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Effect of salinity on seed germination and seedling growth of tomato

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ABSTRACT

The study was carried out to investigate the effects of different salt concentrations on germination and seedling growth of four varieties of tomato. Experimental treatment included five levels of NaCl concentration (0, 25, 50, 100 and 150 mM) and four varieties of tomato (Binatomato-6, Binatomato-7, Binatomato-8, Binatomato-9). Data on germination percentage, radicle and plumule length, fresh weight of plumule and radicle, dry weight of plumule and radicle were recorded at different days after sowing (DAS) in Petri dishes. Results on main effects of varieties on germination of seed revealed that there was significant difference among four varieties of tomato at different days after sowing. At 9th days after sowing seeds, the highest percentage of seed germination (94.67%) was recorded in the variety Binatomato-6 and the lowest percentage of seed germination (61.33%) was observed in the variety Binatomato-8. NaCl solutions significantly affected seed germination in tomato with the increase of NaCl solutions. At 11 days after sowing seeds, the highest percentage of seed germination (81.33%) of tomato was recorded in case of control (0 mM NaCl) and the lowest percentage of seed germination (0%) was observed in case of 150 mM NaCl salt solution. In case of combined effects of varieties and different levels of NaCl solutions on seed germination of tomato, the highest seed germination was recorded in the variety Binatomato-6 with control i.e. without any NaCl at 11 days after seed sowing. The germination percentage, germination coefficient, radicle and plumule length, seed vigor index, fresh weight of plumule and radicle, dry weight of plumule and radicle decrease with increasing NaCl salt solutions in the germination media compare to control. Result showed that among the four varieties of tomato, Binatomato-6, Binatomato-7 and Binatomato-9 are relatively more salt tolerant than Binatomato-8.

Keywords: Germination, growth, seedling, stress, tomato

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1 Introduction

Tomato (*Lycopersicon esculentum*) belongs to the family Solanaceae, is one of the most popular and nutritious vegetable crops in Bangladesh. It is cultivated all over the country due to its adaptability to wide range of soil and climate (Ahmed et al., 2012). Loamy soil along with adequate supply of organic matter, good moisture holding and drainage capacity are ideal for tomato cultivation. It ranks next to potato in Bangladesh and tops the list of canned vegetable (BBS, 2016). It is an important cash generating crop for small scale farmers and also provides employment opportunities in production and pro-

cessing industries (Meena et al., 2015). Tomato is consumed either fresh or utilized in preparation of wide range of process products such as juice, ketchup, soups, pickles, sauces, conserves, puree, paste, powder, jam and jelly. Tomato is a vegetable with high anti-oxidant property and it is popularly called as love apple. It is considered as one of the most important, popular and nutritious vegetables crops that has achieved tremendous popularity around the world (FAOSTAT, 2014) because of its taste, high nutritional value, multipurpose uses and commercial importance's (Demirkaya, 2014). It is an excellent source of minerals (notably potassium, calcium and magnesium), carboxylic acids, including ascorbic, citric, malic, fumaric and oxalic acids (Suárez et al., 2007; Caputo et al., 2004), antioxidants, such as lycopene, β-carotene, lutein, phytophene, phytofluene, vitamin C and E (Ray et al., 2011; Capanoglu et al., 2010; Suárez et al., 2007), phenolic compounds, such as flavonoids and hydroxycinnamic acid derivates including quercetin. kaempferol, rutin, myricetinandnaringenin (Ray et al., 2011; Suárez et al., 2007), vitamins such as vitamin C, E, folic acid, niacin and trace elements e.g. selenium, copper, manganese, iron and zinc (Molla et al., 2012). Surprisingly, tomato is low in fat and free of cholesterol. Therefore, consumption of tomato and tomato products reduced the risk of cardiovascular disease and certain types of cancer, such as cancers of prostate, lung and stomach.

Salinity is one of the most brutal environmental factors limiting the productivity of crop plants because most of the crop plants are sensitive to salinity caused by high concentrations of salts in the soil. A considerable amount of land in the world is affected by salinity, which is increasing day by day. More than 45 million hectares (M ha) of irrigated land which account to 20% of total land have been damaged by salt worldwide and 1.5 M ha are taken out of production each year due to high salinity levels in the soil (Pitman and Lauchli; Munns and Tester, 2008). On the other hand, increased salinity of agricultural land is expected to have destructive global effects resulting in up to 50% loss of cultivable lands by the middle of the twenty-first century (Mahajan and Tuteja, 2005).

Under conditions of high soil salinity, many crop plants, including tomato, are susceptible and cannot survive or can survive only with decreased yields. To alleviate the deleterious effects of salinity, the measures such as the reclamation of salinized lands, the improvement of irrigation with saline water and the cultivation of salt tolerant variety have been applied (Tuna et al., 2007). The positive changes in tomato quality have been obtained under certain salinity treatments (Zushi and Matsuzoe, 2011) but the tomato yield has been reported to be negatively affected by the increasing salinity (Maomao et al., 2014). Therefore, identification of salinity tolerant cultivars for a moderately sensitive crop like tomato becomes an important aspect of research. Therefore, the present research has been undertaken to investigate the effect of different salinity levels on seed germination and seedling growth of tomato varieties, and to select the suitable varieties for further field study.

2 Materials and Methods

The present study was conducted at the Mycology Laboratory, Professor Golam Ali Fakir Seed Pathology Centre, Bangladesh Agricultural University, Mymensingh. Effect of different concentrations of NaCl (0, 25, 50, 100 and 150 mM) on seed germination and subsequent seedling growth of four varieties (V1 = Binatomato-6, V2 = Binatomato-7, V3 = Binatomato-8 and V4 = Binatomato-9) of tomato were investigated.

2.1 Seed germination

Twenty five seeds of each of tomato varieties were germinated in two folds of Whatman no. 1 filter paper placed in Petri dishes (9 cm diameter). The moisture level and salt solution were assessed daily and respected solutions were applied time to time as per requirement. The Petri dishes were kept under constant incubator temperature set at 25±10 °C for 11 days in the laboratory.

2.2 Data collection

Data regarding germination percentage (G_p), coefficient of germination (CG), radicle length, plumule length, radicle fresh weight, plumule fresh weight, plumule dry weight, radicle dry weight, and seedling vigor index were recorded at 2 days interval up to 11 days after sowing (DAS).

2.3 Germination percentage

The Petri dishes were observed every day and the numbers of germinated seeds were recorded at 10:30 a.m. After two days of seed setting in Petri dishes, few of the seeds were germinated. Within 11 days of seed setting in Petri dishes maximum number of seeds were germinated. The germination percentage was calculated using the following formula (Rashid et al., 2010; **?**):

$$G_p = \frac{N_T}{N} \times 100 \quad (1)$$

where N_T is the number of germinated seeds of each treatment for the last time measurement. N is the number of seeds used in the bioassay.

2.4 Coefficient of germination

Co-efficient of germination (CG) was calculated using the following formula (Rashid et al., 2010; **?**).

$$CG = \frac{N_1 + N_2 + \ldots + N_n}{(N_1 \times T_1) + (N_2 \times T_2) + \ldots + (N_n \times T_n)} \times 100 \quad (2)$$

where N_1, N_2,N_n is the number of germinated seeds on T_1 (first), T_2 (second), and T_n (nth) days following the setup of the germination experiment.

2.5 Radicle and plumule length

Randomly selected four seedlings were taken from each Petri dish to measure radicle and plumule length. Length of seedlings was measured after 5 days of seed setting. Radicle and plumule lengths were expressed in centimeter (cm) with the help of a measuring scale.

2.6 Seed vigor index

For determination of seedling vigor index, five seedlings were selected randomly from each Petri dish and their individual plumule and radicle length were measured. The vigor of the seedlings was determined by following the formula (Rauf et al., 2020):

$$VI = \frac{L_R + L_S}{G_p} \quad (3)$$

where L_R, L_S and G_p length of root (cm), length of shoot (cm) and percent germination, respectively.

2.7 Radicle and plumule fresh weight

Radicles and plumule of four seedlings from Petri dish were cut and their fresh weights were expressed in milligram (mg). Weights were taken in four successive periods at 5, 7, 9, and 11 DAS with the help of digital balance.

2.8 Radicle and plumule dry weight

For dry weight, four radicles and plumule were taken randomly from the Petri dishes and dried in an oven at 70 °C for 48 hours till the weight become constant. The dry weights were measured with the help of digital balance and expressed in milligram (mg) and the mean value was calculated.

2.9 Statistical analysis

Data collected during experimental period were tabulated and analyzed following MSTAT-C computer package program. The data were statistically analyzed in respect of seed germination and seedling characters to investigate the statistical significance of the experimental results. The means for all the treatments were calculated and analysis of variance for all the characters under consideration was performed by T variance test. Mean separation was performed by Least Significant Difference (LSD) test (Gomez and Gomez, 1984).

3 Results and Discussion

3.1 Seed germination

The interaction effects of salinity and variety on seed germination percentage have been placed in Table 1. The maximum seed germination (93.33%) was found in the combination of variety Binatomato-6 with the control and the minimum germination percentage (0%) was recorded by the combination of all varieties with 150 mM NaCl concentration (Table 1). V1T0 was statistically similar with V2T0; V1T1 was statistically similar with V4T0 at 11 days after sowing. The combined effect between variety and NaCl concentration were found significant in case of seed germination percentage of tomato (Table 1). Germination percentage was high in lower salinity level and germination percentage gradually decreased with the high salt concentration compare to control. Germination was inhibited at 150mM NaCl concentration in four variety. Similar reductions in germination with increasing salt concentrations was reported in Atriplexgliffithii (Khan et al., 2000). Exposure of tomato seeds to high salt concentrations did not only inhibit germination but also decreased germination rate. Jamil et al. (2005) reported that salinity caused significant reduction in germination percentage, germination rate, root and shoot lengths and fresh root and shoot weights in four species of vegetables. Seed germination percentage was reported to decrease gradually with the increase in salt concentration and germination percentage was satisfactory at low levels of salinity but 0% at higher levels of salinity in other studies (Mostafizur, 2013; Rofekuggaman, 2014; Tofayel, 2018).

3.2 Seed germination coefficient

Data regarding the effect of salinity and variety interaction on germination coefficient of tomato have been placed in Table 2. From the experiment it was found that the maximum germination coefficient (15.55%) was found in the combination of variety Binatomato-6 with the control salt concentration (0 mM) and the minimum germination coefficient (0.00%) was recorded by the combination of all varieties with 150 mM NaCl concentration at 11 DAS (Table 2). V1T0 was statistically similar with V2T0; V1T1 was statistically similar with V3T0 and V4T0; V1T2 was statistically similar with V3T1; V1T2 was statistically similar with V2T2, V4T2; V2T2 was statistically similar with V3T2 and V4T2, V1T3 was statistically similar with

Table 1. Combined effect of varieties and NaCl concentrations on seed germination of tomato at different days after sowing (DAS)

Treatment	Seed germination (%) at different days after sowing (DAS)							
	2 DAS	3 DAS	4 DAS	5 DAS	6 DAS	7 DAS	9 DAS	11 DAS
Binatomato-6								
T0	38.67a	54.67a	81.33a	85.33a	93.33a	93.33a	93.33a	93.33a
T1	13.33e	45.33bc	61.33c	74.67bc	85.33ab	85.33b	85.33b	85.33b
T2	0.00h	12.00g	25.33fg	40.00ef	46.67ef	54.67g	54.67g	54.67g
T3	0.00h	0.00h	9.33hi	22.67hi	26.67hij	33.33k	33.33k	33.33k
T4	0.00h	0.00h	0.00i	0.00j	0.00l	0.00n	0.00o	0.00o
Binatomato-7								
T0	36.0b	50.67ab	72.00ab	82.67ab	92.00a	92.00a	92.00a	92.00a
T1	8.00f	34.67d	42.67d	62.67d	69.33c	74.67d	74.67d	74.67d
T2	0.00h	10.67g	21.33fg	34.67fg	38.67fg	46.67h	49.33h	49.33h
T3	0.00h	0.00h	8.00hi	18.67i	22.67ijk	26.67l	29.33l	29.33l
T4	0.00h	0.00h	0.00i	0.00j	0.00l	0.00n	0.00o	0.00o
Binatomato-8								
T0	18.67d	42.67c	58.67c	65.33cd	81.33b	81.33c	81.33c	81.33c
T1	4.00g	22.67f	30.67ef	41.33ef	54.67de	65.33f	65.33f	65.33f
T2	0.00h	6.67g	16.00gh	22.67hi	29.33hi	38.00j	38.67j	38.67j
T3	0.00h	0.00h	5.33hi	13.33i	14.67k	18.67m	18.67n	18.67n
T4	0.00h	0.00h	0.00i	0.00j	0.00l	0.00n	0.00o	0.00o
Binatomato-9								
T0	21.33c	46.67bc	65.33bc	74.67bc	86.67ab	86.67b	86.67b	86.67b
T1	5.33g	29.33e	37.33de	49.33e	61.33cd	69.33e	69.33e	69.33e
T2	0.00h	8.00g	20.00g	29.33gh	33.33gh	42.67i	42.67i	42.67i
T3	0.00h	0.00h	6.67hi	16.00i	18.67jk	20.00m	22.67m	22.67m
T4	0.00h	0.00h	0.00i	0.00j	0.00l	0.00n	0.00o	0.00o
$LSD_{0.05}$	2.23	5.16	9.68	9.64	8.64	2.48	2.61	2.71
Sig. level	**	**	**	**	**	**	**	**
CV (%)	18.63	17.22	20.9	15.93	12.25	3.24	3.37	3.51

** = Significant at 1% level of probability

Table 2. Combined effect of varieties and NaCl concentrations on germination Coefficient and seed vigor index of tomato seed at 11 days after sowing (DAS)

Treatment	Germination coefficient (%) at 11 DAS	Seed vigor index (%) at 11 DAS
Binatomato-6		
T0	15.55 a	1251.00 a
T1	14.90 b	1006.00 c
T2	13.75 ef	559.50 f
T3	13.09 h	218.90 ij
T4	0.00 i	0.00 m
Binatomato-7		
T0	15.38 a	1134.00 b
T1	14.54 c	803.60 d
T2	13.64 fg	428.00 g
T3	12.98 h	169.00 jk
T4	0.00 i	0.00 m
Binatomato-8		
T0	14.97 b	834.80 d
T1	13.98 e	531.50 f
T2	13.43 g	247.90 i
T3	13.09 h	80.84 l
T4	0.00 i	0.00 m
Binatomato-9		
T0	15.08 b	958.00c
T1	14.28 d	677.90e
T2	13.63 fg	334.10 h
T3	13.11 h	118.80 kl
T4	0.00 i	0.00 m
$LSD_{0.05}$	0.239	58.63
Sig. level	**	**
CV (%)	1.29	7.6

** = Significant at 1% level of probability

Table 3. Combined effect of varieties and NaCl concentrations on radicle length of tomato at different days after sowing (DAS)

Treatment	Radicle length (cm)			
Binatomato-6	5 DAS	7 DAS	9 DAS	11 DAS
T0	5.01 a	6.73 a	7.23 a	7.63 a
T1	4.26 b	5.85 b	6.05 c	6.54 c
T2	3.43 cd	4.68 c	5.07 e	5.48 ef
T3	0.00 i	1.91 h	3.12 h	3.60 i
T4	0.00 i	0.00 j	0.00 l	0.00 l
Binatomato-7				
T0	4.83 a	5.77 b	6.49 b	6.95 b
T1	4.05 b	4.82 c	5.37 d	5.74 de
T2	2.55 f	3.83 e	4.30 f	4.73 g
T3	0.00 i	1.60 hi	2.80 i	3.23 j
T4	0.00 i	0.00 j	0.00 l	0.00 l
Binatomato-8				
T0	3.21 d	4.23 d	4.94 e	5.51 ef
T1	2.91 e	3.75 e	4.15 fg	4.62 gh
T2	1.84 h	2.83 g	3.17 h	3.65 i
T3	0.00 i	1.33 i	1.86 k	2.34 k
T4	0.00 i	0.00 j	0.00 l	0.00 l
Binatomato-9				
T0	3.52 c	4.81 c	5.55 d	6.01 d
T1	3.47 c	4.28 d	4.94 e	5.25 f
T2	2.11 g	3.34 f	3.88 g	4.36 h
T3	0.00 i	1.46 i	2.29 j	2.96 j
T4	0.00 i	0.00 j	0.00 l	0.00 l
$LSD_{0.05}$	0.24	0.35	0.3	0.32
Sig. level	**	**	**	**
CV (%)	7.25	6.88	5.16	4.99

** = Significant at 1% level of probability

Table 4. Combined effect of varieties and NaCl concentrations on plumule length of tomato at different days after sowing (DAS)

Treatment	Plumule length (cm)			
Binatomato -6	5 DAS	7 DAS	9 DAS	11 DAS
T0	3.64 a	4.55 a	5.243 a	5.76 a
T1	3.24 b	4.42 a	4.82 b	5.25 bc
T2	2.53 d	3.34 d	4.34 cd	4.74 de
T3	0.00 h	1.43 h	2.14 gh	2.95 h
T4	0.00 h	0.00 j	0.00 k	0.00 l
Binatomato -7				
T0	3.24 b	4.15 b	4.85 b	5.37 b
T1	2.91 c	3.83 c	4.36 c	5.01 cd
T2	1.85 e	2.90 e	3.55 e	3.93 f
T3	0.00 h	1.22 hi	1.91 hi	2.51 ij
T4	0.00 h	0.00 j	0.00 k	0.00 l
Binatomato -8				
T0	2.54 d	3.64 c	4.25 cd	4.74 de
T1	1.49 f	2.55 f	3.04 f	3.51 g
T2	0.82 g	1.94 g	2.42g	2.75 hi
T3	0.00 h	1.01 i	1.52 j	1.97 k
T4	0.00 h	0.00 j	0.00 k	0.00 l
Binatomato -9				
T0	2.93 c	3.843 c	4.653 b	5.03 cd
T1	2.51 d	3.310d	4.057 d	4.51 e
T2	1.25 f	2.363f	3.047f	3.45 g
T3	0.00 h	1.100 i	1.723 ij	2.25 jk
T4	0.00 h	0.0000 j	0.0000 k	0.00 l
$LSD_{0.05}$	0.244	0.27	0.28	0.295
Sig. level	**	**	**	**
CV (%)	10.26	7.14	6.05	5.64

** = Significant at 1% level of probability

V2T3, V3T3 and V4T3 at 11 days after sowing. The germination coefficient was significantly influenced with the increasing levels of NaCl concentration. Effect of different varieties and NaCl concentrations on germination coefficient of tomato was found significant at different day after sowing (DAS). Similar results in six tomato seeds were found by Rofekuggaman (2014).

3.3 Seed vigor

Table 2 shows the effect of salinity and variety interaction on seed vigor of tomato at 11 days after sowing. The maximum seed vigor (1251.00) was found in the combination of variety Binatomato-6 with the control salt concentration (0 mM) and the minimum seed vigor (0.00) was recorded by the combination of all varieties with 150mM NaCl concentration at 11 DAS (Table 2). The seed vigor was significantly affected with the increasing levels of NaCl concentration. Effect of different varieties and NaCl concentrations on seed vigor of tomato was found significant at 11 days after sowing (DAS). Supporting findings was also observed by other researchers (Mostafizur, 2013; Rofekuggaman, 2014; Tofayel, 2018).

3.4 Radicle length

Data regarding the effect of salinity and variety interaction on radicle length of tomato have been placed in Table 3. The combined effect of variety and NaCl concentration had significant effect on the radicle length of tomato. The maximum radicle length (7.63 cm) was found in combination of the variety Binatomato-6 with the control salt concentration (0 mM) and the minimum radicle length (0.00 cm) was recorded by the combination of all varieties with 150mM NaCl concentration at 11 DAS (Table 3). The radicle length was significantly influenced with the increasing levels of NaCl concentration. Effect of different varieties and NaCl concentrations on radical length of tomato was found significant at different days after sowing (DAS). The result finding under the present study was conformity with Abdelhamid et al. (2010), Shibli et al. (2007), Jamil et al. (2005) and Kayum (2016).

3.5 Plumule length

Data regarding the combined effect of varieties and NaCl concentrations on plumule length of tomato have been placed in Table 4. From the experiment it was revealed that the plumule length was significantly influenced by the interaction effect of varieties and NaCl concentrations. The maximum plumule length (5.76 cm) was found in the combination of the variety Binatomato-6 with the control salt concentration (0 mM) at 11 DAS. The minimum plumule length (0 cm) was recorded with the combination of all varieties of tomato seed with 150 mMNaCl concentration at 11 DAS (Table 4). V1T1 was statistically similar with V2T0, V2T1, V4T0; V2T1 is statistically similar with V1T2, V3T0 and V4T0. V1T2 was statistically similar with V3T0 and V4T1. V3T1 was statistically similar with V4T2. The plumule length was significantly influenced with the increasing levels of NaCl concentration. Effect of different varieties and NaCl concentrations on plumule length of tomato was found significant at different days after sowing (DAS). The result obtained from the present study was similar with the findings of Abdelhamid et al. (2010), Shibli et al. (2007), Jamil et al. (2005), Eaftakher (2017), Tofayel (2018) and Rofekuggaman (2014).

3.6 Radicle fresh weight

Data regarding the combined effect of varieties and NaCl concentrations on radicle fresh weight of tomato have been placed in Table 5. From the experiment it was found that the radicle fresh weight was significantly influenced by the interaction effect of varieties and NaCl concentrations. The maximum radicle fresh weight (14.51 mg) was found in the combination of variety Binatomato-6 with the control salt concentration (0 mM) and the minimum radicle fresh weight (0.00 mg) was recorded by the combination of all varieties with 150 mM NaCl concentration at 11 DAS (Table 5). V3T0 was statistically similar with V4T1; V3T0 was statistically similar with V2T2; V3T1 was statistically similar with V4T2 at 11 days after sowing. The radicle fresh weight was significantly influenced with the increasing levels of NaCl concentration (Table 5). The result obtained from the present study was similar with the findings of Kayum (2016), Eaftakher (2017), Mostafizur (2013), Tofayel (2018) and Rofekuggaman (2014).

3.7 Radicle dry weight

Data regarding the effect of salinity and variety interaction on radicle dry weight of tomato at different days after sowing (DAS) have been placed in Table 6. From the experiment it was found that the radicle dry weight was significantly influenced by the interaction effect of varieties and NaCl concentrations. The maximum radicle dry weight (2.05 mg) was found in the combination of variety Binatomato-6 with the control salt concentration (0 mM) and the minimum radicle dry weight (0.00 mg) was recorded by the combination of all varieties with 150 mM NaCl concentration at 11 DAS (Table 6).

V4T0 was statistically similar with V1T1, V2T1, V2T0 and V3T0; V4T1 was statistically similar with V2T1, V1T2, V3T0 and V3T1; V3T1 was statistically similar with V1T2 and V2T2; V1T3 was statistically similar with V3T2 and V4T2; V4T3 was statistically similar with V2T3 and V3T3 at 11 days after sowing.

Table 5. Combined effect of varieties and NaCl concentrations on radicle fresh weight of tomato at different days after sowing (DAS)

Treatment	Radicle fresh weight (mg)			
Binatomato-6	5 DAS	7 DAS	9 DAS	11 DAS
T0	6.07 a	9.25 a	12.83 a	14.51 a
T1	5.05 b	8.86 b	10.03 c	12.05 c
T2	4.03 c	6.03 d	8.05 e	11.06 d
T3	0.00 g	2.94 i	4.52 k	6.76 j
T4	0.00 g	0.00 m	0 p	0.00 o
Binatomato-7				
T0	5.04 b	8.00 c	10.82 b	12.57 b
T1	4.06 c	5.53 e	7.44 f	9.53 f
T2	3.04 d	4.51 g	6.05 i	8.05 h
T3	0.00 g	2.20 j	3.5 m	5.53 l
T4	0.00 g	0.00 m	0 p	0.00 o
Binatomato-8				
T0	3.25 d	5.15 f	7.1 g	8.25 gh
T1	2.74 e	3.24 hi	5.05 j	7.36 i
T2	2.00 f	3.04 i	4.05 l	6.31 k
T3	0.00 g	1.51 l	2.52 o	4.05 n
T4	0.00 g	0.00 m	0 p	0.00 o
Binatomato-9				
T0	4.05 c	6.25 d	8.65 d	9.95 e
T1	3.05 d	4.51 g	6.35 h	8.43 g
T2	2.74 e	3.54 h	5.06 j	7.24 i
T3	0.00 g	1.85 k	3.05 n	5.03 m
T4	0.00 g	0.00 m	0 p	0.00 o
$LSD_{0.05}$	0.245	0.309	0.291	0.304
Sig. level	**	**	**	**
CV (%)	6.58	4.86	3.36	2.7

** = Significant at 1% level of probability

Table 6. Combined effect of varieties and NaCl concentrations on radicle dry weight of tomato at different days after sowing (DAS)

Treatment	Radicle dry weight (mg)			
Binatomato-6	5 DAS	7 DAS	9 DAS	11 DAS
T0	1.55 a	1.74 a	1.95 a	2.05 a
T1	1.31 b	1.55 b	1.73 b	1.84 b
T2	1.00 d	1.24 c	1.35 d	1.45 ef
T3	0.00 h	0.74 f	0.85 f	0.90 h
T4	0.00 h	0.00 h	0.00 i	0.00 k
Binatomato-7				
T0	1.40 b	1.53 b	1.75 b	1.85 b
T1	1.15 c	1.31 c	1.51 c	1.61 cde
T2	0.75 f	0.93 de	1.16 e	1.25 g
T3	0.00 h	0.55 g	0.66 g	0.74 i
T4	0.00 h	0.00 h	0.00 i	0.00 k
Binatomato-8				
T0	1.14 c	1.36 c	1.50 c	1.62 cd
T1	0.83 ef	1.05 d	1.22 de	1.33 fg
T2	0.50 g	0.70 f	0.85 f	0.94 h
T3	0.00 h	0.40 g	0.44 h	0.55 j
T4	0.00 h	0.00 h	0.00 i	0.00 k
Binatomato-9				
T0	1.31 b	1.40 bc	1.62 bc	1.75 bc
T1	0.95 de	1.24 c	1.35 d	1.48 def
T2	0.60 g	0.80 ef	0.95 f	1.05 h
T3	0.00h	0.45g	0.55 gh	0.65ij
T4	0.00h	0.00h	0.00 i	0.00k
$LSD_{0.05}$	0.116	0.148	0.148	0.157
Sig. level	**	**	**	**
CV (%)	11.28	10.52	9.02	8.87

** = Significant at 1% level of probability

Table 7. Combined effect of varieties and NaCl concentrations on plumule fresh weight of tomato at different days after sowing (DAS)

Treatment	Plumule fresh weight (mg)			
Binatomato-6	5 DAS	7 DAS	9 DAS	11 DAS
T0	14.05 a	17.95 a	21.46 a	23.51 a
T1	13.04 b	16.50 b	18.02 c	20.03 c
T2	9.03 f	13.06 f	14.95 g	18.06 e
T3	0.00 l	8.11 k	11.06 m	14.07 j
T4	0.00 l	0.00 o	0.00 q	0.00 n
Binatomato-7				
T0	12.01 c	16.10 c	19.62 b	21.56 b
T1	10.53 d	14.55 d	16.06 e	18.15 e
T2	7.99 h	11.15 h	13.05 j	16.07 g
T3	0.00 l	7.08 l	9.01 n	12.05 k
T4	0.00 l	0.00 o	0.00 q	0.00 n
Binatomato-8				
T0	9.01 f	13.88 e	15.55 f	18.05 e
T1	7.55 i	12.03 g	13.57 i	16.05 g
T2	6.05 k	9.03 j	11.55 l	15.04 i
T3	0 l	5.03 n	7.04 p	10.16 m
T4	0 l	0 o	0 q	0.00 n
Binatomato-9				
T0	10.04 e	14.83 d	17.05 d	19.53 d
T1	8.51 g	13.06 f	14.66 h	17.45 f
T2	7.03 j	9.96 i	12.54 k	15.42 h
T3	0 l	6.03 m	8.05 o	11.05 l
T4	0 l	0 o	0 q	0.00 n
$LSD_{0.05}$	0.239	0.281	0.271	0.271
Sig. level	**	**	**	**
CV (%)	2.54	1.8	1.46	1.23

** = Significant at 1% level of probability

Table 8. Combined effect of varieties and NaCl concentrations on plumule dry weight of tomato at different days after sowing (DAS)

Treatment	Plumule dry weight (mg)			
Binatomato-6	5 DAS	7 DAS	9 DAS	11 DAS
T0	0.81 a	0.93 a	1.10 a	1.20 a
T1	0.60 bc	0.81 ab	0.94 b	1.02 b
T2	0.35 ef	0.50 de	0.67 de	0.75 de
T3	0.00 h	0.30 fg	0.35 gh	0.44 gh
T4	0.00 h	0.00 h	0.00 j	0.00 j
Binatomato-7				
T0	0.65 b	0.81 ab	0.95 b	1.05 b
T1	0.45 de	0.60 cd	0.70 d	0.91 bc
T2	0.25 fg	0.38 ef	0.48 fg	0.60 ef
T3	0.00 h	0.23 g	0.27 hi	0.34 ghi
T4	0.00 h	0.00 h	0.00 j	0.00 j
Binatomato-8				
T0	0.41 e	0.65 c	0.76 cd	0.83 cd
T1	0.34 ef	0.46 e	0.55 ef	0.62 ef
T2	0.15 g	0.22 g	0.27 hi	0.35 ghi
T3	0.00 h	0.16 g	0.19 i	0.24 i
T4	0.00 h	0.00 h	0.00 j	0.00 j
Binatomato-9				
T0	0.52 cd	0.70bc	0.86 bc	0.95bc
T1	0.40 e	0.50de	0.62 def	0.79cd
T2	0.20 g	0.27 fg	0.35 gh	0.50 fg
T3	0.00h	0.20g	0.24 hi	0.29 hi
T4	0.00h	0.00h	0.00 j	0.00 j
$LSD_{0.05}$	0.104	0.128	0.138	0.148
Sig. level	**	**	**	**
CV (%)	23.94	19.38	17.37	16.21

** = Significant at 1% level of probability

The radicle dry weight was significantly influenced with the increasing levels of NaCl concentration. Similar results on radicle dry weight also observed by Shibli et al. (2007), Jamil et al. (2005), Eaftakher (2017), Kayum (2016) and Tofayel (2018).

3.8 Plumule fresh weight

Data regarding the combined effect of varieties and NaCl concentrations on plumule fresh weight of tomato have been placed in Table 7. From the experiment it was found that the plumule fresh weight was significantly influenced by the interaction effect of varieties and NaCl concentrations. The maximum plumule fresh weight (23.51 mg) was found in the combination of variety Binatomato-6 with the control salt concentration (0 mM) and the minimum plumule fresh weight (0.00 mg) was recorded by the combination of all varieties with 150 mMNaCl concentration at 11 DAS (Table 7). V1T2 was statistically similar with V2T1 and V3T0; V2T2 was statistically similar with V3T1 at 11 days after sowing. Effect of different varieties and NaCl concentrations on plumule fresh weight of tomato was found significant at different days after sowing (DAS). Similar findings were observed by Mostafizur (2013), Rofekuggaman (2014), Abdelhamid et al. (2010), Jamil et al. (2005) and Yilmaz et al. (2004).

3.9 Plumule dry weight

Data regarding the combined effect of varieties and NaCl concentrations on plumule dry weight of tomato seedlings have been placed in Table 8. From the experiment it was found that the plumule fresh weight was significantly influenced by the interaction effect of varieties and NaCl concentrations (Table 8). The maximum plumule dry weight (1.20 mg) was found in the combination of variety Binatomato-6 with the control salt concentration (0 mM) and the minimum plumule dry weight (0.00 mg) was recorded by the combination of all varieties with 150 mMNaCl concentration at 11 DAS (Table 8). V4T0 was statistically similar with V1T1, V2T0, V2T1 and V3T0; V4T1 was statistically similar with V1T2 and V3T0; V3T1 was statistically similar with V1T2, V2T2 and V4T2; V2T3 and V3T2 were statistically similar with V1T3, V4T2 and V4T3; V3T3 was statistically similar with V4T3 at 11 days after sowing. Effect of different varieties and NaCl concentrations on plumule dry weight of tomato was found significant at different days after sowing (DAS). These results were in agreement with the findings of Abdelhamid et al. (2010), Shibli et al. (2007), Jamil et al. (2005), Yilmaz et al. (2004) and **?**.

4 Conclusion

From the results of the varieties of tomato were evaluated against five salinity levels, the germination of seed was varied significantly with the variety and salt concentrations. The results showed that the performance of Binatomato-6 was comparatively better in salt concentration. In case of the combined effect of variety and salt concentration, Binatomato-6, Binatomato-7, Binatomato-9 showed better performance than Binatomato-8. The results demonstrated that the variety Binatomato-6, Binatomato-7 and Binatomato-9 are relatively salt tolerant than Binatomato-8.Therefore it can be concluded that germination and seedling growth decreased with the increasing levels of NaCl concentration, the studied tomato cultivars can tolerate salinity below 150 mM regarding to all germination and seedling growth parameters, and the performance of Binatomato-6 was comparatively better in salt concentration.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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