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HORTICULTURE | ORIGINAL ARTICLE

Effects of salinity stress on the seed germination and seedling characters of carrots (*Daucus carota* L.)

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ABSTRACT

Carrot is an important root vegetable and salinity has strong effect on its seed germination and seedling characters. An experiment was conducted at the Postgraduate Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from July to August, 2023 to study the effect of salinity stress on the seed germination and seedling characters of four carrot varieties. The two-factor experiment consisted of four carrot varieties viz. Orange king, Orange star, Sangal and Red lady, and five salinity levels viz. control (tap water), 25 mM, 50 mM, 75 mM and 100 mM NaCl. The experiment was laid out in completely randomized design with three replications. Results revealed that salinity and carrot varieties significantly influenced all the parameters studied. The highest seed germination (44.44%) was obtained from Orange king while the lowest (32.89%) was obtained from Red lady. The highest seed germination (41.11%) was obtained from 100 mM NaCl solution and the lowest (34.44%) was found from 75 mM NaCl. Among the treatment combinations, the highest seed germination (60.00%) was obtained from Orange king along with 50 mM NaCl. The maximum radicle (15.46 mm) and plumule length (12.36 mm), leaf size (5.50 mm), number of leaves (2.73) and seedling height (27.82 mm) was obtained from Orange king. Maximum plumule length (13.27 mm), leaf size (5.98 mm) and seedling height (23.27mm) was obtained from control treatment and maximum number of leaves (2.08) from 25 mM NaCl solution. Among the treatment combinations, highest radicle length (18.27 mm), plumule length (17.40 mm), leaf size (7.60 mm), seedling height (35.67 mm) was obtained from Orange king along with 25 mM NaCl solution. Therefore, Orange king along with 50 mM NaCl solution and 25 mM NaCl solution was found to be better in respect of seed germination and seedling characters of carrots compared to other treatments respectively.

1. Introduction

Carrot (*Daucus carota* L.) is a biennial, dicotyledonous, herbaceous plant belongs to the family Apiaceae (Peirce, 1987) and it is thought to be native to the Mediterranean region (Shinohara, 1984), where it was first cultivated as a crop. It is an important vegetable crop in the world. Carrot is one of the most ancient vegetables grown all over the temperate regions in spring, summer and autumn. Carrots, however, are grown in the winter in tropical and subtropical regions. Carrots are valuable because of their high nutritional content, versatility in cooking, and ability to store for a long time. It contains appreciable amount of carotene (10 mg/100 g), thiamine (0.04 mg/100 g), riboflavin (0.05 mg/100 g) (Sharfuddin and Siddique, 1985) and also a considerable amount of carbohydrates (10.6%), protein (0.9 g/100 g), fat (0.2 g/100 g) and vitamin C (3mg/100 g) (Jahan et al., 2019). Carrot roots have endogenous sugar levels that are ten times higher in sucrose than in glucose and fructose. Moreover, carrot is a rich source of vitamin A. This vital ingredient may even help prevent measles, cancer, and age-related macular degeneration since it functions as an antioxidant that protects cells. Deficiency of vitamin A can cause xerophthalmia, a disorder that can impair normal vision and cause night blindness (NIH, 2022). It is used to make pickles, jam, and sweet foods, as well as salads and cooked vegetables in soups, stews, and curries, among other recipes (Kabir et al., 2000).

Carrots are becoming more and more popular every day, mostly in urban areas of Bangladesh. In Bangladesh, the

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total amount of carrots produced in the year 2018–19 was 30387.416 tonnes, with 2321.508 hectares under cultivation (BBS, 2020). Carrot is grown in most of the districts of Bangladesh mainly Dhaka, Manikgonj, Pabna, Rajshahi, Bogra, Dinajpur, Gaibandha, Rangpur and Panchagar. Carrot production is greatly influenced by mulching and micronutrients (Akand et al. 2023). However, there are a number of reasons for low carrot yields in Bangladesh such drought, salinity and poor soil management. Throughout the world's arid and semi-arid regions, salinity is a significant abiotic environmental barrier to agricultural productivity (Foolad and Lin, 1997). Annually, 10 million hectares of land are becoming salinized to a point where the land can no longer sustain adequate crop production. This is because of high rates of evapotranspiration and widespread irrigation, which cause more salt to build up in the soil (Rozema and Flowers, 2008). The majority of plants classified as glycophytic include the farmed carrot (Daucus carota var. sativus). While halophytes, or salt-loving plants, can flourish in extreme salinity, glycophytes growth is significantly inhibited in saline soils due to their absence of physiological processes like salt glands and bladders (Flowers et al., 2010). Water absorption can be hindered by harmful ions entering the plant, which decreases water absorption, and can also negatively impact seed germination and development. Germination of carrot seed is greatly influenced by salinity stress (Bolton and Simon, 2019). Salinity has the potential to impact carrot growth and yield by either producing osmotic pressure that inhibits water absorption or by causing toxic effects from salt and chloride ions (Hopper et al., 1979). In addition to cytoplasmic sodium toxicity and drought stress, high salinity also results in ion imbalance (Ward et al., 2003).
Bangladesh, a low-lying deltaic land, with total area of 1, 47, 570 km2. The Ganges, Brahmaputra, Tista, Jamuna, Meghna, and their tributaries which are directly or indirectly connected with the Bay of Bengal, causes majority of the alluvial deposition (around 80%). The country's continuously increasing sea level has recently led to an increase in the salinity of the soil in the southern part of the nation. A one-meter rise in sea level will have an impact on Bangladesh's vast coastal region and flood plain zone (Sarwar, 2005). In an experiment, Jahan et al. (2019) showed that carrot can tolerate low salinity condition. In areas where salt affects the fields, it causes plants to grow less, which is a huge challenge for agriculture yield. Considering the above statements it is important to find out salt tolerant carrot variety for cultivation in saline prone areas of Bangladesh. Therefore, this study was conducted to find out the effects of different levels of salinity stress on seed germination and seedling characters of four carrot varieties.

2. Materials and Methods

2.1. Experimental site

The experiment was carried out at the Postgraduate Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from July-August 2023.

2.2. Experimental treatments

The experiment consisted of two factors viz., Factor A: four types of carrot varieties (G_1=Orange king, G_2=Orange star, G_3=Sangal, G_4=Red lady) and Factor B: five salinity levels (T_0= Control, T_1= 25 mM saline solution, T_2= 50 mM saline solution, T_3= 75 mM saline solution, T_4= 100 mM NaCl solution). Two-factor experiment was carried out in completely randomized design with three replications.

2.3. Methods of preparation of saline solution

The saline solutions were prepared by dissolving 0.73, 1.46, 2.19, 2.92 g of sodium chloride (NaCl) in 500 ml of distilled water for making the concentration of 25 mM, 50 mM, 75 mM and 100 mM salt solutions, respectively.

2.4. Experimental setup

Firstly, the filter papers were cut according to the size of the petri dishes and placed properly in petri dishes. Then fifteen seeds of each carrot varieties were placed on them and the recommended treatments were applied in each petri dish.

2.5. Parameters measured

Data on various parameters such as percentage of seed germination, radicle and plumule length, leaf size, number of leaves, seedling height were recorded from the sample during experimentation at 10, 13, 16 and 19 days after planting. Number of seeds germinated were counted at three days interval and then converted into percent germination.

$$Seed\ germination\ (\%) = \frac{\text{No. of seeds germinated}}{\text{Total number of seeds}}\ x\ 100$$

Radicle length, plumule length, leaf length were measured by using a scale and expressed in millimeters (mm). Mean value of five randomized seeds were calculated from each petri dish and expressed in millimeters**.**

2.6. Statistical analysis

The data on various parameters were statistically analysed using MSTAT computer program. The mean values for all the parameters were calculated and the analysis of variance for the characters was accomplished by F variance test. The significance of difference between pair of means was tested by the Least Significant Difference (LSD) test at 5 and 1% levels of probability (Gomez and Gomez, 1984).

3. Results

3.1. Seed germination percentage

Seed germination percentage was recorded at 10, 13, 16 and 19 days after planting. The highest seed germination percentage attained from Orange king were 2.67, 24.00, 34.22 and 44.44 at 10, 13, 16 and 19 days whereas the lowest percentage attained from Red lady were 3.11, 26.67, 29.78 and 32.89 at 10, 13, 16 and 19 days respectively (Figure 1).

Salinity level also significantly influenced seed germination percentage. The highest seed germination percentage was recorded from 100 mM NaCl solution were 1.67, 23.89, 32.50 and 41.11 and lowest from 75mM NaCl solution were 0.56, 18.34, 26.39 and 34.44 at 10, 13, 16 and 19 days (Figure 2). Simon et al., (2019) stated that there were several carrot genotypes collected from naturally saline non-agricultural land had shown tolerance to salinity. This might be a cause to show higher germination percentage at 100 mM NaCl solution. The interaction of genotype and salinity level had significant effect on seed germination. At 19 days, highest germination percentage (60.00) was recorded from Orange king with 50mM NaCl solution (G_1T_2) and the lowest (26.67) was recorded from Red lady with 50mM NaCl solution (G_4T_2) (Table 1). This might be due to the genotypic characters of Orange king to be tolerant to salinity (Bolton and Simon, 2019.)

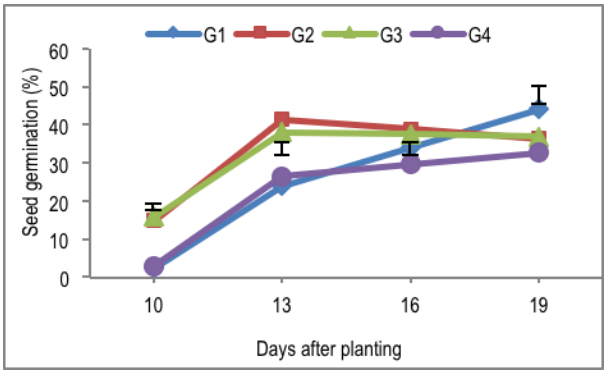

Figure 1. Effect of genotype on seed germination percentage at different days after planting (10, 13, 16 and 19 days) and vertical bar represents LSD at 1% level of significance. G1= Orange king, G2= Orange star, G3= Sangal, G4= Red lady.

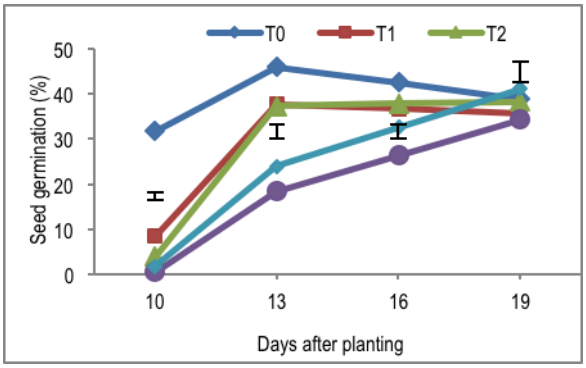

Figure 2. Effect of treatment on seed germination percentage at different days after planting (10, 13, 16 and 19 days) and vertical bar represents LSD at 1% level of significance. T0= Control, T1= 25mM, T2= 50 mM, T3¬= 75mM, T4= 100 mM of NaCl solution.

3.2. Length of radicle

There was a significant effect of genotype on radical length of carrot at different days after planting Orange king was observed with highest radicle length 13.29, 13.71, 14.10 and 15.46 mm and Red lady with the lowest length 5.28, 5.51, 5.95 and 5.45 mm at 10, 13, 16 and 19 days, respectively (Figure 3). The usage of different treatment levels had shown a significant effect on radicle length of carrot. Treatment with 100 mM NaCl solution had shown the highest radicle length 8.99, 9.20, 9.61 and 10.99 mm and that of 75 mM treatment with the lowest radicle length 7.25, 7.60, 8.02 and 7.51 mm at 10, 13, 16 and 19 days interval (Figure 4). Effect of salinity level on different genotypes of carrot was found significant. The genotype Orange king treated with 25 mM NaCl solution was observed with highest radicle length (18.27 mm) whereas the Red lady treated with 75 mM NaCl solution was found with lowest radicle length (3.67 mm) (Table 2).

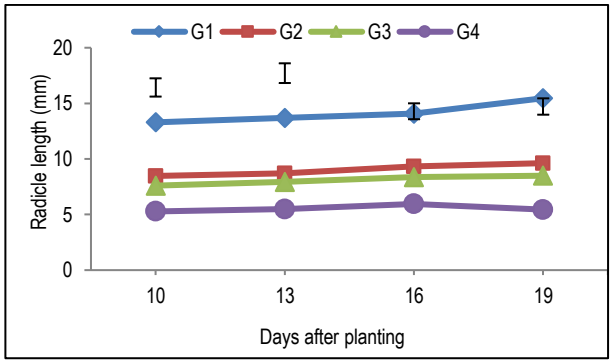

Figure 3: Effect of genotype on radicle length at different days after planting (10, 13, 16 and 19 days). Vertical bar shows the LSD at 1% level of significance. G1 = Orange king, G2 = Orange star, G3 = Sangal, G4 = Red lady.

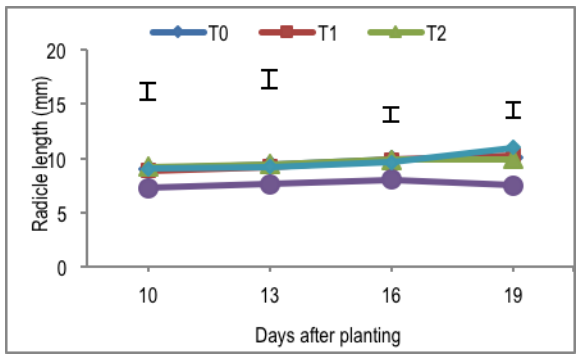

Figure 4. Effect of treatment on radicle length at different days after planting (10, 13, 16 and 19 days) and the vertical bar represents LSD at 1% level of significance. T_0= Control, T_1= 25mM, T_2= 50 mM, T_3= 75mM, T_4= 100 mM of NaCl solution.

3.3. Length of plumule

There was a significant effect of genotype on plumule length. Orange king was found with highest plumule length 11.28, 11.48, 11.65 and 12.36 mm and that of Orange star with a lowest plumule length 7.51, 7.71, 7.88 and 8.57 mm at 10, 13, 16 and 19 days respectively (Figure 5). Salinity level had a significant effect on plumule length of carrot. Highest length of plumule was observed in control (tap water) treatment 12.37, 12.43, 12.63 and 13.27mm at 10,

13, 16 and 19 days. The result obtained is in similarity with the findings of Jahan et al., (2019). The lowest plumule length was observed in treatment of 75 mM NaCl solution 7.28, 7.47, 7.64 and 8.01 mm at 10, 13, 16 and 19 days respectively (Figure 6). The combined effect of salinity level and genotypes of carrot on plumule length was found significant. The highest plumule length (17.40 mm) was observed in Orange king treated with 25 mM NaCl solution and that of lowest plumule length (3.73 mm) was observed in Orange star in 25 mM NaCl solution (Table 3).

3.4. Leaf size

Genotype had a significant effect on leaf size of carrot at different days after planting. Orange king was found with highest leaf size 4.78. 5.28 and 5.50 mm and that of Orange star with lowest leaf size 3.74, 4.22 and 4.42 mm at 13, 16 and 19 days after planting (Figure 7). There was a significant effect of salinity levels on leaf size of carrot at different days after planting. In control condition (tap water) the highest size of leaf was obtained 4.85, 5.46 and 5.98 mm and lowest size of leaf was obtained in treatment of 75mM NaCl solution 3.34, 3.79 and 3.93 mm at 13, 16 and 19 days after planting respectively (Figure 8). There was a significant combined effect of genotype and salinity level on leaf size of carrot at different days after planting. Orange king treated with 25 mM NaCl solution (G_1T_1) was found with highest leaf size (7.60 mm) and Orange star treated with 75 mM NaCl (G_2T_3) solution had the lowest leaf size (2.27 mm) at 19 days after planting (Table 4).

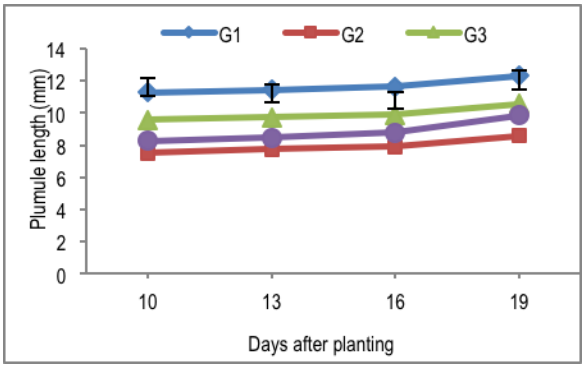

Figure 5. Effect of treatment on plumule length at different days after planting (10, 13, 16 and 19 days) and vertical bar represents LSD at 1% level of significance. T0= Control, T1= 25mM, T2= 50 mM, T3¬= 75mM, T4= 100 mM of NaCl solution.

3.5. Number of leaves

Genotype had a significant effect on number of leaves/plant of carrot at different days after planting. The highest number of leaves/plant was found in Orange king 1.60, 2.73, 2.73 and the lowest number of leaves/plant was found in Red lady 0.73, 1.07, 1.13 at 13, 16 and 19. The highest number of leaves/plant was observed with 25mM NaCl solution 1.58, 1.92, 2.08 whereas the lowest number of leaves/plant was observed in 50mM NaCl solution 0.75, 1.75, 1.75 at 10, 13, 16 and 19 days after planting (Figure10). Combined effects of genotype and salinity level on number of leaves/plant were found significant.

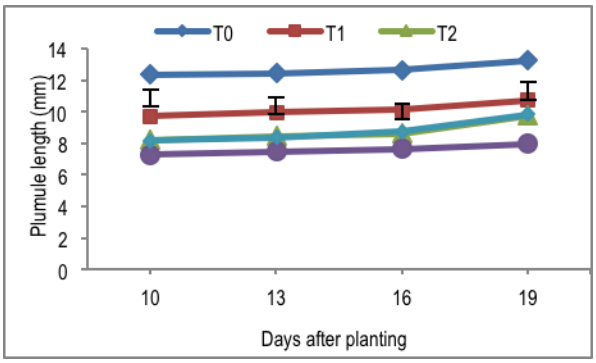

Figure 6. Effect of treatment on plumule length at different days after planting (10, 13, 16 and 19 days) and vertical bar represents LSD at 1% level of significance. T0= Control, T1= 25mM, T2= 50 mM, T3¬= 75mM, T4= 100 mM of NaCl solution.

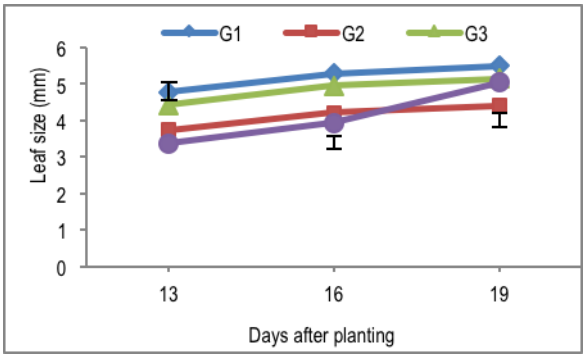

Figure 7. Effect of genotype on leaf size at different days after planting (10, 13, 16 and 19 days) and vertical bar represents LSD at 1% level of significance. G1= Orange king, G2= Orange star, G3= Sangal, G4= Red lady.

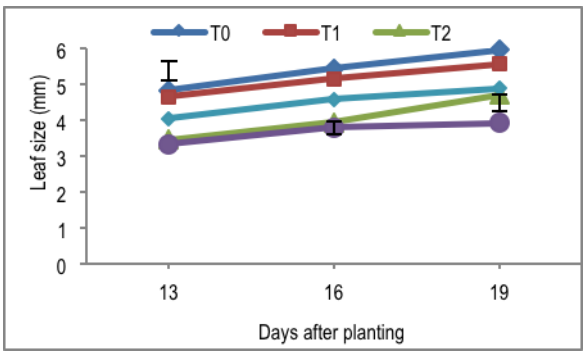

Figure 8. Effect of treatment on leaf size at different days after planting (10, 13, 16 and 19 days) and vertical bar represents LSD at 1% level of significance. T0= Control, T1= 25mM, T2= 50 mM, T3¬= 75mM, T4= 100 mM of NaCl solution.

The highest number of leaves/plant (4.00) was observed in Orange star in controlled condition (tap water) (G_2T_0) and the lowest number of leaves/plant (0.00) was observed in Sangal treated with 75 mM NaCl solution (G_2T_3) at 19 days after planting (Table 5).

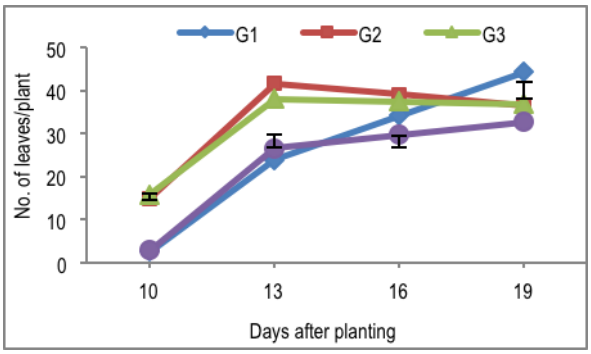

Figure 9. Effect of genotype on number of leaves at different days after planting (13, 16 and 19 days) and vertical bar represents LSD at 1% level of significance. G1= Orange king, G2= Orange star, G3= Sangal, G4= Red lady.

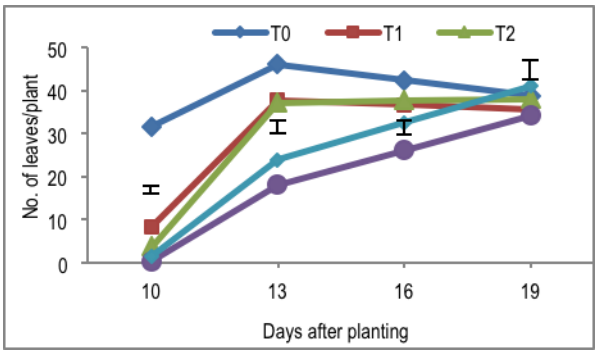

Figure 10. Effect of treatment on number of leaves/plant at different days after planting (13, 16 and 19 days) and the vertical bar represents LSD at 1% level of significance. T_0= Control, T_1= 25mM, T_2= 50 mM, T_3= 75mM, T_4= 100 mM of NaCl solution.

3.6. Seedling height

Genotype had a significant effect on seedling height of carrot at different days after planting. The highest seedling height was observed in Orange king 24.57, 25.19, 24.88 and 27.82 mm and that of lowest height was observed in Red lady 13.53, 13.98, 14.75 and 15.30 mm at 10, 13, 16 and 19 days after planting (Figure 11). Salinity level had a significant impact on seedling height at different days after planting. The highest seedling height was observed in controlled condition (tap water) 21.42, 21.83, 22.48 and 23.27 mm at 10, 13, 16 and 19 days after planting (Figure 12).

The result is in accordance with the findings of Jahan et al., (2019). The lowest seedling height was observed in treatment of 75 mM NaCl solution 14.53, 15.08, 15.65 and 15.52 mm at 10, 13, 16 and 19 days after planting. There was a significant combined effect of genotype and salinity level on seedling height of carrot at different days after planting. The highest seedling height was observed in Orange king treated with 25 mM NaCl solution (G_1T_1) (35.67 mm) and the lowest seedling height was observed in Red lady treated with 75 mM NaCl solution (G_4T_3) (10.87 mm) at 19 days after planting (Table 6). This might be due to the genotypic characters of Orange king to be tolerant to salinity.

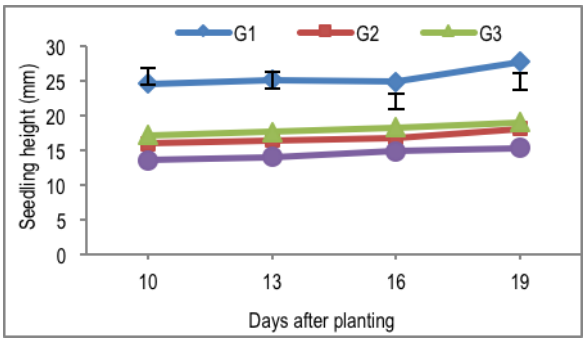

Figure 11. Effect of genotype on seedling height at different days after planting (10, 13, 16 and 19 days) and vertical bar represents LSD at 1% level of significance. G_1= Orange king, G_2= Orange star, G_3= Sangal, G_4= Red lady.

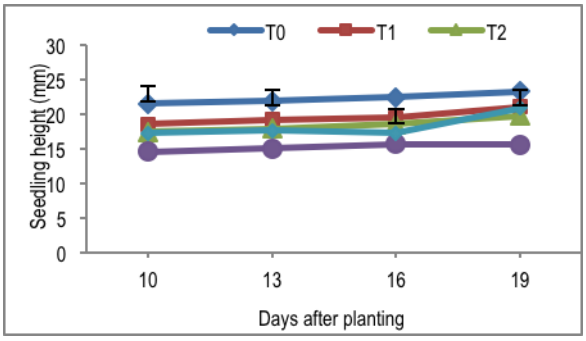

Figure 12. Effect of treatment on number of leaves/plant at different days after planting (10,13, 16 and 19 days) and vertical bar represents LSD at 1% level of significance. T_0= Control, T_1= 25mM, T_2= 50 mM, T_3= 75mM, T_4= 100 mM of NaCl solution.

Table 1. Combined effects of genotype and salinity level on percent seed germination of carrot at different days after planting

Treatment combination	Seed germination (%) at different days after planting			
	10	13	16	19
G_1T_0	8.89	51.11	44.45	37.78
G_1T_1	2.22	31.11	36.67	42.22
G_1T_2	0.00	20.00	40.00	60.00
G_1T_3	0.00	13.33	24.45	35.55
G_1T_4	2.22	4.43	25.55	46.67
G_2T_0	53.33	40.00	43.33	46.67
G_2T_1	8.89	40.00	37.78	35.55
G_2T_2	11.11	51.11	41.11	31.11
G_2T_3	2.22	31.11	30.00	28.88
G_2T_4	0.00	46.67	43.33	40.00
G_3T_0	48.89	46.67	44.44	42.22
G_3T_1	22.22	53.33	41.11	28.89
G_3T_2	4.44	48.89	42.22	35.56
G_3T_3	0.00	15.57	23.33	31.11
G_3T_4	4.44	26.67	36.67	46.67
G_4T_0	15.56	46.67	37.78	28.89
G_4T_1	0.00	26.66	31.11	35.56
G_4T_2	0.00	28.89	27.78	26.67
G_4T_3	0.00	13.33	27.78	42.22
G_4T_4	0.00	17.78	24.44	31.11
$LSD_{0.05}$	3.08	5.68	5.64	8.04
$LSD_{0.01}$	4.12	7.60	7.55	10.76
Level of sig.	**	**	**	**

** = Significant at 1% level of probability G1= Orange king, G2 =Orange star, G3=Sangal, G4= Red lady; T0 = Control, T1 =25 mM, T2=50 mM, T3= 75 mM, T4= 100 mM.

Table 2. Combined effects of genotype and salinity level on radicle length of carrot at different days after planting

Treatment combination	Radicle length (mm) at different days after planting			
	10	13	16	19
G_1T_0	9.57	10.33	10.78	11.13
G_1T_1	15.73	16.00	16.45	18.27
G_1T_2	16.47	16.67	17.12	17.33
G_1T_3	12.20	12.93	13.23	13.60
G_1T_4	12.47	12.60	12.90	16.97
G_2T_0	11.33	11.53	11.98	11.93
G_2T_1	7.07	7.20	8.50	8.47
G_2T_2	8.97	9.27	9.72	9.93
G_2T_3	5.58	5.82	6.27	6.17
G_2T_4	9.40	9.67	10.12	11.60
G_3T_0	9.87	10.07	10.52	10.73
G_3T_1	7.43	8.27	8.72	8.83
G_3T_2	6.73	6.93	7.38	7.20
G_3T_3	5.47	5.67	6.12	6.60
G_3T_4	8.50	8.73	9.18	9.07
G_4T_0	5.43	5.67	6.12	6.20
G_4T_1	5.07	5.33	5.78	5.73
G_4T_2	4.57	4.77	5.17	5.33
G_4T_3	5.73	6.00	6.45	3.67
G_4T_4	5.60	5.80	6.25	6.33
$LSD_{0.05}$	1.93	2.06	1.67	1.72
$LSD_{0.01}$	2.58	2.76	2.24	2.31
Level of sig.	**	**	**	**

** = Significant at 1% level of probability G1= Orange king, G2 =Orange star, G3=Sangal, G4= Red lady; T0 = Control, T1 =25 mM, T2=50 mM, T3= 75 mM, T4= 100 mM.

Table 3. Combined effects of genotype and salinity level on plumule length of carrot at different days after planting

Treatment combination	Plumule length (mm) at different days after planting			
	10	13	16	19
G_1T_0	11.04	11.27	11.47	12.27
G_1T_1	16.30	16.53	16.73	17.40
G_1T_2	11.37	11.60	11.80	13.07
G_1T_3	9.98	10.13	10.27	10.53
G_1T_4	7.71	7.87	8.00	8.53
G_2T_0	13.04	13.27	13.47	14.07
G_2T_1	3.39	3.47	3.53	3.73
G_2T_2	7.90	8.13	8.33	8.53
G_2T_3	5.59	5.82	6.02	6.65
G_2T_4	7.64	7.87	8.07	9.87
G_3T_0	14.70	14.27	14.47	14.93
G_3T_1	9.84	10.40	10.60	11.10
G_3T_2	6.66	6.89	7.09	7.37
G_3T_3	7.18	7.33	7.47	7.67
G_3T_4	9.50	9.73	9.93	11.73
G_4T_0	10.70	10.93	11.13	11.80
G_4T_1	9.24	9.47	9.67	10.67
G_4T_2	7.11	7.27	7.40	10.28
G_4T_3	6.37	6.60	6.80	7.20
G_4T_4	7.84	8.07	9.00	9.27
$LSD_{0.05}$	1.39	1.34	1.29	1.44
$LSD_{0.01}$	1.86	1.79	1.73	1.93
Level of sig.	**	**	**	**

** = Significant at 1% level of probability G1= Orange king, G2 =Orange star, G3=Sangal, G4= Red lady; T0 = Control, T1 =25 mM, T2=50 mM, T3= 75 mM, T4= 100 mM.

Table 4. Combined effects of genotype and salinity level on leaf size of carrot at different days after planting

Treatment combination	Leaf size (mm) at different days after planting		
	13	16	19
G_1T_0	3.23	3.83	4.92
G_1T_1	6.87	7.47	7.60
G_1T_2	5.73	6.20	6.33
G_1T_3	4.28	4.68	4.60
G_1T_4	3.80	4.20	4.07
G_2T_0	6.20	6.80	7.00
G_2T_1	1.89	2.09	2.33
G_2T_2	3.93	4.53	4.97
G_2T_3	2.02	2.42	2.27
G_2T_4	4.67	5.27	5.55
G_3T_0	6.47	7.08	7.33
G_3T_1	5.97	6.57	7.00
G_3T_2	1.72	2.12	2.30
G_3T_3	4.07	4.47	4.47
G_3T_4	3.87	4.48	4.58
G_4T_0	3.51	4.11	4.67
G_4T_1	3.93	4.53	5.40
G_4T_2	2.53	2.93	5.33
G_4T_3	3.00	3.60	4.40
G_4T_4	3.83	4.43	5.37
$LSD_{0.05}$	0.81	0.57	0.67
$LSD_{0.01}$	1.08	0.76	0.90
Level of sig.	**	**	**

** = Significant at 1% level of probability G1= Orange king, G2 =Orange star, G3=Sangal, G4= Red lady; T0 = Control, T1 =25 mM, T2=50 mM, T3= 75 mM, T4= 100 mM.

Table 5. Combined effects of genotype and salinity level on number of leaves/plant of carrot at different days after planting

Treatment combination	No. of leaves/plant at different days after planting		
	13	16	19
G_1T_0	0.33	1.67	1.67
G_1T_1	3.00	3.67	3.67
G_1T_2	1.00	2.67	2.67
G_1T_3	2.67	3.00	3.00
G_1T_4	1.00	2.67	2.67
G_2T_0	3.33	4.00	4.00
G_2T_1	0.67	0.67	0.67
G_2T_2	0.33	0.67	0.63
G_2T_3	0.00	0.00	0.00
G_2T_4	0.33	0.67	0.67
G_3T_0	2.00	1.67	1.67
G_3T_1	1.67	2.33	2.67
G_3T_2	0.00	1.00	1.00
G_3T_3	1.00	1.67	1.67
G_3T_4	1.33	2.33	2.33
G_4T_0	1.00	0.67	0.67
G_4T_1	1.00	1.00	1.33
G_4T_2	0.33	1.00	1.00
G_4T_3	1.00	1.33	1.33
G_4T_4	0.33	1.33	1.33
$LSD_{0.05}$	0.43	0.77	0.88
$LSD_{0.01}$	0.57	1.03	1.18
Level of sig.	**	**	**

** = Significant at 1% level of probability G1= Orange king, G2 =Orange star, G3=Sangal, G4= Red lady; T0 = Control, T1 =25 mM, T2=50 mM, T3= 75 mM, T4= 100 mM.

Table 6. Combined effects of genotype and salinity level on seedling height of carrot at different days after planting

Treatment combination	Seedling height (mm) at different days after planting			
	10	13	16	19
G_1T_0	20.60	21.60	22.25	23.40
G_1T_1	32.04	32.53	33.18	35.67
G_1T_2	27.84	28.27	28.92	30.40
G_1T_3	22.18	23.07	23.50	24.13
G_1T_4	20.18	20.47	16.57	25.50
G_2T_0	24.37	24.80	25.45	26.00
G_2T_1	10.46	10.67	10.03	12.20
G_2T_2	16.87	17.40	18.05	18.47
G_2T_3	11.17	11.63	12.28	12.82
G_2T_4	17.04	17.53	18.18	21.47
G_3T_0	24.57	24.33	24.98	25.67
G_3T_1	17.27	18.67	19.32	19.93
G_3T_2	13.39	13.82	14.47	14.57
G_3T_3	12.65	13.00	13.58	14.27
G_3T_4	18.00	18.47	19.12	20.80
G_4T_0	16.14	16.60	17.25	18.00
G_4T_1	14.30	14.80	15.45	16.40
G_4T_2	11.68	12.03	12.57	15.62
G_4T_3	12.10	12.60	13.25	10.87
G_4T_4	13.44	13.87	15.25	15.60
$LSD_{0.05}$	2.86	2.79	2.46	2.78
$LSD_{0.01}$	3.83	3.74	3.29	3.71
Level of sig.	**	**	**	**

** = Significant at 1% level of probability G1= Orange king, G2 =Orange star, G3=Sangal, G4= Red lady; T0 = Control, T1 =25 mM, T2=50 mM, T3= 75 mM, T4= 100 mM.

4. Conclusion

Salinity has significant effect on germination of carrot genotypes. Orange king has shown significant response to salt stress. The highest radicle length, plumule length, leaf size and seedling height were observed from Orange king in 25 mM NaCl solution. Highest seed germination percentage was obtained from Orange king in 50 mM nutrient solution. But number of leaves per plant was observed in Orange star in controlled condition. Therefore, it can be concluded that Orange king showed relatively salt tolerant capacity than the other varieties.

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Conflict of interest

The authors have declared that no competing interests exist.

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