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In Vitro Brassica Genotypes Growth Evaluation against NaCl Salt Stress

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Abstract. A hydroponic study was conducted to see the performance of fifteen Brassica genotypes (BARD-I, Sultan Raya, 19-H, Shiralle, Dunkled, 85-508, Toria, 85-499, BSA, 85-397, 85-500, 85-497, 85-5001, CON-I, and Jewel) for their salt tolerance. Four levels of NaCl (0, 30, 60 and 90 mM/L) were developed. One week old two healthy seedlings of each Brassica genotypes were transplanted in holes of thermopole sheet floating over a 200 mL capacity container having half strength Hoagland solution. Increasing the NaCl salinity significantly reduced the shoot and root dry weight of all Brassica genotypes. On an average, about 47% reduction in shoot dry weight was observed under higher salinity level (90 mM/NaCl). Although, all the genotypes differed among themselves in ability to tolerate salinity however, ranking order of genotypes showed that Sultan Raya performed well followed by BARD-I than rest of the genotypes. Genotype 85-500 produced comparatively the least shoot and root dry weights and accumulated more Na^+, less K^+ and Ca^{+2} than rest of the genotypes. The reverse was true for Sultan Raya and BARD-I. The farmers could be benefitted through growing the selected comparatively more tolerant genotypes which could grow and survive under salt stress conditions rather than complete crop failure.

Keywords: Brassica genotypes, NaCl salt stress, hydroponic study, growth performance, germplasm screening, ion accumulation

Introduction

Brassica is one of the most important oil seed crops grown on an area of 305×10^3 hectares and its total oil seed production is 251×10^3 tonnes in Pakistan. It contributes to 21 percent of the total edible oil consumption in the country (ESP, 2015). NaCl is one of the most important salts influencing the growth of plants. Dissolved Na^+ and Cl^- ions from NaCl salt cause osmotic stress in plants which interfere with root uptake of both water and nutrients (Mahmood *et al*., 2007; Sadiq *et al*., 2002). Accumulation of these ions also cause injury and toxicity in leaves resulting in reduced growth and yield (Cassaniti *et al*., 2009; Parida and Das, 2005). Rapeseeds and mustard are the most imperative source of edible oil (Haq *et al*., 2002) but the farmers do not pay much attention on this crop and grow mostly on marginal lands. The tolerance of plant to NaCl is generally related to the concentration of Na in tissues (Flowers, 2004; Ashraf and McNeilly, 2004). Besides this, the salt-affected areas can have a good potential to grow some salt tolerant genotypes of oil seed crops and hence, oil seed production can be increased by exploiting genetic potential of Brassica cultivars. Initially, salinity tolerance of Brassica germplasms was tested with NaCl salt before sowing directly in salt-affected fields because NaCl salt is generally considered comparatively more toxic due to its high solubility and higher uptake of Na^+ and Cl^- ions than rest of the salts (Bilkis *et al*., 2016; Lee and Iersel, 2008; Chen *et al*., 2003) therefore, the species which could tolerate NaCl stress may be able to stand with other salts under field conditions. Keeping in view the fact, a hydroponic study was conducted at National Agricultural Research Centre during 2014 to see the performance of fifteen Brassica genotypes (BARD-I, Sultan Raya, 19-H, Shiralle, Dunkled, 85-508, Toria, 85-499, BSA, 85-397, 85-500, 85-497, 85-5001, CON-I and Jewel) for their salinity tolerance.

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Materials and Methods

Viable seeds of each genotype were sown in polyethylene coated trays containing washed sand. Distilled water was used to maintain optimum moisture for germination and seedlings establishment. One week old two healthy seedlings of each genotype were transplanted in foam plugged thermopole sheets floating over half strength Hoagland nutrient solution (Hoagland and Arnon, 1950) of 200 L capacity tubs. Four levels of NaCl (0, 30, 60 and 90 mM/L) were developed in three increments after the complete establishment of seedlings. Aeration in the rooting medium was provided throughout growth period by air pumps. The pH of the solution was adjusted around 6.0 by adding 1N HCl or NaOH. Arrangement of treatments was done according to completely randomize design (CRD) with five replications. After four weeks of growth, the plants of each genotype were harvested, washed with distilled water and dried by using tissue paper. Shoots and roots were separated for taking their length and fresh weights. Plant samples thus collected were dried at 60 °C to a constant weight and then weighed for their dry weights. The samples were ground to pass through 40 mm mesh sieve using Wiley Mills. Ground samples of root and shoot were digested in 2:1 di-acid mixture (2 Perchloric + 1 Nitric acid) to estimate Na^+, K^+, Ca^{+2} and Mg^{+2} using atomic absorption spectroscopy. The data thus collected were subjected to statistical analysis and treatment means were compared using Duncan's Multiple Range (DMR) test (Gomez and Gomez, 1984).

Results and Discussion

Increase in NaCl salinity decreased shoot dry weight of all Brassica genotypes. There were non-significant differences between 60 mM/L and 90 mM/L salinity levels in terms of shoot dry weight in all genotypes, however, genotypes differed significantly among each other at all salinity levels (Table 1). Akhtar *et al*. (2002) has shown the adverse effects of salinity on Brassica growth and reported variable responses of different species and varieties of Brassica to salt stress. Root dry weight of all genotypes was also adversely affected due to increasing the level of salt stress except for Sultan Raya (Table 2). There was a comparable increase in root dry weight in case of Sultan Raya with increase in shoot dry weight. Among all genotype, Sultan Raya performed the best even under higher NaCl salinity (90 mM/L) and recorded as the most salt tolerant genotype whereas the genotype 85-500 was the least salt tolerant with respect to total biomass production.Sodium content (%) in shoot and root of different Brassica genotypes increased with increase in salinity. However, there were non-significant differences between genotypes for Na^+ content in shoots under control, 30 mM/L and 90 mM/L NaCl concentration (Table 3).Genotype Sultan Raya produced more shoot and root dry weight and accumulated less Na^+ in its shoot while genotype 85-500 produced least shoot and root dry weights and

Table 1. Shoot dry weight (SDW, g/plant) of Brassica genotypes as affected by different levels of NaCl salinity (mean of five replications)

Variety	Control	30 mM	60 mM	90 mM	Means
		NaCl			
BARD-I	4.02 b*	3.87 b	2.12 bc	2.86 b	3.22 B
Sultan Raya	8.48 a	6.86 a	3.26 a	3.88 a	5.62 A
19-H	3.36 bcd	3.87 b	1.41 de	1.49 cd	2.53 C
Shiralle	1.90 e	1.60 ef	1.71 cd	1.77 c	1.75 DE
Dunkled	2.05 e	0.92 f	1.44 de	1.43 cde	1.46 EF
85-508	1.82 e	1.34 f	1.04 ef	0.95 ef	1.29 FG
Toria	3.89 b	2.68 cd	2.27 b	1.35 cde	2.55 C
85-499	2.16 e	0.94 f	1.42 de	0.69 f	1.30 FG
BSA	2.60 cde	1.84 def	1.85 bcd	1.44 cde	1.93 D
85-397	2.70 cde	1.34 f	0.54 f	1.18 def	1.44 EF
85-500	0.60 f	1.48 ef	0.91 ef	1.00 def	1.00 G
85-497	2.13 e	1.25 f	0.82 f	1.72 c	1.48 EF
85-5001	3.74 bc	2.93 bc	2.02 bc	1.16 def	2.46 C
CON-I	1.85 e	2.42 cde	1.69 cd	1.41 cde	1.85 DE
Jewel	2.23 de	1.41 f	0.86 f	0.74 f	1.31 FG
Mean	2.90 A	2.32 B	1.56 C	1.54 C	

* = means bearing same letter(s) in each column are statistically similar at $p \leq 0.05$.

Table 2. Root dry weight (g/plant) of Brassica genotypes as affected by different levels of NaCl salinity (Mean of five replications)

Variety	Control	30 mM	60 mM	90 mM	Means
		NaCl			
BARD-I	0.21 cd*	0.46 a	0.30 a	0.16 cd	0.28 B
Sultan Raya	1.24 a	0.52 a	0.21 bc	0.42 a	0.60 A
19-H	0.20 cd	0.17 cd	0.14 de	0.11 de	0.15 DE
Shiralle	0.08 fg	0.11 de	0.23 b	0.11 de	0.13 DEF
Dunkled	0.10 efg	0.08 e	0.11 d-g	0.14 cde	0.11 FG
85-508	0.09 efg	0.06 e	0.07 fg	0.10 de	0.08 G
Toria	0.24 bc	0.25 b	0.15 de	0.19 bc	0.21 C
85-499	0.11 d-g	0.12 cde	0.12 d-g	0.11 de	0.12 EFG
BSA	0.17 c-f	0.12 cde	0.17 cd	0.17 cd	0.16 D
85-397	0.18 cde	0.07 e	0.06 g	0.11 de	0.11 FG
85-500	0.05 g	0.10 de	0.09 efg	0.11 de	0.09 G
85-497	0.16 c-f	0.11 de	0.13 def	0.14 cde	0.13 DEF
85-5001	0.31 b	0.19 bc	0.20 bc	0.23 b	0.24 C
CON-I	0.12 d-g	0.13 cde	0.12 d-g	0.08 e	0.11 FG
Jewel	0.16 c-f	0.14 cde	0.09 efg	0.13 cde	0.13 DEF
Mean	0.23 A	0.18 B	0.15 C	0.15 C	

* = means bearing same letter(s) in each column are statistically similar at $p \leq 0.05$.

accumulated Na^+ the most. This fact was exhibited by a strong negative correlation between shoot Na^+ content and shoot/root dry weights in all Brassica genotypes (-0.42 and -0.38, respectively, (Table 11). In case of Na^+ content in roots (Table 4) all the genotypes differed significantly at all salinity levels. Genotypes 85-500 accumulated more Na^+ in its roots than all other genotypes followed by Sultan Raya, 85-508, 85-397, Jewel, BSA, 85-5001, Toria, Dunkeld, 85-497, CON-1, 19-H, 85-499 and BARD-I. Genotype Sultan Raya accumulated more Na^+ than all other genotypes except 85-500. Na^+ content of root in Sultan Raya were equal to Na^+ content in shoot (1.90%) while Na^+ content in shoot increased significantly as compared with roots in all other genotypes (Table 4-5). The existence of genotypic variation for salt tolerance representing the physiological characters; the difficulty could be faced if the differences between genotypes are very minute considering the physiological parameters i.e. K^+ and Ca^{+2} contents (Bilkis *et al*., 2016; Cassaniti *et al*., 2009; Shirazi *et al*., 2007; Mahmood *et al*., 2007). Potassium content of shoot and root (Table 5-6) in Brassica genotypes decreased with increase in salinity. Genotype BSA contained more potassium than rest of the genotypes. All other genotypes followed the ranking order as BARD-1 > 85-500 > 85-508 > Sultan Raya > 85-397 > Jewel > 19-H > Shiralle > Toria > 85-499 > 85-5001 > CON-1 > Dunkled > 85-497. In case of root potassium content, the order was somewhat different such as Shiralle > 85-500 > 19-H > CON-1> 85-397 > Sultan Raya > 85-499 > 85-5001 > BARD-1 > Jewel > Toria > BSA> Dunkled > 85-508 > 85-497.

It was noted that there was a poor correlation between shoot/root potassium content and shoot/root dry weights (Table 11). The fact was again depicted by higher K^+ content of roots in case of 85-500 than in Sultan Raya. There was a significant positive correlation between shoot K^+ content and root Na^+ content in all genotypes (Table 11). Sodium chloride salinity significantly affected the calcium uptake by plants with increase in salinity (Table 7-8). Sultan Raya exhibited 23% more calcium contents as compared to genotype 85-500. This indicated that high Na^+ concentration induced Ca^{+2} deficiencies in plant which effected plant growth (correlation coefficient of -0.321, Table 11) because calcium concentration in root was also significantly affected with increase in salinity level (Table 8). Where salinity level was zero, Ca^{+2} uptake was high. However, increase in NaCl salinity level, Ca^{+2} uptake were reduced. Positive

Table 3. Sodium content (%) in shoot of Brassica genotypes as affected by different levels of NaCl salinity (Mean of three replications)

Variety	Control	30 mM	60 mM	90 mM	Means
		NaCl			
BARD-I	0.43 N.S.	1.09 N.S.	3.36 de	3.52 N.S.	2.10 ABC
Sultan Raya	0.36	1.11	3.11 de	3.03	1.90 CD
19-H	0.49	1.23	3.37 de	4.45	2.39 AB
Shiralle	0.40	1.24	3.36 de	4.57	2.39 AB
Dunkled	0.41	1.28	3.42 de	3.63	2.49 A
85-508	0.39	1.45	3.58 bcd	5.27	2.19 AB
Toria	0.42	1.99	4.15 ab	4.75	2.83 A
85-499	0.34	1.12	4.26 a	4.69	2.60 A
BSA	0.43	1.94	4.01 abc	5.18	2.89 A
85-397	0.38	1.65	2.96 e	2.78	1.94 C
85-500	0.32	1.15	4.43 a	5.02	2.73 A
85-497	0.36	1.95	3.46 cde	4.38	2.54 AB
85-5001	0.36	1.94	3.63 bcd	4.47	2.60 A
CON-I	0.31	1.91	2.90 e	3.52	2.16 ABC
Jewel	0.35	1.89	4.13 ab	3.41	2.45 AB
Mean	0.38 B	1.49	3.61 A	4.18 A	

* = means bearing same letter(s) in each column are statistically similar at $p \leq 0.05$; NS = means in each column are non-significant.

Table 4. Sodium content (%) in root of Brassica genotypes as affected by different levels of NaCl salinity (Mean of three replications)

Variety	Control	30 mM	60 mM	90 mM	Means
		NaCl			
BARD-I	0.45 c*	0.87 h	1.61 b-e	0.59 f	0.88 H
Sultan Raya	0.48 c	1.89 ab	2.34 a	2.86 a	1.90 AB
19-H	0.51 c	1.07 gh	1.55 b-f	1.21 e	1.09 GH
Shiralle	0.61 c	1.43 cde	1.78 a-d	2.21 abc	1.51 CDE
Dunkled	0.35 c	1.19 efg	1.60 b-e	1.92 bcd	1.27 EFG
85-508	1.38 c	1.82 bc	1.53 b-f	2.46 abc	1.80 BC
Toria	0.38 c	1.22 d-g	1.67 a-d	1.91 bcd	1.30 D-G
85-499	0.58 c	1.10 gh	1.13 def	1.43 de	1.06 GH
BSA	0.43 c	1.39 def	1.98 abc	2.06 bcd	1.47 DEF
85-397	0.46 c	1.52 bcd	1.90 abc	2.50 ab	1.60 BCD
85-500	2.47 a	2.13 a	2.03 ab	1.80 cde	2.11 A
85-497	0.37 c	1.18 efg	0.94 ef	2.53 ab	1.26 EFG
85-5001	0.49 c	1.34 def	1.33 c-f	2.51 ab	1.42 DEF
CON-I	0.47 c	1.11 fg	0.89 f	2.25 abc	1.18 FG
Jewel	0.43 c	1.41 def	2.11 ab	2.01 bcd	1.49 DEF
Mean	0.67 C	1.44 B	1.63 B	2.02 A	

* = means bearing same letter(s) in each column are statistically similar at $p \leq 0.05$.

Table 5. Potassium content (%) in shoot of Brassica genotypes as affected by different levels of NaCl salinity (Mean of three replications)

Variety	Control	30 mM	60 mM	90 mM	Means
		NaCl			
BARD-I	26.76 N.S.	14.65 ab*	8.00 ab	9.19 a	14.65 AB
Sultan Raya	25.41	13.72 a-d	9.26 a	6.49 b	13.72 A-D
19-H	25.46	13.00 b-f	7.53 abc	5.99 bc	13.00 B-F
Shiralle	26.51	12.73 c-g	6.37 b-e	5.30 bcd	12.73 C-G
Dunkled	24.69	11.42 fg	5.26 def	4.31 cd	11.42 FG
85-508	30.11	13.77 a-d	6.65 b-e	4.53 cd	13.77 A-D
Toria	28.09	12.72 c-g	5.54 c-f	4.54 cd	12.72 C-G
85-499	26.59	12.68 c-g	5.80 c-f	5.65 bcd	12.68 C-G
BSA	28.00	14.95 a	7.03 bcd	9.82 a	14.95 A
85-397	31.10	13.33 a-e	4.75 ef	4.13 d	13.33 A-E
85-500	28.83	14.44 abc	6.25 b-e	8.26 a	14.45 ABC
85-497	23.47	11.07 g	4.70 ef	5.04 bcd	11.07 G
85-5001	26.44	12.55 d-f	6.76 b-e	4.45 cd	12.55 D-F
CON-I	26.02	11.57 efg	3.93 f	4.77 cd	11.57 EFG
Jewel	27.00	13.04 b-f	7.02 bcd	5.11 bcd	13.04 B-F
Mean	26.97 A	13.04 B	6.32 C	5.84 C	

* = means bearing same letter(s) in each column are statistically similar at $p \leq 0.05$; NS = means in each column are non-significant.

Table 6. Potassium content (%) in root of Brassica genotypes as affected by different levels of NaCl salinity (Mean of three replications)

Variety	Control	30 mM	60 mM	90 mM	Means
		NaCl			
BARD-I	15.04 cd*	8.55 cd	3.71 ab	1.21g	7.13 CD
Sultan Raya	16.21 cd	9.46 bc	3.25 bcd	3.20 bc	8.03 BC
19-H	16.72 cd	9.92 bc	4.31 ab	3.02 bcd	8.49 BC
Shiralle	22.12 b	10.61 a	2.22 de	1.76 fg	9.18 A
Dunkled	3.72 ef	5.88 fg	3.97 ab	4.26 a	4.46 FG
85-508	5.12 ef	5.51 fg	2.51 cde	3.19 bc	4.08 FG
Toria	7.76 e	6.61 ef	3.61 b	2.75 cde	5.18 EF
85-499	17.56 cd	9.19 bc	2.10 e	2.21 def	7.77 BCD
BSA	6.14 e	6.42 f	4.79 a	2.62 cde	4.99 F
85-397	14.19 d	9.45 b	4.80 a	3.65 ab	8.02 BC
85-500	18.95 a	10.59 a	3.94 ab	3.19 bc	9.17 A
85-497	1.72 f	4.58 g	3.53 bc	2.79 b-e	3.16 G
85-5001	17.38 cd	9.19 bc	2.35 de	2.13 ef	7.76 BCD
CON-I	18.76 bc	9.49 b	1.54 e	2.47 c-f	8.07 BC
Jewel	13.79 d	7.90 de	2.14 de	2.09 ef	6.48 DE
Mean	13.01 A	8.22 B	3.25 C	2.70 CD	

* = means bearing same letter(s) in each column are statistically similar at $p \leq 0.05$.

Table 7. Calcium content (%) in shoot of Brassica genotypes as affected by different levels of NaCl salinity (Mean of three replications)

Variety	Control	30 mM	60 mM	90 mM	Means
		NaCl			
BARD-I	4.49 b-e*	4.30 a	3.11 a	2.30 bcd	3.55 BC
Sultan Raya	4.43 cde	4.11 a	2.86 abc	3.89 a	3.82 A
19-H	4.56 b-e	4.21 a	2.88 abc	2.20 bcd	3.46 CD
Shiralle	4.23 e	3.99 ab	2.43 def	2.66 bc	3.33 CD
Dunkled	5.34 b	4.62 a	2.79 a-d	2.73 b	3.87 AB
85-508	5.22 bc	4.32 a	2.65 bcd	2.09 cd	3.57 BC
Toria	4.33 de	3.40 b	2.64 bcd	2.03 cd	3.10 CD
85-499	6.51 a	4.79 a	2.44 def	2.42 bcd	4.04 A
BSA	4.17 e	3.58 ab	2.64 bcd	2.39 bcd	3.20 CD
85-397	5.13 bcd	4.17 a	2.54 cde	1.83 d	3.28 CD
85-500	3.92 e	2.72 c	2.95 ab	2.50 bc	3.02 CD
85-497	4.05 e	3.24 abc	2.58 bcd	2.49 bc	3.09 CD
85-5001	4.41 cde	3.78 a	2.18 ef	2.53 bc	3.23 CD
CON-I	4.11 e	3.87 a	2.45 def	2.05 cd	3.12 CD
Jewel	4.69 b-e	3.99 a	2.12 f	2.15 bcd	3.24 CD
Mean	4.64 A	3.94 A	2.62 B	2.42 C	

* = means bearing same letter(s) in each column are statistically similar at $p \leq 0.05$.

Table 8. Calcium content (%) in root of Brassica genotypes as affected by different levels of NaCl salinity (Mean of three replications)

Variety	Control	30 mM	60 mM	90 mM	Means
		NaCl			
BARD-I	1.81 cd*	1.39 cd	1.36 cd	1.20 bcd	1.44 C-F
Sultan Raya	1.85 cd	0.99 ef	1.00 ef	1.34 bcd	1.30 C-F
19-H	1.81 cd	0.84 fg	0.90 efg	1.29 bcd	1.21 DEF
Shiralle	2.86 b	1.33 cd	1.11 def	1.05 cd	1.59 CD
Dunkled	1.71 cd	0.90 efg	0.93 efg	1.10 bcd	1.16 EF
85-508	1.88 cd	0.88 efg	1.05 ef	1.24 bcd	1.26 DEF
Toria	1.51 d	0.66 g	0.68 g	1.31 bcd	1.04 F
85-499	2.74 bc	2.86 a	2.34 a	1.58 abc	2.38 B
BSA	1.92 bcd	0.79 fg	0.82 fg	1.15 bcd	1.17 DEF
85-397	1.77 cd	1.87 b	1.90 b	1.42 bcd	1.74 CD
85-500	6.94 a	3.88 a	0.88 efg	0.84 d	3.14 A
85-497	1.80 cd	1.62 c	1.61 c	1.44 bc	1.62 CDE
85-5001	1.84 bcd	0.86 efg	0.92 efg	1.43 bc	1.26 DEF
CON-I	1.71 cd	1.29 cd	1.13 de	1.70 ab	1.46 C-F
Jewel	1.85 bcd	1.01 ef	1.44 c	2.10 a	1.60 C
Mean	2.27 A	1.41 B	1.20 B	1.35 B	

* = means bearing same letter(s) in each column are statistically similar at $p \leq 0.05$.

Table 9. Magnesium content (%) in shoot of Brassica genotypes as affected by different levels of NaCl salinity (Mean of three replications)

Variety	Control	30 mM	60 mM	90 mM	Means
			NaCl		
BARD-I	0.44	2.61N.S.	3.61N.S.	3.47 N.S.	2.53 N.S.
Sultan Raya	0.45	2.57	3.57	3.59	2.55
19-H	0.49	2.52	3.52	3.55	2.52
Shiralle	0.51	2.58	3.58	3.55	2.56
Dunkled	0.52	2.58	3.58	3.53	2.55
85-508	0.43	2.59	3.59	3.49	2.53
Toria	0.44	2.56	3.56	3.52	2.52
85-499	0.48	2.58	3.58	3.54	2.55
BSA	0.40	2.54	3.54	3.54	2.51
85-397	0.51	2.45	3.45	3.43	2.46
85-500	0.44	2.59	3.59	3.51	2.53
85-497	0.42	2.57	3.57	3.50	2.52
85-5001	0.49	2.49	3.49	3.52	2.50
~~CON-I~~	~~0.39~~	~~2.55~~	~~3.55~~	~~3.49~~	~~2.50~~
Jewel	0.46	2.52	3.52	3.53	2.51
Mean	0.46 C	2.55 B	3.55 A	3.52 A	

* = means bearing same letter(s) in each column are statistically similar at $p \leq 0.05$; N.S. = means in each column are non-significant.

Table 10. Magnesium content (%) in root of Brassica genotypes as affected by different levels of NaCl salinity (Mean of three replications)

Variety	Control	30 mM	60 mM	90 mM	Means
			NaCl		
BARD-I	0.49 b*	1.45 b	3.45 d	3.43 N.S.	2.21 D
Sultan Raya	0.54 b	1.48 b	3.43 d	3.48	2.23 D
19-H	0.49 b	1.48 b	3.38 d	3.58	2.23 D
Shiralle	0.87 b	1.64 ab	3.45 d	3.59	2.39 D
Dunkled	0.40 b	1.54 ab	3.79 cd	3.45	2.30 D
85-508	0.53 b	2.08 a	5.22 a	3.80	2.91 A
Toria	0.46 b	1.47 b	3.43 d	3.51	2.22 D
85-499	0.57 b	1.65 ab	3.94 c	3.45	2.40 D
BSA	0.58 b	1.47 b	3.41 d	3.44	2.23 D
85-397	0.50 b	1.50 b	3.58 cd	3.41	2.25 D
85-500	2.08 a	2.65 a	3.49 d	3.69	2.98 A
85-497	0.56 b	1.55 b	3.54 d	3.54	2.30 D
85-5001	0.59 b	1.51 b	3.42 d	3.51	2.26 D
~~CON-I~~	~~0.59 b~~	~~1.90 a~~	~~3.73cd~~	~~4.07~~	~~2.58 C~~
Jewel	0.59 b	1.98 a	4.59 b	3.77	2.73 BC
Mean	0.68 C	1.64 B	3.82 A	3.60 A	

* = means bearing same letter(s) in each column are statistically similar at $p \leq 0.05$; N.S. = means in each column are non-significant.

Table 11. Correlation coefficients for different growth and ionic content variables recorded

Ca^{++} root	1							
Ca^{++}shoot	-0.083	1						
K^{+} root	0.439**	0.002	1					
K^{+} shoot	0.187	-0.014	0.243	1				
Na^{+} root	0.326*	-0.224	0.13	0.357*	1			
Na^{+} shoot	0.154	-0.325*	-0.266	-0.017	-0.067	1		
RDW	-0.284*	0.306*	0.174	0.24	0.151	-0.382**	1	
SDW	-0.4**	0.288*	0.198	0.227	0.036	-0.423**	0.97***	1
	Ca^{+2} root	Ca^{+2} shoot	K^{+} root	K^{+} shoot	Na^{+} root	Na^{+} shoot	RDW	SDW

* = significant at 0.05; ** = significant at 0.01; *** = significant at 0.001 according to Little and Hills (1992).

correlation between shoot Ca^{+2} contents and shoot/root dry weights (0.308 and 0.288) indicated positive effect of Ca^{+2} content on growth (Table 11). In case of root Ca^{+2} contents, reverse trend was observed. Genotype 85-500 accumulated more Ca^{+2} in roots than any other genotype and Sultan Raya accumulated far less Ca^{+2} than this genotype. The Mg^{+2} content in shoot tissues of Brassica genotypes were found to be non-significant (Table 9-10) however, a close observation indicates that increasing NaCl salinity in rooting medium increased tissue Mg^{+2} concentration and maximum content (3.59%) were observed in the shoots of Sultan Raya under 90 mM/L NaCl salt stress. These results could be supported by the findings of Flowers (2004) and Sadiq *et al*. (2002).

Conclusion

Growth of all Brassica genotypes were significantly reduced with increase in NaCl salinity levels. Among all the genotypes, some species showed tolerance to salinity and performed well even under higher salinity (90 mM/L NaCl) level. Among all the genotypes, Sultan Raya gave promised results and performed well even at 90 mM/L NaCl salt stress while CV. 85-500 was found to be the most sensitive Brassica genotype. Performance of Sultan Raya will be tested under naturally salt-affected soil conditions.

Conflict of interest. The authors declare no conflict of interest.

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