CARBON POOLS IN LATERITIC SOIL AMENDED WITH COIRPITH-VERMICOMPOST AND ITS EFFECT ON TOMATO (*Solanum lycopersicum* L.)

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THESIS

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COLLEGE OF HORTICULTURE, VELLANIKKARA

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DECLARATION

I, hereby declare that this thesis entitled **"Carbon pools in lateritic soil amended with coirpith-vermicompost and its effect on tomato (*Solanum lycopersicum* L.)"** is a bona-fide 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 to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara

5-10-2019

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CERTIFICATE

Certified that this thesis, entitled **"Carbon pools in lateritic soil amended with coirpith-vermicompost and its effect on tomato (*Solanum lycopersicum* L.)"** is a record of research work done independently by **Ms. Aiswarya R.** (2017-11-028) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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We, the undersigned members of the Advisory Committee of **Ms. Aiswarya R. (2017-11-028)**, a candidate for the degree of **Master of Science in Agriculture** with major field in **Soil Science and Agricultural Chemistry**, agree that the thesis entitled **"Carbon pools in lateritic soil amended with coirpith-vermicompost and its effect on tomato (*Solanum lycopersicum* L.)"** may be submitted by Ms. Aiswarya R. in partial fulfilment of the requirements for the degree.

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Symbols / Notations and Abbreviations

μg TPF g^{-1} soil $24hr^{-1}$	-	Microgram TPF per gram soil per 24 hour
cmol (+) kg^{-1}	-	Centimole proton per kilogram
CD	-	Critical difference
dS m^{-1}	-	Desi Siemen per meter
DAT	-	Days after transplanting
DOC	-	Dissolved organic carbon
DMP	-	Dry matter production
DHY	-	Dehydrogenase activity
EC	-	Electrical conductivity
EM		Effective microorganisms
et al.	-	Co-workers
Fig.	-	Figure
HWSC	-	Hot water soluble carbon
LFC	-	Light fraction carbon
Mg	-	Mega gram
meq $100g^{-1}$	-	Milli equivalents per 100 gram
Mg m^{-3}	-	Mega gram per cubic meter
MSL	-	Mean sea level
MRT	-	Mean residence time
MWHC	-	Maximum water holding capacity
MBC	-	Microbial biomass carbon
$NO3^{-}$		Nitrate nitrogen
OPSTAT	-	Online agriculture data analysis tool
Pg	-	Petagram
PGPR	-	Plant growth promoting rhizobacteria
POP	-	Package of practices
POM	-	Particulate organic matter
POXC	-	Permanganate oxidizable carbon
RDF	-	Recommended dose of fertilizers

RBD	-	Randomized block design
STCR		Soil test crop response
SOC	-	Soil organic carbon
SOM	-	Soil organic matter
TOC		Total organic carbon
TPF	-	Tri Phenyl formazan
WSC	-	Water soluble carbon
WASP	-	Web Agri Stat Package

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Introduction

1. INTRODUCTION

Soil is a living system with both inherent and dynamic properties. This dynamic entity, teeming with life, is essential for recycling of dead and decaying organic matter, storage and release of nutrients, denaturation of pollutants, water filtration and carbon sequestration, climate moderation and provisioning of habitat security. The health of soil is of primary concern to the farmers and the global community whose livelihood depend on well managed agriculture that starts with soil, the most precious natural resource. Carbon cycle is the fundamental part of life on earth and soils are the largest reservoir of carbon in the terrestrial carbon cycle. The quantity of carbon stored in the soil is highly significant, because it is nearly three times more than that in vegetation and twice as much as that which is present in the atmosphere (Batjes, 1998). The soil organic carbon (SOC) concentration along with its quality and dynamics is essential to the diverse soil functions and ecosystem services. Thus, soil can be designated as an organic carbon mediated realm in which solid, liquid and gaseous phases interact at a scale ranging from nanometers to kilometers and to create a dynamic environment conducive to the growth and development of plants and other biota.

Lateritic soils, the most highly weathered soils in the classification system are wide spread in tropical areas and subtropical climates. Laterite and lateritic soils formed under regions of very high rainfall and temperature occupy more than 65 per cent of the total geographical area in Kerala (KAU, 1989). The significant features of these soils are their unique colour, poor fertility, lower CEC and clay content and significantly high amounts of iron and aluminum oxide. Humus content is altogether low. One of the most important functions of humus is that it makes the soil more porous, improving soil aeration, infiltration and drainage. Humus less soil can become extremely compacted and airless and form very hard crusts that resist the infiltration of air, rain, or irrigation water and hence also prevent the emergence of seedlings. This function of humus improves the structure of the soil which in conjunction with its capacity to retain important nutrients helps the plant to grow more easily. Through proper irrigation and regular use of organic fertilizers the lateritic soils can be made suitable to grow a variety of crops.

Agricultural sector continues to play a crucial role for development, especially in low-income countries where the sector is large both in terms of aggregate income and total labour force. Development in the agriculture sector is usually accompanied by waste generation by the irrational application of intensive farming methods and the misuse of chemicals in cultivation, remarkably affecting the rural environment in particular and global environment in general, thus polluting the land, air and water. Waste utilization technologies must either use the residue rapidly or store it under condition that do not cause spoilage. The concept of minimizing the quantity of waste accumulated envisages the principle of 3 "R" that is reduce, reuse and recycle and it aims at extracting maximum practical benefits from the products in an environmentally friendly manner. One of the conventional technologies for waste management is composting, which is the process of controlled biological maturity under aerobic/anaerobic conditions, where materials of animal or vegetative origin is decomposed into products with shorter molecular chain that are more stable, hygienic humus rich and finally beneficial for the crops grown and for recycling of soil organic matter (Sequi, 1996). Unlike composting, vermitechnology is a process in which earthworms are used for converting organic waste and has emerged as an environmentally sustainable, economically viable and socially acceptable technology the world over.

As ecosystem engineers, the earthworms have over 600 million years of experience. The Greek philosopher Aristotle called them as the 'intestine of earth', which conveys their ability in digesting a wide range of organic materials including the waste organics from earth. They feed lavishly not only on the organic waste but also on microorganisms that invade and colonize the waste biomass. These worms can consume organic matter at a rate equal to their body weight. The participation of earthworm enhances natural biodegradation and decomposition of organic waste from 60-80 per cent. Being rapid and nearly an odourless process, reducing composting time more than half, vermitechnology is preferred much above the conventional composting technology. The earth worms through a type of biological alchemy are thus able to transform garbage into gold. Long term researches into vermiculture have indicated that the tiger worm *Eisenia foetida* is one of the best species suited for vermicomposting a variety of organic wastes.

Coirpith, the fluffy spongy material is produced in large amounts as a byproduct of coir industry. It has no commercial value as such and so is being rejected in and around coir processing units in large heaps, road sides or in no man's land, creating disposal problems. The quantity of coir waste available in India amounts to 7.5 million tones (Patil *et al*., 2017). Chances of phenols getting leached into the ground water is very high during rainy season and being so dusty and light in weight, the probability of air pollution is also more. The high lignin, tannin and cellulose content and amorphous powdery nature makes it the toughest biological material to resist biological degradation by common microbes. Nevertheless, it is remarkable for its extremely high water holding capacity and highly compressible nature. Vermicomposting can be suggested as a potential and eco- friendly mechanism for effective management of coirpith.

It is in this backdrop that the present study titled "Carbon pools in lateritic soil amended with coirpith vermicompost and its effect on tomato (*Solanum lycopersicum* L.) has been proposed as a pioneer work in Kerala Agricultural University for composting coirpith through the process of vermitechnology. In any soil, there are several pools and fractions of SOC with different degrees of decomposition and stability. Studying the dynamics of SOC is important for understanding the pathways of carbon stabilization into different SOC pools.

The objectives of present study thus include:

- ✓ Unravelling the effect of coirpith-vermicompost application on dynamics of carbon in lateritic soil
- ✓ Relating the material influence on crop performance and fruit quality

Review of Literature

2. REVIEW OF LITERATURE

Composting

Composting of agricultural waste and municipal solid waste has a long history and is commonly used to recycle organic matter back into the soil and to maintain soil fertility. The recent increase in composting methodologies and its extended adoption however has been due to the need for environmentally sound waste treatment technologies. Composting is considered as an environmentally acceptable waste treatment method. It is a biological process which uses naturally occurring microorganisms to convert biodegradable organic matter into a humus like product.

Composting rate depends to a great extent on C:N ratio, lignin and polyphenol contents, presence or absence of suitable microbial agents of decomposition, pH, temperature, aeration, moisture content, *etc*. Almost any organic material is suitable for composting. The compost pile needs a proper rate of carbon rich materials or browns and nitrogen rich materials or greens. Carbon provides energy for microbes and nitrogen provides protein. Lignin present in coirpith in higher amounts prevent easy decomposition and mineralization. Any effective composting method devised should therefore ensure delignification to the maximum extent possible.The availability of a low-cost, simple and rapid composting technology based on local resources, which is capable of producing good quality compost, is the key factor influencing the acceptance and widespread use by resource-poor farmers. It is in this context that vermicomposting is accepted as an effective and environment friendly process for composting coirpith.

Conventional modes of coirpith composting

Despite many advantages and availability in large quantities, coirpith is not fully utilized for productive purposes and every year large amounts of coirpith accumulate near to the coir processing units, causing severe disposal problems, fire hazards and ground water contamination due to the release of phenolic compounds.

Because of its high C:N ratio (80-120:1), high content of lignin and cellulose (about 40% each) and high polyphenol content, its degradation under natural conditions and mineralization rates are very much slow, preventing its direct use as an organic manure (Prabhu and Thomas, 2002).

Coirpith can be made suitable for use in agri-horticulture after stabilization by proper composting process that employs suitable organisms capable of degrading lignin and polyphenols and bringing down C:N ratio. According to Nagarajan *et al.* (l985) coir pith having a C:N ratio of 24: 1 or less could be used as a good source of organic matter for agricultural use. Composting of coir pith results in increased content of N, P, K and micronutrients and reduction in lignin and C:N ratio.

Coirpith compost improves the soil aggregation, cation exchange capacity and water holding capacity (more than 5 times its dry weight) contributing towards increased soil moisture retention (Joshi *et al*., 2013).

The development of composting technologies for coir pith with high C:N ratio and lignin content involved fertilizer nitrogen supplements and lignin degrading microbial cultures. Steiner *et al.* (2010) reported that co-composting of coir pith having low nitrogen and wide C:N ratio with poultry manure having more nitrogen content can solve the recent problems in coirpith composting.

Thomas *et al*. (2013) found that the composting of coirpith can be enhanced upon inclusion of lime and rock phosphate along with poultry manure, which significantly increased the growth and nodule numbers in cowpea.

Tripetchkul *et al*. (2012) opined that co-composting of coirpith with cow manure, coconut juice, and rice bran exhibited low nitrogen losses and least C:N ratio. Kannan *et al.* (2013) found that coirpith can be decomposed by employing the fungus *Pleurotus sajar-caju* with urea supplementation.

Nagarajan *et al.* (1985) also opined that the inoculation of coir pith with *Pleurotus* spp. had resulted in drastic reduction in the content of lignin and cellulose indicating the ability of *Pleurotus* spp. in degrading lignocelluloses.

Vermitechnology as an alternative tool for composting coirpith

Decomposition of various organic substrates (kitchen waste, agro-residues, institutional and industrial wastes including textile industry sludge and fibers) into valuable vermicompost has been extensively studied using an exotic earthworm species, *Eisenia foetida* (Ndegwa and Thompson, 2001).

Nattudurai *et al*. (2014) opined that *E. eugeniae* decomposes the coirpith with the supplementation of cowdung and produced nutrient rich vermicompost by means of intestinal microbial action.

Vijaya *et al*. (2008) found that lignin content of the coirpith decreased from 28.4 to 22.7 per cent when composted with the effective microorganisms (EM) culture, and to 17.3 per cent with earthworms. Cellulose content decreased to 17.2 and 13.6 per cent with the EM culture and earthworms, respectively. Phenol level was reduced more in the vermicomposted coirpith (2.60 mg/g) than in the EM treatment (4.75 mg/g) indicating the superiority of vermicomposting over EM treatment.

Vasanthy *et al*. (2005) stated that cowdung influenced the rate of vermicomposting and helped to increase the amount of macronutrients in the vermicompost.

Patil *et al.* (2017) reported that the total nutrient content of coirpith increased gradually with inoculation of earthworms probably because of physical decomposition of organic wastes due to biological grinding during passage through the gut, coupled with enzymatic activity in earthworm’s gut.

Sathianarayanan (2008) found that, though the time period required for composting and then subjecting the composted coir pith to vermicomposting is quite longer, considering the amount of vermicast and biomass produced and a relatively higher amount of nutrients (N, P and K) made available at the end of this double composting (composting, then vermicomposting), it can be promoted as a feasible technology for managing coirpith effectively while yielding a potential manure as well.

Coirpith treated with E. *eugeniae* exhibited significant increase in total nitrogen, phosphorus, potassium and calcium. The average value of NPK got increased significantly in the vermicompost in comparison to the raw coir pith. The nitrogen, phosphorus and potassium values ranged from 0.62 to 1.02 per cent, 0.02 to 0.05 per cent and 0.78 to 0.99 per cent respectively in *Eudrilus eugeniae* mediated compost (Thenmozhi, 2015).

Effect of vermicompost on soil properties

Physical properties

Soil, the medium for plant growth need to be proper in respect of physical, chemical and biological properties to support crop growth and production. The physical properties of soil including texture and structure are important to plant growth with the former affecting the soils ability to hold nutrients and water and the latter influencing aeration, water holding capacity, drainage and penetration of roots.

Worm castings, the organic form of fertilizer produced from earthworms, also known as vermicast/worm castings/worm manure is essentially earthworm waste/excreta otherwise known also as worm poo. As earthworms eat through organic wastes or soil, their excreta turns into an optimal soil enricher.

Wormcasts are a resource that may be used in agriculture because of their effects on soil property enhancement and nutrient dynamics. Improvement in soil structure following wormcast application may significantly enhance plant growth (Lee, 1985).

Vermicomposts are finely divided peat-like material with excellent structure, porosity, aeration and drainage, which enhances the moisture holding capacity of soil (Ali *et al*., 2007).

Earthworm casts are usually considered to be responsible for a good soil structure that improve soil physical properties like infiltration, water retention and resistance to erosion (Rose and Wood, 1980). Singh *et al*. (2013) reported that soils amended with vermicompost had significantly lesser soil bulk density in comparison to control plot and also that increase in the rates of vermicompost reduced soil bulk density and increased the total pore space in soil from 51.2 to 56.36 per cent.

Aggregation of soil and its water use efficiency improved with increasing dose of vermicompost upto a particular level according to the reports of (Bhattacharjee *et al*., 2001).

Generally, vermicompost was found to be rich in nitrogen and phosphorous, possessing good structure with low level of heavy metals, low conductivity, high humic acid content and also having good stability and maturity (Kaushik and Garg, 2004).

Selvaseelan and Maheswari (2003) reported that earthworms incorporated surface organic matter, thus improving soil aggregate stability and nutrient availability.

Chemical properties

Status of soil in terms of chemical properties is all the more important in regulating crop production. Several research findings have proved beyond doubt the beneficial effect of vermicompost in modifying soil in terms of chemical properties.

Tomati *et al*. (1988) opined that vermicomposting of organic waste enhanced organic matter stabilization and phytohormonal elements. Ilker *et al.* (2016) observed that vermicompost appeared to be more effective to increase organic matter, N, P and Ca, compared to farmyard manure.

The highest availability of N, P, Ca and Mg was observed when 25 tonnes of vermicompost with full dose of inorganic fertilizers was used for tomato production (Pushpa, 1996). Soil pH shifted remarkably toward neutrality (5.89 to 6.96) following the application of vermicompost in tomato cultivation (Goswami *et al.*, 2017).

According to Senthilkumar and Surendran (2002), vermicompost had improved the water holding capacity of soil and acted as a mine for various plant nutrients and trace elements. Taleshi *et al*. (2011) reported that plant-available form of nitrogen (NO_3^-) was high in vermicompost than conventionally composted manure.

Azarmi *et al.* (2008) found that the Mn availability in the soil was significantly affected by vermicompost treatments. The highest Mn concentration was 5.7 ppm, in the soil amended with 15 t ha^{-1} vermicompost. Application of vermicompost increased the nutrient availability of soils and also reduced the solubility of heavy metals (Bhattacharya *et al*., 2012).

Carbon pools and compost application

For understanding how carbon is cycled and how atmospheric CO_2 will change in the future, one should study the places in which carbon is stored (pools), how long it resides there and processes that transfer it from one pool to another. Collectively all of the major pools and fluxes of carbon on earth comprise what we refer to as the global carbon cycle. The amount of carbon in soil represents a substantial portions of the carbon found in the terrestrial ecosystems of the planet, which is approximately 3170 GT. Of this nearly 80% (2500 GT) is found in soil. Carbon in soil can be either organic or inorganic although most of the carbon in terrestrial ecosystem exists in organic form. Organic carbon is made of different pools that decomposes at different rates.

Soil carbon pools is influenced by ever so many factors like climate, plant species, primary productivity, litter quantity and quality, soil properties, *etc*. and often its estimation will help to identify the dominant carbon fraction under different land use and also to prioritize land for varied uses.

Compost application was found to be a win-win strategy to increase C storage in soil and at the same time, to promote plant growth and yield to levels similar to those obtained with mineral fertilization (Baldi *et al*., 2018).

The compost application rates of 5 and 10 t $ha^{-1}yr^{-1}$ resulted in linear increases of soil organic carbon. Microbial biomass C in the soil surface layers (0–0.15 m) was higher in the compost-fertilized plots than in the mineral-fertilized and control plots. The application of compost at the rate of 10 t ha^{-1} showed the highest capacity to sequester C in the soil. The orchard ecosystem fertilized with compost at the rate of 10 t ha^{-1} sequestered approximately 32 t C ha^{-1} in soil directly from the amendment applied (Baldi *et al*., 2018).

Chaudary *et al.* (2017) opined that application of NPK fertilzers along with organic manures had a positive effect on labile carbon pool. Yang *et al*. (2017) observed that incorporation of compost significantly increased SOC, MBC and POXC when compared to the control and their contents were increased with increasing additions of compost.

On analyzing the rate of C sequestration in different cropping systems, it was seen that the application of compost resulted in carbon accumulation to the extent of 1.32 Mg C $ha^{-1}yr^{-1}$ which further raised to 5.29 t C $ha^{-1}yr^{-1}$ when the organic amendment application rate was more than 10 t ha^{-1} yr^{-1} (Aguilera *et al*., 2013)

Carbons pools and sequestration

Carbon sequestration is a general term used for the capture and long-term storage of carbon dioxide in which the capture can happen at the point of emission from power plants, through burning of crop residues or through natural processes like photosynthesis, which remove carbon dioxide from the earth’s atmosphere and stores it in underground geological formations, oceans, vegetation and soil or convert it into inorganic carbonates through chemical reactions. The prime intention behind sequestration is to prevent carbon from entering the atmosphere leading to global warming and climate change. Management practices have a say on enhancing the quantity of carbon stored in different reservoirs which are designated as carbon pools.

Carbon sequestration is the process by which atmospheric CO_2-C is transferred to soil carbon pools, namely organic C, and secondary carbonates, with long residence times (Whalen *et al*., 2014).

The SOC constitutes a large pool of carbon in the global carbon cycle, representing a dynamic balance between C input and output (Stewart *et al*., 2007). Cotrufo *et al*. (2011) reported that including the major part of global carbon pool of 2500 Pg, the soil organic carbon pool of 1550 Pg is 3.1 times the atmospheric pool and 4.5 times the biotic pool.

The various fractions like labile, hot water soluble and aggregate - associated carbon have been proposed as a sensitive indicator of change in land use and management practices (Camberdella and Elliott, 1992).

The rate at which carbon is cycled between the soil and atmosphere is partly dependent on the carbon compounds present in SOM (Izaurralde *et al*., 2001).

The dynamics of soil carbon pool depends mainly on the equilibrium attained with regard to movement of carbon by different pathways due to various soil management practices (Ding *et al*., 2014).

Selvi *et al*. (2004) reported that continuous manuring and fertilization for more than thirty years results in about 40 per cent gain in SOC. Purakayastha *et al.* (2008) opined that balanced fertilization with N, P and K along with organic fertilizers enhanced the soil organic carbon status. Fan *et al.* (2014) found that there was an increase in soil organic carbon stock in 0-60 cm soil depth which ranges from 3.7 to 31.1 per cent over 20 years by the addition of compost, inorganic N and P, but decreased at proportions ranging from 1.4 to 10.7 per cent in plots where there is no inorganic P or N addition.

Soil organic carbon stock includes labile or active pool and stable, recalcitrant pools with different residence time (Xu *et al*., 2011).

Labile organic carbon refers to the fractions with a high activity and is therefore sensitive to plant and microbial activities and is highly susceptible to be oxidized and decomposed (Chen *et al*., 2010). Labile organic carbon is usually termed to include microbial biomass carbon (MBC), water soluble carbon (WSC) and permanganate oxidizable carbon (POXC). These fractions, which display different turnover rates and stabilities, are easily influenced by agricultural soil tillage practices, and they can be used to detect the changes in SOC initially and sensitively (Morrissey *et al*., 2014).

Culman *et al.* (2012) reported that $KMnO_4$ oxidisable carbon provides a instant quantification of labile C pools in soil which was closely related to smaller sized particulate organic carbon (53-250 μm). Permanganate oxidisable carbon serves as one of the ideal benchmark for organic carbon instability (Souza *et al*., 2016).

Microbial biomass carbon is a well known index for the global metabolic activities of the soil microorganisms (García *et al*., 2002) and it provides useful information on the capacity of the soil to store and recycle nutrients and energy.

Shen *et al*. (2018) reported that soil labile organic carbon fractions and enzyme activities decreased with increasing soil depth. Labile carbon serve as a good indicator to study SOC changes on a short term basis. A soil with a high proportion of its carbon in labile pools possess greater biological fertility.

Stabilized pool is composed of organic materials which are highly resistant to microbial attack and serve as ideal indicator for assessing soil quality (Majumder *et al*., 2008). Organic materials with higher C:N ratio had more impingement on stabilized fraction of soil organic carbon whereas narrow C:N ratio had more impact on active fractions of soil organic carbon (Verma *et al*., 2010) .

Passive fraction is the largest pool, chemicaly stable and takes more than 200-1500 years for turnover. It is very little influenced by changes in management practices or microbial activities. Mandal *et al*. (2008) reported that long term soil submergence under rice cultivation induced the formation of passive pools of soil organic carbon, and as much as 29 per cent of organic carbon applied to soil was stabilized into recalcitrant carbon pools.

Ryals and Silver (2013) showed that, a higher organic amendment application rate leads to an increase in the amount of carbon sequestered into the soil.

Biological properties

In any soil, it is the microbial load which is all the more important for it is the activity of microbes of various size and category that makes the soil biologically fertile and lively.

Ilker *et al.* (2016) reported that vermicompost has higher potential to stimulate microorganism involved in carbon and phosphorus cycles**.** Several scientists reported greater microbial activity and diversity in vermicompost amended soils (Aira *et al*., 2008; Sebastian *et al*., 2009; Doan *et al*., 2013).

In a study conducted by Doan *et al.* (2013) it was observed that soils amended with vermicompost were characterized by higher bacterial and catabolic diversity and higher enzymatic activities than control soils which received only mineral fertilizers.

The population of beneficial microorganisms like N fixing organisms, P solubilizing bacteria and entomophagous fungi were in the range of 10^5 and 10^6 in soils amended with vermicompost (Esakkiammal *et al*., 2015).

Dehydrogenase activity, which has been considered as an index for determining the microbial activity were higher in vermicompost treatment compared to FYM (Manjaiah and Singh, 2011). Vermicompost increased the microbial population and root biomass production that resulted in more production of root exudates increasing the population of bacteria, fungi and actinomycetes.

Effect of vermicompost on growth, yield and quality of crops

Vermicompost, at an optimum concentration has a tremendous potential of plant nutrient supply for sustainable crop production. Enhanced nutrient supply is the result of increased microbial activity occurring in the intestine of earthworms which is subsequently excreted through earthworm gut. Vermicompost addition thus increases the quality and quantity of nutrient resulting in quick absorption of nutrients which in turn will increase the growth and yield parameters of crop plants.

Nattudurai *et al*. (2014) opined that plant growth parameters such as height, total weight, shoot weight and root weight were maximum in the coirpith vermicompost treated plants than those treated with the ordinary compost. Vijaya *et al*. (2008) found that, amending garden soil with coirpith vermicompost increased the protein content of *Andrographis paniculata* as compared to control.

The maximum increase in plant height of *Matricaria chamomomile* was observed by Hadi *et al*. (2011) when vermicompost was applied at the rate of 20 t ha^{-1}.Vermicompost application at 6 t ha^{-1} improved the plant height of eggplant (*Solanum melongena)* as compared to control (Moraditochaee *et al*., 2011).

Sailajakumari and Ushakumari (2001) reported that application of vermicompost @ 20 t ha-1 showed significantly higher nutrient uptake in cowpea (79, 12, 34, and 26 kg NPK and Ca ha^{-1}) when compared to control (40, 4.5, 18.4, and 11 kg NPK and Ca ha^{-1}) from their study in sandy loam soils of Trivandrum.

Vermicompost improved germination percentage, growth and yield of plants due to faster release of nutrients and production of plant growth hormones (Arancon *et al*., 2008). According to Yadav and Malik (2005) application of vermicompost @ 20 kg N ha^{-1} increased plant height, dry matter production, seeds per pod, pods per plant and yield per plant in cowpea.

Rajkhowa *et al*. (2002) examined the effect of vermicompost alone and in combination with inorganic fertilizers in greengram and concluded that yield components and growth parameters were higher in integrated application of vermicompost and inorganic fertilizers.

Abdou *et al*. (2016) reported that combined application of vermicompost and NPK fertilizers showed the highest millet yield of 1762 and 866 kg ha^{-1} and also the highest yield of cowpea which ranged from 360.5 and 389 kg ha^{-1}.

Effect of vermicompost on yield and quality of tomato

Azarmi *et al*. (2008) revealed that addition of vermicompost at the rate of 15 t ha^{-1} significantly increased growth and yield of tomato, increased EC of fruit juice and percentage of fruit dry matter up to 30 and 24 per cent respectively. Plant growth parameters such as shoot length, root length, number of leaves, fresh weight and dry weight of tomato were better in vermicompost treated plants rather than the untreated control plants (Vaidyanathan and Vijayalakshmi, 2017).

Yield and quality parameters of tomato fruit were significantly affected by the combined use of compost and inorganic fertilizers. Higher number of fruits and fruit yield, dry matter production and N, P and K uptake by tomato plant were obtained from the treatment where the full dose of N, P and K with10 tons of compost were applied (Khan *et al*., 2017).

Wang *et al*. (2017) reported that vermicompost effectively promoted plant growth, including stem diameter and plant height compared with other fertilizer treatments. Also vermicompost improved fruit quality, increased the sugar/acid ratio, and led to greater improvements in fruit yield (74 %), vitamin C (47 %), and soluble sugar (71 %) in tomato.

Combined application of mineral fertilizer and vermicompost in the field positively influenced the total organic carbon, microbial biomass carbon, activity of enzymes like alkaline phosphatase, dehydrogenase and fertility of soils, when compared to the application of mineral fertilizer or vermicompost alone (Srivastava *et al*., 2012).

Premuzic *et al*. (1998) revealed that the fruit of tomato plants grown in vermicompost applied plots contained significantly more Ca and vitamin C but less Fe compared with those grown in a hydroponics medium with inorganic fertilization. Vermicompost applied at a rate of 5 t ha $^{-1}$ have been reported to significantly increase yield of tomato (5.8 t ha^{-1}) in farmers' field compared with control (Nagavallemma *et al*., 2004).

Vermicompost applied at a rate of 25 per cent improved stem length by 11 mm and diameter by 40 mm in tomato plants compared with the control plants (Atiyeh *et al*., 2002). Alam (2014) found that a mixture of 75 per cent chemical fertilizers and 25 per cent vermicompost produced the largest tomato plant with higher fruit yield.

Higher titrable acidity in tomato (3.01 %) was achieved for vermicompost amended plots (Goswami *et al*., 2017). Vermicomposting can induce the growth of tomato plants by fixing the nitrogen-fixing bacteria in rhizosphere soil (Wang *et al*., 2017).

Tomato yield was also found to be enhanced by the presence of plant growth promoting rhizobacteria in vermicomposts (Saravanan *et al*., 2013). Troung *et al*. (2018) was of the opinion that soil amended with vermicompost provided better nutrient absorption of tomato plants for improving the productivity, total biomass and quality of tomato fruit.

Materials and Methods

3. MATERIALS AND METHODS

The materials made use of and the methods adopted for realizing the objectives mentioned under introduction are presented in this chapter. Production of coirpith compost and coirpith based vermicompost was undertaken in vermi unit of the department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara. Efficacy of the compost thus produced was tested on tomato *var*. Manulakshmi through an experiment laid out in the STCR field, College of Horticulture, Vellanikkara.

3.1. Production and characterization of coirpith compost

3.1.1. Production of coirpith – vermicompost

Coirpith based vermicompost intended for the study was prepared by combining regular coirpith composting technology with vermitechnology and coirpith compost was also prepared simultaneously by adopting standard procedures.

3.1.1.1. Preparation of coirpith compost

Raw materials

1. Coirpith
2. *Pleurotus sajor-caju*
3. Urea

Composting process

A shaded area of 5 m x 3 m dimension near to the composting unit College of Horticulture, Vellanikkara was selected and levelled after removing weeds. For preparation of one tonne coirpith compost, 5 kg urea and 1.5 kg spawn of mushroom, *Pleurotus* sp were made use of. A layer of 100 kg of coirpith was initially spread over the area. Over this layer, *Pleurotus* spawn (300 g) was applied uniformly. As the second layer, another 100kg coirpith was again spread uniformly over which one kg of urea was sprinkled. This procedure of alternate application of *Pleurotus* and urea over coirpith or the sandwitching process was repeated for the whole one tonne of coir pith upto 1 m height.

The compost heap was turned once in ten days to allow the stale air trapped inside the compost material to go out and fresh air to get in. As optimum moisture is the pre-requisite for uniform composting of any organic residue care was taken to maintain moisture at around 60 per cent to assist in speedy decomposition of the material. The heap was left undisturbed during which lignin and cellulose content got reduced leading to a narrow C:N ratio. The matured compost was adjudged from its colour, earthy odour and C:N ratio. The prepared compost was shade dried, sieved and stored.

3.1.1.2. Preparation of coirpith vermicompost

For this purpose, coirpith was initially degraded for a period of one month using urea and *Pleurotus sajar-caju* in a shaded area and the partially composted coirpith was subjected to vermitechnology using the compost worm *Eisenia foetida.* The process was carried out in ferrocement tanks of $1m^3$ diameter and 300 kg capacity. Seven parts of partially degraded coirpith and one part each of banana pseudostem and glyricidia leaves were mixed with cowdung to maintain 8:1 ratio on volume basis. After 7 days, the earthworms were introduced @ 1500 numbers per tank. Moisture was maintained at 40 to 50 per cent. The compost attained maturity by 64 days (30 days for partial degradation and 34 days for vermicomposting). When the compost was ready as indicated by the change in colour, appearance and odour, it was removed from the pit along with the worms and heaped in shade. The worms moved to bottom of the heap. After one or two days, the compost from the top of the heap was removed, sieved and stored. The quality of the compost thus produced was assayed using standard procedures.

Plate 1. Preparation of coirpith compost

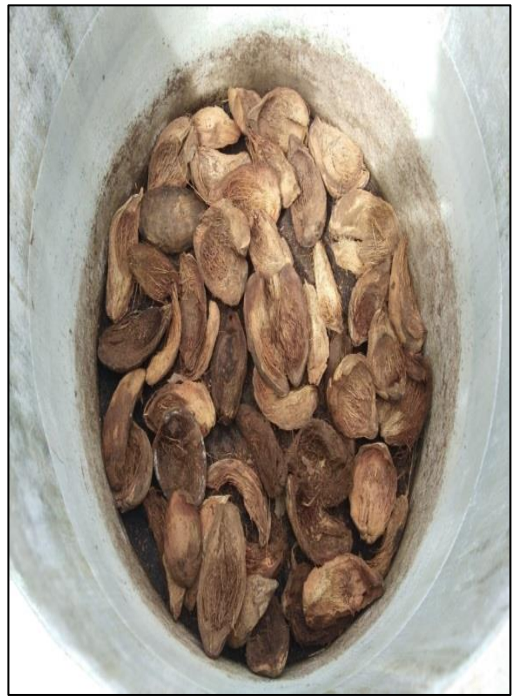


Plate 2. Preparing vermitanks

Plate 3. Transferring coirpith to vermitank

Plate 4. Coirpith in vermitanks

Plate 5. Introducing earthworms

Plate 6. Introducing biowaste

Plate 7. Sprinkling of cow dung slurry

Plate 8. Final compost

3.1.2. Characterization of raw and composted coirpith

The raw coirpith, coirpith compost and vermicomposted coirpith were characterized for electro-chemical and chemical properties using standard procedures as detailed in Table 1.

Table1. Analytical methods employed for characterization of raw coirpith and vermicomposted coirpith

<table>
<tr><th rowspan="2">Sl. No.</th><th rowspan="2">Characteristics</th><th colspan="2">Method</th><th rowspan="2">Reference</th></tr>
<tr><th>Extraction</th><th>Estimation</th></tr>
<tr><td>1</td><td>Moisture</td><td colspan="2">Gravimetric method</td><td>Jackson, 1973</td></tr>
<tr><td>2</td><td>pH</td><td>1:2 organic fertilizer solution</td><td>Potentiometry</td><td rowspan="2">GOI, 1985</td></tr>
<tr><td>3</td><td>EC</td><td>1:5 organic fertilizer solution</td><td>Conductometry</td></tr>
<tr><td>4</td><td>CEC</td><td colspan="2">Saturation and displacement method</td><td>Kalra and Maynard, 1994</td></tr>
<tr><td>5</td><td>Total C</td><td colspan="3" rowspan="2">CHNS Analyzer Model : Elementar’s vario EL cube</td></tr>
<tr><td>6</td><td>N</td></tr>
<tr><td>7</td><td>P</td><td rowspan="4">Microwave digestion system (HNO_3)</td><td>Colorimetry</td><td rowspan="2">Jackson, 1973</td></tr>
<tr><td>8</td><td>K</td><td>Flame photometry</td></tr>
<tr><td>9</td><td>Ca</td><td colspan="2" rowspan="2">ICP-OES (Model: Optima® 8x00 series)</td></tr>
<tr><td>10</td><td>Mg</td></tr>
<tr><td>11</td><td>S</td><td colspan="3">CHNS Analyser Model: Elementar’s vario EL cube</td></tr>
<tr><td>12</td><td>Fe, Mn, Zn, Cu</td><td>Microwave digestion system (HNO_3)</td><td colspan="2">ICP-OES (Model:Optima®8x00 series)</td></tr>
</table>

3.1.2.1. Assay of lignin

The lignin content of coirpith sample was determined by the procedure outlined by Prasad and Govindarajan (2001).

Nearly, 200 mg of ground coirpith sample was weighed out and one ml of 72 per cent H_2SO_4 was added. The mixture was then placed in a water bath at 30 ± 5^oC and stirred frequently. After an hour, the sample was diluted with 28 ml of water per ml of acid and the contents were transferred to 125 ml flask and hydrolyzed again by autoclaving at 120^oC for an hour. The hot solution was filtered through a tared gooch crucible. This filtrate (kalson lignin residue) was washed with water to remove the acid. Crucibles containing samples were dried to constant weight at 105^oC and the lignin content was expressed as per cent of the original sample.

3.1.2.2. Assay of cellulose

Cellulose content of coirpith was estimated by adopting the method described by Updegraff (1969).

Around 100 mg of oven dried sample was mixed with 3 ml of acetic: nitric reagent (10 : 1 ratio) in a test tube. The tube was then placed in a water bath at 100^oC for 30 minutes. The contents were centrifuged at 8000 rpm for 15 minutes.The supernatant was discarded and the residue was washed using distilled water. Ten ml of 67 per cent H_2SO_4 was added to the residue and allowed to stand for one hour. From this one ml was pipetted and diluted to 100 ml, added with 10 ml of anthrone reagent and treated in a boiling water bath for 10 minutes. After cooling, the per cent transmission was measured in a spectrophotometer at 630 nm. Anthrone reagent with distilled water served as the blank.

A standard curve with cellulose was prepared. For this, 100 mg cellulose was taken in a test tube; to which 67 per cent H_2SO_4 was added. This was allowed to stand for an hour. From this one ml was taken and diluted to 100 ml and a series of volumes

(0.4 to 2 ml corresponding to 40-200 µg of cellulose) was taken. To this 10 ml anthrone reagent was added, treated in boiling water bath for 10 minutes, cooled and per cent transmittance was measured at 630 nm.

3.2. Field experiment

3.2.1. Location

The field experiment was conducted at the STCR field, College of Horticulture, Vellanikkara, Thrissur, Kerala. The field is located in the Agroclimatic zone – II (midland laterites), AEU – 10 (North central laterites of Kerala) at 13° 32' N latitude and 76° 26' E longitude, at an altitude of 40 m above MSL.

3.2.2. Climate and weather conditions

The experimental site enjoyed a humid tropical climate.

3.2.3. Soil type and initial characteristics

The soil of experimental site comes under Velappaya series belonging to Sub group Typic plinthustults. Soil samples were collected from 0-15 cm depth using an auger before the start of the experiment. The soil samples were air dried, powdered using a wooden mallet and then sieved through 0.5 mm sieve for organic carbon analysis and through 2 mm sieve for analysis of other physical and chemical properties. The analytical techniques followed for the estimation of physical and chemical properties of soil analysis are presented in Table 2.

Table 2. Analytical methods employed for characterization of experimental soil

Sl. No.	Characteristics	Method		Reference
		Extraction	Estimation	
1	Textural analysis	International pipette method		Robinson,1922
2	Bulk density	Cylinder method		Piper, 1966
3	Particle density			
4	Porosity			
5	WHC	Keen – Raczkowski Box method		Piper, 1966
6	pH	1: 2.5 Soil-Water suspension	Potentiometry	Jackson, 1973
7	EC		Conductometry	Jackson, 1973
8	CEC	Summation method		Hendershot and Duquette,1986
9	Organic carbon	Chromic acid wet digestion method		Walkley and Black, 1934
10	Available N	Alkaline permanganometry		Subbiah and Asija, 1956
11	Available P	Bray No. 1	Colorimetry	Bray and Kurtz, 1945
12	Available K	Neutral Normal Ammonium Acetate	Flame photometry	Jackson, 1973
13	Available Ca, Mg		ICP-OES	
14	Available S	0.15 per cent $CaCl_2$	Turbidimetric method	Piper, 1996
15	Available Fe, Mn, Zn, Cu	0.1 *M* HCl	ICP-OES	Sims and Johnson, 1991
16	Available boron	Hot water	ICP-OES (Model: Optima® 8x006series)	

3.2.3.1. Carbon pools

Total carbon

The total carbon in soil samples was determined by dry combustion method, using Elemental analyser (Model: multi EA 4000)

Water soluble carbon (WSC)

Field moist soil samples were extracted with distilled water in the ratio 1:3 for 30 minutes on an end-over-end shaker and centrifuged for 20 minutes at 8000 rpm. The supernatant was filtered and the extract was estimated for water soluble carbon by dichromate oxidation method (Ghani *et al*., 2003).

Hot water soluble carbon (HWSC)

To the soil left after WSC extraction, 30 ml distilled water was added and shaken for 30 minutes in a horizontal shaker. These centrifuge tubes with sediments were treated in a hot water bath at 80^0 C for 16 hours. After shaking in a horizontal shaker for 10 minutes, centrifugation was done at 8000 rpm for 20 minutes and the supernatant was used for determination of HWSC by dichromate oxidation method (Ghani *et al*., 2003).

Permanganate oxidisable carbon (POXC)

Field moist samples was extracted with 333 *mM* $KMnO_4$ in the ratio 1:12.5 for 30 minutes and centrifuged for 5 minutes at 2000 rpm. Two ml of the aliquot was pipetted and the volume was made to 50 ml and the absorbance was measured at 560 nm using spectrophotometer (Blair *et al*., 1995).

Microbial biomass carbon (MBC)

Microbial biomass carbon was determined by the chloroform fumigation-extraction method in field moist soil following the procedure outlined by Jenkinson and Powlson (1976).

3.2.3.2. Biological properties of soil

Dehydrogenase activity

Dehydrogenase activity was estimated by Triphenyl Tetrazolium Chloride extraction followed by Triphenyl formazan estimation as described by Casida *et al.* (1964).

Microbial population

Enumeration of bacteria, fungi and actinomycetes was done as per the serial dilution plate technique outlined by Wollum (1982).

3.2.4. Cropping season

The cropping season extended from October 2018 to February 2019.

3.2.5. Crop and variety

Test crop was tomato with variety Manulakshmi, characterized by semi determinate growth habit and oval shaped fruits.

3.2.6. Experimental details

Treatment details

Details of treatments adopted in the experiment were as follows.

T_1 : Absolute control

T_2 : Coirpith compost at 10 t ha^{-1}

T_3 : Coirpith based vermicompost at 10 t ha^{-1}

T_4 : T_3 + 100 % of soil test based KAU POP

T_5 : FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP

T_6 : T_3 + 25 % of soil test based KAU POP

T_7 : T_3 + 50 % of soil test based KAU POP

T_8 : T_3 + 75 % of soil test based KAU POP

T_9 : FYM at 20 t ha^{-1} + 25 % of soil test based KAU POP

T_{10}: FYM at 20 t ha^{-1} + 50 % of soil test based KAU POP

T_{11}: FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP

T_{12} : *Adhoc* KAU organic POP

- Lime was added as per soil test data to all the plots, irrespective of treatments, except control
- POP – Package of practices recommendations of KAU
- In *Adhoc* KAU organic POP, FYM at 25 t ha^{-1} was applied as basal dose to which *Trichoderma* and PGPR mix I each at 2.5 kg ha^{-1} was also mixed. Seedlings were dipped in *Pseudomonas fluorescens* at the time of transplanting.

Treatments	: 12
Replications	: 03
Design	: RBD
No. of plots	: 36
Plot size	: 3 m X 3 m (9 m^2)
Spacing	: 60 cm x 60 cm
No. of plants per plot	: 25
Crop	: Tomato
Variety	: Manulakshmi (seeds were collected from Agricultural Research Station, KAU, Mannuthy)

3.2.7. Crop husbandry

Experimental land

Experimental land was ploughed thoroughly with disc plough and worked with cultivator and cleared off weeds. Gross plot size was 10 cents and net plot size 8.1 cents. Raised beds and furrows were taken to undertake crop planting at a spacing of 60 cm. Layout of the field is given in Fig 1.

Nursery preparation

Seeds were sown in portrays. The potting mixture consisted of compost and sand in the ratio of 3:1. Seedlings were maintained in the nursery upto 30 days before transplanting.

Transplanting

Seedlings were planted in main field after one month at a spacing of 60 cm × 60 cm on 10th October 2018. Temporary shade was given for three to four days and the crop was sufficiently irrigated.

Gap filling

Gap filling was done with healthy seedlings, wherever necessary.

Manures and fertilizers

Half of nitrogen, full dose phosphorus and half dose of the potash were applied basally at the time of transplanting and the remaining nitrogen and potash were applied after one month. Lime was applied to all plots irrespective of treatments except control after checking initial soil pH (5.89). Quantity of fertilizers applied in each treatments are listed in Table 3. Organic manures *viz.* coirpith compost, coirpith vermicompost and FYM were applied basally as per the treatments. Table 4 shows the content of major nutrients in the organic (manures) and inorganic sources (fertilizers) used in the research work.

Table 3. Quantity of fertilizers applied in different treatments

Treatments	Urea	Rajphos	MOP	Lime
	kg ha^{-1}			
T_1	-	-	-	
T_2	-	-	-	250
T_3	-	-	-	250
T_4	127.17	120	25	250
T_5	127.17	120	25	250
T_6	30.29	30	6.25	250
T_7	63.5	60	12.5	250
T_8	95.3	90	18.75	250
T_9	30.29	40	6.25	250
T_{10}	63.5	60	12.5	250
T_{11}	95.3	90	18.75	250
T_{12}	-	-	-	250

Table 4. Nutrient content of manures and fertilizers used in the experiment

Sl. No.	Manures / Fertilizers	Nutrient content (%)		
		N	P_2O_5	K_2O
1	Farm yard manure	1.0	0.5	1.0
2	Coirpith compost	1.10	0.32	0.86
3	Coirpith vermicompost	1.24	1.02	1.57
4	Urea	46	-	-
5	Rajphos	-	20	-
6	Muriate of potash	-	-	60

Plate 9. Sowing seeds in Pro-tray

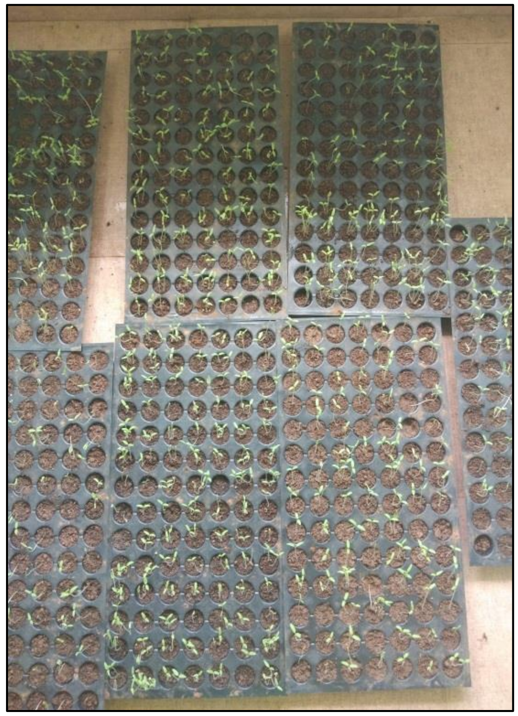


Plate 10. Germinated seeds

Plate 11. Seedlings for transplanting

Plate 12. Planting of seedlings

	T_7	T_1	T_4	T_2
R_1	T_5	T_{11}	T_8	T_3
	T_6	T_{10}	T_{12}	T_9
	T_4	T_{12}	T_9	T_6
R_2	T_{11}	T_1	T_{10}	T_2
	T_5	T_7	T_3	T_8
	T_1	T_6	T_{12}	T_4
R_3	T_7	T_3	T_{11}	T_9
	T_5	T_{10}	T_8	T_2

N ↑

Fig.1. Layout of the experimental field

Irrigation

Hose irrigation was given as and when required.

Weed management

Care was taken to maintain the experimental field weed free by resorting to hand weeding.

Plant protection

Appropriate plant protection measures were taken to control pests and diseases. Virus infected plants were rogued off and disposed from the field. Yellow sticky traps were installed in the field to control whiteflies. Quinalphos was sprayed @ 2 ml per litre of water to control fruit and shoot borer. For controlling bacterial wilt copper hydroxide (Kocide) @ 0.2 per cent was drenched.

Harvesting

When the fruits were ready to harvest, they were hand picked on alternate days. The first harvest was done at 65 days after transplanting (DAT). A total of 8 harvests could be carried out.

3.2.8. Observations

Observations of field experiment included post harvest soil analysis for electro - chemical, chemical and biological properties, plant analysis for nutrient content, biometric parameters and fruit quality parameters.

3.2.8.1. Biometric observations

For recording biometric observations, five plants were selected randomly from each plot and tagged. The following observations were recorded from these plants and the mean values were worked out.

Plant height

Plant height was recorded at 20 days interval from the ground portion up to nodal base of the fully opened leaf and the mean plant height was expressed in centimeters.

Number of days to flowering

Number of days required for flowering was noted in randomly selected plants and mean value was computed.

Number of fruits per plant

Number of fruits per plant was recorded from randomly selected plants and mean value was computed.

Fruit weight

Individual fruit weight was recorded and expressed in grams.

Yield per plant

Fruits were harvested from the tagged plants, yield was noted, mean value was computed and expressed in kilograms per plant.

Yield per plot ($9m^2$)

Weight of the fruits from each plot after each harvest was recorded and added to get the total yield per plot which was expressed in kilograms per plot.

Dry matter production

The total dry weight of the tagged plants was recorded after harvest. The samples were dried to constant weight in a hot air oven at a temperature of 70^0 C, the dry weights were recorded and expressed in kilograms per hectare.

Plate 13. Crop at flowering

Plate 14. Fruit emergence

Plate 15. Different stages of fruit growth

Plate 16. General field view at the time of fruiting

Plate 17. Ripened fruit

Plate 18. Harvested fruits

3.2.8.2. Deficiency symptoms, if any

Deficiency symptoms noticed in the crop during the experimental period were fruit cracking (boron deficiency) and blossom end rot (calcium deficiency) which were timely attended to.

3.2.8.3. Quality attributes of tomato fruit

Total soluble solids

Total soluble solids of fruit samples was estimated by using refractometer (Sadasivam and Manickam 1992).

Titrable acidity

Five gram of fruit pulp was taken and grinded with 10 ml of distilled water in a mortar and pestle, and later subjected to centrifugation at 3000 rpm for 5 min. It was diluted to 100 ml. From this diluted sample, 10 ml aliquot was pipetted into a 250 ml conical flask and titrated against 0.1*N* NaOH until the end point was reached (colorless to light pink). Titrable acidity was calculated by using the formula given by Sadasivam and Manickam (1992).

Ascorbic acid content

Ascorbic acid in fruits was estimated by using 2, 6 dichloro indophenol dye. 10 ml of clarified tomato juice was taken and made upto 100 ml with 2 per cent oxalic acid. This sample was diluted again. 10 ml was pipetted into conical flask and titrated against 2, 6 dichloro indophenol dye until the solution changed its colour from colourless to light pink. The ascorbic acid content was calculated by using the formula given by Sadasivam and Manickam (1992).

Lycopene content

Lycopene content of the fruits was estimated at the full ripe stage by the method of Sadasivam and Manickam (1992).

Blossom end rot

Fruit cracking

Plate 19. Deficiency symptoms noticed during field experiment

3.2.8.4. Analysis of soil

Soil samples were collected at harvest stage at a depth of 0-15 cm and analyzed for pH, EC, OC, available nutrients (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B), carbon fractions *viz.* water soluble carbon, hot water soluble carbon, permanganate oxidizable carbon, total carbon and microbial biomass carbon, dehydrogenase activity and microbial population (Bacteria, Fungi and Actinomycetes). The analytical methods employed for soil electrochemical and chemical properties are given in Table 2. The procedure for carbon fraction estimation is given in 3.2.3.1.

3.2.8.5. Analysis of plant and fruit samples

At the time of harvest, five plants which were randomly selected was uprooted carefully, and washed with tap water in order to remove dirt and other adhering soil particles. The plants were again washed with single and double distilled water and shade dried for a week. In the same way, fruits were also collected and cut into small pieces and kept in an oven at 60^0 C for 10 days. The samples were powdered and stored in polythene covers and used for estimation of nutrients *viz* (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B). The methodology followed to determine the above parameters are detailed in Table 5.

3.2.8.6. Nutrient uptake

From the nutrient content of plant and fruit, the nutrient uptake by both plant and fruit was also worked out using the following formula.

$$\text{Nutrient uptake} = \frac{\text{Nutrient content (\%)}}{100} \times \text{dry matter}$$

Table 5. Analytical methods employed for plant analysis

S. No.	Element	Method of analysis		Reference
		Extraction	Estimation	
1	N	H_2SO_4-Salicylic acid digestion	Steam distillation	Bremner, 1949
2	P	Microwave digestion system (HNO_3)	Colorimetry	Jackson, 1973
3	K		Flame photometry	Jackson, 1973
4	Ca		ICP-OES (Model: Optima® 8x00 series)	
5	Mg		ICP-OES (Model: Optima® 8x00 series)	
6	S		Turbidimetry	Jackson, 1973
7	Fe, Mn, Zn, Cu, B		ICP-OES (Model: Optima® 8x00 series)	

3.3. Economics of cultivation

The economics of cultivation was worked out based on the cost of cultivation and prevailing price of the crop produce in the market.

$$\text{Net income (Rs. ha}^{-1}\text{)} = \text{Gross income} - \text{Total expenditure}$$

The Benefit: Cost ratio (B: C ratio) was worked out according to the formula given below.

$$\text{B : C ratio} = \frac{\text{Gross income}}{\text{Total expenditure}}$$

3.4. Statistical analysis

Experimental data obtained was subjected to statistical analysis following the procedure outlined by Gomez and Gomez (1976) using WASP package. To draw valid conclusions, correlation analysis and path coefficient analysis were also carried out using OPSTAT package.

Results

4. RESULTS

The present investigation was carried out with the objectives of unravelling the effect of coirpith vermicompost application on the dynamics of carbon in lateritic soil and to relate the material influence on crop performance and fruit quality. The objectives were realized by carrying out two experiments *viz.* preparation and characterization of coirpith based vermicompost and a field experiment. The data generated from the experiments are presented in this chapter under different subheads.

4.1. Characterization of raw and composted coirpith

Coirpith, the fluffy spongy material which is the main by-product from coir industry is not amenable to degradation by the common microorganisms present in the soil ecosystem because of its high cellulose, lignin and tannin content. However after proper composting, it could be turned into a highly potential organic resource with many enviable features. In the present study, the coirpith compost and coirpith based vermicompost was prepared adopting the procedure outlined in chapter 3. Raw coirpith utilized for the compost preparation, coirpith compost and vermicomposted coirpith were characterized for their electrochemical and chemical properties after sieving the material through a 2 mm sieve. The results are presented in Table 6.

4.1.1. Raw coirpith

The raw coirpith recorded a moisture content of 35.6 per cent. The pH was 5.70 indicating the acidic nature, electrical conductivity was 0.98 dS m^{-1} and CEC was 25.5 cmol (+) kg^{-1}.

The content of total carbon, nitrogen, phosphorous and potassium was 29.6, 0.26, 0.05, and 0.75 per cent, respectively. It also contained 0.44 per cent calcium, 0.32 per cent magnesium and 0.28 per cent sulphur. In addition, micronutrients were also present to the extent of 1195 mg kg^{-1} iron, 60.5 mg kg^{-1} manganese, 78.0 mg kg^{-1} zinc and 40.5

mg kg^{-1} copper. The other characteristics included 32 per cent lignin and 25.5 per cent cellulose. C: N ratio of coirpith worked out to 113:1.

Table 6. Physical, electro-chemical and chemical properties of raw and composted coirpith

Sl. No.	Properties		Raw coirpith	Coirpith compost	Vermicomposted coirpith
A. Physical properties					
1	Moisture (%)		35.6	19.2	18.5
B. Electro-chemical properties					
2	pH		5.70	6.60	7.0
3	EC (dS m^{-1})		0.98	0.43	0.5
4	CEC (cmol (+) kg^{-1})		25.5	26.1	27.5
C. Chemical properties					
5	Total carbon	per cent	29.6	26.4	25.5
6	Nitrogen		0.26	1.10	1.24
7	Phosphorous		0.05	0.32	1.02
8	Potassium		0.75	0.86	1.57
9	Calcium		0.44	0.47	0.53
10	Magnesium		0.32	0.39	0.48
11	Sulphur		0.28	0.37	0.42
12	Iron	mg kg^{-1}	1195	1745	1812
13	Manganese		60.5	83.5	90.4
14	Zinc		78.0	82.1	95.2
15	Copper		40.5	54.0	65.3
16	Lignin	per cent	32.0	18.2	16.7
17	Cellulose		25.50	11.4	10.2
18	C : N ratio		113 : 1	24: 1	20.5: 1

4.1.2. Coirpith compost

The coirpith compost prepared had a moisture content of 19.2 per cent, pH of 6.60, electrical conductivity of 0.43 dS m^{-1}, CEC of 26.1 cmol (+) kg^{-1} and total carbon of 26.4 per cent (Table 6).

Regarding macronutrients, coirpith compost contained 1.10 per cent N, 0.32 per cent P, 0.86 per cent K, 0.47 per cent Ca, 0.39 per cent Mg and 0.37 per cent S. It also contained micronutrients *viz.* Fe (1745 mg kg^{-1}), Mn (83.5 mg kg^{-1}), Zn (82.1 mg kg^{-1}) and Cu (54.0 mg kg^{-1}).

Composting reduced the lignin content of coirpith to 18.2 per cent and cellulose content to11.4 per cent. The composted coirpith registered a C: N ratio of 24:1.

4.1.3.Vermicomposted coirpith

Coirpith vermicompost was prepared by combining regular coirpith composting technology with vermitechnology. The vermicomposted coirpith had a moisture content of 18.5 per cent, pH of 7.02, electrical conductivity of 0.51 dS m^{-1} and CEC of 27.5 cmol (+) kg^{-1}. Total carbon was found to be 25.5 per cent (Table 6).

Regarding macronutrients, vermicomposted coirpith contained 1.24 per cent N, 1.02 per cent P, 1.57 per cent K, 0.53 per cent Ca, 0.48 per cent Mg and 0.42 per cent S. It also contained micronutrients *viz.* Fe (1812 mg kg^{-1}), Mn (90.4 mg kg^{-1}), Zn (95.2 mg kg^{-1}) and Cu (65.3mg kg^{-1}).

The process of vermicomposting reduced the lignin content of partially degraded coirpith to 16.7 per cent and cellulose content to 10.2 per cent. The vermicomposted coirpith registered a C: N ratio of 20.5:1.

4.2. Characterization of the experimental soil

The field experiment was carried out in STCR field, College of Horticulture, Vellanikkara, Thrissur. Representative soil samples were collected before the start of the experiment. The soil samples were air dried, powdered and then sieved through 0.5 mm sieve for organic carbon analysis and through 2 mm sieve for analysis of other physical and chemical properties. The results are presented in Table 7.

The texture of the experimental soil was sandy clay loam with a dominant proportion of sand (57.1 %). The silt and clay fraction constituted to only 17.6 and 21.2 per cent. The bulk density and particle density was 1.34 and 2.46 Mg m^{-3}, respectively. The maximum water holding capacity accounted to 38.9 per cent.

The soil pH was 5.89 and electrical conductivity was 0.03 dS m^{-1}.Cation exchange capacity was found to be 2.13 cmol (+) kg^{-1} and organic carbon content was 1.25 per cent.

Available phosphorous content was high (23.20 kg P ha^{-1}) but available nitrogen and potassium content was in medium range (293.40 kg N ha^{-1} and 252.0 kg ha^{-1} respectively).The NH_4OAc extractable calcium and magnesium were 289.7 and 63.42 mg kg^{-1}, respectively and $Cacl_2$ extractable sulphur content amounted to 10.56 mg kg^{-1}. The available micronutrient content was 11.4 mg kg^{-1} Fe, 25.4 mg kg^{-1} Mn, 2.7 mg kg^{-1} Zn, 13.2 mg kg^{-1} Cu and 0.412 mg kg^{-1} B.

In respect of carbon fractions, the water soluble carbon was found to be 86.5 mg kg^{-1}, hot water extractable carbon 228.5 mg kg^{-1}, microbial biomass carbon 72.68 mg kg^{-1}, permanganate oxidizable carbon 765.3 mg kg^{-1} and total carbon 1.37 mg kg^{-1}.

Regarding the biological properties, the dehydrogenase activity was 41.82 µg TPF g^{-1} soil $24hr^{-1}$ and the microbial population followed the order, bacteria (62.5 x 10^6 CFU g^{-1} soil) > fungi (10.42 x10^4 CFU g^{-1} soil) > actinomycetes (8.45 x 10^3 CFU g^{-1} soil).

Table 7. Initial characteristics of the experimental soil

Sl. No.	Characteristics		Value
1	Mechanical composition (%)		
	Coarse sand		30.8
	Fine sand		26.2
	Silt		17.6
	Clay		21.2
2	Textural class		Sandy clay loam
3	Bulk density (Mg m^{-3})		1.34
4	Particle density (Mg m^{-3})		2.46
5	Maximum water holding capacity (%)		38.9
6	pH (1:2.5)		5.89
7	Electrical conductivity (dS m^{-1})		0.034
8	Cation exchange capacity (cmol (+) kg^{-1})		2.13
9	Organic carbon (g/kg)		12.5
10	Available nitrogen	kg ha^{-1}	293
11	Available phosphorus		23.2
12	Available potassium		252
13	Available sulphur	mg kg^{-1}	10.56
14	Available calcium		289
15	Available magnesium		63.4
16	Available boron		0.41
17	Available iron		11.4
18	Available manganese		25.4
19	Available zinc		2.7
20	Available copper		13.2
21	Water soluble carbon		86.5
22	Hot water extractable carbon		228.5
23	Microbial biomass carbon		72.6
24	Permanganate oxidizable carbon		765.3
25	Total carbon (%)		1.37
26	Dehydrogenase activity (µg TPF g^{-1}soil $24hr^{-1}$)		41.8
27	Bacteria (x 10^6 CFU g^{-1}soil)		62.5
28	Actinomycetes (x 10^3 CFU g^{-1}soil)		8.45
29	Fungi (x10^4 CFU g^{-1}soil)		10.4

4.3. Field experiment

4.3.1. Effect of treatments on soil properties after harvest

After the harvest of the crop, representative soil samples were collected, processed and analysed for electro-chemical and chemical properties. The results are presented under respective titles.

4.3.1.1. Soil reaction

There was a change in soil pH consequent to imposing different treatments. Statistical analysis revealed that there was significant difference among the treatments with respect to soil pH (Table 8). The initial pH of the experimental soil was 5.89.

The pH of the soil was significantly higher in all the treatments in comparison with absolute control. Maximum pH (6.96) was recorded in T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP) which was comparable with the treatments T_4 (coirpith based vermicompost at 10 t ha^{-1} +100 % of soil test based KAU POP), T_{12} (*Adhoc* KAU organic POP), T_5, T_7, T_3 and T_9. Significantly the lowest pH (5.50) was recorded in the control.

4.3.1.2. Electrical conductivity

The electrical conductivity of soil after harvest differed significantly among the various treatments imposed (Table 8). It was maximum (0.185 dS m^{-1}) in T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP) followed by T_8 and T_7. The lowest electrical conductivity (0.149 dS m^{-1}) was observed in absolute control which was on par with the treatments T_5, $T_{2,}$ and T_{12}.

4.2.1.3. Organic carbon

Application of different levels of coirpith vermicompost, FYM and chemical fertilizers significantly increased the organic carbon content of experimental soil after harvest (Table 8). Among the different treatments, the highest organic carbon was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (13.61 %) which was on par with T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP) and T_7 (coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP). Significantly the lowest organic carbon was noticed in absolute control (6.76 %).

4.3.1.4. Cation exchange capacity

The data on cation exchange capacity of soil after harvest is given in Table 8. Significantly highest cation exchange capacity was (4.80 cmol (+) kg^{-1}) recorded in T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP), while the lowest CEC was noticed in absolute control (2.57 cmol (+) kg^{-1}).

4.3.1.5. Labile carbon fractions

Water soluble carbon (WSC)

Table 9 reveals the effect of different treatments on the water soluble carbon content of soil. The highest WSC (130.5 mg kg^{-1}) was recorded in T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP) which was on par with T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP), T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP), T_{11} (FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP) and T_6 (coirpith based vermicompost at 10 t ha^{-1} + 25% of soil test based KAU POP). However, the lowest WSC was associated with the control plot (95.0 mg kg^{-1}).

Table 8. Effect of different treatments on physico-chemical properties of soil after harvest

Treatments	**pH**	**EC dS m^{-1}**	**OC g/kg**	**CEC cmol (+) kg^{-1}**
T_1: Absolute control	5.50	0.149	6.76	2.57
T_2: Coirpith compost at 10 t ha^{-1}	6.55	0.150	8.54	3.10
T_3: Coirpith based vermicompost at 10 t ha^{-1}	6.67	0.173	9.75	3.27
T_4: T_3 + 100 % of soil test based KAU POP	6.84	0.185	13.61	4.80
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	6.79	0.152	11.05	3.73
T_6: T_3 + 25% of soil test based KAU POP	6.51	0.173	10.10	4.17
T_7: T_3 + 50% of soil test based KAU POP	6.70	0.183	12.70	4.37
T_8: T_3 + 75% of soil test based KAU POP	6.96	0.184	13.35	4.43
T_9: FYM at 20 t ha^{-1} + 25% of soil test based KAU POP	6.62	0.161	10.53	3.43
T_{10}: FYM at 20 t ha^{-1} + 50% of soil test based KAU POP	6.54	0.159	11.22	3.33
T_{11}: FYM at 20 t ha^{-1} + 75% of soil test based KAU POP	6.58	0.163	11.18	3.63
T_{12}: *Adhoc* KAU organic POP	6.81	0.153	9.79	3.13
CD (0.05)	**0.41**	**0.005**	**2.43**	**0.38**

Hot water soluble carbon (HWSC)

The HWSC content of soil after harvest as influenced by different treatments is presented in Table 9. The highest HWSC (358.5 mg kg^{-1}) was noticed in FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP which was comparable with coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP. Significantly the lowest HWSC (252.0 mg kg^{-1}) was observed in absolute control.

Permanganate oxidizable carbon (POXC)

The data furnished in Table 9 shows the effect of different treatments on POXC content of soil. Application of coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP had registered higher POXC (1286 mg kg^{-1}). Significantly the lowest POXC (821 mg kg^{-1}) was recorded in absolute control.

Microbial biomass carbon (MBC)

Statistical analysis of the data on MBC of soil is presented in Table 9. It can be seen from the table that, the effect of treatments *viz.* coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP, coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP on this parameter was comparable (164.6 and 157.7 mg kg^{-1} respectively). Significantly the lowest MBC content was associated with absolute control (80 mg kg^{-1}).

Total carbon

The data from the Table 9 revealed that the total carbon (1.570 %) was significantly higher in T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP). Significantly the lowest total carbon (1.067 %) was observed in control plot.

Table 9. Effect of different treatments on labile carbon pools in the experimental soil after harvest

Treatments	WSC	HWSC	POXC	MBC	Total carbon (%)
	mg kg^{-1}				
T_1: Absolute control	95	252	821	80	1.06
T_2: Coirpith compost at 10 t ha^{-1}	101	292	1167	119	1.22
T_3: Coirpith based vermicompost at 10 t ha^{-1}	106	313	1178	134	1.34
T_4: T_3 + 100 % of soil test based KAU POP	130	355	1286	165	1.48
T_5: FYM at 20 t ha^{-1} +100 % of soil test based KAU POP	124	358	1280	155	1.36
T_6: T_3 + 25% of soil test based KAU POP	117	331	1245	146	1.23
T_7: T_3 + 50% of soil test based KAU POP	112	346	1266	152	1.17
T_8: T_3 + 75% of soil test based KAU POP	130	346	1267	158	1.57
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	108	327	1259	144	1.13
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	111	337	1252	146	1.29
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	117	338	1258	152	1.27
T_{12}: *Adhoc* KAU organic POP	103	273	1112	145	1.12
CD (0.05)	**14**	**9**	**131**	**8**	**0.03**

4.3.1.6. Available nutrient status of soil

The nutrient status in terms of available N, P, K, Ca, Mg, S and micronutrients (Fe, Mn, Zn, Cu and B) of soil after harvest of tomato are furnished in Tables 10, 11and 12.

$KMnO_4$- N

Available nitrogen content of soil increased significantly due to different levels of compost, FYM and fertilizer application as presented in Table10. The nitrogen content varied from 143.7 to 208.3 kg ha^{-1}. It was found to be higher for the treatments *viz*. coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP, coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP, FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP application, which were all comparable. The lowest nitrogen content of 143.7 kg ha^{-1} was recorded in control plots.

Bray- P

The available phosphorous content as influenced by different treatments is presented in Table 10. It is clear from the table that higher phosphorous content was recorded in the plot that received coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (49.1 kg ha^{-1}) though it was comparable with coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (47.2 kg ha^{-1}) and FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (44.33 kg ha^{-1}). Control treatment recorded the lowest phosphorous content of 17.4 kg ha^{-1}.

NH_4OAc- K

It can be inferred from Table 10 that, available potassium content of soil after the experiment differed significantly among treatments. Significantly the highest potassium content (281kg ha^{-1}) was noticed in T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP) followed by T_8 (coirpith based vermicompost at 10 t ha^{-1} +

75 % of soil test based KAU POP), T_7 (coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP) and T_6 (coirpith based vermicompost at 10 t ha^{-1} + 25 % of soil test based KAU POP, which were comparable with each other. Significantly the lowest potassium content (181.3 kg ha^{-1}) was observed in control plots.

NH_4OAc- Ca

Data in Table 11 showed that, the effect of treatments T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP, T_8 (coirpith based vermicompost at 10 t ha^{-1}+ 75 % of soil test based KAU POP) and T_7 (coirpith based vermicompost at 10 t ha^{-1}+ 50 % of soil test based KAU POP) in registering higher Ca values was only comparable. All other treatments differed significantly. Control plots showed significantly lower calcium content (176.0 kg ha^{-1}).

NH_4OAc- Mg

The perusal of the data in Table 11 showed that, the available magnesium content differed significantly among treatments. The highest magnesium content (93.33 mg kg^{-1}) was noticed in T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP) which was on par with T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP) and T_{11} (FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP). The lowest magnesium content was observed in control plots (70.33 mg kg^{-1}), which was on par with T_{12} (*Adhoc* KAU organic POP).

$CaCl_2$- S

From the data in Table 11, it can be concluded that, there was significant increase in sulphur content in all the treatments. Significantly, the higher sulphur content (18.30 mg kg^{-1}) was registered by T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP) followed by T_{11} (FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP). The lowest sulphur content was recorded by T_2 (coirpith compost at 10 t ha^{-1}) and T_1 (absolute control) which were comparable.

Table 10. Effect of different treatments on available major nutrient status in experimental soil after harvest

(kg ha^{-1})

Treatments	N	P	K
T_1: Absolute control	144	17.4	181
T_2: Coirpith compost at 10 t ha^{-1}	158	26.6	220
T_3: Coirpith based vermicompost at 10 t ha^{-1}	166	29.4	221
T_4: T_3 + 100 % of soil test based KAU POP	208	49.1	281
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	204	44.3	240
T_6: T_3 + 25% of soil test based KAU POP	174	41.7	260
T_7: T_3 + 50% of soil test based KAU POP	195	43.4	265
T_8: T_3 + 75% of soil test based KAU POP	206	47.2	266
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	172	42.7	234
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	178	40.3	241
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	182	42.0	241
T_{12}: *Adhoc* KAU organic POP	172	38.7	222
CD (0.05)	**25**	**11.4**	**8**

Table 11. Effect of different treatments on available secondary nutrient (mg kg^{-1}) status of experimental soil after harvest

Treatments	Ca	Mg	S
T_1: Absolute control	176	70.3	15.8
T_2: Coirpith compost at 10 t ha^{-1}	200	81.0	16.1
T_3: Coirpith based vermicompost at 10 t ha^{-1}	211	83.0	16.4
T_4: T_3 + 100 % of soil test based KAU POP	237	93.3	17.7
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	252	86.0	18.3
T_6: T_3 + 25% of soil test based KAU POP	224	81.0	17.0
T_7: T_3 + 50% of soil test based KAU POP	244	87.0	17.1
T_8: T_3 + 75% of soil test based KAU POP	252	90.0	17.3
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	221	84.3	16.9
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	218	86.0	17.7
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	228	89.0	17.9
T_{12}: *Adhoc* KAU organic POP	202	76.3	16.1
CD (0.05)	**8**	**6.3**	**0.2**

HCl- Fe

Data pertaining to the available iron content of soil as affected by different treatments is presented in Table 12. The iron content was found to be the highest (15.3 mg kg^{-1}) in the soil applied with T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP) which was on par with all other treatments, except T_{12} (*Adhoc* KAU organic POP), T_3 (coirpith based vermicompost at 10 t ha^{-1}), T_2 (coirpith compost at 10 t ha^{-1}) and T_1 (Absolute control).

HCl- Mn

Perusal of the data in Table 12 showed that the highest available manganese content was recorded (75.33 mg kg^{-1}) in T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP) which was superior to all other treatments. The control plot registered lower managanese content (39.66 mg kg^{-1}) which was comparable with T_{12} (*Adhoc* KAU organic POP).

HCl- Zn

Statistical analysis of the data presented in Table 12 revealed that, the available zinc was higher (8.0 mg kg^{-1}) in T_7 (coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP) which was on par with T_3 (coirpith based vermicompost at 10 t ha^{-1}). Significantly the lower zinc content (3.67 mg kg^{-1}) was recorded in control plot.

HCl- Cu

It can be inferred from the Table 12 that, the highest copper content (13.10 mg kg^{-1}) was associated with T_3 (coirpith based vermicompost at 10 t ha^{-1}) though it was comparable with T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP). The control plot exhibited lower copper content (7.10mg kg^{-1}) which was comparable with T_{12} (*Adhoc* KAU organic POP).

Table 12. Effect of different treatments on available micronutrient status (mg kg^{-1}) of experimental soil after harvest

Treatments	Fe	Mn	Zn	Cu	B
T_1: Absolute control	10.5	39.7	3.67	7.10	0.36
T_2: Coirpith compost at 10 t ha^{-1}	12.6	45.0	6.90	9.23	0.37
T_3: Coirpith based vermicompost at 10 t ha^{-1}	11.8	52.0	7.40	13.10	0.41
T_4: T_3 + 100 % of soil test based KAU POP	14.8	75.3	7.33	12.27	0.45
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	14.8	70.0	6.43	11.83	0.44
T_6: T_3 + 25% of soil test based KAU POP	13.7	60.0	6.90	10.63	0.43
T_7: T_3 + 50% of soil test based KAU POP	13.5	67.0	8.00	10.60	0.42
T_8: T_3 + 75% of soil test based KAU POP	15.3	68.0	7.17	11.30	0.47
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	13.3	57.0	7.23	10.23	0.40
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	14.3	56.0	6.77	10.60	0.41
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	13.7	63.3	6.60	10.60	0.43
T_{12}: *Adhoc* KAU organic POP	12.6	42.0	5.00	7.17	0.39
CD (0.05)	**2.2**	**3.9**	**0.65**	**0.98**	**0.05**

Hot water soluble B

The hot water soluble B content of soil significantly vary due to the imposed treatments (Table 12). Higher boron content (0.47 mg kg^{-1}) was noticed in T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP). The lowest boron content (0.36 mg kg^{-1}) was recorded by control plot.

4.3.1.7. Dehydrogenase activity

The data presented in Table 13 showed that the different treatments tried brought about variation in the dehydrogenase activity of soil. The effect in registering higher value (146.3 µg TPF g^{-1} soil $24hr^{-1}$) was associated with the treatment T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP) which was significantly superior to other treatments. Control plots registered significantly lower value of 52.0 µg TPF g^{-1} soil $24hr^{-1}$.

4.3.1.8. Microbial population

Microbial population was assessed by enumerating the population of bacteria, fungi and actinomycetes through serial dilution plate technique.

Bacteria

The bacterial population of soil after harvest differed significantly among the various treatments tried (Table 14).The highest bacterial count (109.3 x 10^6 CFU g^{-1}) was obtained in T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP) which was on par with T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP), FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP and T_7 (coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP). Significantly the lower bacterial count (57.7 x 10^6 CFU g^{-1}) was registered in control.

Table 13. Effect of different treatments on dehydrogenase activity (μg TPF g^{-1} day^{-1}) of experimental soil after harvest

Treatments	Dehydrogenase activity
T_1: Absolute control	52.0
T_2: Coirpith compost at 10 t ha^{-1}	76.3
T_3: Coirpith based vermicompost at 10 t ha^{-1}	78.3
T_4: T_3 + 100 % of soil test based KAU POP	146.3
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	119.7
T_6: T_3 + 25% of soil test based KAU POP	108.0
T_7: T_3 + 50% of soil test based KAU POP	124.0
T_8: T_3 + 75% of soil test based KAU POP	125.0
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	99.0
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	107.0
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	105.0
T_{12}: *Adhoc* KAU organic POP	117.7
CD (0.05)	**8.5**

Fungus

Inference from Table 14 is that the fungal population in soil after the experiment differed significantly among treatments. Coirpith based vermicompost added at 10 t ha^{-1} + 50 % of soil test based KAU POP registered a higher fungal population of 13.0 x 10^4 CFU g^{-1} which was on par with coirpith based vermicompost at 10 t ha^{-1} + 25 % of soil test based KAU POP. The control plot recorded the lowest population of 3.3 x 10^4 CFU g^{-1}.

Actinomycetes

Statistical analysis of the data presented in Table 14 revealed that higher actinomycetes population (10.33 x 10^3 CFU g^{-1}) was in T_6 (coirpith based vermicompost at 10 t ha^{-1} + 25 % of soil test based KAU POP) and T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP) which was on par with all other treatments except T_{11} (FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP), T_3 (coirpith based vermicompost at 10 t ha^{-1}), T_2 (coirpith compost at 10 t ha^{-1}) and control. The population was lower (4.33 x 10^3 CFU g^{-1}) in control plot.

4.3.2. Effect of treatments on growth components and yield of tomato

4.3.2.1. Plant height

The plant height of tomato was significantly influenced by treatments tried (Table 15). At 20 DAT, the plant height ranged from 28.8 to 35.0 cm. Among the different treatments, T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP) exhibited higher plant height (35.0 cm) which was comparable with T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75% of soil test based KAU POP), T_4 (coirpith based vermicompost at 10 t ha^{-1} +100 % of soil test based KAU POP) and T_7 (coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP).

At 40 DAT, higher plant height (61.5 cm) was registered by T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP) which was on par with T_{11} (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP).

The treatments exerted a significant effect on plant height as recorded at both 60 and 80 DAT. Significantly the highest plant height (94.5 cm) was noticed in T_4 (coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP) followed by T_8 (coirpith based vermicompost at 10 t ha^{-1}+ 75 % of soil test based KAU POP) during 60 DAT.

Table 14. Effect of different treatments on microbial population of experimental soil after harvest

Treatments	Bacteria ($\times 10^6$ cfu g^{-1}soil)	Fungus ($\times 10^4$ cfu g^{-1}soil)	Actinomycetes ($\times 10^3$ cfu g^{-1} soil)
T_1: Absolute control	57.7	3.33	4.33
T_2: Coirpith compost at 10 t ha^{-1}	72.3	7.00	6.33
T_3: Coirpith based vermicompost at 10 t ha^{-1}	81.0	8.33	8.00
T_4: T_3 + 100 % of soil test based KAU POP	109.3	10.33	8.33
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	102.7	8.00	8.33
T_6: T_3 + 25% of soil test based KAU POP	93.0	12.00	10.33
T_7: T_3 + 50% of soil test based KAU POP	102.3	13.00	8.33
T_8: T_3 + 75% of soil test based KAU POP	106.7	10.33	10.33
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	95.0	8.00	8.33
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	94.3	7.00	8.33
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	101.3	6.67	6.00
T_{12}: *Adhoc* KAU organic POP	99.0	8.00	9.67
CD (0.05)	**7.9**	**2.50**	**2.30**

At 80 DAT, the highest plant height (104.7 cm) was recorded in T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP) followed by the treatment received T_8 (coirpith based vermicompost at 10 t ha^{-1}+ 75 % of soil test based KAU POP) which was on par with T_7 (coirpith based vermicompost at 10 t ha^{-1}+ 50 % of soil test based KAU POP) and T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP). At all stages of the crop growth, the lowest plant height was associated with control plot.

4.3.2.2. Days to flowering

In the case of days to flowering, there was significant difference between the treatments (Table 16). Maximum number of days to flowering (29.6 days) was noticed in absolute control though it was comparable with T_{11} (FYM at 20 t ha^{-1} + 75% of soil test based KAU POP), T_{10} (FYM at 20 t ha^{-1} + 50 % of soil test based KAU POP) and T_2 (coirpith vermicompost at 10t ha^{-1}). The days to flowering was the lowest (26.6 days) in the treatment T_9 (FYM at 20 t ha^{-1} + 25 % of soil test based KAU POP).

4.3.2.3. Dry matter production

It can be inferred from the Table 16 that coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP recorded higher dry matter production (1262 kg ha^{-1}) which was comparable with other treatments, except T_9 (FYM at 20 t ha^{-1} +25 % of soil test based KAU POP), T_{12} (*Adhoc* KAU organic POP), T_3 (coirpith based vermicompost at 10 t ha^{-1}), T_2 (coirpith compost at 10 t ha^{-1}) and absolute control.

Table 15. Effect of different treatments on plant height (cm) of tomato

Treatments	Plant height			
	20 DAT	**40 DAT**	**60 DAT**	**80 DAT**
T_1: Absolute control	28.8	42.1	60.0	70.1
T_2: Coirpith compost at 10 t ha^{-1}	31.6	44.6	63.3	76.4
T_3: Coirpith based vermicompost at 10 t ha^{-1}	32.5	48.2	71.3	83.8
T_4: T_3 + 100 % of soil test based KAU POP	34.2	61.5	94.5	104.7
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	35.0	57.1	89.3	94.8
T_6: T_3 + 25% of soil test based KAU POP	32.4	49.4	85.1	89.9
T_7: T_3 + 50% of soil test based KAU POP	33.8	57.2	89.7	95.9
T_8: T_3 + 75% of soil test based KAU POP	34.7	59.4	91.1	97.2
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	30.2	48.2	74.4	81.7
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	31.2	49.8	79.8	85.7
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	32.5	52.2	83.2	89.5
T_{12}: *Adhoc* KAU organic POP	33.4	50.2	72.6	82.5
CD (0.05)	**1.9**	**2.9**	**2.2**	**2.7**

4.3.2.4. Number of fruits per plant

The data furnished in Table 16 shows the positive effect of different treatments on the number of fruits per plant. Significantly the highest number of fruits per plant (44.0) was recorded in T_4 (coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP). This was followed by T_{11} (FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP) which was on par with all other treatments except T_2 (coirpith vermicompost at 10 t ha^{1}), T_3 (coirpith based vermicompost at 10 t ha^{-1}) and control (T_1). Significantly lower number of fruits (25.3) was recorded in absolute control.

4.3.2.5. Fruit weight

Perusal of the data in Table 16 indicated that there was significant difference in fruit weight of tomato due to different treatments. The fruit weight (42.33 g) was maximum in the treatment T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP), T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP), and T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP). The lowest fruit weight was recorded in control plot (31.60 g).

4.3.2.6. Yield per plant

Significantly higher yield per plant (1.84 kg) was observed in treatment that received coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP ($T_{4)}$. This was followed by FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (1.59 kg), T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP) (1.57 kg), T_7 (coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP) (1.52 kg), T_6 (coirpith based vermicompost at 10 t ha^{-1} + 25 % of soil test based KAU POP) (1.50kg) and T_{11} (FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP) (1.43 kg) which was comparable with each other. Signficantly the lowest value was observed in absolute control (0.80 kg) (Table 17).

Table 16. Effect of different treatments on growth components of tomato

Treatments	No. of fruits per plant	Fruit weight (g)	Days to flowering	DMP (kg ha^{-1})
T_1: Absolute control	25.3	31.60	29.7	889
T_2: Coirpith compost at 10 t ha^{-1}	30.7	32.67	28.3	930
T_3: Coirpith based vermicompost at 10 t ha^{-1}	30.0	34.50	26.7	987
T_4: T_3 + 100 % of soil test based KAU POP	44.0	42.00	28.7	1262
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	37.7	42.17	27.7	1238
T_6: T_3 + 25% of soil test based KAU POP	38.0	40.03	27.3	1214
T_7: T_3 + 50% of soil test based KAU POP	37.7	40.03	27.7	1219
T_8: T_3 + 75% of soil test based KAU POP	37.0	42.33	27.7	1249
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	35.7	35.00	28.7	1201
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	35.7	36.83	26.7	1215
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	38.7	37.00	29.0	1218
T_{12}: *Adhoc* KAU organic POP	36.0	36.00	27.3	1118
CD (0.05)	**3.9**	**4.01**	**1.4**	**59**

4.3.2.7. Yield per plot (9 m^2)

In case of per plot yield, there was significant difference between the treatments (Table 17). Significantly the highest per plot yield (46.11 kg) was observed in T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP) followed by FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (39.83 kg), coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (39.12 kg), coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP (38.02 kg) and coirpith based vermicompost at 10 t ha^{-1}+ 25 % of soil test based KAU POP (37.64 kg) which was on par with each other. Significantly the lowest yield was observed in absolute control (0.837 kg).

Table 17. Effect of different treatments on yield of tomato

Treatments	Yield per plant (kg)	Yield per plot (kg 9m^{-2})
T_1: Absolute control	0.80	20.1
T_2: Coirpith compost at 10 t ha^{-1}	1.00	25.0
T_3: Coirpith based vermicompost at 10 t ha^{-1}	1.03	25.8
T_4: T_3 + 100 % of soil test based KAU POP	1.84	46.1
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	1.59	39.8
T_6: T_3 + 25% of soil test based KAU POP	1.50	37.6
T_7: T_3 + 50% of soil test based KAU POP	1.52	38.0
T_8: T_3 + 75% of soil test based KAU POP	1.57	39.1
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	1.25	31.2
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	1.32	32.9
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	1.43	35.7
T_{12}: *Adhoc* KAU organic POP	1.29	32.3
CD (0.05)	**0.19**	**4.7**

4.3.3. Effect of treatments on quality attributes of tomato fruit

4.3.3.1. Total soluble solids (TSS)

The TSS of fruit as influenced by different treatments is presented in the Table 18. Higher TSS (5.17^{o}B) was associated with FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP though it was comparable with coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP, coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP and coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP. The lowest TSS (4.03^{o}B) was noticed in T_1 (absolute control).

4.3.3.2. Titrable acidity

By examining the data in Table 18 it is clear that there was a significant difference in titrable acidity of tomato due to various treatments. Higher titrable acidity (1.11 %) was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP which was on par with FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP, FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP and FYM at 20 t ha^{-1} + 50 % of soil test based KAU POP. Significantly the lowest titrable acidity (0.54 %) was obtained in absolute control.

4.3.3.3. Ascorbic acid

Perusal of the data in Table 18 revealed that there was significant difference in ascorbic acid content of tomato due to application of treatments. The highest ascorbic acid content (24.40 mg 100 g^{-1}) was noticed in coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP which were on par with other treatments except FYM at 20 t ha^{-1} + 25 % of soil test based KAU POP, T_2 (coirpith compost at 10 t ha^{-1}) , T_{12} (*Adhoc* KAU organic POP) and T_1. Ascorbic acid content in the fruit was the lowest (17.67 mg 100 g^{-1}) in control plot.

4.3.3.4. Lycopene

Data from Table 18 revealed that higher lycopene content (4.50 mg 100 g^{-1}) was associated with coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (T_8) which was comparable with coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP (T_7). Lower lycopene content (3.07 mg 100 g^{-1}) was registered in absolute control which was on par with T_{12} (*Adhoc* KAU organic POP).

4.3.4. Effect of treatments on nutrient content of tomato

4.3.4.1. Nitrogen

From the Table 19 it is clear that nitrogen content in plant was the highest (1.63 per cent) in the treatments which received coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4) which was on par with all other treatments except T_2 (coirpith compost at 10 t ha^{-1}), T_3 (coirpith based vermicompost at 10 t ha^{-1}) and T_9 (FYM at 20 t ha^{-1} + 25 % of soil test based KAU POP). The lowest nitrogen content (0.80 %) was observed in absolute control (T_1).

With respect to the N content in tomato fruit, coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP exhibited higher nitrogen content (2.92 %) which was on par with all other treatments except control.

4.3.4.2. Phosphorous

The phosphorous content in tomato plant as influenced by different treatments is presented in Table 19. Higher phosphorous content (0.32 per cent) was recorded in plots that received coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP which was comparable with all other treatments except control, which recorded the lowest (0.12 per cent).

Table 18. Effect of different treatments on quality attributes of tomato fruit

Treatments	TSS (^oB)	Titrable acidity (%)	Ascorbic acid (mg $100g^{-1}$)	Lycopene (mg $100g^{-1}$)
T_1: Absolute control	4.03	0.54	17.67	3.07
T_2: Coirpith compost at 10 t ha^{-1}	4.20	0.73	22.43	3.60
T_3: Coirpith based vermicompost at 10 t ha^{-1}	4.07	0.85	23.17	3.73
T_4: T_3 + 100 % of soil test based KAU POP	5.10	1.11	24.40	4.23
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	5.17	1.11	23.93	4.23
T_6: T_3 + 25% of soil test based KAU POP	4.30	0.95	23.10	4.20
T_7: T_3 + 50% of soil test based KAU POP	4.93	0.93	24.00	4.43
T_8: T_3 + 75% of soil test based KAU POP	5.03	1.00	23.50	4.50
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	4.10	0.88	22.50	4.03
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	4.50	1.03	23.27	4.17
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	4.53	1.07	24.33	4.33
T_{12}: *Adhoc* KAU organic POP	4.10	0.89	22.10	3.40
CD (0.05)	**0.30**	**0.16**	**1.54**	**0.40**

In case of fruit, the treatment T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP) showed higher phosphorous content (0.5 %) which was comparable with T_7 (coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP) and T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP). Significantly low phosphorous content (0.25 per cent) was registered by control plot.

4.3.4.3. Potassium

It is evident from the data (Table 19), that application of different treatments could bring about a significant effect on plant potassium content. The plants that received coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP contained higher potassium content (3.43 %) which was on par with coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP, FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP and coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP. Lower potassium content (2.07 %) was recorded in plants from control plot.

Significantly higher potassium content in tomato fruit (3.07 %) was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP followed by coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP. Control plots registered lower potassium content (2.03 %).

4.3.4.4. Calcium

Treatment effect was significant as regard to calcium content in tomato plant (Table 20). The treatment T_4 (coirpith based vermicompost at 10 t ha^{-1} +100 % of soil test based KAU POP) registered the highest content of calcium (1.51%) which was comparable with other treatments except *Adhoc* KAU organic POP and absolute control.

Higher calcium content in tomato fruit (0.24 %) was noticed in FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP which were comparable with coirpith based

Table 19. Effect of different treatments on major nutrient (%) content of tomato

Treatments	N		P		K	
	Plant	Fruit	Plant	Fruit	Plant	Fruit
T_1: Absolute control	0.80	1.62	0.12	0.25	2.07	2.03
T_2: Coirpith compost at 10 t ha^{-1}	1.30	2.6	0.21	0.33	2.25	2.20
T_3: Coirpith based vermicompost at 10 t ha^{-1}	1.33	2.27	0.26	0.35	2.77	2.26
T_4: T_3 + 100 % of soil test based KAU POP	1.63	2.92	0.32	0.52	3.43	3.07
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	1.53	2.85	0.31	0.51	3.20	2.53
T_6: T_3 + 25% of soil test based KAU POP	1.53	2.69	0.29	0.42	2.67	2.40
T_7: T_3 + 50% of soil test based KAU POP	1.57	2.51	0.28	0.46	3.20	2.70
T_8: T_3 + 75% of soil test based KAU POP	1.53	2.72	0.31	0.53	3.27	2.80
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	1.30	2.5	0.29	0.36	2.53	2.31
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	1.43	2.9	0.25	0.42	2.75	2.44
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	1.57	2.87	0.28	0.46	2.88	2.50
T_{12}: *Adhoc* KAU organic POP	1.37	2.33	0.24	0.33	2.57	2.11
CD (0.05)	**0.3**	**0.66**	**0.05**	**0.05**	**0.37**	**0.19**

vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP, coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP and coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP. Control plot registered significantly lower calcium content (0.11%) which was on par with T_2 (coirpith compost at 10 t ha^{-1}).

4.3.4.5. Magnesium

Statistical scrutiny of the data presented in Table 20 revealed that, there was a significant difference between treatments tried with respect to magnesium content in tomato plants. FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP recorded significantly higher magnesium content (0.60 %). The content of magnesium was significantly lower (0.18 %) in control plot.

Magnesium content of tomato fruit did not vary significantly due to applied treatments.

4.3.4.6. Sulphur

Data pertaining to the effect of various treatments on the content of sulphur in tomato plants is presented in Table 20. The plant sulphur content was higher (0.77 %) in coirpith based vermicompost at 10 t ha^{-1} + 25 % of soil test based KAU POP which was comparable with all other treatments except T_2 (coirpith compost at 10 t ha^{-1}), T_{12} (*Adhoc* KAU organic POP), FYM at 20 t ha^{-1} + 50 % of soil test based KAU POP and T_1.

As regards the fruit, FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP registered higher content of sulphur (0.39 %) which was on par with all other treatments except control.

Table 20. Effect of different treatments on secondary nutrient (%) content of tomato

Treatments	Ca		Mg		S	
	Plant	Fruit	Plant	Fruit	Plant	Fruit
T_1: Absolute control	0.63	0.11	0.18	0.12	0.63	0.10
T_2: Coirpith compost at 10 t ha^{-1}	1.22	0.13	0.26	0.13	0.72	0.29
T_3: Coirpith based vermicompost at 10 t ha^{-1}	1.45	0.18	0.52	0.13	0.74	0.32
T_4: T_3 + 100 % of soil test based KAU POP	1.51	0.22	0.46	0.14	0.75	0.33
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	1.43	0.24	0.60	0.15	0.76	0.39
T_6: T_3 + 25% of soil test based KAU POP	1.36	0.18	0.34	0.14	0.77	0.33
T_7: T_3 + 50% of soil test based KAU POP	1.36	0.21	0.36	0.15	0.73	0.32
T_8: T_3 + 75% of soil test based KAU POP	1.39	0.24	0.39	0.15	0.74	0.34
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	1.35	0.16	0.32	0.14	0.73	0.35
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	1.37	0.18	0.35	0.14	0.71	0.34
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	1.38	0.21	0.35	0.14	0.74	0.34
T_{12}: *Adhoc* KAU organic POP	1.15	0.18	0.24	0.12	0.72	0.37
CD (0.05)	**0.31**	**0.04**	**0.06**	**NS**	**0.04**	**0.11**

4.3.4.7. Iron

Application of different treatments had significant effect on iron content in plant (Table 21). Higher iron content (1232mg kg^{-1}) was obtained when coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4) was applied which was on par with (T_8) coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP. Significantly the lower iron content (771mg kg^{-1}) was recorded in control plots.

The content of iron in tomato fruit was higher (91.2 mg kg^{-1}) in FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP which was on par with coirpith based vermicompost at 10 t ha^{-1}+ 75 % of soil test based KAU POP and coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP. Significantly the lower iron content (69.3 mg kg^{-1}) was noticed in control plot.

4.3.4.8. Manganese

The data furnished in Table 21 shows the positive effect of different treatments on manganese content in plant. T_3 (coirpith based vermicompost at 10 t ha^{-1}) recorded higher manganese content (154.7 mg kg^{-1}) which was comparable with coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP. Plants with significantly low manganese content (125.0 mg kg^{-1}) was obtained from control plot.

The content of manganese in fruit was higher (27.3 mg kg^{-1}) in T_6 (coirpith based vermicompost at 10 t ha^{-1} + 25 % of soil test based KAU POP) which was on par with T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP), T_6 (coirpith based vermicompost at 10 t ha^{-1}+ 25 % of soil test based KAU POP)and T_4 (coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP). Significantly the lowest manganese content (17.3 mg kg^{-1}) was observed in control plots.

4.3.4.9. Zinc

Perusal of the data in Table 21 revealed that there was a significant difference in zinc content of tomato plant due to different treatments applied. Zinc content was higher (179.0 mg kg^{-1}) in FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP which was on par with T_7 (coirpith based vermicompost at 10 t ha^{-1}+ 50 % of soil test based KAU POP and FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP. Control plots exhibited significantly lower zinc content (80.0 mg kg^{-1})

There was a significant difference in zinc content of tomato following treatment application. FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP showed higher zinc content (47.7 mg kg^{-1}) which was comparable with coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP and coirpith based vermicompost at 10 t ha^{-1} +100 % of soil test based KAU POP. Significantly low zinc content (33.0 mg kg^{-1}) was observed in control plot.

4.3.4.10. Copper

There was a significant difference between treatments with respect to copper content (Table 21). T_3 (coirpith based vermicompost at 10 t ha^{-1}) registered significantly higher copper content (53.0 mg kg^{-1}) followed by T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP. Copper content in control plots was significantly lower (17.5 mg kg^{-1}) but was on par with T_{12} (*Adhoc* KAU organic POP).The content of Cu in fruit did not vary much among the treatments.

4.3.4.11. Boron

From the data in Table 21, it can be concluded that, there was an increase in boron content in all the treatments studied. However, T_5 (FYM at 20 t ha-1 + 100% of soil test based KAU POP) registered higher boron content (12.3 mg kg^{-1}) which was comparable with all other treatments, except control. There was no significant difference between treatments with respect to boron content in tomato.

Table 21. Effect of different treatments on micronutrient content (mg kg^{-1}) of tomato

Treatments	Fe		Mn		Zn		Cu		B	
	Plant	**Fruit**	**Plant**	**Fruit**	**Plant**	**Fruit**	**Plant**	**Fruit**	**Plant**	**Fruit**
T_1: Absolute control	771	69.3	125	17.3	80	33.0	17.5	8.1	11.2	10.03
T_2: Coirpith compost at 10 t ha^{-1}	905	82.0	137	22.0	126	45.0	21.0	12.7	11.4	10.73
T_3: Coirpith based vermicompost at 10 t ha^{-1}	940	85.5	155	23.3	128	46.0	53.0	13.8	12.0	11.23
T_4: T_3 + 100 % of soil test based KAU POP	1232	89.1	151	24.8	154	47.3	25.0	14.5	12.3	10.83
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	1122	91.2	145	26.3	179	47.7	33.3	13.8	12.3	11.07
T_6: T_3 + 25% of soil test based KAU POP	1112	86.5	142	27.3	154	43.5	21.0	13.9	12.3	10.57
T_7: T_3 + 50% of soil test based KAU POP	1115	84.7	144	25.0	173	44.7	24.0	13.7	12.2	10.67
T_8: T_3 + 75% of soil test based KAU POP	1193	89.7	145	24.0	163	47.7	24.7	13.5	12.1	10.80
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	1037	83.2	137	21.3	133	42.0	22.0	13.2	12.0	10.77
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	1025	83.0	138	24.0	153	46.0	27.7	13.0	12.3	10.20
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	1079	87.0	142	23.7	170	42.3	31.3	13.2	12.4	10.90
T_{12}: *Adhoc* KAU organic POP	851	73.7	128	20.0	134	37.7	17.7	13.1	12.1	10.67
CD (0.05)	**63**	**3.8**	**4**	**2.7**	**14**	**3.5**	**1.5**	**NS**	**3.2**	**NS**

4.3.5. Effect of treatments on uptake of nutrient by tomato crop

4.3.5.1. Nitrogen

The perusal of the data in Table 22 showed that the nitrogen uptake by tomato plant differed significantly due to treatments imposed. The highest nitrogen uptake (75.44 kg ha^{-1}) by tomato plant was noticed in the treatment coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4) followed by T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP).

The uptake of nitrogen by tomato fruit differed significantly among the treatments (Table 22). The highest uptake of nitrogen by fruit (49.86 kg ha^{-1}) was observed in the treatment coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4) which was comparable with coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (T_8) and FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (T_5).

Total uptake of nitrogen by tomato varied significantly among treatments (Table 22). Significantly the highest nitrogen uptake (125.29 kg ha^{-1}) was observed in the treatment that received coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4). Uptake of N by plant, fruit and the total was significantly lowest in absolute control.

4.3.5.2. Phosphorous

The perusal of the data in Table 23 showed that the phosphorus uptake by tomato plant differed significantly due to treatment application. Significantly higher phosphorus uptake (24.40 kg ha^{-1}) by tomato plant was noticed in the treatments coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4), coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (T_8), coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP (T_7) which were comparable with each other.

The highest uptake of phosphorus by fruit (4.64 kg ha^{-1}) was found in the treatment that received coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4) which was on par with coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (T_8) and coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP (T_7).

Total uptake of phosphorus by tomato crop differed significantly among treatments (Table 23). Significantly the highest phosphorus uptake (29.07 kg ha^{-1}) was noticed in treatment that received coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based POP (T_4). Significantly the lowest uptake in case of plant, fruit and so the total vested with control plots.

Table 22. Effect of different treatments on the uptake of N by tomato

Treatments	**N uptake (kg ha^{-1})**		
	Plant	**Fruit**	**Total**
T_1: Absolute control	15.7	21.7	37.4
T_2: Coirpith compost at 10 t ha^{-1}	32.5	30.1	62.6
T_3: Coirpith based vermicompost at 10 t ha^{-1}	34.4	35.8	70.1
T_4: T_3 + 100 % of soil test based KAU POP	75.4	49.9	125.3
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	60.8	47.5	108.3
T_6: T_3 + 25% of soil test based KAU POP	58.3	44.8	103.1
T_7: T_3 + 50% of soil test based KAU POP	59.1	45.8	104.9
T_8: T_3 + 75% of soil test based KAU POP	60.1	48.6	108.7
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	40.6	40.5	81.1
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	47.7	42.6	90.4
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	56.1	41.0	97.1
T_{12}: *Adhoc* KAU organic POP	44.1	34.2	78.3
CD (0.05)	**12.9**	**3.9**	**13.7**

Table 23. Effect of different treatments on the uptake of P by tomato

Treatments	P uptake (kg ha^{-1})		
	Plant	Fruit	Total
T_1: Absolute control	6.02	1.60	7.60
T_2: Coirpith compost at 10 t ha^{-1}	8.50	2.14	10.63
T_3: Coirpith based vermicompost at 10 t ha^{-1}	9.20	2.63	11.83
T_4: T_3 + 100 % of soil test based KAU POP	24.40	4.64	29.07
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAUPOP	19.35	4.25	23.57
T_6: T_3 + 25% of soil test based KAU POP	15.20	3.36	18.57
T_7: T_3 + 50% of soil test based KAU POP	16.43	3.33	19.77
T_8: T_3 + 75% of soil test based KAU POP	19.56	4.41	23.97
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	11.33	2.76	14.10
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	14.0	3.28	17.23
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	15.83	3.25	19.07
T_{12}: *Adhoc* KAU organic POP	10.24	2.24	12.47
CD (0.05)	**2.0**	**0.62**	**1.91**

4.3.5.3. Potassium

The data on potassium uptake by tomato crop differed significantly due to various treatments imposed (Table 24). Coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4) recorded higher potassium uptake (138.78 kg ha^{-1}).

As regards the K uptake by fruit, coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4) registered higher potassium uptake (43.3 kg ha^{-1}) which was comparable with coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (T_8). The lowest uptake (18.4) of potassium was found in absolute control (T_1) which was on par with coirpith compost at 10 t ha^{-1} (T_2).

The total K uptake was significantly higher (182.10 kg ha^{-1}) in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4). The uptake of K by plant and the total uptake was significantly lower in absolute control (T_1).

Table 24. Effect of different treatments on the uptake of K by tomato

Treatments	K uptake (kg ha^{-1})		
	Plant	Fruit	Total
T_1: Absolute control	40.8	18.4	59.2
T_2: Coirpith compost at 10 t ha^{-1}	55.0	20.9	75.9
T_3: Coirpith based vermicompost at 10 t ha^{-1}	58.3	27.3	85.6
T_4: T_3 + 100 % of soil test based KAU POP	138.8	43.3	182.1
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	108.7	39.7	148.4
T_6: T_3 + 25% of soil test based KAU POP	91.2	32.4	123.6
T_7: T_3 + 50% of soil test based KAU POP	97.9	39.0	136.9
T_8: T_3 + 75% of soil test based KAU POP	109.6	40.9	150.5
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	72.2	30.5	102.6
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	79.5	33.4	112.9
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	86.9	35.2	122.1
T_{12}: *Adhoc* KAU organic POP	65.5	25.9	91.3
CD (0.05)	**12.4**	**4.8**	**13.2**

4.3.5.4. Calcium

The data on calcium uptake by tomato crop showed significant difference among treatments (Table 25). Significantly higher calcium uptake by plant (10.29 kg ha^{-1}) was noticed in coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4). However the lowest uptake (2.39 kg ha^{-1}) was noted in absolute control (T_1) which was comparable with coirpith compost at 10 t ha^{-1} (T_2).

Significantly higher uptake of calcium (18.57 kg ha^{-1}) by fruit was noticed in coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4) which was on par with FYM at 20 t ha^{-1} + soil test based KAU POP (T_5).

The total uptake of calcium by tomato crop differed significantly among different treatments imposed. Significantly the highest uptake of calcium by tomato crop (28.85 kg ha^{-1}) was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4). The uptake of Ca by fruit and the total uptake was significantly lower (10.99 kg ha^{-1}) in absolute control (T_1).

Table 25. Effect of different treatments on the uptake of Ca by tomato

Treatments	Ca uptake (kg ha^{-1})		
	Plant	**Fruit**	**Total**
T_1: Absolute control	2.39	8.6	10.9
T_2: Coirpith compost at 10 t ha^{-1}	3.16	12.3	15.4
T_3: Coirpith based vermicompost at 10 t ha^{-1}	3.88	15.1	18.9
T_4: T_3 + 100 % of soil test based KAU POP	10.29	18.6	28.8
T_5: FYM at 20 t ha^{-1} +100 % of soil test based KAU POP	9.07	17.8	26.9
T_6: T_3 + 25% of soil test based KAU POP	6.33	15.9	22.3
T_7: T_3 + 50% of soil test based KAU POP	7.41	16.8	24.2
T_8: T_3 + 75% of soil test based KAU POP	9.13	17.4	26.5
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	4.16	16.0	20.2
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	5.49	16.7	22.2
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	6.90	16.8	23.7
T_{12}: *Adhoc* KAU organic POP	3.77	10.5	14.2
CD (0.05)	**1.04**	**0.9**	**1.4**

4.3.5.5. Magnesium

The perusal of the data in Table 26 showed that, magnesium uptake by tomato plant differed significantly due to different treatments. Highest magnesium uptake (6.46 kg ha^{-1}) by tomato plant was noticed in the treatment coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4) which was on par with FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (T_5) and coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (T_8). Lowest uptake of calcium by tomato crop (2.41 kg ha^{-1}) was noticed in absolute control (T_1) which was comparable with coirpith compost at 10 t ha^{-1} (T_2).

Significantly highest uptake of magnesium by fruit (7.43 kg ha^{-1}) was noted in the treatment FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (T_5). However, significantly lowest uptake (1.60 kg ha^{-1}) was noticed in absolute control (T_1).

Highest total magnesium uptake (13.34 kg ha^{-1}) was noticed in FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (T_5) which was comparable with coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4). Significantly lowest uptake (4.01 kg ha^{-1}) was seen in absolute control (T_1).

Table 26. Effect of different treatments on the uptake of Mg by tomato

Treatments	**Mg uptake (kg ha^{-1})**		
	Plant	**Fruit**	**Total**
T_1: Absolute control	2.41	1.60	4.01
T_2: Coirpith compost at 10 t ha^{-1}	3.33	2.42	5.75
T_3: Coirpith based vermicompost at 10 t ha^{-1}	3.43	5.17	8.60
T_4: T_3 + 100 % of soil test based KAU POP	6.46	5.81	12.27
T_5: FYM at 20 t ha^{-1} +100 % of soil test based KAU POP	5.91	7.43	13.34
T_6: T_3 + 25% of soil test based KAU POP	5.44	4.17	9.61
T_7: T_3 + 50% of soil test based KAU POP	5.49	4.43	9.92
T_8: T_3 + 75% of soil test based KAU POP	5.75	4.96	10.71
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	4.47	3.80	8.27
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	4.61	4.22	8.83
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	4.98	4.30	9.28
T_{12}: *Adhoc* KAU organic POP	3.88	2.41	6.29
CD (0.05)	**0.92**	**0.74**	**1.07**

4.3.5.6. Sulphur

The data on sulphur uptake by tomato crop showed a significant difference among treatments (Table 27). The uptake of sulphur by plant was higher (17.51 kg ha^{-1}) with coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4). Highest sulphur uptake by fruit (9.51kg ha^{-1}) was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4) which was comparable with FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (T_5).

Regarding the total S uptake, significantly highest value (27.02 kg ha^{-1}) was registered by coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4). Uptake of S by plant, fruit and total was found be significantly lowest in absolute control.

Table 27. Effect of different treatments on the uptake of S by tomato

Treatments	S uptake (kg ha^{-1})		
	Plant	**Fruit**	**Total**
T_1: Absolute control	5.57	5.61	11.19
T_2: Coirpith compost at 10 t ha^{-1}	8.09	6.74	14.83
T_3: Coirpith based vermicompost at 10 t ha^{-1}	8.69	7.34	16.03
T_4: T_3 + 100% of soil test based KAU POP	17.51	9.51	27.02
T_5: FYM at 20 t ha^{-1} +100 % of soil test based KAU POP	13.36	9.45	22.81
T_6: T_3 + 25% of soil test based KAU POP	12.42	9.35	21.77
T_7: T_3 + 50% of soil test based KAU POP	12.17	8.90	21.06
T_8: T_3 + 75% of soil test based KAU POP	14.34	9.24	23.59
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	10.61	8.77	19.37
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	10.29	8.63	18.92
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	14.13	9.02	23.15
T_{12}: *Adhoc* KAU organic POP	9.82	7.22	17.03
CD (0.05)	**2.40**	**0.70**	**2.30**

4.3.5.7. Iron

The data on iron uptake by tomato plant showed significant difference among treatments (Table 28). Significantly higher uptake by plant (0.410 kg ha^{-1}) was found in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4). In case of fruit, highest uptake of iron (1.553 kg ha^{-1}) was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4) which was comparable with coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (T_8).

The total uptake of iron by tomato crop differed significantly among different treatments imposed. Significantly highest uptake of iron (1.967 kg ha^{-1}) by tomato crop was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4) which was comparable with coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (T_8). The uptake of Fe by plant, fruit and total was found be significantly lowest in absolute control.

4.3.5.8. Manganese

The data on manganese uptake by tomato crop showed significant difference among different treatments (Table 29). Significantly highest manganese uptake (0.117 kg ha^{-1}) was noted in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4). Highest manganese uptake by fruit (0.190 kg ha^{-1}) was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4) which was comparable with coirpith based vermicompost at 10 t ha^{-1} +75 % of soil test based KAU POP (T_8).

Regarding the total Mn uptake, significantly highest value (0.310 kg ha^{-1}) was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4). Control plots recorded significantly lowest Mn uptake.

Table 28. Effect of different treatments on the uptake of Fe by tomato

Treatments	Fe uptake (kg ha^{-1})		
	Plant	**Fruit**	**Total**
T_1: Absolute control	0.153	0.683	0.833
T_2: Coirpith compost at 10 t ha^{-1}	0.210	0.843	1.057
T_3: Coirpith based vermicompost at 10 t ha^{-1}	0.233	0.927	1.160
T_4: T_3 + 100 % of soil test based KAU POP	0.410	1.553	1.967
T_5: FYM at 20 t ha^{-1}+100 % of soil test based KAU POP	0.363	1.387	1.753
T_6: T_3 + 25% of soil test based KAU POP	0.333	1.350	1.677
T_7: T_3 + 50% of soil test based KAU POP	0.330	1.360	1.687
T_8: T_3 + 75% of soil test based KAU POP	0.363	1.490	1.853
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	0.260	1.243	1.503
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	0.273	1.243	1.523
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	0.310	1.317	1.627
T_{12}: *Adhoc* KAU organic POP	0.250	0.860	1.107
CD (0.05)	**0.04**	**0.08**	**0.07**

Table 29. Effect of different treatments on the uptake of Mn by tomato

Treatments	Mn uptake (kg ha^{-1})		
	Plant	**Fruit**	**Total**
T_1: Absolute control	0.037	0.107	0.147
T_2: Coirpith compost at 10 t ha^{-1}	0.057	0.127	0.180
T_3: Coirpith based vermicompost at 10 t ha^{-1}	0.070	0.153	0.223
T_4: T_3 + 100 % of soil test based KAU POP	0.117	0.190	0.310
T_5: FYM at 20 t ha^{-1} +100 % of soil test based KAU POP	0.103	0.177	0.280
T_6: T_3 + 25% of soil test based KAU POP	0.093	0.170	0.260
T_7: T_3 + 50% of soil test based KAU POP	0.093	0.177	0.263
T_8: T_3 + 75% of soil test based KAU POP	0.093	0.183	0.277
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	0.067	0.163	0.230
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	0.077	0.173	0.250
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	0.093	0.173	0.267
T_{12}: *Adhoc* KAU organic POP	0.063	0.130	0.197
CD (0.05)	**0.01**	**0.01**	**0.01**

4.3.5.9. Zinc

The perusal of the data in Table 30 showed significant difference in zinc uptake by tomato plant due to treatments. Significantly highest uptake by plant (0.220 kg ha^{-1}) was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4). With respect to the fruit, the highest uptake of zinc (0.220 kg ha^{-1}) was registered in FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (T_5) which was comparable with coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP (T_7), FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP (T_{11}) and coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (T_8).

Total uptake of zinc by tomato crop differed significantly among various treatments. Significantly the highest zinc uptake (0.410 kg ha^{-1}) was noticed in coirpith based vermicompost at 10 t ha^{-1} +100 % of soil test based KAU POP (T_4) which was comparable with FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (T_5). The uptake of Zn by plant, fruit and so the total was found be significantly lowest in absolute control.

4.3.5.10. Copper

The perusal of the data in Table 31 showed that copper uptake by tomato crop varied significantly due to treatments applied. The uptake of copper was higher (0.060 kg ha^{-1}) in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4) which was comparable with coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (T_8) and FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (T_5).

The uptake of copper by tomato fruit differed significantly among different treatments. Significantly the highest uptake of copper (0.050 kg ha^{-1}) was recorded by T_3 (coirpith based vermicompost at 10 t ha^{-1}).

Total uptake of copper by tomato crop varied significantly among treatments. Highest copper uptake (0.090 kg ha^{-1}) was noticed in FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (T_5) which was comparable with coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4) and T_3 (coirpith based vermicompost at 10 t ha^{-1}). Significantly the lowest Cu uptake (plant, fruit and total) was observed in absolute control.

Table 30. Effect of different treatments on the uptake of Zn by tomato

Treatments	**Zn uptake (kg ha^{-1})**		
	Plant	**Fruit**	**Total**
T_1: Absolute control	0.067	0.070	0.137
T_2: Coirpith compost at 10 t ha^{-1}	0.113	0.120	0.230
T_3: Coirpith based vermicompost at 10 t ha^{-1}	0.117	0.127	0.247
T_4: T_3 + 100 % of soil test based KAU POP	0.220	0.193	0.413
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	0.190	0.220	0.410
T_6: T_3 + 25% of soil test based KAU POP	0.167	0.187	0.350
T_7: T_3 + 50% of soil test based KAU POP	0.170	0.210	0.380
T_8: T_3 + 75% of soil test based KAU POP	0.187	0.203	0.390
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	0.130	0.163	0.293
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	0.150	0.187	0.337
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	0.150	0.207	0.360
T_{12}: *Adhoc* KAU organic POP	0.123	0.137	0.257
CD (0.05)	**0.02**	**0.02**	**0.02**

Table 31. Effect of different treatments on the uptake of Cu by tomato

Treatments	Cu uptake (kg ha^{-1})		
	Plant	**Fruit**	**Total**
T_1: Absolute control	0.027	0.017	0.043
T_2: Coirpith compost at 10 t ha^{-1}	0.033	0.020	0.053
T_3: Coirpith based vermicompost at 10 t ha^{-1}	0.037	0.050	0.090
T_4: T_3 + 100 % of soil test based KAU POP	0.060	0.030	0.093
T_5: FYM at 20 t ha^{-1} +100 % of soil test based KAU POP	0.053	0.040	0.093
T_6: T_3 + 25% of soil test based KAU POP	0.050	0.027	0.077
T_7: T_3 + 50% of soil test based KAU POP	0.050	0.030	0.080
T_8: T_3 + 75% of soil test based KAU POP	0.053	0.030	0.083
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	0.040	0.030	0.070
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	0.043	0.030	0.077
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	0.043	0.040	0.083
T_{12}: *Adhoc* KAU organic POP	0.040	0.020	0.060
CD (0.05)	**0.009**	**0.004**	**0.008**

4.3.5.11. Boron

The perusal of the data in Table 32 showed that boron uptake by tomato plant was found to be significant due to different treatment application. Highest boron uptake (0.050 kg ha^{-1}) was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4). Uptake of boron by tomato fruit did not differed significantly among different treatments.

Highest total boron uptake (0.067 kg ha^{-1}) was noticed in the treatment that received coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4). Significantly lowest B uptake was registered by control plots.

Table 32. Effect of different treatments on the uptake of B by tomato

Treatments	B uptake (kg ha^{-1})		
	Plant	**Fruit**	**Total**
T_1: Absolute control	0.020	0.010	0.030
T_2: Coirpith compost at 10 t ha^{-1}	0.027	0.010	0.040
T_3: Coirpith based vermicompost at 10 t ha^{-1}	0.030	0.010	0.040
T_4: T_3 + 100 % of soil test based KAU POP	0.050	0.017	0.067
T_5: FYM at 20 t ha^{-1} +100 % of soil test based KAU POP	0.043	0.020	0.060
T_6: T_3 + 25% of soil test based KAU POP	0.040	0.013	0.057
T_7: T_3 + 50% of soil test based KAU POP	0.040	0.013	0.053
T_8: T_3 + 75% of soil test based KAU POP	0.043	0.017	0.057
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	0.030	0.010	0.050
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	0.033	0.017	0.050
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	0.040	0.017	0.053
T_{12}: *Adhoc* KAU organic POP	0.033	0.010	0.047
CD (0.05)	**0.006**	**NS**	**0.010**

4.3.6. Correlation analysis

Correlation analysis among the post-harvest soil properties revealed that pH had positive correlation with EC, OC, N, P, K, Ca, Mg, Fe, Mn, Zn, Cu, B and dehydrogenase activity**.** Sulphur had positive correlation with Mn, Cu, B, pH, OC, N, P, K, Ca, Mg, whereas, all other soil properties had significant correlation with each other (Table 33). Significant correlation existed among all soil properties and labile carbon fractions (Table 34). Significant and positive correlation existed between the carbon fractions (Table 35). Days to flowering maintained significant positive correlation only with fruit number. Whereas, all other growth components and yield were significantly and positively correlated (Table 36).

Soil properties exhibited significant correlation with growth components, yield and quality whereas ascorbic acid and sulphur content, days to flowering and soil properties (pH, EC, OC, CEC, Available P, Mg, S, Fe, Zn, Cu and B) were not significant. (Table 37). There was no significant correlation between days to flowering and any of the carbon fractions (WSC, HWSC, MBC, POXC and TOC) whereas, all other growth components, yield and quality showed significant correlation with carbon fractions (Table 38).

There was no significant correlation among fruit copper content and post-harvest soil properties. Fruit boron content however showed positive correlation with CEC, Mg, Zn and Cu. Magnesium content of fruit did not show significant correlation with pH, EC, CEC, OC, S and Fe (Table 39). Significant and positive correlation existed among available major, secondary and Fe, Mn, Zn content in fruit with carbon fractions. There was no significant correlation between Mg and TOC (Table 40).

Table 33. Correlation analysis among soil properties of the experimental soil after harvest

	pH	EC	OC	CEC	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B	DHy
pH	1.000															
EC	0.387*	1.000														
OC	0.713**	0.918**	1.000													
CEC	0.205^{NS}	0.422*	0.391*	1.000												
N	0.517**	0.566**	0.636**	0.437**	1.000											
P	0.389*	0.600**	0.608**	0.501**	0.672**	1.000										
K	0.466**	0.688**	0.702**	0.615**	0.770**	0.909**	1.000									
Ca	0.599**	0.609**	0.699**	0.541**	0.771**	0.849**	0.875**	1.000								
Mg	0.426**	0.614**	0.641**	0.579**	0.644**	0.823**	0.814**	0.764**	1.000							
S	0.253^{NS}	-0.017^{NS}	0.099^{NS}	0.151^{NS}	0.459**	0.401*	0.399*	0.374*	0.484**	1.000						
Fe	0.585**	0.349*	0.489**	0.397*	0.588**	0.625**	0.721**	0.661**	0.520**	0.327^{NS}	1.000					
Mn	0.463**	0.679**	0.700**	0.595**	0.798**	0.897**	0.954**	0.899**	0.806**	0.427**	0.654**	1.000				
Zn	0.454**	0.636**	0.664**	0.511**	0.452**	0.666**	0.634**	0.656**	0.718**	0.100^{NS}	0.446**	0.646**	1.000			
Cu	0.390*	0.596**	0.597**	0.407*	0.541**	0.657**	0.671**	0.662**	0.671**	0.405*	0.397*	0.700**	0.723**	1.000		
B	0.532**	0.578**	0.655**	0.467**	0.657**	0.625**	0.665**	0.767**	0.691**	0.393*	0.498**	0.701**	0.435**	0.548**	1.000	
DHy	0.404*	0.525**	0.554**	0.433**	0.721**	0.761**	0.818**	0.654**	0.772**	0.540**	0.568**	0.827**	0.497**	0.591**	0.546**	1.000

Table 34. Correlation analysis between soil properties after crop harvest and carbon fractions

	WSC	HWSC	POXC	MBC	TC
pH	0.493**	0.482**	0.491**	0.575**	0.516**
EC	0.583**	0.606**	0.547**	0.644**	0.577**
OC	0.626**	0.646**	0.598**	0.710**	0.650**
CEC	0.605**	0.599**	0.636**	0.606**	0.440**
DHy	0.794**	0.750**	0.663**	0.745**	0.660**
N	0.797**	0.777**	0.654**	0.732**	0.654**
P	0.777**	0.906**	0.836**	0.879**	0.615**
K	0.868**	0.934**	0.838**	0.911**	0.711**
Ca	0.804**	0.910**	0.826**	0.901**	0.651**
Mg	0.696**	0.810**	0.811**	0.812**	0.651**
S	0.388*	0.461**	0.363*	0.438**	0.454**
Fe	0.648**	0.693**	0.636**	0.695**	0.593**
Mn	0.863**	0.930**	0.803**	0.882**	0.685**
Zn	0.436**	0.757**	0.871**	0.777**	0.468**
Cu	0.585**	0.781**	0.761**	0.754**	0.694**
B	0.700**	0.669**	0.583**	0.708**	0.608**

Table 35. Correlation analysis among the carbon fractions in the soil after crop harvest

	WSC	HWSC	POXC	MBC	TC
WSC	1.000				
HWSC	0.792**	1.000			
POXC	0.670**	0.932**	1.000		
MBC	0.780**	0.961**	0.941**	1.000	
TC	0.797**	0.663**	0.593**	0.667**	1.000

Table 36. Correlation analysis among the growth components, yield and quality attributes of tomato

	Plant height	Days to flowering	No. of fruits	Fruit weight	Yield	DMP	TSS	Acidity	Ascorbic	Lycopene
PLH	1.000									
Days to flowering	0.304^{NS}	1.000								
No. of fruits	0.899**	0.387*	1.000							
Fruit weight	0.829**	0.241^{NS}	0.815**	1.000						
Yield	0.946**	0.323^{NS}	0.908**	0.838**	1.000					
DMP	0.811**	0.325^{NS}	0.830**	0.700**	0.849**	1.000				
TSS	0.859**	0.388*	0.815**	0.748**	0.859**	0.716**	1.000			
Acidity	0.780**	0.245^{NS}	0.781**	0.616**	0.793**	0.783**	0.707**	1.000		
Ascorbic	0.715**	0.203^{NS}	0.725**	0.537**	0.729**	0.687**	0.649**	0.770**	1.000	
Lycopene	0.844**	0.254^{NS}	0.833**	0.772**	0.893**	0.843**	0.804**	0.725**	0.762**	1.000

Table 37. Correlation analysis between the growth components, yield, quality and soil properties

	PLH	Days to flowering	No. of fruits	Fruit weight	Yield	DMP	TSS	Acidity	Ascorbic	Lycopene
pH	0.579**	0.094^{NS}	0.423*	0.543**	0.487**	0.466**	0.536**	0.451**	0.588**	0.523**
EC	0.676**	0.058^{NS}	0.557**	0.598**	0.595**	0.463**	0.443**	0.338*	0.436**	0.591**
OC	0.788**	0.167^{NS}	0.642**	0.723**	0.695**	0.597**	0.600**	0.463**	0.581**	0.711**
CEC	0.463**	0.183^{NS}	0.518**	0.502**	0.558**	0.533**	0.449**	0.378*	0.516**	0.662**
DHy	0.834**	0.266^{NS}	0.783**	0.756**	0.882**	0.678**	0.724**	0.713**	0.610**	0.738**
N	0.786**	0.399*	0.772**	0.762**	0.788**	0.720**	0.780**	0.649**	0.599**	0.740**
P	0.842**	0.291^{NS}	0.856**	0.722**	0.873**	0.894**	0.727**	0.746**	0.682**	0.848**
K	0.916**	0.337*	0.912**	0.855**	0.968**	0.905**	0.838**	0.786**	0.737**	0.924**
Ca	0.879**	0.385*	0.856**	0.741**	0.845**	0.849**	0.836**	0.762**	0.726**	0.804**
Mg	0.775**	0.284^{NS}	0.795**	0.657**	0.807**	0.724**	0.674**	0.668**	0.673**	0.777**
S	0.335*	0.225^{NS}	0.453**	0.386*	0.439**	0.411*	0.407*	0.514**	0.296^{NS}	0.342*
Fe	0.665**	0.284^{NS}	0.681**	0.671**	0.684**	0.699**	0.690**	0.652**	0.617**	0.663**
Mn	0.916**	0.415*	0.904**	0.814**	0.946**	0.859**	0.856**	0.733**	0.699**	0.903**
Zn	0.600**	0.126^{NS}	0.635**	0.434**	0.611**	0.589**	0.451**	0.472**	0.763**	0.660**
Cu	0.636**	0.044^{NS}	0.646**	0.600**	0.672**	0.520**	0.486**	0.557**	0.651**	0.653**
B	0.744**	0.248^{NS}	0.696**	0.656**	0.683**	0.628**	0.600**	0.608**	0.458**	0.679**

Table 38. Correlation analysis between growth components, yield, quality and carbon fractions

	WSC	HWSC	POXC	MBC	TC
Plant height	0.855^{**}	0.852^{**}	0.736^{**}	0.853^{**}	0.719^{**}
Days to flowering	0.217^{NS}	0.312^{NS}	0.196^{NS}	0.262^{NS}	0.039^{NS}
No. of fruits	0.774^{**}	0.908^{**}	0.808^{**}	0.883^{**}	0.631^{**}
Fruit weight	0.842^{**}	0.749^{**}	0.635^{**}	0.750^{**}	0.759^{**}
Yield	0.874^{**}	0.906^{**}	0.795^{**}	0.881^{**}	0.742^{**}
Dry matter production	0.758^{**}	0.895^{**}	0.812^{**}	0.881^{**}	0.515^{**}
TSS	0.816^{**}	0.784^{**}	0.648^{**}	0.733^{**}	0.697^{**}
Acidity	0.755^{**}	0.793^{**}	0.740^{**}	0.805^{**}	0.576^{**}
Ascorbic	0.636^{**}	0.802^{**}	0.848^{**}	0.849^{**}	0.569^{**}
Lycopene	0.810^{**}	0.883^{**}	0.826^{**}	0.869^{**}	0.659^{**}

Table 39. Correlation analysis between nutrient content in tomato fruit and carbon fractions

		WSC	HWSC	POXC	MBC	TC
Nutrient content in fruit	**N**	0.651^{**}	0.705^{**}	0.746^{**}	0.768^{**}	0.504^{**}
	P	0.900^{**}	0.895^{**}	0.755^{**}	0.851^{**}	0.808^{**}
	K	0.860^{**}	0.853^{**}	0.720^{**}	0.812^{**}	0.790^{**}
	Ca	0.853^{**}	0.849^{**}	0.680^{**}	0.793^{**}	0.793^{**}
	Mg	0.354^{*}	0.590^{**}	0.549^{**}	0.526^{**}	0.319^{NS}
	S	0.574^{**}	0.547^{**}	0.542^{**}	0.618^{**}	0.517^{**}
	Fe	0.716^{**}	0.839^{**}	0.816^{**}	0.802^{**}	0.788^{**}
	Mn	0.582^{**}	0.725^{**}	0.702^{**}	0.717^{**}	0.658^{**}
	Zn	0.606^{**}	0.788^{**}	0.827^{**}	0.780^{**}	0.750^{**}
	Cu	-0.150^{NS}	0.032^{NS}	0.063^{NS}	0.023^{NS}	0.101^{NS}
	B	0.286^{NS}	0.310^{NS}	0.332^{*}	0.303^{NS}	0.303^{NS}

Table 40. Correlation analysis between nutrient content in fruit and soil properties after harvest

		Nutrient content in fruit										
		N	**P**	**K**	**Ca**	**Mg**	**S**	**Fe**	**Mn**	**Zn**	**Cu**	**B**
pH		0.529**	0.484**	0.526**	0.498**	0.149NS	0.391*	0.509**	0.353*	0.405*	0.026NS	0.317NS
EC		0.333*	0.545**	0.591**	0.531**	0.288NS	0.355*	0.559**	0.528**	0.493**	0.174NS	-0.007NS
OC		0.496**	0.666**	0.715**	0.670**	0.309NS	0.466**	0.660**	0.557**	0.523**	0.114NS	0.148NS
CEC		0.572**	0.564**	0.518**	0.493**	0.313NS	0.306NS	0.513**	0.401*	0.536**	-0.046NS	0.367*
Dehydrogenase activity		0.728**	0.849**	0.844**	0.728**	0.360*	0.554**	0.599**	0.546**	0.599**	-0.072NS	0.177NS
Available nutrient status	**N**	0.535**	0.820**	0.826**	0.770**	0.464**	0.377*	0.631**	0.499**	0.579**	-0.145NS	0.097NS
	P	0.681**	0.865**	0.819**	0.810**	0.557**	0.599**	0.731**	0.570**	0.640**	-0.050NS	0.200NS
	K	0.707**	0.951**	0.906**	0.902**	0.487**	0.589**	0.769**	0.659**	0.703**	0.018NS	0.167NS
	Ca	0.606**	0.876**	0.832**	0.884**	0.544**	0.527**	0.803**	0.608**	0.697**	0.011NS	0.256NS
	Mg	0.702**	0.805**	0.750**	0.726**	0.476**	0.624**	0.720**	0.631**	0.650**	-0.100NS	0.357*
	S	0.423*	0.506**	0.448**	0.454**	0.169NS	0.331*	0.306NS	0.316NS	0.338*	-0.157NS	0.078NS
	Fe	0.587**	0.692**	0.679**	0.686**	0.231NS	0.355*	0.572**	0.380*	0.550**	0.085NS	0.182NS
	Mn	0.642**	0.944**	0.933**	0.916**	0.513**	0.560**	0.792**	0.671**	0.676**	-0.022NS	0.246NS
	Zn	0.608**	0.541**	0.564**	0.490**	0.460**	0.466**	0.748**	0.649**	0.731**	0.124NS	0.423*
	Cu	0.436**	0.669**	0.669**	0.643**	0.443**	0.549**	0.860**	0.869**	0.771**	0.320NS	0.391*
	B	0.405*	0.711**	0.713**	0.697**	0.350*	0.448**	0.606**	0.518**	0.425**	-0.030NS	0.244NS

4.3.7. Path analysis

Path coefficients explaining the direct as well as the indirect effect of different carbon fractions on available N, P and S is presented in Table 41, 42 and 43, respectively. The direct effect of HWSC on available N, P and S was very high and positive. Considering the direct effect of WSC on available N and P, it was very high and medium (positive), respectively, whereas the effect on available S was high and negative. As regards the POXC, the direct effect was negative on available N and S. The direct effect of MBC on available S was high and positive, whereas the effect was medium but negative in case of available N. All other direct effects were negligible. With respect to the indirect effects of carbon fractions on available N, P and S, all the labile carbon fractions had very high indirect effect through HWSC and the effect was positive.

The direct and indirect effect of labile carbon fractions on DMP and fruit yield as indicated by path coefficients are given in Table 44 and 45 respectively. Direct effect of HWSC on DMP and yield was very high and positive, whereas the effect of WSC was high and positive. Regarding the MBC fraction, it had very high direct effect on DMP and medium direct effect on the yield. Considering the direct effect of POXC on DMP and yield, the effect was medium but negative. As in the case of available N, P and S, the indirect effect of different labile carbon fractions through HWSC was very high.

Table 46, indicating the direct and indirect effect of soil properties on the tomato yield revealed the very high and positive direct effect of organic carbon and available K on tomato yield. The direct effect of hot water soluble boron and dehydrogenase activity was medium and high (positive) respectively.

Table 41. Path coefficients of different fractions of carbon to available nitrogen

	WSC	HWSC	POXC	MBC	TC	Correlation coefficient
WSC	**0.421**	0.637	-0.164	-0.131	0.033	0.797
HWSC	0.333	**0.805**	-0.228	-0.161	0.027	0.777
POXC	0.282	0.750	**-0.244**	-0.157	0.024	0.654
MBC	0.328	0.774	-0.230	**-0.167**	0.028	0.732
TC	0.336	0.534	-0.145	-0.112	**0.041**	0.654

Table 42. Path coefficients of different fractions of carbon to available phosphorus

	WSC	HWSC	POXC	MBC	TC	Correlation coefficient
WSC	**0.217**	0.565	0.007	0.055	-0.067	0.777
HWSC	0.172	**0.713**	0.009	0.068	-0.055	0.906
POXC	0.146	0.664	**0.010**	0.066	-0.050	0.836
MBC	0.170	0.685	0.009	**0.070**	-0.056	0.879
TC	0.173	0.473	0.006	0.047	**-0.084**	0.615

Table 43. Path coefficients of different fractions of carbon to available sulphur

	WSC	HWSC	POXC	MBC	TC	Correlation coefficient
WSC	**-0.382**	0.699	-0.493	0.244	0.320	0.388
HWSC	-0.303	**0.882**	-0.685	0.301	0.266	0.461
POXC	-0.256	0.822	**-0.735**	0.295	0.238	0.363
MBC	-0.298	0.848	-0.692	**0.313**	0.267	0.438
TC	-0.305	0.585	-0.436	0.209	**0.401**	0.454

Table 44. Path coefficients of different fractions of carbon to DMP

	WSC	HWSC	POXC	MBC	TC	Correlation coefficient
WSC	**0.304**	0.518	-0.154	0.349	-0.257	0.758
HWSC	0.240	**0.654**	-0.214	0.430	-0.214	0.895
POXC	0.203	0.609	**-0.230**	0.421	-0.191	0.812
MBC	0.237	0.628	-0.216	**0.447**	-0.215	0.881
TC	0.242	0.434	-0.136	0.298	**-0.323**	0.515

Table 45. Path coefficients of different fractions of carbon to tomato yield

	WSC	HWSC	POXC	MBC	TC	Correlation coefficient
WSC	**0.300**	0.550	-0.181	0.139	0.067	0.874
HWSC	0.238	**0.694**	-0.252	0.171	0.056	0.906
POXC	0.201	0.647	**-0.270**	0.167	0.050	0.795
MBC	0.234	0.667	-0.254	**0.178**	0.056	0.881
TC	0.239	0.460	-0.160	0.118	**0.084**	0.742

Table 46. Path coefficients of soil properties after crop harvest and available nutrient status to the tomato yield

	pH	EC	OC	CEC	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B	DHy	Correlation coefficient
pH	**-0.340**	-0.274	0.569	-0.011	0.007	-0.052	0.435	0.001	-0.047	-0.014	-0.031	-0.004	0.036	0.009	0.070	0.132	0.487
EC	-0.132	**-0.707**	0.732	-0.023	0.008	-0.080	0.642	0.001	-0.068	0.001	-0.018	-0.006	0.051	0.014	0.076	0.172	0.663
OC	-0.242	-0.649	**0.798**	-0.021	0.009	-0.081	0.655	0.001	-0.071	-0.005	-0.026	-0.006	0.053	0.015	0.087	0.181	0.696
CEC	-0.070	-0.298	0.312	**-0.054**	0.006	-0.067	0.573	0.001	-0.064	-0.008	-0.021	-0.005	0.041	0.010	0.062	0.142	0.558
N	-0.176	-0.400	0.507	-0.024	**0.014**	-0.090	0.718	0.001	-0.072	-0.025	-0.031	-0.007	0.036	0.013	0.087	0.236	0.788
P	-0.132	-0.424	0.485	-0.027	0.009	**-0.133**	0.848	0.001	-0.091	-0.022	-0.033	-0.007	0.053	0.016	0.083	0.249	0.873
K	-0.159	-0.487	0.560	-0.033	0.011	-0.121	**0.932**	0.001	-0.090	-0.022	-0.038	-0.008	0.051	0.016	0.088	0.268	0.968
Ca	-0.204	-0.430	0.558	-0.029	0.011	-0.113	0.816	**0.001**	-0.085	-0.021	-0.035	-0.007	0.053	0.016	0.101	0.214	0.845
Mg	-0.145	-0.434	0.512	-0.031	0.009	-0.110	0.759	0.001	**-0.111**	-0.027	-0.027	-0.007	0.058	0.016	0.091	0.253	0.807
S	-0.086	0.012	0.079	-0.008	0.006	-0.054	0.372	0.000	-0.054	**-0.055**	-0.017	-0.004	0.008	0.010	0.052	0.177	0.439
Fe	-0.199	-0.247	0.390	-0.022	0.008	-0.083	0.672	0.001	-0.058	-0.018	**-0.052**	-0.005	0.036	0.010	0.066	0.186	0.684
Mn	-0.157	-0.480	0.558	-0.032	0.011	-0.120	0.890	0.001	-0.090	-0.024	-0.034	**-0.008**	0.052	0.017	0.093	0.271	0.946
Zn	-0.154	-0.450	0.530	-0.028	0.006	-0.089	0.591	0.001	-0.080	-0.006	-0.023	-0.005	**0.080**	0.018	0.058	0.163	0.611
Cu	-0.133	-0.421	0.476	-0.022	0.007	-0.088	0.626	0.001	-0.075	-0.022	-0.021	-0.006	0.058	**0.024**	0.072	0.193	0.672
B	-0.181	-0.409	0.523	-0.025	0.009	-0.083	0.620	0.001	-0.077	-0.022	-0.026	-0.006	0.035	0.013	**0.132**	0.179	0.683
DHy	-0.137	-0.372	0.442	-0.024	0.010	-0.102	0.763	0.001	-0.086	-0.030	-0.030	-0.007	0.040	0.014	0.072	**0.327**	0.882

4.3.8. Economics of cultivation

Analysis of benefit: cost ratio of different treatments are given in Table 47. The highest gross returns was recorded in treatment T_4 (coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP) followed by T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP).The lowest gross returns was noticed in T_1, absolute control.

The highest B:C ratio of 2.43 was registered in T_4 (coirpith based vermicompost at 10 t ha^{-1} +100 % of soil test based KAU POP) followed by T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP). The lowest B:C ratio (1.57) was observed in the treatment, absolute control (T_1).

Table 47. Cost of cultivation, gross and net returns and B:C ratio under different treatments

Treatments	Total cost of cultivation	Gross returns	Net returns	B : C ratio
	Rs. (in lakhs)			
T_1: Absolute control	4.93	7.8	2.87	1.57
T_2: Coirpith compost at 10 t ha^{-1}	6.43	10.2	3.77	1.58
T_3: Coirpith based vermicompost at 10 t ha^{-1}	6.62	10.5	3.88	1.59
T_4: T_3 + 100 % of soil test based KAU POP	7.30	17.8	10.5	2.43
T_5: FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP	8.30	15.5	7.20	1.86
T_6: T_3 + 25% of soil test based KAU POP	7.02	14.7	7.68	2.09
T_7: T_3 + 50% of soil test based KAU POP	7.12	14.5	7.38	2.03
T_8: T_3 + 75% of soil test based KAU POP	7.21	15.2	8.0	2.10
T_9: FYM at 20 t ha^{-1} +25% of soil test based KAU POP	8.02	13.1	5.08	1.63
T_{10}: FYM at 20 t ha^{-1} +50% of soil test based KAU POP	8.12	13.6	5.48	1.67
T_{11}: FYM at 20 t ha^{-1} +75% of soil test based KAU POP	8.21	14.0	5.79	1.70
T_{12}: *Adhoc* KAU organic POP	8.00	13.2	5.20	1.65

Discussion

5. DISCUSSION

Soil organic carbon plays an important role in the stability and fertility of soils, and soils are an important sink for carbon globally. Soil carbon is recognized as the largest store of terrestrial carbon. Globally, its storage capacity is much larger compared with the pools of carbon in the atmosphere and vegetation. This chapter deals with justification of the results obtained from the study titled “Carbon pools in lateritic soil amended with coirpith- vermicompost and its effect on tomato’’ carried out during 2018-19 in the Department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara. Discussion is carried forward in the light of supporting literature under seven titles.

- ✓ Characterisation of raw coirpith and composted coirpith
- ✓ Characterisation of experimental soil
- ✓ Effect of coirpith vermicompost on soil properties after harvest
- ✓ Effect of coirpith vermicompost on labile carbon pools in soil
- ✓ Effect of coirpith vermicompost on growth attributes and yield of tomato
- ✓ Effect of coirpith vermicompost on quality parameters of tomato
- ✓ Effect of coirpith vermicompost on nutrient uptake of tomato

5.1. Characterisation of raw coirpith and composted coirpith

Coirpith is a ligno-cellulosic biomass formed during the extraction of coir fibre from coconut husk, which is accumulated as a waste material near coir processing factories, generating environmental and disposal problems. Agricultural use of the raw coirpith would lead to microbial immobilization of nutrients in soil, besides polluting environment and water bodies. These shortcomings of raw coirpith can be solved if it is subjected to proper composting process, which leads to its biochemical conversion yielding a potential organic resource.

Physical, electrochemical and chemical properties of raw and vermicomposted coirpith

Coirpith is a light and compressible material. It is highly hygroscopic with excellent water holding capacity, *i.e.* 6-8 times of its weight. Ross *et al*. (2012) reported that due to high water holding nature, it can be used as a mulch and soil amendment, especially for dry and sandy areas with low water retention. Generally potassium content of coirpith is rather high, though the bulk density and particle density are low. CEC of coirpith obtained in the present study was 25.5 cmol (+) kg^{-1} which allowed it to retain large amount of nutrients like K, Na, Ca and Mg in the absorption sites as reported by Joshi *et al*. (2013). Structural similarity of coirpith with peat makes it an ideal soil amendment and component of soilless container media for horticultural crops.

Coirpith made use of in the present study contained high lignin (30-31 %) and cellulose (26.8 %) and possessed a C:N ratio of 113:1 which imparted resistance to degradation and mineralization by microorganisms under natural condition. It had 8-12 per cent soluble tannin like phenolics which can be phytotoxic, inhibiting plant growth. The inhibitory effect can be eliminated after composting process using microorganisms which have the capacity to degrade lignin, cellulose, polyphenols and to bring down the C: N ratio to acceptable level as suggested by Jeyaseeli *et al*. (2010).

Composting of coirpith by urea and *Pleurotus* was suggested by Nagarajan *et al.* (1985) which showed reduction in lignin and cellulose content. Composing of coirpith using *Pleurotus* exhibited an increase in the values of pH (5.70 to 6.60) and decrease in EC (0.98 to 0.43 dS m^{-1}).The nitrogen, phosphorus and potassium values increased from 0.26 to 1.10 per cent in case of N, 0.05 to 0.32 per cent in case of P and 0.75 to 0.86 per cent in case of K. Secondary and micronutrient contents increased after composting. Lignin and cellulose content reduced from 32.0 to 18.2 per cent and from 25.5 to 11.4 per cent respectively. C: N ratio reduced from 113:1 in the beginning to 24: 1.

Biodegradation of wastes by earthworms is generally considered to be a safe, effective and environmentally friendly process. Earthworms are well known natural machineries which plays a major role in plant material degradation and this concept is used in vermicomposting of coirpith to promote plant growth. It can transform organic waste into good quality compost with minimum period of time as reported by Arancon *et al*. (2008) and Sathianarayanan and Anisa (2008).

Vermicomposting of coirpith exhibited a marginal increase in the values of pH (5.70 to 7.02) and a decrease in EC (0.98 to 0.51 dSm^{-1}).This proves that effective mineralization has happened during its composting process as outlined by (Vijaya *et al*., 2008).

The nitrogen, phosphorus and potassium values increased from 0.26 to 1.24% in case of N, 0.05 to 1.02 per cent in case of P and 0.75 to 1.57 per cent in case of K in vermicomposted coirpith, revealing that the coir pith ingested by the worms underwent physical, chemical and biological degradation due to biological grinding during passage through the gut, coupled with enzymatic activity in worm's gut. These results are in accordance with the findings of Thenmozhi, (2015), Nattudurai *et al*. (2014) and Vijaya *et al*. (2008).

Levels of secondary and micro nutrients were also significantly higher in the coirpith vermicompost than in the raw coir pith and coirpith compost indicating the breaking activity of earthworms, where the heavier particles are broken down into smaller particles during the passage of coir pith through the gut of earthworm. Lignin and cellulose content reduced from 32.0 to 16.7 per cent and from 25.2 to 10.2 per cent respectively. C: N ratio showed a reduction from 113:1 to 20.5: 1 due to the microflora in the intestine of earthworm which is actively involved in the decomposition (Arancon *et al*., 2008; Vijaya *et al.*, 2008).

The main constraint in using raw coirpith for both vermicomposting and plant growth is the soluble salts present which could be alleviated by the process of vermicomposting. This closely matches with the findings of Thenmozhi (2015). In the present study, degradation of partially composted coirpith by earthworm could be achieved in 34 days and the product thus obtained was used as a source of manure for nourishing tomato.

5.2. Characterization of the experimental soil

The experiment was conducted in lateritic soil, formed normally by the prolonged and intensive weathering of parent rock and characterized by low CEC and base saturation with dominance of sesquioxides and high phosphorous fixation. On characterizing, the experimental soil was found to be sandy clay loam in texture with coarse sand (30.89 %), fine sand (26.28 %), silt (17.65 %) and clay (21.23 %) in the proportions shown. With respect to pH and EC, the soil was acidic in nature and non-saline.

As regard to available nutrient status, it was found to be high in phosphorous and medium in nitrogen and potassium. Among the secondary and micronutrients, Ca, Mg and B was deficient in the experimental soil, whereas other nutrients were in sufficient range.

In respect of carbon fractions, the water soluble carbon was found to be 86.5 mg kg^{-1}, hot water soluble carbon 228.5 mg kg^{-1}, microbial biomass carbon 72.68 mg kg^{-1}, permanganate oxidisable carbon 765.3 mg kg^{-1} and total carbon 1.37 mg kg^{-1}. Dehydrogenase activity was in the range of 41.82 (µg TPF g^{-1} soil $24hr^{-1}$) and the microbial population followed the order bacteria (62.5 x 10^6 CFU g^{-1} soil), fungi (10.42 x 10^4 CFU g^{-1} soil) and actinomycetes (8.45 x 10^3 CFU g^{-1}soil).

5.3. Effect of treatments on soil properties after harvest

5.3.1. Soil reaction

Soil reaction is the foremost soil property which decides the availability of nutrients in soil. There was significant difference among the treatments with respect to soil pH. Maximum pH (6.96) was recorded in T_8 (coirpith based vermicompost at 10 t ha^{-1}+ 75% of soil test based KAU POP) and the lowest in control. The significant rise in soil pH was due to application of calcium carbonate having neutralizing value of 100 per cent coupled with compost high in basic cations. The slightly alkaline pH of the compost helped in reducing acidity by replacing acidic cations from exchange sites, which was in accordance with the findings of Bekele *et al*. (2018) and Truong *et al*. (2018).

5.3.2. Electrical conductivity

Electrical conductivity is the measure of soluble salts in soil and the maximum allowed limit in lateritic soil is 4 dSm^{-1}. In the present study, the EC increased in soil on applying specified treatments. Coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP registered a higher value of 0.185 dS m^{-1}. The increase in EC might be due to higher proportion of soluble salts in coirpith leading to an increase in electrolyte content in soil which corresponds to the findings of Nattudurai *et al*. (2014).

5.3.3. Available macronutrients

Enhanced nutrient status observed after composting using earthworm has been attributed to their excretory products, mucus, body fluids, and enzyme activity. In the present study, chemical fertilizers were also applied along with compost to act as a ready nutrient source. Treatment effect on available nutrients is shown in Fig 2. Higher nitrogen content in soil was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (208.3 kg ha^{-1}) which was higher than that of FYM with full dose of inorganic fertilizers. The residual nitrogen content of soil was significantly increased due to vermicompost application, which might be due to higher percentage of nitrogen in wormcasts, compared to FYM. Parmer and Sharma (2002) reported that application of fertilizers along with organic sources increased soil total nitrogen. Wiqar *et al.* (2013) also reported an increase in soil total N due to the integrated application of organic and inorganic fertilizers.

Vermicompost can also intensify the growth of nitrogen fixing microorganisms in rhizosphere, which increase nitrogen availability by making available biologically fixed nitrogen through the intimate mixing of ingested particles with soil. Elevation in microbial biomass carbon and soil respiration leads to increased mineralization of nitrogen in soil. This was in accordance with the findings of Mackay *et al*. (1982).

Higher phosphorous content was recorded in the plot that received coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (52 kg ha^{-1}) though it was comparable with coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP (48.5 kg ha^{-1}) and FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP (46 kg ha^{-1}). Increased phosphorous availability might be due to increased phosphatase activity. The organic source supplied along with fertilizers stimulate phosphatase producing organisms. This is in accordance with the findings of Azarmi *et al*. (2008) and Goswami *et al.* (2017). Availability of phosphorous in soil increased when P fertilizers were applied in combination with organic fertilizers, which revealed that the latter enhanced solubilization of insoluble phosphorous and reduced P adsorption and fixation in soils. Similar results were reported by Azam *et al*. (2013) and Wiqar *et al*. (2013) who found higher available phosphorous in the treatments where organic manures were applied in different combination with inorganic fertilizers.

On the other hand, significant increase in potassium content for the treatment coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP was mainly due to higher potassium content in coirpith conjoined with its addition from chemical fertilizers applied at different levels. Wiqar *et al.* (2013) noticed an increase in soil extractable K by the combined use of organic and inorganic fertilizers.

Vermicompost being a rich source of microorganisms produces a number of organic acids specially oxalic acid, which enable the solubilization of bound phosphorus and potassium in soil (Zhang *et al*., 2000).

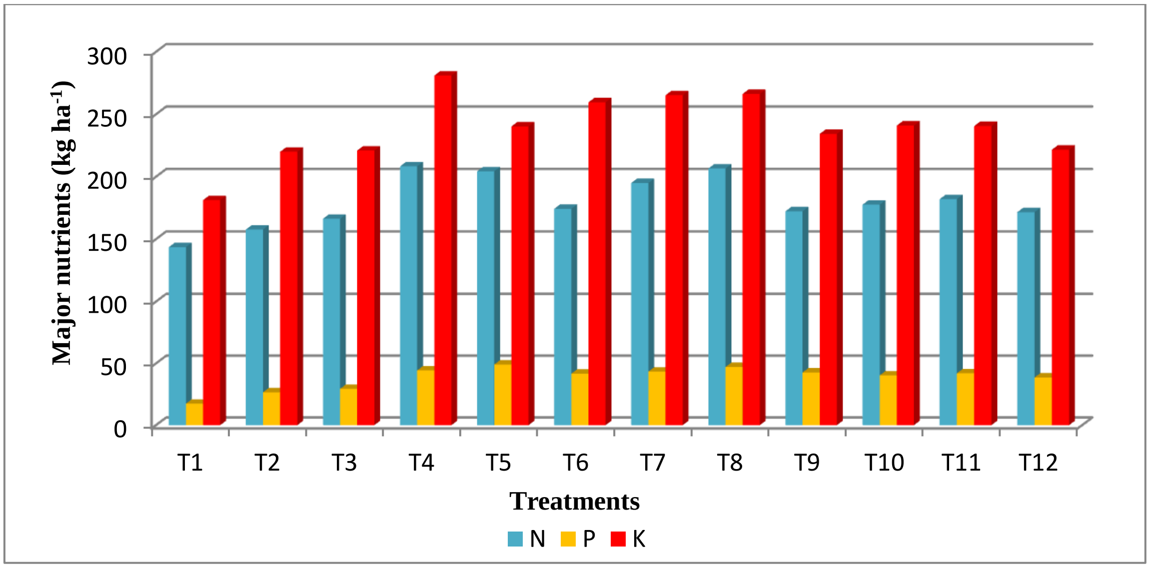


Fig. 2 Effect of different treatments on major nutrient status in soil

5.3.4. Secondary nutrients

Effect of treatments on secondary nutrients is depicted in Fig 3Of the treatments, T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP), T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP) and T_7 (coirpith based vermicompost at 10 t ha^{-1} + 50 % of soil test based KAU POP) registered higher content of calcium which was mainly observed in treatments where coirpith vermicompost was applied.. It might be due to the higher calcium present in vermicompost than FYM as suggested by Pushpa, (1996).

The highest magnesium content (93.3mg kg^{-1}) was noticed in T_4 (coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP) which was on par with T_8 (coirpith based vermicompost at 10 t ha^{-1}+ 75% of soil test based KAU POP) and T_{11} (FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP). Vermicompost seems to be effective in enhancing exchangeable Ca and Mg contents of soils when both vermicompost and farmyard manure are used as organic sources. This result is in agreement with the findings of Azarmi *et al*. (2008).

Significantly higher sulphur content was registered by T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP) followed by T_{11} (FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP). FYM along with chemical fertilizers added sulphur directly to the soil available pool. Similar results were reported by Warjri *et al*. (2017), Trivedi *et al*. (2000) and Poongothai *et al*. (1999).

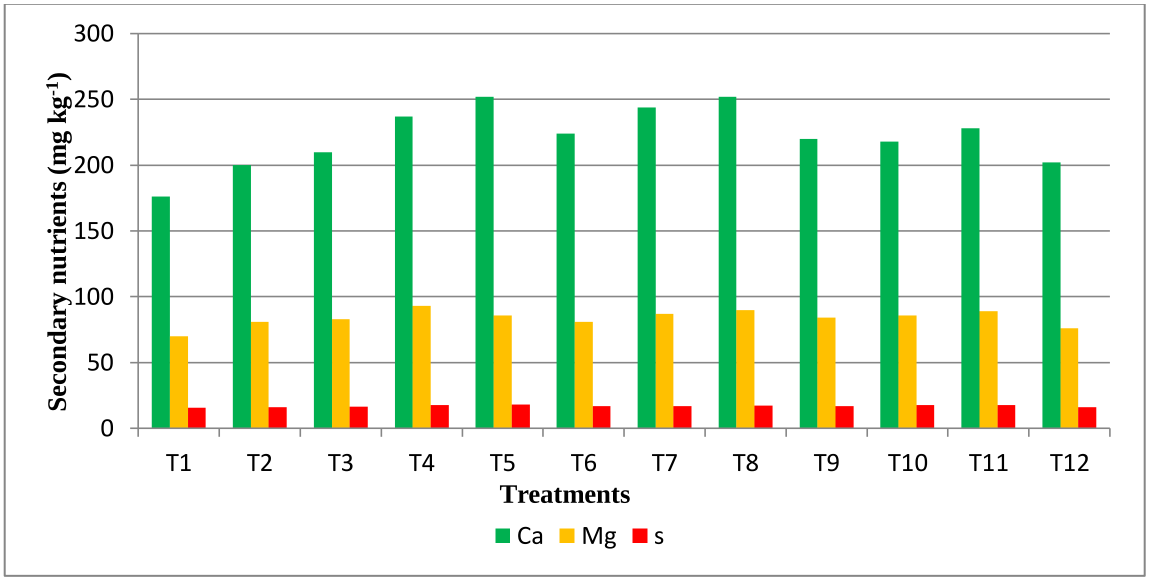


Fig. 3 Effect of different treatments on secondary nutrient status in soil

5.3.5. Available micronutrients in soil

Like macronutrients, presence of micronutrients in optimum quantity is all the more essential for crop growth and production. Regarding micronutrients, iron content was found to be highest (15.3mg kg^{-1}) in the soil applied with T_8 (coirpith based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP). The iron content increased in treatments where organic sources along with fertilizers were applied, which may be due to its release from the organic sources because of increased microbial activities in the soil. In general, content of micronutrients was significantly improved over the initial level primarily due to the integrated application of organics with inorganics (Fig. 4).

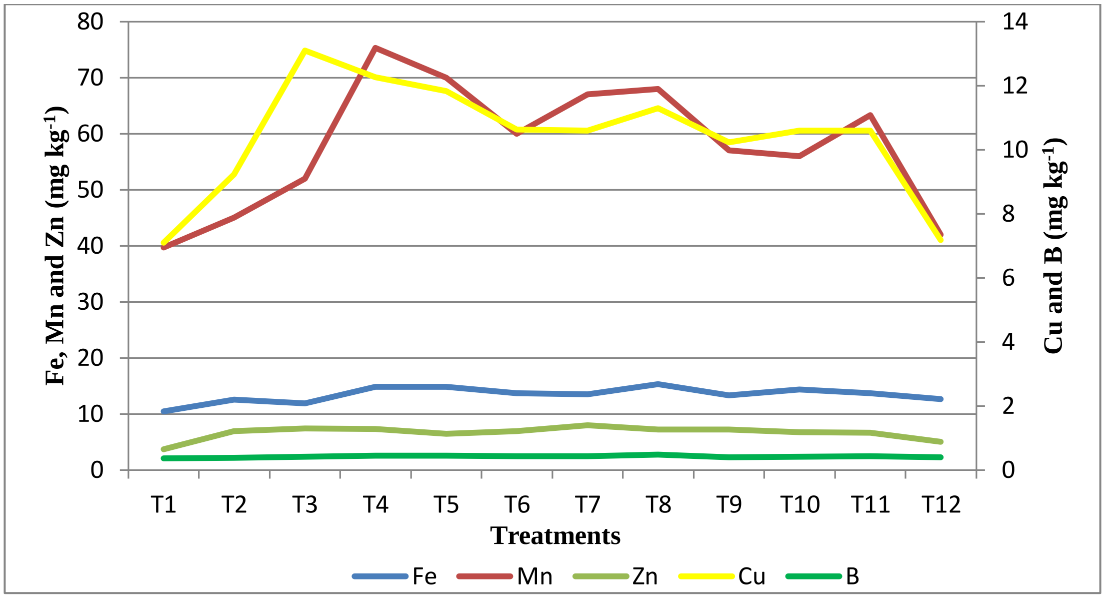


Fig. 4 Effect of different treatments on micronutrient nutrient status in soil

5.3.6. Microbial load in soil

Microbial load in any soil is indicative of its healthy nature. Earthworms enhance microbial activities and metabolism which influence microbial population in soil. As a consequence, more available nutrients and microbial metabolites are released into the soil (Tomati *et al*., 1988). The highest soil bacterial count (109.3 x 10^6 CFU g^{-1}) was obtained in T_4 (coirpith based vermicompost at 10 t ha^{-1} +100 % of soil test based KAU POP) which was on par with T_8 (coirpith based vermicompost at 10 t ha^{-1}+ 75 % of soil test based KAU POP), T_{11} (FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP) and T_7 (coirpith based vermicompost at 10 t ha^{-1}+ 50 % of soil test based KAU POP). Since the compost is a more decomposed and stabilized organic substrate with lower forms of C and more N in forms available to microorganisms their population get multiplied abundantly. Bacterial population increased from the initial value which might be due to the shift in pH towards the neutral value.

Microbial populations were more active and diversified in the soil amended with compost which agrees with the findings of Ngo *et al*., 2011 and Yakushev *et al* 2009. Application of vermicompost along with fertilizers possibly improved available phosphorous concentration in soil by increasing the relative population of fungus in the soil as reported by (Gibertoni *et al*., 2015, Smith and Smith, 2011).

The enhancement of actinomycetes population in the present study may be due to multiplication of actinomycetes during their transit through the gut of earthworms. Vermicompost containing higher amount of growth promoting substances, vitamins and enzymes once applied in soil increases the microbial population in rhizosphere and root biomass production leading to increased production of root exudates thus increasing the population of bacteria, fungi and actinomycetes

5.3.7. Dehydrogenase activity

Dehydrogenase activity is considered as an index for determining the microbial activity in soil. In the present study, the promising effect in registering higher value (146.3 µg TPF g^{-1} soil $24hr^{-1}$) was associated with the treatment T_4 (coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP) (Fig. 5) which was significantly superior from other treatments including FYM with full dose of fertilizers. Dehydrogenase activity is influenced more by the quality than by the quantity of organic matter added into soil. Increased dehydrogenase activity in coirpith vermicompost is due to more nutrient content than FYM. Dehydrogenase activity changes with application of organic sources might be linked to more substrate availability in the soil. Similar results were reported by Pramanik *et al*. (2010) and Manjaiah and Singh (2001).

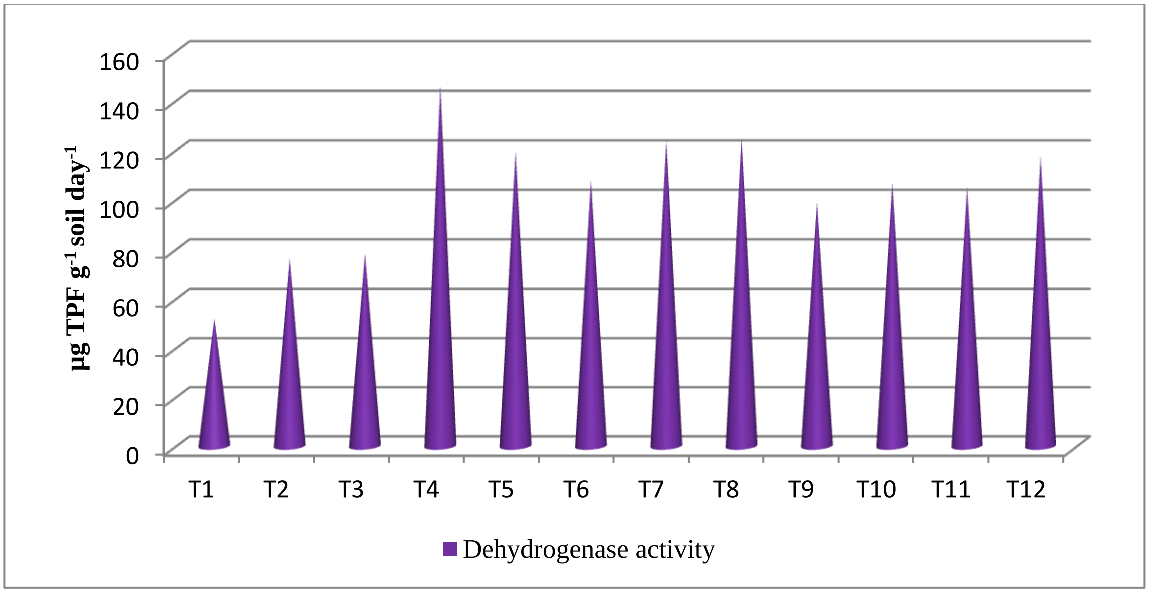


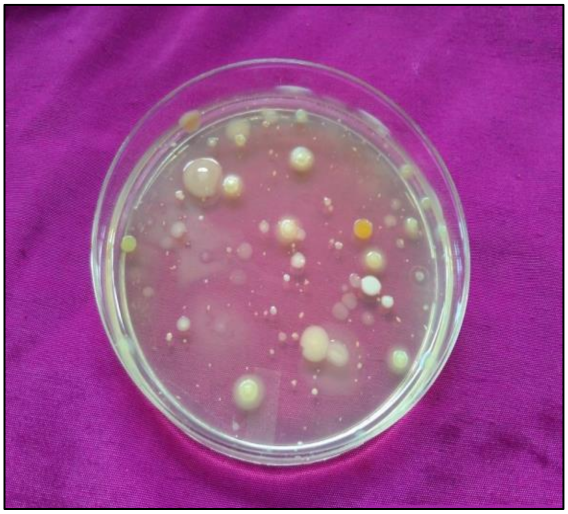
Fig. 5 Effect of different treatments on dehydrogenase activity in soil

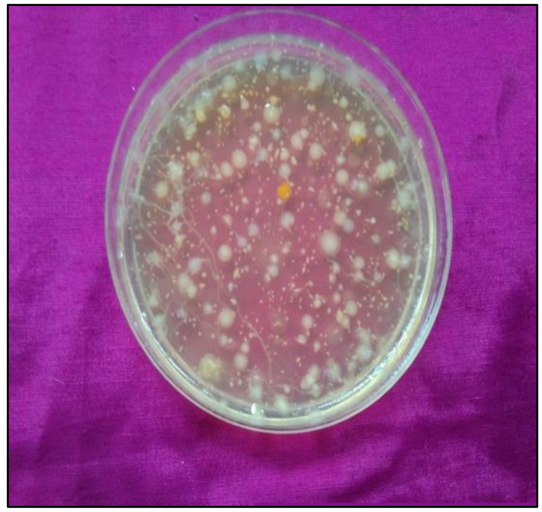
5.4. Effect of coirpith vermicompost on labile carbon pools in soil

Soil labile carbon fractions are a series of small, but sensitive, proportions of soil organic carbon with different turnover times. It has been reported that, soil labile carbon fractions, like dissolved organic C (DOC) and microbial biomass C (MBC) were major determinants for the preservation of soil microbial diversity in long-term fertilization trials. Treatment effect on labile carbon pools is shown in Fig 6 and 7. The application of organic manures had increased the amounts of labile organic carbon pools in soil (Purakayastha *et al*., 2008). Das and Maiti (2016) from their work on oxidisable organic C fractions revealed that labile C fractions were much larger in the NPK+FYM treatments, whereas the less-labile C or non-labile C fractions were larger under control.

5.4.1. Water soluble carbon

Water soluble carbon (WSC) is defined as the entire pool of WSC either sorbed on soil or sediment particles or dissolved in interstitial pore water (Tao and Lin, 2000). In the present study, the highest WSC (130.5 mg kg $^{-1}$) was recorded in T_8 (coirpith





Control

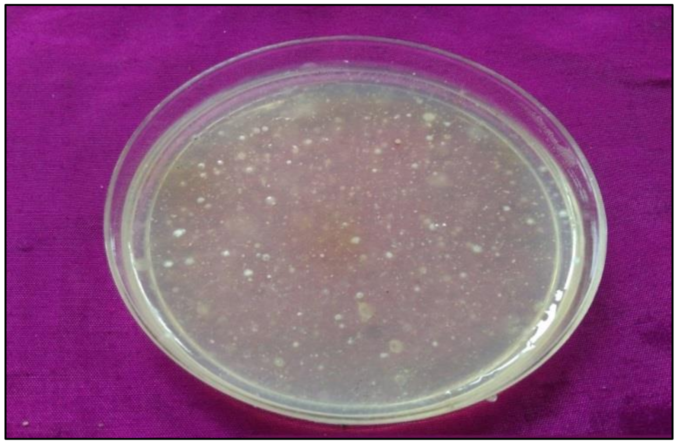
T_4: T_3+ soil test based KAU POP

Plate 20. Effect of treatments on bacterial population

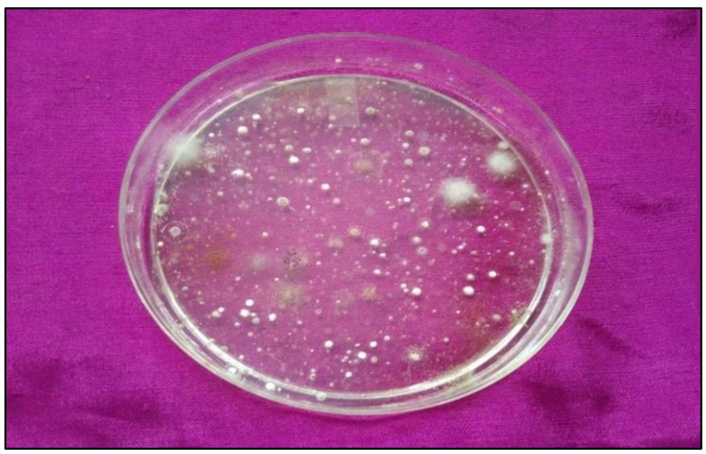
Control

T_7 : T_3+75 % of soil test based KAU POP

Plate 21. Effect of treatments on fungal population



Control



T_6: T_3+25 % of soil test based KAU POP

Plate 22. Effect of treatments on actinomycetes population

based vermicompost at 10 t ha^{-1} + 75 % of soil test based KAU POP) which was on par with T_4 (coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP), T_5 (FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP), T_{11} (FYM at 20 t ha^{-1} +75 % of soil test based KAU POP) and T_6 (coirpith based vermicompost at 10 t ha^{-1}+ 25 % of soil test based KAU POP). Due to water soluble nature, leaching losses have resulted in lowering the value of this fraction in other treatments. Carbon pools were higher in the plots where integrated nutrient management practice was followed rather than chemical fertilizers alone. Similar results were also reported by Sulaiman, (2017) and Yan *et al*. (2007).

5.4.2. Hot water soluble carbon

HWSC comprises of chemical extraction using hot distilled water which contains simple organic compound and microbial biomass which are hydrolysable under the given extraction condition (Weigel *et al*., 2011). Ghani *et al.* (2003) opined that soil micro-aggregate characteristics had a significant correlation with amount of hot water soluble carbon. In the present study the highest HWSC (358.5 mg kg^{-1}) was noticed in FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP which was comparable with coirpith based vermicompost at 10 t ha^{-1}+ soil test based KAU POP. Significantly lower HWSC (252.0 mg kg^{-1}) was observed in control. Weigal *et al*. (2011) reported that a strong correlation existed between hot water extractable carbon and organic carbon. They considered it to confirm that hot water soluble carbon was more related to labile carbon and thus reflected carbon changes as affected by management practices. Hot water soluble carbon was significantly and positively correlated with yield (0.906**). Similar findings were reported by John, 2019.

5.4.3. Permanganate oxidisable carbon

Permanganate oxidisable carbon comprises of readily oxidisable components including polysaccharides, humic materials, which accounts to 5-30 per cent of soil organic carbon (Blair *et al*., 1995). Culman *et al*. (2012) opined that, POXC was closely related with smaller and heavier particulate organic carbon fractions, pointing out that POXC reflects a relatively processed pool of soil carbon. Effect of different treatments on POXC of soil showed that coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP had higher POXC (1286 mg kg^{-1}). Significantly lower POXC (820.5 mg $kg^{-}1$) was noticed in control. The POXC proved to be more sensitive as an index of labile pool of soil organic carbon compared to microbial biomass carbon. The addition of organic carbon input could enhance the accumulation of POXC. This is in line with the findings of Rudrappa *et al*. (2006) and Verma *et al*. (2010). Contech *et al*. (1997) reported a higher POXC in wheat grown with fertilizers, due to left-over root biomass of wheat entering the labile pools of carbon as an after effect of applying chemical fertilizers.

5.4.4. Microbial biomass carbon

MBC is a measure of carbon contained in the living component of soil organic matter which consist of bacteria, fungi and contributes to 1-5 per cent of total soil organic carbon. The effect of coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP, FYM at 20 t ha^{-1} + 100 % of soil test based KAU POP on this parameter was comparable (164.6 and 157.67 mg kg^{-1} respectively). The addition of NPK fertilizers along with manures almost doubled the microbial biomass carbon compared to soils treated with inorganic fertilizers alone (Goyal *et al.*, 1999). Surekha *et al.* (2004) reported that in plots treated with FYM and chemical fertilizers, there was an increase in soil biomass carbon and nitrogen due to the enhanced activity of microorganisms. In the present study, microbial biomass carbon revealed a significant positive correlation with organic carbon (0.710**) and dehydrogenase activity (0.745**) which was in accordance with the findings of Adak *et al.* (2014) and Sulaiman, (2017).

5.4.5. Total carbon

Total carbon in soil consist of elemental, organic and inorganic forms of carbon, but in lateritic soils, the content of total carbon will be almost equal to organic carbon.

The highest total carbon (1.57 %) was recorded in T_8 (coirpith based vermicompost at 10 t ha^{-1}+ 75 % of soil test based KAU POP) followed by T_4 (coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP. Significantly the lower (1.06 %) total carbon was observed in control plot. The increase in TOC in optimal and balanced application of NPK is because of greater input of root biomass due to better crop growth. Similar results were observed by Manjaiah and Singh (2001). In the present study, total carbon had significant and positive correlation with all other carbon fractions. Such a significant and positive correlation of total carbon with organic carbon was also reported by John, (2019) on investigating carbon and nitrogen dynamics in rice soils of kerala.

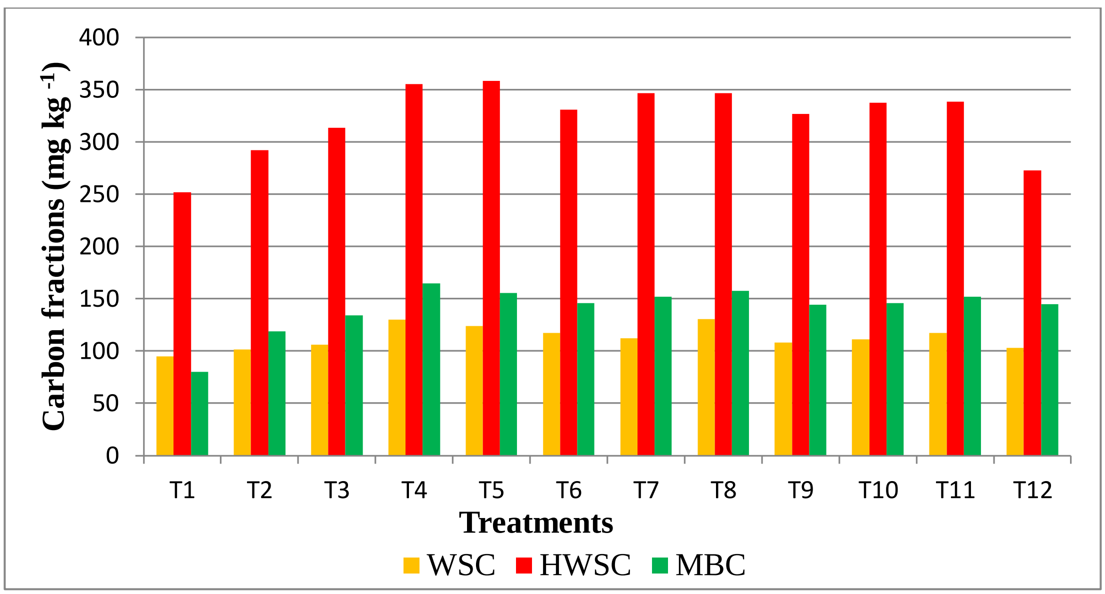


Fig.6 Effect of different treatments on labile carbon fractions (WSC, HWSC and MBC)

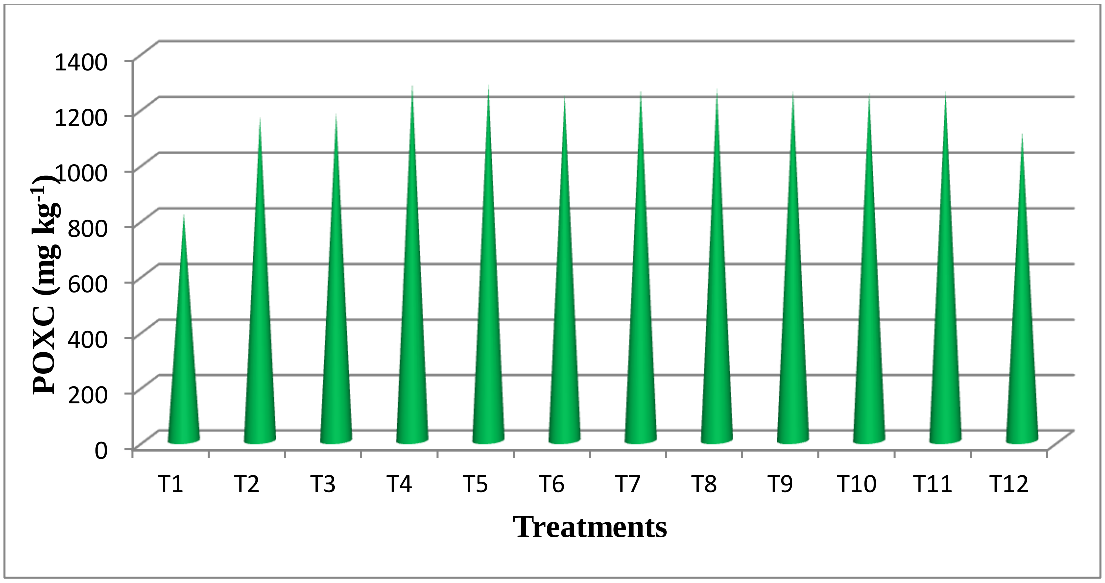


Fig.7 Effect of different treatments on labile carbon fraction (POXC)

5.5 Effect of coirpith vermicompost on growth parameters and yield

5.5.1. Plant height

At 60 & 80 DAT, significantly highest plant height was noticed (94.5 cm and 104.7cm respectively) in the treatment coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP which was higher than that of FYM (Fig. 8) .The increase in plant height is attributed to rapid meristamatic activity following vermicompost application which increased the vegetative growth of plant and also due to applying full dose of chemical fertilizers. The more readily available nutrients and plant growth promoting substances of PGPR present in the vermicompost in fact stimulates vegetative growth. Vermicompost having hormone-like activity helps in greater root initiation, higher root biomass and enhanced plant growth. Similar results were also reported by Chanda *et al*. (2011) and Thenmozhi, (2015).

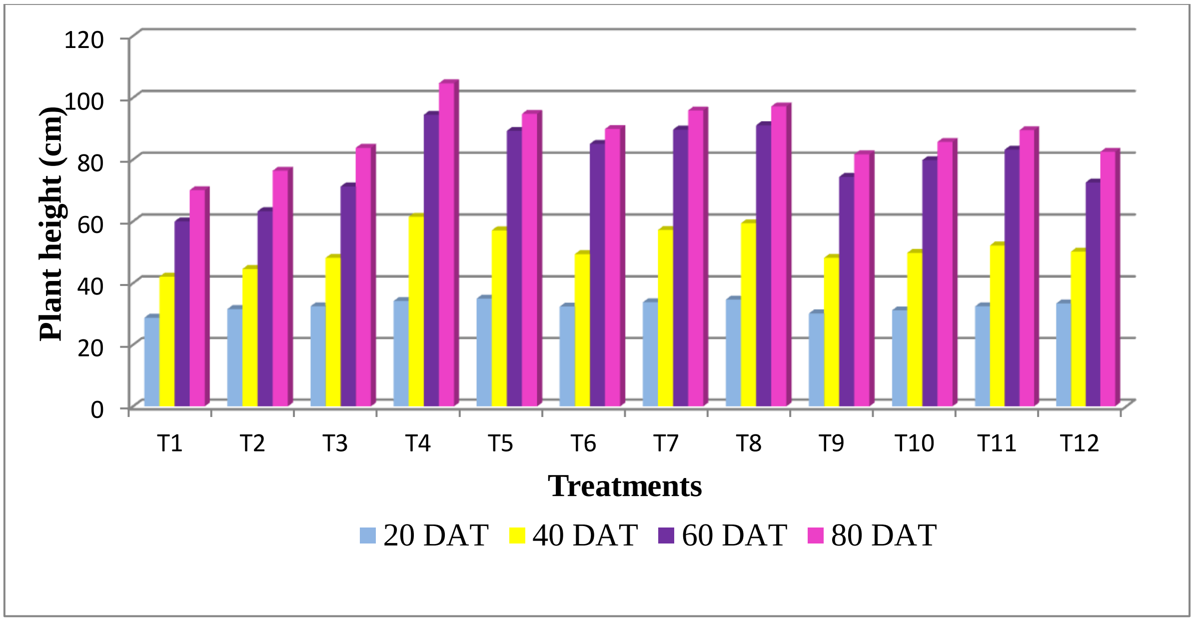


Fig. 8 Effect of different treatments on plant height

5.5.2. Yield

There was a significant effect on yield per plant among various treatments studied (Fig. 9). Significantly highest yield per plant (1.84 kg/ plant) was observed in treatment receiving coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP. Control plot recorded significantly lower yield. Vermicompost, an organic source of plant nutrients, contains a higher percentage of nutrients for plant growth in readily available form (Nagavallemma *et al*., 2004). Vermicomposting can influence the growth of tomato plants by stimulating the nitrogen-fixing bacteria in rhizosphere soil. Similar observations were reported by Arancon *et al*. (2008) and Wang *et al*. (2017). Eventhough vermicompost contains many plant growth promoting substances, enzymes and hormones, the superiority is reflected in the yield when applied with inorganic fertilizers. The better performance of tomato plants with organic and NPK fertilizers support the results of Ogundare *et al*. (2015), Adekiya and Agbede (2009) and Rajya *et al*. (2015), who suggested that maximum nutrient availability due to integrated use of organic and inorganic fertilizers enhanced nutrient uptake by the plant which in turn lead to higher fruit yield.

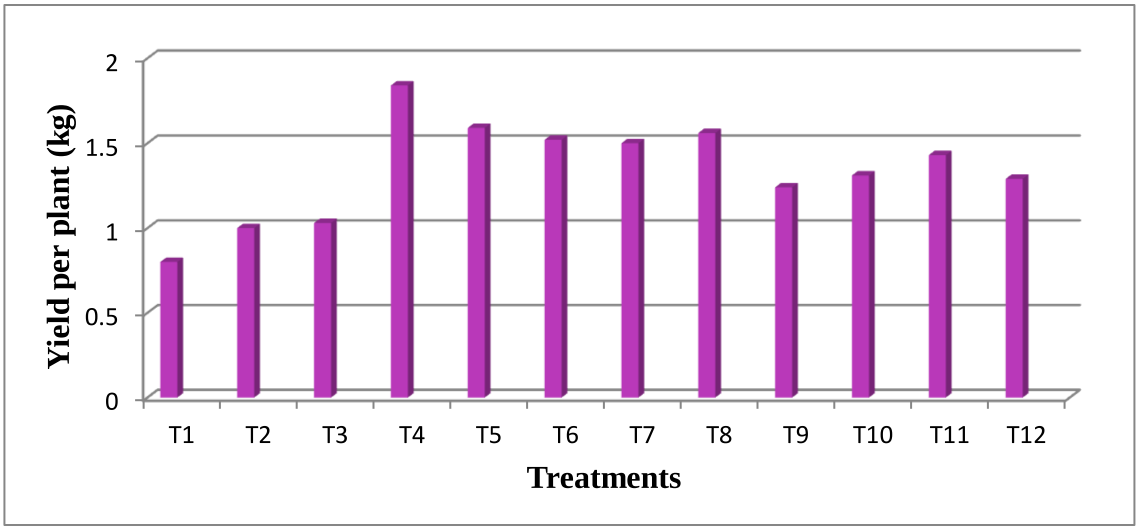


Fig.9. Effect of different treatments on yield of tomato

5.5.3. Number of fruits per plant

Significantly highest number of fruits (44.0) was recorded in T_4 (coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP). Increase in fruit number with full N, P and K and 10 tons of compost might be due to the regular supply of nutrients from inorganic fertilizers and growth promoting hormones from compost at adequate amount which resulted in accumulation of more photosynthates, which ultimately leads to more fruits. The same results were reported by Lal and Dayal (2014), who worked on integrated management practices on acid lime.

5.6 Effect of coirpith vermicompost on quality parameters

5.6.1. Titrable acidity

Higher titrable acidity (1.13 %) was noticed in coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP which was on par with FYM at 20 t ha^{-1}

+ 100 % of soil test based KAU POP, FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP and FYM at 20 t ha^{-1} + 50 % of soil test based KAU POP. Razzaque *et al. (*2001) reported that fruit acidity tends to increase with increasing potassium content which was in confirmation with results of present study. The significant and positive correlation of titrable acidity with potassium (0.786**) adds support to above findings. Sreedevi and Suma (2015) reported that higher acidity of plants grown under recommended dose of fertilizers was due to high acid content of chemical fertilizers.

5.6.2. TSS

Higher TSS (5.16^0B) was associated with FYM at 20 t ha-1 + soil test based KAU POP though it was comparable with coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP shown in Fig. 10. Significant increase in fruit quality of tomatoes was attributed to better uptake of N, P and K from organic amendments as well as with addition of chemical fertilizers (Tejada *et al.*, 2007; Zekri and obreza, 2003). Wright and Harris (2012) reported that increased nitrogen and potassium fertilization increased total soluble solids of tomatoes which may be due to efficient nutrient absorption which resulted in more luxuriant vegetative growth by the translocation of metabolites to developing fruits. Similar findings were also observed by Sharma and Bhargava (2003). The positive and significant correlation of TSS with nitrogen 0.780**) reaffirms the above findings. Sainju *et al.* (2003) opined that TSS of fruit increased with potassium concentration. Significant and positive correlation of TSS with potassium (0.838**) obtained in the study further adds meaning to the above interpretation.

5.6.3. Ascorbic acid

Significant difference in ascorbic acid content of tomato was noticed due to application of treatments. The highest ascorbic acid content (24.4 mg 100 g^{-1}) was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP shown in (Fig.10) which may be attributed to increased phosphorous and potassium contents in treatments. Rajya *et al.* (2015) opined that the increase in quality parameters might be due to increased availability of macro especially nitrogen and potassium as well as micronutrients as they play a key role in enhancing the vitamin C content of tomato fruit. The results of the study corresponds with that of Meherunnessa *et al*. (2011) and Ibrahim and Fadni (2013), who found that compost and chemical fertilizer alone or in combination imparted a positive influence on vitamin C content of tomato fruit Significant and positive correlation of ascorbic acid content with nitrogen (0.599^{**}), phosphorus (0.682^{**}), potassium (0.737^{**}), calcium (0.726^{**}), magnesium (0.668^{**}), iron (0.652^{*}), manganese (0.733^{**}) further confirms the above inference.

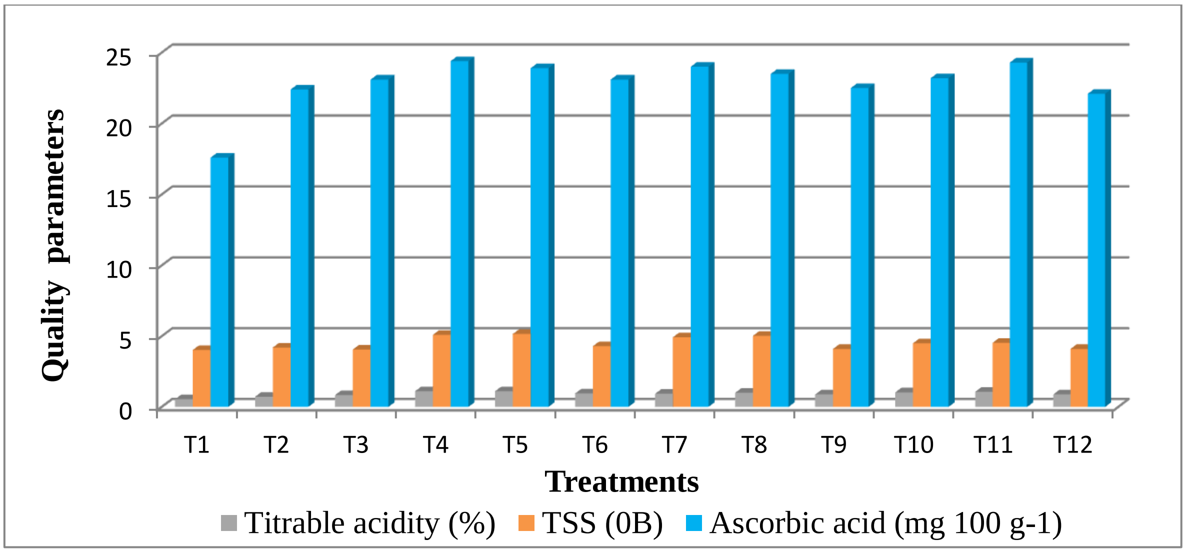


Fig. 10 Effect of different treatments on quality parameters of tomato

5.7. Uptake of major nutrients by tomato

Nutrient uptake depends on concentration of nutrients in different plant parts and the dry matter production. Generally it is a function of partioning of nutrient supply between the plant parts. During the initial stage of crop growth there is higher concentration of nutrients, where the nutrient supply exceeds dry matter production but at later stages rate of dry matter production will be more than nutrient supply.

Significantly the highest nitrogen uptake (125.3 kg ha^{-1}) was observed in treatment that received coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4) as shown in Fig.11 which might be due to improved utilization of applied nitrogen along with chemical fertilizers. Also a major portion of non oxidisable nitrogen present in organic matter would have been made available to plants through vermicomposting and activity of microbes. However only little contribution would have occurred through biological nitrogen fixation. Effect of vermicompost in enhancing nitrogen uptake in chilly was reported by Zaharia, (1995). The combined application of compost and inorganic fertilizers increased the nutrient availability and soil microbial activity which lead to more nutrient uptake and enhanced the growth of tomato. These results are in accordance with findings of Abdul *et al*. (2013) and Laxminarayanan (2004) who reported high N uptake with integrated application of organic and inorganic fertilizers

Significantly highest phosphorus uptake (29.06 kg ha^{-1}) was noticed in treatment that received coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4). The results of present study were similar to the findings of Islam and Munda (2012) and Manoj *et al*. (2012) who reported the highest uptake of N, P and K with the integration of organic fertilizers along with synthetic fertilizers

Higher uptake of potassium was recorded in coirpith based vermicompost at 10 t ha^{-1}+ 100 % of soil test based KAU POP (T_4). This might be due to the release of potassium from coirpith and also due to application of full dose of chemical fertilizers. Higher potassium uptake by tomato plants is due to the application of compost on solubilization of soil K. Sreelatha *et al*. (2006) and Ghosh *et al*. (2014) while working on integrated nutrient management practices on nutrient uptake in rice showed that combined use of organic and inorganic fertilizers significantly increased the plant potassium uptake.

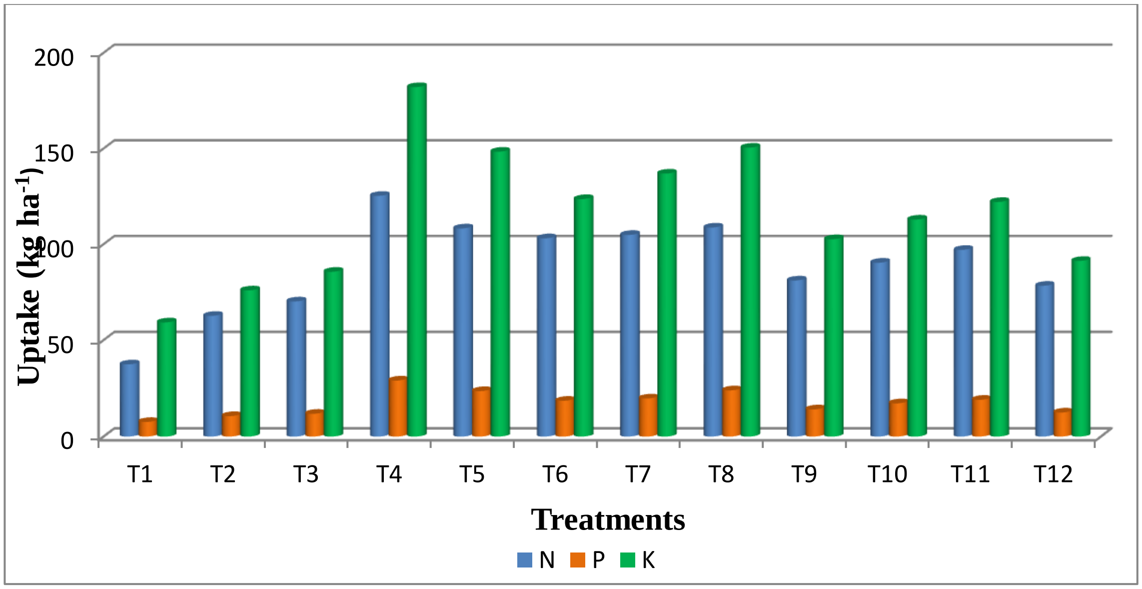


Fig. 11 Effect of different treatments on uptake of major nutrients

Uptake of secondary nutrients in tomato

Highest uptake of calcium by tomato crop was noticed in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4), (Fig. 12). Increase in calcium uptake was mainly associated with higher biomass production. This was in accordance with the findings of (Shayma *et al*., 2009). Uptake of magnesium and sulphur was higher in coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4) due to more amount of fertilizers added and release of nutrients during mineralization. Organics in association with inorganics increase plant growth thus helping in better absorption of nutrients.

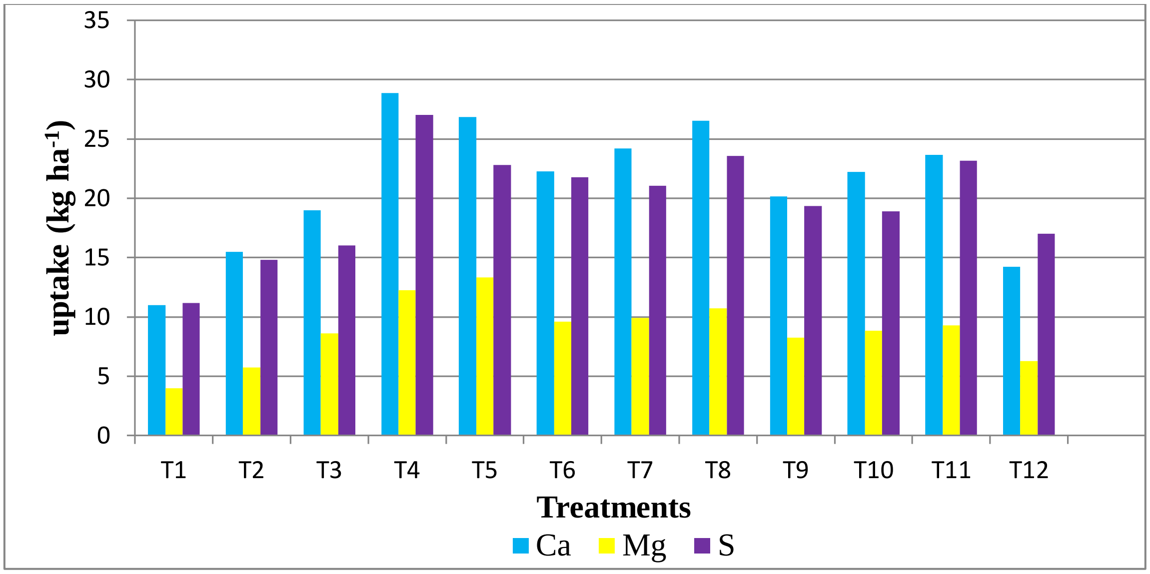


Fig. 12 Effect of different treatments on uptake of secondary nutrients

Uptake of micronutrients in tomato

Uptake of micronutrients was mostly higher in the treatment coirpith based vermicompost at 10 t ha^{-1} + 100 % of soil test based KAU POP (T_4). The higher uptake of micronutrients due to incorporation of organic amendments along with chemical fertilizers was observed by Manasa, (2013) and Shashi (2003) from their studies on nutrient uptake by the combined application of organics and inorganics in groundnut and soyabean.

Summary

6. SUMMARY

The present study titled "Carbon pools in lateritic soil amended with coirpith-vermicompost and its effect on tomato (*Solanum lycopersicum* L.)" was carried out in two phases *viz.* 1. characterization of raw coirpith and vermicomposted coirpith conducted at vermi unit of department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara 2. field experiment laid out at STCR field, College of Horticulture, Vellanikkara. The coir pith based vermicompost intended for the study was prepared by combining regular coirpith composting technology with vermitechnology. The field experiment was carried out to relate the material influence on crop performance and fruit quality of tomato. The initial soil was characterized for its physical, chemical and biological properties. Soil and plant samples were collected at harvest to analyze the effect of different treatments on soil properties, nutrient content, yield and quality of tomato and also on its nutrient uptake. The salient features of the study are summarized, experiment wise, as follows.

Experiment I – Characterization of raw and vermicomposted coirpith

- Raw coirpith was characterized for electrochemical and chemical properties. In raw state, coirpith moisture content worked out to 35.6 per cent. It had a pH of 5.7, EC 0.98 dS m^{-1} and CEC 25.5 cmol (+) kg^{-1}

- The content of total carbon, nitrogen, phosphorous and potassium was 29.6, 0.26, 0.05, and 0.75 per cent, respectively

- It also contained secondary nutrients *viz.*0.44 per cent Ca, 0.32 per cent Mg and 0.28 per cent S

- Micronutrients were also present to the tune of Fe (1195 mg kg^{-1}), Mn (60.5 mg kg^{-1}), Zn (78.0 mg kg^{-1}) and Cu (40.5 mg kg^{-1})

- Higher content of lignin (32 per cent) and cellulose (25.5 per cent) was another noticeable feature

- C: N ratio was 113:1

Coirpith compost

- The coirpith compost had a moisture content of 19.2 per cent, pH of 6.6, electrical conductivity of 0.43 dS m^{-1}, CEC of 26.1 cmol (+) kg^{-1} and total carbon of 26.4 per cent

- Coirpith compost contained 1.10 per cent N, 0.32 per cent P, 0.86 per cent K, 0.47 per cent Ca, 0.39 per cent Mg and 0.37 per cent S. It also contained micronutrients *viz.* Fe (1745 mg kg^{-1}), Mn (83.5 mg kg^{-1}), Zn (82.1 mg kg^{-1}) and Cu (54.0 mg kg^{-1})

- Composting reduced the lignin content of coirpith to 18.2 per cent and cellulose content to 11.4 per cent

- C:N ratio narrowed down to 24:1 through composting

Vermicomposted coirpith

- In vermicomposted coirpith, moisture content was 18.5 per cent. A pH of 7.02, electrical conductivity of 0.51 dS m^{-1} and CEC of 27.5 cmol (+) kg^{-1} were the other noticeable changes brought about on vermicomposting

- Total nutrients increased significantly in composted coirpith. The values were 1.24 per cent for N, 1.02 per cent for P, 1.57 per cent for K, 0.53 per cent for Ca, 0.48 per cent for Mg and 0.42 per cent for S

- Vermicomposting enhanced the content of micronutrients as well, the values being Fe (1812 mg kg^{-1}), Mn (90.4 mg kg^{-1}), Zn (95.25 mg kg^{-1}) and Cu (65.3mg kg^{-1})

- Process of vermicomposting decreased the lignin content of coirpith to 16.70 per cent and cellulose content to10.2 per cent from the initial value of 32.0 and 25.5 per cent
- The C: N ratio narrowed down to 20.5:1 from the initial value of 113:1

Experiment II – field experiment

- Soil pH after harvest increased to 6.84 from the initial value of 5.89 in the treatment coirpith based vermicompost at 10 t ha^{-1} + 75% of soil test based KAU POP
- With regard to EC and organic carbon, coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP registered higher value followed by T_8 and T_7
- CEC was significantly higher 4.80 cmol (+) kg^{-1} in coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP
- Among the carbon fractions, WSC (130.5 mg kg^{-1}) and total carbon (1.57 %) was the highest in T_8, whereas HWSC (358.5 mg kg $^{-1}$) was the highest in T_5. Application of coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP registered higher POXC (1286 mg kg^{-1}) and MBC (164.6 mg kg $^{-1}$).
- Carbon fractions increased significantly from the initial value due to the effect of treatments. Control registered lower value in case of all fractions
- Available major nutrients in soil after harvest increased significantly by the treatments imposed. Available NPK was higher in coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP
- With regard to secondary and micronutrients, higher calcium (93.3mg kg^{-1}) and sulphur content (18.30mg kg^{-1}) was noticed in T_5, whereas magnesium content was higher (93.3mg kg^{-1}) in T_4. Iron was higher (15.3 mg kg^{-1}) in T_8, manganese

(75.3 mg kg^{-1}) in T_4, zinc (8.0 mg kg^{-1}) in T_7, copper (13.1 mg kg^{-1}) in T_3 whereas boron was higher in T_8

- With regard to biological properties, higher dehydrogenase activity (146.3 µg TPF g^{-1} soil $24hr^{-1}$) and bacterial population (109.3 x 10^6 CFU g^{-1}) was recorded in T_4. Fungal population and actinomycetes population was higher in T_7 and T_6 respectively

- The growth parameters were significantly influenced by treatment application

- Plant height measured at 60 DAT and 80 DAT (94.5 cm and 104.7cm respectively) was significantly the highest in T_4. Maximum number of days to flowering (29.6) was noticed in absolute control. Significantly higher number of fruits (44.0), yield (1.84 kg) and yield per plot (46.11 kg) was registered in T_4. Fruit weight (42.3 g) was higher in T_8

- The results on quality aspects of tomato indicated that the titrable acidity (1.13%) and ascorbic acid (24.4 mg 100 g^{-1}) were higher in T_4. Total soluble solids (5.16 ^oB) was maximum in T_5 whereas, lycopene content was higher (4.73 mg 100 g^{-1}) in T_8. Control recorded lower value in all the parameters tested

- The effect of different treatments on major and secondary nutrient content in plant was only comparable. Whereas in case of micronutrients iron was higher in T_4, manganese and copper were higher in T_3 and boron was higher in T_5

- Nutrient content in tomato varied due to different treatments imposed though comparable. The nutrients Mg, Cu and B proved as exceptions to treatment effect

- The total uptake of nutrients differed significantly among nutrients. The highest uptake of major nutrients was noticed in T_4

- The B: C ratio was found to be the highest (2.43) in the treatment coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP (T_4). The lowest B:C ratio (1.57) was registered in control.

The experimental results bring out the efficacy of vermicomposting for enhancing nutrient content of coirpith, as against normal composting. The C: N ratio which was initially very high in raw coirpith could be drastically narrowed down through vermitechnology, proving the efficiency of vermicomposting in converting coirpith to a quality manure. Labile carbon pools in soil increased on applying vermicomposted coirpith. Among the carbon pools, hot water soluble carbon had more direct effect on available nutrients like N, P, S and also on tomato yield.

This study thus summarizes the influence of vermicomposted coirpith along with 100 per cent of chemical fertilizers in improving all biological properties and a few of the soil chemical properties. Complementary application of organic and inorganic fertilizers for increasing nutrient synchrony and reducing nutrient losses is already a proven fact. But the present investigation has come out with an organic manure "vermicomposted coirpith", that can reduce the quantity of organic manure recommended through KAU POP by 50 per cent, as reflected from the B:C ratio. This substitution of FYM with vermicomposted coirpith sounds promising and appealing especially in the context of FYM becoming a scarce but precious input in farming. The *Adhoc* KAU organic POP included as one of the treatments did not contribute towards improving either soil properties or crop performance as evidenced from the results, though not conclusive. Detailed studies are required in a continued manner at different locations to arrive at valid conclusions both in terms of main effect and residual effect. Adopting a nutrient integration strategy which is ecologically, socially and economically viable and environment friendly need to be practiced to derive higher productivity, sustaining soil fertility simultaneously.

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CARBON POOLS IN LATERITIC SOIL AMENDED WITH COIRPITH-VERMICOMPOST AND ITS EFFECT ON TOMATO (*Solanum lycopersicum* L.)

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ABSTRACT OF THE THESIS

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Abstract

Soil organic carbon (SOC) is considered as the key indicator of soil quality and agricultural sustainability. Among the different management practices that are being followed, application of chemical fertilizers and manures has been recognized as the most systematic and effective means to either enhance soil organic carbon accumulation or reduce the rate of SOC loss. Hence, for studying the effect of coirpith based vermicompost on dynamics of carbon in a lateritic soil, a field experiment was laid out during October 2018 – February 2019, in RBD with 12 treatments replicated thrice, with tomato, variety Manulakshmi, as the test crop. The plot size was 3 x 3 m and plant spacing was 60 x 60 cm. The treatments consisted of an absolute control (T_1), coirpith compost at 10 t ha^{-1} (T_2), coirpith based vermicompost at 10 t ha^{-1} (T_3), Coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP (T_4), , FYM at 20 t ha^{-1} + soil test based KAU POP(T_5), T_3 + 25 % of soil test based KAU POP (T_6), T_3 + 50 % of soil test based KAU POP (T_7), T_3 + 75 % of soil test based KAU POP (T_8), FYM at 20 t ha^{-1} + 25 % of soil test based KAU POP (T_9), FYM at 20 t ha^{-1} + 50 % of soil test based KAU POP (T_{10}), FYM at 20 t ha^{-1} + 75 % of soil test based KAU POP (T_{11}), *Adhoc* KAU organic POP (T_{12}).

Raw coirpith was converted into compost using vermitechnology employing the compost worm *Eisenia foetida* .The composting process got completed within 64 days time span. Coirpith in the raw stage and after composting was characterized for physical, electro-chemical and chemical properties. Advantages of vermicomposting coirpith included a reduction in the content of lignin (32 to 16.7 %), cellulose (25.2 to 10.2 %), C: N ratio (113:1 to 20.5:1) and EC (0.98 to 0.51 dS m^{-1}) and an increase in pH and total nutrients.

Soil analysis after the experiment revealed the significance of treatments on electro-chemical and chemical properties as against the control. Significantly higher available K (281.0 kg ha^{-1}) and Mn (75.33 mg kg^{-1}) was obtained in coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP (T_4). In case of N, P, Ca and Fe the effect of the treatments T_4, T_5 (FYM + soil test based POP) and T_8 (Coirpith

vermicompost + 75 % soil test based POP) were comparable. The labile C fractions viz. water soluble carbon (WSC), hot water soluble carbon (HWSC), permanganate oxidizable carbon (POXC) and microbial biomass carbon (MBC) were also significantly influenced by the treatments and it followed the order POXC > HWSC > MBC = WSC. Further analysis revealed that the treatments T_4, $T_{5,}$ T_6 (Coirpith vermicompost + 25 % soil test based POP), T_8 and T_{11} (FYM + 75 % soil test based POP) were comparable in influencing WSC, whereas T_4 and T_5 were similar in deciding HWSC and T_4 and T_8 in case of MBC. Significantly higher total C was registered by coirpith vermicompost + 75 per cent soil test based KAU POP.

Dehydrogenase activity which is considered as an index of microbial activity in soil was significantly higher (146.3 µg TPF g^{-1}soil $24hr^{-1}$) in coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP. Integration of chemical fertilizers at different levels with organics, either coir pith vermicompost or FYM, increased microbial population which followed the order bacteria > fungi > actinomycetes. However, the impact of treatments was more pronounced in enhancing bacterial population due to the shift in pH towards neutral value.

On considering biometric observations, it was seen that the plant height (104.7 cm), number of fruits per plant and fruit yield (1.84 kg/plant) were significantly higher for the treatment coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP. The effect of coirpith based vermicompost and FYM along with fertilizers at different levels were comparable in determining fruit quality parameters like total soluble solids, ascorbic acid, lycopene and titrable acidity. Applying coirpith based vermicompost at 10 t ha^{-1} + soil test based KAU POP registered a higher B: C ratio of 2.43 in contrast to 1.57 recorded in the absolute control.