Efficacy of different organic manures on the growth of *Solanum lycopersicum* L.

By

R.S. THULAJA

(20PBO019)

Thesis submitted to the

Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore – 641 043.

In Partial Fulfillment of the Requirement for the Degree of Master of Science in Botany

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Signature of the Head of Department

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R.S. THULAJA

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CHAPTER – 1

INTRODUCTION

Agriculture is much more vital for the nation's growth and survival. Therefore maintaining the quantity and quality is crucial for the people and economic exports. Now a days, many hybrid varieties and new ideas are prevailing in agriculture. In contemporary Agriculture, chemical pesticides and fertilizers are used for getting better yield and high productivity in short time without any infection. So, unremitting convention of these harmful chemicals leads to decrease in the soil fertility and also distressing the nutritional values of fruits and vegetable (Sneha *et al*.,2018).

The excellent food choice for a healthy body is fresh vegetables that are naturally low in fat, salt and sugar. Vegetable provides energy, vitamins, minerals and fibres and there is growing evidence of additional health benefits from a range of phytonutrients (Joao Silva Dias, 2012). No single vegetable provides all these nutrients needed for our daily life. Various types of vegetables contain different types of energy rich nutritious value.

ORGANIC FARMING

In India, the organic farming system is widely practised from ancient times and it is mentioned in most of the Indian ancient literatures like Vedas, Ramayana, Mahabharata (Behera *et al*., 2011). It is another type of farming system which aims at cultivating the land and raising crops in such a way, so that the soil is alive and in good health by use of organic wastes (crop, animal and farm waste, aquatic waste) and other biological materials along with beneficial microbes (Bio fertilizers) to release nutrients to crop for the sustainable production by increase in the quantity of yield and making the environment pollution free and they are eco-friendly in nature.

NEED OF ORGANIC FARMING

The essential of organic farming is not only to enlarge the agricultural production but also increase them in sustainable manner as the population keeps on increasing. The scientist have realized that the "Green revolution" with high inputs use has reached a plateau and is now sustained with retreating of falling dividends (Behera *et al*., 2011).Thus, there is a need to preserve the natural balance at all cost for phenomenon of life and property. The palpable choice for that would be more significant in the present era, when these agrochemicals which is produced from fossil fuels are non renewable and are diminishing in availability. It is very beneficial for economic status when there is doable foreign exchange in future.

CHARACTERISTICS OF ORGANIC FARMING

- Protecting the long term fertility of soils by maintaining organic matter levels, encouraging soil biological activity and careful mechanical intervention.
- Providing crop nutrients using relatively insoluble nutrient sources which are made available to the plant by the action of soil microorganisms.
- Nitrogen self-sufficiency through use of legumes and biological nitrogen fixation, as well as effective recycling of organic materials including crop residues and livestock manures.
- Weed, disease and pest control relying primarily on crop rotations, natural predators, diversity, organic manure, resistant varieties and limited thermal, biological and chemical intervention (Behera *et al*., 2011)
- Careful attention on the impact of the farming system on the wider environment and the conservation of wildlife and natural habitats (Behera *et al*., 2011).

BIOFERTILIZERS

In recent years, many natural fertilizers have been found to act as natural stimulants for plant growth. Among these, a particular group of micro organisms have been found to augment the growth and production of crop plants, which we call as "BIOFERTILIZERS". These biofertilizers have the capability to fix the atmospheric nitrogen or even solubilize the insoluble phosphorus for use by the crop plants (Sneha *et al*.,2018).

Biofertilizers are the organisms that enrich the nutrient quality of the soil. These are the substance that contains micro organisms living or latent cells. It increases the nutrients of host plants when applied to their seeds, plant surface or soil by colonizing the rhizosphere of the plant (Sneha *et al*.,2018).

How do Biofertlizers work?

Biofertilizers trap the atmospheric nitrogen and fix it to the soil and convert them into usable forms for the plants to absorb. They stimulate the root growth by producing some hormones and anti-metabolites (Sneha *et al*.,2018).

TYPES OF BIOFERTILIZERS

TYPES*:* (Kawalekar *et al*.,2013)

Biofertilizers are of two types. They are,

- Nitrogen fixing micro-organisms
- Phosphorus solubilising micro- organisms

Under Nitrogen fixing micro organism

- Symbiotic (*Rhizobium, Azolla*)
- Non symbiotic(Blue green algae*, Azotobacter, Azospirillum*)

Under phosphorus solubilising micro organism

- Symbiotic (Vesicular Arbuscular Mycorrhiza)
- Non symbiotic (fungi, bacteria)

CHARACTERISTICS FEATURES OF COMMON BIOFERTILIZERS

NITROGEN FIXING BIOFERTILIZERS

Nitrogen is the most limiting nutrition factor needed for the growth of the plant. About 80% of the nitrogen is found in the atmosphere, but most of the plants cannot utilize atmospheric nitrogen. Some special group of micro organisms can fix the nitrogen in the soil. These microbes are called as nitrogen fixers.

This will help to transfer the nitrogen into organic form for the growth of the plant. They are grouped into free living bacteria (*Azotobacter* and *Azospirillium*), blue-green algae, and symbionts, such as *Rhizobium, Frankia and Azolla* .

The N_2-fixing bacteria associated with legumes include *Rhizobium, Mesorhizobium, Azorhizobium*, *Bradyrhizobium*, *Sinorhizobium, and Allorhizobium*and those withnon-legumes include *Achromobacter, Alcaligenes, Arthrobacter, Acetobacter, Azomonas, Beijerinckia, Clostridium, Bacillus, Enterobacter, Erwinia, Desulfovibrio, Derxia, Corynebacterium, Campylobacter, Herbaspirillum, Klebsiella, Lignobacter, Mycobacterium, Rhodospirillum, Rhodo-pseudomonas, Xanthobacter, Mycobacterium and Methylosinus.* (Kawalekar *et al*.,2013)

Azolla:

It is a free floating fern. *Azolla* leaves contain 4-5% nitrogen(on dry weight) and 0.2-0.4% nitrogen (on wet weight). It is used as Biofertilizer in many countries such as Vietnam, China, Thailand and Philippines. It has metal tolerance ability so it could be used in the heavy metal polluted areas. (Nosheen *et al*.,2021)

Rhizobium :

Rhizobium is relatively more effective and widely used bio fertilizer. *Rhizobium*, in association with legumes, fixes atmospheric nitrogen**.** The legumes and their symbiotic association with the *Rhizobium* bacterium results in the formation of root nodules that fix atmospheric N (Kumar *et al.*, 2017). Rhizobium population in the soil is dependent on the presence of leguminous crops in field, when the legumes are absent there is a reduction in the population of *Rhizobium*.

Rhizobacteria uses and its effect on plant yield (Nosheen *et al*.,2021)

Microbial strains	Name of the plant	Effect
Bradyrhizobium sp.	**Mungbeans**	Increases growth parameters and seed yield
Rhizobium meliloti	**Peanuts**	Increases growth, yield attributes, quality of pods and efficiency in the use of nitrogen
R.leguminosarum	**Soybean**	Increases growth and yield performance under drought stress
Bacillus sp.	**Strawberry**	Increases fresh and dry weight parameters, increases yield over the control plant
Chryseobacterium sp.	**Chickpea**	Increases grain yield, shoot mass and nodule mass
Herbaspirillum sp.	**Maize**	Enhances mineral uptake and increases yield
Paenibacillus glucanolyticus	**Black pepper**	Increases tissue dry weight and nutrient uptake in the plant
Sterptomyces sp.	**Tomato**	Increases growth parameter and modulates metabolic activity
Burkholderia sp.	**Fenugreek**	Increases growth and yield performance

Azospirillum :

In the higher plant community, the Azospirillum have good associative symbiosis in the graminaceous plants (Kumar *et al*., 2017). The Azospirillum have a close association with cereals and millets. Some of them are sorghum, maize, pearl millet, finger millet, foxtail millet and other minor millets and also fodder grasses.

***Azotobacter* :**

Azotobacter is a free-living bacterium which grows well on a nitrogen free medium. It belongs to the family *Azotobacteriaceae.* These bacteria utilize the atmospheric nitrogen gas for their cell protein synthesis. It has the ability to produce vitamins like thiamine and riboflavin. It is used for the growth of all non- leguminous plants especially rice, cotton, vegetables, sugarcane, sweet potato and sweet sorghum. ***A.chroococcumis*** is the most prevalent species found in the soil, but other species like ***A. vinelandii, A. insignis, A. beijerinckii and A. Macrocytogenes*** are also present in nature. They produce vitamin B complex, different phytohormones such as gibberellins and naphthalene acetic acid (NAA).It improves the root growth of the plants by producing growth substances. It has been found that the population of *Azotobacter* is generally low in the rhizosphere of the crop plants such as rice, maize, sugarcane, bajra, vegetables and plantation crops (Nosheen *et al*., 2021).

Blue green algae :

Blue green algae are referred to as rice organisms because of their abundance in the rice field and are able to fix atmospheric Nitrogen (Hillol Chakdar *et al*., 2012). In tropical conditions, species comeing under the genera *Tolypothrix*, *Nostoc*, *Calothrix*, *Anabaenopsis* and *Plectonema* are huge in number. Most of the nitrogen fixation BGA are filamentous, consisting of chain of vegetative cell including specialized cells called heterocyst which function as a micro nodule for synthesis and N fixing.

Phosphate solubilizing bacteria (PSB) :

Most of the soil bacteria and fungi secretes organic acids and lower the pH in their surroundings and these help in the dissolution of phosphates present in the soil. The yield of Potato and Wheat are increased due to the inoculation of peat based cultures of some PSB like *Bacillus polymyxa* and *Pseudomonas striata* (Kumar *et al*., 2017).

IMPORTANCE OF BIOFERTILIZERS

Biofertilizers are important for the following reasons (Kumar *et al*., 2017)

1. The soil texture and yield of plants could be improved by the application of biofertilizers.

2. They do not allow pathogens to flourish.

3. They are eco-friendly and cost effective.

4. As the biofertilizers are natural fertilizers, it could protect the environment from pollutants.

5. Plant disease causing harmful substances present in the soil are destroyed by the application of biofertilizers.

6. Under semi- arid conditions, biofertilizers are more effective.

The use of biofertilizers will increase the yield of the vegetable as well as the fertility of the soil. The present study is on the growth of vegetable crop *Solanum lycopersicum* L. under different types of biofertilizer application.

Tomato's scientific name is *Solanum lycopersicum* and is a member of the *Solanaceae* family. This family also includes other commonly used vegetables like potato, pepper, and many others. It is a perennial plant, although most producers grow it as an annual.

Tomato plant is a dicot and herbaceous plant. The plant forms a pile root that grows to a depth of up to 2 meters. It develops vines that grow as branching stems.

Wild tomato varieties were small and mostly yellow, not red. We could say that they were similar to what we know today as cherry tomatoes. Nowadays, apart from different sizes, we can also find different colors of tomatoes varying from our familiar red, to pink, yellow, orange, purple, white and black.

Tomatoes are considered as a dietic food for Americans, because of its vitamin and phytosterols. It can lower the cholesterol level and research underscores concludes that the intake of tomatoes could reduce the risk of cancer and heart diseases (Debjit bhowmik *et al*.,2012)

The main objective of this study is

- To study the growth of tomato plants in terms of root length, shoot length, number of leaves, diameter of leaves, number of lateral roots and number of flowers at different intervals by the application of biofertilizers.

CHAPTER - 2

REVIEW OF LITERATURE

Literature related to the organic farming using different type of fertilizers that is relevant to the present study are reviewed and presented in this chapter.

Sathish kumar *et al*. (2021) showed that the plant associated microbes play a vital role in enhancing plant biomass and crop yield. They have done a detailed study on plant growth mechanism including nutrient availability, phytohormone modulation, biocontrol of phyto pathogens, amelioration of biotic and abiotic stresses. They have also explained about solid and liquid base inoculum preparation.

Reddy et al.,(2021) had conducted the experiment is to reduce the use of synthetic fertilisers and other chemical inputs in strawberry farming. using bio-inoculants in combination with inorganic nutrients have shown that various inoculants, such as *Azotobacter*, *Azospirillum*, *Pseudomonas*, *Bacillus*, Mycorrhizal fungi *Aspergillus* and *Penicillium*, can boost nutrient uptake and fertiliser use efficiency in strawberry plants. As a result, biofertilizers have an important role in boosting soil fertility, crop output, lowering production costs and reducing pollution.

Salem Al-Amri (2021) have studied the use of different microorganisms as bio-fertilizer agents to improve the development and production of common bean plants (*Phaseolus vulgaris* L.) cultivated under varying water stress levels. When comparing AMF + endophytic bacteria under second water stress (WS1) to other treatments, common bean produced seeds had considerably higher nutrient content (nitrogen, potassium, phosphorus, magnesium, and calcium), vitamin B1, Folic acid, crude protein, and crude fibres.

Riaz *et al*. (2021) in their studies have concluded that the biofertilizers as a valuable tool for Organic Agriculture's Future and Organic farming is both environmentally benign and financially viable, with numerous health benefits; organic foods have a large market potential, and it might be a significant step towards sustainable agriculture.

Mustafa *et al*. (2021) have reported the effect of fertilisation with different phosphorus sources- calcium superphosphate (CSP) and monoammonium phosphate (MAP) when combined with biofertilizers (i.e., phosphorin or mycorrhiza inoculation) on plant growth aspects, antioxidants, enzyme activity, chemical constituents, yield and quality of broccoli leaves and heads *(Brassica oleracea* var. italica Plenck). In this study , they have concluded that depending on the fertiliser source, phosphorus may affect plant growth, yield and chemical parameters in broccoli plants, while mycorrhiza inoculation may also have a beneficial impact on these parameters.

Badawi *et al*. (2021) studied the effect of promoting *Rhizobacteria*, organic and mineral fertilisation, and sprinkler irrigation on the growth, chemical composition, yield, and some yield components of wheat (T*riticum aestivum* cv. Misr 3). Among all fertilisation treatments, the superiority of treatments containing rhizobacterial inoculation and compost amendment in the presence of half dose or 75% mineral fertilisation, which caused significant augmentation and achieved the highest values of all wheat growth parameters (plant height, number of tillers/plant, and dry weight of roots and shoots), nutrients accumulated in tissues, was demonstrated. As a result, rhizobacterial inoculation (as grain coating) in combination with compost manure (10 tonne fed-1) and half dose of mineral NPK fertilisers may be a good practise not only for sustaining wheat yield in sandy soil but also for accelerating nutrient-use efficiency and reducing reliance on chemical fertilisers in agriculture, improving soil fertility, and minimising environmental pollution.

Kadhum *et al*. (2021) conducted the experiment to examine the effects of bio-fertilizer (BF) and different rates of mineral fertiliser (MF) from fertiliser recommendation (FR) on wheat growth and yield (IBAA cultivar). Except for the total number of organisms in the soil, the results showed that the treatment of adding biological fertiliser with 100 % mineral fertiliser (T5) was superior in most of theParameters studied. As a result, it is possible to replace 50% of mineral fertiliser, reduce pollution, and save money on mineral fertiliser.

Mohammed Anli *et al*. (2020) had conducted the experiment by single or multiple combinations of exotic and native arbuscular mycorrhizal fungi (AMF1 and AMF2, respectively), and/or selected consortia of plant growth-promoting rhizobacteria

(PGPR: B1 and B2), and/or composts from grasses and green waste. Their study implemented an adapted management programme to improve date palm development and tolerance to water deficit (C1 and C2, respectively).This research makes biofertilization technology more cheap for farmers in tough environments, as well as those in developing nations, who want to raise crops in a sustainable way. For these reasons, conducting field trials is the next important step (an ongoing study) toward a more stable use of biofertilizers in agriculture and a better understanding of the possible effects of indigenous biofertilizers.

Hassan and Abd El-Azeim (2020) in their study examined the effects of compost at four levels (0, 5, 10 and 15 tons/feed) in combination with Microbein biofertilizer (M.B.) 50 ml/herb and/or in some antioxidant treatments (salicylic and ascorbic acids) on vegetative growth and flowering of *Gladiolus grandiflorus* var. jester plants. The vegetative growth and leaf length (cm), number of leaves/plant, flowering parameters, leaf dry weight/plant (g), spike length (cm), spike diameter (mm), spike fresh weight (g), number of flowers/spike, lower flower diameter (cm) and lower flower fresh weight (g)showed significant differences by increasing the compost levels.

Diksha Sharma and Pratima Vaidya (2020) had conducted an experiment in paddy by comparing biofertilizer and chemical fertilizer treatments. They have concluded that the use of biofertilizers reduces the use of chemical fertilisers by 50%. In saline soils, applying 107 kg N/ha of biofertilizers (yeast extract, *Azolla*, BGA, and *Rhizobium*) results in a slight increase in paddy yield. Therefore, biofertilizers can be used in conjunction with inorganic fertilisers to increase paddy yield on a sustainable basis.

Suriya Sabarinath *et al*. (2020) in their study on the growth and yield using bioinoculants and inorganic fertilizers on Tomato (*Solanum lycopersicum* L.). showed that a significant difference in the combined application of bioinoculants and inorganic fertilizers.

Gawade *et al*. (2019) Conducted experiment on the "Response of biostimulants and biofertilizer on growth, yield and quality of *Chrysanthemum cv. Ratlam*.

Sutrishna Bordoloi and Madhumita Choudhury Talukdar (2019) conducted as experiment to examine the effect of GA3 and Biofertilizer on Anthurium (*Anthurium* *andreanum* Lindex Ex Andre) growth and yield. T3 showed a significant increase in the growth parameters when RDF+*Azospirillium*+100ppm GA3 was supplemented.

V.S. Mor *et al*. (2019) reported the effect of organic manures, fertilisers, and their combined application on wheat seed quality parameters (cv WH 711). The application of organic manures in conjunction with nitrogen (N) and phosphorus (P) fertilisers significantly increased wheat seed yield (5.54, 5.25, and 5.32 t/ha) when the recommended dose of N and half of P was combined with FYM, poultry manure, and pressmud, respectively). When compared to organic manures and chemical fertilisers used alone, the integrated approach resulted in higher seed yield and higher quality.

Vinod Kumar *et al*. (2019) investigated the effect of organic manures and bio-fertilizers on tomato cv. Roma growth, yield, and quality traits. They used Randomized Block Design, with twelve treatments replicated three times. They have reported that the increase in vegetative growth and yield may be attributed to nutrient sources such as inorganic, organic, and bio-fertilizers (Phosphorus solubilizing bacteria and *Azospirillum*).

Lebin Thomas and Ishwar Singh (2019) in their studies have concluded that for efficient and sustainable agriculture, the use of microbial biofertilizers is an excellent way to increase and maintain soil nutrient economy while lowering the usage of chemical fertilizers.

Kumar *et al*. (2018) have concluded that the number of fruits/ plant increases when higher level of NPK biofertilizer treatment was used. Also the maximum fresh fruit weight was higher in the treatment where the usage was 100%RDF+*Azospirillum.* This was due to enhanced uptake of water and nutrients by *Azospirillum*.

Rukshana *et al*. (2018) concluded that inoculation of PSB improves the yield character by solubilisation and increased availability of P from insoluble phosphorus. The inoculation of VAM in soil also significantly plays an important role in P recycling, mobilization and uptake by plants thereby having a greater root extension, higher nutrient uptake, higher photosynthesis and yield attributes.

Hanafi *et al*. (2018) have conducted an experiment on Spent Mushroom Substrate and concluded that this substrate is used as a fertilizer as it is rich in nutrient content. It is also helpful in several applications such as soil amendment and enrichment, animal feedstock, fertilizer, energy production, waste water treatment, dye- decolourization and ammonia emission reduction.

Shashi kamal *et al*. (2018) conducted an experiment to study the effect of biofertilizers (*Azotobacter, Azospirillium*, PSB, VAM) on growth and yield attributes of tomato and they have shown a significant difference on plant fresh weight, dry weight, diameter of stem, fruits per plant, yield while plant height, days to first harvest, days to final harvest, and number of primary branches showed the non-significant difference.

Vaibhav *et al*. (2018) had suggested that Municipal Solid Waste Vermicompost had a greater significance in the effect of biochemical, physiological and yield response of *A. esculentus* when amended with upto 60% MSWVC. An increase in the rate of photosynthesis, stomatal conductance and improved antioxidant response was seen with a greater significance in the parameters like leaf area, total biomass and yield responses when compared to control. Thus, Municipal Solid Waste Vermicompost was found to be very much useful for the soil fertility in agricultural applications.

Murthy *et al*. (2018) conducted the experiment to study the organic fertilizers that works superior on primary metabolite contents of *Ocimum basilicum* and *Marjorana hortensis* than chemical fertilizers. but there was major difference between the two plants signifying organic fertilizers to be in good health. This work also showed better yield in organic fertilizers compared to chemical fertilizers. It can be concluded that, the NPK fertilizers could be replaced by organic fertilizers to get quality crops.

Sneha *et al*. (2018) in their studies have conclude that the Biofertilizers are an alternate source for crops' nutritional requirements. Beneficial bacteria found in biofertilizers include *Azotobacter, Azospirillium, Rhizobium,* and Mycorrhizae, all of which are critical in crop productivity. Biofertilizer can also help plants withstand adverse environmental conditions.

Itelima *et al*. (2018) from their experiment concluded that the use of biofertilizers leads to improved nutrient and water uptake, plant growth and plant tolerance to abiotic and biotic factors. These potential biofertilizers will play an important role in soil productivity and sustainability as well as environmental protection as eco-friently and cost-effective inputs for farmers.

Narendra kumawat *et al*. (2017) had studied the biofertilizers which are living microbial inoculants of bacteria, algae, fungi alone or in combination and they augment the availability of nutrients to the plants. The role of biofertilizers in agriculture assumes special significance, particularly in the present context of increased cost of chemical fertilizer and their hazardous effects on soil health.

Preeti Shrimal and Khan (2017) had conducted an experiment to determine the effects of vermicompost on Bengal gram (*Cicer arietinum* L.). They used different treatment levels of vermicompost i.e. T1 which was control level (soil without vermicompost), T2, T3, T4, T5 and T6. With the increase in the amount of vermicompost, the growth increased up to T6. The results revealed that there is a need for a transition from the use of chemical fertilizers to the use of organic fertilizers farming using vermicompost. These results can be applied at larger farm levels for safety and sustainable Agriculture.

Dikr and Belete (2017) had conducted an experiment to study the effect of Organic fertilizers, Biofertilizers and Inorganic Fertilizers (NPK) on Growth and Flower Yield of Marigold (Tagetus erecta L.). Amongst the organic manures and inorganic fertilizers, the application of N120 P80 K40 gave the maximum flower yield of African marigold. Manure has a significant effect on plant height, fresh weight of flower, branch number, increase soil property and microbial activity in the soil and possess long lasting supply as compared to NPK

Khan *et al*. (2017) carried out research on the impact of biofertilizers on *Pisum sativum* L. plant growth and yield characteristics. Treatment involves 100 % RDF + *Rhizobium* 30g/kg was judged to be the optimum treatment for plant growth and seed yield based on the average performance. As a result, seed farmers may find that using biofertilizers is a better alternative for achieving seed yield and yield components in pea.

Vidhyashree Venkatarao *et al*. (2017) had conducted the experiment on the effect of Phosphorus and Biofertilizers on Growth and Yield of Mungbean (*Vigna radiata* (L.) Wilczek) .They have concluded that, the application of phosphorus @ 40 kg ha-1 and dual inoculation of biofertilizers (PSB + *Aspergillus awamori*) had a substantial effect on increasing the growth characteristics and yield (grain and straw) in comparison to other mungbean treatments

Mohammad Moneruzzaman Khandaker *et al*. (2017) had used different types of fertilizers like poultry manure, goat, rats and rabbit manure and NPK fertilizers. In their study, they have shown significant increase in plant growth in terms of leaf area, chlorophyll content, Number of flowers, Number and weight of pod, photosynthetic rate especially in poultry manure. NPK fertilizers is good for early harvesting, while the use of organic manure like poultry manure can reduce the production cost, but increase soil physical properties as it is friendly to the environment.

Amin Farnia (2015) have reported that using different types of biofertilizers can increase the production of Maize. The selection of supernitroplus biofertilizers and siloking cultivar lead to an increase in the growth of maize crop when compared with other biofertilizers.

Dinu *et al*. (2015) have conducted experiment on foliar treatment of humic acid extracted from brown coal, humic acid mixed with polyphenolic extract of *vitis vinifera* seeds and Boron on the content of chlorophyll in tomato plants. They observed the development of plants and fruits according to its stages and the production was different depending on the nature of fertilizer. They also concluded that the best results occurring in the variant fertilized with humic acids +extract from the *vitis vinifera* seeds + Boron (HA + ESVv + B).

Roy *et al*. (2015) in their studies have concluded that both substrates of oyster mushroom and button mushroom compost are the good source of biofertilizer when they are applied to the *Capsicum annuum* crop. They are much useful in the field to increase the crop production and also acts as a soil conditioner.

Kirti Choudhary *et al*. (2015) have concluded that maximum growth, highest yield and yield attributing characters of okra are achieved by the application of biofertilizers and chemical fertilizers. The results obtained from Shivran *et al*. (2017) have shown that the use of biofertilizers and zinc levels enhanced the quality of broccoli when compared to control. They also concluded that inoculation of *Azotobacter* + PSB with 30 kg of Zinc sulphate (Zn So4) is highly recommended for the production of broccoli under Lucknow conditions.

Taufiq Ahmad *et al*. (2015) conducted an experiment on the effect of organic fertilizers on growth and yield of Coriander, Among the organic fertilizers used poultry manure performed best and therefore recommended for growers in the agro-climatic conditions of Peshawar.

Manal Gad El-Moula and Abou-El-Hassan (2015) have carried out a study on partial replacement of mineral nitrogen fertilization tomato with or without nitrogen-fixing bacteria adding compost to sandy soil. The results showed that using 50% or 75% of N-mineral fertilizer + compost + nitrogen-fixing bacteria gave the highest growth values, mineral composition and yield of tomatoes.

Fernandes Peter and Bhalerao Satish (2015) conducted the experiment on the influence of azotobacter spp. biofertilizers on the growth and yield of Mungbean *Vigna radiata* (L. Wilczek) After 45 days, the results of treating mungbean seeds with biofertilizer were recorded. The findings demonstrated that plants treated with the biofertilizer Azotobacter spp produced good morphological and biochemical outcomes. Biofertilizers should therefore be promoted.

Ritika (2014) in her study have shown that biofertilizers and organic manures are the alternate source that supplies nutrient requirement to crops. Biofertilizers such as *Azotobacter*, *Azospirillum*, Phosphobacteria and *Rhizobacter* are very important for the growth of the plant. The use of these biofertilizers not only increases the economic development, but also contributes to a sustainable ecosystem and holistic well-being of the country.

Yadav *et al*. (2013) has reported that organic farming can provide the quality foods and it is not affecting the soil environment. The seeds of chick pea inoculated with *Rhizobium* + PSB increase the yield of grain and grain protein content and also the level of total nitrogen and phosphorous uptake.

Ghany *et al*. (2013) in their studies conveyed that bio-fertilizer could promote an adequate supply of nutrients to the host plants and ensure proper growth and physiology regulation.They concluded that the Biofertilizers enrich soil and are compatible with long-term sustainability. They are also environment friendly and can be replaced with chemical fertilisers.

Arshad (2011) from his experiment concluded that the use of both bio power and EM can be combined well with the suitable soil amendment. Both the fertilizers are useful to enhance the rice shoot biomass (*Oryza sativa*) and grain yield in the green manure amendment.

Suge *et al.* (2011) conducted an experiment to see how combining two levels of suggested mineral fertilizers with three types of organic manures affected egg plant (*Solanum melongena* L) var. black beauty growth, fruit output, and quality. The plants in the organic manure-treated plots exhibited rapid vegetative development, which resulted in increased total fruit yields and improved fruit quality. As a result , the best reaction was obtained when 100 % of the necessary NPK was mixed with farm yard manure.

Abd EI –Kader *et al*. (2010) showed that there is a significant effect on biometric characters such as plant height, fresh weight, dry weight, leaf area, Number of leaves, stem diameter, Number of branches per plant when combination of organic fertilizer treatment was used. The use of drip system in combination with plant residues and chicken manure also increased the okra yield.

Mustafa Paksoy *et al*. (2010) in their experiment had concluded that both potassium (K) and humic acid (HC) has a great significance in the yield and nutrient uptake and growth parameters of vegetable crops. Humic acid not only increase the content of macro-nutrients, but also increase the content of micro-nutrients in plants.

Sheraz Mahdi *et al*. (2010) had concluded that selection of efficient location soil specific strains for N-fixing, P, Zn- solubilizing and absorbing (Mycorrhizal) to suit different agro climatic conditions are essential. They also concluded that developing suitable alternate formulations viz liquid inoculants granular formulations for all bio inoculants, to carrier based inoculants is important.

Gosavi *et al.* (2010) had studied the effect of organic manures with biofertilizers on fruit characters of tomato hybrid RTH-2. Farmyard manure, cotton seed cake and poultary manure were used as N source. Vermiphos and Sulphate of potash were used as source of potassium and phosphorus. They have shown the pericarp thickness, TSS, Acidity, ascorbic acid, Lycopene, to be better in the treatment with organic fertilizers.

They concluded that the combination biofertilizer results in more yield and high quality in the Crop.

Adesemoye *et al*. (2009) in tomato studied if reduced rates of inorganic fertilizer combined with microbial inoculants could produce better plant growth, yield, and nutrient uptake when compared to full rates of fertilizer. Plant growth, yield, and nutrient (nitrogen and phosphorus) uptake were statistically equal when inoculants were added to 75% of the recommended fertiliser rate. The findings show that PGPR-based inoculants can be used and should be investigated further as part of integrated nutritient management schemes.

Surindra Suthar (2009) had conducted the experiment on the impact of vermicomposted and composted farmyard manure (FYM) along with some combination of NPK fertilizers, on field crop of garlic (*Allium stivum* L.) .He prepared six experimental plots and noted the plant parameters namely root length, shoot length, leaf length, fruit weight, number of cloves in garlic fruit and number of leaves per plant . The results indicated that the vermicompost and composted farmyard manure along with some combinations of NPK gave excellent plant growth as well as yield in garlic plants that received vermicompost as nutrient supplier in field.

Fawzy *et al*. (2007) studied the impact of poultry rates fertilizer and chemical nitrogen fertilizer "Nitrobin" with or without biofertilizer at rates of 500 g./feed. cv. on growth, yield, quality and chemical content of tomato plants. Highest yield and fruit quality (fruit length, fruit diameter, fruit weight and T.S.S) was observed is 25% poultry manure + 75% nitrogen mineral fertilizer. In addition, the use of biofertilizers had increased significantly total yield and quality of tomato fruits.

Jilani *et al*. (2007) in this experiments used the Biological Potassium Fertilizer (BPF) and NP as fodder that gave maize growth, yield and nutrients uptake equal to that of full use of NPK. They also found that bio power + effective microorganisms (EM) + Half NP, was effective in giving more economic return.

CHAPTER III

MATERIALS AND METHODS

The plant taken for the current study was ***Solanum lycopersicum*** L. and it is a member of the *Solanaceae* family. Growth studies were carried out under different treatments of biofertilizers namely ***Azospirillum*, Phosphobacteria and Farmyard manure** against untreated control at different stages of growth of the plant.

Collection of the seeds

Seeds of *solanum lycopersicum* L. were obtained from Tamil Nadu Agricultural University, Coimbatore.

Morphology of the plant

Solanum lycopersicum L. (**Plate 1, 2 & 3**)

Systematic position

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Solanales

Family: Solanaceae

Genus: *Solanum*

Species: *S. lycopersicum*

Description

- The **Tomato** is the edible berry of the plant *Solanum lycopersicum* L., commonly known as the tomato plant.
- There are **over 1500 species worldwide** and at least 100 indigenous species spread across Africa.
- They are generally much branched, spreading 60–180 cm (24–72 inches).

- It can be erect with short stems or vine-like with long, spreading stems.
- The stems are covered in coarse hairs and the leaves are arranged spirally.
- Leaves are more or less hairy, strongly odorous, pinnately compound, and up to 45 cm (18 inches) long.
- The five-petaled flowers are yellow, 2 cm (0.8 inch) across, pendant and clustered. It produces yellow flowers.
- These fowers which can develop into a cyme of 3–12, and usually a round fruit (berry) which is fleshy, smoothed skinned and can be red, pink, purple, brown, orange or yellow in color.
- Fruits are berries that vary in diameter from 1.5 to 7.5 cm (0.6 to 3 inches) or more. Each fruit contains at least two cells of small seeds surrounded by jellylike pulp.
- They are usually red, scarlet, or yellow, though green and purple varieties do exist, and they vary in shape from almost spherical to oval and elongate to pear-shaped.
- It may also be referred to as love apple and originates from South America.

Plate 1 Habit of *Solanum lycopersicum* L.

Plate 2 Flower of *Solanum lycopersicum* L.

Origin and distribution

The spanish found in the American hemisphere a herbaceous plant whose fruit was edible, called "tomatl", which translated to Spanish became tomato (Porcuna et al., 2012).

Plate 3 Plant showing development of Fruit

Food Value

Tomato (*Solanum lycopersicum* L.) is an most important herbaceous plant . It has source of nutrients such as vitamin C, Potassium, Folic acid and carotenoids. It contributes to tha absorption of carotenoids and lycopenes in the human serum. It also contain components include neoxanthen, lutin, α-carotene, β-carotene 5,6-epoxide. It has the power to inhibit ADA (Adenosene deamenase) which cures the regression of tumour and they have dietary fiber and protein (Rashida *et al*.,2013)

Health Benefits

The plant consists of carotene lycopene which is one of the natural antioxidant, it also helps to prevent cancer. Presence of lycopene helps to improve the Skin's abilty. A Researchers from Manchester and Newcastle Universities revealed that tomato has the ability to protect from sunburn and helps to keep the skin glow and youthful (Izharul Hasan *et al*., 2014)

1.Cardiovascular support

Tomato helps in extreme level to reduce the risk of heart disease. Heart is responsible for taking oxygen through lungs. For this oxygen supply the main requirement is antioxidant nutrients. Tomato is rich in antioxidants, so they contribute to the cardiovascular support and the lycopene present in the tomato and other antioxidants helps to reduce the risk of lipid peroxidation in blood stream.

2.Supports Bone Health

The intake of tomato helps to improve bone health. Lycopene and other antioxidant in tomatoes gives support to bone health.

3.Anti-Cancer Benefits

Tomatoes possess anti-cancer benefits. Tomatoes have antioxidant nutrients and anti-inflammatory nutrients, so, tomatoes are record as a cancer protective food.

4.Antibiotic (leaves)

Tomato is used as a natural antiseptic, because of its leaves having nicotinic acids. Tribal people use the tomato leaf as an antiseptic agent for curing injuries.

Collection of biofertilizers

The biofertilizers namely Farmyard manure, *Azospirillum* and Phosphobacteria were obtained from TNAU, Coimbatore.

Trichoderma viride was added as a biocontrol agent for controlling the disease. The application of *Trichoderma* is beneficial as it helps in reducing the fertilizer application as well as increases the yield of the crop.

Farmyard Manure

Cowdung is an most major source of biofertilizer, and it can help/ boost productivity. It increased the pH, Cation Exchange Capacity , total N, organic C, ignition loss and exchangeable Mg and Ca. Sulphate absorption was reduced. It aids in the improvement of soil fertility as well as water infiltration and storage capacity. Cowdung manure should be applied at a rate of 40 t/ hectare (Sultana et al., 2012).

Azospirillum

Azospirillum is well known for its nitrogen-fixing capacity and ability of phytohormone production. *Azospirillum* helps in fixing atmospheric nitrogen and benefit the host plants by the supplying vitamins and growth hormone. *Azospirillum* inoculation increases the growth, nitrogen uptake and yield in number of crops. The recommended dosage of *Azospirillium* is 5kg/hectare.

Phosphobacteria

Phosphobacteria is the organism that helps in converting the insoluble phosphorus into an available form to the plants. Next to nitrogen, Phosphorus is the second most important nutrient required by crop plants. The phosphate solubilizing bacteria (PSB) solubilize the insoluble phosphates and make them available for crop plants in the rhizosphere region (Mallikarjuna Rao *et al*., 2014). The recommended dose of phosphobacteria is 10 kg/hectare.

Methods

Experiment in Grow Bags

The seeds obtained from TNAU, Coimbatore were soaked in different organic fertilizers overnight. Later, the seeds were sown in Grow bags (30cm×30cm×45cm sized bags) containing garden soil and cocopeat in the ratio 1:1. The treated bags were maintained in triplicates. The effect of different biofertilizers on the growth and yield parameters of *Solanum lycopersicum* L. were assessed.

The growth parameters at different stages of growth of the plants were analyzed. Neem extract was sprayed at intervals to control the growth of insects. The different organic fertilizer treatments given were:

T0 – Control

T1 – Farmyard Manure

T2 – *Azospirillum*

T3 - Phosphobacteria

Growth Parameters

To measure the growth parameters, plant samples were uprooted carefully on 15^{th}, 30^{th} and 45^{th} Days after showing (DAS) and the following parameters were recorded for all the treatments.

1. Root length (cm)

2. Shoot length (cm)

3. Number of lateral roots

4. Number of leaves

5. Diameter of leaves (cm)

Root Length

The plants were taken from control bag and other treatment bags and washed to get rid of adhering soil particles. Then, the length of the roots were measured with the help of a scale from root collar point to root tip and expressed in centimetre. Three seedlings were randomly selected from each treatment and their root length was measured using cm scale and recorded in cm/seedling.

Shoot Length

To measure the shoot length of the plants, the measurement was taken from the shoot collar point to shoot apex and expressed in centimetre. Three seedlings were randomly selected from each treatment and their shoot length was measured using cm scale and recorded in cm/seedling. Three readings were taken for statistical analysis.

Number of lateral root

The number of lateral roots arising from the main primary root was measured.

Number of leaves

The number of leaves present was recorded in the uprooted plants.

Diameter of leaves

The diameter of the leaves were measured for all the treatments along with the control plant and expressed in centimetre.

STATISTICAL ANALYSIS

The data obtained from various morphological observations as well as yield parameters were subjected to statistical analysis as per the procedure of Panse and Sukhatme (1978).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted in tomato plant (S*olanum lycopersicum* L.) with a control and three different treatments (Plate 4) namely Phosphobacteria, *Azospirillum* and Farmyard Manure (FYM) and the growth parameters of the plant were estimated.

The germination and initial leaflet formation of the Tomato is seen in Plate 5. The parameters such as shoot length, root length, number of lateral roots, Number of leaves and diameter of leaves were measured on the 10 (Plate 6 & 7) , 15 (Plate 8 & 9) and 30 days after sowing (DAS). Buds started forming after 45 DAS/, so the number of buds formed was also measured after 45 days. The growth parameters were statistically analyzed and the results are tabulated.

Ten days after the seeds were sown, measurement of shoot length, root length, number of lateral roots formed, number of leaves formed and diameter of the leaves were calculated and tabulated (Table 1). The shoot length was significantly higher in the grow bag in which Phosphobacteria was used. The value obtained was **6± 0.5 cm** (Fig.1).

Plate 4

Seeds of *Solanum lycopersicum* L. sown in Grow Bag

Table 1

Growth parameters of *Solanum lycopersicum* L. on 10th day after the seeds were sown

Bags	Shoot length (cm)	Root length (cm)	No.of lateral roots	No of leaves	Diameter of leaves(cm)
T0	5± 0.2	1.8± 0.3	**8± 0.2**	**6± 0.8**	**2.5± 0.4**
T1	4.5± 0.4	1.5± 0.1	7± 0.6	4± 0.4	1.5± 0.1
T2	4.8± 0.6	2± 0.2	4± 0.1	3± 0.3	1.5± 0.3
T3	**6± 0.5**	**2.5± 0.7**	7± 0.5	4± 0.2	**2.5± 0.2**
SEd CD(P<0.04)	0.3674 0.8473	0.3240 0.7472	0.3317 0.7648	0.3937 0.9079	0.2236 0.5156

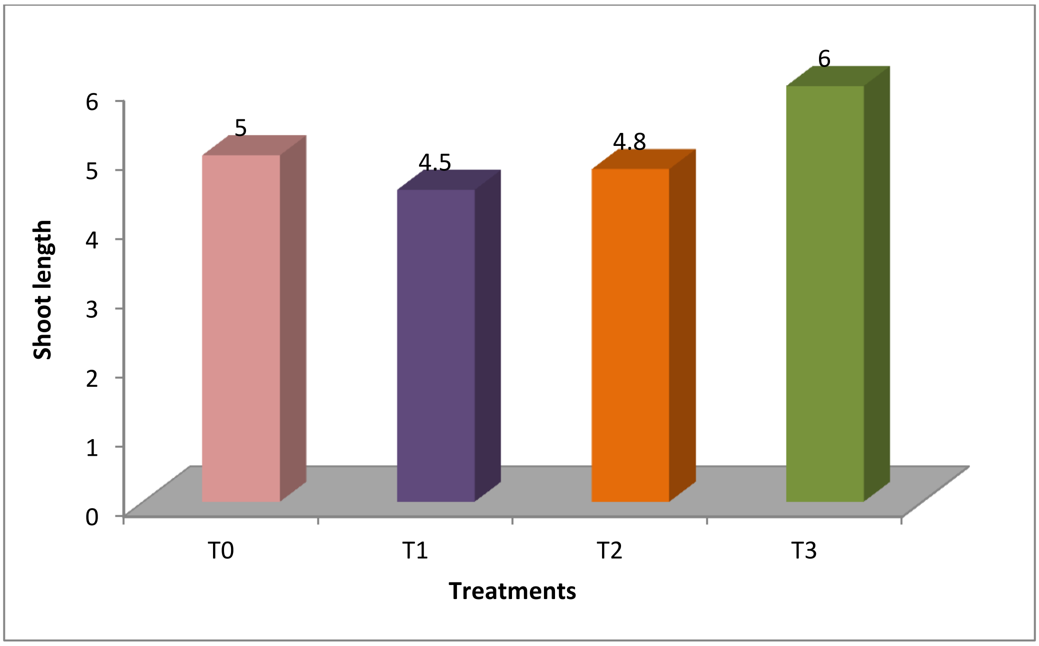
Plate 5

Seedling growth of *Solanum lycopersicum* L. 10th day in control and treatments

Plate 6

Measurement of morphological parameters on the 10th day

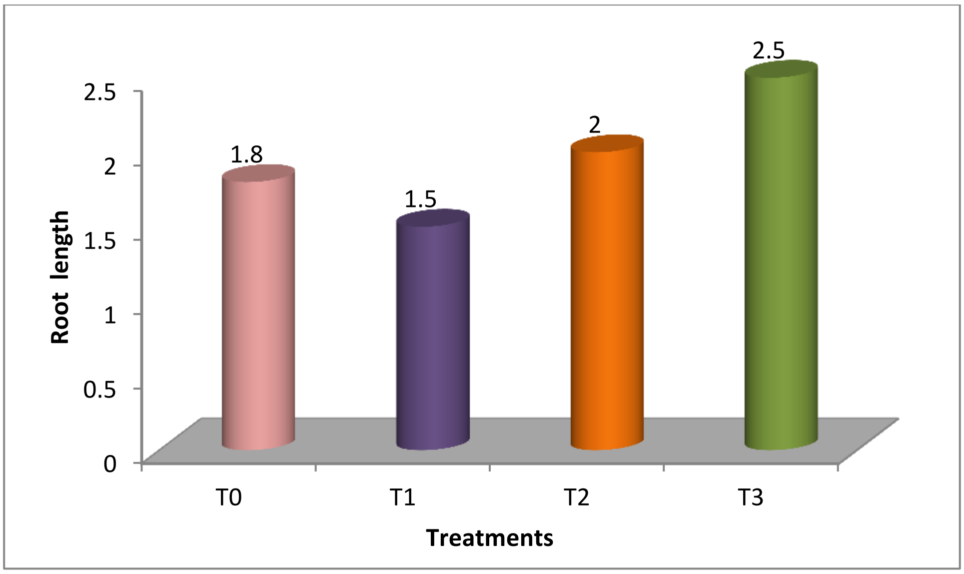
Figure 1



Shoot Length on 10th DAS

T0 – Control
T1 – Farmyard Manure
T2 – *Azospirillum*
T3 - Phosphobacteria

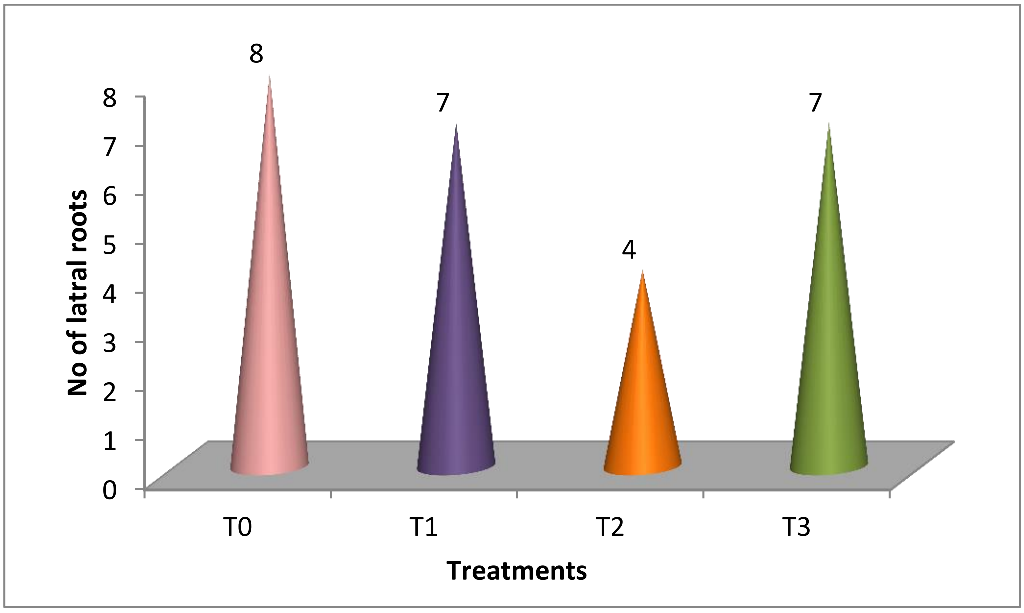
Figure 2



Root Length on 10th DAS

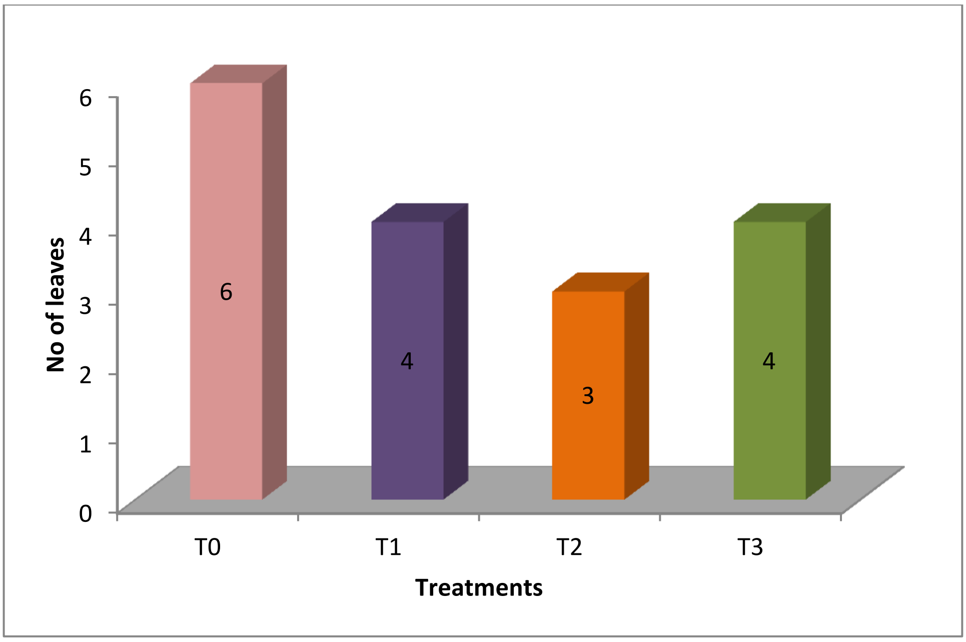
The root length of the Tomato plant was found to be higher in plants treated with Phosphobacteria (T_3) (Fig.2) and the reading observed was 2.5± 0.7 cm. The number of lateral roots formed on the 10th day was higher in Control plants (T_0) and the value recorded was 8± 0.2 (Fig.3). Both the number of leaves and the diameter of the leaves on the 10th day were higher in T_0 . The measurement observed were 6± 0.8 (Fig.4) and 2.5± 0.4 cm (Fig.5).

Figure 3



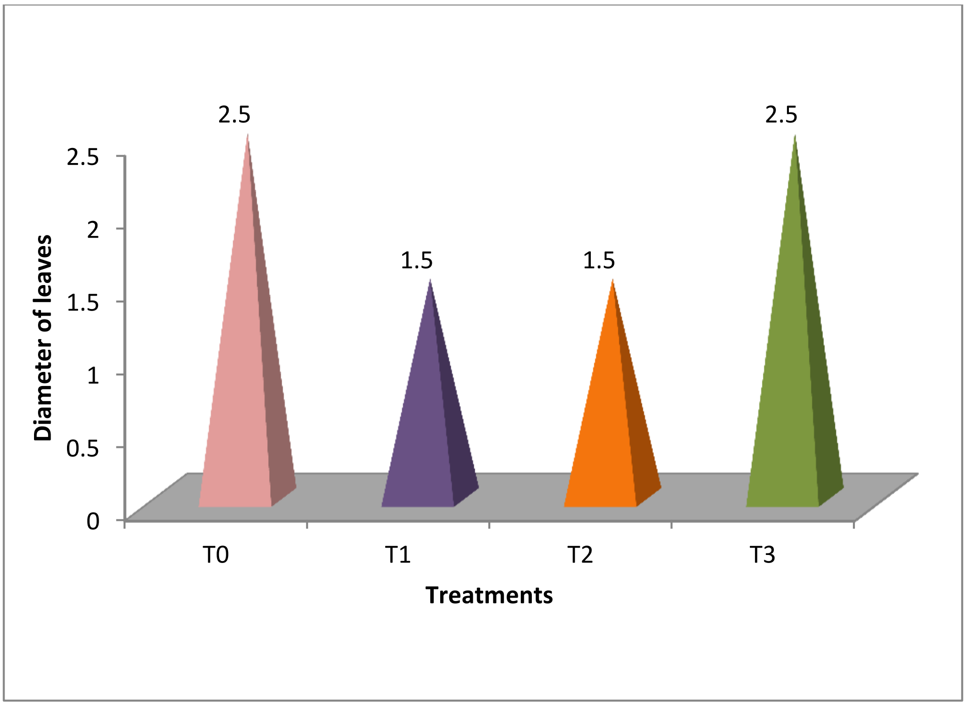
No. of lateral roots

Figure 4



No. of Leaves

Figure 5



Diameter of Leaves

On the 15th day (Table 2), the shoot length was found to be significantly higher in T3 i.e. the Tomato plant that was grown using Phosphobacteria. The reading was observed to be 7± 0.5cm (Fig.6). The root length on the 15th day was higher in T_0 (2.5± 0.7cm; Fig.7).

Table 2

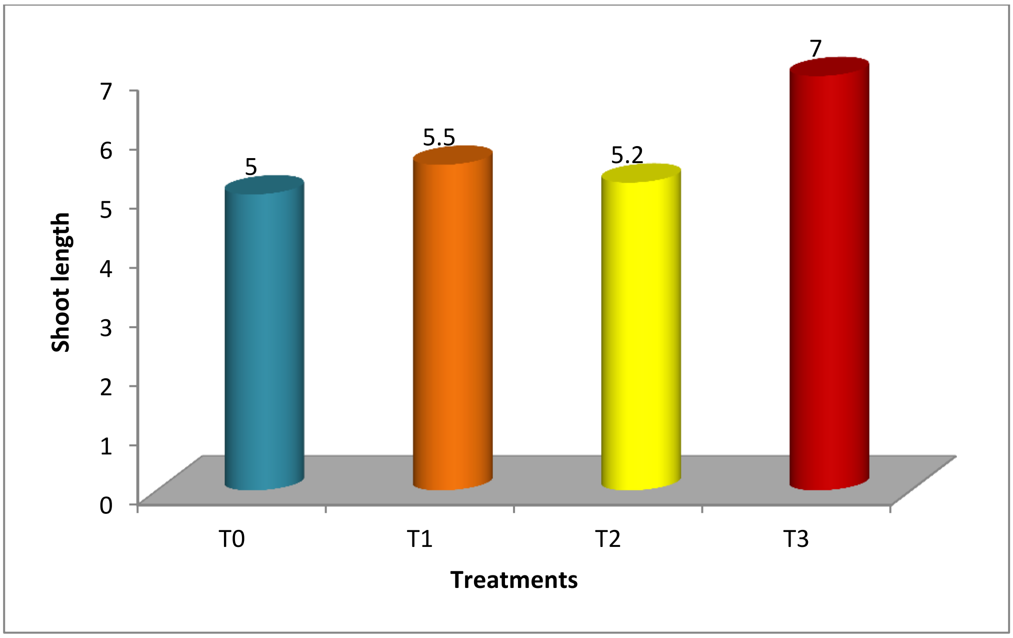
Growth parameters of *Solanum lycopersicum*(L.) on the 15th day

Bags	Shoot length (cm)	Root length (cm)	No.of lateral roots	No of leaves	Diameter of leaves(cm)
T0	5± 0.2	**2.5± 0.7**	**12± 0..4**	**8± 0.3**	2.5± 0.3
T1	5.5± 0.1	2± 0.8	8± 0.6	5± 0.1	2.5± 0.1
T2	5.2± 0.4	2.4± 0.3	7± 0.1	4± 0.9	1.8± 0.4
T3	**7± 0.5**	2 ± 0.9	8± 0.2	6± 0.8	**2.7± 0.6**
SEd CD(P<0.04)	0.2769 0.6385	0.1325 0.3055	0.3082 0.7108	0.6042 1.3932	0.2090 0.4819

Plate 7

Growth of *Solanum lycopersicum* (L.) after 15th day in control and treatments

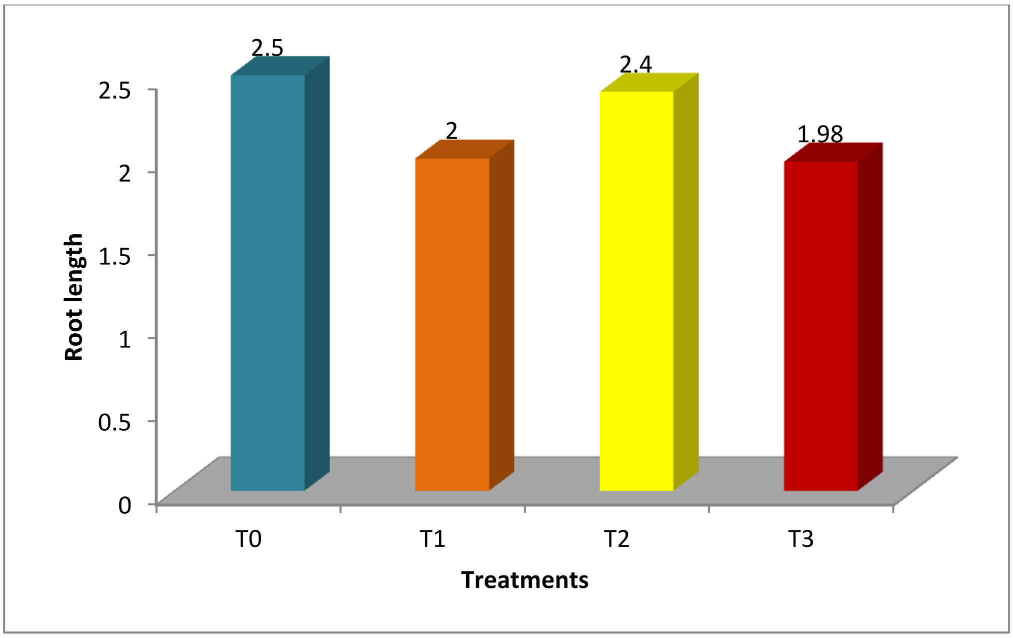
Figure 6



Shoot Length on the 15th DAS

T0 – Control
T1 – Farmyard Manure
T2 – *Azospirillum*
T3 - Phosphobacteria

Figure 7

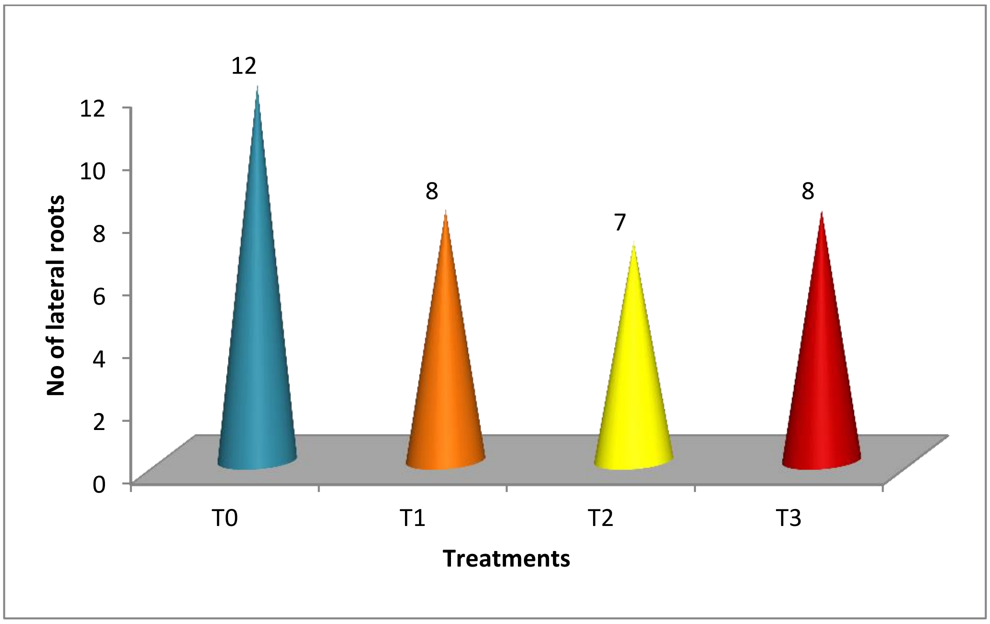


Root Length on the 15th DAS

Plate 8

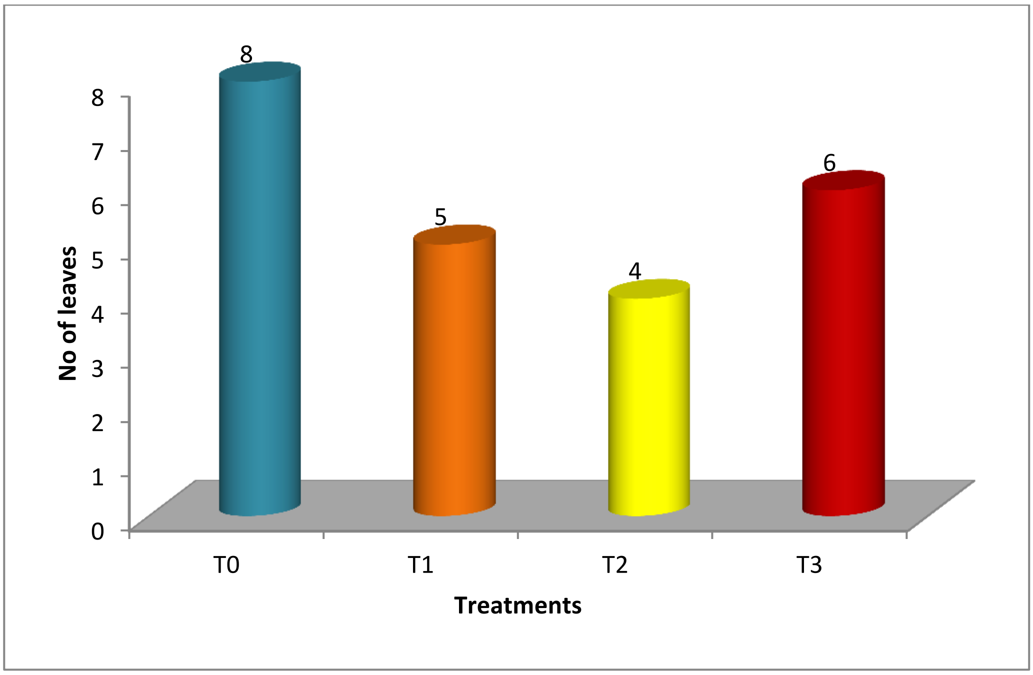
Measurement of morphological parameters on the 15th day

Figure 8



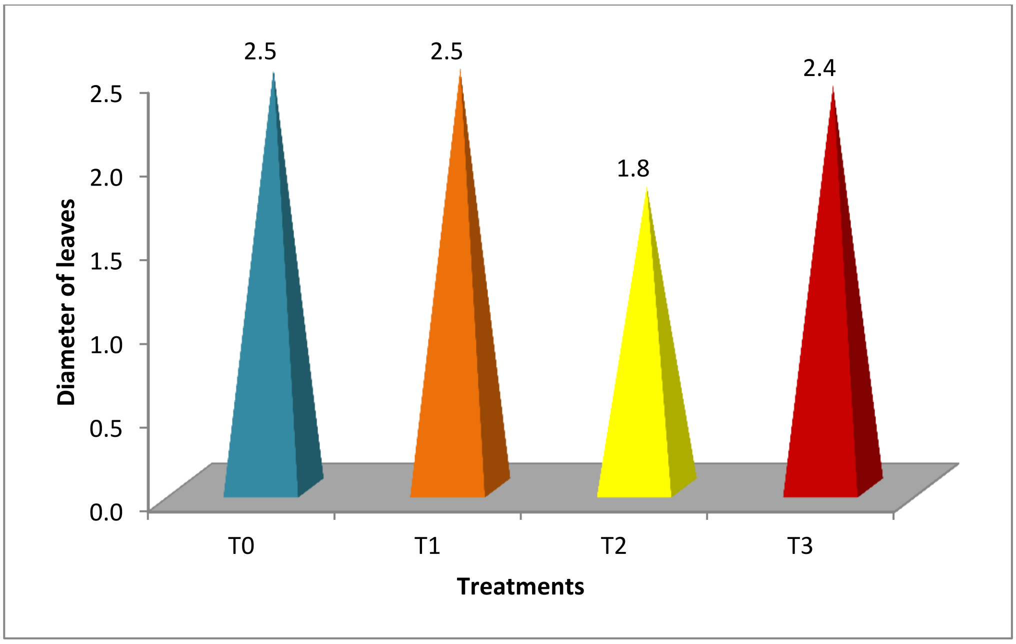
No. of lateral roots

Figure 9



No. of Leaves

Figure 10



Diameter of Leaves

The number of lateral roots was found to be maximum in Control plants (T_0) on the 15th day and the value was 12± 0.4 (Fig.8). Significantly higher number of leaves (Fig.9) and diameter of leaves (Fig.10) were observed in T_0 and T_3 on the 15th day and the values were found to be 8± 0.3 and 2.7±0.6 cm respectively. The diameter of the leaves was found to be similar in both control plants and plants treated with Phosphobacteria.

On the 30th day (Table 3; Plate 9 & 10), all the morphological parameters such as, shoot length,root length, number of lateral roots, number of leaves, and diameter of leaves were found to be higher in control plants.

Plate 9

Growth of *Solanum lycopersicum* (L.) after 30th day in control and treatments

Plate 10

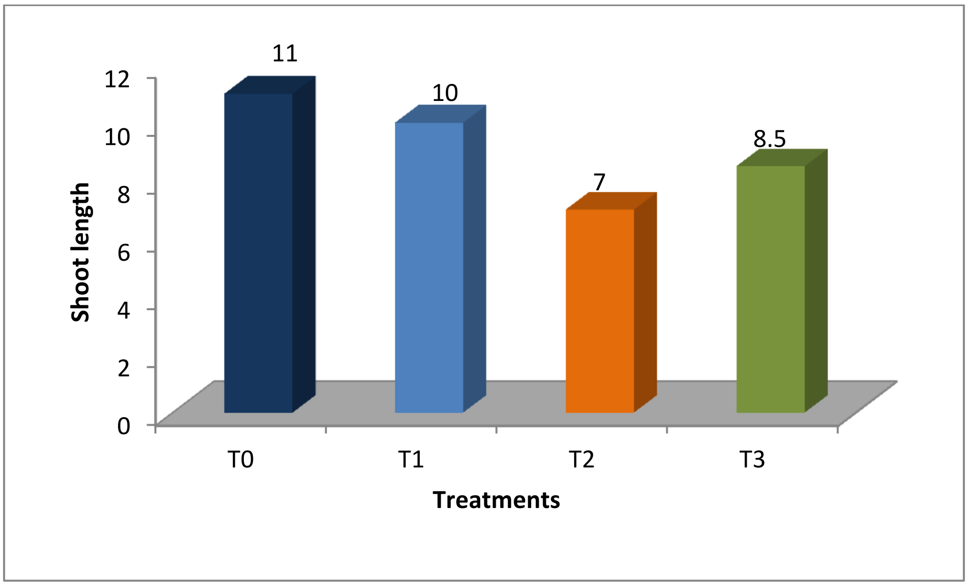
Measurement of morphological parameters on the 30th day

The readings observed were shoot length (11± 0.5cm),root length (6.5± 0.1cm), number of lateral roots (25± 3.7),number of leaves (20± 2.1) and diameter of leaves (3.8± 0.1cm)

Table 3
Growth parameters of *Solanum lycopersicum* L. on 30th day

Bags	Shoot length (cm)	Root length (cm)	No. of lateral roots	No of leaves	Diameter of leaves(cm)
T0	**11± 0.5**	**6.5± 0.1**	**25± 3.7**	**20± 2.1**	**3.8± 0.1**
T1	10± 0.7	5± 0.4	20± 2.2	15± 1.4	3.2± 0.3
T2	7± 0.6	4.5± 0.2	10± 0.9	10± 0.3	3.1± 0.3
T3	8.5± 0.3	4± 0.9	10± 0.5	14± 1.8	3± 0.2
SEd CD(P<0.04)	0.4453 1.0270	0.4123 0.9508	1.8069 4.1668	1.2715 2.9321	0.1958 0.4515

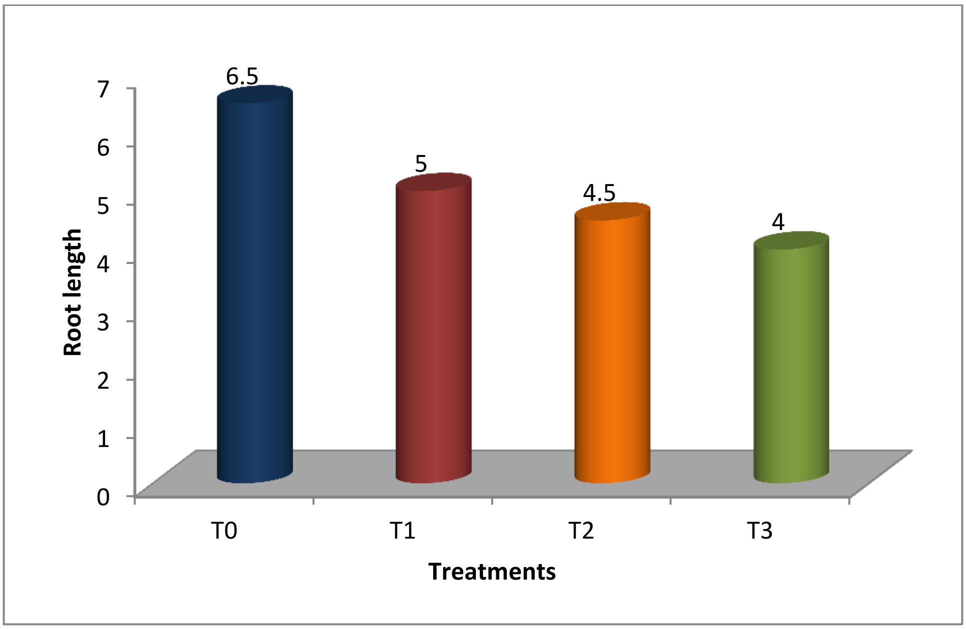
Figure 11



Shoot Length on 30th DAS

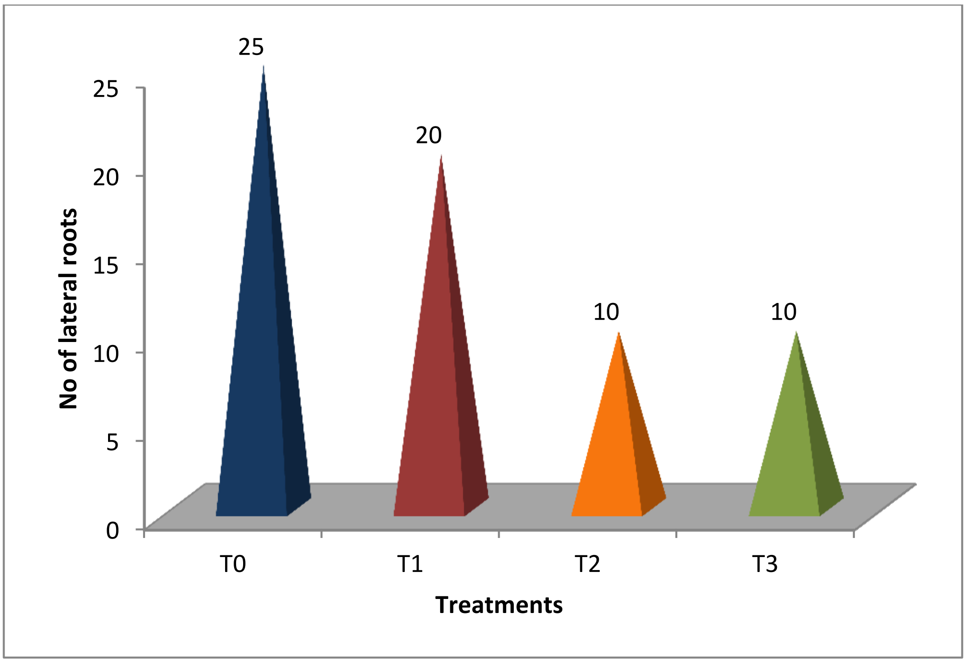
T0 – Control
T1 – Farmyard Manure
T2 – *Azospirillum*
T3 - Phosphobacteria

Figure 12



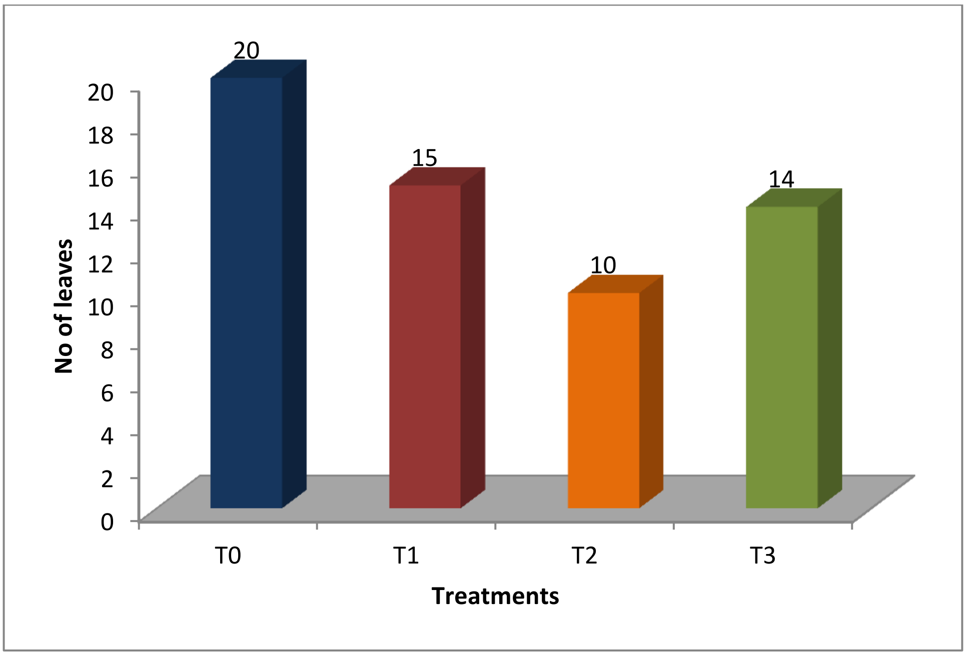
Root Length on 30th DAS

Figure 13



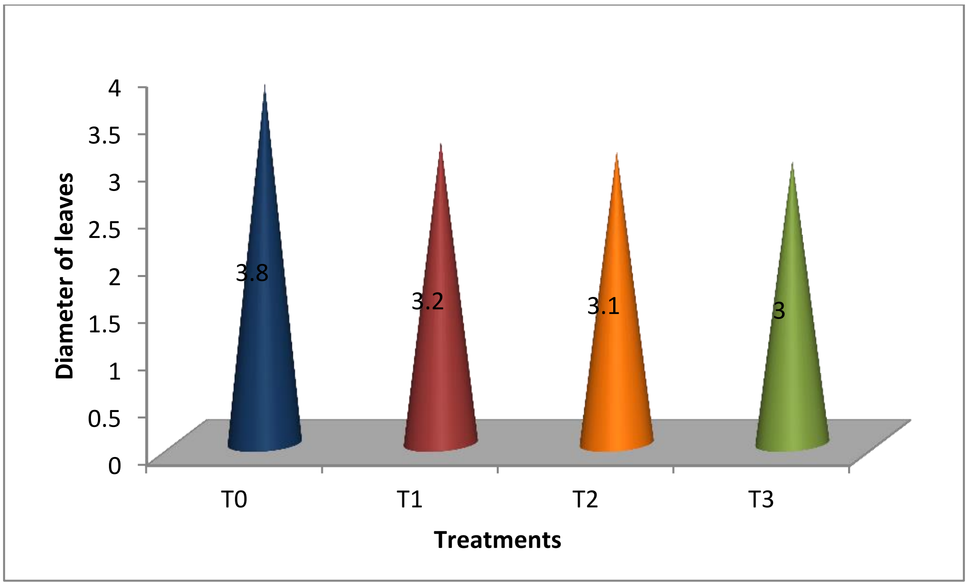
No. of lateral roots on 30th DAS

Figure 14



Number of Leaves on 30th DAS

Figure 15



Diameter of Leaves on 30th DAS

Plate 11 shows the growth of *Solanum lycopersicum* L. in control and biofertilizer treated Tomato plants after 43 days. Bud formation occurred at this stage.

Plate 11

Growth of *Solanum lycopersicum* L. in control and treatments after 43 days showing flowering

On the 45th day, the morphological parameters were observed and tabulated (Table 4; Plate 12 & 13). The morphological parameters observed were shoot length, root length, number of lateral root, number of leaves and diameter of leaves. The reproductive parameters observed were number of buds formed on the 45th day.

Plate 12

Measurement of morphological parameters on the 45th day

On the 45th day also,similar results were obtained. The control plants showed higher shoot length (25± 3.5cm), root length (9± 0.1cm), number of lateral roots (29± 3.7), number of leaves (25± 3.8) and diameter of leaves (5± 0.2cm)

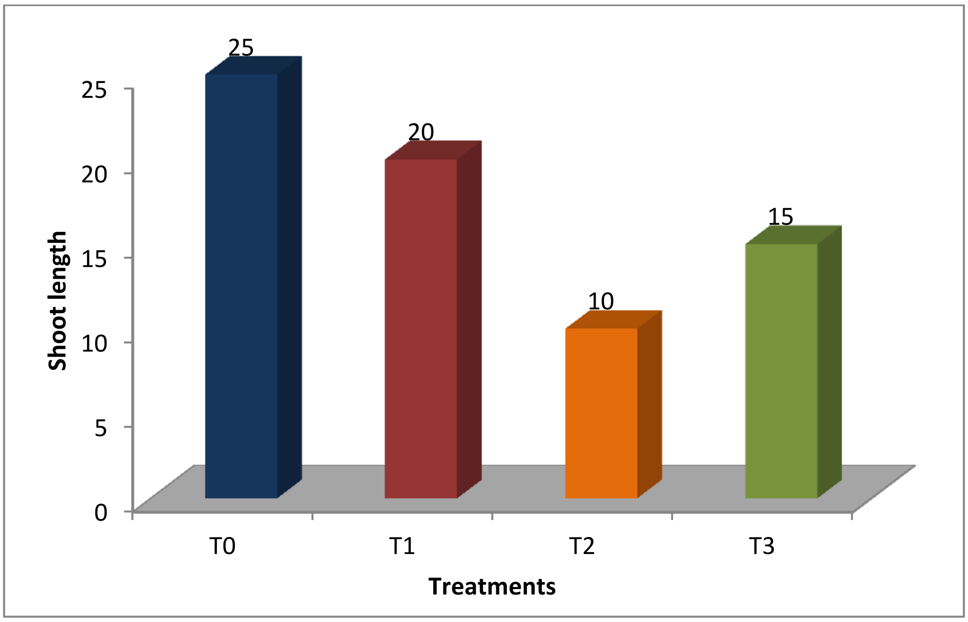
Table 4

Growth parameters of *Solanum lycopersicum* L. on 45th day

Bags	Shoot length (cm)	Root length (cm)	No.of lateral roots	No of leaves	Diameter of leaves(cm)	No of Buds
T0	**25± 3.5**	**9± 0.1**	**29± 3.7**	**25± 3.8**	**5± 0.2**	**3± 0.6**
T1	20± 2.3	7± 0.3	27± 3.8	20± 2.5	4± 0.1	**3± 0.9**
T2	10± 0.4	6.5± 0.2	13± 1.6	15± 1.8	3.8± 0.4	2± 0.5
T3	15± 1.2	6± 0.2	12± 1.3	16± 1.1	3.6± 0.3	1± 0.7
SEd CD(P<0.04)	1.7861 4.1187	0.1732 0.3994	2.3231 5.3571	2.0469 4.7203	0.2236 0.5156	0.2236 0.5156

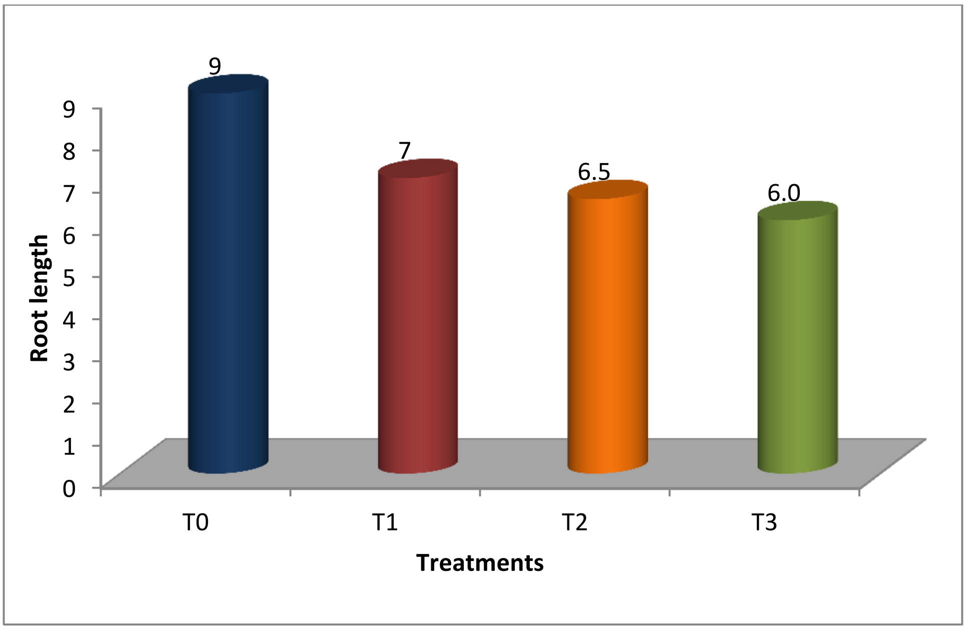
In the case of reproductive stage, control plants (T0) and plants treated with Farmyard manure (T1) showed higher number of bud formation (3± 0.6 and 3± 0.9) respectively.(fig.20)

Figure 16



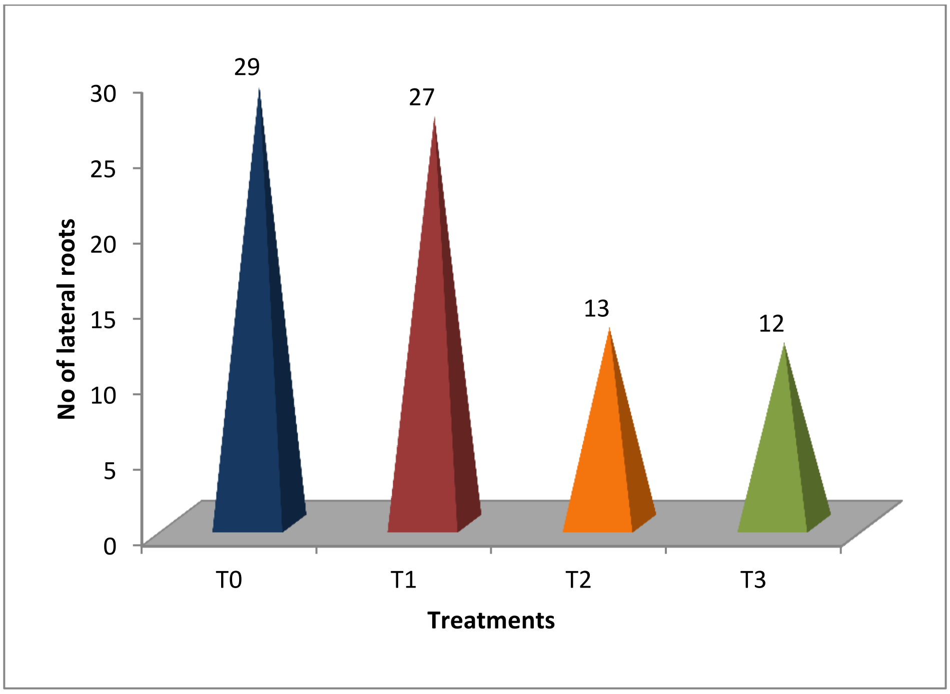
Shoot Length on 45th DAS

Figure 17



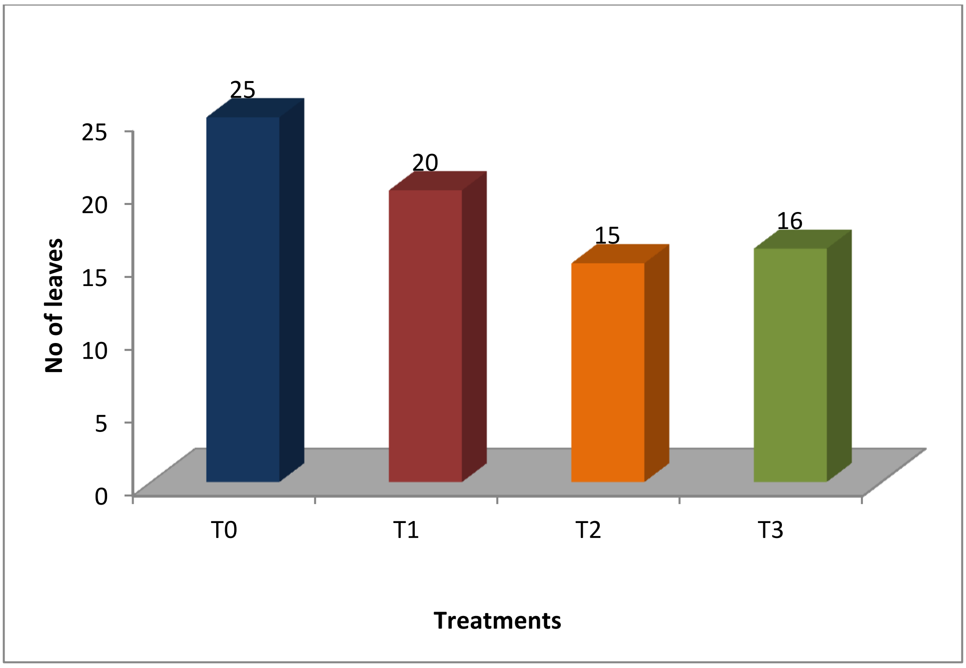
Root Length on 45th DAS

Figure 18



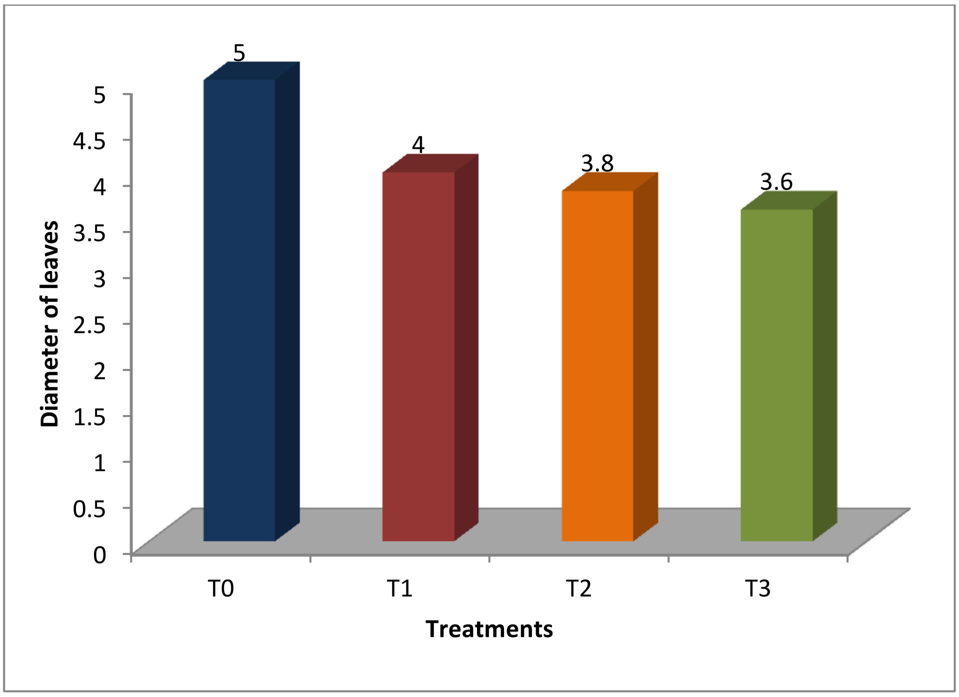
No. of lateral roots

Figure 19



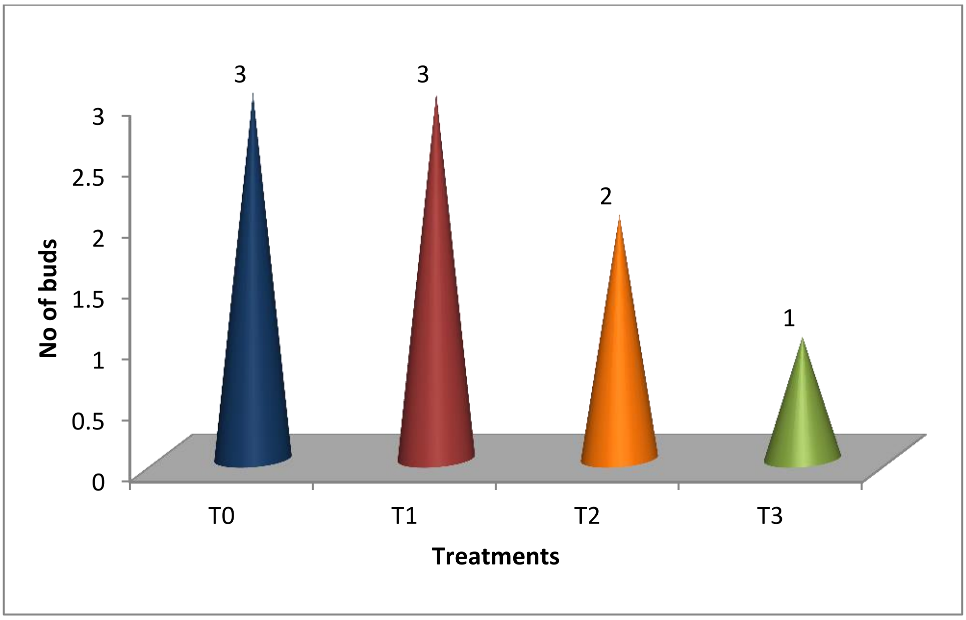
Number of Leaves

Figure 20



Diameter of Leaves

Figure 21



Number of Buds

There is increase in the growth parameters in control plants in the later stages might be due to the release of nutrients from farmyard manure at a slow face resulting in increased growth.

From the result obtained, with this short duration reading, we cannot come to a conclusion that FYM alone is better than other organic fertilizers. We need to do further studies till fruit yield and also do many replications to prove the study.

Shashi Kamal *et al*. (2018) have earlier studied the effect of biofertilizers on the growth and yield of tomato and proved that the application of Azotobacter + recommended dose of NPK and Azospirillum + recommended dose of NPK through chemical fertilizers gave better growth of the plant and fruit yield.

Farmyard manure helps to increase the soil capacity for holding water and nutrients. It also improves the soil structure and is used as a natural fertilizer in farming. The microbial activity also is increased by the application of farm yard manure.

The substitution of mineral fertilizers with organic fertilizers and biofertilizers for plant growth and crop yield is a promising cultivation practice towards a sustainable agriculture (Mohamed *et al*.,2021).

Suriya Sabarinath *et al*. (2020) have earlier reported that combined application of Bio inoculants and inorganic fertilizers significantly increased the growth as well as yield in tomato crop. In the current study, farm yard manure, *Azospirillum* and Phosphobacteria have been used individually in the test crop, due to which, the growth rate is not significantly higher in biofertilizer treated plants. So, we cannot conclude from the present investigation that the biofertilizers used for the study is not efficient in increasing the growth and yield of crop, instead further study is required to prove the efficiency of the biofertilizers taken for the study.

The increase in the growth parameters of the test plant at the initial stage might be due to the fixing of Atmospheric nitrogen by the biofertilizers and its quick release for the plants to absorb. These results are in conformity with Chaudhary *et al*. (2005), Meena *et al*. (2014) and Wang and Kale (2004).

Studies by Suge *et al*. (2011) have shown that organic sources such as FYM, Compost and Tithonia applied in combination with inorganic fertilizer could meet the nutrient requirement for eggplant. In their study, they have concluded that FYM shows better yield than the rest of the fertilizer. The current study is in accordance with the above result, where the groeth of tomato plant was higher in FYM in the initial stages.

The use of *Azospirillum* also showed higher growth at one stage which is similar to the findings by Sahoo *et al*. (2014) on the growth and yield of rice crop.

Fertilizer application normally results in an increased yield with low returns until maximum yield is reached (Payne *et al*., 1991). Sometimes, application of more fertilizer would result in soil contamination with foreign elements.

Some of the other parameters that influence the growth of the crop are the abiotic factors such as light, temperature, rain, etc. The amount of sunlight determines the crop growth. Too much of radiation is rarely a problem as long as water and nutrients are in adequate supply. Solar radiation is important during the yield stage.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in Tomato plant with control and three different biofertilizer treatments namely, Farmyard Manure (FYM), Phosphobacteria and *Azospirillum* to estimate the growth parameters of the plant.

The seedling formation after germination of the tomato plant started on the 8th day of growth. The growth parameters observed were shoot length, root length, number of lateral roots, number of leaves and diameter of leaves on the 10^{th}, 15^{th}, 30^{th} and 45^{th} day after sowing. The reproductive character that is number of buds formed after 45^{th} day was also estimated.

On the 10^{th} and 15^{th} day, the shoot length was found to be higher in Phosphobacteria (T_3). The root length and the number of leaves on the 10^{th} day were found to be significantly higher in (T_3) Phosphobacteria treated tomato plants. The number of lateral root formed, number of leaves and diameter of the leaves were more in control plants (T_0) on the 10^{th} day.

On the 15^{th} day, the shoot length and the diameter of leaves was found to be higher in Phosphobacteria (T_3), but the root length, number of lateral roots and the number of leaves were more in control plants.

On the 30^{th} day and 45^{th} day, the shoot length, root length, number of lateral roots formed, number of leaves and diameter of leaves were significantly higher in control plants (T_0), whereas, Farmyard Manure (T_1) showed more bud formation on the 45^{th} day of growth of tomato plant.

In the present study, there was an increase in the growth of the vegetable crop during the early stages, but in the later stages, the growth was affected or it decreased in plants treated with biofertilizers. This effect might have occurred due to the sunlight condition in the place where the crop was grown or the use of excess biofertilizer in the soil would have contaminated the soil resulting in decreased growth at the later stage.

If only further studies till the yield is carried out or a study for a second season trial is done, we can come to a conclusion on why the control plants showed better growth at the later stages of development of tomato plant.

Organic farming is not a mere nonchemical farming practice, but it is an integrated system of farming involving relationship between soil, plant and water. Biofertilizers help in enriching the soil and are compatible with long-term sustainability.

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