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EFFECTS OF SOIL SUPPLEMENTATION TO IMPROVE GROWTH, YIELD AND QUALITY OF TOMATO

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The soil supplementation with green waste has the potential to improve the soil quality and nutrient status of crop and their productivity. A greenhouse experiment was conducted to investigate the effects of green waste on tomato growthandtheir fruit quality. In fruit quality mineral contents (N, P, K), total soluble sugars, proteins, lycopene, total soluble solids and ascorbic acid were estimated. In results seed germination with 50%, plant length with 6.34 cm, fresh and dry weight with 0.17gm and 0.07gm, respectively of tomato plant were recognized significantly higher in Behror compost soil with respected to without supplement of soil and other compost soil. The results of fruit quality werealso observed significantly better than normal soil. The results concluded that the plant growth and quality of fruit can be enhanced by using green waste as supplement in soil. This research can be proved efficient to agriculture field.

Keywords: Green waste, Greenhouse experiment, Fruit quality

INTRODUCTION

Tomato (*Lycopersiconesculentum*) is one of the most popular and versatile vegetables in the world, because of its taste, color, high nutritive value and its diversified use. It is the world's largest vegetable crop after potato and sweet potato, and tops the list of canned vegetables. According to recent FAO (Food and Agricultural Organization) statistics, approximately 160 million tones tomatoes are produced annually on 4.7 million hectares of land (FAOSTAT, 2011). Tomato and its products are rich in antioxidants and considered to be a good source of vitamins C, E and carotenoids, particularly lycopene and β-carotene and other phenolic compounds (Ilahy *et al.*, 2011, Pinela *et al.*, 2012). Italso contains carbohydrates, amino acids and minerals. The reactive oxygen species (ROS) like superoxide and hydrogen peroxide (H_2O_2) can cause direct damage to membrane lipids, proteins and DNA leading to cell death (Mittler, 2002, Simova-Stoilova *et al.*, 2008). The enzymes Superoxide dismutase (SOD), Catalase (CAT), Peroxidase (PO), Ascorbate Peroxidase (APO) and Glutathione Reductase (GR) are key antioxidants playing a central role in the defense against ROS (Noctor and Foyer, 1998, Simova-Stoilova *et al.*, 2008). Tomatoes have endogenous defense mechanisms which include oxidative enzymes Peroxidase (PO) and Polyphenol Oxidase (PPO) which are generally produced in response to pathogens (Bhonwong *et al.*, 2009). These enzymes catalyze the formation of lignin and other oxidative phenols that contribute to the formation of defense barriers for reinforcing the cell structure (Avdiushko *et al.*, 1993).

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Conventional farm systems have been characterized by high input of chemical fertilizer, leading to quality deterioration of both soil and edible products due to reductions in soil organic matter content (Liu *et al.,* 2009; Singh *et al.,* 2007). The application of inorganic fertilizer, tomato yield and their nutrient content are dramatically affected (Dumas *et al.,* 2003). In fact, non-judicious use of inorganic fertilizer may lead to environmental pollution including contamination of groundwater, and soil acidification as well as increase denitrification resulting in higher the emission of nitrous oxide (N_2O) to the atmosphere which is responsible for global warming (Molla *et al.,* 2012).Therefore the use of organic farming with organic amendments to soil as nutrient inputs is increasing and it is an alternative agricultural practice for sustaining economically viable crop production with minimal environmental pollution (Padel *et al.*, 2009).

Organic farming is one of the fastest-growing sectors of agriculture worldwide and its goal is to balance systems of soil organisms, plants, animals, and humans (Karanatsidis and Berova, 2009). An ideal organic fertilizer should be capable of giving reasonable yields, increasing soil fertility and quality and sustaining productivity. The concept of organic fertilizers was popularized because the negative effect of the intensive use of chemical fertilizers resulted in soil degradation. Moreover, excessive fertilization has been reported to have an influence on the phyto-nutritional quality of crops and reduction in the antioxidant levels, besides causing pollution (Arancon *et al.,* 2004; Toor *et al.,* 2006).Therefore a significant level of organic fertilizers is effective to plant productivity and soil quality.Organic farmers often use composts as soil amendments, particularly in intensive vegetable production systems, to improve soil fertility and quality and sustain productivity (Dick and McCoy, 1993; Maynard, 1994; Quarles and Grossman, 1995). Composts improve biological, chemical, and physical properties of amended soils (Epstein *et al.,* 1976; Khaleel *et al.*, 1981; Meek *et al.*, 1982; Ndayegamiye and Cote, 1989). Furthermore, composts incorporated into soil or planting mixes can provide effective biological control of diseases caused by soilborne plant pathogens (Chellemi *et al.*, 1992; Gamliel and stapleton, 1993; Hardy and Sivasithamparam, 1991; Hoitink and Boehm, 1999; Hoitink and Fahy, 1986; Hoitink *et al.*, 1991; Kwok *et al.*, 1987; Lumsden *et al.*, 1983; Quarles and Grossman, 1995; Schüler *et al.*, 1993; Workneh and van Bruggen, 1994). They also may reduce the severity of diseases caused by foliar plant pathogens (Miller *et al.,* 1997; Tränkner, 1992). Among the compost, green waste compost contains various macro- and microelements required for soil and plants (Huotari *et al.,* 2015). Researchers have found that the addition of green waste compost has effectively increased the macro-and microelements of the final product, including P, K, Mg, Ca, as well as Cu and Zn (Kuba *et al.*, 2008), while other researchers have found improved microorganism activity (Jokinen *et al.*, 2006). Other reports have found that green waste compost (a) increased the amount of organic matter in the soil; (b) improved the physical, chemical, and biological properties of the soil; (c) improved the soil texture (air and water permeability); and (d) improved the plant yield (Koivula *et al.*, 2004). Thus, composts may improve the ability of plants to resist diseases caused by root as well as foliar pathogens by inducing systemic resistance in plants (Han *et al.,* 2000; Zhng *et al.*, 1998; Zhang *et al.,* 1996). Therefore, the present study has been carried out to evaluate the effect of soil supplements (compost soil) on the morphological parameters of tomato plants and tomato fruit quality in comparison to the soil without supplements.

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Material and Method

A. Collection of Soil Samples

The suitable soil samples were collected from the different Alwar district (Mundawer, Thanagazi and Behror) of Rajasthan from the farmer's field (Hopkins *et al.*, 2009). The suitable green waste was also collected from the various farmer's field and prepared compost soil by using standard procedure.

B. Surface sterilization of seeds and Pot experiment

Uniform, healthy and viable tomato seeds were taken for the experiment. The seeds were surface sterilized with 0.01% mercuric chloride solution for three minutes, thoroughly washed with distilled water three times each for 5 minutes, and then dried with paper towel. In pot experiment, seeds were placed in plastic pots contained compost soil and seeds also grown in normal soil as control. 15 seeds per sample were sown in pots (5seeds/pot) and experiment was performed in triplicate form. Pots were incubated at 25±2°C for 12/12 h alternating cycles of light and darkness up to 30 days respectively and data on seed germination, plant length, fresh and dry weight and nutrient quality of tomato were recorded.

C. Effect of compost enriched soil on the morphological parameters and quality of tomato fruit

1. Morphological parameters

a) Seed germination (%)

$$\%\ \text{germination} = \frac{\text{Number of germinated seeds}}{\text{Total no. of seed sowed}} \times 100$$

b) Plant length (cm)

The whole plant length (length of root and shoot) were separately measured with the help of a ruler and the total plant length was the sum of individual lengths of root and shoot.

c) Fresh and dry weight (gm)

After proper washing, excess water was removed and then the fresh weight of seedling were measured, and for dry weight the seedling were dried in an oven at 80^{o}C for 24 hours and then weighed.

2. Nutrient quality of tomato fruit

a) Mineral contents

Nitrogen, phosphorus and potassium were determined from tomato fruits in mineral contents. As described above Kjeldahl method (Kjeldahl, 1883) was used for the determination of

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nitrogen (N), phosphorus (P) was determined by olsen's method (Drewry *et al.*, 2013) and the concentrations of potassium (K) was estimated by the method described by Knudsen *et al.*, 1982.

b)Total Soluble Sugars

The 50 mg of tomato fruits was homogenized in mortar-pestle with 20 ml of 80% ethanol separately and left overnight. Each sample was centrifuged at 1200 rpm for 15 minutes; the supernatants were collected separately and concentrated on a water bath using the method ofLoomis and Shull (1973).Distilled water was added to make up the volume up to 50 ml and processed further for quantitative analysis.1ml of aliquot of each sample was used for the estimation of carbohydrates using the phenol-sulphuric acid method of Dubois *et al.* (1951).A stock solution of glucose (100µg/ml) was prepared to standard regression curve in distilled water. From this solution, 0.1 to 0.8 ml was pipette out into eight separate test tubes and volume was made up to 1 ml with distilled water. These tubes were kept on ice; 1 ml of 5% phenol was added in each tube and shaken gently. 5 ml of conc. sulphuric acid added was rapidly poured so that the steam hits the liquid and tubes were gently shaken during the addition of the acid. Finally the mixture was allowed to stand on water bath at 26-30°C for 20 minutes.The optical density of yellow orange mixture was measured at 490 nm using spectrophotometer (Carl Zeiss, Jena DDR, VSU 2 P), after setting for 100% transmission against a blank (distilled water). Standard regression curve was computed between the known concentration of glucose and their respective optical density, which followed Lambert Beer's Law. The content of total soluble sugars was calculated by computing optical density of each of the samples with standard curve.

c) Proteins

The 50mg of tomato fruits were separately homogenized in 10 ml of cold 10% trichloroacetic acid (TCA) for 30 min and kept at 40°C for 24 hours. These mixtures were centrifuged separately and supernatants were discarded. Each of the residues was again suspended in 10 ml of 5% TCA and heated at 80°C on a water bath for 30 minutes. The samples were cooled, centrifuged and supernatants of each were discarded. The residue was then washed with distilled water, dissolved in 10 ml of 1N NaOH, and left overnight at room temperature(Osborne, 1962).Each of the above samples (1 ml) was taken and the total protein content was estimated using the spectrophotometer through method ofLowry *et al.* (1951).A stock solution of BSA (Sigma Chem. Co., St. Louis, USA) was prepared to regression curve in 1N NaOH (1mg/l). Eight concentrations (ranging from 0.1 to 0.8 mg/l) were separately measured in test tube and volume of each sample was made to 1 ml by adding distilled water. To each, 5 ml of freshly prepared alkaline solution (Prepared by mixing 50 ml of 2% Na_2CO_3 in 0.1 N NaOH and 1 ml of 0.5 % $CuSO_4$. $5H_2O$ in 1% Sodium potassium tartarate) was added and kept at room temperature for 10 minutes. In each sample 0.5ml of Folin-Ciocalteau reagent (commercially available reagent was diluted with equal volume of distilled water just before use) was added rapidly with immediate mixing and optical density of each sample was measured after 30 minutes at 750 nm using spectrophotometer against blank. The concentration

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of the total protein content in each sample was calculated by referring the optical density of each sample with standard curve. Three replicates of each concentration were taken and their mean value was calculated.

d) Lycopene determination

Total lycopene content was determined spectrophotometrically according to method described by Perkins-Veazie *et al.* (2001).1 gm of samples (fresh tomato) was added to a mixture consisting of 25 ml of hexane, 12.5 ml of acetone, 12.5 ml of ethanol and 0.05 % (w/v) butylated hydroxyl toluene. The mixture was stoppered and placed on an orbital shaker to mix at 180 rpm for 15 minutes (temperature of mixing was 5°C). After shaking, 7.5 ml of cold deionized water was added and the mixture was agitated for another 5 min. The suspension was left at room temperature for 10 minutes to allow separation of polar and non-polar layers. The absorbance of non-polar (upper) layer was measured at 503 nm versus a blank of hexane solvent using Jenway 6105 UV/Vis spectrophotometer (Jenway, United Kingdom). The lycopene content was calculated using following equation:

$$\text{Lycopene content (mg/kg)} = \frac{A_{503} \text{ X } 17.7}{W}$$

Here, W is weight of tomato and A_{503} is absorbance of sample at 503nm

e) Total soluble solids (TSS)

The pulp of the fruits was crushed in a mortar with pestle and the juice was squeezed by hand through muslin cloth. The juice was immediately utilized for determination of TSS by a digital refractometer ATAGO PR-32 (ATAGO, USA Inc. Kirkland, WA, USA). Pulp from three fruits was crushed at a time and there were three replications per treatment. The values were expressed as percent total soluble solids.

f) Ascorbic acid content

AsA levels were measured using a modified version of the procedure described by Kampfenkel *et al.*, 1995. Frozen tissue (250 mg) was placed in a 1.5-ml tube with a bead and 200 µl of ice-cold 6% TCA (Sigma), and was homogenized at 50 Hz in a TissueLyzer (Qiagen) for 2 × 1 min. Samples were then incubated on ice for 10 min and centrifuged for 25 min at 25,000 × g and 4°C. The supernatant was supplemented with 6% TCA to a total volume of 500 µl, and then centrifuged as above for 10 min. A 50-µl aliquot was transferred to a fresh 1.5-ml tube containing 150 µl 0.2 M phosphate buffer (pH 7.4) and this was supplemented with 50 µl double distilled water, 250 µl 10% TCA, 200 µl 42% H_3PO_4, 200 µl 2,2′-dipyridyl and 100 µl 3% $FeCl_3$. The mixtures were vortexed and incubated at 42° C for 40 min prior to measurement at 525 nm in a Beckman DU-640 UV spectrophotometer using 6% TCA as a reference. The AsA concentration was expressed in µmol/g fresh weight according to the standard curve A_{525} = 3.6593 × µmolAsA, designed over a dynamic range of 0-0.7 µmolAsA (R^2 = 0.9982). The value was then converted into µg/g.

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Result and Discussion

A. Morphological parameters

1. Seed germination

In this study it was analyzed that 50% was the maximum seed germination which was seen in the incubated compost soil of Behror and was comparatively higher than those growing in compost soil. With Thanagazi and Mundawer compost soil 40% and 20% germination of tomato seed was observed. In Wani *et al.*, 2017 study, germination percentage was maximum (86.60%) withmulberry verity of T2 (Dalweed) being at par with (82.90) with T1 (FYM) and significantly higher than rest of the manure supplement in soil. The least value for germination percentage (58.90%) was found in T6 (control). Results indicated that the type of manure in the medium used for seedling rising in mulberry had a great effect on the germination of seeds and the consequent growth and development of mulberry seedlings. It was observed that soil supplementation have potential to increase germination rate as compared to soil without supplement.

2. Whole plant length

This study determined that the highest plant length was in the compost soil of Behror which was 6.32 cm absolutely higher than the rest of the treatment of soil. A study conducted by Molla *et al.*, 2012 in which each plant was significantly influenced by the application of biofertilizer alone or in combination with N:P:K. Treatments T2 (dose of N:P:K (120:108:10), T4 (50 % BioF/compost + 50 % N:P:K), and T7 (50 % BioF/liquid + 50 % N:P:K) offered significantly ($P \leq 0.05$) higher plant height and number of leaves per plant. However, moderate plant height was recorded in treatments T3 and T8. BioF/compost (T3) produced significantly higher plant height. Application of 50 % BioF/compost or 50 % BioF/liquid combined with 50 % N:P:K (i.e., treatments T4 and T7) enhanced significantly higher plant height as compared to control.

3. Fresh and dry weight (gm)

The chemical fertilizers, increased levels of composted manure resulted in positive response of essential oil, fresh and dry matter of marjoram plants (Edris *et al.*,2003). Saha (2016) stated that the fresh weight of lettuce increased with the use of organic matter of food waste composted treated with miraculous soil microorganisms, unlike using the mineral fertilizers. In the present study it was evaluated that fresh weight and dry weight of plant growing in the compost soil had the maximum weight in comparison to those of control soil plants. 0.17gm was the fresh weight of tomato plant grown in behrorcompost soil and dry weight was 0.07gm.

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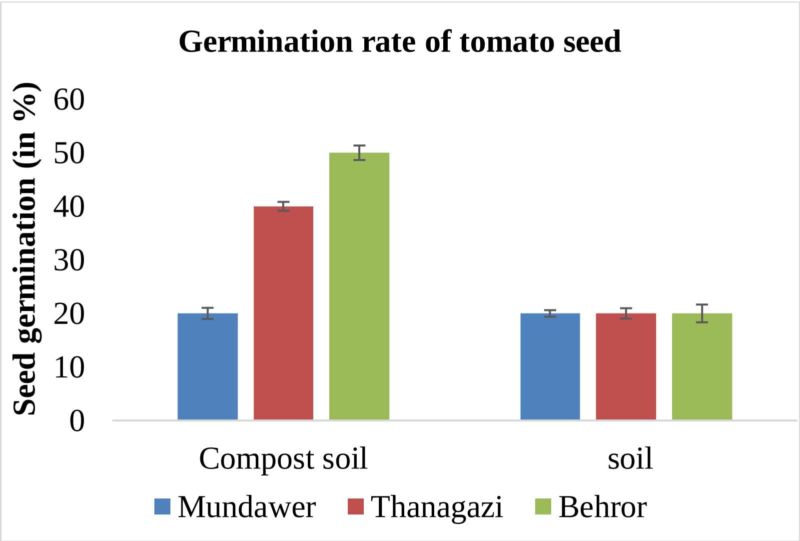

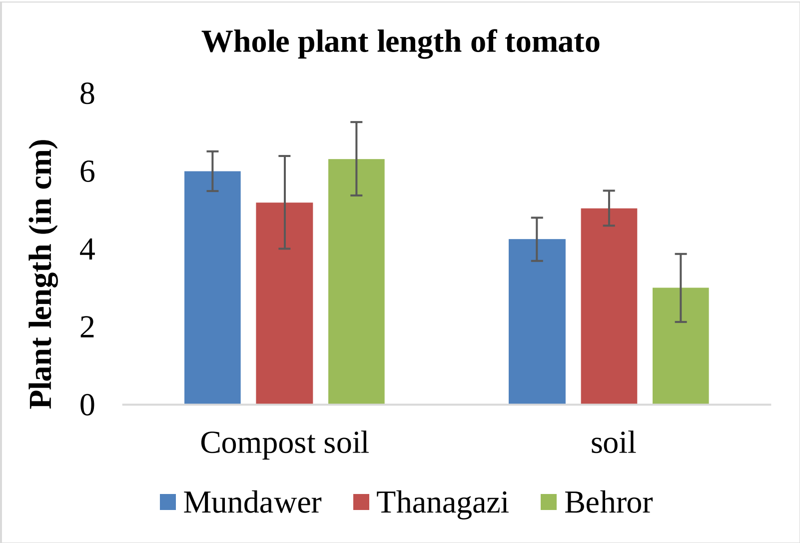

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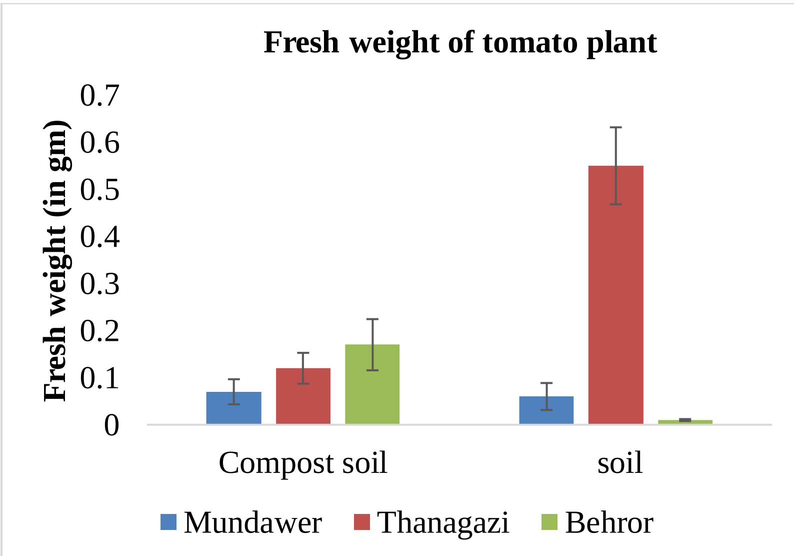

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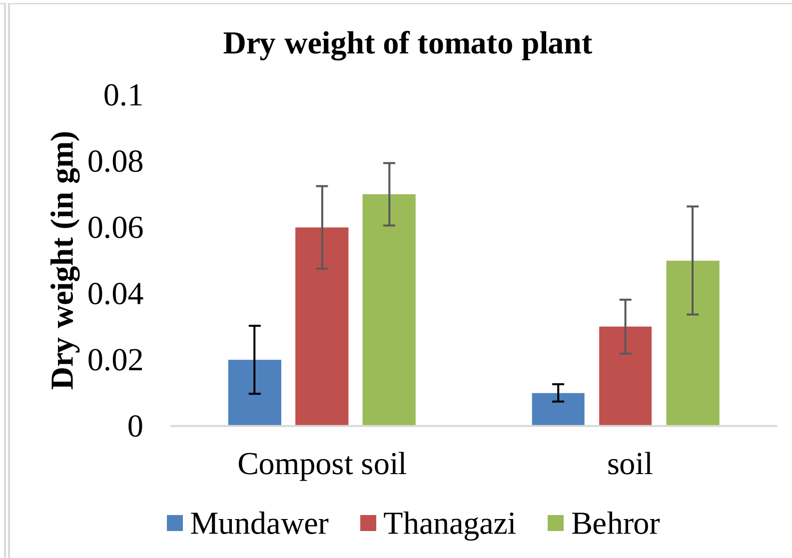

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Figure 1: Morphological parameters of tomato plant (A) seed germination (B) whole plant length (C) Fresh weight (D) Dry weight

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B. Nutrient quality of tomato fruit

1. Mineral content

Nitrogen concentration in plant increases with increasing N concentration in compost. Masunga *et al.*, 2016 reported that organic fertilizers with high-N organic substances usually show a high N release. The previously added N uptake by the crop increased with increasing the availability of N from organic fertilizers. So, this variation in findings of N may be due to the degree of maturity compost, which influences the availability of N in compost. Similarly in the present study the nitrogen content in tomato fruit was 10.94 mg/kg with behror compost soil, 9.02 mg/kg with Tharangazi and 8.37 mg/kg with Mundawarthat was higher N level than control.The nitrogen content in the soil without supplement of Tharangazi, Behror, and Mundawar was found to be8.09 mg/kg, 6.00 mg/kg, and 5.85 mg/kg respectively. According to the results, it was observed that compost soil is helpful to raise nitrogen level in plant parts.

Here, the potassium (K) content was found in higher amounts in the tomato fruit cultivated in the compost soil of Behror, Tharangazi, and Mundawar as 83.49gm, 60.86gm, and 56.4gm respectively. In Thomas *et al.* (1973) study, the range of K concentration in lettuce tissues was between 1.18% and 1.79% for compost. While reporting about the tissues of lettuce leaf, Jones *et al.*, 1991 stated that a 6% concentration of K is recommended in these tissues. It is revealed that the level of K needs to improve among all the compost types by selecting suitable raw materials. Generally, data indicated that there is a variation in the nutritional status of lettuce tissues among different types of compost. The plant availability of K in organic waste was found by Wen *et al.* (1996) because it is present in the mineral fertilizers.

In this study, the phosphorus (P) content in the incubated compost soil was 366gm, 348gm, and 322gm in the Tharangazi, Behror, and Mundawar respectively.According to Thomas *et al.* (1973), P concentration in lettuce tissues ranged between 0.17% and 0.26% for compost C and O, respectively. The sufficient level for P in lettuce tissues was 0.2%. Therefore, the concentration of P in most treatments was among the appropriate level. The increases uptake of P from manure and raw poultry unlike the immature compost causing P immobilization was reported by Cooperband *et al.*, 2002. It has also been stated that the uptake of crop nutrients was significantly affected based on maturity of the compost.According to the results mineral contents in tomato fruit was improved after using compost soil prepared by green waste.

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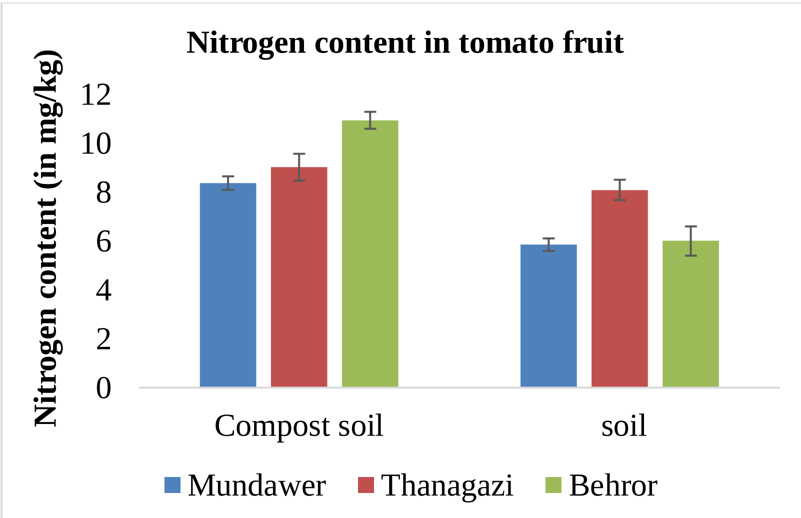

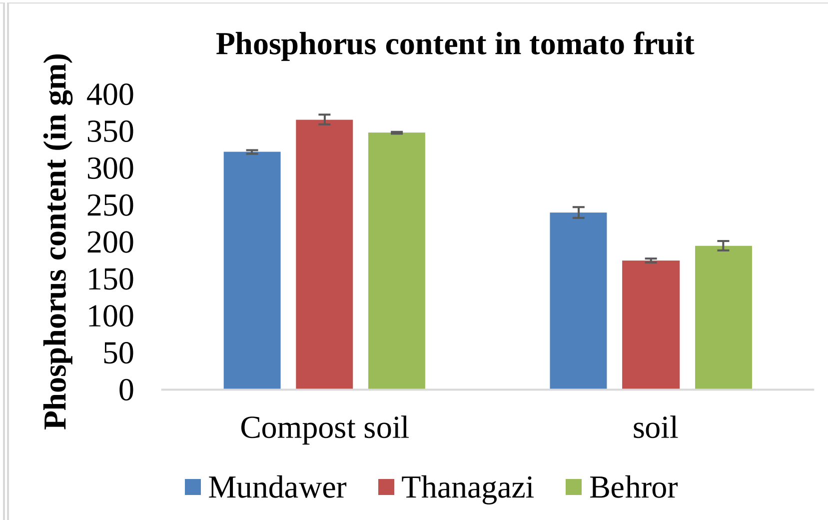

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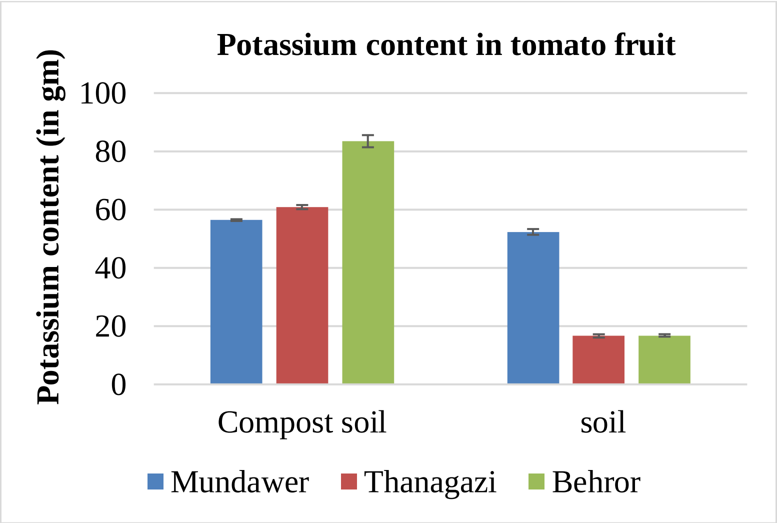

(C)

Figure 2: Mineral contents in tomato fruit (A) Nitrogen content (B) Phosphorus content (C) Potassium content

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2. Total Soluble Sugars

The compost soil increased total soluble sugar value in tomato fruit with significant amount collected from the Tharangazi, Behror, and Mundawar which were 4.9gm, 4.2gm and 3.4gm, respectively. The results suggested that total soluble sugar has been raised after addition of green waste as supplement in soil as compared to control soil. Likewise Molla *et al.*, 2012 reported higher sugar content (5.11 mg/100 g) in tomato fertilized with BioF/ compost (T3) followed by the treatments T4 (50 % BioF/compost + 50 % N:P:K), T6 (BioF/liquid [broth containing spores and mycelia of *T. harzianum* T22 grown in liquid media]), T7 (50 % BioF/liquid + 50 % N:P:K), and T8 (75 % BioF/liquid + 25 % N:P:K).

3. Proteins

In the compost soil of Tharangazi, Behror and Mundawar, the protein content in tomato fruit was raised i.e. 18.66gm, 20.83gm and 24.96gm, respectively. Protein level in tomato fruit was increased after using green waste in soil in comparison with soil (control). The results of Chaturvedi, 2011 revealed that in case of soil treated with composted Jatropha cake, pectin for Jatropha (1%), protein contents were enhanced for all the treatments. In the case of Jatropha, the greater N availability in Pongamia-treated soil manifested itself by greater presence of protein in the fruit.

3. Lycopene determination

Lycopene concentration was detected in the tomato fruit grown in the compost soil of Tharangazi, Behror, Mundawar and the concentration was as following 42mg/g, 48 mg/g, and 57 mg/g respectively higher than those growing in the soil in this study. A significantly higher amount of lycopene (8.81 mg/100gm fresh wt.) was recorded in the tomato fruits harvested from treatment T4 supplemented with $N_{50}P_{30}K_{25}$ + EM compost at the rate of 5 t/ha. Thus, lycopene content were enhanced by 35.52% by treatment T4, over the fertilizer control in Verma *et al.*, 2015 study. Similarly, Riahi and Hdider, 2013also reported that compost as organic fertilizers influences the lycopene content and antioxidant properties in different cultivars of tomato. In their experiment lycopene content varied ranging 78.0–117.8 μg/gfresh wt. in different cultivars by application of different organic fertilizers. Chaturvedi, 2011 revealed in their study that in case of soil treated with composted Jatropha cake, significant increase in lycopene was recorded for Jatropha (3%). For soil treated with composted Pongamia cake, lycopene content was significantly greater only for Pongamia (3%). Lee *et al.*, 2008 also reported higher lycopene content of tomato fruits when treated with bio-fertilizer, *Rhodopseudomonas* species than untreated control. Smita *et al.*, 2013 suggest the role of specific carotenoid pathway-related genes in accumulation of high lycopene during the fruit ripening processes.

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4. Total soluble solids (TSS)

It was analyzed that the TSS content in the fresh tomato from the compost soil of Tharangazi, Behror, and Mundawar contained 4.9gm, 5.01gm, and 5.4gm respectively.Compost application significantly increased total soluble solids. Aminifard *et al.*, 2013 revealed 4.70 ◦Brix total soluble solid in sweet pepper fruit that was higher level from the control (3.75 ◦ Brix) due to addition of compost in soil. Similar results were also reported by Toor *et al.*, 2006 and Santiago, *et al.*, 2009 observed that fruits harvested from plants that received compost had significantly greater total soluble solid (TSS) than those harvested from the mineral fertilizer plot. In the study of Molla *et al.*, 2012, the nutritional quality of tomato as affected by Trichoderma-enriched biofertilizer alone or in combination with N:P:K. Significantly the highest value of total soluble solids (TSS) was found in treatment T3 (BioF/ compost) but statistically similar reflections were also noted in treatments T2 (standard dose of N:P:K), T4 (50 % BioF/compost, i.e., T3 + 50 % N:P:K, i.e., T2), T7 (50 % BioF/liquid, i.e., T6 + 50 % N:P:K, i.e., T2), and T8 (75 % BioF/liquid, i.e., T6 +25 % N:P:K, i.e., T2).

5. Ascorbic acid content

In the compost soil of Tharangazi, Behror, and Mundawar it was determined that the ascorbic acid content was high comparatively with 2.65 mg/g, 12.82 mg/g and 13.71 mg/g respectively. In soil without supplement, 0.81 mg/g, 4.89 mg/g, 3.78 mg/g, respectivelylower level of ascorbic acid were determined from tomato fruit.Organic fertilization has been reported to give a low yield of tomatoes with high ascorbic acid content, whereas mineral or mineral+ organic fertilizer gave a high yield of fruit with lower ascorbic acid content (Dumas*et al.*, 2003). According to the result, it was observed that fruit quality and plant yield depend on the mixture of fertilizer.

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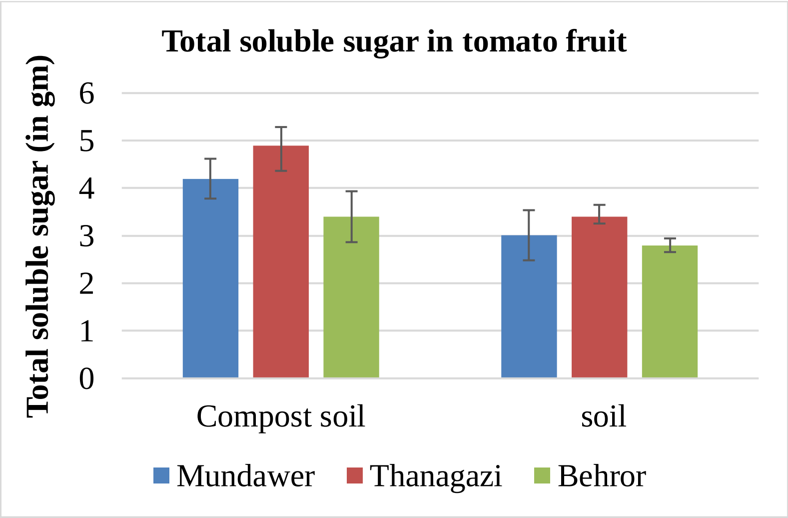

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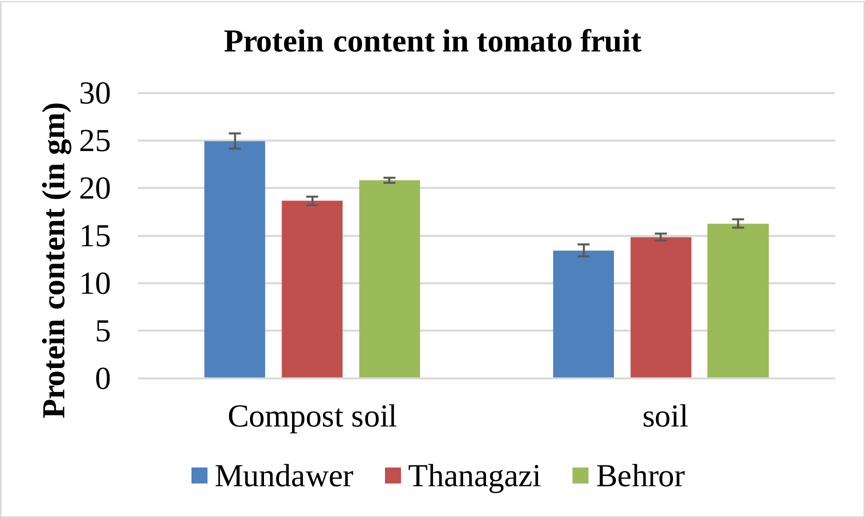

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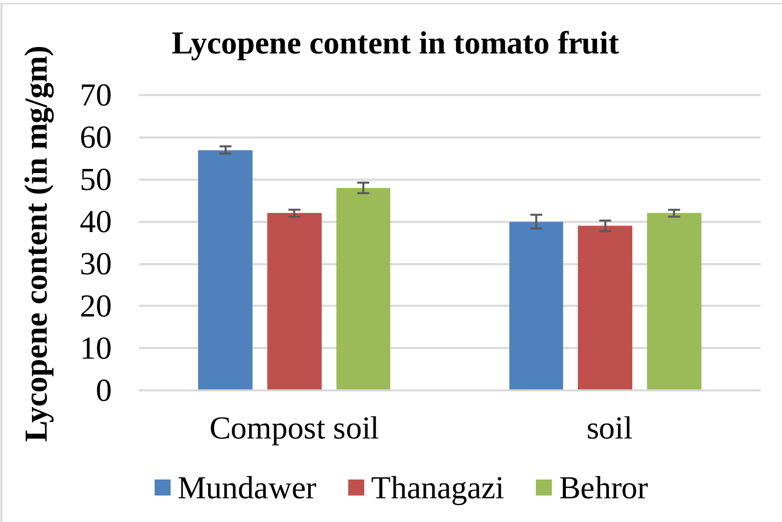

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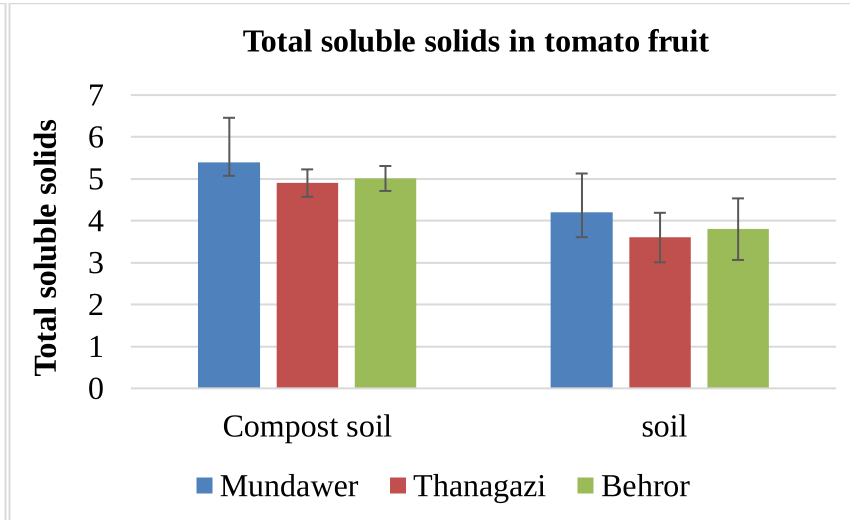

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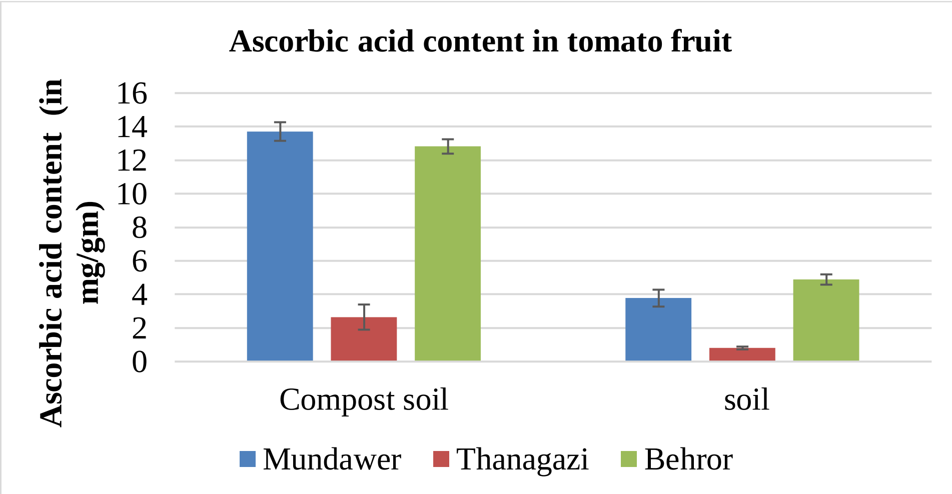

(E)

Figure 3: Tomato fruit quality (A) Total soluble sugar (B) Protein content (C) Lycopene content (D) Total soluble solid (E) Ascorbic acid.

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CONCLUSION

Green waste, also known as "biological waste", is any organic waste that can be composted. It is most usually composed of refuse from gardens such as grass clippings or leaves, and domestic or industrial kitchen wastes. Green waste compost improves qualitative and quantitative characters. Quantitative in terms of yield, no. of fruit and qualitative in terms of protein, sugar, total soluble solids, antioxidant activity. In our study it was concluded that by utilizing green waste compost as a manure to the soil had significantly enhanced content of mineral nutrients, protein, total soluble sugar, total soluble solids, lycopene content and ascorbic acid with respect to control soil. Irrespective of using chemical fertilizer which damages soil, green waste compost is a better way to utilize products which are naturally healthy as they contain beneficial components. By looking to the future also it is cost effective and produce better yield without any harmful effects on the soil quality, plant productivity and indirectly on human life.

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