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Original Article

Degradation of Leaf Litter by Composting and its Effect on Growth of *Solanum lycopersicum*

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Abstract

Compost is the stable, humus-like product resulting from the biological decomposition of organic matter under controlled conditions. Compost is a rich source of vitamins, hormones, enzymes, macro and micro nutrients which when applied to plants help in efficient growth. The major thrust of this investigation was focused on the biodegradation of the leaf litter to produce compost. The present study has been carried out to analyze enzymes, physicochemical characteristics, and micro and macro nutrients present in the compost at regular interval of time and also a comparative study was done on the effect of compost on growth parameters namely germination percentage, root length, shoot length and number of leaf count in *Solanum lycopersicum* after 30th day of planting. The results of the study revealed that the enzyme activities (amylase, cellulase, protease and invertase) and total macronutrients (N, P, K) and micronutrients (Mn and Cu) showed elevated levels in compost than control. The compost applied plant (*Solanum lycopersicum)* showed increased germination percentage, root length, shoot length and number of leaves than the compost untreated plant. Hence based on the studies performed it was concluded that this quality of compost obtained from the degradation of leaf litter by microorganism is an effective biofertilizer which would facilitate the increased uptake of the nutrients by the plants resulting in higher growth and yield.

1. Introduction

One of the major problems in the developed and developing countries is the increasing quantity of solid waste. Due to the rapid growth of industrialization, most of the rural populations have shifted towards the urban area in search of employment. India produces 12,000 tones of solid wastes every day. The rapid increase in the volume of waste is one of the aspects of the environmental crisis, accompanying global development. The uncontrolled dumping of this wastes causes mainly water and soil pollution. Although various physical, chemical and microbiological methods are used for the disposal of organic solid wastes, these methods are time consuming and expensive.

Composting is the biological process of decomposition of various organic matters under controlled condition by the action of microorganism. Composting is a biological treatment that is cost-effective to treat different types of organic waste. Composting was the first concept for using effective microorganisms (EM) in environmental management. Crop residues and animal wastes have been effectively composted to produce bio fertilizers. Basically, this microbial solution was developed for natural or organic farming systems, however, with further research its uses have been expanded to resolve some environmental issues, through which it facilitates the reuse of most waste. The composting may result in the production of humus like substance, compost. Composting stabilizes organic matter, yielding an end product that contains humus, and has a uniform crumbly texture. Compost is defined as the product resulting from the controlled biological decomposition of organic material[1].

Composting is the transformation of residual organic matter into fertilizer accomplished by microorganism, which secrete hydrolytic enzymes to assimilate diverse energy sources available in the substrate inorder to survive. Compost piles can reach upto 80˚C due to microbial metabolism, favoring the development of thermophilic organisms. In this process, the interaction between biotic and non biotic factors leads to constant transformation of the complex microbial community over time, which is the mechanism underlining organic matter transformation. The process of composting represents the cell wall of microorganisms through which mass transfer is possible. Low molecular weight and water-soluble molecules can easily pass through the cell wall where they take part in the cell metabolism, providing energy and being built up into larger polymers, with the help of intracellular enzymes. To attack high molecular components, which cannot pass through the cell wall, microorganisms secrete extracellular enzymes. They break molecules down into the fragments that can be assimilated, while the rest is converted into a stable product, humus or compost[2].

Compost as a organic fertilizer plays an important role in mobilizing existing soil nutrients, so that good growth is achieved with lower nutrient densities while wasting less, Releasing nutrients at a slower, more consistent rate, helping to avoid a boom-and-bust pattern, helping to retain soil moisture, reducing the stress due to temporary moisture stress, Improving the soil structure, helping to prevent top soil erosion (responsible for desertification) and the dust blow. Compost also have certain advantages of avoiding problems associated with the regular heavy use of artificial fertilizers such as the necessity of reapplying artificial fertilizers regularly (and perhaps in increasing quantities) to maintain fertility. Extensive runoff of soluble nitrogen and phosphorus leading to eutrophication of bodies of water (which causes fish kills), and costs are lower for if fertilizer is locally available.

Solanum lycopersicum belong to the family *Solanaceae.* The plants typically grow to 1–3 meters (3–10 ft) in height and have a weak stem that often sprawls over the ground and vines over other plants. It is a perennial in its native habitat, although often grown outdoors in temperate climates as an annual. An average common tomato weighs approximately 100 grams. The present study was undertaken to investigate the conversion of leaf litter into organic compost with cow dung and soil and their effect on growth parameters of *Solanum lycopercisum* and to create awareness among farmers about composting of organic waste and uses of EM solution in sustainable agriculture. This study also evaluates the amount of enzymes, physico chemical parameters and nutrients during fixed intervals of time.

2. Materials and Methods

2.1 Collection of waste

The leaf litter waste was collected from the Karunya University campus, Coimbatore, Tamil Nadu, India. The collected wastes were allowed to partial decomposition for 10 days. Then the wastes were mixed with cow dung and soil in the ratio 3:1:1.

2.2 Composting technique

Pits of 0.75×0.75×0.75 m size were dug and floor of the pit was covered with a lattice of wood strips to provide drainage. Totally 3 pits were maintained for the experimental purposes. The pit T_1 was maintained as control for leaf litter waste (without cowdung). Pit T_2 and T_3 were taken for composting leaf litter. Care was taken to avoid light and rainfall. The control as well as the experimental sample was taken on 30th and 45th day respectively for the analysis of enzymes, macro and micro nutrients, physicochemical parameters and its effect on growth parameters of Tomato (*Solanum lycopersicum*).

2.3 Enzymes Involved in the degradtion of complex organic material into simple compounds

Amylase, cellulase, invertase and protease are the enzymes involved in the degradation of complex organic material into simple compounds

2.3.1 Amylase

Starch degrading enzymes act on glycogen and related polysaccharides, α- amylase causes endo-cleavage of substrate and hydrolysis α 1, 4 linkage in a random manner. It has the ability to by-pass α-1,6 branch points. β- amylase hydrolyses alternate bond from the non-reducing end of the substrate. The enzyme degrades amylose, amylopectin or glycogen in an exo or stepwise fashion by hydrolyzing alternate glycosidic bonds. The end product is β- maltose. The activity of amylase was estimated by the method of Bernfield[3].

2.3.2 Cellulase

Hydrolysis of crystalline cellulose is a complex process. Initiation of hydrolysis of native cellulose is done by exo – β 1, 4 glucanase (c_1 –cellulase). This enzyme split alternate bonds from the non-reducing end of cellulose chain yielding cellobiose. The endo-glucanase (c_x – cellulase) act on carboxy methylcellulose. This enzyme does not act on native cellulose. β – glucosidases (cellobiase) play an important function in the degradation of cellulose by hydrolyzing cellobiose which is an inhibitor of exo-glucanase. Assay of enzyme was done according to the procedure to the procedure described by Denison and Koehn[4].

2.3.3 Invertase

Invertase is the enzyme that catalyzes the hydrolysis of sucrose to fructose and glucose. Assay of invertase enzyme was done according to the procedure described by Miller[5].

2.3.4 Protease

The blue colour developed by the reduction of phosphomolybdic phoshotungustic components in the Folin-Ciocalteau reagent by the aminoacids tyrosine present in the protein plus the blue colour developed by biuret reaction of the protein with alkaline cupric tartarate were measured in the Lowry's method. Assay of protease enzyme was done according to the procedure described by Ladd and Butler[6].

2.4 Estimation of physicochemical parameters

2.4.1 pH [11]

3gm of finely powdered organic compost was taken in a volumetric beaker and 50 ml of distilled water was added and the pH was measured by pH meter.

2.4.2 Moisture content

The moisture content was then calculated as follows:

P = Weight of the empty plate
PW = Weight of the plate with wet sample
PD = Weight of the plate with the dry sample

$$\text{Percentage of moisture content} = \frac{(PW - PD)}{(PD - P) + (PW - PD)} \times 100$$

2.5 Nutrient content

2.5.1 Macronutrients and micronutrients

Organic compost is a rich source of macro nutrients and micro nutrients like nitrogen, phosphorus, potassium, and micro nutrients namely copper, manganese.

2.5.2 Estimation of total Nitrogen [10]

The nitrogen in organic material is converted to ammonium sulphate by sulphuric acid during digestion. This salt, on steam-distillation, liberates ammonia which is collected in boric acid solution and titrated against standard acid.

2.5.3 Estimation of total Phosphorus [11]

Inorganic phosphate reacts with ammonium molybdate in an acid solution to form phosphomolybdic acid. Addition of a reducing agent reduces the molybdenum in the phosphomolybdate to give a blue colour, but does not affect the uncombined molybdic acid. The blue colour produced is proportional to the amount of phosphorus present in the samples.

2.5.4 Estimation of total Potassium [11]

In flame photometry, the solution under test is passed under carefully controlled conditions as a very fine spray in the air supply to a burner. In the flame, the solution evaporates and the salt dissociates to given neutral atoms. A very small proportion of this move into a higher energy state. When these excited atoms fall back to the ground state, the light emitted is of characteristic wavelength which is measured.

2.5.5 Estimation of Manganese and Copper [9]

The technique involves determination of concentration of a substance by the measurement of absorption of the characteristic radiation by the atomic vapour of an element. When radiation characteristic to a particular element passes through the atomic vapour of the same element, absorption of radiation occurs in proportion to the concentration of the atoms in the light path.

2.6 Studies on the effect organic compost on growth parameters of, Tomato (*Solanum lycopersicum*).

The seeds were sowed in three different pots 1, 2 and 3

1 -Organic compost
2 -Inorganic Fertilizer (NPK)
3 -Control

The following parameters were observed on 30th day of planting.

1. Gemination percentage.
2. Root length
3. Shoot length
4. Leaf count

1. Germination percentage

Germination percentage is an estimate of the viability of a population of seeds. The equation to calculate germination percentage is: GP = seeds germinated/total seeds x 100. The germination rate provides a measure of the time course of seed germination.

2. Root length

The length of the root was measured from collar region to the growing tip of the root and expressed in cm.

3. Shoot length

The length of the shoot was measured from collar region upto tip of the shoot and expressed in cm.

4. Number of leaves

The total number of leaves per needles in each plant was counted and expressed as number of leaves per plant.

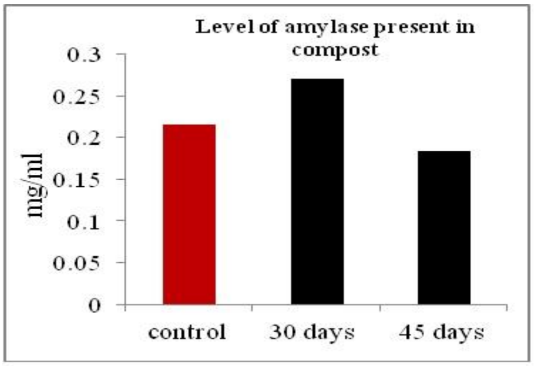
3. Results and Discussion

3.1 Enzymes present in compost

3.1.1 Enzymes involved in the degradation of complex organic materials into simple compounds

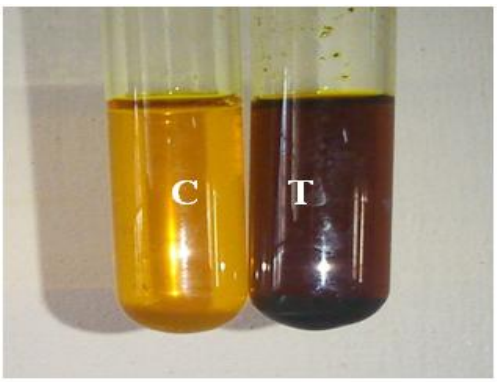
a) Amylase

Figure 1: Level of amylase present in compost



The values of data are expressed as mean ± SD. **P<0.001

Figure 2: Amylase assay

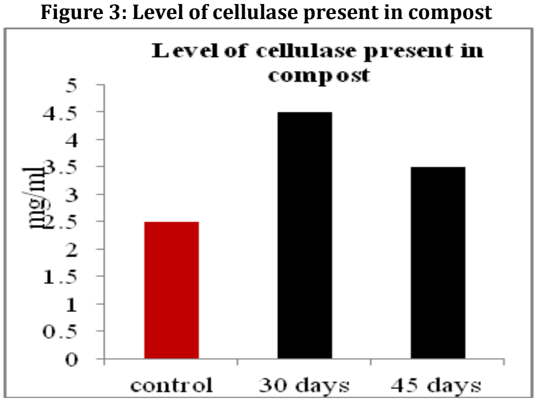


C- control, T- test

The results revealed that higher amylase activity was noticed on 30th day of organic composting when compared to control. Then the amylase content was decreased after 30th day steadily. With increase in incubation time, the amylase activity had decreased steadily to 45th day of composting with leaf litter wastes. Ageing processes greatly affected the activity of amylase; since 30th and 45th day old casts, there was a significant continuous decline in the substrate, namely starch present in leaf litter wastes. Breaking down of starch present in the waste by amylase results in decreased level of starch as composting time increases and decrease in starch concentration might be the reason for low levels of amylase[7].

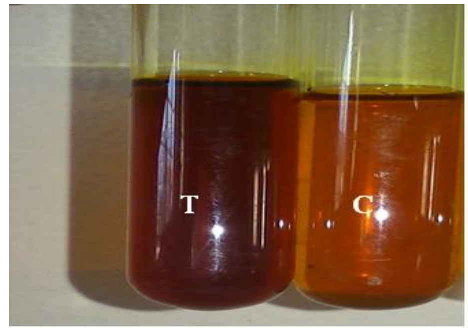
b) Cellulase

Figure 3: Level of cellulase present in compost



The values of data are expressed as mean ± SD. **P<0.001.

Figure 4: Cellulase assay

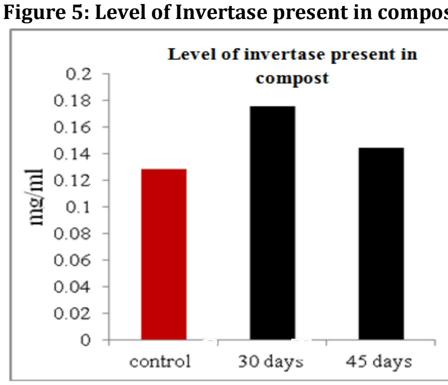


C- Control, T- test

In the present study, the cellulase activity was increased in compost when compared to control. The enzyme cellulase acts upon the substrate carbohydrate which is metabolized by the reproductively active microorganism. The cellulase activity was decreased on 45th day of composting. The cellulase activity was decreased due to the catabolism of carbohydrates during composting. The decrease in enzyme activity could depend on the decrease of relative substrate concentration during composting.

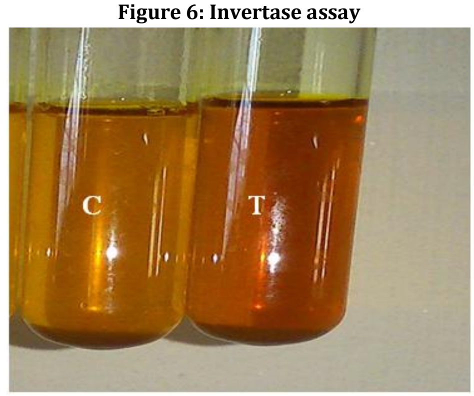
c) Invertase

Figure 5: Level of Invertase present in compost



The values of data are expressed as mean ± SD. **P<0.001.

Figure 6: Invertase assay

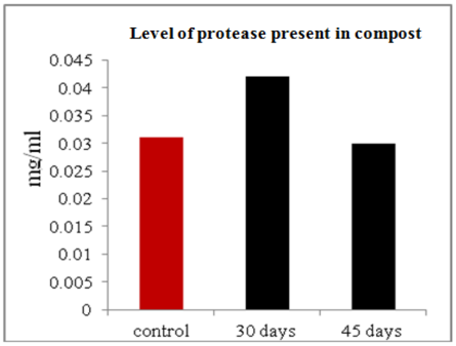


C- Control, T- test

The activity of invertase on leaf litter waste composted is found to be increased. In the present study, the invertase activity was decreased as the composting period increases and maximum invertase activity was noticed with leaf litter on 30 days of inoculation and decreases significantly to 45 days. The enzyme invertase acts upon the substrate in leaf litter wastes and degrades the complex material into simple compounds.

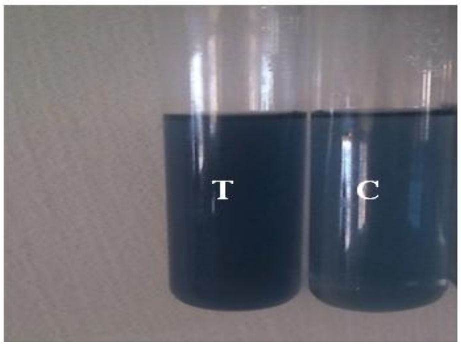
d) Protease

Figure 7: Level of Protease present in compost



The values of data are expressed as mean ± SD. **P<0.001.

Figure 8: Protease assay



C- Control, T- test

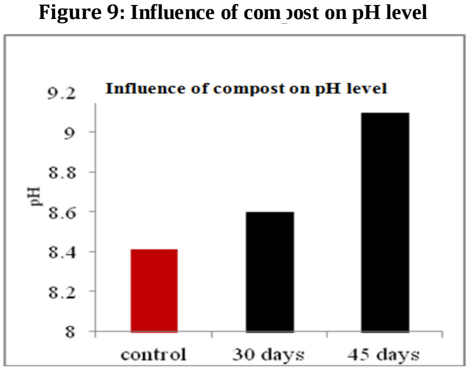
The activity of protease on leaf litter waste composted is found to be increased. In the present study, the protease activity was decreased as the composting period increases and maximum protease activity was noticed with leaf litter on 30 days of inoculation and decreases significantly to 45 days. The enzyme protease was found to be elevated in the compost due to the presence of proteolytic enzyme producing microbes which enhanced the trypsin activity.

3.2 Assay of Physicochemical parameters in organic compost

Assay of various physicochemical parameters play a key role in determining the quality of organic compost obtained from decomposition of leaf litter.

3.2.1 pH

Figure 9: Influence of compost on pH level



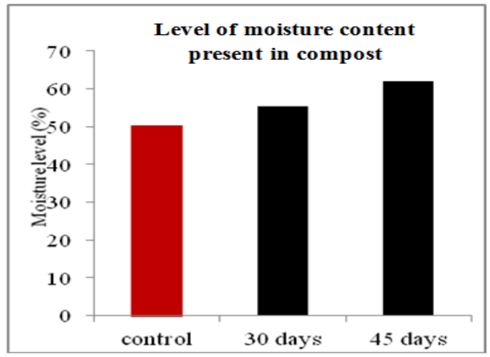
The values of data are expressed as mean ± SD. **P<0.001.

The level of pH in compost and which indicates that they are non-acidic. The level of pH was increased in compost when compared to control. Increase of pH in compost might be due to participation of microbes in the degradation of organic wastes representing aerobic metabolism.

3.2.2 Moisture content

The level of moisture was found to be more in compost when compared to control. The moisture content was found to be high on 45 days of composting. The moisture content of 60–70% was observed during microbial activity, while 50% moisture content was the minimal requirement for the rapid rise in microbial activity[8].

Figure 10: Level of moisture content present in compost



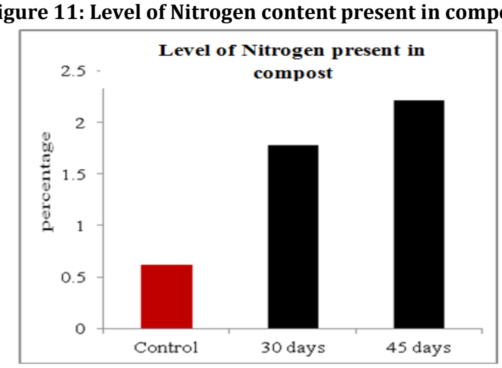
The values of data are expressed as mean ± SD. **P<0.001.

3.3 Macronutrients and Micronutrients present in compost

3.3.1 Macronutrients

a) Nitrogen

Figure 11: Level of Nitrogen content present in compost

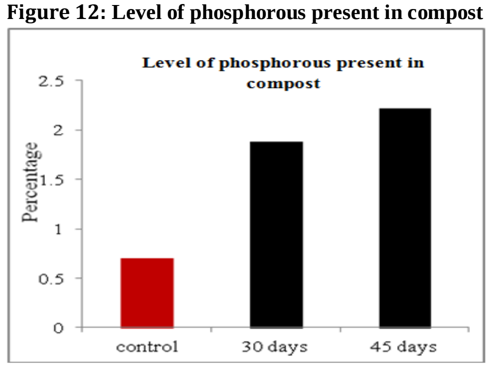


The values of data are expressed as mean ± SD. **P<0.001.

In the present study the nitrogen content in compost is found to be increased significantly to 45 days of composting. During early stages of composting very little if any nitrate-N is formed. As the rapid decomposition or thermophilic stage is passed, the mesophilic microorganisms that convert organic N to ammonium- and nitrate-N begin to flourish. The appearance of significant quantities of nitrate-N can be an indicator of maturing compost.

b) Phosphorous

Figure 12: Level of phosphorous present in compost

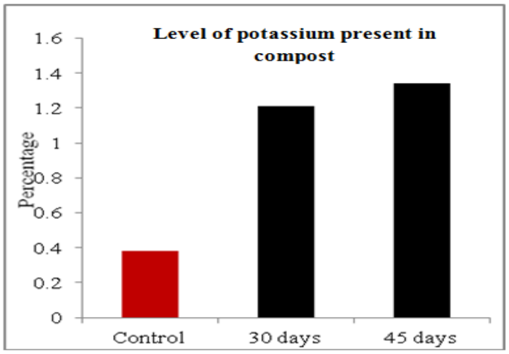


The values of data are expressed as mean ± SD. **P<0.001.

The level of high phosphorous content present in compost when compared to control. The maximum level of phosphorous content was noticed on 45 days of composting. The enhanced phosphorous level in compost is due to mineralization of phosphorous during composting. The leaf litter was found to contain more available phosphorus which may be due to the breakdown of the leaf material[9].

c) Potassium

Figure 13: Level of Potassium present in compost



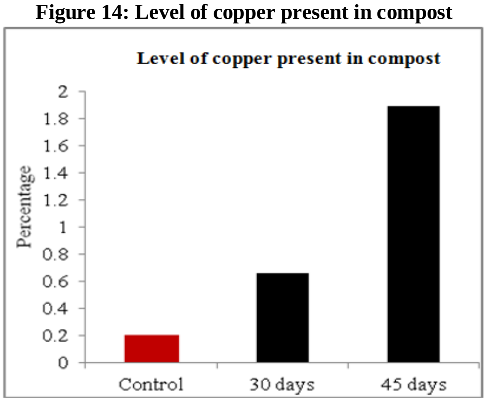
The values of data are expressed as mean ± SD. **P<0.001.

The total potassium present in compost is higher than in control. The increase of potassium content in compost which might be due to changes in the distribution of potassium between non exchangeable and exchangeable forms. An increased in potassium level during composting may be due to the microbes present in the which might have played an important role in this process. Premuzic *et al.,* (1998) claimed that acid production by the microorganisms is the major mechanism for solubilizing insoluble potassium in the organic waste.

3.3.2 Micronutrients

a) Copper

Figure 14: Level of copper present in compost

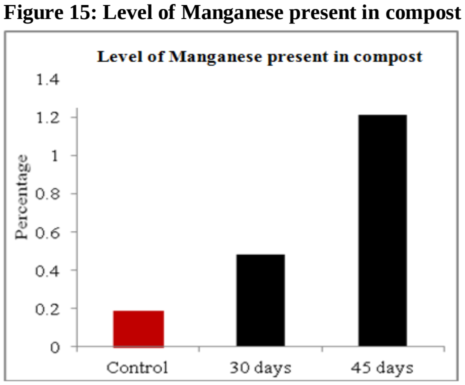


The values of data are expressed as mean ± SD. **P<0.001.

Higher content of copper was seen in compost when compared to control. Increase of copper content in compost might be due to the increased content of several Cu containing oxidizing enzymes. Higher levels of copper content in compost might be due to the presence of copper containing oxidizing enzymes. Copper is responsible for healthy, vigorous growth and strengthens stalks, stems and branches. It is also necessary for the production of plant proteins.

b) Manganese

Figure 15: Level of Manganese present in compost



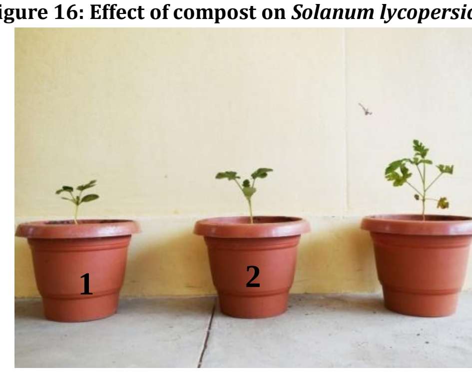
The values of data are expressed as mean ± SD. **P<0.001.

The manganese content in compost was found to be elevated in relative to that of control. of manganese content in compost which is due to mineralization of this element by the microbial activity. Manganese is a catalyst for many enzymes and also facilitates the photosynthesis and chlorophyll production.

3.4 Study on the effect of compost on growth parameters of selected vegetable plant

The vegetable plants play a vital role in maintaining health to control and cure certain diseases and hence an attempt was made to study the effect of compost on growth parameters like germination percentage, shoot length and number of leaves of selected vegetable, Tomato (*Solanum lycopersicum*)

Figure 16: Effect of compost on *Solanum lycopersicum*



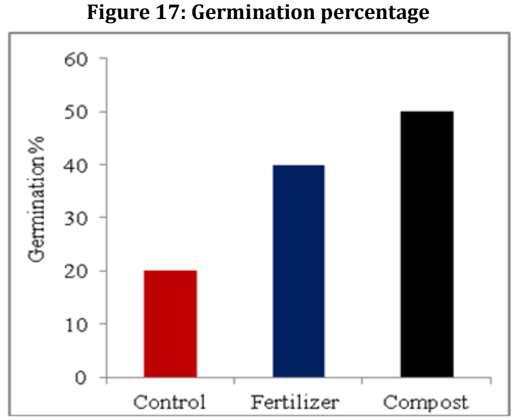
1-Control
2- Inorganic fertilizer(NPK)
3- Organic compost

3.4.1 Growth parameters

The effect of compost and inorganic fertilizer on growth parameters of selected vegetable plant is depicted as given below.

a) Germination percentage

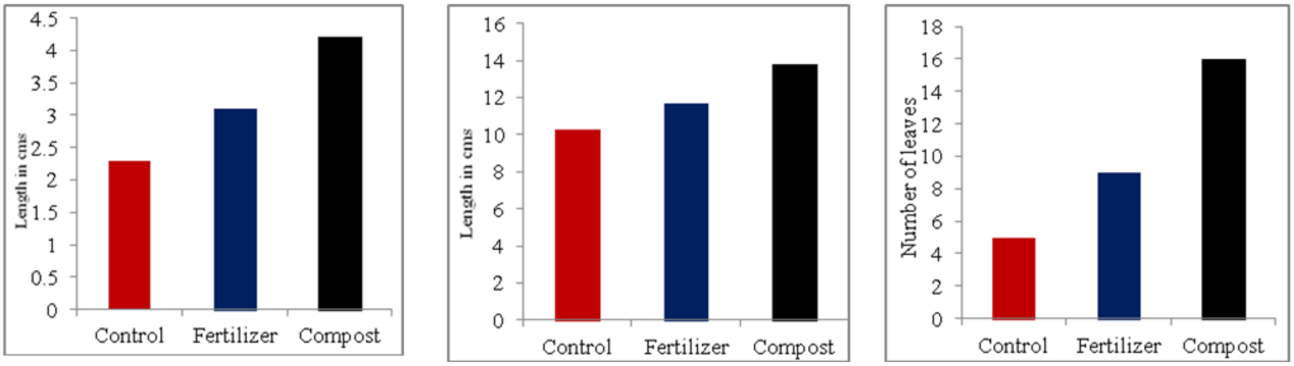
Figure 17: Germination percentage



The values of data are expressed as mean ± SD. **P<0.001.

B) Root length , Shoot length, Number of leaves

Figure 18: Effect of Compost and Inorganic fertilizer on Root length, shoot length and number of leaves of *Solanum lycopersicum*



Root length **Shoot length** **Number of leaves**

The values of data are expressed as mean ± SD. **P<0.001.

The effect of compost on growth parameters of *Solanum lycopersicum* was observed. The plant treated with compost shows higher effects in germination percentage, shoot length, root length and leaves count.

4. Conclusion

Our present study on the growth parameters in the selected vegetable plants substantiates the compost action on the yield of the vegetable plant Tomato (*Solanum lycopersicum*). Thus it is a very good organic manure for the efficient growth of the plants. Further investigation is needed to study the biochemical characterization of leaf litter.

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