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EVALUATION OF SODIUM FLUORIDE INDUCED STRESS ON GROWTH AND YIELD OF *LYCOERSICON ESCULENTUM* L.

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ABSTRACT: Industrial growth and human activities are responsible for increasing environmental pollution. Soil salinity is a threat to crop production in the Pakistan. Fluoride behaves as an environmental pollutant, although it occurs in minor amount in earth's crust. Even at lower ambient fluoride concentrations, a number of physiological variations may be initiated in plant. Some of these variations may have important consequences like reduction in growth and yield. Tomato is an important vegetable globally and is also a significant crop of Pakistan. Present experiment was carried out to determine stress effects of sodium fluoride on growth responses and yield parameters. Tomato variety (Rio Grande) was used in experimental study during growth season 2019-2020. Plants were treated with 50, 100, 150, 200, 250, and 300 ppm concentrations of fluoride twice a week to create stress conditions. It was observed that morphological parameters, i.e., shoot length, root length, number of leaves, number of leaflets, and leaflet area were decreased under increasing NaF stress. Sequential reduction in biomass production was also analyzed. Yield parameters showed declining trend in their values at higher NaF stress, i.e., 300 ppm. By observing prominent reductions caused by NaF, present pot experiment proved toxic and deleterious effects of sodium fluoride on productivity and yield characteristics of tomato crop. So, tomato is sensitive crop towards salt-stress and its alleviation should be carried out.

Keywords: *Lycopersicon Esculentum* L.*;* Growth; Sodium fluoride*;* Yield.

INTRODUCTION

Salinity is one of the major abiotic environmental stressors threatening worldwide crop production. The extent of area affected with salinity is expected about 50% of the whole agricultural land by 2025 [1]. It has adverse impact on physio-biochemical plant processes and leads eventually toward the growth and yield reduction [2]. Soil salinity is considered as worldwide problem [3] and Pakistan is one of those countries, which are affected severely by the process of salinization and sodification [4]. Extensive industrialization has resulted in release of more toxic pollutants into the environment [5]. Fluoride is one of these pollutants having higher electronegativity and constitute the earth's crust of about 0.3gkg^{-1} [6]. It is present in water, air and soil naturally and anthropogenically [7]. The main industrial sources to fluoride release into the environment are coal combustion, mining, and using fluoride as a fertilizer [5]. The main inorganic fluoride natural source in soil is considered as parent rock [8].

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Fluoride is highly phytotoxic and easily diffuses into soil and readily taken up by plants through roots when the pH of soil is highly acidic [9]. When the concentration of the fluoride salt rises into the soil, it acts as salt stress for plant. Salt stress or salinity decreases the plant growth [10]. Fluoride reduces up to 50% of the agricultural harvests because some plants are highly sensitive to fluoride toxicity [11]. Fluoride is taken up through roots and transported via xylem to various parts of plant and accumulated there [6]. The F which is absorbed moves towards the shoots and causing structural, physiological, and biochemical damages. The first symptom of injury in plants is necrosis and chlorosis [12]. Fluoride changes the nutritional values of plants by minimizing the yield [13].

Tomato is one of the economically important plant species, belongs to the solanaceae family, and has high nutritional value [14]. Several studies show that consumption of tomato and other tomato-based products decreases the risk of chronic diseases like cancer and cardiovascular disease. It is the source of minerals, vitamins, dietary fiber, sugar, and amino acids [5]. Therefore, tomato was chosen to study F uptake, its toxicity, and accumulative effects by growing on contaminated soil. The experimental work was done to evaluate the effect of sodium fluoride on various growth parameters and productivity of *Lycopersicon esculentum* L. grown under NaF stress.

MATERIALS AND METHODS

Certified seedlings of tomato (*Lycopersicon esculentum* L.) having variety Rio Grande, were obtained from Roshan seed center, Lahore. The healthy seedlings were selected and unhealthy were discarded. The experimental site for conducting experiment was Botanical Garden, University of the Punjab, Department of Botany, Quaid-e-Azam Campus, Lahore. The experimental work was performed from October 2019 to March 2019. For experimental analysis, sandy loamy soil (in mixture form) having ratio 1:3 was used. For using normal agricultural strategies urea, farm manure, and leaf manure were used to make soil fertile for effective growth and better yield. The experimental work was performed with 42 clay pots. The pots were arranged according to their treatments, a randomized complete block design (RCBD) was applied for this experiment. For each treatment six replicates were organized. According to their respective treatment and replicate number, pots were categorized and labeled.

For the preparation of solutions, six different concentrations of sodium fluoride (NaF) were measured by using weighing balance and mixing them into distilled water in order to make different solutions in ppm. To check the stress effects on tomato crop, different dilutions of NaF were applied. For experimental work, 210 healthy seedlings were taken from Roshan seed center. The transplantation of seedlings was done in 42 pots on October 2, 2019. In each pot, 5 seedlings were transplanted. After transplantation, on November 11, 2019, manual thinning was done and seedlings were reduced to 1. In order to eliminate the fog effects, the wire house was covered with polythene sheets. During experimental work, the NaF treatment was carried out twice a week as soil drench. The first NaF treatment on plants was applied on November 21, 2019. The 42 pots were divided into 7 groups. On the basis of different concentrations of NaF, like 50, 100, 150, 200, 250, and 300 ppm, these pots were arranged into 7 groups. There were 3 replicates of first harvest

and 3 other were replicates of second harvest per group. All the concentrations of the NaF were appropriate and accurate. The six pots present in controls were not applied to any stress and were given 100mL of distilled water till final harvest. After 29 days of transplantation, the first treatment of sodium fluoride was given to plants on November 21, 2019. During experimental work, 2 harvests were taken at 45 and 106 days after transplanting (DAT). In response to NaF stress different parameters were studied like productive, biochemical and yield parameters. In response to NaF stress different morphological parameters were studied like length of plant (cm), length of roots (cm), length of shoots (cm), length of leaves (cm), length of leaflets (cm), number of leaves, number of leaflets, number of branches, leaf area (cm^2), and leaflet area(cm^2).

The leaf area is calculated through Charleton and Foote (1965) formula:

Leaf area = Length of the plant × maximum width of plant × 0.75 (correction factor)

The parameters for biomass assessment were plant fresh weight (g), plant dry weight (g), root fresh weight (g), root dry weight (g), leaves dry weight (g), and leaves fresh weight (g). Yield parameters calculated at 150 DAS were fruit fresh weight, fruit dry weight, and diameter of fruit. Yield parameters calculated at 150 DAS were fruit fresh weight, fruit dry weight, and diameter of fruit. During the growing season of tomato crop, the data obtained from the pot experiment was investigated through SPSS software by one-way ANOVA means. For means separation Duncan's multiple range test (DMRT) was employed for significant treatments at $p \leq 0.05$. The values stated were means of 3 replicates ± S.E (standard error).

RESULTS

Determination of morphological growth

Shoot and root length: At 45 DAT, the highest length of shoot recorded in control which was 43.1cm and lowest length recorded was 20.47 cm for plants treated with 300 ppm concentration of sodium fluoride (Table 1A). For root length during first harvest, the values for 50, 100, 150, 200, 250, and 300 ppm Na-F concentration treated plants were 22.5 cm, 17.33 cm, 12.6 cm, 10.8 cm, 6.83 cm, and 5.6 cm respectively. At 106 DAT, the root length followed the same order of reduction as demonstrated in Table 1B.

Number of leaves, leaflets per petiole and leaflets per plant: Number of leaves of tomato plants were decreased with the increasing concentration of NaF. At 45 DAT, the average values for number of leaves were 15.67, 13, 10, 8.67, 7, 5.67, and 4.67 for control, 50 ppm, 100 ppm, 150 ppm, 200 ppm, 250 ppm, and 300 ppm concentration of Na-F treated plants as shown in Table 1A. The calculated leaf number at 106 DAT also narrated the same trend as in 45 DAT (Table 1B). The overall trend for the number of leaflets per petiole and per plant were decreasing from control to 300 ppm NaF treated plants.

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Table1A. Morphological growth parameters of *Lycopersicon esculentum* L. harvested at 45 DAT under 7 treatments of sodium fluoride during growing season 2018-2020

Treatment	Parameters (45 DAT)							
	Shoot Length (cm)	Root Length (cm)	No. of Leaves	Leaf Area (cm^2)	No. of Leaflets per petiole	Leaflet Area (cm^2)	No. of Leaflets per plant	No. of Branches
Control	43.1 ± 0.26g	32.93 ± 0.40g	15.6 ± 0.33e	347.7 ± 0.38g	12.33 ± 0.33f	51.83 ± 0.38 g	84.67 ± 0.33g	14.67 ± 0.33e
50ppm	36.4 ± 0.41f	22.5 ± 0.28f	13 ± 0.58d	263.3 ± 0.30f	10 ± 0.58 e	40.55 ± 0.23 f	69 ± 0.58f	12.67 ± 0.33d
100ppm	32.47 ± 0.29e	17.33 ± 0.38e	10 ± 0.58c	204.2 ± 0.22e	8.67 ± 0.33 d	31.34 ± 0.37 e	58.33 ± 0.33e	10 ± 0.58c
150ppm	30.53 ± 0.37d	12.6 ± 0.38d	8.67 ± 0.33c	166.0 ± 0.43d	6.0 ± 0.58 c	21.20 ± 0.34 d	41.0 ± 0.58d	8.67 ± 0.33c
200ppm	25.13 ± 0.24c	10.8 ± 0.15c	7 .0 ± 0.58b	123.0 ± 0.47c	5.33 ± 0.33bc	17.39 ± 0.29c	35.67 ± 0.33c	6.67 ± 0.33b
250ppm	22.87 ± 0.35b	6.83 ± 0.23b	5.6 ± 0.33ab	86.6 ± 0.25b	4.67 ± 0.33b	14.0 ± 0.24 b	31.0 ± 0.58b	6.0 ± 0.58ab
300ppm	20.47 ± 0.26a	5.6 ± 0.23a	4.67 ± 0.33a	35.9 ± 0.27a	3.33 ± 0.3 a	8.97 ± 0.36 a	22.33 ± 0.33a	5.0 ± 0.58a

Each treatment mean is sum of three replicates and ± represents standard error (SE); the values not followed by identical letters in each parameter, are significantly different at $p \leq 0.05$ according to Duncan's multiple range test (DMRT).

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Table1B. Morphological growth parameters of *Lycopersicon esculentum* L. harvested at 106 DAT under 7 treatments of sodium fluoride during growing season 2018-2020

Treatment	Parameters (106 DAT)							
	Shoot Length (cm)	Root Length (cm)	No. of Leaves	Leaf Area (cm^2)	No. of Leaflets per petiole	Leaflet Area (cm^2)	No. of Leaflets per plant	No. of Branches
Control	58.23 ± 0.27 g	24.4 ± 0.21 g	14.33 ± 0.33 f	275.98 ± 0.30 g	11.0 ± 0.58f	33.31 ± 0.54 g	76.33 ± 0.33 g	12.67 ± 0.33 f
50ppm	54.17 ± 0.23 f	14.7 ± 0.26 f	12.0 ± 0.58 e	158.65 ± 0.12 f	9.33 ± 0.33e	27.0 ± 0.46 f	66.0 ± 0.58 f	10.33 ± 0.33 e
100ppm	49.6 ± 0.40 e	12.4 ± 0.15 e	9.67 ± 0.33 d	95.26 ± 0.45 e	8.33 ± 0.33de	19.3 ± 0.29 e	57.67 ± 0.33 e	9.0 ± 0.58 d
150ppm	42.6 ± 0.25 d	9.87 ± 0.20 d	8.67 ± 0.33 d	60.42 ± 0.45 d	7.0 ± 0.58cd	14.13 ± 0.44 d	45.0 ± 0.58 d	7.33 ± 0.33 c
200ppm	37.93 ± 0.46 c	7.23 ± 0.12 c	7.33 ± 0.33 c	38.75 ± 0.12 c	6.33 ± 0.33bc	11.14 ± 0.35 c	38.67 ± 0.33 c	6.33 ± 0.33 bc
250ppm	31.63 ± 0.43 b	5.73 ± 0.20 b	6.0 ± 0.58 b	31.76 ± 0.30 b	5.0 ± 0.58ab	8.04 ± 0.20 b	23.0 ± 0.58 b	5.33 ± 0.33 b
300ppm	24.77 ± 0.18 a	3.63 ± 0.18 a	4.66 ± 0.33 a	21.67 ± 0.42 a	3.67 ± 0.33a	5.94 ± 0.04 a	17.0 ± 0.58 a	4.0 ± 0.58 a

Each treatment mean is sum of three replicates and ± represents standard error (SE); the values not followed by identical letters in each parameter, are significantly different at $p \leq 0.05$ according to Duncan's multiple range test (DMRT).

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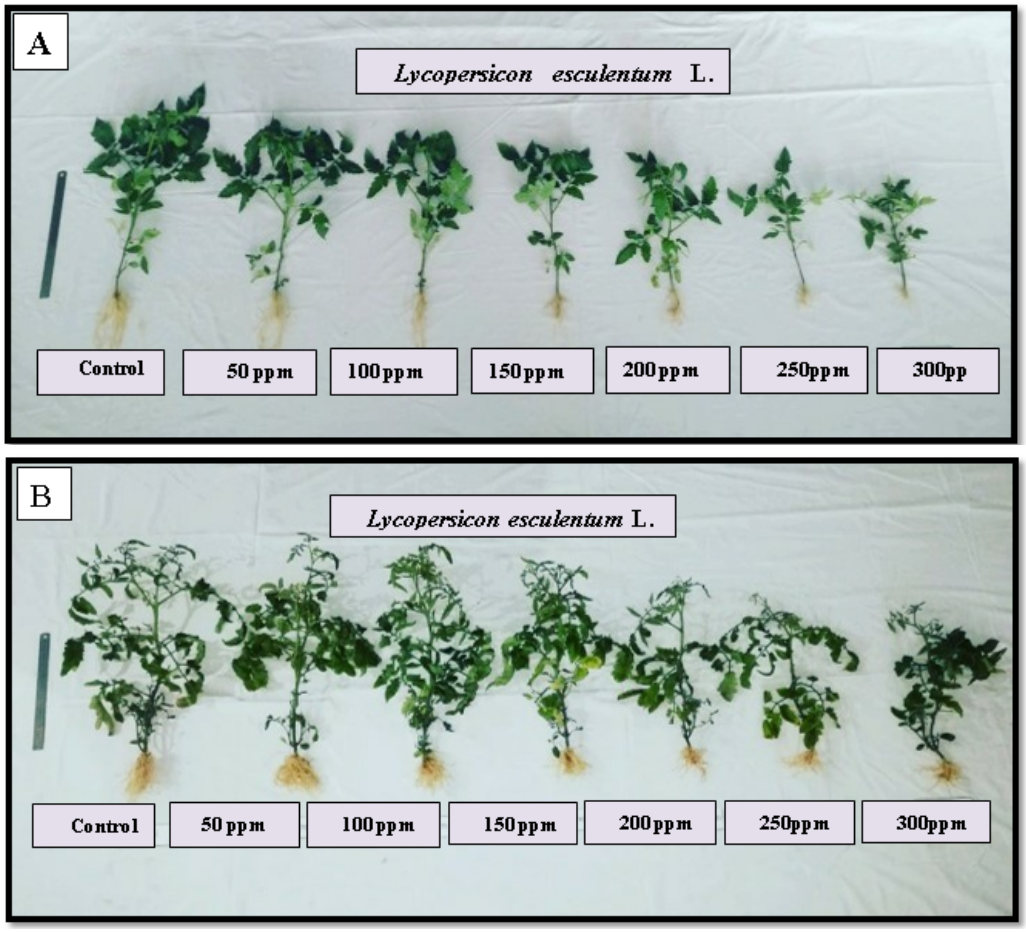

Figure 1. Growth of *Lycopersicon esculentum* L. harvested at 45 (A) and 106 (B) DAT under seven treatments of Sodium fluoride during growth season 2018-2020.

Leaf and leaflet area (cm^2): The maximum leaf area was showed by the control plants whose value was 347.72 cm^2 at 45 DAT (Table 1A). At 106 DAT, decline in trend was same. Similarly, the overall pattern of the 50, 100, 150, 200, 250, and 300ppm of NaF concentration treated plants were 40.55 cm^2, 31.34 cm^2, 21.20 cm^2, 17.39 cm^2, 14 cm^2, and 8.97 cm^2, respectively, during first harvest. At 106 DAT, decline in trend was same as shown in Table 1B. The maximum leaf area showed by the control plants that was 33.31 cm^2 while the plants treated with the NaF-300ppm showed the minimum leaf area.

Number of branches: The minimum number of branches was found in those plants treated with NaF-300 concentration at 45 DAT. The average values calculated for decreasing trend was 14.67 g > 12.67 > 10 > 8.67 > 6.67 > 6 > 5, respectively, for the plants treated with 50, 100, 150, 200, 250, and 300 ppm of Na-F concentration as shown in Table 1A. At 106 DAT, the same trend in average value was found (Table 1B).

Fresh and dry weight of shoot: The plants treated with 50, 100, 150, 200, 250, and 300 ppm of NaF having reducing trend of mean values 17.67 g > 16.13 g > 13.77 g > 10.63 g > 8.63 g > 7.4 g > 6.1 g for fresh weight of shoot during first harvest. At 45 DAT, the dry weight mean values for the control plants was more as compared to the plants treated and recorded as 5.4 g (Tables 2A and 2B).

Fresh and dry weight of root: At 45 and 106 DAT, the control plants which were not treated by salt stress showed maximum fresh weight of roots, i.e., 5.23 g and 11.05 g (Table 2A). Similarly, the dry weight of roots which were calculated at 106 DAT showed the reduction in the same manner as 45 DAS plants. The overall trend for the average values of dry weight of roots at the time of second harvest was 5.25 g > 4.34 g > 2.42 g > 1.59 g > 1.09 g > 0.63 g > 0.27 g as demonstrated in Table 2B.

Fresh and dry weight of leaves: The control plants showed maximum average value, i.e., 15.37 g while the minimum value was showed by 300 ppm treated plants, i.e., 3.03 g recorded at 45 DAT (Table 2A). Apparently, 106 DAT plants showed more fresh weight (Table 2B). However, order of reduction was similar to 45 DAT. The dry weight calculated at 106 DAT followed same trend of reduction. The recorded dry weight average value for control was 6.8 g during second harvest.

Total fresh and dry weight of plant: Total Fresh and Dry Weight of Plants treated with 50,100, 150, 200, 250, and 300 ppm Na-F concentrations showing the average values for total fresh weight of plants were such as 39.5 g, 32.57 g, 26.37 g, 20 g, 16.6 g, 12.87 g, and 9.87 g during first harvest (Table 2A). At 106 DAT, it was found that total plant's dry weight badly affected and prominent reduction was visualized and calculated. The overall average values recorded were 21.98 g, 17.36 g, 12.51 g, 9.25 g, 7.44 g, 5.07 g, and 2.89 g for treated with 50,100, 150, 200, 250 and 300 ppm Na-F at the time of second harvest (Table 2B).

Assessment of yield and yield components

Fresh and dry weight of fruit: Highest fresh weight of fruit was recorded for control plants as 35.21 g during first harvest. Plants treated with 50 ppm sodium fluoride concentration showed more content for fresh weight as compared to 100, 150, 200, 250 and 300 ppm treated plants. Maximum recorded dry weight of fruit was for control plants as they were not damaged by NaF stress. Least recorded weight was for plants treated with 300 ppm NaF concentration, showed reduction in sequence that was depicted in their results.

Diameter of fruit: Least diameter was recorded for plants treated with 300 ppm solutions of sodium fluoride and greater for control plants. The values of diameter were observed as 3.91g, 3.74 g, 3.61g, 3.55g, 3.37g, 3.28g, and 3.08g for control, 50, 100, 150, 200, 250 and 300 ppm treated plants respectively with sodium fluoride stress as shown in Table 3.

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Table 2A. Biomass assessment of *Lycopersicon esculentum* L. harvested at 45 DAT under 7 treatments of sodium fluoride during growing season 2019-2020

Treatments	Parameters (45DAT)							
	Shoot Fresh Weight (g)	Root Fresh Weight (g)	Leaf Fresh Weight (g)	Total Fresh Weight (g)	Shoot Dry Weight (g)	Root Dry Weight (g)	Leaf Dry Weight (g)	Total Dry Weight (g)
Control	17.67 ± 0.27g	5.23 ± 0.34e	15.37 ± 0.59f	39.5 ± 0.35g	5.4 ± 0.15f	1.1 ± 0.15c	3.9 ± 0.15d	10.07 ± 0.37f
50ppm	16.13 ± 0.30f	4.23 ± 0.15d	12.37 ± 0.41e	32.57 ± 0.50f	5.03 ± 0.09f	0.53 ± 0.15b	3.77 ± 0.03d	9.57 ± 0.27f
100ppm	13.7 ± 0.52e	3.1 ± 0.44c	9.4 ± 0.35d	26.37 ± 0.41e	4.2 ± 0.17e	0.42 ± 0.03ab	3.57 ± 0.15d	8.07 ± 0.08e
150ppm	10.63 ± 0.38d	2.23 ± 0.13b	7.97 ± 0.15c	20 ± 0.21d	3.53 ± 0.26d	0.34 ± 0.02ab	3.1 ± 0.06c	6.97 ± 0.22d
200ppm	8.63 ± 0.54c	2.03 ± 0.09b	6.2 ± 0.64b	16.6 ± 0.29c	2.9 ± 0.15c	0.33 ± 0.03ab	2.5 ± 0.21b	5.7 ± 0.30c
250ppm	7.4 ± 0.40b	1.26 ± 0.15a	4.2 ± 0.26a	12.87 ± 0.49b	2 ± 0.17 b	0.25 ± 0.02a	2.07 ± 0.03b	4.5 ± 0.26b
300ppm	6.1 ± 0.06a	0.73 ± 0.03a	3.03 ± 0.23a	9.8 ± 0.26 a	1.43 ± 0.12a	0.15 ± 0.02a	1.5 ± 0.23a	3.08 ± 0.23a

Each treatment mean is sum of three replicates and ± represents standard error (SE), the values not followed by identical letters in each parameter, are significantly different at $p \leq 0.05$ according to Duncan's multiple range test (DMRT).

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Table 2B: Biomass assessment of *Lycopersicon esculentum* L. harvested at 106 DAT under 7 treatments of sodium fluoride during growing season 2019-2020

Treatments	Parameters (106DAT)							
	Shoot Fresh Weight (g)	Root Fresh Weight (g)	Leaf Fresh Weight (g)	Total Fresh Weight (g)	Shoot Dry Weight (g)	Root Dry Weight (g)	Leaf Dry Weight (g)	Total Dry Weight (g)
Control	39.14 ± 0.14g	11.05 ± 0.12g	42.13 ± 0.23g	92.32 ± 0.43g	9.93 ± 0.22g	5.25 ± 0.02g	6.8 ± 0.05g	21.98 ± 0.20g
50ppm	35.1 ± 0.06f	9.44 ± 0.25f	36.32 ± 0.27f	80.86 ± 0.54f	7.36 ± 0.28f	4.34 ± 0.13f	5.66 ± 0.15f	17.36 ± 0.43f
100ppm	28.6 ± 0.06e	7.26 ± 0.14e	30.59 ± 0.26e	66.45 ± 0.23e	5.49 ± 0.10e	2.42 ± 0.16e	4.61 ± 0.18e	12.51 ± 0.08e
150ppm	19.1 ± 0.49d	6.68 ± 0.05d	25.41 ± 0.25d	51.19 ± 0.68d	4.32 ± 0.11d	1.59 ± 0.04d	3.35 ± 0.15d	9.25 ± 0.23d
200ppm	13.63 ± 0.20c	5.53 ± 0.07c	21.21 ± 0.18c	40.38 ± 0.24c	3.7 ± 0.07c	1.09 ± 0.08c	2.64 ± 0.12c	7.44 ± 0.22c
250ppm	10.63 ± 0.32b	4.28 ± 0.17b	15.48 ± 0.09b	30.39 ± 0.46b	2.54 ± 0.10b	0.63 ± 0.07b	1.9 ± 0.02b	5.07 ± 0.15b
300ppm	8.06 ± 0.08a	3.35 ± 0.10a	10.55 ± 0.11a	21.95 ± 0.18a	1.28 ± 0.19a	0.27 ± 0.09a	1.34 ± 0.11a	2.89 ± 0.26a

Each treatment mean is sum of three replicates and ± represents standard error (SE), the values not followed by identical letters in each parameter, are significantly different at $p \leq 0.05$ according to Duncan's multiple range test (DMRT).

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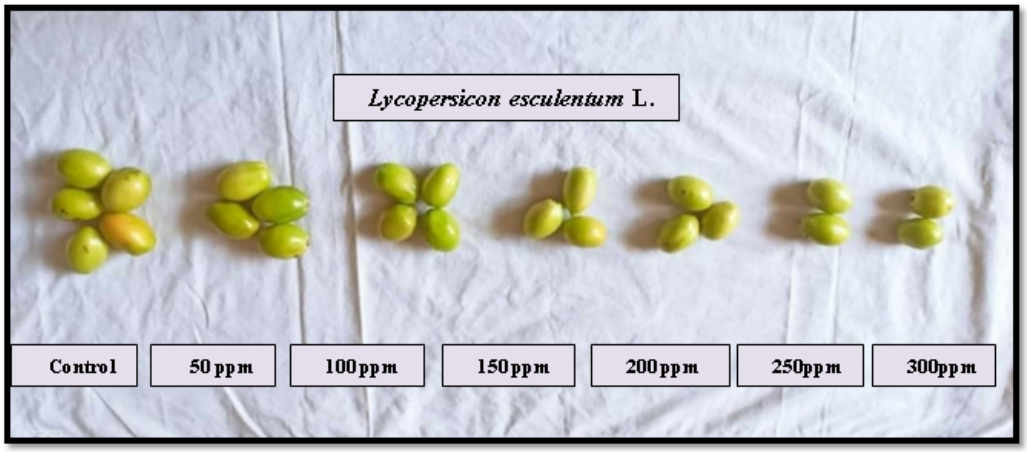

Figure 2. Yield of *Lycopersicon esculentum* L. harvested at 106 DAT under seven treatments of Sodium fluoride during growth season 2018-2020.

Table 3. Yield assessment of *Lycopersicon esculentum* L. harvested at 106 DAT under 7 treatments of sodium fluoride during growing season 2019-2020

Treatments	Fruit fresh weight (g)	Fruit dry weight (g)	Diameter of fruit (g)
Control	32.29 ± 0.18 f	30.07 ± 0.07 g	3.9 ± .01 g
50ppm	30.04 ± 0.01 e	27.34 ± 0.07 f	3.24 ± 0.01 f
100ppm	26.96 ± 0.02 d	25.35 ± 0.01 e	2.75 ± 0.05 e
150ppm	25.62 ± 0.15 c	23.28 ± 0.18 d	2.43 ± 0.01 d
200ppm	24.22 ± 0.05 c	22.4 ± 0.15 c	2.12 ± 0.01 c
250ppm	22.01 ± 0.01 b	20.5 ±0.19 b	1.64 ± 0.06 b
300ppm	25.52 ± 0.12 a	18.75 ±0.10 a	1.48 ± 0.03 a

Each treatment mean is sum of three replicates and ± represents standard error (SE), the values not followed by identical letters in each parameter, are significantly different at $p \leq \delta$ 0.05 according to Duncan's multiple range test (DMRT

.DISCUSSION

The present study was based on the evaluation of sodium fluoride induced stress on growth and yield of *Lycopersicum esculentum* L. This study examined the effect of Fluoride stress, at concentrations of 50, 100, 150, 200, 250, and 300 ppm, on the Rio Grande variety of tomato plant and found that the maximal negative effect occurred with a concentration of 300 ppm on growth and yield while minimal effect on 50 ppm

NaF treated plants. The control plants showed maximum growth and yield as compare to 300 ppm NaF treated plants.

Pant [15] studied the effect of different concentrations of sodium fluoride (NaF) on the seedling growth of tomato (*Lycopersicon esculentum*), Bengal gram (*Cicer arietinum* L.), wheat (*Triticum aestivum*) and mustard (*Brassica juncea*). After applying seven days' treatment, significantly reduced growth in the root and shoot lengths occurred in all the seedlings, except the root lengths in tomato seedlings at 0.02 M NaF. In general, wheat, Bengal gram, and mustard were observed to be more susceptible to the toxic nature of F than tomato. While the results of present study depicted that the shoot and root length were substantially reduced at the increasing salt concentration which was deviated from the findings of Pant [15] in case of tomato. The maximum shoot and root length were found in control plants and minimum lengths were found in the plants treated with 300 ppm sodium fluoride. So, the decreasing trend was found with the increasing concentration of NaF. The reductions in the morphological parameters were significantly seen in both harvests and the results were noted down.

With the increase of fluoride concentration different morphological growth parameters including shoot growth, root growth, number of leaves and leaves area reduced progressively. More reduction occurred in plants treated with 100 and 200 ppm concentration of sodium fluoride than 500 and 600 ppm [10]. Similar results were evaluated in the present experiment and plants are more effected at higher sodium fluoride concentration like 300 ppm than the plants treated with the 50 ppm concentration.

Two tomato variety seedlings were used including Chinar and Roma in order to check the effect of fluoride on leaves growth. Plants of these two varieties were grown under six different treatments (0, 10, 30, 50, 100, and 200 mgF/L). it was concluded that the growth of Roma variety was more affected than the Chinar variety [16]. The number of leaves and leaflets were also reduced and affected with the increase of sodium fluoride concentration. The minimum number of leaves were calculated at 300 ppm concentration of fluoride.

To check the effect of fluoride toxicity on two varieties of tomato (Meiguodahong and Roma) under the application of various concentrations of fluoride (F=0, F=10, F=25, F=50 and F=100 ppm). Growth parameters like plant growth rate and leaf area were calculated under different levels of stress. The adverse impact of fluoride was checked at 50 ppm of fluoride concentration. Roma variety was less resistant towards fluoride toxicity than Meiguodahong [5]. The negative impact of sodium fluoride on growth and development of five species including tomato at seedling stage was done. The sodium fluoride application led to decrease the root length significantly of all the examined species of plants in comparison to the control plants. The lowest reduction in the root length was found in tomato as compare to the other species when the plants treated with fluoride concentration from 0.01 to 8.0 mM [17]. In contrast, the root length of tomato plants was gradually decreased with the increase of concentration from 50 to 300 ppm in present pot experiment.

The yield assessment was also severely affected under the application of sodium fluoride in concentrations of 100 and 200 ppm as a soil drench, on solanaceae family

member. It resulted in the reduction of size and number along with fresh and dry weight of yield [18]. Mishra [19] evaluated that the NaF application reduced the primary net productivity of tomato (*Lycopersicon esculentum*). In comparison to the present experiment, yield assessment undergone decline trend with the increase of sodium fluoride concentration from 50 to 300 ppm.

CONCLUSION

The present study was carried out to evaluate the effects on *Lycopersicon esculentum* L. under soil drench application of sodium fluoride. The toxic effects were studied under controlled conditions by applying different concentrations of sodium fluoride. Fluoride caused deleterious effects on yield characteristics, morphological parameters of growth and stressed plants attributes. At 45 DAT and 106 DAT, the tremendous reduction in growth parameters of plants was visualized. As a result of increasing stress, the plant biomass and morphological growth parameters were reduced. The tomato production was decreased in plants treated with high concentration of sodium fluoride. In Pakistan, soils are contaminated with high toxic concentration of sodium fluoride so the removal of high sodium fluoride from soil is a major point of concern in irrigated lands. This study concludes that tomato crop is sensitive to salt stress. So, further research should be conducted in order to alleviate the salt stress.

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