

**Efficacy of *Azospirillum*, Phosphobacteria and Spent Mushroom Compost
on the growth parameters of *Solanum lycopersicum* L.**

By

DHARSHINI, K.

(19PBO006)

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**

MAY 2021

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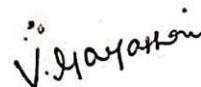
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**Signature of the
Lead of Department**



**Signature of the
Supervisor**

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INTRODUCTION

CHAPTER-I

INTRODUCTION

Organic farming method is not a new practice in agriculture; it has been followed from ancient times. It is the main method of farming system directed at cultivating the land and raising crop to manage the soil condition in good health by the use of organic wastes (crop, animal waste) and also biological materials along with the biofertilizers, to release nutrients to crops to produce an eco friendly organic product. The basic of organic farming deals with environmental, social and economic sustainability (Stockdale *et al.*, 2001).

The common name of *Solanum lycopersicum* L. is tomato. It belongs to the family Solanaceae. It's a perennial herbaceous plant but it is often grown as an annual crop even if biennial and perennial forms exist. Tomato cultivated in tropical and temperate climates in open field or under greenhouse in temperate climate (Geisenberg and Stewart, 1986). Fruit contain vitamins, large quantity of water, minerals and low amounts of proteins, fats and carbohydrates.

It also contains carotenes, such as lycopene that gives the fruit its red colour and Beta-carotene which gives the fruit its orange colour. Warm condition with the right light intensity is required during growing period and it requires 45 days from germination for flowering and 90-100 days to begin the fruit ripening (Nuez, 2001).

Tomato plants are vines, initially decumbent typically growing with a support to a height of 180 cm (6 ft) or more above the ground, although erect bush varieties have been bred, generally 100 cm (3 ft) tall or shorter. Indeterminate types originally native to tropical highlands are "tender" perennials, dying annually in temperate climates, although they can live up to three years in a greenhouse in some cases. Determinate types are annual in all climates.

Tomato plants are dicots, and grow as a series of branching stems, with a terminal bud at the tip that does the actual growing. When that tip eventually stops growing, whether because of pruning or flowering, lateral buds take over and grow into other, fully functional, vines.

Tomato vines are typically pubescent, meaning covered with fine short hairs. These hairs facilitate the veining process, turning into roots wherever the plant is in contact with the ground and moisture, especially if the vine's connection to its original root has been damaged or severed.

Most tomato plants have compound leaves, and are called regular leaf plants, but some cultivars have simple leaves known as potato leaf style because of their resemblance to that particular relative. The leaves are 10–25 cm (4–10 in) long, odd pinnate, with five to 9 leaflets on petioles (Acquaah, 2002), each leaflet up to 8 cm (3 in) long, with a serrated margin; both the stem and leaves are densely glandular-hairy. Their flowers, appearing on the apical meristem, have the anthers fused along the edges, forming a column surrounding the pistil's style. Flowers in domestic cultivars can be self-fertilizing. The flowers are 1–2 cm (0.4–0.8 inch) across, yellow, with five pointed lobes on the corolla; they are borne in a cyme of three to 12 together.

Tomato fruit is classified as a berry. The tomato is grown worldwide for its edible fruits, with thousands of cultivars. Most modern tomato cultivars are smooth surfaced. While virtually all commercial tomato varieties are red, some cultivars – especially heirlooms – produce fruit in blue, green, yellow, orange, pink, black, brown, ivory, white, and purple. Such fruits are not widely available in grocery stores, nor are their seedlings available in typical nurseries, but they can be bought as seed. Variations include multicolored fruit with stripes (Green Zebra), fuzzy skin on the fruit (Fuzzy Peach, Red Boar), multiple colors (Hillbilly, Burracker's Favorite, Lucky Cross), etc.

Throughout the world tomato is now grown and eaten. It is used in diverse ways, including raw in salads, and processed into ketchup or tomato soup. Unripe green tomatoes can be used to make pickles and can also be breaded and fried and used to make salsa. Tomato juices sold as a drink, and are used in cocktails such as the Bloody Mary.

Tomatoes could be preserved due to its acidic nature in home canning method, in pieces, as tomato sauce or paste. The fruit could be dried in sun and preserved and sold either in bags or in jars with oil. Although tomatoes originated in the Americas, they have become extensively used in Mediterranean cuisine. They are commonly used in pasta sauces and a key ingredient in pizza.

Nutrition

A tomato contains 95% water, 4% carbohydrates and less than 1% each of fat and protein. In a 100 gram amount, raw tomatoes supply 18 calories and are a moderate source of vitamin C (17% of the Daily Value), but otherwise are absent of significant nutrient content.

Biofertilizers

Biofertilizers are assumed to be an alternative to chemical fertilizers to reduce the pollution in the environment. Biofertilizers form an eco-friendly, cost effective and useful method of farming system. Biofertilizers are important and favorable for soil due to the use of micro organisms. It possesses the ability to convert the nourishment elements from non usable form to an easily available form of nutrient for balancing the soil fertility to increase the crop yield (Kumar *et al.*, 2001). Some of the common biofertilizers are, *Azospirillum*, phosphobacteria and Blue-green algae.

Types of biofertilizers

There are two types of biofertilizers.

1. Symbiotic Nitrogen- fixing
2. Asymbiotic nitrogen fixing bacteria

Azospirillum

Azospirillum is an asymbiotic nitrogen fixing bacteria. It grows on decomposing soil organic matter and it fixes the atmospheric nitrogen in the soil. So it has high potential for nitrogen fixation. It produces the growth hormone especially for the development of root which helps to increase the yield in numbers of crops by 5 to 20% (Dart, 1986). It can be easily absorbed by the plant roots and provides 10- 30% nitrogen to plants.

Phosphobacteria

Phosphobacteria biofertilizer are a major group of biological fertilizer. It has the ability to solubilize the inorganic phosphate into an easily available organic phosphorus, so that the plants can uptake and grow well resulting in increased yield of the crop (Kale *et al.*, 1992).

Advantages of bio fertilizers

- Bio fertilizers improve the soil texture and yield of plants.
- They do not allow the pathogens to flourish.
- Biofertilizers are eco friendly and cost effective.
- They will protect the environment from pollution since they are natural fertilizers.
- It destroys the harmful substance present in the soil that can cause diseases in plants.
- Bio fertilizers are proved to be effective even under semi - arid condition.

COMPONENTS OF ORGANIG FARMING

SPENT MUSHROOM COMPOST:

Bacteria and fungi play a major role of decomposing organic material and without these powerful decomposers earth could have been completely covered with the organic materials. Spent mushroom compost (SMC) is a substance which we get after harvesting the mushroom that could be potentially used for the growth of plants. It contains a simple form of protein rich compound, lignocellulosic materials, lignin, hemicellulose, fungal mycelium and its products that form the compost by the activities of the microbes. It also possess rich organic matter, moderate level of nutrient required for the growth of crops, neutral pH and also beneficial microbial population that makes the Spent mushroom compost a suitable growth medium that could retain the nutrients for the growth of crops (Ahlawat *et al.*, 2011).

The addition of spent mushroom compost to garden soil acts as a very good soil conditioner that has been found to greatly increase the yield of tomatoes plants (Chang and yau, 1981; Iwase *et al.*, 2000). SMC is found to be rich in macro and micro elements that are necessary for the growing plants. It helps to increase the soil biological activity (Vandenkoornhuyse *et al.*, 2002).

ORGANIC MANURE:

Organic manure is the organic materials derived from animal, plant and human residues. It helps in increasing the crop growth directly by improving the humid substance and indirectly by promoting the soil productivity by increasing the availability of major and minor plant nutrients through the activity of micro organisms (Santhosh kumar *et al.*, 2017)

Uses of organic farming

- It helps to maintain the health of the environment by reducing pollution.
- It also increases the agricultural production in a sustainable way.
- It helps in improving soil health.
- It improves the availability of essential nutrients required for the plants to grow (macro nutrients & micro nutrients).
- It increases the water holding capacity of the soil .

The main objective of the present study is to analyze the growth parameters of *Solanum lycopersicum* L. under different biofertilizer treatments.

REVIEW OF LITERATURE

CHAPTER-II

REVIEW OF LITERATURE

The literature available on the use of bio-fertilizer on the growth parameters pertaining to the current investigation has been reviewed and presented in this chapter.

Angadi *et al.* (2017) have reported higher yield of tomato in bio-fertilizer treated plant when compare to control plants. They studied the effect of organic manures and bio-fertilizers on plant growth, seed yield and seedling characteristics in tomato plant.

A field experiment carried out to study the effect of organic manures and bio-fertilizers on the quality parameters of black night shade have shown an increased in yield due to the application of Vermicompost (Ammaan and Subramanian, 2017).

Saeed *et al.* (2015) have reported a significant increase in fruit yield of tomato when treated with different levels of phosphate and bio-fertilizer.

A significant improvement in growth and biochemical parameters of *Vigna unguiculata* has been reported by Badar *et al.*, (2015). They studied the influence of organic, inorganic and bio-fertilizes on physical and biochemical parameters of *Vigna unguiculata*.

A study by Kaur (2014) on the effect of nitrogen-fixing bacteria *Azotobacter* and *Azosprillum* on the growth of *Rosa polyantha* have shown a significant increase in yield by the application of mixed inoculants.

Earlier the effect of biofertilizers on the growth,yield of quality of Knol-Khol has been studied by Choudhary *et al.* (2017).

Bandopadhyay (2015) had carried out studies on the effect of dual inoculation of studies on the effect of dual inoculation of plant growth promoting Rhizobacteria on different non-leguminous plants under pot condition. He has reported that all parameters than the control plants.

A review on the Arbuscular mycorrhizal fungi as a biofertilizer has been studied by Sadhana (2014).

Aadeoluwa and Akinyemi (2014) studied the, dry mater and soil qualities of *Amaranthus* under organic and inorganic fertilizer treatments.

Earlier Paramanik and Chikkaswamy (2014) have reported a maximum growth and yield of some medicinal plants treated with VAM and biofertilizers.

The study carried out by Hemavani and Thippeswamy (2014) have reported a marked increase in shoot length, root length, fresh and dry weight of ground nut due to AMF colonization.

Aggani (2013) have done a broad spectrum of analysis on the development of bio-fertilizers and its future perspective.

Bio-fertilizers are eco-friendly and enhance germination. They also reduce the chemical inputs and enhance the yield both qualitatively and quantitatively (Darzi, 2012).

Abbasniyzare *et al.*, (2012) have studied the effect of bio-fertilizer on the growth of *Spathiphyllum illusion*. The effect of inorganic, organic and bio-fertilizers on the growth and yield of bitter gourd have been carried out by Thriveni *et al.* (2015). In their study, they have reported that application of NPK integrated with vermicompost and bio-fertilizers turned to be the best treatment for increasing growth and yield of bitter gourd.

Ramakrishnan and Selvakumar (2012) studied the effect of bio-fertilizers on enhancement of growth and yield of tomato. They observed that there was significant increase in growth and yield parameters in bio-fertilizer treated plants rather than the control plants.

Wajhmode *et al.* (2010) studied the effect of bio-fertilizer and gibberellic acid on the yield of onion. Kumar *et al.* (2002) have done studies on the effect of bio-fertilizers and their methods of inoculation on growth and yield of potato.

Ghanti and Sharanji (2009) have studied the effect of bio-fertilizers on the growth, yield and quality of onion. Their study was based on the use of different combinations of bio-fertilizer to the crop.

Addition of organic fertilizer to bio-fertilizer to bio-fertilizers has shown an enhanced growth in potato (Awad, 2002) and rice (Naseer and Bali, 2007).

Apart from usage of animal feeds, compost produced by mushroom cultivation could be directly used as an organic fertilizer (Rinker, 2002). Earlier work by Lopes *et al.* (2015) have concluded that the use of spent *Agaricus subrufescens* compost for seedling production have resulted in higher tomato production compared to organic cultivation systems including organic fertilization and green manuring.

Earlier Jasinska (2018) has done a review research on the potential use of Spent Mushroom Substrate (SMS) / Spent Mushroom Compost (SMC) and proved its recycling ability for agricultural and horticultural industry and also its role as a substitute for peat in greenhouse production of crops.

MATERIALS & METHODS

CHAPTER-III

MATERIALS AND METHODS

The plant taken for the present study was *Solanum lycopersicum* L. PKM-1 belonging to the family Solanaceae. Growth studies were carried out under different treatments of biofertilizers namely *Azospirillum*, Phosphobacteria and Spent Mushroom Compost against untreated control at different stages of growth of the plant.

Collection of the seeds

Seeds of *Solanum lycopersicum* L. PKM-1 were obtained from Tamil Nadu Agricultural University, Coimbatore.

Morphology of the plant

Solanum lycopersicum L.

Systematic position

Order	:Solanales
Family	: Solanaceae
Genus	: <i>Solanum</i>
Species	: <i>S. lycopersicum</i> L.

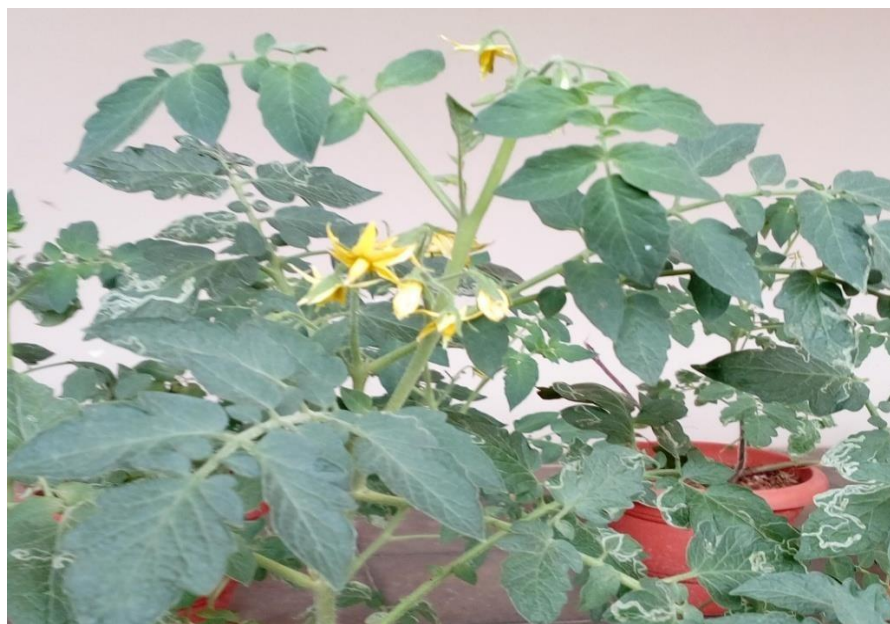


Plate: 1 Habit of *Solanum lycopersicum* L.

A. Description of the plant

- The tomato is native to South America, but, grows in temperate climates worldwide.
- Tomato is an easily grown vine plant that belongs to the night shade family
- The tomato (*Lycopersicon esculentum*) is a short-lived perennial plant, grown as an annual plant, typically growing to 1-3 m tall, with a weakly woody stem that usually scrambles over other plants.
- The fruit is a brightly colored (usually red, from the pigment lycopene) berry, 1-2 cm diameter in wild plants that is edible, commonly much larger in cultivated forms.
- The tomato begins its colorful and varied history upon the coastal highlands of Western South America, where it was being enjoyed by the native people for a long time.
- Tomatoes are consumed raw, or in salads, sauces and drinks. Tomatoes are rich in Vitamin A and are a kitchen- favourite throughout the world.
- Fruits can be harvested within 60-70 days' time.

Medicinal uses

- Tomato is good for liver health. Tomato has detoxification effect in the body.
- A reduced risk of cancer diseases such as lung, prostate, stomach, cervical, breast, oral, colorectal, esophageal, pancreatic and many other types of cancer is noted in people eating tomatoes
- It reduces the risk of cardiovascular diseases because of lycopene in it.
- Maintain healthy blood pressure and reduce blood glucose in people with diabetes.
- The main carotenoids namely lutein and lycopene are present in tomatoes. These can protect the eye against light-induced damage.

Collection of biofertilizers

The biofertilizers namely *Azospirillum* and Phosphobacteria were obtained from TNAU, Coimbatore. The Spent Mushroom Compost was collected from the Mushroom cultivation at Department of Botany, Avinashilingam Institute for Home Science and Higher Education for Women, 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.

Azospirillum

Azospirillum is known for its nitrogen-fixing and phytohormone production ability. *Azospirillum* helps in fixing atmospheric nitrogen and benefit the host plants by the supply of vitamins and growth hormone. The growth, nitrogen uptake and yield in number of crops is found to increase due to the inoculation of *Azospirillum*. The recommended dosage of *Azospirillum* is 5kg/hectare.

Phosphobacteria

Phosphobacteria is the organism involved in making the insoluble phosphorus available to the plants. 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.

Spent Mushroom Compost

The average pH of fresh mushroom compost is 6.6, which is an excellent pH for any compost used as an organic fertilizer or soil amendment. It is mainly used as a mulch and soil conditioner to improve ornamental and vegetable garden.

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. PKM 1 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 – *Azospirillum*

T₂ – Phosphobacteria

T₃ - Spent Mushroom Compost

Growth Parameters

To measure the growth parameters, plant samples were uprooted carefully on 15th, 30th and 45th day and the following parameters were recorded for all the treatments.

1. Root length (cm)
2. Shoot length (cm)
3. Number of leaves
4. 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 centimeter. 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 centimeter. Three seedlings were randomly selected from each treatment and their root length was measured using cm scale and recorded in cm/seedling. Three readings were taken for statistical analysis.

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 centimeter

STATISTICAL ANALYSIS

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

RESULTS & DISCUSSION

CHAPTER-IV

RESULTS AND DISCUSSION

The experiment was conducted in tomato plant *Solanum lycopersicum* (L) with a control and three different biofertilizer treatments namely *Azospirillum*, Phosphobacteria and Spent Mushroom Compost (SMC) on the growth parameters of the plant. The parameters such as shoot length, root length, number of leaves and diameter of leaves were measured on the 15, 30 and 45 day after sowing (DAS). The growth parameters have been statistically analyzed. The results are tabulated and given below.

On the 15th day (Table 1; Plate 2), the shoot length was found to be higher in T₃ i.e. the tomato plant that was supplemented with Spent Mushroom Compost (SMC). The reading was observed to be 5.30 ± 0.46 cm (Fig.1). The root length on the 15th day was higher in T₂ (3.43 ± 0.59 cm; Fig.2). T₂ is Phosphobacteria supplemented tomato plant.

Significantly higher number of leaves was found in tomato plants treated with SMC and the value recorded was 4.33 ± 0.58 (Fig.3). The diameter of leaves (Fig.4) was observed to be more in both control plant and Phosphobacteria treated plants on the 15th day and the values were found to be 1.63 ± 0.42 and 1.63 ± 0.45 cm respectively. The values are mean \pm SD of three samples in each group.

On the 30th day (Table 2; Plate 3), the shoot length was found to be significantly higher in T₁ (21.70 ± 1.65 cm) i.e. the tomato plant that was treated with *Azospirillum* (Fig.5). The root length was found to be higher in control plant (Fig.6) that was supplied with only farmyard manure. The value was found to be 15.30 ± 2.15 cm.

Similar to root length, the number of leaves formed were also found to be higher in control plant and the reading observed was 44.33 ± 6.81 (Fig.7). The diameter of the leaves was significantly higher in the control plant. The value recorded was 5.07 ± 0.76 cm (Fig.8). As far as the 30th day is concerned, the root length, number of leaves and the diameter of leaves were found to be significantly higher in the control plant rather than the tomato plants treated with *Azospirillum*, Phosphobacteria and Spent Mushroom Compost.

On the 45th day, the morphological parameters were observed for the tomato plant and tabulated (Table 3; Plate 4). The shoot length (Fig.9) was significantly higher in control plant (46.67 ± 9.71 cm). The root length (Fig.10), number of leaves (Fig.11) and the diameter of leaves (Fig.12) were also found to be higher in control plant of tomato. The root length,

Table 1

Growth Parameters of *Solanum lycopersicum* (L) under control and different Biofertilizer treatment on the 15th day

Treatments	Shoot Length (cm)	Root Length (cm)	No of Leaves	Diameter of Leaves (cm)
T0	3.43 ± 0.67	1.60 ± 0.79	4.00 ± 1.00	1.63 ± 0.42
T1	4.07 ± 0.21	1.90 ± 0.70	1.67 ± 0.58	1.40 ± 0.53
T2	4.13 ± 0.61	3.43 ± 0.59	3.00 ± 1.00	1.63 ± 0.45
T3	5.30 ± 0.46	3.27 ± 0.47	4.33 ± 0.58	1.53 ± 0.32
SED	0.4223	0.5302	0.6667	0.3559
CD(P<0.5)	0.9738	1.2227	1.5374	0.8207

Values are mean ± SD of three samples in each group

TREATMENTS

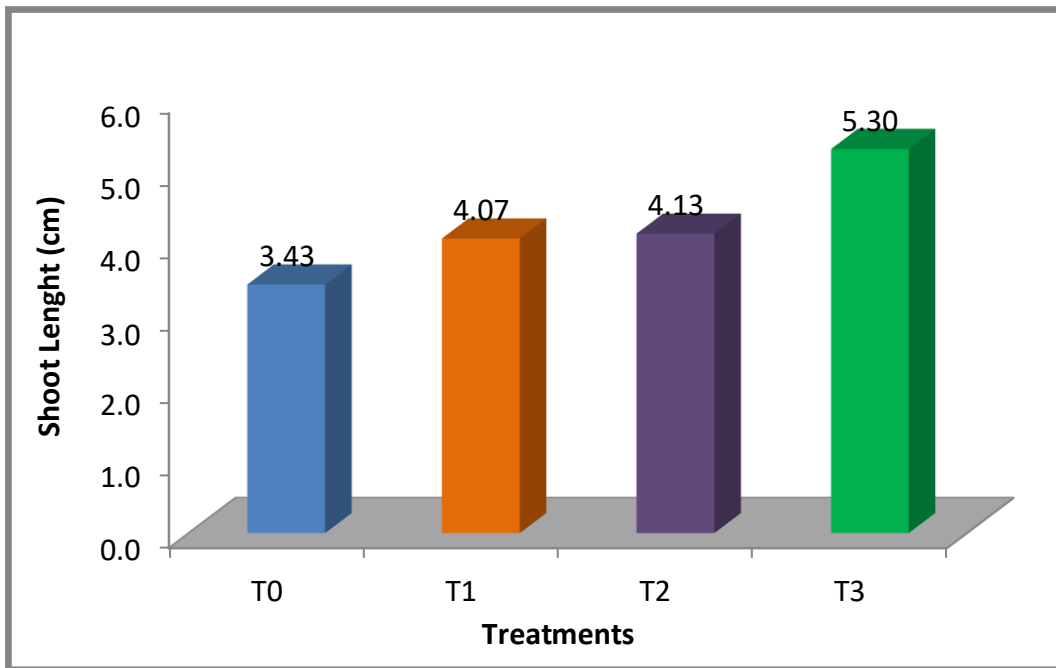
T₀ - Control

T₁ - *Azospirillum*

T₂ - Phosphobacteria

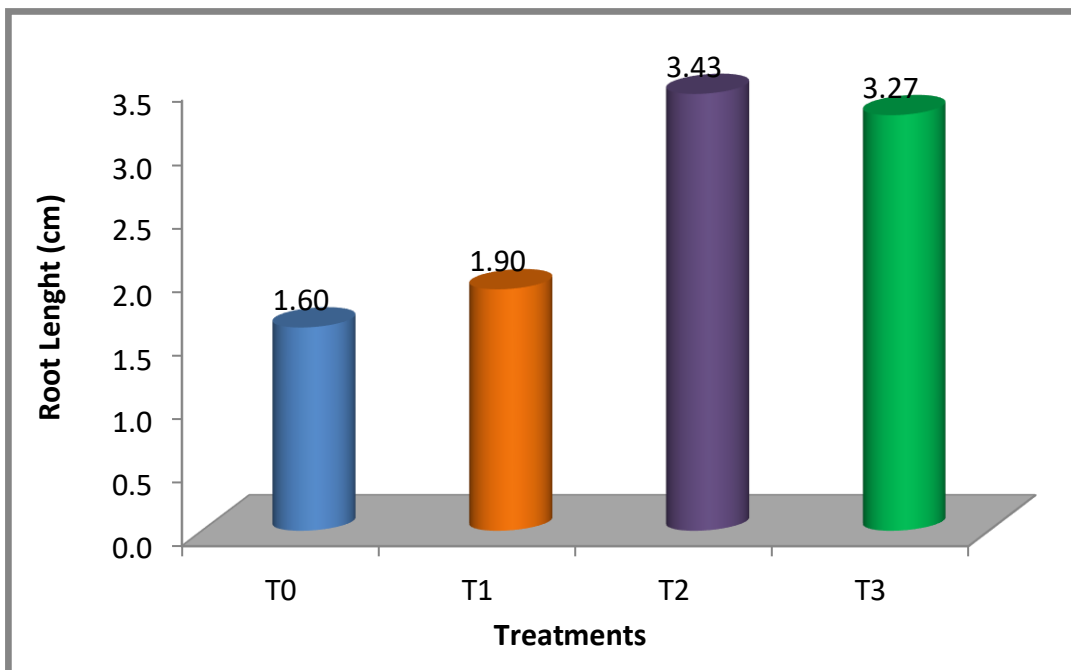
T₃ – Spent Mushroom Compost

Figure 1



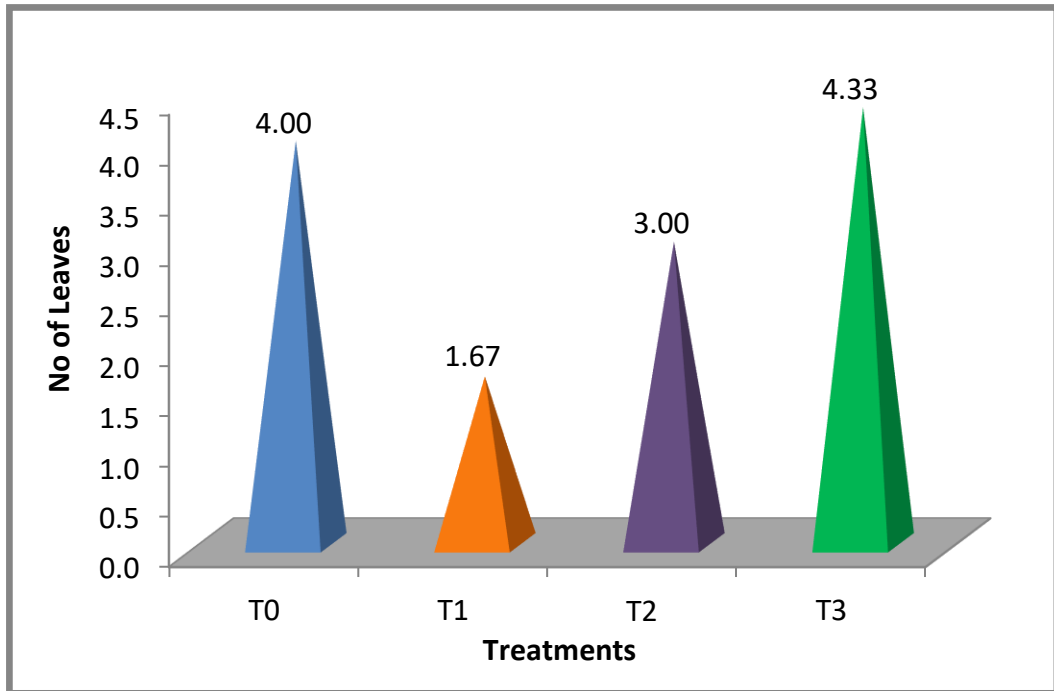
Shoot Length

Figure 2



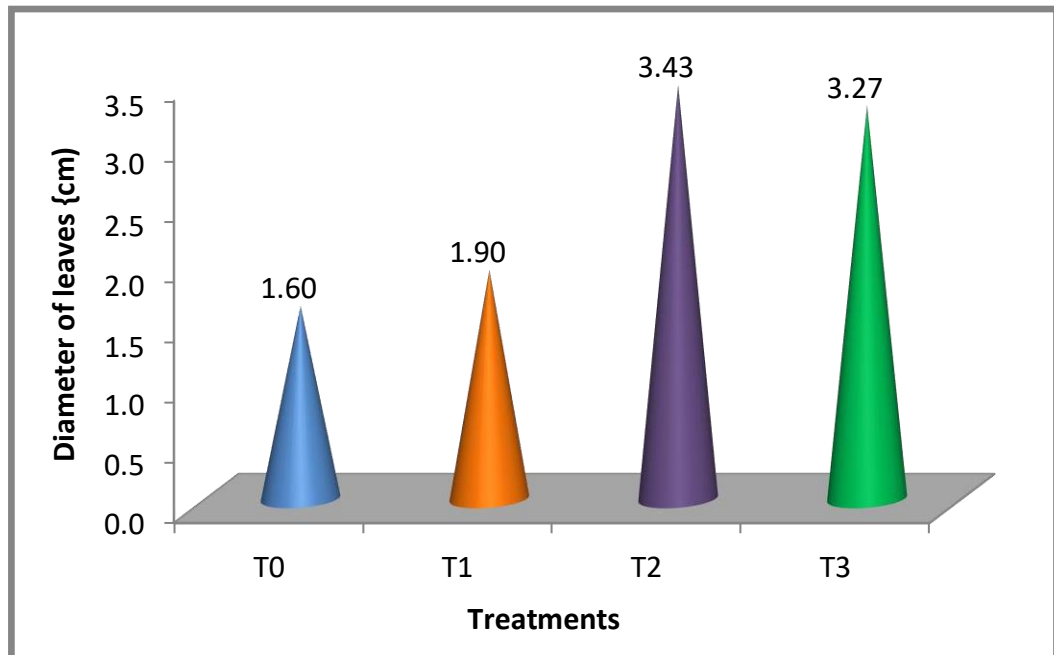
Root Length

Figure 3



No of Leaves

Figure 4



Diameter of Leaves

Table 2

Growth Parameters of *Solanum lycopersicum* (L) under control and different Biofertilizer treatment on the 30th day

Treatments	Shoot Length (cm)	Root Length (cm)	No of Leaves	Diameter of Leaves (cm)
T0	3.50 ± 0.66	15.30 ± 2.15	44.33 ± 6.81	5.07 ± 0.76
T1	21.70 ± 1.65	6.67 ± 1.00	34.00 ± 9.54	3.20 ± 0.70
T2	17.67 ± 1.84	5.23 ± 1.11	22.00 ± 4.58	3.57 ± 0.60
T3	13.73 ± 2.14	4.47 ± 0.55	19.00 ± 6.56	2.20 ± 0.26
SED	1.3624	1.0924	5.7927	0.4994
CD(P<0.5)	3.1417	2.5191	13.3582	1.1517

Values are mean ± SD of three samples in each group

TREATMENTS

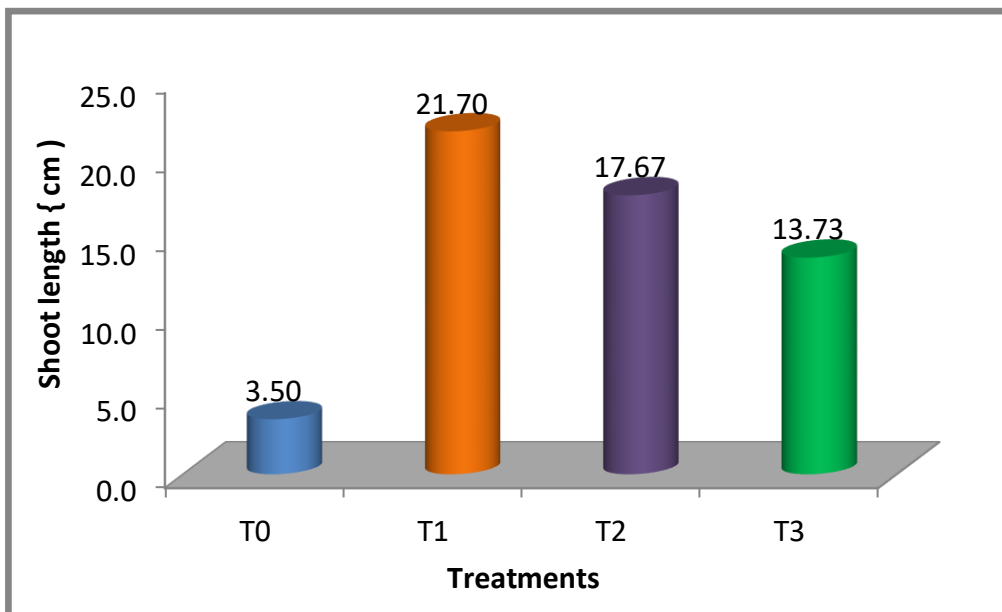
T₀ - Control

T₁ - *Azospirillum*

T₂ - Phosphobacteria

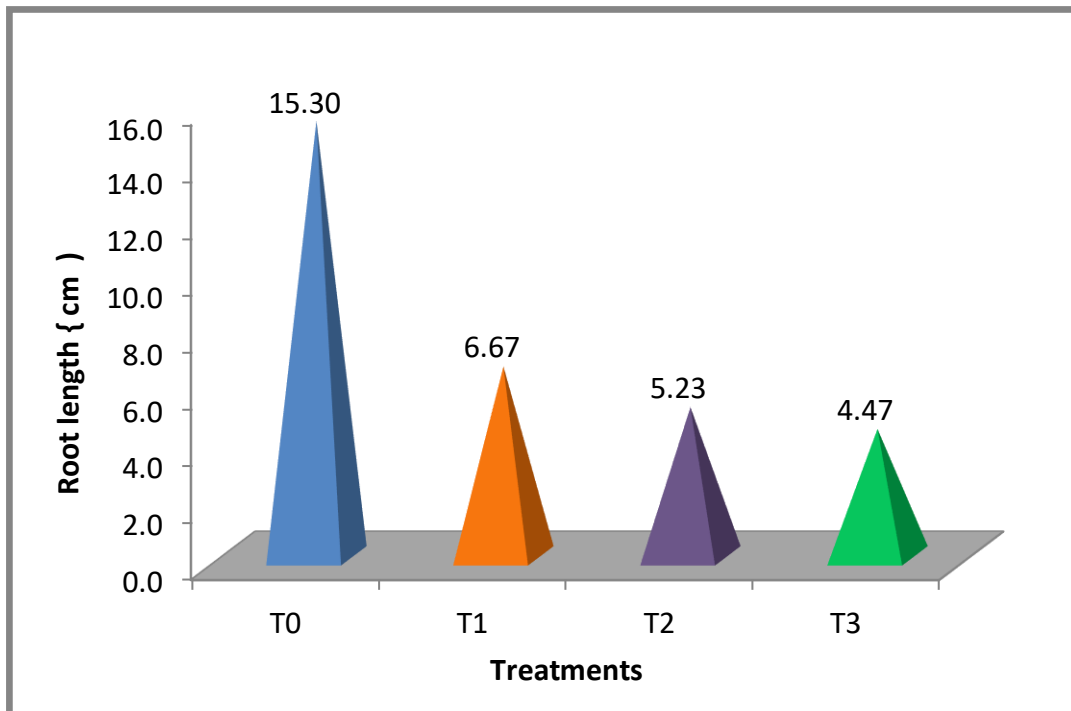
T₃ – Spent Mushroom Compost

Figure 5



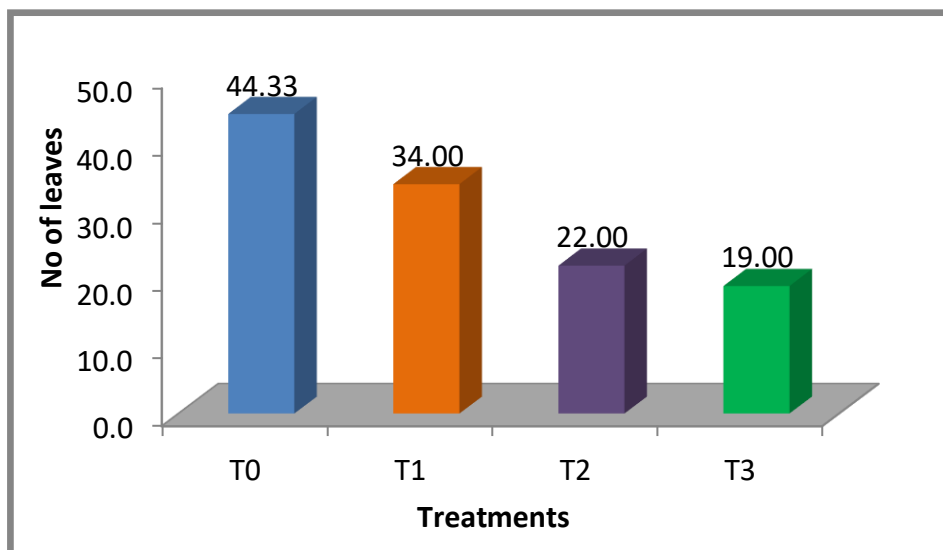
Shoot Length

Figure 6



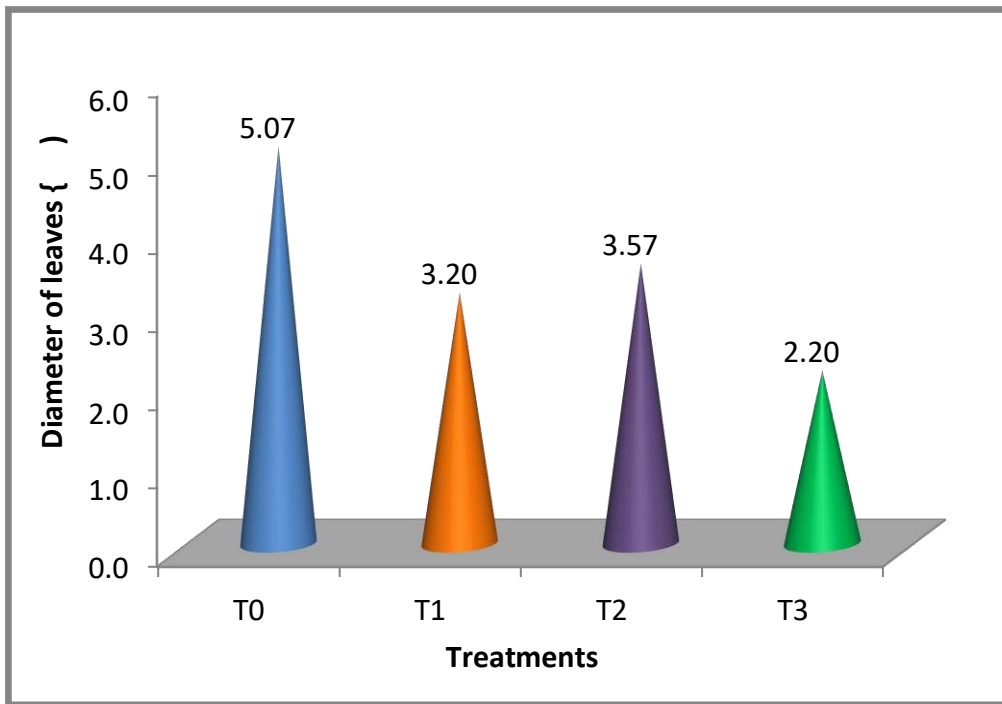
Root Length

Figure 7



No of Leaves

Figure 8



Diameter of Leaves

Table 3

Growth Parameters of *Solanum lycopersicum* (L) under control and different Biofertilizer treatment on the 45th day

Treatments	Shoot Length (cm)	Root Length (cm)	No of Leaves	Diameter of Leaves (cm)
T0	46.67 ± 9.71	16.53 ± 1.40	83.67 ± 7.77	7.27 ± 1.07
T1	35.67 ± 6.03	8.63 ± 1.23	67.33 ± 4.73	4.53 ± 0.65
T2	29.37 ± 3.00	10.13 ± 1.01	52.67 ± 4.73	5.27 ± 0.83
T3	24.33 ± 2.25	8.17 ± 0.85	41.67 ± 3.51	4.37 ± 0.67
SED	4.9118	0.9339	4.4222	0.6712
CD(P<0.5)	11.3267	2.1537	10.1976	1.5479

Values are mean ± SD of three samples in each group

TREATMENTS

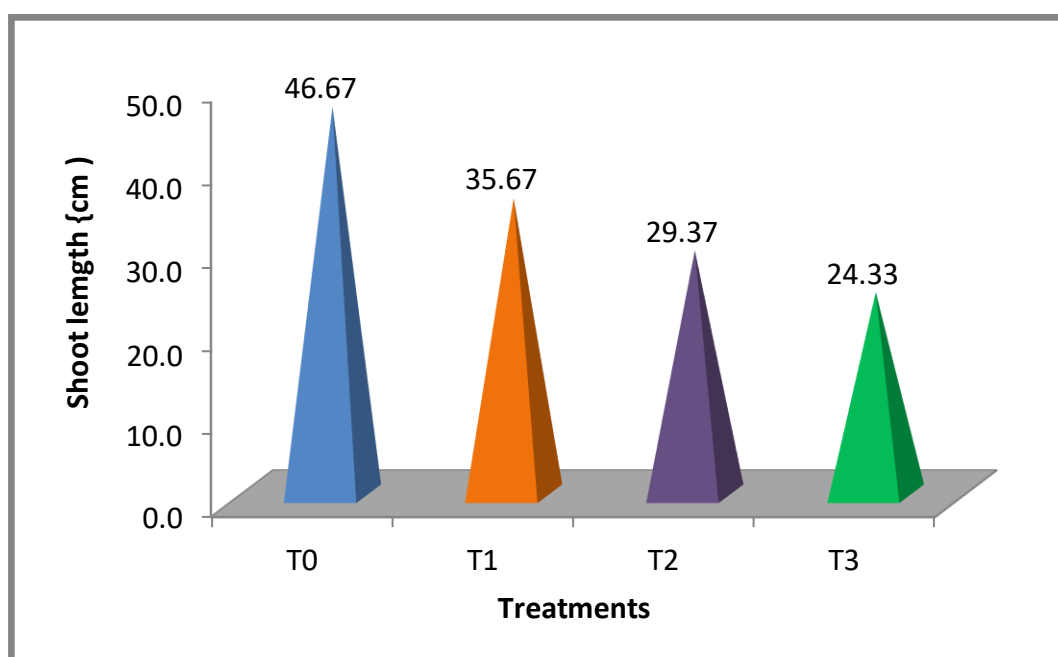
T₀ - Control

T₁ - *Azospirillum*

T₂ - Phosphobacteria

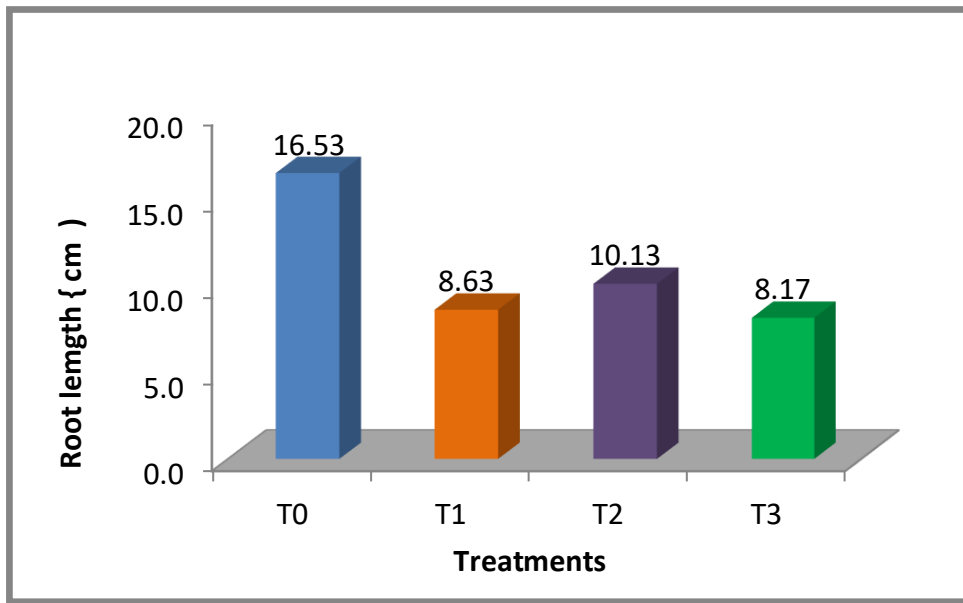
T₃ – Spent Mushroom Compost

Figure 9



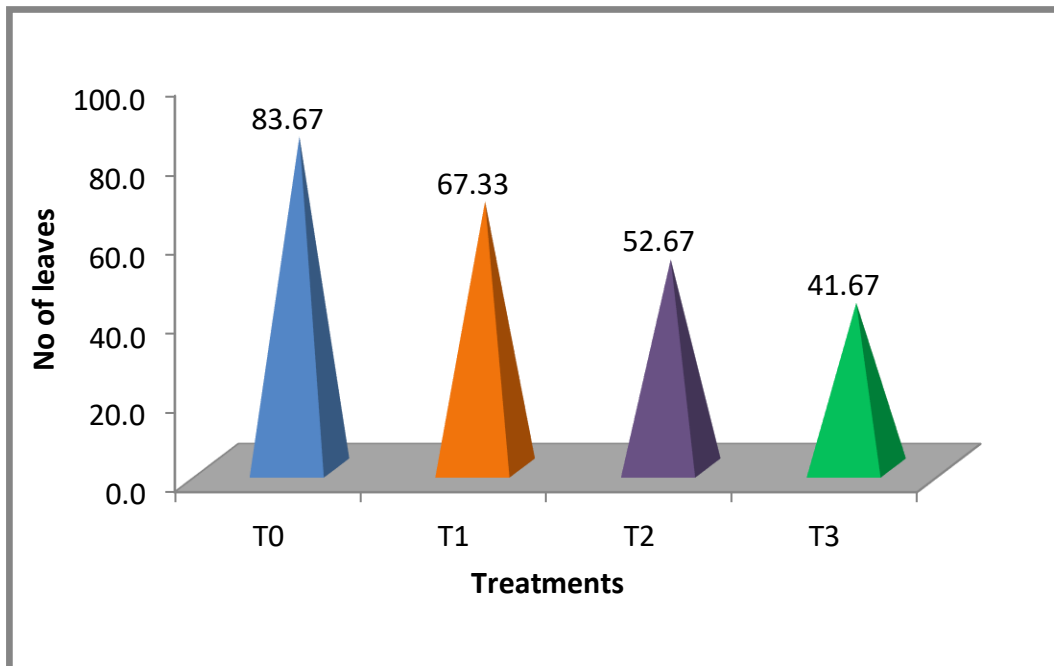
Shoot Length

Figure 10



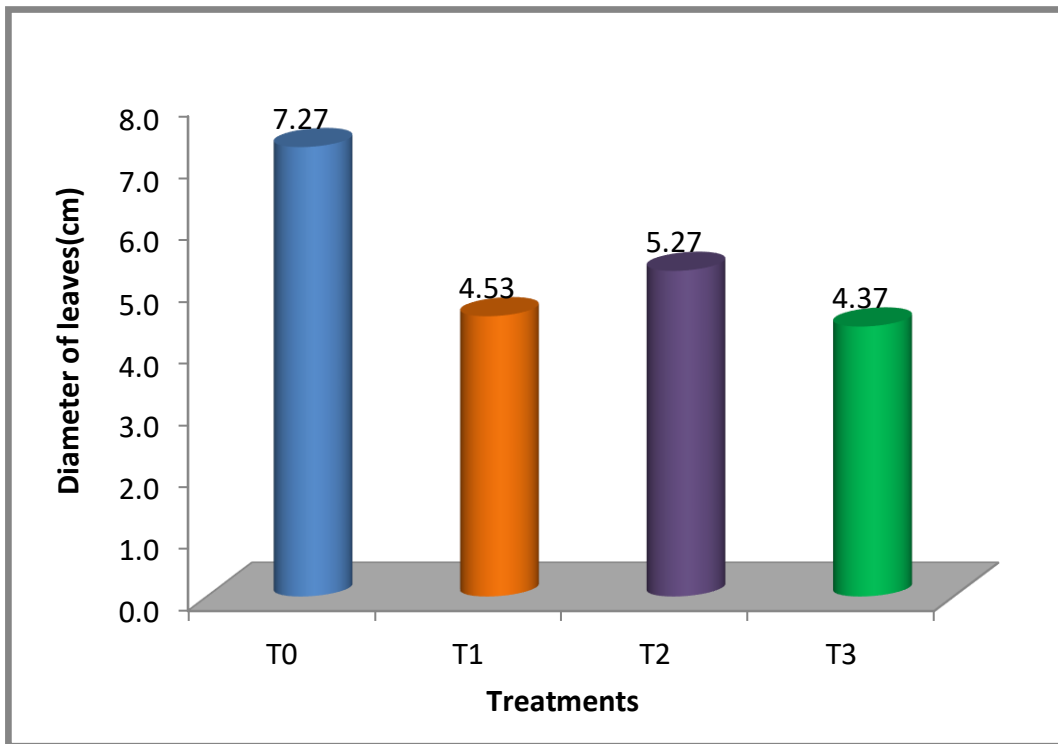
Root Length

Figure 11



No of Leaves

Figure 12



Diameter of Leaves

Plate 2



Growth of *Solanum lycopersicum* L. under different biofertilizer treatments on 15th day

Plate 3



Growth of *Solanum lycopersicum* L. under different biofertilizer treatments on 30th day

Plate 4



Growth of *Solanum lycopersicum* L. under different biofertilizer treatments on 45th day

number of leaves and diameter of leaves were found to be 16.53 ± 1.40 cm, 83.67 ± 7.77 and 7.27 ± 1.07 cm respectively.

The present study is just a trial conducted to study the growth parameters of tomato plant when grown under Spent Mushroom Compost as substrate. For comparison, the other biofertilizers such as *Azospirillum* and Phosphobacteria were selected. In the initial stage of growth, the shoot length and the number of leaves increased in SMC, but later on the growth was slow which might be due to loss of the microorganism and usage of the same by the plants for its growth. With this simple grow bag study; we cannot arrive at a conclusion. We need to do further study on the growth of tomato as well as other vegetable crops by supplementing with the SMC.

Among the treatments, *Azospirillum* supplemented tomato plants showed better shoot length on the 30th and 45th day, but the root length and the number of leaves as well as diameter of leaves showed variation between the treatments. Further study is to be carried out to prove the efficacy of the biofertilizers including the Spent Mushroom Compost on the morphological parameters of tomato plant. The plant requires a considerable amount of phosphorus for growth which is being supplied by the phosphorus solubilizing bacteria (Phosphobacteria). So, there was an increase in the root length and diameter of leaves on the 45th day in Phosphobacteria treated tomato plants.

Improvement in growth and yield parameters in plants treated with bio-fertilizers were due to enhanced uptake of nutrients by the plants (Borea, 1991).

Bio-fertilizers such as *Azospirillum*, Phosphorus solubilizing bacteria and mycorrhiza are capable of improving the mineral nutrients of plants and enhance the soil fertility. Phosphorus solubilizing bacteria are capable of solubilizing unavailable form of phosphorus into available form and make it available to plants (Veena *et al.*; 2009; Shankarappa *et al.*; 2012).

Earlier studies by Ghanti and Sharangi (2009) have revealed better growth, yield and quality of onion when *Azotobacter* was used in combination with *Azospirillum*.

Singh (2014) studied the yield parameters of coriander and found significant increase in plants treated with bio-fertilizers when compared to control. The result obtained in the present study on the uses of bio-fertilizers is in accordance with the studies carried out by Singh (2014).

Application of higher dosage of inorganic fertilizers along with the bio-fertilizers influenced the growth and yield of onion significantly (Singh *et al.*, 2017).

In the study carried out by Sridevi and Ramakrishnan (2010). On the plant growth and yield of cotton, AM inoculation significantly increased the plant growth and yield of cotton at all the levels of NPK.

Studies on the effect of PSB, *Azospirillum* and *Azotobacter* by Choudhary *et al.* (2017) have indicated that the application of bio-fertilizers not only improves the quality of Knol-Khol, but also gives a maximum monetary benefit. They have concluded that the use of PSB, *Azospirillum* and *Azotobacter* could significantly increase the yield of Knol-Khol and also the net return of the crop. Bio-fertilizers are natural fertilizers containing microorganisms that enhance crop productivity through nitrogen fixation, solubilizing of plant nutrients and produce plant growth regulators. Work done by Kumar *et al.* (2002) has proved that the potato yield could be significantly increased by the application of bio-fertilizer.

The current investigation is just a preliminary work carried out to understand the growing ability of vegetable crop when supplemented with SMC in grow bags instead of pot culture experiments. Further studies are required to prove the importance of SMC in the growth of plants.

SUMMARY & CONCLUSION

CHAPTER-V

SUMMARY AND CONCLUSION

The experiment was conducted in tomato plant in grow bags under control and three different biofertilizer treatments namely *Azospirillum*, Phosphobacteria and Spent Mushroom Compost (SMC). The parameters tested were shoot length, root length, number of leaves and diameter of leaves on the 15th, 30th and 45th day after sowing.

On the 15th day, the shoot length and number of leaves were found to be significantly higher in SMC. The root length and diameter of leaves were found to be higher in Phosphobacteria treated tomato plants.

On the 30th day, the root length, number of leaves and the diameter of leaves were found to be significantly higher in the control plant rather than the biofertilizer treated plants, whereas the shoot length significantly increased in tomato plants treated with *Azospirillum* on the 30th day. Similar to the 30th day, almost all the parameters such as shoot length, root length, number of leaves and diameter of leaves were found to be higher in control tomato plants on the 45th day.

In the initial stage of growth, the shoot length and the number of leaves increased in SMC, but later on the growth was slow which might be due to loss of the microorganism and usage of the same by the plants for its growth. With this simple grow bag study; we cannot arrive at a conclusion. Further study is required to prove the efficacy of the biofertilizers as well as the SMC in field conditions.

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