J. Hortic. Agric. Sci. Vol. 2(1), 91-99, 2025
www.jahps.org
https://doi.org/10.63459/jhas.2025.1.19

Research article Available on: https://jahps.org OPEN ACCESS

Journal of Horticulture and Agricultural Sciences

Effect of Salt Stress (Nacl) on Seed Germination and Vegetative Growth of Hollyhock (*Althea rosea* L.)

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Submitted on: 15-04-2025 ***Revised on: 29-05-2025*** ***Accepted on: 22-06-2025***

ABSTRACT

Salinity is alarming issue to crop production worldwide. Evaluation of crop plants at early growth stages is perquisite to determine tolerance of plants to salt stress. The pot experiment was performed during 2019 to analyze the impact of salt stress (NaCl) on germination and growth attributes of hollyhock (*Althea rosea* L.) genotypes. The trial was set up at the nursery of Sindh Agriculture University Tandojam employing completely randomized design (factorial). The seed germination and vegetative growth was evaluated in two genotypes of hollyhock that included Halo Blush and Scarlet Eye. The treatments included S_1 = Canal water (Control), S_2 =3.0 dS m^{-1}, S_3 =6.0 dS m^{-1}, S_4 = 9.0 dS m^{-1} and S_5 = 12.0 dS m^{-1}. The germination and growth of plants were substantially affected by salinity levels. The seeds sown by applying canal water produced vigorous plants with higher germination. Moreover, plants irrigated with canal water revealed maximum foliage production with better shoot and root growth. Additionally minimum electrolyte leakage was also noticed in plants irrigated with canal water. Plants irrigated with water having EC 3 dSm^{-1} ranked 2nd and considerably showed better germination and performance for other studied parameters. The salinity at 6, 9 and 12 dS m^{-1} caused simultaneously undesirable impact on all the investigated traits with the exception to electrolyte leakage of leaf that augmented parallel to the elevated salt stress conditions. In case of genotypes "Halo Blush" performed better for most of the investigated traits as compared to "Scarlet Eye" This indicates that Halo Blush had more tolerance to salinity as compared to Scarlet Eye.

Key words: Salt stress, NaCl, Seed germination, Growth, Holly hock

INTRODUCTION

Hollyhock (*Althea rosea* L.) is a famous landscape plant that comes in Malvaceae family, native to Southern Europe, the Middle East and Central Asia. A hollyhock displays a variety of colours, such as white, pink, yellow, orange, dark red, and purple. Based on its life cycle, this tall and attractive flower can be annual, biennial or perennial in nature and normally attains a height up to 9 feet. It is well known for its upright growth and large crinkled corolla (petals) (Fahamiya et al., 2016.). It can be sown as rear view in landscapes or as a bedding plant in gardens as well as grown near fences and walls. It is also recommended for cottage gardens and for border plantations. Moreover, the tall stems of hollyhock make it an ideal choice for use as a cut flower. Hollyhock has a wide range of medicinal properties and is recommended for relieving asthma, cough, irritated stomach, throat swelling and its pain and kidney pain, due to presence of bodily fluid mucilage extracted from roots and seeds of plants (Parvaiz et al., 2015). Salinity is the major abiotic concern, limiting productivity of crop plants, especially in areas where the soil contains medium to high salt concentration and the evaporation rate is high (Hayat et al., 2020). The occurrence of sodium chloride (NaCl) is common in most salt-affected soils. The abundance of NaCl in soil reduces the consumption of water and nutrients. It results in osmotic pressure, toxicity of ions, instabilities of nutrients and water shortage. Increased salt ion levels also damage photosynthetically active leaves, leading to chlorosis and early senescence of the leaves (El Sabagh et al., 2011). Germination and early growth phases of

crop plants are regarded as one of the most susceptible phases to salt stress (Shelke et al. 2017). The excessive salinity above tolerance levels led to a huge reduction in germination ratio, germination rate, individual root lengths and shoots, and fresh root weights. (Jamil et al., 2006). Such impacts cause negative modifications inside the physiological and biochemical processes in seed germination. Excessive saline conditions can also prevent water absorption, making germination impossible, whereas lower salinity levels cause dormant conditions within the seed (Ibrahim, 2018). The latest reviews have examined numerous antioxidant compounds, like plant growth regulators that are effective in reducing toxicity to salt stress (Shalata & Neuman 2001). The plants' growth cycle, life span and productivity remain hinder under salt stress conditions. Salt stress causes drastic impacts on plants' life. (Ashraf, 2003). An excessive amount of salt in the water and soil showed a highly adverse effect on the physiological, biochemical and morphological characteristics of crop plants (Yadav et al. 2011). Biochemical and molecular research have shown dramatic increases in reactive oxygen species (ROS), along with single oxygen ($1O_2$), superoxide (O_2), hydroxyl radical (OH) and hydrogen peroxide (H_2O_2) respectively. (Ahmad etal., 2010).

Sodium chloride (NaCl) is the dominant salt that triggers salinization, and plants are supposed to have evolved mechanism to regulate its accumulation. (Munns & Tester, 2008). As soon as NaCl is consumed by plant roots, elevated salt absorption in plants can generate ionic toxicity, hyper osmotic pressure, and oxidative damage, harm metabolic processes and decrease photosynthetic activity (Dkhil et al., 2014). Excessive salinity inside the root area impacts the growth of numerous plant species (Sikder, 2020). Saline soils comprise more than one kind of soluble salt additives, each of which has a specific effect on the preliminary growth of plants (Tobe et al., 2003). Therefore, the physiological processes of poor seed germination induced by salt stress should be studied and appropriate measures should be developed to minimize the adverse effects of salinity on seed germination, thus adopting sustainable strategies for farming crops on saline soils (Wu et al., 2014).

Considering the aforementioned facts, a pot experiment was carried out to investigate the *e*ffect of salinity on germination and growth of hollyhock

MATERIALS AND METHOD

Location of the experiment: The pot experiment was conducted at the nursery of Sindh Agriculture University during 2019 to evaluate seed germination and growth response of hollyhock (*Althea rosea* L) genotypes under salt stress.

Experimental design and treatment details: For the current study, completely randomized design (CRD) was applied with three replications. Plants were irrigated against five salinity doses/concentrations that included canal water having EC 0.7 dS m^{-1}) and 3, 6, 9 and 12 dS m^{-1}. Seeds were sown in earthen pots. Two pots represent each replication and in each pot nine seeds were sown. Earthen pots were filled with the growing medium comprises of canal sediments and compost at the ratio of 3:1 for sowing of the seeds.

Plant material: The seeds of two commonly grown genotypes of holly hock flower (Halo Blush and Scarlet Eye) were procured from Sky Seeds Company

Preparation of salinity levels/concentrations: Salinity levels were prepared and adjusted in a definite volume of canal water by applying common salt sodium chloride (NaCl). The calculated amount of NaCl was dissolved in canal water to create saline water with definite salinity concentrations, Saline water was applied to the plants on every 3rd day and critically monitored for any insect pests and disease incidence. All the required cultural practices including hoeing and weeding were performed manually to all the pots uniformly. The experiment was run up to 45 days. The data for germination and shoot and root associated parameters were taken. The electrolyte leakage in leaves of plants of each treatment was also measured to evaluate the impact of salt stress on plants.

Observations recording methodology

Germination percentage: Germination of seeds was examined up to 11th day of sowing of seeds and the germination percentage was measured by following equation suggested by Larsen and Andreasen (2004).

$$\mathbf{GP = \Sigma n/ N \times 100}$$

Where n is number of germinated seeds and N is total seeds sown in each treatment.

Seedling vigor index (SVI): was measured by using the formula described by Abdul-Baki and Anderson, (1970).

Vigor index (VI) = seedling length (cm) × germination percentage

The leftover parameters including leaves count, fresh shoot and root biomass, root length and electrolyte leakage in leaves of plants were measured after one and half months (45 days) old seedlings

Electrolyte leakage of leaf (EL): The electrolyte leakage (membrane integrity) was assessed by applying the formula suggested by (Bajji et al., 2002). First of all, leaf tissues weighing 0.5 g were rinsed in distilled water for removal of surface ions. Samples were then placed in test tube filled with 25 ml of distilled water for incubation for period of three hours at room temperature. After incubation, initial conductivity of solution was taken which was considered as value A. The same leaf samples were then boiled for 15 minutes to rupture all cells for complete release of electrolytes. After the cooling process final conductivity of solution was measured that was considered as value B. The EL was then calculated by applying the formula:

$$\mathbf{EL\ (\%) = (Value\ A/Value\ B) \times 100}$$

Statistical analysis: The data were analyzed using Statistix-8.1 computer software (Statistix, 2006). The least significant difference (LSD) test at P≤ 0.05 probability level was performed to compare the results and performance of the treatments.

RESULTS

Germination (%): The results revealed highly significant effects of salt stress conditions and genotypes on hollyhock germination, while interactions results showed no significant influence on germination. The results in (Table-1) reveal that the maximum germination of hollyhock (85.00%) was observed in seeds given canal water (Control), followed by average germination of 82.50% and 68.00%, noted in the pots treated with 3 dS m^{-1} and 6 dS m^{-1}, respectively. while the minimum germination (40.50%) was found under 12 dS m^{-1}. The results pertaining to genotypes showed that the germination of "Halo Blush" was notably superior (67.53%) than its counterpart "Scarlet Eye" (63.93%). The interaction results showed that best germination (86.66%) was observed in Halo Blush irrigated with canal water; and the poorest germination (38.33%) was noted in "Scarlet Eye" irrigated with high saline water having EC 12 dS m^{-1}. The LSD test displayed no significant difference between canal water and 3 dS m^{-1} saline condition, while a highly significant difference was found among other salt stress conditions.

Table-1 Germination (%) of hollyhock genotypes as affected by different salinity levels

Salinity levels	**Genotypes**		**Mean**
	Halo Blush	**Scarlet Eye**	
S_1 = Canal Water (Control)	86.66	83.33	85.00 A
S_2 =3 dS m^{-1}	84.00	81.00	82.50 A
S_3 =6 dS m^{-1}	70.00	66.00	68.00 B
S_4 =9 dS m^{-1}	54.33	51.00	52.66 C
S_5 =12 dS m^{-1}	42.66	38.33	40.50 D
Mean	67.53 A	63.93 B	
Variables	**Salinity levels**	**Genotypes**	**S x G**
SE±	1.9854	1.2557	2.8078
LSD 0.05	4.1713	2.6381	5.8990
P-Value	0.0000	0.0103	0.9970

Germination index: The maximum germination index of hollyhock (1.13) was noted in seeds sown in pots irrigated with canal water (Control), followed by germination index of 1.08 and 0.75, noted in the seeds sown in pots treated with 3dS m^{-1} and 6dS m^{-1}, respectively. Whereas the minimum germination index (0.22) was found under 12 dS m^{-1}. Pertaining to genotypes, the germination index of "Halo Blush" was considerably higher (0.75) than "Scarlet Eye" (0.71).

Table-2 Germination index of hollyhock genotypes as affected by different salinity levels

Salinity levels	**Genotypes**		**Mean**
	Halo Blush	**Scarlet Eye**	
S_1 = Canal water (Control)	1.16	1.11	1.13 A
S_2 =3 dS m^{-1}	1.10	1.06	1.08 B
S_3 =6 dS m^{-1}	0.78	0.73	0.75 C
S_4 =9 dS m^{-1}	0.48	0.45	0.47 D
S_5 =12 dS m^{-1}	0.25	0.19	0.22 E
Mean	0.75 A	0.71 B	
Variables	**Salinity levels**	**Genotypes**	**S x G**
SE±	0.0199	0.0126	0.0281

LSD 0.05	0.0418	0.0264	0.0591
P-Value	0.0000	0.0029	0.9681

Seedling vigour index: There was a significant (P<0.05) impact of different salinity doses and genotypes on hollyhock seedling vigour index. However, the interactive effect of genotype x treatment on plant seedling vigour index was not significant (Table 3). The highest seedling vigour index of hollyhock (1720.4) was noticed in plants given canal water (Control), followed by seedling vigour index of 1594.6 and 944.0, noted in the plants treated with 3 dS m^{-1} and 6 dS m^{-1}, respectively. However, the lowest seedling vigour index (217.4) was noted in plants irrigated with saline water having an EC 12 dS m^{-1}. Regarding genotypes, the seedling vigour index of "Halo Blush" was significantly higher (1076.4) than "Scarlet Eye" (929.9).

Table-3 Seedling vigour index of holly hock genotypes as affected by different salinity levels

Salinity levels	**Genotypes**		
	Halo Blush	**Scarlet Eye**	**Mean**
S_1 = Canal water (Control)	1834.4	1606.5	1720.4 A
S_2 =3 dS m^{-1}	1704.6	1484.5	1594.6 A
S_3 =6 dS m^{-1}	1005.4	882.6	944.0 B
S_4 =9 dS m^{-1}	542.3	458.3	500.3 C
S_5 =12 dS m^{-1}	295.5	217.4	256.4 D
Mean	1076.4 A	929.9 B	
Variables	**Salinity levels**	**Genotypes**	**S x G**
SE±	68.365	43.238	96.682
LSD 0.05	143.63	90.839	203.12
P-Value	0.0000	0.0033	0.6899

Number of leaves plant^{-1}: The maximum foliage production (leaves count) in individual plant (7.66) was seen in plants supplied with canal water (Control), followed by leaves counting plant^{-1}of 7.06 and 5.01, recorded in the pots treated with saline water having EC 3 dS m^{-1} and 6 dS m^{-1}, respectively (Table 4). The least foliage production/leaves plant^{-1} (2.66) was observed under 12 dS m^{-1}. In case of genotypes, the number of leaves plant^{-1}of "Halo Blush" was significantly higher (5.59) than "Scarlet Eye" (4.77).

Table 4- Number of leaves plant^{-1}of hollyhock genotypes as affected by different salinity levels

Salinity levels	**Genotypes**		
	Halo Blush	**Scarlet Eye**	**Mean**
S_1 = Control	8.00	7.33	7.66 A
S_2 =3 dS m^{-1}	7.30	6.83	7.06 A
S_3 =6 dS m^{-1}	5.66	4.36	5.01 B
S_4 =9 dS m^{-1}	4.00	3.00	3.50 C
S_5 =12 dS m^{-1}	3.00	2.33	2.66 D
Mean	5.59 A	4.77 B	
Variables	**Salinity levels**	**Genotypes**	**S x G**
SE±	0.3573	0.2260	0.5053
LSD 0.05	0.7507	0.4748	1.0617

P-Value	0.0000	0.0019	0.7882

Shoot length (cm): Significant difference was noted among salt stress environment and genotypes; however, interaction results showed no significant difference for shoot length of hollyhock genotypes (Table 5). The tallest plants with maximum shoot length (cm) of hollyhock (20.18 cm) were seen in pots given canal water (Control), followed by shoot length of 19.29 cm and 13.84 cm, noted in the pots treated with saline water having EC 3 dS m^{-1} and 6 dS m^{-1}, respectively. The minimum shoot length (6.30 cm) was noted in plants irrigated with saline water having EC 12 dS m^{-1}. With regards to genotypes, "Halo Blush" had a maximum shoot length (14.54 cm) in comparison with "Scarlet Eye" that showed (13.10 cm).

Table 5-Shoot length (cm) of holly hock genotypes as affected by different salinity levels

Salinity levels	**Genotypes**		**Mean**
	Halo Blush	**Scarlet Eye**	
S_1 = Canal water (Control)	21.16	19.20	20.18 A
S_2 =3 dS m^{-1}	20.29	18.29	19.29 A
S_3 =6 dS m^{-1}	14.36	13.33	13.84 B
S_4 =9 dS m^{-1}	10.00	9.00	9.50 C
S_5 =12 dS m^{-1}	6.90	5.70	6.30 D
Mean	14.54 A	13.10 B	
Variables	**Salinity levels**	**Genotypes**	**S x G**
SE±	0.7303	0.4619	1.0328
LSD 0.05	1.5343	0.9704	2.1699
P-Value	0.0000	0.0060	0.9154

Fresh shoot biomass (g): Different salt stress conditions showed injurious effect on hollyhock fresh shoot biomass (g). Maximum fresh shoot biomass (g) of hollyhock (5.00) was found in plants given canal water (Control), followed by shoot biomass of 4.70 g and 3.20 g noticed in the plants treated with 3dS m^{-1} and 6 dS m^{-1}, respectively. The lowest shoot biomass (0.91 g) was noted in plants treated with saline water with EC 12 dS m^{-1}. With regards to genotypes, shoot biomass of "Halo Blush" was significantly higher (3.53 g) than variety "Scarlet Eye" (2.80 g).

Table 6-Fresh shoot biomass (g) of hollyhock genotypes as affected by different salinity levels

Salinity levels	**Genotypes**		**Mean**
	Halo Blush	**Scarlet Eye**	
S_1 =Canal water (Control)	5.42	4.58	5.00 A
S_2 =3 dS m^{-1}	5.16	4.23	4.70 A
S_3 =6 dS m^{-1}	3.56	2.83	3.20 B
S_4 =9 dS m^{-1}	2.43	1.66	2.05 C
S_5 =12 dS m^{-1}	1.09	0.73	0.91 D
Mean	3.53 A	2.80 B	
Variables	**Salinity levels**	**Genotypes**	**S x G**
SE±	0.2582	0.1633	0.3651
LSD 0.05	0.5424	0.3431	0.7671
P-Value	0.0000	0.0003	0.8342

Root length (cm): The results pertaining to root length shown in Table-7 displayed that the longer roots of hollyhock (14.13 cm) was noted in plants supplied canal water (Control), followed by average root length of 13.63 cm and 11.33 cm, recorded in the pots treated with saline water with EC of 3 dS m^{-1} and 6 dS m^{-1}, respectively. The shorter roots having length (4.51 cm) were recorded under 12 dS m^{-1}. Pertaining to genotypes, root length of Halo Blush was significantly higher (10.81cm) than "Scarlet Eye" (9.71 cm).

Table 7- Root length (cm) of hollyhock genotypesas affected by different salinity levels

Salinity levels	Genotypes		Mean
	Halo Blush	Scarlet Eye	
S_1 = Canal water (Control)	14.59	13.67	14.13 A
S_2 =3 dS m^{-1}	14.20	13.06	13.63 A
S_3 =6 dS m^{-1}	12.00	10.66	11.33 B
S_4 =9 dS m^{-1}	8.32	7.11	7.71 C
S_5 =12 dS m^{-1}	4.96	4.06	4.51 D
Mean	10.81 A	9.71 B	
Variables	**Salinity levels**	**Genotypes**	**S x G**
SE±	0.5088	0.3218	0.7195
LSD 0.05	1.0689	0.6761	1.5117
P-Value	0.0000	0.0030	0.9910

Fresh root biomass (g): A significant impact of salt stress conditions and genotypes was noted on hollyhock fresh root biomass (g). However, the interactive effect of genotype x treatment on fresh root biomass (g) were not significant (Table 8). Heavier roots having weight (0.52 g) were recorded from plants given canal water (Control) (Table 8). Plants supplied with saline water with EC of 3 dSm^{-1} and 6 dSm^{-1} produced root biomass of 0.50 g and 0.41 g, respectively. Minimum fresh root biomass (0.20 g) was recorded in plants treated with water having EC of 12 dS m^{-1}. Regarding genotypes, heavier roots having biomass (0.41g) were obtained from Halo Blush.

Table 8- Fresh root biomass (g) of holly hock genotypes as affected by different salinity levels

Salinity levels	Genotypes		Mean
	Halo Blush	Scarlet Eye	
S_1 = Canal water (Control)	0.55	0.50	0.52 A
S_2 =3 dS m^{-1}	0.53	0.47	0.50 A
S_3 =6dS m^{-1}	0.43	0.40	0.41 B
S_4 =9dS m^{-1}	0.34	0.30	0.32 C
S_5 =12dS m^{-1}	0.22	0.17	0.20 D
Mean	0.41 A	0.37 B	
Variables	**Salinity levels**	**Genotypes**	**S x G**
SE±	0.0240	0.0152	0.0339
LSD 0.05	0.0504	0.0319	0.0713
P-Value	0.0000	0.0079	0.9888

Electrolyte leakage of leaf (%): There was a substantial impact of salt stress conditions and genotypes on electrolyte leakage of leaf (%). However, the interactive effect of genotype x treatment on electrolyte leakage of leaf (%) was insignificant (Table 9). The outcomes shown in Table-9 depicted that the maximum electrolyte leakage of leaf (82.69 %) was measured in pots given 12dS m^{-1}, followed by average electrolyte leakage of leaf of 71.37 % and 56.73%,

observed in the leaves of plants treated with 9 dS m^{-1} and 6 dS m^{-1}, respectively. However, the minimum electrolyte leakage of leaf (42.86 %) was observed in plants supplied with canal water (Control). In case of genotypes, electrolyte leakage of leaf (%) of hollyhock genotype "Scarlet Eye" was significantly higher (68.87 %) than "Halo Blush" (58.21 %). The interaction results elaborated that the interactive effect of 12 dS m^{-1} × Scarlet Eye showed maximum electrolyte leakage of leaf (84.81%)

Table 9- Electrolyte leakage of leaf (%) of hollyhock genotypes as affected by different salinity levels

Salinity levels	Genotypes		Mean
	Halo Blush	Scarlet Eye	
S_1 = Control	42.70	43.03	42.86 D
S_2 =3 dS m^{-1}	42.87	45.20	44.04 D
S_3 =6d S m^{-1}	55.10	58.36	56.73 C
S_4 =9 dS m^{-1}	69.80	72.94	71.37 B
S_5 =12 dS m^{-1}	80.56	84.81	82.69 A
Mean	58.21 B	60.87 A	
Variables	**Salinity levels**	**Genotypes**	**S x G**
SE±	0.8041	0.5086	1.1372
LSD 0.05	1.6894	1.0685	2.3891
P-Value	0.0000	0.0001	0.2015

DISCUSSION

During growth, plants are exposed to different abiotic stresses. The high temperature and salinity are one of the principal factors that significantly reduce the yield of field crops. Salinity is a main environmental constraint adversely influencing plant performance globally. Several lines of evidence show that about 10% of arable land and 24% of irrigated areas are under the threat of salinity, especially the accumulation of sodium chloride (NaCl) salt (Singh, 2022). Salinity negatively affects most of the traits of cultivated plants (Sayyed et al., 2014). Salinity is increasing issue significantly reduces the cropped area and is major threat to sustainable crop production and food security (Jamil et al., 2006). The present investigation was conducted to assess the influence of salt stress (NaCl) on seed germination and vegetative growth of hollyhock (*Althaea rosea* L.) genotypes under salt stress. The findings of the present investigation demonstrated that saline water had a highly detrimental effect on the growth and development of hollyhock genotypes. The seeds sown under the influence of salt stress showed poor germination with weaker seedlings. Similarly seeds sown with saline irrigation produced weaker plants with poor shoot and root growth and less foliage production. Moreover, maximum electrolyte in leaves (membrane damage) occurred in plants grown under the influence of salt stress conditions. Based on the current investigation findings, it was noted that salt stress had a negative effect on germination, and both shoot and root related traits of both genotypes of hollyhock flower. The maximum seed germination and growth of plants were recorded irrigated with canal water. In case of genotypes "Halo Blush" performed better for most of the investigated traits as compared to "Scarlet Eye". In accordance with our results, Rasha & El-Sheshtawy (2017) also reported that elevated salt stress conditions decreased seed germination percentage and plant growth, as well as reduced crop yield. This reflects that under salt stress environment the endogenous levels of phyto-hormones might be reduced that lead to poor seed germination and plant growth (Ashraf et al., 2003) Munns & Tester, (2008) reported that high rate of salts caused an inhibition of many physiological and biochemical processes which affect plant performance for both shoot and root morphological traits. Likewise, our findings showed that NaCl had greater inhibitory effects on both germination and seedling growth because significant reduction in germination and seedling growth was noted with each increase in salinity level. Our findings agree with the results of Keutgen & Pawelzik, (2008) and Kasukabe et al., (2004) who determined that the reduction in root length caused the decrease in biomass which is commonly observed under salt stress conditions. These findings are also consistent of Dasgan et al., (2002) and Guan et al., (2009) who reported that decrease in values of all investigated traits including germination and emergence %, plant height, length of root, shoot and root dry weight were mainly associated with the adverse effect of Na and Cl ions. The same findings were obtained by Akhtar et al. (2003) who reported that salt stress showed a highly negative effect on all scored traits mainly due to toxicity of ions and osmosis reduction. Similarly, Werner & Finkelstein (1995) reported that salt stress drastically affected the length of root and height of plants. This might be due to less acquisition of the nutrients and water by plant roots under elevated salinity that in turn reduce the elongation of both shoot and root. Cachorro et al. (1993)

also reported that salt stress showed highly adverse effect on plant traits including fresh shoot and root biomass. The foliar application of sodium in large quantity reduced the assimilation of CO_2 due to the toxicity of ion. Silveira et al. (2009) investigated that okra plants exhibited significant decrease in each growth parameters, such as plant height, leaf area and dry weight of root, stem and leaf, under salt stress. This depressed growth of okra plants under NaCl stress could be attributed to less acquisition of water and toxic effect of Na+ and Cl- ions present in the rooting media. In the current study, the performance of holly hock genotype Halo Blush was relatively better than scarlet eye under salt stress conditions across all traits. This might be due to genetic behavior and adaptation of each cultivar in managing osmotic stress and protection from oxidative damage. Moreover, the better performance of Halo Blush in comparison with its counterpart scarlet eye might have been associated with less acquisition of salt from the soil and avoiding too much accumulation of salt in the organs of Halo Blush.

CONCLUSIONS

It is concluded that germination and growth behaviour of hollyhock genotypes were significantly affected by salinity levels. The maximum seed germination and growth were recorded under the canal water (Control). However, the difference between (canal water) and 3 dS m^{-1} salt stress environmentally was non-significant. The salinity concentrations of 6, 9 and 12 dS m^{-1} caused simultaneously undesirable impact on all the investigated traits with the exception to electrolyte leakage of leaf that augmented parallel to the elevated salt stress conditions. In case of genotypes "Halo Blush" performed better for most of the investigated traits as compared to "Scarlet Eye" This indicates that Halo Blush had more tolerance to salt stress environment as compared to Scarlet Eye.

SUGGESTIONS

It is suggested that further study should be carried out under field conditions. This would be highly valuable to validate the findings of current study and to determine the tolerance of holly hock flower under salt stress conditions.

ACKNOWLEDGEMENT

The author extends sincere thanks to staff of the nursery of Sindh Agriculture University Tandojam for their support in carrying out study smoothly and effectively.

AUTHOR'S CONTRIBUTION

The entire research team contributed equally to both carrying out of research and manuscript development

STATEMENT OF COMPETING INTEREST

No competing interest has been declared by the authors

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