INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 18, No. 1, p. 10-18, 2021

RESEARCH PAPER OPEN ACCESS

Effect of foliar application of water soluble fertilizer on growth, yield and quality attributes of tomato (*Solanum lycopersicum* Mill.)

M Irfan Ashraf[1], M Bilal Shaukat[1], Bakhatawar Liaqat*[2], Shazia Kiran[2], Waqar Khalid[1], Laraib Anam[2], Zohaib Kaleem[2], M Abdullah[3]

[1]*Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan*

[2]*Department of Botany, University of Agriculture, Faisalabad, Pakistan*

[3]*Wheat Research Institute, AARI, Faisalabad, Pakistan*

Article published on January 30, 2021

Key words: Nitrogen, Phosphorus, Potassium, Tomato, Yield, Quality

Abstract

The tomato is the one of the most famous crops in Pakistan. It is used and consumed as fresh as well as in processed form. Its botanical name is *Solanum lycopersicon* Mill. The proposed study had been conducted in the year 2017-2018 in order to find the best combination of water soluble NPK fertilizers as compared to control. Five different types of water soluble fertilizers were collected from different sources and were applied at 5% concentration during the entire growing period of the tomato crop. The experiment was designed using Randomized Complete Block Design (RCBD) with five treatments and three replications of each. Different vegetative, reproductive and bio-chemical parameters were recorded and analyzed statistically at 5% level of significance. The treatments were compared using LSD test. It was concluded that different NPK water soluble fertilizers showed variation in physical and bio chemical parameters in tomato plants as compared to control. The plants showed variation in plant height, No. of fruit per plant, fruit yield per hectare, Individual fruit weight, fruit weight per plant, No. of diseased fruit per plant, date of first harvest, Fruit color Fruit length (cm), fruit size (cm), fruit firmness, total NPK contents, vitamincmg Chlorophyll concentration, pH, (TSS), Electricity conductivity (EC) and Titratable acidity Among all the water soluble treatments, the T_3 treatment (WSF 20:20:20) yielded the comparatively better results as compared to other WSF treatments. So it was concluded that T_3 was the recommended water soluble fertilizer for tomato.

* **Corresponding Author:** Bakhatawar Liaqat ✉ bakhatawarliaqat777@gmail.com

Introduction

Tomato (*Solanum lycopersicum* Mill.) is considered as domesticated plant of Western and South America (Ali *et al.,* 2012). Tomato ranks second after the potato crop in family Solanaceae while ranks first in term of processed crop. It is an annual vegetable crop grown in summer season. Temperature of 25-28^{o}C is favorable temperature for its growth and development (Ejaz *et al*., 2011). In Pakistan, spring and autumn crops are cultivated twice a year (Naz *et al.,* 2011). China, India, Turkey, Egypt, Italy and Iran are main producer of tomato crop (Ali *et al*., 2013).

Tomato (*Solanum Lycopersicum* Mill.) is a rich source of vitamins as well as antioxidants. It does not form acid stones and possesses a great amount of citric acid but forms alkaline, when enters into bloodstream. It also works as a liver cleanser when used in green vegetable juices. About 11 million acres in the world are under cultivation of tomato. India and China contribute about 40 percent in global production of tomato. Its demand is increasing with growing population of the world. Currently, Pakistan is standing at the 30th position while the United States of America is at the 1st and China is at the 2nd rank. (GOP, 2015).

In Pakistan per acre yield of tomato is very low as compared to the yield of the world. It currently produces 4.00 tons per acre while the global production of tomato is 43 tons per acre. The maximum yield has been achieved in Belgium which is 202 tons per acre. Tomato (*Solanum lycopersicon* Mill.) is an herbaceous plant. It is a very important cash crop for small as well as bourgeois farmers and cultivated on wide area all over the world. It is a good source of vitamins as well as minerals (GOP, 2015).

On the globe, annual production of fresh tomato is accounted for about 159 million tons. While, about quarter of these 159 million tons is used for the processing industry, which makes this crop the world's leading vegetable crop for processing. Tomato (*Solanum lycopersicon* Mill.) production in Pakistan was 530 thousand tones during the year 2015. The top 8 producing countries account for 74.2% of the world's yearly production. Tomato crop enjoys a huge export potential owing to its need in the international market. Tomatoes are exported to a number of countries including Afghanistan, Iran, U.A.E, Saudi Arabia, Sri Lanka and India. Afghanistan as well as Iran and UAE are central market hubs for tomatoes' export from Pakistan. Pakistan is capable of increasing its share in these markets (GOP, 2015).

The area, production and average yield of tomato in Pakistan have been getting varied in different eras. Since the year 2000-01 to the year 2009-10, area under tomato crop has been expanded from 27.9 to 50 thousand hectares and yield has jumped from 268.8 tons to 476.8 thousand tons. The current national yield of tomato crop is based on ten year's average (10.1 tons/ha) which is very low. To get high yield, vigorous yielding varieties and improved production technologies should have to be adopted. The Province Baluchistan is leading province in tomato cultivation annually with an average area of 18.1 thousand hectares followed by KPK and Sindh with area of 15.6 and 10.7 thousand hectares, respectively (GOP, 2016).

Low quality and low production of tomato is due to unbalanced application of micro and macro nutrients. The main function of the nutrients is to help the synthesis of chlorophyll and to activate the process of photosynthesis. Micro and macro nutrients are required to tomato crop in specific dose for proper growth and development (Rub and Haq, 2012).

To overcome this production deficiency an experiment was arranged to find out best dose of water soluble N, P and K fertilizer. So that the foliar application of soluble fertilizers NPK in different doses is needed to examine to attain a good crop establishment, growth, quality fruit production and healthy yield of tomato crop. It can be beneficial for earning high market price.

Materials and methods

The study was carried out at Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture Faisalabad.

Five different combinations of water soluble NPK fertilizers comprised of T_0: Water spray (control),T_1: Water Soluble NPK (19:19:19), T_2: Water Soluble NPK (21:21:21), T_3 Water Soluble NPK (20:20:20), T_4: Water Soluble NPK (15:15:15), T_5: Water Soluble NPK (19:17:17) were applied with the concentration of 5% on two cultivars of tomato which was purchased from Sohail Sons, Dijkot Road, Faisalabad. Nursery was transplanted on raised beds. First application of soluble NPK was applied in January and rest applications were applied every fortnight. Recommended dose of irrigation and fertilizers was given according to requirement. While, standard plant protection measures were employed, to keep insects and diseases under control.

When fruit got ready for harvesting, they were harvested, with calibration of 2-3 days' duration and vegetative, reproductive and biochemical parameters including Plant height (cm), No. of fruit per plant, Fruit yield per hectare (tons), Individual fruit weight (grams), Fruit weight per plant (kilograms), No. of diseased fruit per plant, Date of first harvest, Fruit colour, Fruit length (cm), Fruit size (cm), Fruit firmness, Total NPK Contents (GAE g^{-1}), Vitamincmg 100 $^{-1}$, Chlorophyll Concentration (SPAD meter), pH, Total soluble solids (TSS), Electricity conductivity (EC) and Titratable acidity were analyzed and recorded.

Land Preparation

The Land for plantation was prepared ploughing three to four times followed by planking. Raised beds were prepared keeping a distance of three feet after adding DAP @ one bag per acre. The FYM was mixed one month before the land preparation.

Plot Size and Dimension

The Dimension of the plot was 30 m length and 6.0m width. So, dimension of the plot was (30m * 6.0m) 180m^2.

Transplanting

Seedlings were transplanted into the prepared field on both sides of raised beds with keeping space about 45cm between plants. While bed to bed distance was kept at 75cm.

Cultural Practices

Irrigation and Fertilizer Application

After transplantation of seedlings, the first irrigation was applied through drip irrigation. Later on irrigations were applied as per crop requirements, usually at interval of two to three days. Moreover, the crop was fertigated using a 5kg NPK (17:17:17) per kanal, three times upto March, 2018. Ammonium Nitrate (AN) @ 15kg per kanal was applied three times in furrows.

Hoeing and Weeding

Hoeing and weeding were practiced frequently only in furrows between beds. Weeding practices were performed as per requirement.

Pesticide Application

Tomato plants were sprayed twice with fungicide (2.5g Mancozeb lit^{-1}. of water) at ten to fifteen days interval for controlling of fungal diseases, while insecticides (Imidacloprid and Match) were applied to protect the crop from the fruit borer and aphid attacks respectively.

Harvesting

Fruits were harvested on once a week and respective data was recorded.

Experimental Design and Statistics

Research trial was accompanied by using Randomized Complete Block Design (RCBD) with four replications and each replication contained hundred plants while each treatment contains twenty plants. Data was analyzed statistically using LSD test at 5% probability level (Steel *et al.,* 1997).

Results and discussion

Plant height (cm)

Plants were treated with NPK fertilizer in which concentration 20:20:20 of NPK respectively applied, showed the positive response in plant height. It was categorized the best treatment than others. Among all treatments regarding plant height, T_3 treated plant showed result (78cm) while control treatment T_0 showed plant height (70cm). Average plant height was observed in the T_5 treated plants which were treated with the concentration of NPK (19:17:17).

So, from this fig. it was concluded that T_3 treated plants showed the significant result as compared to others.

This result was parallel to the research of (Karpagam *et al.* 2004) in which experiments showed that NPK foliar spray of water soluble fertilizers yielded the tallest plants, higher number of primary and secondary shoots, bunch of flowers per plant, the fruit weight and the highest fruit yield per plant.

Average number of fruits per plant

Among all treatments regarding average number of fruit per plant, T_3 (20:20:20 of NPK) treated plant showed result (31.167) while control treatment T_0 showed result (20.167). Average result was observed in the T_5 treated plants which were treated with the concentration of NPK (19:17:17).

This result was parallel to the research of (Chaurasia, *et al.*, 2005) in which experiments showed that NPK foliar spray of water soluble fertilizers yielded the highest average fruit weight, higher number of primary and secondary shoots, bunch of flowers per plant, and the highest fruit yield per plant.

Fruit yield per hectare (ton)

Fruit yield per hectare observed in T_3 (20:20:20 of NPK) treated plant showed (11.305 tons) while control treatment T_0 showed (9.688 tons). Average/ result were observed in the T_5 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T_3 treated plants showed the significant result as compared to others.

These results similar to the results of (Guievence and Budence, 2000). They also concluded that the foliar application of water soluble fertilizers increased the fruit yield per hectare. This was growing to increase in accumulation of carbohydrates in the tomato fruit which ultimately increased the total yield of fruit per hectare.

Average fruit weight

Average fruit weight in T_3 (20:20:20 of NPK) treated plant showed result (79.83g) while control treatment T_0 showed result (67g). Average result was observed in the T_5 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T3 treated plants showed the significant result as compared to others. This result was parallel to the research of (Chaurasia *et al.*, 2005). In which experiments showed that NPK foliar spray of water soluble fertilizers yielded the highest average fruit weight, higher number of primary and secondary shoots, bunch of flowers per plant, and the highest fruit yield per plant.

Among all treatments regarding plant height, T_3 treated plant showed result (5.400kg) while control treatment T_0 showed result (4.200kg). Average result was observed in the T_5 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T_3 treated plants showed the significant result as compared to others. This result was linked to the research of (Guievence and Badem, 2000) in which experiments showed that NPK foliar spray of water soluble fertilizers increased the fruit yield of the tomato crop owing to the fact that availability of the fertilizers increased the accumulation of the carbohydrates in the fruits.

Table 1. The effect of foliar application of water soluble fertilizer on physiological attributes of Tomato.

Treatments	Plant height		Number of Fruits per Plant		Fruit Yield Per Hectare (tons)		Individual fruit weight (grams)		Fruit weight per plant	
Varieties	V1	V2	V1	V2	V1	V2	V1	V2	V1	V2
T_0	70.00^{F}	71.00^{G}	20.33^{D}	20.00^{D}	9.93^{F}	9.44^{G}	62.66^{F}	71.33^{CDE}	4.20^{F}	4.200^{F}
T_1	71.00^{E}	73.16^{E}	27.00^{BC}	27.00^{BC}	10.33^{CDEF}	10.24^{DEF}	69.33^{E}	70.33^{DE}	4.80^{E}	5.00^{CD}
T_2	73.50^{CD}	73.83^{B}	24.33^{C}	24.66^{C}	10.70^{BC}	10.54^{CDE}	73.16^{CDE}	73.83^{CD}	4.36^{C}	5.20^{B}
T_3	77.33^{A}	78.66^{A}	31.00^{A}	31.33^{A}	11.46^{A}	11.14^{AB}	80.66^{A}	79.00^{AB}	5.40^{A}	5.40^{A}
T_4	74.00^{CDE}	76.00^{BCD}	28.00^{B}	26.00^{BC}	10.15^{EF}	10.21^{EF}	75.33^{BC}	75.66^{BC}	4.90^{CDE}	5.01^{BCD}
T_5	74.00^{BCD}	75.00^{BC}	26.00^{BC}	25.33^{BC}	10.68^{CD}	10.31^{CDEF}	74.66^{BCD}	74.00^{CD}	5.06^{BC}	4.86^{DE}
Mean	73.30^{A}	74.61^{A}	26.11^{A}	25.72^{A}	10.54^{A}	10.31^{B}	72.63^{B}	74.02^{A}	4.76^{A}	4.77^{A}

No. of diseased fruit per plant

Among all treatments regarding number of diseased fruit per plant, T_3 treated plant showed result (3.333) while control treatment T_o showed result (9.333). Average result was observed in the T_4 treated plants which were treated with the concentration of NPK (15:15:15). So, from this fig. it was concluded that T_3 treated plants showed the significant result as compared to others.

These results were similar to the results of (Narayanamma *et al.*, 2006) who also studied the impact of water soluble fertilizers on the diseased fruit and no. of fruit per plant in brinjal. He concluded that the application of water soluble fertilizers improved the overall performance of the brinjal crop which ultimately equipped it to cope with the incidence of the disease attack.

Date of first harvest

Among all treatments regarding days of first harvest, T_3 treated plant showed result (62.833 days) while control treatment T_o showed the maximum days (71days). Average days to 1st harvest were observed in the T_5 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T_3 treated plants showed the significant result as compared to others.

This result was parallel to the research of (Kamal *et al.*, 2011) who explained that NPK foliar spray of water soluble fertilizers also affected the 1st fruit bearing. This was due to early availability of fertilizers to plants.

Fruit color

The T_3 treatment showed the best results as it was best combination in all the applied treatments. Effects of foliar application of NPK on the tomato fruit color development and quality improvement maturity stages tomato color was evaluated by using image analysis. My results revealed that tomato fruit color changes with NPK soluble fertilizers and varied depending upon the maturity stage of fruit.

These results are in accordance with Takahashi *et al.* (2013) who also studied the different parameters which affected the fruit color development in tomato fruits.

Fruit length (cm)

Among all treatments regarding fruit length, T_4 treated plant showed result (4.7751cm) while control treatment T_o showed result (4.0333cm). Average result was observed in the T_3 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T_4 treated plants showed the significant result as compared to others.

This result was parallel to the research of (Jeybal, *et al.,* 1998) in which experiments showed that NPK foliar spray of water soluble fertilizers increased the fruit length. This increase was due to higher rate of photosynthesis which has increased the carbohydrate content of the fruit which ultimately increased the length of tomato fruit.

Fruit size

The treatments T_3 yielded the maximum fruit size (5.400cm) for both varieties on the other hand the control treatment T_o yielded the minimum value (4.2000cm) for both varieties. The results showed that the adequate supply of water soluble fertilizers through foliar spray could improve and enlarge the fruit size. The plants in control treatment T_o showed the minimum fruit size as compared to other foliar supplied treatments this was owing to the fact that in control treatment there had been no foliar application of water soluble fertilizers.

My results are in accordance with results of (*Chaurasia et al.*, 2005) who also observed that the foliar application of water soluble fertilizers in tomato plant enlarged the fruit size.

Fruit firmness

Among all treatments regarding plant height, T_3 treated plant showed result (1.9567) while control treatment T_o showed result (1.7083). Average result was observed in the T5 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T_3 treated plants showed the significant result as compared to others. This result was similar to the research of (Batra *et al.*, 2006) in which experiments showed that NPK foliar spray of water soluble fertilizers increased the pericarp thickness which ultimately improved the fruit firmness.

Table 2. The effect of foliar application of water soluble fertilizer on physiological attributes of Tomato.

Treatments	No. of diseased fruit per plant		Date of first harvest		Fruit Length		Fruit size (cm)		Fruit firmness	
Varieties	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_0	7.00^{B}	11.66^{A}	71.00^{A}	71.00^{A}	4.04^{E}	4.04^{E}	4.200^{F}	4.20^{F}	2.96^{H}	2.96^{H}
T_1	5.33^{CD}	7.00^{B}	68.66^{AB}	67.66^{B}	4.22^{D}	4.23^{D}	4.800^{E}	4.80^{E}	3.16^{G}	3.21^{F}
T_2	7.00^{B}	7.33^{B}	68.00^{B}	68.00^{B}	4.56^{C}	4.61^{C}	5.00^{CD}	5.20^{B}	3.37^{D}	3.30^{E}
T_3	2.66^{E}	4.00^{DE}	63.00^{C}	62.66^{C}	4.69^{B}	4.78^{A}	3.55^{A}	5.40^{A}	3.55^{A}	3.55^{A}
T_4	7.00^{B}	6.66^{BC}	66.00^{B}	66.00^{B}	4.74^{AB}	4.76^{A}	4.90^{CDE}	5.01^{BCD}	3.42^{C}	3.45^{B}
T_5	7.00^{B}	7.00^{B}	67.33^{B}	66.66^{B}	4.74^{AB}	4.75^{A}	5.06^{BC}	4.86^{DE}	1.85^{BC}	3.42^{BC}
Mean	6.00^{B}	7.27^{A}	67.33^{A}	67.00^{A}	4.49^{B}	4.53^{A}	4.89^{A}	4.91^{A}	3.30^{B}	3.33^{A}

Nitrogen Content (GAE g $^{-1}$)

Among all treatments regarding nitrogen content, T_3 treated plant showed result (4.7167 GAE g -1) while control treatment T_0 showed result (4.1750 GAE g -1). Average result was observed in the T_4 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T_3 treated plants showed the significant result as compared to others.

This result is closely linked the research of (Anand, 1973) in which experiments showed that NPK foliar spray of water soluble fertilizers improved the analytical leaves qualities such as NPK content and leaf area.

Phosphorous Content (GAE g $^{-1}$)

Among all treatments regarding plant height, T_3 treated plant showed result (0.465078 GAE g -1) while control treatment T_0 showed result (0.3733 GAE g -1). Average result was observed in the T_5 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T_3 treated plants showed the significant result as compared to others.

This result is closely linked the research of (Anand, 1973) in which experiments showed that NPK foliar spray of water soluble fertilizers improved the analytical leaves qualities such as NPK content and leaf area.

Potassium Content (GAE g $^{-1}$)

Among all treatments regarding plant height, T_3 treated plant showed result (1.9567 GAE g -1) while control treatment T_0 showed result (1.7083 GAE g -1). Average result was observed in the T_5 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T_3 treated plants showed the significant result as compared to others.

These results are in accordance with results (Lester *et al.,* 2010) in which he studies the impact of potassium application through spray improved the overall attributes of the watermelon crop.

Vitamincmg 100^{-1}

Among all treatments regarding Vitamin C, T_3 treated plant showed result (25.48mg 100^{-1}) while control treatment T_0 showed result (18.383mg 100^{-1}). Average result was observed in the T_2 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T_3 treated plants showed the significant result as compared to others.

This result was parallel to the research of (Anand, 1973) stated that ascorbic acid content was improved with N application. The experiments showed that NPK foliar spray of water soluble fertilizers increased the ascorbic acid (Vitamin C) content of the tomato fruit.

Chlorophyll Concentration (SPAD meter)

Among all treatments regarding chlorophyll concentration, T_0 treated plant showed result (18.383) while control treatment T_5 showed result (25.483). Average result was observed in the T_4 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T_5 treated plants showed the significant result as compared to others. This result was parallel to the research of (Souri *et al.*, 2018) in which experiments

showed that NPK foliar spray of water soluble fertilizers yielded the best vegetative qualitative parameters especially the nutrient concentrations in the leaf areas. The chlorophyll concentrations are considerable improved through the application of foliar sprays of nitrogenous fertilizers.

Table 3. The effect of foliar application of water soluble fertilizer on biochemical attributes of Tomato.

Treatments	Nitrogen Content (GAE g $^{-1}$)		Phosphorous Content (GAE g $^{-1}$)		Potassium Content (GAE g $^{-1}$)		Vitamincmg 100^{-1}		Chlorophyll Concentration (SPAD meter)	
Varieties	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_0	4.13^{D}	4.21^{D}	0.37^{F}	0.37^{F}	1.70^{D}	1.71^{E}	18.46^{E}	18.30^{E}	1.82^{G}	1.82^{E}
T_1	4.34^{C}	4.35^{C}	0.41^{E}	0.42^{DE}	1.79^{D}	1.83^{C}	21.53^{D}	20.83^{D}	1.95^{BC}	1.95^{BC}
T_2	4.36^{C}	4.36^{C}	0.43^{CD}	0.44^{C}	1.88^{B}	1.86^{BC}	22.43^{C}	23.46^{B}	1.89^{E}	1.94^{CD}
T_3	4.73^{A}	4.70^{A}	0.46^{AB}	0.47^{A}	1.94^{A}	1.97^{A}	25.36^{A}	25.60^{A}	2.02^{A}	1.85^{F}
T_4	4.38^{C}	4.57^{B}	0.44^{C}	0.43^{CD}	1.84^{C}	1.86^{BC}	21.40^{D}	22.66^{BC}	1.92^{D}	1.95^{BC}
T_5	4.55^{B}	4.51^{B}	0.44^{C}	0.45^{BC}	1.85^{BC}	1.85^{BC}	4.26^{BC}	23.43^{B}	1.95^{BC}	1.97^{B}
Mean	4.41^{A}	4.45^{A}	0.42^{A}	0.43^{A}	1.83^{A}	1.84^{A}	22.00^{B}	22.38^{A}	1.94^{A}	1.91^{B}

pH

Among all treatments regarding pH, T_3 treated plant showed result (4.2183) while control treatment T_0 showed result (4.4183). Average result was observed in the T_5 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T_3 treated plants showed the significant result as compared to others.

This result was parallel to the research of (Batra *et al.*, 2006) in which experiments showed that NPK foliar spray of water soluble fertilizers yielded good quality parameters of tomato which ultimately influenced the biochemical parameters of the tomato.

Total soluble Solids (TSS)

Among all treatments regarding TSS, T_3 treated plant showed result (4.5233 brix) while control treatment T_0 showed result (4.2483 brix). Average result was observed in the T_5 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T_3 treated plants showed the significant result as compared to others.

This result was parallel to the research of (Anoop and Indiresh, 2015) in which experiments showed that NPK foliar spray of water soluble fertilizers yielded the higher level of TSS, good pericarp thickness minimum physiological loss, the fruit weight and the highest fruit yield per plant.

Electricity conductivity (EC)

Among all treatments regarding electricity conductivity, T_3 treated plant showed the best results (4.2473sm^{-1}) while control treatment T_0 showed result (2.9838sm^{-1}). Average result was observed in the T_5 treated plants which were treated with the concentration of NPK (19:17:17). So, from this fig. it was concluded that T^3 treated plants showed the significant result as compared to others.

Titratable Acidity

Among all treatments regarding plant height, T_3 treated plant showed result (0.6367) while control treatment T_0 showed result (0.5267). Average result was observed in the T_4 treated plants which were treated with the concentration of NPK (15:15:15). So, from these fig. it was concluded that T_3 treated plants showed the significant result as compared to others. This was due to greater photosynthesis activity and carbohydrates accumulation which caused increased TSS, titratable acidity and fruit firmness.

This result was parallel to the research of (Bhatt and Srivastava, 2005) in which experiments showed that NPK foliar spray of water soluble fertilizers improved the TSS, Titratable acidity and fruit firmness of the tomato fruits.

Table 4. The effect of foliar application of water soluble fertilizer on biochemical attributes of Tomato.

Treatments	pH		Total soluble Solids (TSS)		Electricity conductivity (EC)		Titratable Acidity	
Varieties	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_0	4.47^{A}	4.36^{AB}	4.34^{ABC}	4.34^{ABC}	2.98^{I}	2.98^{I}	0.52^{DE}	0.51^{E}
T_1	4.26^{BC}	4.30^{B}	4.40^{ABC}	4.09^{BC}	3.03^{D}	3.07^{CD}	0.57^{B}	0.56^{BC}
T_2	4.26^{BC}	4.30^{B}	4.07^{C}	4.42^{ABC}	3.15^{CD}	4.30^{B}	0.55^{C}	0.54^{CD}
T_3	4.13^{D}	4.16^{CD}	4.51^{A}	4.53^{A}	4.23^{A}	4.25^{A}	0.64^{A}	0.63^{A}
T_4	4.33^{B}	4.30^{B}	4.48^{AB}	4.47^{ABC}	3.57^{B}	3.35^{BC}	0.57^{B}	1.86^{BC}
T_5	4.26^{BC}	4.26^{BC}	4.43^{ABC}	4.47^{ABC}	3.57^{B}	3.62^{B}	0.57^{B}	0.57^{B}
Mean	4.28^{A}	4.28^{A}	4.37^{A}	4.38^{A}	3.42^{A}	3.42^{A}	0.57^{A}	0.56^{A}

Conclusion

It is concluded that among all the water soluble treatments, the T_3 treatment (WSF 20:20:20) yielded the comparatively better results as compared to other WSF treatments. So this it was concluded that T_3 was the recommended water soluble fertilizer for tomato.

References

Ali A, Hussain I, Gul H, Masoud S, Khan A, Wahab F, Khan J. 2015. Effect of different doses of foliar fertilizer on yield and physiochemical characteristics of tomato (*Solanum lycopersicum* Mill.) cultivars under the agro climatic condition of Peshawar. International Journal of Biosciences **7(1),** 58-65.

Ali W, Jillani MS, Naeem N, Waseem K, Khan J, Ahmad MJ, Ghazanfarullah. 2012. Evaluation of different hybrids of tomato under the climatic conditions of Peshawar. Sarhad Journal of Agriculture **28(2),** 207-212.

Anand N. 1973. Studies on leaf analysis and an index of fertilizer needs in tomato M.Sc. (Ag) Dissertation, Tamil Nadu Agricultural University, Coimbatore, T.N. (India).

Anoop K, Indiresh KM. 2015. Effect of water soluble fertilizers on qualitative parameters of tomato. Asian Journal of Horticulture sciences **10(1),** 41-44.

Batra VK, Makhan L, Kampoj OP, Arora SK, Suthar MR. 2006. Effect of foliar application of micro nutrients on quality and shelf-life of tomato. Haryana Journal of Horticulture sciences **35(2),** 140-142.

Bhatt L, Srivastava BK. 2005. Effect of foliar application of micronutrients on physical characteristics and quality attributes of tomato (*Lycopersicon esculentum* Mill.) fruits. Indian Journal of Agricultural Sciences **75(9),** 591-592.

Chaurasia SNS, Singh KP, Rai M. 2005. Effect of foliar application of water soluble fertilizers on growth, yield and quality of tomato (*Lycopersicon esculentum* L.*)*. Sri Lankan Journal of Agricultural Sciences **42,** 66-70.

Chaurasia SNS, Singh KP, Rai M. 2006. Response of tomato to foliar application of water soluble fertilizers. Vegetable Science **33(1),** 96-97.

Ejaz M, Rehman SU, Waqas R, Manan A, Imran M, Bukhari MA. 2011. Combined efficacy of macronutrients and micronutrients as a foliar application on growth and yield of tomato grown by vegetable forcing. International Journal of Agronomy Veternity and Medicine Sciences **5(3),** 327-335.

Government of Pakistan. 2015. Fruits, Vegetables and Condiments statistics of Pakistan. Government of Pakistan, Ministry of food and Agriculture. (Economic Wing), Islambad.

Government of Pakistan. 2016. Pre-feasibility study (offseason vegetable farming–high tunnel).

Guvence I, Badem H. 2000. Effect of foliar application of different sources and levels of nitrogen on growth and yield of tomato (*Lycopersicon esculentum* L.). Indian Journal of Agruicultural sciences **72(2),** 104-105.

Jeybal A, Murlidhar RM, Palanippam SP, Helliah SC. 1998. Technical Bulletin on specialty Fertilizers. Agriculture Research Development Institute Secunderabad.

Karpagam R, Kannan M, Natarajan S, Srinivа K. 2004. Studies on the efficacy of foliar feeding of water soluble fertilizers on growth parameters and yield of Brinjal hybrid COBH. Journal of Horticulture **52(6),** 139-142.

Kumar U, Chandra G, Raghav M. 2017. Nitrogen management in potato for maximum tuber yield, quality and environmental conservation. Vegetable Science **44(2),** 43-418.

Lester GE, Jifon JL, and Makus DJ. 2010. Impact of potassium nutrition on postharvest fruit quality: Melon (*Cucumis melo* L) case study. Plant and soil **335(1),** 117-131.

Narayanamma M, Chiranjeevi C, Reddy CS. 2006. Influence of water soluble fertilizers on yield of brinjal. Journal of vegetable sciences **33,** 94-95.

Naz FI, Haq U, Asghar S, Shah AS, Rahman A. 2011. Studies on growth, yield and nutritional composition of different tomato cultivars in Battal Valley of district Mansehra, Khyber Pakhtunkhwa, Pakistan. Sarhad Journal of Agriculture **27(4),** 569-571.

Rab A, Haq IU. 2012. Foliar application of calcium chloride and borax influences plant growth, yield and quality of tomato (*Solanum lycopersicon* Mill.) fruit. Turkey Journal of Agriculture and Forest **36,** 695-701.

Souri MK, Dehnavard S. 2018. Tomato plant growth, leaf nutrient concentrations and fruit quality under nitrogen foliar applications. Advances Horticulture Sciences **32(1),** 41-47.

Takahashi N, Maki H, Nishina H, Takayama K. 2013. Evaluation of tomato fruit color change with different maturity stages and storage temperatures using image analysis. IFAC Proceedings **46(4),** 147-149.