacing chemical fertilizers by using vermicompost as an organic manrue has been reported by Senapathi *et al.* (1985). The application of vermicompost along graded levels of chemical fertilizers significantly increased the yield over sole application of vermicompost, the difference within the vermicompost treatments being nonsignificant (Venkatesh *et al.*, 1997). This may be attributed to the fact that vermicompost is a rich source of humus forming micros, N - fixers and micronutrients besides improrving physical properties of soil. Similar results were reported by Barley and Jennings (1959).

The reason for highest yield in treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost) may be its high values in tuber girth and tuber weight. It also showed medium values in the case of girth of the tuber.

Vermicompost is a source of growth substances, group B vitamins, mucous deposits of epidermal cells and hormones. Besides it improves the soi physico-chemical properties in a better way. The cumulative effect of all these might have contributed to the higher tuber wieght and tuber girth in the treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost) which ultimately contributed to higher tuber yield.

Eventhough in terms of yield the treatment T_4 is on par with the treatments T_2 (inorganic fertilizers + o.m. as vermicompost) and T_3 ($3/4^{th}$ inorganic fertilizers + o.m. as vermicompost), economically it is a viable alternative to these treatments. It is clearly evident from the B C ratio. By reducing the inroganic level upto 50 per cent, the production cost can be very much reduced in presence of vermicompost application.

The results of the marketable tuber yield (Table 9) show the same trend as that of total tuber yield. Maximum marketable tuber yield was given by treatment T_4 . The highest marketable tuber yield in T_4 may be due to its lower weevil affected tubers and under-sized tubers. Advantage of reducing the inorganic fertilizer level upto 50 per cent of recommended dosage with organic manure as vermicompost is further magnified by this highest marketable tuber yield in T_4.

5.2.8. Tuber bulking rate

The results of the tuber bulking rate (Table 10) reveals significant differences among various treatments. The maximum value 1.93 g day^{-1} $plant^{-1}$ was recorded by the treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost). This is found to be on par with T_2 and T_3. The treatments in which vermicompost component is reduced tuber bulking rate also reduced. Inorgaic fertilizers in combination with higher doses of vermicompost recorded higher values. The treatment T_7 (N as vermicompost + o.m. as vermicompost) recorded lower value than inorganic fertilizers + full vermicompost combinaiton. So it is clear that inorganic fertilizers + full dose of organic manure is necessary for higher tuber bulking rate in sweet potato.

5.3. Number of weevil affected tubers per plot

The Table 11 shows the numbr of weevil affected tubers per plot by giving different treatments. It shows that there is no significant difference among various treatments. Maximum number of weevil affected tubers were obtianed while applying the treatment T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost) and minimum number in treatment T_3 ($3/4^{th}$ inorganic fertilizers + o.m. as vermicompost). It is evident that in all treatments with higher doses of vermicompost was applied the weevil infection was found to be less. When the vermicompost level is reduced infection increased.

5.4. Plant nutrient content

5.4.1. Nitrogen

The effect of various treatments on nitrogen content in leaves, vines and tubers are presented in the Table 12. The treatments had no significant influence on nitrogen content in the case of leaf and vine while significant difference was observed for tuber. The maximum value of nitrogen content in the tuber was recorded by applying the treatment T_4 (0.52 per cent). Reducing the dose of inorganic fertilizers to half of the recommended dose and applying the entire dose of vermicompost might have contributed to the maximum uptake of nitrogen and its partitioning to the economic part. This is evident from the increased nitrogen uptake, tuber yield, tuber bulking rate and tuber weight in the treatment T_4. Reducing inorganic nitrogen to a level of 50 per cent of recommended dose and applying the entire dose of organic manure as vermicompost is found to be a better combination of nitrogen uptake by tubers.

5.4.2. Phosphorus

The data on plant phosphorus content (Table 13) revealed no significant difference among various treatments as far as leaves and vines were concerned while highly significant differences were observed for tubers. The minimum phosphorus content was recorded in leaves which were obtained from the plants with treatments T_1, T_2, T_3, T_4 and T_6 (0.10 %) while maximum was recorded in treatment T_7 (0.11 %).

Minimum phosphorus was observed in vines of plants which were given the treatment T_4 (0.589 %) while the maximum was recorded for treatments T_1, T_2 and T_6 (0.494 %). The data were showing a similar trend to that of plant nitrogen content.

The plants accumulated maximum phosphorus in tubers when they were supplied with T_1 (0.123 %) which differed significantly from the rest. The minimum phosphorus content was observed in tuber in plants which were subjected to the treatment T_7 (0.103 %) which also differs significantly.

5.4.3. Potassium

The results (Table 14) reveals that the potassium content in various parts differed various treatments. The treatment T_2 recorded maximum K content in all plant parts namely leaf, vine and tuber which was significantly superior to all other treatment. From the results it is evident that the K content in various plant parts were maximum when full dose of inorganic fertilizers + organic manure as vermicompost was applied.

Potassium is a nutrient which shows luxury consumption when applied in excess amount over and above the plant requirement. In the case of T_2, the entire recommended dose of inorganic fertilizers as well as organic manure as vermicompost was applied. Analysis of cattle manure and vermicompost shows that vermicompost contains higher amount of potassium compared to cattle dung. This might have resulted in highest K content in various plant parts. The effect of organic manures in increasing the K availability to plants shown by different workers (Sharma *et al.*, 1984 and Dhillon and Dhillon, 1991).

5.4.4. Calcium and Magnesium

Table 15 shows the data on the effect of various treatments on plant calcium and magnesium contents. The treatments did not show any significant difference in these nutrient contents in leaf, vine and tuber. Tubers recorded minimum calcium and magnesium contents while the leaves recorded the maximum values.

Leaves recorded minimum calcium and magnesium percentages when the treatment T_1 was given (0.21 % and 0.21 % respectively). Maximum calcium content was observed in leaves obtained which was given T_5 treatment (0.36 %) while T_3 recorded maximum magnesium content (0.25 %).

T_1 recorded maximum calcium content in vines (0.19 %) while T_5 recorded the minimum (0.15 %). But in the case of magnesium, T_2 recorded the minimum value (0.15 %) and T_7 the maximum value (0.16 %).

In the case of tubers, T_4 obtained the minimum level for calcium (0.004 %) and T_5 for magnesium (0.04 %). The maximum levels (0.006 % for calcium and 0.07 % for magnesium) were obtained when the plants were given the treatment T_6. The treatment T_4 also recorded the same level for magnesium.

5.4.5. Micronutrients

With respect to iron content , leaves, vines and tubers did not show any significant difference for various treatments (Table 16). The iron content in tuber was found to be more (345 ppm) when the entire dose of inorganic fertilizer + organic manure as vermicompost (T_2) was applied. When the inorganic fertilizer dose reduced to 50 per cent of the recommended dosage and organic manure as vermicompost was applied, tuber contained the lowest iron content. It is evident application of full dose of inorganic fertilizers + full dose of organic manure as vermicompost is found to be best treatment combination with regard to iron content in tubers.

In case of manganese significant differences was observed in leaf and tuber for various treatments. The content was highest when the treatment T_2

was applied and lowest was observed when the treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost) was applied. With regard to manganese content in tuber it followed the same pattern as that of iron. Manganese content in tuber was maximum when full dose of inorganic fertilizers + full dose of organic manure as vermicompost was applied and the content was minimum when inorganic fertilizer was reduced to 50 per cent and applied the organic manure as vermicompost.

5.5. Quality characteristics

5.5.1. Starch

The data (Table 20) revealed that there is significant difference among various treatments regarding the starch content of tubers on fresh weight basis. The starch content was highest for the treatment T_7 (N as vermicompost + o.m. as vermicompost) which received the entire source of nitrogen in organic form. It recorded a value of 18.84 per cent which was on par with T_1, T_2, T_5 and T_6 . Minimum starch content was recorded by the treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost). This results show the importance of nitrogen in increasing the starch content in tubers. The lowest value recorded by treatment T_4 is 12.5 per cent. This treatment which received 50 per cent of the recommended dose of inorganic fertilizers + organic manure as vermicompost is found to be on par with the treatment T_3 (3/4th inorganic fertilizers + o.m. as vermicompost) which has given 75 per cent of the recommended inorganic fertilizers + organic manure as vermicompost. So when fertilizer dose is gradually reduced, the starch content also reduced. So the treatment T_7 ,T_1, T_2, T_5 and T_6 were on par. The maximum starch content was recorded for the treatment T_7 which shows the improtance of organic source in increasing the starch content and improving the quality of sweet potato tubers. These results are in agreement with the findings of Ashokan *et al.* (1984).

5.5.2. Reducing sugar

The results (Table 20) revealed that there is significant influence of various treatments on reducing sugar content in tubers. Maximum reducing sugar content was seen in treatments T_3 and T_4 (3.54 per cent) and it is found to be on par with that of treatment T_7 (N as vermicompost + o.m. as vermicompost). The treatment T_7 recorded a value of 3.45 per cent. From the table it is also seen that the reducing sugar content was lowered for treatments receiving full dose of inorgnic fertilizers. Minimum (3.16 per cent) value was recorded for treatment T_2 and T_5. So it evident that when full dose of inorganc fertilizers was applied reducing sugar content decreased. The reducing sugar content increased when the dose of inorganic fertilizers is gradually reduced as well as for the treatment where the entire nitrogen is applied as organic manure (T_7). The study conducted by Ashokan *et al.* (1984) showed that the sugar content of tuber was highest at the lowest levels of N and K. With increasing levels of these nutrients the sugar content also decreased. Similar results were also observed by Stino (1956) and Anon (1978-79).

5.5.3. Crude protein

The crude protein content of the tubers was significantly different for various treatments (Table 21). The treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost) recorded maximum value of 3.27 per cent and the crude protein content was minimum (2.22 per cent) in the case of plants which were given treatments T_2 and T_7. The treatment receiving 50 per cent inorganic fertilizer and organic manure as vermicompost gave the maximum nitrogen content in the tuber. This treatment also recorded higher nitrogen uptake by sweet potato plants. Since the nitrogen content was maximum for this treatment, the crude protein was also maximum.

5.5.4. Crude fibre

There is significant difference among various treatments regarding the crude fibre content. It was maximum for the treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost) which recorded a value of 0.86 per cent. It is on par with T_3 and T_7. The lowest content of the crude fibre was recorded by the treatment T_2 . But it on par with T1, T_5 and T_6 .

5.5.5. Carotene

Results (Table 22) shows that there is significant difference among various treatments with regard to carotene content of tubres. Maximum carotent content (1728.89 I.U. $100g^{-1}$) was recroded for the treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost) and the minimum (1058.667 I.U.

100 g^{-1}) was recorded for the treatment T_7 (N as vermicompost + o.m. as vermicompost). This results show that the carotene content increased when the inorganic fertilizer dose is gradually reduced from full dose to 50 per cent of organic manure as vermicompost. But when the entire dose of nutrients was applied as organic manures (T_7), it gave the lowest value of corotene content. It shows that lower levels of inorganic fertilizer + organic source as vermicompost is required for higher carotene content and better quality of tubers.

5.6. Nutrient uptake

5.6.1. Nitrogen uptake

The Table 23 shows significant differences among various treatment regarding the uptake of nitrogen. The treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost) recorded highest N uptake (127.32 kg ha^{-1}) and it is found to be on par with T_3 ($3/4^{th}$ inorganic fertilizers + o.m. as vermicompost). The lowest value (88.6 kg ha^{-1}) was observed in the treatment T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost). Nitrogen content in various plant parts as well as the tuber yield were maximum for the treatment T_4. Studies conducted by various workers show that application of vermicompost increases the nutrient availability in soil (Albanell *et al.*, 1988 ; Kale *et al.*, 1992 ; Syres and Springett, 1984). Nutrient in the vermicompost is found to be in a more readily available form. Reducing inorganic nitrogen to a level of 50 per cent of recommended dose and applying the entire dose of organic manure as vermicompost is found to be a better combination for nitrogen uptake by sweet potato plants. This may be reason for the maximum uptake of nitroge by applying the treatment T_4 .

5.6.2. Phosphorus uptake

With regard to phosphorus uptake table 23 shows uptake was maximum (20.28 kg ha^{-1}) for the treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost) and the lowest value (11.77 kg ha^{-1}) for the treatment T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost). Higher levels of P uptake in rice treated with vermicompost was observed by Kale *et al.* (1992). Mackay *et al.* (1962) showed that earthworm stimulate P uptake from the re-distribution of the organic matter and increasing enzymatic activities of phosphatase. So the increased P availability in soil together with maximum tuber yield might have resulted in highest P uptake for this treatment T_4.

5.6.3. Potassium uptake

The table 23 shows the data on the uptake of potassium by plants by appliying different treatments. The uptake was maximum (232.7 kg ha^{-1}) for the treatment T_4 and found to be on par with treatment T_2 and T_3. Lowest uptake (149.1 kg ha-1) was noted for for the treatment T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost) and is on par with T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost). So these results show that lowering the dosage of inorganic fertilizers did not affect the potassium uptake by plants while reducing organic manure supply decreased the potassium uptake by plants. It was reported by Bharadwaj (1995) that among the nutrients the most significant role of organic matter is supplying potassium. More (1994) reported additonal farm wastes and organic manures increased the status of the potassium of the soil. Farmyard manure application was beneficial in enhancing the uptake of K by potato and maize (Minhas and Sood, 1994).

5.7. Soil properties

5.7.1. Soil nutrients

Effect of various treatments on the available N, P and K are represented in the table 24.

Among these, N and K of the soil after the crop were significantly influenced by applying different treatments. In the case of available N and available P the lowest value was obtained for the treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost). It recorded an available N content of 248.91 kg ha^{-1} and available P content of 31.62 kg ha^{-1}. The table on yield data (Table 9) and uptake of N and P (Table 23) show that the maximum total tuber yield as well as total N and P uptake were recorded for the treatment T_4 and that explains the lowest available N and P contents in the soil for this treatment T_4.

With regard to available K, the treatment T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost) recorded maximum value which was on par with T_7 (N as vermicompost + o.m. as vermicompost). The minimum value was shown by the treatment T_2 (inorganic fertilizers + o.m. as vermicompost) which is on par with T_1, T_3, T_4 and T_6. If we analyse the K content in various plant parts (Table 14) it is clear that treatment T_2 resulted in maximum K content. The tuber yield for this treatment was also found to be on par with the highest tuber yield given by the treatment T_4. So this may be the reason for the lowest available K content for the treatment T_2.

In the case of available Ca, the lowest value was noted for the treatment T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost) and was found to be on par with treatment T_3 (3/4th inorganic fertilizers + o.m. as vermicompost). The available Mg content was minimum for the treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost). The maximum Ca content was observed in the treatment T_5 and for Mg maximum value was recorded for T_3. This may be the reason for the lowest value available Ca and Mg for soils under these treatments.

5.7.2. Organic carbon

The results presented in the Table 26 shows that the different treatments show highly significant difference regarding the organic content of the soil. The maximum value (0.96 per cent) was observed in plots which has received for the T_7 (N as vermicompost + o.m. as vermicompost). It is evident from the table that organic matter addition increased the organic carbon content of the soil. In the treatment T_7 full organic source was applied. The organic source builds up organic carbon content of the soil. So the organic source not only supplies nutrient requirements of the crops, but also improves organic carbon content of the soil which is a major indicator of improving the fertility status of the soil.

5.7.3. pH

The data on Table 26 reveals the effect of various treatments on the pH of the soil after the crop. The maximum value (4.43) was recorded for the treatment T_5 (inorganic fertilizers + 3/4th of o.m. as vermicompost) and the lowest value (4.31) recroded for the treatment T_7 (N as vermicompost + o.m. as vermicompost). In treatemnt T_7 the entire source of nitrogen and organic manure was applied in the form of vermicompost or no inorgnic fertilizers were applied. So the addition of full organic source resulted in the production of organic acids and which may be the reason for lowest value of pH in this treatment T_7.

5.7.4. Cation Exchange Capacity

The data on the effect of various treatments on the cation exchange capacity of the soil after the crop (Table 26) reveals that the highest cation exchange capacity (4.91 c mol kg^{-1}) was recorded for the treatment T_7 and the lowest value (4.54) was recorded in the treatments T_4 and T_5. The source of high cation exchange capacity in the treatment T_7 is attributed to the higher organic matter content in the soil.

5.8. Correlation studies

Statistical correlation between yield components and growth characters (Table 27) show that the growth characters were negetively correlated with the yield and yield components were positively correlated with the yield. The growth characters like vine yield (R = - 0.334) and number of branches (R = - 0.325) registered a negative non-significant relationship with the yield.

Significant and positive correlations were observed between tuber yield and tuber weight (R = 0.625*), N uptake (R= 0.956*), P uptake (R= 0.797*) and K uptake (R= 0.802*). Positive and significant correlations were also observed between number of branches and vine yield (R = 0.779*), number of tubers per plant and vine yield (R =0.420*), N uptake and vine yield (R =0.551*), tuber weight and number of branches (R = 0.502*), P uptake and tuber weight (R = 0.67*), K uptake and tuber weight (R = 0.738*).

The negative correlation between tuber yield and plant characters like vine yield and number of branches is expected since decrease in vegetative growth will result in translocation of photosynthates to the economic plant part namely tuber thereby increasing the tuber yield. A significant positive correlation between uptake of all the major nutrients and tuber yield stresses the importance of a proper balance of nutrients.

5.9. Economics

The table 28 reveals economics of application of various treatments. The cost of cultivation was maximum (Rs. 26111.25 ha^{-1}) while applying the treatment T_2 (inorganic fertilizers + o.m. as vermicompost). This is because in this treatment full dose of inorganic fertilizers and full dose of organic manure as vermicompost was applied. The net return from these treatment only Rs. 31731.75 ha^{-1}. It reorded a medium value of B C ratio (2.22).

The lowest value for the cost of cultivation was reported with the application of treatment T_6 (inorganic fertilizers + 1/2 of o.m. as vermicompost). But here the tuber yield is very low (15.306 t ha^{-1}) and hence showed less values for gorss returns and net returns. The treatment T_4 (1/2 inorganic fertilizers + o.m. as vermicompost and recorded the highest tuber yield (21.387 t ha^{-1}) and higher gross returns and net returns. So in an economic point of view the treatment T_4 is economically viable alternative to other treatments. The reduction of inorganic fertilizers upto 50 per cent has reduced the cost of inorganic fertilizers to half.

SUMMARY

SUMMARY

An investigation entitled "Vermicompost as a potential organic source and partial substitute for inorganic fertilizers in sweet potato (Ipomoea batatus (L) Lam)" was carried out at the Instructional Farm, in the College of Agriculture, Vellayani during the period December 1995 to April 1996. The main objectives of the study were to study the efficiency of vermicompost as an organic manure, the extent to which inorganic fertilizers can be substituted when vermicompost was used as an organic source and the feasibility of reducing the dose of vermicompost. The experiment was laid out in randomised block design with seven treatments and four replications. The treatments consists of package of practices recommendations of Kerala Agricultural University for sweet potato (Cattle manure + inorganic fertilizers) and vermicompost as organic source with graded doses of inorganic fertilizers. The salient results of the study are summarised below.

The growth parameters like vine length and number of branches did not show any significant variation. However highest vine length and number of branches are noticed in treatment which received vermicompost as a sole source of nutrient. Significant difference was observed in vine yield and highest vine yield was obtained when vermicompost was given as a sole source of nutrients and lowest yield was recorded by the treatment which received cattle manure as organic manure. Use of vermicompost as an organic source and a substitute for inorganic fertilizer enhanced vegetative growth in sweet potato.

Yield attributing characters like length and girth of tubers and number of tubers did not show any significant variation. With respect to mean tuber weight and tuber bulking rate, the treatment differed significantly and maximum effect was observed when vermicompost was applied along with half the recommended dose of inorganic fertilizers. Half the dose of vermicompost along with recommended inorganic fertilizers was equally effective as that of the recommended manurial schedule (Package of Practices Recommendations of Kerala Agricultural University).

Significant treatment effect could be observed in total tuber yield and marketable tuber yield. Vermicompost with half or 3/4 NPK produced highest yield. From this it could be deduced that by using vermicompost as organic manure in sweet potato, it is possible to bring down the usage of chemical fertilizers. This is not only economical but also helps in improving physico-chemical and biological properties of the soil. Another conclusion was that half or 3/4th dose of vermicompost along with recommended dose of inorganic fertilizers was equally effective as that of package of practices recommendations of Kerala Agricultural University (cattle manure + recommended inorganic fertilizers) in yield and yield attributes of sweet potato.

There was reduction in weevil incidence due to vermicompost application but the effect was not significant.

The nitrogen and phosphorus content in the leaves and vines did not show any significant difference by applying various treatments. But in tubers the nitrogen content was maximum when 1/2 inorganic fertilizers + organic manure as vermicompost was applied. The phosphorus accumulation in tuber was maximum in the combination of full inorganic fertilizers + organic manure as cattle manure was given. The treatment combination of full inorganic fertilizers + organic manure as vermicompost resulted in maximum accumulation of phosphorus in leaves, vines and tubers.

Regarding calcium, magnesium and iron contents of leaves, vines and tubers there was no significant difference among various treatments. The application of full inorganic fertilizers + organic manure as vermicompost produced maximum manganese concentration in leaf and tuber. But its content was non-significant in vine. The content of zinc in vines and tubers are significant. The application of inorganic fertilizers + organic manure as cattle manure produced maximum concentration of zinc in vine but 1/2 inorganic fertilizers + organic manure as vermicompost produced maximum concentration in tuber. The content of copper showed significant difference only in the case of vines. It was maximum when inorganic fertilizer + 3/4th organic manure as vermicompost was applied.

The starch content of tubers was maximum when nitrogen was given as vermicompost + organic manure as vermicompost. It showed a decreasing trend with the reduction in the quantity of inorganic fertilizers. But by reducing inorganic fertilizer levels, The reducing sugar percentage increased. It showed the highest value when 1/2 inorganic fertilizers + organic manure as vermicompost and 3/4th inorganic fertilizers + organic manure as vermicompost was applied. The crude protein, crude fibre and carotene contents showed the same trend as that of reducing sugar.

The plant uptake of nitrogen, phosphorus and potassium was maximum when 1/2 inorganic fertilizers + organic manure as vermicompost was applied. The available nitrogen and calcium contents in soil after the crop was highest when inorganic fertilizers + organic manure as cattle manure was given. But inorganic fertilizers + 3/4th organic manure as vermicompost recorded maximum potassium and magnesium contents in the soil after the crop. The phosphorus content in soil was not significant.

The organic carbon level after the crop showed significant difference among various treatments. The maximum organic carbon percentage was noticed when nitrogen as vermicompost + organic manure as vermicompost was given. But a decrease in pH and an increase in CEC of the soil was obtained by applying this treatment.

The correlation studies revealed that the growth characters like vine yield, number of branches were negatively correlated with yield. The yield components like number of tubers per plant, tuber weight, uptake of nitrogen, phosphorus and potassium showed positive correlations with yield. The weight of tuber showed a positive correlation with the uptake of nitrogen, phosphorus and potassium.

The economics worked showed that the highest net profit was obtained when 1/2 inorganic fertilizers + organic manure as vermicompost was given. The cost of cultivation while applying this treatment was minimum and it showed a B C ratio of 2.53.

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*** Original not seen**

APPENDICES

APPENDIX - I

Weather parameters during crop period

	Temperature (^{0}C)		R.H. (%)	Rainfall (mm)
	Maximum	Minimum		
Dec. 1995	23.6	20.6	72	-
Jan. 1996	25.0	20.5	95	-
Feb. 1996	34.2	21.8	70	14.0
March 1996	35.5	22.1	91	4.3
Apr. 1996	32.6	22.9	72	228.6

VERMICOMPOST AS A POTENTIAL ORGANIC SOURCE AND PARTIAL SUBSTITUTE FOR INORGANIC FERTILIZERS IN SWEET POTATO (*Ipomoea batatas* (L.) Lam.)

By

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ABSTRACT

An investigation entitled "Vermicompost as a potential organic source and partial substitute for inorganic fertilizers in sweet potato (Ipomoea batatus (L) Lam)" was carried out at the Instructional Farm, College of Agriculture, Vellayani during the period December 1995 to April 1996. The main objectives of the study were to study the efficiency of vermicompost as an organic manure, the extent to which inorganic fertilizers can be substituted when vermicompost was used as an organic source and the feasibility of reducing the dose of vermicompost. The experiment was laid out in randomised block design with seven treatments and four replications. The treatments consists of package of practices recommendations of Kerala Agricultural University for sweet potato (cattle manure + inorganic fertilizers) and vermicompost as organic source with graded doses of inorganic fertilizers.

The growth parameters like vine length and number of branches did not show any significant variation. However highest vine length and number of branches are noticed in treatment which received vermicompost as a sole source of nutrient. Significant difference was observed in vine yield and highest vine yield was obtained when vermicompost was given as a sole source of nutrients. Yield attributing characters like length and girth of tubers and number of tubers did not show any significant variation. With respect to mean tuber weight and tuber bulking rate, the treatment differed significantly and maximum effect was observed when vermicompost was applied along with half the recommended dose of inorganic fertilizers.

Significant treatment effect could be observed in total tuber yield and marketable tuber yield. Vermicompost with half or 3/4th NPK produced highest yield. From this it could be deduced that by using vermicompost as organic manure in sweet potato, it is possible to bring down the usage of chemical fertilizers. Half or 3/4th dose of vermicompost along with recommended dose of inorganic fertilizers was equally effective as that of package of practices recommendations of Kerala Agricultural University (cattle manure + recommended inorganic fertilizers) in yield and yield attributes of sweet potato.

The nitrogen and phosphorus content in the leaves and vines did not show any significant difference by applying various treatments. But in tubers the nitrogen content was maximum when 1/2 inorganic fertilizers + organic manure as vermicompost was applied. The phosphorus accumulation in tuber was maximum in the combination of full inorganic fertilizers + organic manure as cattle manure was given. The treatment combination of full inorganic fertilizers + organic manure as vermicompost resulted in maximum accumulation of phosphorus in leaves, vines and tubers. Regarding calcium, magnesium and iron contents of leaves, vines and tubers there was no significant difference among various treatments. The application of full inorganic fertilizers + organic manure as vermicompost produced maximum manganese concentration in leaf and tuber.

The starch content of tubers showed a decreasing trend with the reduction in the quantity of inorganic fertilizers. But by reducing inorganic fertilizer levels, the reducing sugar percentage increased. The crude protein, crude fibre and carotene contents showed the same trend as that of reducing sugar.

The plant uptake of nitrogen, phosphorus and potassium was maximum when 1/2 inorganic fertilizers + organic manure as vermicompost was applied. The organic carbon level after the crop showed significant difference among various treatments. The maximum organic carbon percentage was noticed when nitrogen as vermicompost + organic manure as vermicompost was given.

The growth characters like vine yield, number of branches were negatively correlated with yield. The yield components like number of tubers per plant, tuber weight, uptake of nitrogen, phosphorus and potassium showed positive correlations with yield.

The economics worked out show that the highest net profit was obtained when 1/2 inorganic fertilizers + organic manure as vermicompost was given. The cost of cultivation while applying this treatment was minimum and it showed a B C ratio of 2.53.