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Effect of NaCl Stress on Morphological Responses of Tomato Varieties Through Hydroponic Culture System

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A b s t r a c t

A plastic planter and hydroponic experiment was carried out to assess the tolerance of eight varieties of tomato against salinity expressed through morphological attributes of tomato. The experiment comprised four levels of salinity viz., control 2EC (mS/cm), 4EC (mS/cm), 6EC (mS/cm) and 8EC (mS/cm) and eight varieties of tomato viz., BARI Tomato-2, BARI Tomato-3, BARI Tomato-4, BARI Tomato-8, BARI Tomato-14, BARI Tomato-15, BARI Tomato-16, BARI Tomato-17. The two-factor experiment was laid out in randomized complete block design (RCBD) with four replications. The morphological attributes varied significantly with varieties and different salinity levels. Most of the parameters showed decreasing trend with the highest level of salinity 8 EC (mS/cm). In case of combined effects of variety and salinity level BARI Tomato-17 and low level of salinity (2mS/cm) produced maximum number of leaves, and plant height (26.33 and 48.45cm respectively) while the minimum number of leaves and plant height were (9.33& 16.35cm respectively) produced by the combination of BARI Tomato-3 and 8EC (mS/cm) level of salinity. It can be concluded that BARI Tomato-17 was comparatively more salt tolerant than the other varieties used.

Key words: Tomato, NaCl, hydroponic and salinity.

Introduction

Tomato (*Lycopersicon esculentum*) is one of the most important, popular, nutritious vegetables in Bangladesh grown in both winter and summer seasons in almost all districts in the country. Tomato is very rich in nutrients especially potassium, folic acid, vitamin C and contains a mixture of different carotenoids, including vitamin A, effective a-carotene as well as lycopene. Tomato is consumed fresh, cooked or after processing; canning process also transforms tomato into juice, pulp, paste or a variety of sauces (Caurtero and Fernendez, 1999).

Hydroponic culture is a method of growing plants using mineral nutrient solutions, in water, without soil, is supported by using inter medium such as perlite, rockwool, clay pellets, peat moss, or vermiculite instead of the root system (Fan et al., 2012). Meric et al. (2011) reported that soilless cultivation is widely used to improve the control of the growing environment and avoid uncertainties in the water and nutrient status of the soil. It also overcomes the accumulation of salinity, pests and diseases (Fan et al., 2012) and minimizes environmental contamination stemming from fertigation runoff (Savvas, 2002; Rouphael et al., 2006). This technique also aids in saving irrigation water and fertilizers, thereby appreciably increasing the water use efficiency by the crop (Schwarz et al., 1996; Zekki et al., 1996). Salinity is one of the most important factor limiting fruit growth and production of several horticultural crops (Savvas *et al*., 2007; Azarmi *et al*., 2010). Salinity stress limits the productivity of crops, with adverse effects on germination, plant vigour and crop yield (Munns and Tester, 2008). Salinity is an environmental stress that affects growth and development in plants and is a widely recognized problem in irrigated regions worldwide. In plants, salt stress causes reduction of cell turgor pressure and suppresses the rate of root and leaf elongation, indicating that environmental salinity acts primarily on the water uptake mechanism of plants. It is reported that salt affected areas of Bangladesh are increasing day by day and crop production is severely reduced in the southern part of the country. Tomato production is also reducing which is unable to meet up the demand. We can increase tomato production if saline-prone areas of our country can bring under tomato cultivation using salt-tolerant tomato varieties. So this study aims to find out the salt-tolerant variety of tomato for saline-prone areas of Bangladesh.

Materials and Methods

Experimental site

Location: The experimental site was situated between 24˚75´ N latitude and 90˚ 50´E longitudes at an elevation of 18m above sea level. The experiment was done at Polyhouse, West building of Agriculture faculty, Bangladesh Agricultural University (BAU), Mymensingh.

Climate: The experimental site was under the sub-tropical climate, which is characterized by high temperature, high humidity, heavy precipitation with occasional gusty winds and relatively long Kharif season (April-September) and scanty rainfall associated with moderately low temperature, low humidity and short day period during Rabi season (October-March). Weather information regarding the atmospheric temperature, relative humidity, rainfall, and sunshine hours prevailed at the experimental site during the entire period of investigation as recorded by the weather yard, Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh

Planting materials: The research work was conducted with eight varieties of tomato namely BARI Tomato-3, BARI Tomato-8, BARI Tomato-14, BARI Tomato-15, BARI Tomato-16, BARI Tomato-2, BARI Tomato-4, BARI Tomato-17. The seeds of all varieties were collected from Horticulture Division of Bangladesh Agricultural Research Institute (BARI), Gazipur. The seeds were healthy, vigorous, well-matured and free from other crop seeds and inert materials.

Raising of seedlings: Seedlings were raised in a wooden box. The wooden box was prepared with 50% loamy soil and 50% well decomposed cow dung (WDC). All weeds and stubbles were removed from the soil. Seeds of each variety were sown in separate line in the wooden box. Heptachlor 40 WP was applied around the wooden box at the rate of 4 kg/ha as precautionary measure against ants and worms. The emergence of seedlings took place within 5 to 6 days after sowing. Intensive care was taken regularly. Weeding, and watering was remained in the wooden box for 21 days.

Experimental treatment: The experiment consisted of two factors and was carried out to study the field performance of eight tomato germplasm under different salinity levels. The following treatments were included in the experiment:

Factor (A): Variety

V_1 : BARI Tomato-2, V_2 : BARI Tomato-3, V_3 : BARI Tomato -4,V_4 : BARI Tomato-8, V_5 : BARI Tomato-14, V_6 : BARI Tomato- 15, V_7: BARI Tomato-16, V_8 : BARI Tomato-17

Factor (B): Salinity level

EC2 : Control (2 mS/cm), EC4 :4 (mS/cm), EC6 :6 (mS/cm), EC8 :8 (mS/cm)

Design and layout of the experiment: The two-factor experiment was laid out in the randomized complete block design (RCBD) with three replications having four treatments. The individual plastic planter size was 30L. All the experiments were conducted in a polyhouse under 70% RH and pH 7.3.

Experimental set-up

Preparation of modified Hogland's solution: Hogland's solution was prepared by using different salts like $MgSO_4$, $NH_4H_2PO_4$, KNO_3, $Ca(NO_3)_2.4H_2O$, EDTA-Fe, H_3BO_4, $MnSO_4$, $ZnSO_4$, $NaMoO_4$, $CuSO_4$ and $CaCl_2$. Each salt was weighed by an electrical balance (KERN PCB) and then dissolved with water by continuous stirring. Then the prepared salt solutions were poured in a big plastic drum following continuous stirring. Tap water was added to make 80L solution. After the preparation of 80L solution, salinity level of the solution was checked by using an EC (Electrical Conductivity) machine to confirm 2 EC (mS/cm). The pH (7.3) of the solution was also checked by pH machine.

Preparation and application of salt solution: The levels of the treatment of this experiment were 2EC, 4EC, 6EC, 8EC NaCl salt solution. So the sodium chloride was weighed by an electric balance and weighed salt was dissolved in tap water. Then the NaCl salt solution was added to the 2EC Hogland's solution at the recommended dose to make 4EC, 6EC, 8EC solution respectively. The salinity levels of the culture solution were closely monitored by EC machine at 2 days interval and salt solution was adjusted in all the treatments during the experiment period.

Collection of plastic planters: Plastic planters were purchased from market. Then they were cleaned properly. The volume of each plastic planter was 90 cm× 30 cm× 30 cm (length × breadth × height).

Preparation of plastic planters: At first all the plastic planters were filled with 2EC Hogland's solution. Then the NaCl salt solution was added to the 2EC Hogland's solution at recommended dose to make 4EC, 6EC, 8EC solution respectively. For better aeration air pump was set with each of the planters.

Transplanting and crop management: Three-week-old seedlings were transplanted from a wooden box to 1ECHogland's solution for 10 days. Then again the seedlings were transplanted in the recommended doses of salt solution (2EC, 4EC, 6EC & 8EC respectively) on 20 December, 2017. Growth and EC were frequently observed and pH (7.3) of the culture solution was closely monitored and adjusted in all the treatments during the experiment period.

Intercultural operations

Staking: After 15 days of transplanting when the tomato plants were well established, staking was performed using plastic rope by hanging system to keep the plants erect.

Insect pests: Malathion 57EC was applied at the rate of 2 ml/L as preventive measure against insect pests like cutworms, leaf hoppers and fruit borers. The insecticides were applied fortnightly as a routine work from a week after transplanting to a week before first harvesting.

Disease: Dithane M-45 was applied @ 2 g/L at the early stage against late blight of tomato (Mohanta, 2005).

Data recording: Data on the following parameters were gathered from the individual plants during the course of the experiment.

Plant height (cm): The height of the plants was measured by centimeter scale from plants of each plastic planter after 0 DAT and up to 35 DAT at 5 days interval. The height was measured from the base to the tip of the plant.

Number of leaves per plant: The number of leaves per plant was counted individually after 35 DAT , before closing of the experiment. Then the number of leaves was recorded in a notebook.

Specific Leaf Area (SLA): For determining of Specific Leaf Area, at first same leaf number of each plant was collected and leaf area (cm^2) was measured by leaf area machine in Central Laboratory, BAU. Then the leaves were oven (memmert) dried for 3 days at 65^0C. After that they were weighed by using an electrical balance (KERN PCB) .The weight was expressed in gram (g). Specific Leaf Area was measured by using the following equation-

$$\text{SLA} = \frac{\text{Leaf area}}{\text{Leaf dry weight}}$$

Leaf Dry Weight (g): At first fresh leaves were weighed immediately after harvesting. Then they were oven (memmert) dried for 3 days at 65^0C. After that they were weighed by using an electrical balance (KERN PCB). The weight was expressed in gram (g).

Leaf Weight Ratio (LWR): Leaf Weight Ratio was measured by the division of leaf dry weight and total dry weight. Leaf Weight Ratio was measured by using the following equation-

$$\text{LWR} = \frac{\text{Leaf dry weight}}{\text{Total dry weight}}$$

% Moisture content: For determining of moisture content (%) of leaves, at first fresh leaves were weighed by using an electrical balance (KERN PCB) immediately after harvesting from same leaf number of each plant. Then the leaves were oven (memmert) dried for 3 days at 65^0C. After that they were weighed by using an electrical balance (KERN PCB). The weight was expressed in gram (g).

% Moisture content was measured by using the following equation-

$$\%M = \frac{Fw - Dw}{Hw} \times 100$$

Here, Fw = Fresh weight of leaf, Dw = Dry weight leaf

Leaf Weight Ratio (LWR): Leaf Weight Ratio was measured by the division of leaf dry weight and total dry weight. Leaf Weight Ratio was measured by using the following equation-

$$\text{LWR} = \frac{\text{Leaf dry weight}}{\text{Total dry weight}}$$

Analysis of data: The data regarding growth were statistically analyzed to determine the statistical significance of the experimental results. The means for all the treatments were calculated and the analyses of variance for all the characters were performed by F test. The significance of difference between the pairs of means was separated by LSD test at 5% and 1% levels of probability (Gomez and Gomez, 1984).

Results and Discussions

Plant height

Main effect of variety on plant height: Plant height varied significantly with the varieties at different days after transplanting. In all the stages of growth, variety affects the plant height and those were significantly different. At the maximum vegetative stage (35 DAT), the maximum plant height (43.63 cm) was recorded from BARI Tomato-17 while the minimum plant height (20.01 cm) was recorded from BARI Tomato-3 (Figure 1).

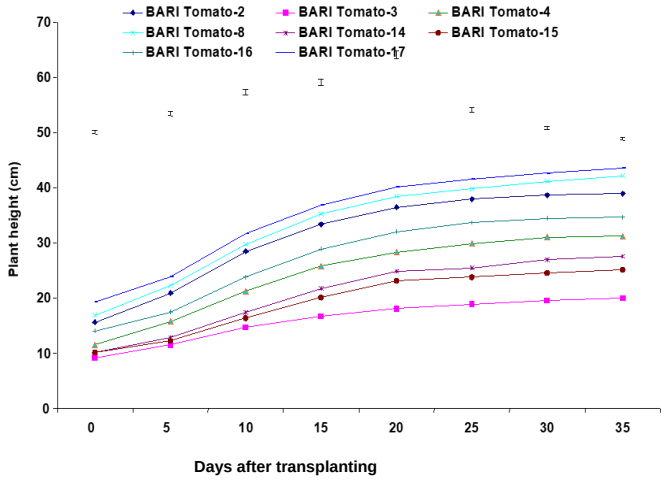

Figure1. Main effect of different varieties on plant height at different days after transplanting. Vertical bars represent LSD at 1% level of significance.

Main effect of salinity level on plant height: Salt concentrations had significant influence on plant height of tomato. Plant height of tomato was increased gradually up to 35 DAT (Figure 2). The maximum plant height (38.62 cm) was recorded at 35 DAT from 2EC (mS/cm) salt concentration while the minimum (26.92 cm) was recorded at the same time from 8EC (mS/cm) salt concentration (Figure 2).

Combined effects of variety and salinity level on plant height: The combined effect of variety and salt concentration on plant height differ significantly. At 35DAT the maximum plant height (48.45 cm) was recorded from the variety and treatment combination of V8EC2and the minimum height of plant (16.35 cm) was form the combination of V2EC8. (Table1)

This result is in conformity with Javed et al. (2000) who observed decreased plant height under salinity in tomato. Salinity decreased the emergence index and vigour index of seedlings (Robina and Sheela; 2006).

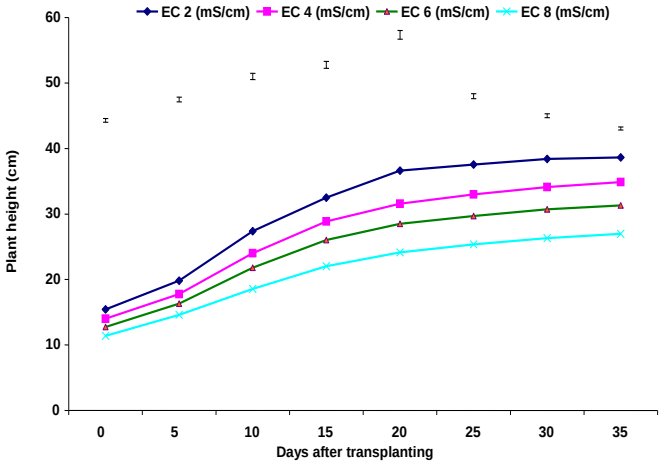

Figure 2. Main effect of different salinity level on plant height at different days after transplanting. Vertical bars represent LSD at 1% level of significance.

Number of leaves per plant

Main effect of variety on number of leaves per plant: The number of leaves per plant was recorded at the stage of growth of 35DAT. The differences were highly significant. The maximum number of leaves (24.33) was recorded from plants in case of BARI tomato-17 and the minimum number of leaves (7.92) was obtained from the BARI Tomato-3 (Figure 3).

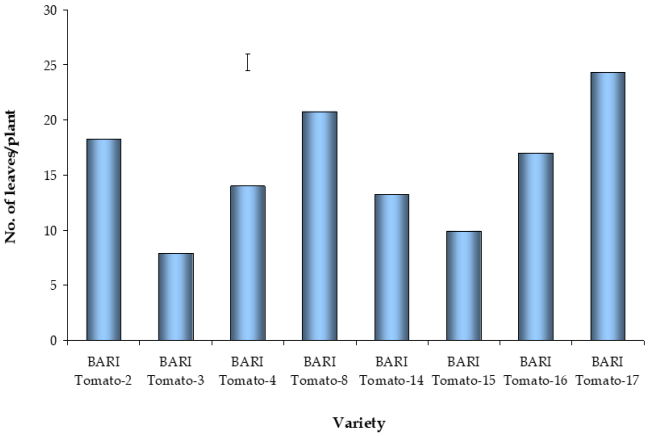

Figure 3. Main effect of variety on number of leaves per plant. Vertical bars represent LSD at 1% level of significance.

Main effect of salinity level on number of leaves per plant: Salt concentration influenced number of leaves per plant significantly. The maximum number of leaves per plant (17.58) was recorded from 2EC (mS/cm) salt concentration at maximum vegetative growth stage (35 DAT) while the minimum number of leaves (13.75) was observed from 8EC (mS/cm) level of salinity (Figure 4).

Combined effects of variety and salinity level on number of leaves per plant: The maximum number of leaves per plant (26.33) was recorded from the variety and treatment combination of V8EC2and the minimum number of leaves per plant (9.33) was form the combination of V2EC8 (Table 6).

This finding is supported by Yadav *et al*. who stated that the number of leaves/plant, fresh and dry weight of leaves was reduced in high salinity condition. Salinity also inhibits tomato leaf expansion under hydroponics system. Adams et al. (1990) also

Table 1. Combined effects of variety and treatment on plant height at different days of tomato

Treatment combination	Plant height (cm) at different DAT							
	0	5	10	15	20	25	30	35
V_1EC2	17.55	24.70	34.80	41.25	44.60	46.25	46.80	47.05
V_1EC4	16.75	21.05	29.00	33.25	36.00	37.60	38.35	38.71
V_1EC6	14.70	20.15	25.85	30.20	34.10	35.45	36.35	36.70
V_1EC8	13.55	17.85	24.30	28.80	31.25	32.55	33.15	33.35
V_2EC2	10.25	13.05	18.00	21.95	24.15	25.05	25.55	25.75
V_2EC4	9.30	11.55	14.65	16.55	17.90	18.70	19.10	19.20
V_2EC6	9.15	10.90	13.45	14.75	15.65	16.50	17.38	18.75
V_2EC8	8.25	10.65	12.80	13.50	14.75	15.50	16.25	16.35
V_3EC2	12.50	17.45	26.15	31.15	35.30	36.55	37.40	37.80
V_3EC4	12.10	17.05	22.65	27.35	29.75	31.45	32.10	32.35
V_3EC6	11.90	16.50	18.95	24.20	26.55	27.70	28.85	29.10
V_3EC8	9.75	12.00	17.15	20.55	21.65	24.00	25.75	25.95
V_4EC2	21.40	26.95	36.40	41.40	45.55	46.95	47.60	48.05
V_4EC4	17.20	22.45	29.50	36.70	39.70	41.30	43.00	45.75
V_4EC6	15.30	20.90	28.80	32.15	34.75	35.70	37.88	38.70
V_4EC8	13.80	18.60	24.40	30.65	33.95	35.15	36.20	36.35
V_5EC2	11.75	14.10	19.25	25.35	32.15	30.85	32.92	32.50
V_5EC4	10.05	13.35	19.15	25.25	28.50	29.95	30.80	31.10
V_5EC6	9.90	12.35	18.05	21.60	23.55	24.70	26.13	27.65
V_5EC8	9.35	11.65	13.05	14.88	15.38	16.40	17.90	19.13
V_6EC2	11.55	13.40	18.50	23.40	28.95	28.45	29.25	29.55
V_6EC4	9.90	12.70	18.15	22.15	25.05	26.15	26.90	27.55
V_6EC6	9.80	11.80	16.15	20.75	23.25	24.65	25.25	25.45
V_6EC8	9.25	11.15	12.80	14.15	15.35	15.95	16.83	18.10
V_7EC2	16.05	21.45	28.85	32.80	36.35	38.75	39.45	39.80
V_7EC4	14.85	17.20	24.75	30.50	33.60	35.40	36.65	36.85
V_7EC6	14.15	16.65	23.85	29.90	32.10	33.10	33.60	33.75
V_7EC8	11.30	14.70	17.85	22.60	26.05	27.60	28.15	28.30
V_8EC2	22.30	27.30	37.15	42.65	46.00	47.50	48.25	48.45
V_8EC4	21.85	26.80	34.25	39.15	42.05	43.45	46.00	47.38
V_8EC6	17.00	21.30	29.35	34.60	37.95	39.55	40.15	40.40
V_8EC8	15.95	20.20	26.05	31.15	34.65	35.75	36.25	38.29
$LSD_{0.05}$	1.43	1.95	2.52	2.79	3.53	2.03	1.56	1.25
$LSD_{0.01}$	1.90	2.59	3.36	3.71	4.69	2.70	2.07	1.66
Level of significance	**	**	**	**	*	**	**	**

** = Significant at 1% level of probability, * = Significant at 5% level of probability

reported a significant decrease in tomato plant leaves with increasing salinity levels.

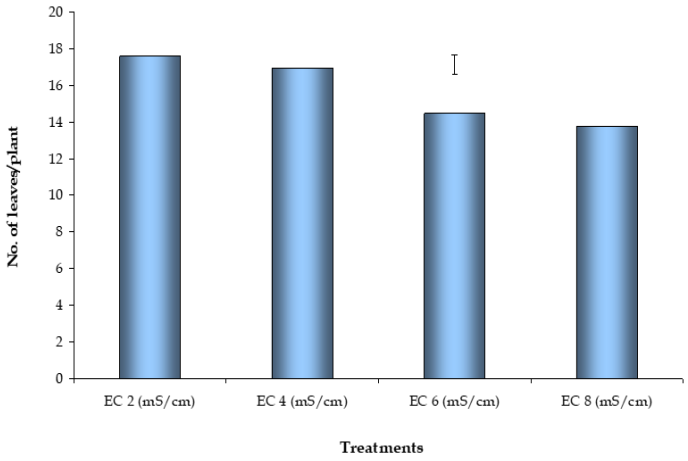

Figure 4. Main effect of salinity level on number of leaves per plant. Vertical bars represent LSD at 1% level of significance

% moisture of leaves

Main effect of variety on % of moisture per plant: % of moisture per plant varied significantly by the effect of variety. The highest% of moisture per plant (89.12) was observed from V8 (BARI tomato-17) and the lowest % of moisture per plant (78.00) was found from V_2(BARI tomato -3) (Table 2).

Table 2. Main effect of variety on fresh weight of leaves, dry weight of leaves and percent moisture content of tomato leaves

Variety	Fresh weight of leaves (g)	Dry weight of leaves (g)	% Moisture content
BARI Tomato-2	13.61	1.51	88.17
BARI Tomato-3	1.33	0.28	78.00
BARI Tomato-4	9.63	1.17	86.44
BARI Tomato-8	15.27	1.65	88.84
BARI Tomato-14	7.69	1.07	84.92
BARI Tomato-15	6.40	0.96	84.12
BARI Tomato-16	11.43	1.37	87.23
BARI Tomato-17	16.83	1.71	89.12
$LSD_{0.05}$	0.33	0.04	0.26
$LSD_{0.01}$	0.45	0.06	0.35
Level of significance	**	**	**

** = Significant at 1% level of probability

Main effect of salinity level on % of moistureper plant: Significant variations were observed in number of % of moisture per plant with different salinity level treatment. At the maximum vegetative growth stage (35 DAT) the maximum % of moistureper plant (89.27) was recorded from EC2concentration, on the other hand the minimum % of moistureper plant (82.52) was recorded from EC8(mS/cm) concentration which was the highest level 8EC (mS/cm) NaCl of treatment (Table 3).

Table 3. Main effect of treatment on fresh weight, dry weight and percent moisture content of tomato leaves

Treatments	Fresh weight of leaves (g)	Dry weight of leaves (g)	% Moisture content
EC 2 (mS/cm)	14.99	1.43	89.27
EC 4 (mS/cm)	10.69	1.27	87.11
EC 6 (mS/cm)	8.49	1.15	83.50
EC 8 (mS/cm)	6.52	1.00	82.52
$LSD_{0.05}$	0.24	0.03	0.18
$LSD_{0.01}$	0.31	0.04	0.24
Level of significance	**	**	**

** = Significant at 1% level of probability

Combined effects of variety and salinity level on % of moisture per plant: The combined effect of variety and salt concentration showed significant influence on % of moisture. The maximum % of moisture (92.40) was found under the combination of V8EC2and the minimum % of moisture (73.53) was found under the combination of V2EC8(Table 6).

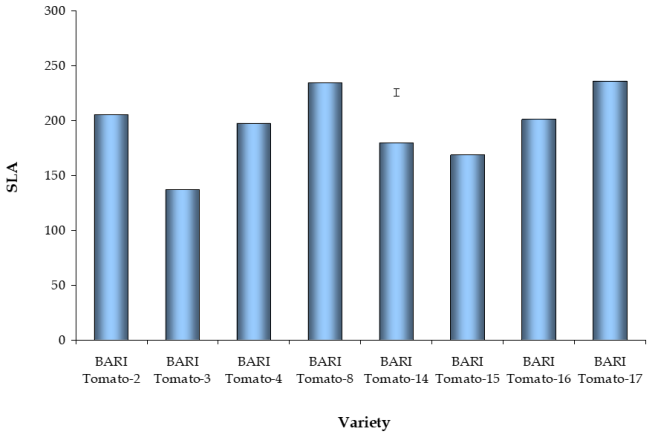

Figure 5. Main effect of variety on Specific Leaf Area per plant. Vertical bars represent LSD at 1% level of significance.

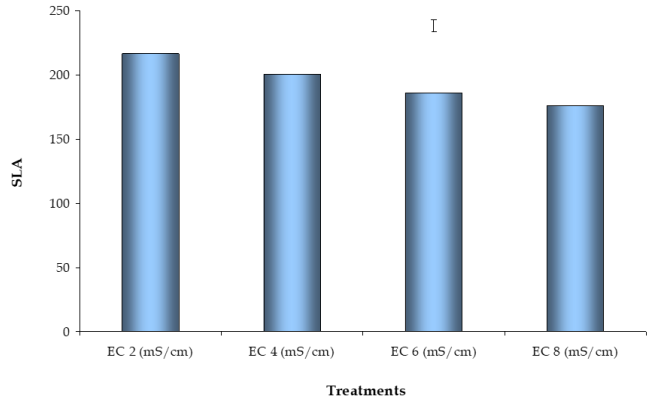

Figure 6. Main effect of salinity level on Specific Leaf Area per plant. Vertical bars represent LSD at 1% level of significance.

Specific Leaf Area

Main effect of variety on Specific Leaf Area per plant: Specific leaf area per plant varied significantly by the effect of variety. The maximum specific leaf area perplant (235.82) was observed from V8 (BARI tomato-17) and the minimum specific leaf area per plant (136.86) was found from V_2 (BARI tomato -3) (Figure 5).

Main effect of salinity level on Specific Leaf Area per plant: Significant variations were observed in number of specific leaf area per plant with different salinity level treatment. At the maximum vegetative growth stage (35 DAT) the maximum specific leaf area per plant (216.58) was recorded from EC2concentration, the low level of treatment 2EC (mS/cm) while the minimum specific leaf area per plant (176.08) was recorded from EC8 (mS/cm) concentration which was the highest level 8EC (mS/cm) NaCl of treatment (Figure 6).

Combined effects of variety and salinity level on Specific Leaf Area per plant: The combined effect of variety and salt concentration showed significant influence on specific leaf area. The maximum specific leaf area (270.46) was found under the combination of V8EC2and the minimum specific leaf area (112.01) was found under the combination of V2EC8. Shalhevet (1994) also stated that it is still controversial whether the reduction in water uptake with increasing salinity is the cause or the result of reduction in specific leaf area(Table 6).

Table 4. Main effect of variety onLeaf Weight Ratio and shoot weight ratio of tomato

Variety	Leaf wt. ratio	Shoot wt. ratio
BARI Tomato-2	0.58	0.79
BARI Tomato-3	0.58	0.75
BARI Tomato-4	0.65	0.76
BARI Tomato-8	0.51	0.79
BARI Tomato-14	0.88	0.73
BARI Tomato-15	0.66	0.75
BARI Tomato-16	0.52	0.78
BARI Tomato-17	0.52	0.77
$LSD_{0.05}$	0.026	0.008
$LSD_{0.01}$	0.034	0.011
Level of significance	**	**

** = Significant at 1% level of probability

Leaf Weight Ratio

Main effect of variety on Leaf Weight Ratio per plant: Leaf weight ratio per plant varied significantly by the effect of variety. The maximum leaf weight ratioper plant (0.88) was observed from V5 (BARI tomato-14) and the minimum leaf weight ratio per plant (0.51) was found from V_4(BARI tomato -8) (Table 4).

Table 5. Main effect of treatment on leaf weight ratio and shoot weight ratio of tomato

Treatments	Leaf wt. ratio	Shoot wt. ratio
EC 2 (mS/cm)	0.55	0.77
EC 4 (mS/cm)	0.59	0.77
EC 6 (mS/cm)	0.64	0.76
EC 8 (mS/cm)	0.67	0.76
$LSD_{0.05}$	0.018	0.006
$LSD_{0.01}$	0.024	0.008
Level of significance	**	**

** = Significant at 1% level of probability

Main effect of salinity level on Leaf Weight Ratio per plant: Significant variations were observed in number of leaf weight ratio per plant with different salinity level treatments. At the maximum vegetative growth stage (35 DAT) the maximum leaf weight ratio

Table 6. Combined effects of variety and treatment no of leaves/plant, % moisture content, SLA, leaf weight ratio and shoot weight ratio of tomato

Treatment combination	No. of leaves/plant	% Moisture content	SLA	Leaf wt. ratio	Shoot wt. ratio
V_1EC2	20.00	91.78	209.54	0.55	0.79
V_1EC4	18.67	87.89	206.48	0.57	0.79
V_1EC6	17.67	86.92	204.51	0.60	0.79
V_1EC8	16.67	86.09	200.31	0.60	0.77
V_2EC2	9.33	80.38	167.96	0.53	0.74
V_2EC4	9.00	79.20	150.68	0.57	0.73
V_2EC6	7.00	78.89	116.79	0.58	0.74
V_2EC8	6.33	73.53	112.01	0.63	0.78
V_3EC2	17.00	90.09	207.89	0.60	0.78
V_3EC4	15.33	88.98	203.93	0.68	0.76
V_3EC6	12.00	83.09	189.79	0.68	0.75
V_3EC8	11.67	83.60	187.47	0.67	0.75
V_4EC2	22.33	91.15	263.09	0.51	0.79
V_4EC4	22.33	88.85	254.96	0.50	0.79
V_4EC6	19.67	87.56	225.73	0.48	0.79
V_4EC8	18.67	87.80	193.38	0.54	0.80
V_5EC2	15.67	88.43	191.82	0.71	0.74
V_5EC4	15.00	87.81	182.08	0.81	0.74
V_5EC6	11.67	83.46	173.86	0.94	0.73
V_5EC8	10.67	79.99	170.64	1.06	0.71
V_6EC2	11.33	86.47	178.57	0.53	0.78
V_6EC4	11.33	84.06	174.73	0.57	0.77
V_6EC6	9.00	83.96	161.26	0.76	0.71
V_6EC8	8.00	81.99	159.20	0.76	0.71
V_7EC2	18.67	90.51	243.35	0.48	0.79
V_7EC4	18.00	88.60	200.07	0.52	0.78
V_7EC6	16.00	87.59	187.75	0.54	0.78
V_7EC8	15.33	82.22	172.43	0.56	0.79
V_8EC2	26.33	92.40	270.46	0.50	0.77
V_8EC4	25.67	90.55	230.63	0.52	0.76
V_8EC6	22.67	88.56	228.95	0.51	0.77
V_8EC8	22.67	84.97	213.24	0.55	0.79
$LSD_{0.05}$	0.85	0.52	7.55	0.052	0.016
$LSD_{0.01}$	1.12	0.69	10.04	0.069	0.022
Level of significance	**	**	**	**	**

** = Significant at 1% level of probability

per plant (0.67) was recorded from EC8 concentration, on the other hand, the minimum leaf weight ratio per plant (0.55) was recorded from EC2(Table 5).

Combined effects of variety and salinity level on Leaf Weight Ratio per plant: The combined effect of variety and salt concentration showed significant influence on leaf weight ratio. The maximum leaf weight ratio (1.06) was found under the combination of V5EC8and the minimum leaf weight ratio (0.48) were found under the combination of V4EC6, &V_7EC2 (Table 6).

Shoot Weight Ratio

Main effect of variety on Shoot Weight Ratio per plant: Shoot weight ratio per plant varied significantly by the effect of variety. The maximum shoot weight ratio per plant (0.79) were observed from V1 (BARI tomato-2) and V_4 (BARI tomato-8). On the other hand the minimum shoot weight ratio per plant (0.73) was found from V_5 (BARI tomato -14) (Table 4).

Main effect of salinity level on Shoot Weight Ratio per plant: Significant variations were observed in number of shoot weight ratio per plant with different salinity level treatment. At the maximum vegetative growth stage (35 DAT) the maximum shoot weight ratio per plant (0.77) were recorded from EC2&EC4concentration, on the other hand the minimum shoot weight ratio per plant (0.76) were recorded from EC6 & EC8(Table 5).

Combined effects of variety and salinity level on Shoot Weight Ratio per plant: The combined effect of variety and salt concentration showed significant influence on shoot weight ratio. The maximum shoot weight ratio (0.80) was found under the combination of V4EC8and the minimum shoot weight ratio (0.71) werefound under the combination of V5EC8, V_6EC6 &V_6EC8 (Table 6).

Conclusions

In hydroponic trial, eight varieties of tomato were evaluated against four NaCl salinity level conditions. The parameters were responded significantly with the varieties and the degree of salinity levels. The results showed, BARI tomato-17 performed better than the others varieties in all cases. In case of the combined effect of variety and salt concentration, BARI tomato-17 showed better morphological growth than the other varieties when combined with the highest salinity level 8EC (mS/cm). It can be concluded that BARI tomato-17 is comparatively salt tolerant than the other varieties studied in this experiment. However, further studies can be conducted at field or pot condition with more tomato varieties using more salt concentrations to identify any suitable varieties to cultivate under the saline prone areas of Bangladesh.

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Conflict of interest

The authos declare there is no conflict of interest.

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