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Evaluation of Tomato Cultivars Irrigated with Saline Water

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ABSTRACT

Pot experiments were conducted at a sandy soil in West Nubariya, Behayira Governorate, Egypt, to investigate the effect of saline water on the growth of tomato cultivars. Eleven cultivars of tomato (102, Pitobrid, 186, Nivert.737, 449, Nora.765, Logian, Darian.42, Privio, Thoria, 023) are irrigated with saline water. Saline irrigation water was prepared from mixtures of NaCl and $CaCl_2$ pure salts (2:1, w/w) at the levels; none saline water, 2000, 3000 and 4000 ppm.

The obtained data revealed that the applications of saline water (2000, 3000, and 4000 ppm) significantly decrease the either shoot or roots of tomato cultivars compared with control treatment. Maximum shoot of tomato cultivars is achieved with the application of non-saline water. Also, the obtained data showed that cultivars of tomato can be descending according to salinity tolerance as: 102 > Pitobrid > 186 > 449 > Nivert737 > Nora 765 > Logian > Darian 42 > Privio > Thoria > 023.

The data showed the differences of Na^+ and Cl^- content in shoot of tomato cultivars were significant and increased with increasing application rates of saline water. The highest content of sodium chloride was found in "023" tomato cultivar, which is sensitive to salinity.

Key words: Tomatoes seedlings; Sodium chloride and Calcium chloride, vegetative growth

INTRODUCTION

One of the most important vegetable crops, tomato (*Lycopersicon esculentum* Mill), is grown on the most land of any vegetable (**Jensen *et al*., 2010**). In the world, tomatoes rank third in terms of consumption after potatoes and sweet potatoes. The production of tomatoes worldwide in 2019 was estimated at 1808 million tons.

Salinity of soil or irrigation water is a major factor limiting the growth of vegetable crops. The horizontal expansion in agricultural land depends partially at least on the availability and quality of irrigation water and the level of soil salinity. Use of saline water led to the gradual increase of salinity in the root zone of tomato plants (**Feleafel and Mirdad, 2014**). The maximum soil salinity level tolerated by tomato without reduction in the yield is EC 2.5 dS m^{-1} (**Campos *et al*., 2006**). **Boamah *et al*. (2011)** illustrated that use of saline water (4 dS m^{-1}) for drip irrigation led to a linear reduction in the number of fruits, yield, and average fruit mass of tomato. The use of irrigation water with EC 1.7, 2.3, 3.4 and 5.0 dS m^{-1} led to reductions in tomato yield by 0, 10, 25 and 50%, respectively.

The use of irrigation is essential in the production of tomato seedlings. Water quality is crucial for the better health and quality of tomato seedlings. Cultivating tomato plants on saline soils and irrigation with saline water is one of the main environmental challenges limiting global agricultural production. It must be addressed to obtain high yields **(Oliveira *et al*., 2022**).

Several studies have indicated that when saline water is used for irrigation, more attention should be given to minimize root-zone salinity. Others have indicated the need to select appropriate irrigation systems and practices that will supply a sufficient quantity of water to the root zone to meet the evaporative demand and to minimize salt accumulation inside the root zone. Other approach is to select crops and varieties that can tolerate a degree of water and salinity stress **(Singh *et al*., 2011**; **Helaly *et al*., 2017**; **El-Mogy *et al.*, 2018** and **Sumalan *et al.*, 2020)**.

The main objective of this study is to quantify the effects of saline water irrigation on tomato cultivars growth in sandy soil under pot experiment.

MATERIALS AND METHODS

A pot experiment was conducted in green house, during 1^{st} of March to the 1^{st} of May, 2021 season, farm at Bilal Ibn Rabah village, West Nubariya region, Behayira Governorate, Egypt. (31º 21 N - 30º21 N) to evaluate eleven cultivars of tomato to salt tolerance on vegetative growth, their content of sodium and chloride.

Soil samples were collected from soil depth (0 – 20 cm) before planting. The texture class of soil samples is sandy soil (88% sand, 5.76% silt, and 6.24% clay) with bulk density 1.62 Mg/m^3. EC 1.52 dSm^{-1} and pH 7.65.

Table (1) Chemical properties of the irrigation water used in the study before salting

pH	Ec dS m^{-1}	EC (ppm)	Cation (meq/L)				Anion (meq/L)				SAR
			Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3^{2-}	HCO_3^-	SO_4^{2-}	Cl^-	
7.19	0.58	268.8	2.05	0.72	2.97	0.15	0.00	1.89	1.94	2.06	1.08

Twelve kilograms of sandy soil were introduced into plastic pots with dimensions 20 x 25 cm. The sand was mixed with 5 % organic matter (decomposing compost) and brought to field moisture capacity daily by saline water.

Eleven cultivars of the most common tomato cultivars in Egypt were chosen (102, Pitobrid, 186, Nivert.737, 449, Nora.765, Logian, Darian.42, Privio, Thoria, 023) then tomato seeds previously washed with redistilled water were uniformly sown per pot.

All pots were irrigated with water artificiality slated with sodium chloride and calcium chloride at a ratio of NaCl: $CaCl_2$ (2:1) with concentrations of (0, 2000, 3000 and 4000 ppm) using drip irrigation system and the number of irrigation times was according to the field capacity. Fertilizer application was according to the recommendations of the Egyptian Ministry of Agriculture.

Tomato plants were thinned after 10 days of cultivation to 6 plants for each pot. The agricultural operations continued until the age of 60 days from planting (the end of experiment).

The shoots were harvested at the age of two months (60 days), then they were dried at 70 °C and their dry weight was determined. Also, the root system was collected and dry weight was determined.

After drying, the shoots and roots were ground and samples were wet digested using concentrated sulfuric acid and hydrogen peroxide (30 %).

Sodium was measured in digestion solution using a flame photometer, according to **Chapman and Pratt (1961)**. Also, chloride was determined using Mohrs method (**Jackson, 1973**).

Soil pH and EC were determined before planting and after harvest (**Sparks *et al*., 1996**).

Experiment design:

The experimental design was a split-plots in a randomized complete block design with five replications. The experiment consisted of 44 treatments; which represent the combinations among the two factors; the main plot was the irrigation with saline water which was arranged as the 11 tomato cultivars sub-main plots.

RESULTS AND DISCUSSION

Data in Table (2) represent the response of shoot tomato cultivars to the level of saline water. The applications of saline water at all saline levels (2000, 3000, and 4000 ppm) significantly decrease the shoot of all tomato cultivars compared to non-saline water. Maximum shoot cultivars tomato is achieve with the application compared to non-saline water. These results are in agreement with those obtained by **Oliveira *et al*. (2022) and Guo *et al*. (2022)** who found that the growth characteristic of tomato seedlings was decreased with the increased electrical conductivity (EC_w) of irrigation water. **Shivani *et al*. (2022)** reported that salinity water causes retardation in growth and development of tomato plants during both vegetative as well as reproductive phases. Higher concentrations of NaCl (50 and 100 mM) resulted in significant reduction in all vegetative growth parameters, including number of lateral shoots, fresh and dry weight of shoots and roots and stem diameter.

Moreover, all saline water treatments decreases shoot of tomato by an average of 17.75, 39.71 and 62.06 % with salinity water 2000, 3000 and 4000 ppm, respectively compared to the control. While, an decrease in shoot of tomato cultivars Pitobrid, 186, Nivert.737, 449, Nora 765, Logian, Darian.42, Privio, and Thoria, 023 by an average of 7.96, 14.58, 29.46, 22.91, 33.11, 39.28, 47.09, 49.70, 57.51 and 57.21 % compared to 102 tomato cultivar, respectively.

Data in Table (3) represent the response of root of tomato cultivars due to the application of saline water. The applications of saline water at all concentration (2000, 3000, and 4000 ppm) significantly decrease the root of tomato. Maximum yield of root is achieved with the application of non-saline water. These results are in agreement with those obtained by **Oliveira *et al*. (2022) and Guo *et al*. (2022)** who found that the root and total dry matter of tomato were lower according to the increase in the electrical conductivity of irrigation water, with a decrease of 77 % using 10 dS m^{-1} water.

Saline water decreased root of tomato yield by an average of 14.46, 27.30, and 40.00 % with the application of 2000, 3000 and 4000 ppm, respectively compared to control. Moreover, all saline water decreased root of tomato cultivars yield by an average of 24.44, 35.69, 42.54, 29.82, 42.05, 44.00, 51.10, 53.54, 56.23, and 58.43 % with tomato cultivars Pitobrid, 186, Nivert.737, 449, Nora.765, Logian, Darian.42, Privio, and Thoria, 023, respectively compared to 102 tomato cultivar.

Table (4) shows that the values of Na^+ content in tomato shoot ranged from 0.431 to 1.304 % due to increasing the application levels of saline water. Sodium content in shoots of tomato is affected by either level of saline water application or the tomato cultivars. The highest increment in Na^+ content in tomato shoot was achieved higher application of 4000 ppm of saline water. The highest content of sodium chloride was found in "023" tomato cultivar, which is sensitive to salinity. This result is in agreement with those obtained by **Magan *et al*. (2008), Munns and Tester (2008)** who found that the irrigation with saline water (4.5 dS/m) increased the concentration of chloride and sodium in the leaves regardless of the irrigation method and water management strategy used.

The difference Na^+ content in tomato shoot between tomato cultivars and used of saline water was significant and increased with increasing application rates of saline water. Moreover, the level of saline water application increased sodium content in tomato shoot by an average of 24.63, 93.34 and 203.17% with the application of 2000, 3000 and 4000 ppm respectively, compared to non-saline water. Also, all tomato cultivars increase Na^+ content shoot by an average -7.68, -6.08, 1.59, 4.92, 12.89, 12.89,22.46, 23.76, 32.31 and 37.82 %, with tomato cultivars; Pitobrid, 186, Nivert.737, 449, Nora.765, Logian, Darian.42, Privio, and Thoria, 023, compared to 102 tomato cultivars control, respectively.

Table (5) show that the values of Cl^- content in tomato shoot ranged from 0.293 to 2.388 % due to increasing the application rates of saline water and ranged from 1.278 to 1.853% due to application the tomato cultivars. Cl− content in tomato shoot is affected by either level of saline water or cultivars of tomato application. The highest increment in Cl^- content in tomato shoot was achieved saline water with higher application rates of 4000 ppm.Data presented in Table (5) the difference Cl^- content in tomato shoot between cultivars tomato and used of saline water was significant and increased with increasing application rates of saline water. Moreover, the level of application saline water increased Cl^- content in tomato shoot by an average of 347.44, 551.19 and 715.01 % with the application of 2000, 3000 and 4000 ppm respectively, compared to non-saline water. Also, all tomato cultivars increase Cl^- content shoot by an average -1.76, 2.69, -5.61, -5.68, 4.45, 28.28, 29.05, 27.05, 24.90, and 42.42 % with the application tomato cultivars; Pitobrid, 186, Nivert.737, 449, Nora.765, Logian, Darian.42, Privio and Thoria, 023, respectively, compared to control with the application of 102 tomato cultivar.

Table (2): Effect of interaction between salinity water concentrations and tomato cultivars on dry shoot of tomato (gm/pot).

Tomato cultivars	Salinity water (ppm)				Mean cultivars
	0	2000	3000	4000	
102	17.21	15.06	13.43	8.07	13.44
Pitobrid	15.88	14.41	12.0	7.11	12.37
186	16.04	13.15	10.31	6.41	11.48
Nivert.737	13.99	12.27	8.28	4.58	9.48
449	15.16	13.83	6.18	6.27	10.36
Nora.765	14.45	10.96	6.26	4.30	8.99
Logian	12.49	8.62	8.03	3.51	8.16
Darian.42	9.95	8.49	6.08	3.93	7.11
Privio	9.40	7.65	6.62	3.35	6.76
Thoria	8.48	6.48	4.58	3.28	5.71
023	9.40	6.24	4.11	3.23	5.75
Mean salinity water	12.95	10.65	7.81	4.91	
LSD value at 0.05					
Salinity water	**0.200**				
Cultivars	**0.330**				
Salinity x Cultivars	**0.660**				

Table (3): Effect of interaction between salinity water concentration and tomato cultivars on dry root (gm/pot).

Tomato cultivars	Salinity water (ppm)				Mean cultivars
	0	2000	3000	4000	
102	4.74	4.20	3.99	3.45	4.09
Pitobrid	3.68	3.20	3.07	2.43	3.09
186	3.33	2.9	2.33	1.97	2.63
Nivert.737	2.67	2.5	2.09	2.14	2.35
449	3.79	3.02	2.53	2.17	2.87
Nora.765	3.49	2.41	2.21	1.40	2.37
Logian	3.08	2.40	2.27	1.43	2.29
Darian.42	2.61	2.19	1.74	1.49	2.00
Privio	2.45	2.13	1.72	1.31	1.90
Thoria	2.32	2.06	1.51	1.30	1.79
023	1.95	2.16	1.33	1.37	1.70
Mean Salinity water	3.10	2.65	2.25	1.86	
LSD value at 0.05					
Salinity water	**0.100**				
Cultivars	**0.170**				
Salinity x Cultivars	**0.330**				

Table (4): Effect of interaction between water salinity concentration and tomato cultivars on Na^+ (%) content in shoot of tomato plants.

Tomato cultivars	Salinity water (ppm)				Mean cultivars
	0	2000	3000	4000	
102	0.415	0.540	0.865	0.940	0.690
Pitobrid	0.405	0.470	0.810	0.865	0.637
186	0.400	0.410	0.790	0.990	0.648
Nivert.737	0.415	0.505	0.760	1.125	0.701
449	0.360	0.455	0.790	1.295	0.724
Nora.765	0.320	0.565	0.760	1.470	0.779
Logian	0.485	0.565	0.705	1.395	0.779
Darian.42	0.465	0.575	0.945	1.395	0.845
Privio	0.445	0.610	0.855	1.505	0.854
Thoria	0.505	0.595	0.915	1.635	0.913
023	0.525	0.605	0.950	1.725	0.951
Mean salinity water	0.431	0.536	0.831	1.304	
LSD value at 0.05					
Salinity water	0.020				
Cultivars	0.010				
Salinity x Cultivars	0.050				

Table (5): Effect of interaction between water salinity concentration and tomato cultivars on Cl^- (%) content in the shoot of tomato plants.

Tomato cultivars	Salinity water (ppm)				Mean Cultivars
	0	2000	3000	4000	
102	0.270	1.255	1.490	2.190	1.301
Pitobrid	0.245	1.085	1.680	2.105	1.278
186	0.290	1.175	1.830	2.050	1.336
Nivert.737	0.325	0.975	1.625	1.990	1.228
449	0.270	1.000	1.295	2.425	1.227
Nora.765	0.340	1.090	1.490	2.515	1.359
Logian	0.315	1.680	2.175	2.505	1.669
Darian.42	0.290	1.385	2.285	2.755	1.679
Privio	0.265	1.690	2.055	2.600	1.653
Thoria	0.310	1.390	2.370	2.430	1.625
023	0.305	1.700	2.700	2.705	1.853
Mean salinity water	0.293	1.311	1.908	2.388	
LSD value at 0.05					
Salinity Water	0.040				
Cultivars	0.060				
Salinity x Cultivars	0.120				

Conclusion:

From the results obtained, we can conclude that the high concentration of salinity water, which ranged from 2000 to 4000 ppm, led to significant decreases in the weights of tomato cultivars compared to the control. The obtained data showed that the cultivars of tomato can be descending according tolerance to irrigation water as follow: 102 > Pitobrid > 186 > 449 > Nivert 737 > Nora.765 > Logian > Darian 42 > Privio > Thoria > 023.

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