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Effect of Salt (NaCl) Stress on Seed Germination Seedling Growth and Na^+, K^+ Uptake in Maize

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Abstract:

A lab study was carried out during 2013-14 at Nuclear Institute of Agriculture, Tandojam to investigate the effect of salt stress on seed germination, seedling growth and Na^+/K^+ uptake in maize. Two maize varieties (Akbar and Shaheen) were evaluated for their germination against different salinity levels of 0 (control), 40 mM, 60 mM, 80mM and 100 mMNaCl. The experiment was conducted in a three replicated completely randomized design (CRD).The results revealed that the effect of salinity on all the traits studied was significant ($P<0.05$) with the exception of shoot K/Na ratio ($P>0.05$); while in most cases the varietal effect was non-significant ($P>0.05$) with the exception of root Na and shoot K ($P<0.05$). The seed *germination under 100, 80, 60 and 40 mM salinity levels was 60.00, 64.33, 86.67 and 95.55% against 100.00% germination in control. Under 100 mMNaCl and control the shoot length was 2.12 and 11.56 cm, root length 2.95 and 14.32 cm, shoot fresh weight 850.5 and 5787.50 mg, root fresh weight 368.7 and 3138.3 mg, shoot dry weight 151.33 and 583.50 mg, root dry weight 37.17 and 327.33 mg, shoot Na 5.81 and 0.35%, shoot K 2.16 and 1.44%, root Na 6.01% 0.75, root K 0.48 and0.67%, shoot K/Na ratio 0.37 and 16.10, root K/Na ratio 0.14 and 0.89. Similar trend was observed for lower salinity levels. Seed germination, shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight and root K/Na ratio decreased with increasing salinity levels.*

Key words: Salt (NaCl) Stress, Seed Germination, Seedling Growth, Na^+, K^+ Uptake in Maize

INTRODUCTION

Maize (*Zea mays* L.) is an important multipurpose cereal crop used as food, feed, fodder, fuel and in the manufacture of industrial product ranked first in grain yield production in the world (Stephen *et al*., 2006; Derby *et al*., 2005). Maize is also an important cereal crop of Pakistan and it is increasingly gaining an important position in crop husbandry because of its higher yield potential and short growth duration. It is rich source of food and fodder. Maize constitutes 6.4 % of the total grain production in the country, and occupies a special position in the national economy, as it is good source of food, feed and fodder (Abdullah *et al*. 2007). In view of its increasing importance for fodder as well as grain, improvement on maize has picked considerable attention in the world (Ahsan and Mehdi, 2000). Fodder scarcity is considered a major limiting factor for the development of livestock industry in Pakistan and this problem was identified long ago in the feed balance sheet (Sial and Alam, 1998). In this scenario, vertical improvement of maize production could be achieved by maximum increasing fodder and seed yield per unit area (Bhatti, 1996).

Maize in Pakistan contributes 2.2 percent to the value added in agriculture and 0.5 percent to GDP. Maize was cultivated on an area of 1085 thousand hectares in 2012-13, less by 0.2 percent over last year's area of 1087 thousand hectares. However, the production witnessed 4631 thousand tons during 2012-13 against last year production of 4631 thousand tons suggesting an increase of 6.8 percent over the last year. The yield per hectare in 2012-13 stood at 4268 kg ha^{-1} posted appositive growth of 6.9 percent as compared to 4.9 percent growth last year. The production increased due to the conversion of more area to hybrid varieties of seeds and favourable weather that enhanced the maize yie4lds (GOP, 2013).

Proper seedling emergence and crop stand play vital role for obtaining a good crop harvest. Germination and seedling establishment are critical stages in the plant life cycle. In crop production, stand establishment determines plant density, uniformity and management options (Cheng and Bradford, 1999). However, soil salinity is one of the major constraints to achieve good crop stand and obtain higher crop yields (McDonald, 2000; Farooq *et al*., 2008).

Soil or water salinity is known to cause considerable yield losses in most crops, thereby leading to reduced crop productivity (Ashraf, 2009; Cha-um *et al*. 2011). The salinity-induced crop yield reduction takes place due to a number of physiological and biochemical dysfunctions in plants grown under salinity stress which have been listed in a number of comprehensive reviews on salinity effects and tolerance in plants (Krasensky and Jonak, 2012). Scientists have been vying for the last many decades to overcome the problem of salinity by employing a variety of strategies. Of the various strategies currently under exploitation, improvement in salinity tolerance of crops through exogenous application of different types of chemicals including plant growth regulators, osmoprotectants and inorganic nutrients seems to be an efficient, economical and shot-gun approach (Ashraf and Foolad, 2007). The use of such substances has resulted in a substantial increase in both growth and yield of many crops grown under saline conditions (Kaya *et al*., 2010).

Soil salinity is a major environmental stress that adversely affects plant growth and development (Koyro, 2006). Upto 20% of the irrigated arable land in arid and semiarid regions is already salt affected and is still expanding (Muhling and Lauchli, 2003). Soil salinity inhibits plant growth and cause a decrease in biomass of maize plant. The stomatal resistance and proline concentration of plant increase by salinity, total chlorophyll concentration decreases. This suggests the critical importance of need to unravel the cellular mechanisms such as the correlation between chlorophyll content or proline accumulation and sodium intake so as to give a meaning to salt stress studies. Despite a number of studies on salinity effects on plants, neither the metabolic sites at which salt stress damages plants nor the adaptive components of salt tolerance are fully understood. Distinguishing the cellular metabolisms appears to play an important role in the acclimation of crops to salt stress (Azevedo and Tabosa, 2000).

The plants under salt stress have to cope with stress imposed by the low external water potential and with ion toxicity due to accumulation of ions inside the plants (Romero-Aranda *et al*., 2006). Differences in salt tolerance exist not only among different genera and species, but also within the different organs of the same species (Ismail, 2003). Under low and moderate salinity levels, sugars and consequently the total carbohydrates are decreased (Mostafa, 2004). Soluble protein in plant is generally decreased in response to salt stress (Abdel-Latef, 2005). The process of accumulation of ions such as sodium (Na^+) potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}) in plants are different and depend on variation in the external environment (Shaddad *et al.*, 2005). Suriyan and Kirdmanee (2009) found that salt stress strongly affects the plant growth and development, especially maize plant, which is reported as a salt sensitive species. The salt tolerant identification in the large genetic resources and breeding population is a profitable research topic for solving the salinity problem (Ashraf, 2009).

MATERIALS AND METHODS

The study was carried out to investigate the effect of salt stress on seed germination, seedling growth and Na^+, K^+ uptake in maize. The experiment was laid out in a three completely randomized design(CRD) in the laboratory at Nuclear Institute of Agriculture (NIA) Tandojam. Seeds were grown in petri dishes in the incubator at 25^0C.The details of treatments are as varieties Akbar and Shaheen Treatments Control (distilled water), 40 mMNaCl, 60 mM, 80 mM and 100 mM.

In order to inhibit microbial contamination during germination seeds were surface sterilized with 5% Sodium hypochlorite solution for five minutes and followed by repeated washings with sterilized distilled water and soaked in 0, 40, 60, 80,100 mMNaCl treatment for 8 hours, then twenty selected seeds were placed in two sets of three replicates on a layer of Whattman No.540 ash less filter paper then moistened with 10 ml of distilled water (0 Control) and 40, 60, 80,100 mM of NaCl as salinity treatment and covered with lid. The petriplates were then kept in the growth room at temperature 25 ± 0.5°C adjusting relative humidity of 45±2% for 16 hours of day time and 22 ± 0.5°C temperature with relative humidity of 52±2% for 8 hours night time. Germination was recorded after every 24 hour for 8 days. The observations were recorded on the following parameters: Seed germination (%), Shoot length (cm), Root length (cm), Shoot fresh weight (mg), Root fresh weight (mg), Shoot dry weight (mg) and Root dry weight (mg).Shoot and root fresh and dry weight Shoot fresh weight (g) of all germinated seedlings of each replicate was calculated after eight day of grown with the help of an electric balance. Then seedlings were kept in oven at 60°C for 48 days and dry weights were recorded.

RESULTS

The experiment was conducted during 2013-14 in the laboratory of Nuclear Institute of Agriculture, Tandojamto investigate the effect of salt stress on seed germination, seedling growth and Na^+/K^+ uptake in maize. Two maize varieties (Akbar and Shaheen) were evaluated for their germination against different salinity levels of 0 (control), 40 mM, 60 mM, 80mM and 100 mMNaCl. The observations were recorded on seed germination (%), shoot length (cm), root length (cm), shoot fresh weight (mg), root fresh weight (mg), shoot dry weight (mg), root dry weight (mg), shoot sodium (Na^+) content (%), shoot potassium (K^+) content (%), root sodium (Na^+) content (%), root potassium (K^+) content (%), shoot potassium and sodium (K^+/Na^+) ratio, root potassium and sodium (K^+/Na^+) ratio.

Germination (%)

The seed germination of maize varieties Akbar and Shaheenas affected by different salinity levels was assessed and the data is given in Table-1. The results showed that effect of different salinity levels on seed germination was significant ($P<0.01$); while differences in germination between varieties and interaction between salinity levels and varieties were non-significant ($P>0.05$). The results showed that the seed germination was lowest (60.00%) under highest salinity level (100 mMNaCl) and seed germination increased successively to 64.33, 86.67 and 95.55 when salinity levels decreased to 80 mM, 60 mM and 40 mM, respectively against 100 percent germination in control. Regardless the variety, 100 percent germination was observed when salinity was not induced (control). In case of varieties, average germination was higher (83.46%) in variety Shaheen as compared to Akbar (79.15%). The interactive effect of variety Akbar × 80 mMNaCl) resulted in lowest germination (53.33%), while the interaction (both varieties × Control NaCl) resulted in 100 percent seed germination. This indicates that variety Shaheen is relatively tolerant to salinity, while Akbar is more sensitive to salinity than Shaheen. The effect of salinity upto 80mM on germination was negligible as the differences in germination between 100, 40 and 60 mM levels were non-significant (P>0.05).

Table 1: Germination (%)of maize varieties as affected by different salinity (NaCl) levels (mM)

Treatments	Akbar	Shaheen	Mean
T1 Control	100.00 A	100.00 A	100.00 A
T2 40 mMNaCl	93.43 AB	97.67 AB	95.55 A
T3 60 mMNaCl	89.00 AB	84.33 ABC	86.67 A
T4 80 mMNaCl	53.33 D	75.33 BCD	64.33 B
T5 100 mMNaCl	60.00 CD	60.00 CD	60.00 B
Mean	**79.153 A**	**83.467 A**	

Shoot length (cm)

The shoot length is a principal growth indicator in plants and maize varieties Akbar and Shaheen were determined for their response to various salinity levels and the results are given in Table-2. The analysis of variance indicated that the effect of different salinity levels on shoot length was significant (P<0.01); while differences in shoot length between varieties and interaction between salinity levels and varieties were non-significant (P>0.05). It was noted that the shoot length was lowest (2.12 cm) under highest salinity level of 100 mMNaCl; followed by shoot length of 3.08 cm and 4.11 cm recorded under levels of 80 mM and60 mM, respectively against 11.56 cm shoot length in control. The shoot length significantly increased (7.44 cm) when salinity reduced to 40 mMNaCl; while highest shoot length of 11.56 cm was observed in control. In varieties, shoot length was higher (5.81cm) in variety Akbar as compared to variety Akbar (5.52 cm). The interactive effect of variety Shaheen × 100 mMNaCl) depressed the shoot length maximally (1.93 cm), while the interaction (Variety Akbar × Control NaCl) resulted in maximum shoot length of 11.62 cm. This indicates that variety Shaheen was slightly more sensitive to salinity than variety Akbar so far the shoot length of maize is concerned. There was a simultaneous reduction in shoot length of maize with each increment in the salinity level.

Table 2: Shoot length (cm) of maize varieties as affected by different salinity (NaCl) levels (mM)

Treatments	Akbar	Shaheen	Mean
T1 Control	11.62 A	11.51 A	11.56 A
T2 40 mMNaCl	7.93 B	6.96 B	7.44 B
T3 60 mMNaCl	4.58 C	3.65 CD	4.11 C
T4 80 mMNaCl	3.57 CD	2.60 CD	3.08 CD
T5 100 mMNaCl	2.31 D	1.93 D	2.12 D
Mean	**5.81 A**	**5.52 A**	

Root length (cm)

In physiological studies, the root length is assumed to be one of the most important traits to assess the treatment effects. The maize varieties Akbar and Shaheen were examined for their root length in response to various salinity levels and the data are given in Table-3. The analysis of variance indicated that the effect of different salinity levels on root length was significant ($P<0.01$); while differences in root length between varieties and interaction between salinity levels and varieties were non-significant ($P>0.05$). The highest salinity level of 100 mMNaCl minimized the maize root length (2.95 cm); followed by root length of 3.84 cm and 6.29 cm under salinity levels of 80 mM and60 mM, respectively against 14.32 cm root length in control; while the root length significantly increased (9.84 cm) when salinity reduced to 40 mMNaCl. In varieties, root length was relatively higher (7.96 cm) in variety Shaheen as compared to variety Akbar (6.94 cm). The interactive effect of variety Akbar × 100 mMNaCl) suppressed the root length maximally (2.89 cm), while the interaction (Variety Shaheen× Control NaCl) resulted in maximum root length of 14.83 cm. It was observed that although the differences in root length of both the maize varieties showed similarity in statistical analysis, but the variety Shaheen seems to be less sensitive to salinity for root length character as compared to variety Akbar. The root length decreased simultaneously with increasing salinity level. However, differences in root length between salinity levels of 80 mM and 100 mM were statistically non-significant (P>0.05).

Table 3: Root length (cm) of maize varieties as affected by different salinity (NaCl) levels (mM)

Treatments	Akbar	Shaheen	Mean
T1 Control	13.810 AB	14.830 A	14.32 A
T2 40 mMNaCl	8.163 C	11.533 B	9.84 B
T3 60 mMNaCl	7.030 CD	5.550 DE	6.29 C
T4 80 mMNaCl	2.817 F	4.877 DEF	3.84 D
T5 100 mMNaCl	2.890 F	3.020 EF	2.95 D
Mean	**6.94 A**	**7.96 A**	

Shoot fresh weight (mg)

Shoot fresh weight represents the plant/seedling vigour and healthy seedlings produce greater shoot fresh weight. The maize varieties Akbar and Shaheen were studied for their shoot fresh weight in response to various salinity levels and the results are presented in Table-4. The analysis of variance showed that the effect of different salinity levels on shoot fresh weight was significant (P<0.01); and non-significant (P>0.05) for varieties and interaction between salinity levels and varieties. It is evident from the results that the highest salinity level of 100 mMNaCl resulted in a declined shoot fresh weight (850.5 mg); followed by shoot fresh weight of 1342.00 mg and 2136.30 mg under salinity levels of 80 mM and60 mM, respectively against 5787.50 mg shoot fresh weight in control; while the shoot fresh weight significantly increased to 3594.80

mg when salinity reduced to 40 mMNaCl. In varieties, shoot fresh weight was comparatively higher (2835.00 mg) in variety Akbar as compared to variety Shaheen (2649.50 mg). The interactive effect of variety Shaheen × 100 mMNaClresulted in a minimum shoot fresh weight (803.00 mg), while the interaction of variety Akbar × Control resulted in highest shoot fresh weight of 6025.70 mg. The results indicated that shoot fresh weight of maize variety Shaheen was more adversely affected by the increasing level of salinity as compared to variety Akbar. Statistically, the differences in shoot fresh weight between 100 and 80 mMNaCl levels was also non-significant (P>0.05) and significant (P<0.05) when compared with rest of the treatments.

Table 4: Shootfresh weight (mg) of maize varieties as affected by different salinity (NaCl) levels (mM)

Treatments	**Akbar**	**Shaheen**	**Mean**
T1 Control	6025.7 A	5549.3 A	5787.5 A
T2 40 mMNaCl	3654.0 B	3535.7 B	3594.8 B
T3 60 mMNaCl	2372.3 C	1900.3 CD	2136.3 C
T4 80 mMNaCl	1225.0 DE	1459.0 CDE	1342.0 D
T5 100 mMNaCl	898.0 E	803.0 E	850.5 D
Mean	**2835.0 A**	**2649.5 A**	

Root fresh weight (mg)

Root fresh weight is also an important physiological trait to determine plant vigour and to examine the treatment effect. Two commercial maize varieties (Akbar and Shaheen) were assessed for their root fresh weight in response to various salinity levels and the data are given in Table-5. The analysis of variance demonstrated that the effect of salinity levels on root fresh weightof maize was significant (P<0.01); and non-significant (P>0.05) for varieties and Variety × treatment interaction. The higher salinity level of 100 mMNaCl resulted in a maximum decrease in root fresh weight (368.70 mg); followed by salinity levels of 80 mM and 60 mMNaCl decreasing root fresh weight up to 683.00 mg and 1372.80 mg, respectively against 3138.30 mg root fresh weight in control; while the root fresh weight was significantly increased to 2278.50 mg when salinity reduced to 40 mMNaCl. In case of maize varieties, root fresh weight was comparatively higher (1602.70 mg) in variety Akbar as compared to variety Shaheen (1533.80 mg). The interactive effect of 100 mMNaCl× variety Shaheen resulted in a lowest root fresh weight (296.30 mg), while the interaction of variety Akbar × Control resulted in maximum root fresh weight of 3390.70 mg. Maize variety Shaheen received more adverse effects of increasing salinity levels on its root fresh weight than variety Akbar, indicating that Shaheen variety was relatively more sensitive to salinity for this trait than variety Akbar. The differences in root fresh weight between 100 and 80 mMNaCl levels was statistically non-significant (P>0.05) and significant (P<0.05) when compared with other treatments.

Table 5: Rootfresh weight (mg) of maize varieties as affected by different salinity (NaCl) levels (mM)

Treatments	**Akbar**	**Shaheen**	**Mean**
T1 Control	3390.7 A	2886.0 AB	3138.3 A
T2 40 mMNaCl	2144.0 B	2413.0 B	2278.5 B
T3 60 mMNaCl	1402.7 CD	1343.0 D	1372.8 C
T4 80 mMNaCl	635.3 DE	730.7 DE	683.0 D
T5 100 mMNaCl	441.0 E	296.3 E	368.7 D
Mean	**1602.7 A**	**1533.8 A**	

Shoot dry weight (mg)

Shoot dry weight is obtained by keeping the shoot fresh biomass in the oven at certain temperature for a certain time period when the moisture evaporation is completed. The results for shoot dry weight of two maize varieties (Akbar and Shaheen) as influenced by various salinity levels are presented in Table-6. The analysis of variance indicated that the effect of different salinity levels on shoot dry weight was significant (P<0.01); and non-significant (P>0.05) for varieties and interaction of salinity levels × varieties. The results indicated that the highest salinity level of 100 mMNaCl resulted in a maximum decrease in the shoot dry weight (151.33 mg); followed by shoot dry weight of 223.17 mg and 303.50 mg shoot dry weight recorded under salinity levels of 80 mM and60 mM, respectively against 583.50 mg shoot dry weight in control; while the shoot dry weight increased considerably (447.67 mg) when salinity reduced to 40 mMNaCl. In case of varieties, shoot dry weight was relatively higher (349.13 mg) in variety Shaheen than variety Shaheen (334.53 mg). The interaction study showed that variety Akbar × 100 mMNaClinteraction resulted in a minimum shoot dry weight (144.67 mg), while variety Akbar × Control resulted in highest shoot dry weight of 590.00 mg. It was observed that the shoot dry weight is inversely proportional to the salinity level in the soil media; while variety Akbar was relatively more sensitive to salinity than variety Shaheen in case of shoot dry weight is concerned.

Table 6: Shootdry weight (mg) of maize varieties as affected by different salinity (NaCl) levels (mM)

Treatments	**Akbar**	**Shaheen**	**Mean**
T1 Control	590.00 A	577.00 A	583.50 A
T2 40 mMNaCl	425.00 B	470.33 B	447.67 B
T3 60 mMNaCl	320.33 C	286.67 C	303.50C
T4 80 mMNaCl	192.67 DE	253.67 CD	223.17 D
T5 100 mMNaCl	144.67 E	158.00 E	151.33 E
Mean	**334.53 A**	**349.13 A**	

Root dry weight (mg)

The results in relation to root dry weight of maize varieties Akbar and Shaheen as affected by various salinity (NaCl) levels are given in Table-7. The analysis of variance demonstrated significant ($P<0.05$) effect of different salinity levels on root dry weight; and non-significant ($P>0.05$) for varieties and salinity levels × variety interaction. It can be noted from the results that the highest salinity level of 100 mMNaCl resulted in lowest root dry weightof 37.17 mg; followed by root dry weight of 54.33 mg and 113.50 mg root dry weight noted when salinity was induced at the rate of 80 mM and60 mM, respectively;

while the root dry weight increased considerably to 196.83 mg under 40 mM salinity level against 327.33 mg root dry weight in control. In varieties, root dry weight was comparatively higher (155.47 mg) in variety Akbar than variety Shaheen (136.20 mg). The interaction study indicated that variety Shaheen× 100 mMNa Clinteraction resulted in a minimum root dry weight (30.33 mg), while variety Akbar × Control resulted in highest root dry weight of 199.00 mg. Statistically, the differences in root dry weight under 80 mM and 100 mM salinity levels were non-significant (P>0.05) and significant when compared with rest of the treatments and control. Moreover, variety Shaheen supposed to be more sensitive to salinity; while variety Akber indicated its greater tolerance against salinity when compared with variety Shaheen.

Table 7: Rootdry weight (mg) of maize varieties as affected by different salinity (NaCl) levels (mM)

Treatments	Akbar	Shaheen	Mean
T1 Control	368.67 A	286.00 B	327.33 A
T2 40 mMNaCl	199.00 C	194.67 C	196.83 B
T3 60 mMNaCl	123.67 D	103.33 DE	113.50 C
T4 80 mMNaCl	44.00 EF	66.67 DEF	54.33 D
T5 100 mMNaCl	42.00 EF	30.33 F	37.17 D
Mean	**155.47 A**	**136.20 A**	

CONCLUSION

A lab experiment was conducted during 2013-14 at Nuclear Institute of Agriculture, TandoJam to investigate the effect of salt stress on seed germination, seedling growth and Na^+/K^+ uptake in maize. Two maize varieties (Akbar and Shaheen) were evaluated for their germination against different salinity levels of 0 (control), 40 mM, 60 mM, 80mM and 100 mMNaCl. The observations were recorded on seed germination (%), shoot length (cm), root length (cm), shoot fresh weight (mg), root fresh weight (mg), shoot dry weight (mg), root dry weight (mg), shoot sodium (Na^+) content (%), shoot potassium (K^+) content (%), root sodium (Na^+) content (%), root potassium (K^+) content (%), shoot potassium and sodium (K^+/Na^+) ratio, root potassium and sodium (K^+/Na^+) ratio. The findings of the study are summarized as follows:

The results revealed that the effect of salinity on all the traits studied was significant ($P<0.05$) with the exception of shoot K/Na ratio ($P>0.05$); while in most cases the varietal effect was non-significant ($P>0.05$) with the exception of root Na and shoot K ($P<0.05$). The maize seedlings irrigated with highest salinity level of 100 mMNaCl resulted in lowest seed germination (60.00%) with shoot length of 2.12 cm, root length 2.95 cm, shoot fresh weight 850.5 mg, 368.7 mg root fresh weight, shoot dry weight 151.33 mg, root dry weight 37.17 mg, shoot Na 5.81%, shoot K 2.16%, root Na 6.01%, root K 0.48%, shoot K/Na ratio 0.37 and root K/Na ratio 0.14.

The seedlings given water with salinity level of 80 mMNaCl resulted in seed germination of 64.33%, shoot length 3.08 cm, root length 3.84 cm, shoot fresh weight 1342 mg, root fresh weight 683 mg, shoot dry weight 223.17 mg, root dry weight 54.33 mg, shoot Na 5.26%, shoot K 2.12%, root Na 4.98%, root K 0.51%, shoot K/Na ratio 0.41 and root K/Na ratio 0.27.The maize seedlings watered with salinity level of 60 mMNaCl resulted in seed germination of 86.67%, shoot length 4.11 cm, root length 6.29 cm, shoot fresh weight 2136.3 mg, root fresh weight 1372.8 mg, shoot dry weight 303.50 mg, root dry weight 113.50 mg, shoot Na 3.63%, shoot K 2.11%, root Na 4.81%, root K 0.56%, shoot K/Na ratio 0.62 and root K/Na ratio 0.11.The media containing salinity level of 40 mMNaCl resulted in maize seed germination of 95.55%, shoot length 7.44 cm, root length 9.84 cm, shoot fresh weight 3594.8 mg, root fresh weight 2278.50 mg, shoot dry weight 447.67 mg, root dry weight 196.83 mg, shoot Na 2.22%, shoot K 2.18%, root Na 3.90%, root K 0.71%, shoot K/Na ratio 0.2.21 and root K/Na ratio 0.18.

The maize seedlings irrigated with normal canal water (control) resulted highest germination 100.00%, shoot length

11.56 cm, root length 14.32 cm, shoot fresh weight 5787.5 mg, root fresh weight 3138.3 mg, shoot dry weight 583.50 mg, root dry weight 327.33 mg, shoot Na 0.35%, shoot K 1.44%, root Na 0.75%, root K 0.67%, shoot K/Na ratio 16.10 and root K/Na ratio 0.89.Seed germination, shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight and root K/Na ratio decreased with increasing salinity levels; while shoot Na, shoot K, root Na, root K and shoot K/Na ratio increased simultaneously with increasing salinity levels. In case of varieties, maize variety Shaheen produced higher seed germination (83.46%) with shoot length of 5.52 cm, root length 7.96 cm, shoot fresh weight 2649.5 mg, root fresh weight 1533.7 mg, shoot dry weight 349.13 mg, root dry weight 136.20 mg, shoot Na 3.86%, shoot K 1.96%, root Na 4.24%, root K 0.54%, shoot K/Na ratio 1.03 and root K/Na ratio 0.30. Similarly, the maize variety Akbar produced seed germination of 79.15%, shoot length 5.81 cm, root length 6.94 cm, shoot fresh weight 2835.00 mg, root fresh weight 1602.7 mg, shoot dry weight 334.53 mg, root dry weight 155.47 mg, shoot Na 3.05%, shoot K 2.04%, root Na 3.94%, root K 0.63%, shoot K/Na ratio 6.86 and root K/Na ratio 0.33.It was observed that variety Shaheen produced higher seed germination, root length and shoot Na; while Akbar produced higher values for shoot length, shoot fresh weight, root fresh weight, root dry weight, shoot K, root K, shoot K/Na ratio and root K/Na ratio.

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