THE EFFECTIVENESS OF MORINGA OLEIFERA LEAF EXTRACTS ON THE QUALITY OF HYDROPONICALLY GROWN TOMATOES IN GREENHOUSE CONDITION

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ABSTRACT: Greenhouses offers one of the optimistic approaches to ensuring sustainable food production in water stressed and urban environment. Among vegetable crops, tomato is the most cultivated under greenhouse condition for its better and off-season production which requires extensive usage of nutrient-rich water circulation. Commercially available fertilizers are costly and have adverse effects on tomato quality. Sustainable cultivation of tomatoes require proper application of nutrient management and bio-stimulant i.e. moringa leaf extract (MLE) that offers required macro and micronutrient including phytohormones. A study was conducted to evaluate the consequence of moringa olifera on the quality of hydroponically grown tomatoes. Performance of various concentration rates of moringa leaf extract on the quality parameters including pH, total soluble solids, titratable acidity, ascorbic acid, and fruit firmness were measured. Results showed that different concentrations of moringa leaf extract had an optimistic influence on the quality of tomatoes compared to control T_o (only distilled water). Treatment T_3 pure moringa leaf extract (100% MLE) shown maximum values while the treatment T_o control shows minimum values on the quality. Quality of the tomatoes was improved by increasing the concentration of moringa leaf extract and this has proven a sustainable and environment friendly production technology.

Keywords: Bio-stimulant; Fertilizer; Moringa leaf extract; Nutrient uptake; Tomato;

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INTRODUCTION

Tomato production typically concentrates on the total weight of produce per unit area. Better production of tomatoes promises more profit, but nowadays consumers are quality conscious. Common quality parameters including color, size, texture, aroma and especially flavor [1]. According to the reports, the flavor is often seen as the most important quality factor. The differences in qualities can either make people like or dislike the produce. These qualities are formed by both the tomato's genes and the environment it grows. The quality parameters are deeply associated with production's surrounding and the environment in which harvested tomatoes are placed before final consumption [2][3][4].

Moringa Leaf Extract (MLE) is a valuable organic extract as it consists of a lot of phyto-hormones, vitamins, antioxidants, and minerals. Its foliar usage makes plants grow better and enhance the yields of various crops. MLE enhances the natural plant hormones, growth rate and resultantly increases production. For instance, it increased the levels of chlorophyll and protein in spinach leaves, improved the growth performance of sweet basil plants and enhanced its production, and improved the nutrient levels in mandarin leaves [5][6].

World's rapidly growing population is expected to reach 9.6 billion by 2050, with 70% living in urban areas putting more pressure to produce more food. As a result, there's a higher demand for fresh or minimally processed vegetables. To meet this demand while being careful of the environment and reducing losses during storage or processing, food industries are looking for new ways to grow high-quality and safe food [7][8].

Excessive use of chemical fertilizers to enhance production can be problematic as it may harm human and animal health. Their improper uses also degrade environment and create water pollution. To meet market

demand, it's possible to enhance the quality of leafy vegetables using natural bio-stimulants/resources instead of relying solely on chemicals [9][10][11].

European Bio-stimulant Industry Council defined plant bio-stimulants as substances or micro-organisms that encourage natural processes, when they come into contact with plants or their root systems. These processes can lead to improved nutrient absorption, nutrient use efficiency, and the ability to withstand stress and higher crop quality [12]. Natural bio-stimulant products come from various sources, such as (i) Seaweed extracts; which help plants germinate, grow, and produce more, and also make them more resistant to both living and environmental stress. (ii) Microbial antagonists; which can include things like arbuscular mycorrhizal fungi and rhizobacteria. (iii) Protein hydrolysates (PHs); are made up of peptides and amino acids from different animal or plant sources. (iv) Humic and fulvic acids; the physical, biochemical, and anatomical changes that is the sources include the improvement of antioxidant enzymes, pigments, and secondary metabolites, as well as an increase in hormone activity and carbon metabolism [13][14].

Moringa Leaf Extracts (MLEs) have a significant impact on the natural bio-stimulants due to remarkable changing in the quality of fruits. Some experts have even suggested using MLEs as an alternative to chemical fertilizers [15]. MLEs have also been found to enhance important characteristics even when plants face harsh environmental stress, helping them continue growing well. The best part is that making aqueous MLEs is easy, cost-effective, and environment friendly. Plants leaves like Pinus roxburghii needles/leaves and moringa leaves are rich in protein, essential amino acids, and antioxidants like ascorbic acid, flavonoids, carotenoids, vitamins A and C, phenolics, and a range of macro- and micronutrients [16][17].

According to [18][19], the MLE is regarded as an enhancer of typical plant growth because it is a good cause of zeatin (a purine adenine subordinate of plant hormone bunch cytokinin), phenols, proteins, ascorbic acid, vitamin E, basic amino acids, and a few mineral components. The primary goal of the study was to determine how different Moringa Leaf Extract (MLE) concentrations and application frequency affected the quality of tomatoes (*Lycopersicon esculentum Mill*.) Cv. Sahil in greenhouse environment.

MATERIALS AND METHODS

This section includes study area and methodology used for evaluation of moringa leaves extract as natural quality enhancer of hydroponically grown tomatoes. The MLE spray was applied directly on tomato plants for fruit quality parameters assessment as described below;

Study area

The experiment was conducted at the Institute of Hydroponic Agriculture for growing crop in a greenhouse condition and using different percentage of MLE on tomato plants in the laboratory of the Department of Horticulture, Pir Mehr Ali Shah Arid Agriculture University for measuring fruit quality parameters.

Preparation of moringa leaf extract

MLE (Moringa Leaf Extract) was prepared and the Moringa leaf powder was first weighed and combined with water (distilled) in a 1:10 leaf powder to water ratio. This mixture was then stirred with an electric whisk for four hours before being left at room temperature for a full day (24 hours) in the dark. The mixture was then filtered using Whatman No. 1 paper. The produced liquid was the stock solution, which included only MLE. The stock solution was diluted in the following manner to produce various concentrations: the control, which contains 0% MLE, was made using only distilled water, 35 ml of the extract was combined with 65 ml of water to achieve a 35% dilution, a 70% dilution was created by combining 70 ml of the extract with 30 ml of water and a 100% dilution was made by using only the original MLE and no additional water.

Plant material

Tomato cv. Sahil was selected as experimental unit to evaluate the effects moringa leaf extract on the quality of mature fruits.

Experimental design and treatment

The experiment was set up by using a Completely Randomized Design (CRD) with three replications having three plants per replication. Following were the treatments; T_o Control (Only Distilled water), T_1 (35% MLE), T_2 (70% MLE), and T_3 (100% MLE).

The treatments were applied 30 ml to each plant with an interval of a week after transplanting to the fruit set.

Qualitative parameters

At the completion of each cropping season, various parameters were measured to assess the quality of tomatoes. These parameters include the pH, titratable

acidity, fruit firmness, total soluble solids, and ascorbic acid.

RESULTS AND DISCUSSION

The data recorded for various parameters were statistically analyzed. Performance of Moringa Leaf Extract (MLE) application on tomato fruit was expressed in term of pH, titratable acidity, fruit firmness, total soluble solids, and ascorbic acid. Average of qualitative parameters is presented in (Figure 1-5) for proper understanding and discussion.

pH: In Figure 1 the data regarding pH value was analyzed and results shown that the qualitative parameters were affected significantly by the spraying of Moringa Leaf Extract (MLE). The pH value was significantly different among all the treatments of MLE and control treatment. The average pH values for treatment T_o control (only distilled water), treatment T_1 (35%) MLE, treatment T_2 (70%) MLE, and treatment T_3 (100%) moringa leaf extract (pure moringa leaf extract) was recorded as 4.38, 4.48, 4.54 and 4.6 respectively. The maximum pH (4.60) of tomato was observed in T_3 (Pure moringa leaf extract) followed by T_2 moringa leaf extract (70%) of pH (4.54), whereas pH (4.48) of the tomato was recorded in T_1 moringa leaf extract (35%) and the minimum pH (4.38) was recorded in T_o control (Only distilled water) respectively.

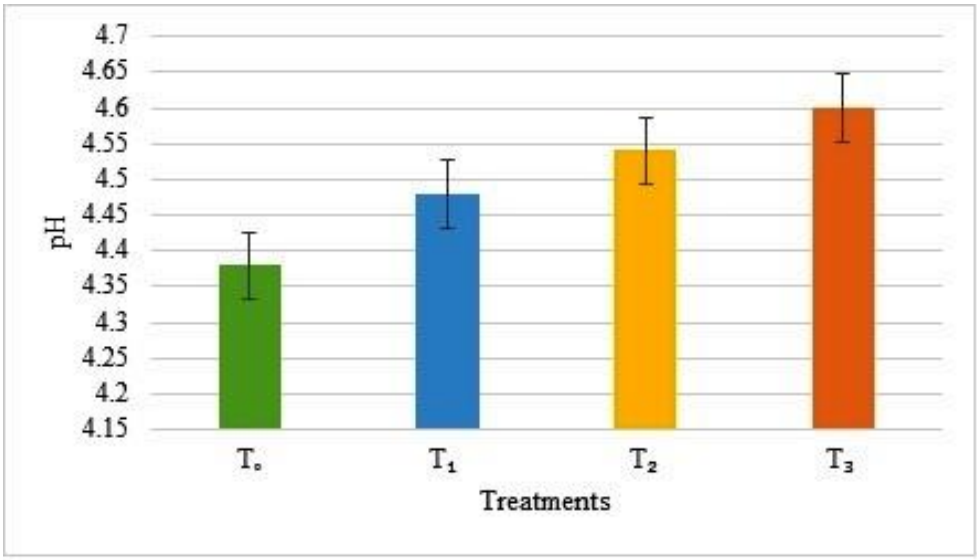

Figure 1. Effect of foliar applications with Moringa Leaf Extract (MLE) on the pH

The results of the given data showed that the pH value of the tomato increased by increasing the amount of Moringa Leaf Extract (MLE) which is in line with the findings of [20], they reported that the pH of the tomato plant's growth medium rises after adding various fertilizer solutions. When the media was supplemented with various nutrient solutions, the pH of the medium changed significantly with the combination of fermented moringa leaves and a medium amount of acidity. As the amount of moringa leaf supplement increased, the pH increased significantly.

Total soluble solid: The data regarding total soluble solids presented in Figure 2 showed that the qualitative parameters (TSS) were affected significantly by the Moringa Leaf Extract (MLE) spraying. The TSS was significantly different among all the treatments of MLE and control treatment. The average values for TSS for treatment T_o control (only distilled water), treatment T_1 (35%) MLE, treatment T_2 (70%) MLE, and treatment T_3 (100%) moringa leaf extract (pure moringa leaf extract) was recorded as 4.46, 4.70, 5.16 and 5.63 °Brix respectively. The higher percentage of TSS (5.63 °Brix) was observed in T_3 (Pure moringa leaf extract) while the lower percentage of TSS (4.46 °Brix) was recorded in T_o control (Only distilled water) respectively.

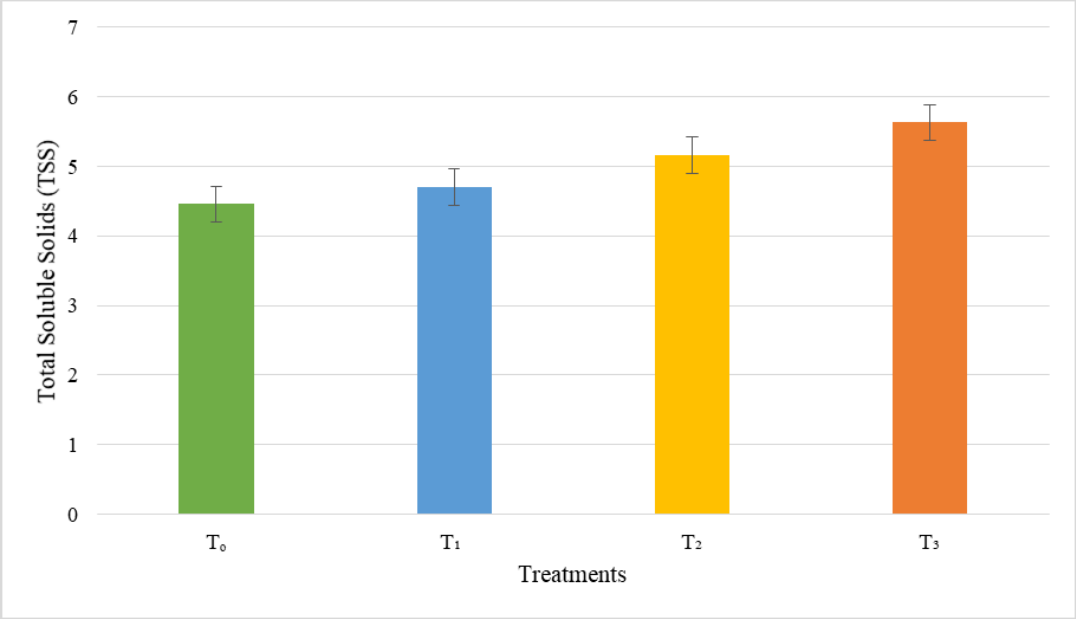

Figure 2: Effect of foliar applications with Moringa Leaf Extract (MLE) on TSS

The total soluble solids of tomato increased by increasing the amount of Moringa Leaf Extract (MLE) which is in line with Thanaa *et al*., (2017) who reported that the amount of soluble solids in the two experiments was significantly increased by applying various concentrations of moringa leaf aqueous extract. In the first and second experiments, foliar application of 6% moringa leaf aqueous extract was found to have the highest soluble solids content (14.87 and 14.95%), while the control treatment of 0% moringa leaf aqueous extract had the lowest soluble solids content (13.67 and 13.66%).

Titratable acidity: The titratable acidity data shown in Figure 3 showed that the qualitative parameters (Titratable acidity) were affected significantly by the Moringa Leaf Extract (MLE) spraying. Titratable acidity was significantly different among all the treatments of MLE and control treatment. The average values for TA for treatment T_o control (only distilled water), treatment T_1 (35%) MLE, treatment T_2 (70%) MLE, and treatment T_3 (100%) moringa leaf extract (pure moringa leaf extract) was recorded as 0.1267, 0.1367, 0.1467 and 0.1633 % respectively. The maximum amount of titratable acidity (0.1633 %) was recorded in T_3 (Pure Moringa leaf extract) followed by treatment T_2 (70%) MLE with (0.1467%) TA, and treatment T_1 (35%) MLE with (0.1367%) TA. However the minimum amount of titratable acidity (0.1276%) was observed in the T_o control (Only distilled water) respectively.

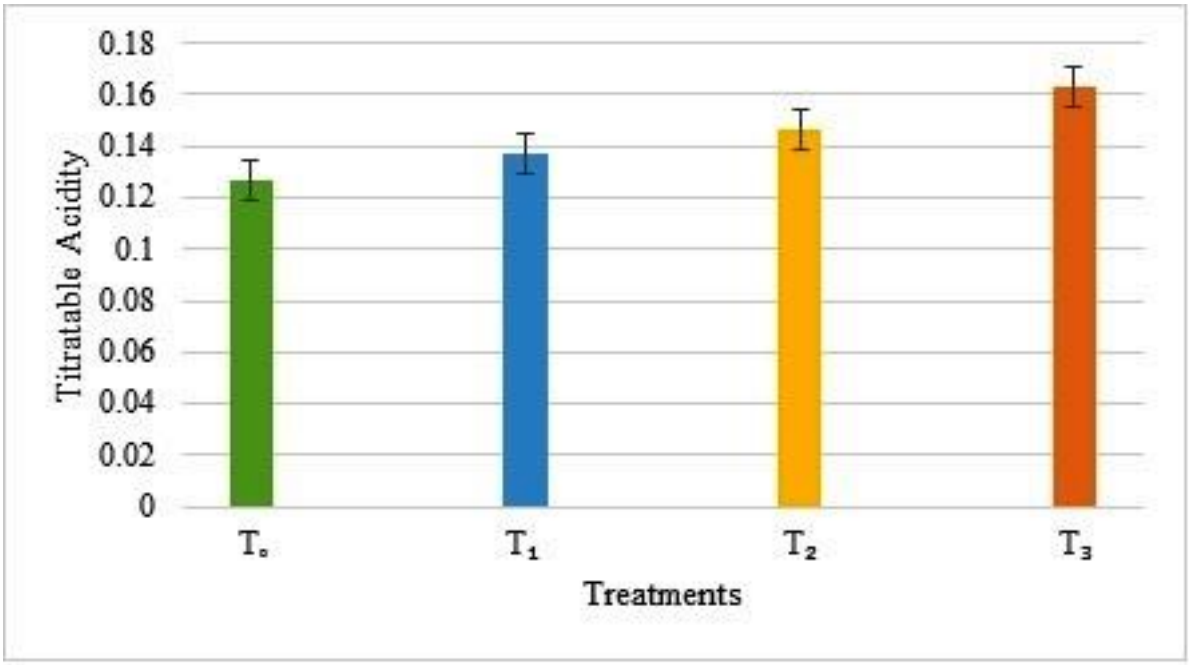

Figure 2. Effect of foliar applications with Moringa Leaf Extract (MLE) on titratable acidity

he results of discussed data shown that the titratable acidity of tomato increased by increasing the amount of Moringa Leaf Extract (MLE) which is supported by literature; application of Moringa Leaf Extract only or with K and Zn considerably enhanced bio-chemical properties of fruit (Vitamin C, titratable acidity, and sugar concentration). As MLE has significant amount of sugar and starch content beside minerals such as Zn and K which when applied to plants increase titratable acidity, K is majorly responsible of the translocation of photo-assimilate (carbohydrates and sugars) to fruit formation and has significant impact on acidity of juice, acidity increases with increase in K value [22].

Fruit firmness: The data regarding fruit firmness presented in Figure 4 showed that the qualitative parameters (Fruit firmness) were affected significantly by the Moringa Leaf Extract (MLE) spraying. Titratable acidity was significantly different among all the treatments of MLE and control treatment. Average values for fruit firmness for treatment T_o control (only distilled water), treatment T_1 (35%) MLE, treatment T_2 (70%) MLE, and treatment T_3 (100%) moringa leaf extract (pure moringa leaf extract) was recorded as 1.74, 1.92, 2.02 and 2.35 kgf respectively. The maximum value for fruit firmness (2.35 kgf) was found in T_3 (Pure moringa leaf extract) and the minimum value for fruit firmness (1.74 kgf) was found in T_o control (Only distilled water).

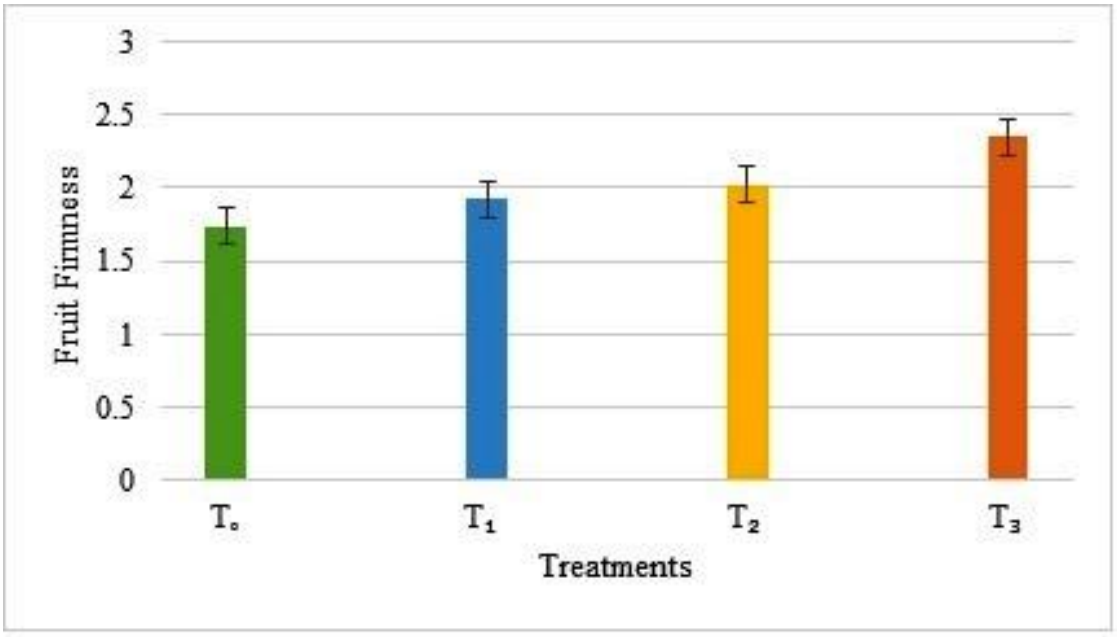

Figure 3. Effect of foliar applications with Moringa Leaf Extract (MLE) on fruit firmness

The fruit firmness of tomatoes increased by increasing the amount of Moringa Leaf Extract (MLE) which is in line with [21], they conducted two experiments, and the outcomes showed that foliar use of moringa leaf extract considerably enhanced the "Hollywood" fruit's firmness. In the two studies, the fruit collected from plants treated with 6% moringa leaf extract had the greatest firmness readings (5.27 and 5.38 lb in^{-2}, respectively). The fruit collected from untreated plants with 0% moringa leaf extract had the lowest firmness during both studies (3.47 and 3.61 lb in^{-2}, respectively).

Ascorbic acid: The data regarding ascorbic acid shown in Figure 5 presented that the qualitative parameters (Ascorbic acid) were affected significantly by the Moringa Leaf Extract (MLE) spraying. Ascorbic acid was significantly different among all the treatments of MLE and control treatment. The average values for ascorbic acid for treatment T_o control (only distilled water), treatment T_1 (35%) MLE, treatment T_2 (70%) MLE, and treatment T_3 (100%) moringa leaf extract (pure moringa leaf extract) was recorded as 1.3212, 1.3478, 1.3733 and 1.3900 mg/100-ml respectively. The maximum value for ascorbic acid (1.39 mg/100 ml) was recorded in T_3 (pure moringa leaf extract) followed by treatment T_2 (70%) MLE with ascorbic acid of 1.3733 mg/100 ml and treatment T_1 (35%) MLE with ascorbic acid of 1.3478 mg/100 ml while the minimum value for ascorbic acid (1.32 mg/100 ml) was found in T_o control (Only distilled water). In this study, the ascorbic acid of tomatoes increased by increasing the amount of Moringa Leaf Extract which is in line to [5], who found that the amount of leaf ascorbic acid were considerably increased in all traits as compared to the control traits. The first experimental trial shown that 3% MLE sprayed have highest amount of ascorbic acid contents in plants. However, in the second trial, the utilization of MLE at the fruit set stage showed about a 1.33 times enhanced ascorbic acid concentraitons as compared with the control. Earlier [23] also stated an enhanced ascorbic acid amount of rocket plants after MLE foliar application. [21] conducted two experiments in which the ascorbic acid content of "Hollywood" fruits was significantly increased by all concentrations of moringa leaf extract. In both experiments, foliar application of 6% moringa leaf extract resulted in higher concentrations of ascorbic acid (8.77 and 9.11 mg/100 ml, respectively). The lowest value was found with 0% moringa leaf extract in both studies (6.70 and 7.02 mg/100 ml, respectively).

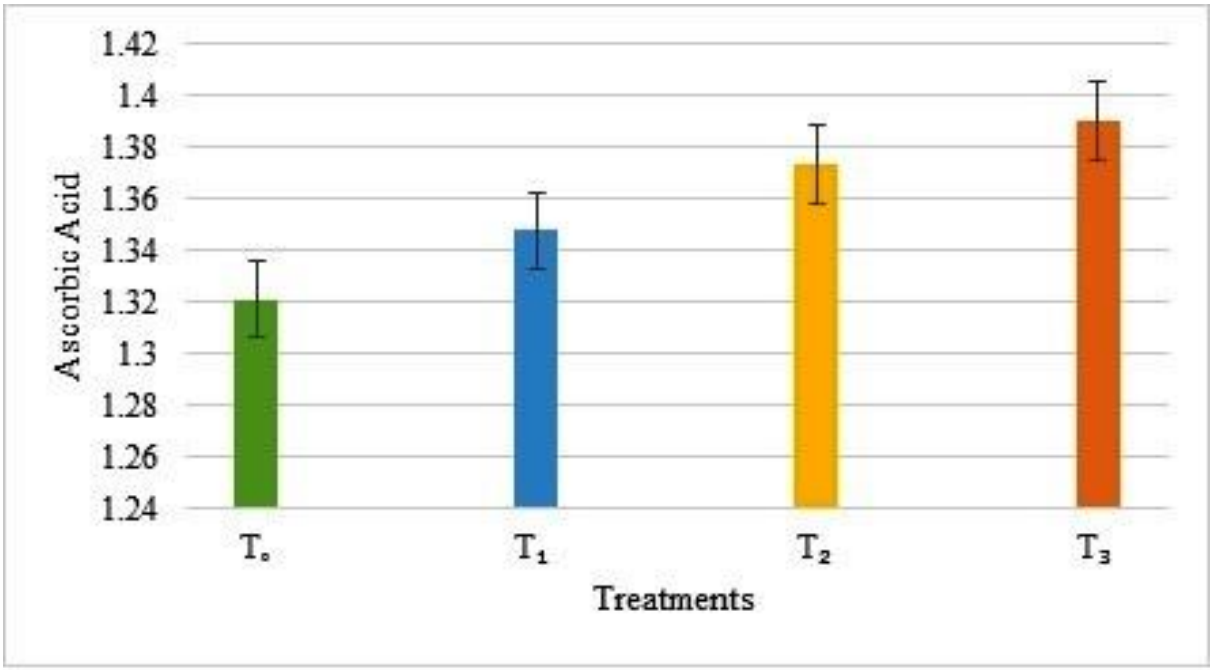

Figure 4. Effect of foliar applications with Moringa Leaf Extract (MLE) on ascorbic acid

Conclusion: The findings of the current study offer evidence of the positive impact of Moringa Leaf Extract (MLE) spraying on the quality (pH, titratable acidity, fruit firmness, total soluble solids, and ascorbic acid) of tomatoes grown in greenhouse condition. The quality of tomatoes increases by increasing the concentration of Moringa Leaf Extract (MLE). Increased prices and shortage of chemical fertilizers enforced growers to adopt bio-fertilizer. MLE proved itself as an alternative bio-fertilizer to improve the tomato quality and resultantly farmer's profit.

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