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SALINITY TOLERANCE AND PHYTOREMEDIATION OF Na^+ AND K^+ IONS BY USING HALOPHYTES FROM CHOLISTAN RANGELAND, PAKISTAN

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ABSTRACT

Salinity has been considered as the most important factor which adversely affects the plant growth and metabolism in arid and semi-arid areas. Salinity is increasing with times and is expected that 50% of arable land would be salinized till 2050. Present study investigated salinity tolerance and phytoremediation of Na^+ and K^+ by using halophytes; *Cymbopogon jwarancusa*, *Aeluropus lagopoides*, *Panicum antidotale* and *Cenchrus setigerus*. Plants were grown for 40 days in hydroponic solution for biomass productions, chlorophyll contents, membrane stability index (MSI) and phytoremediation. Completely Randomized Design (CRD) with four treatments and replications was used to check significance level at 5%. Fresh and dry biomass of each species was increased with increasing salinity level but decreased under highly saline conditions. *P. antidotale* contained highest fresh/dry weight (20.4 A) and (4.2A) at 140 mM NaCl treatment that decreased at 210 mM NaCl. *A. lagopoides* showed highest MSI at T3 (46.3 A) significance level that reduced at 210 mM NaCl (20.7 D). K^+ concentrations in leaves/roots of all species reduced with elevated salinity (9327.4 A) was the highest K^+ in leaves of *A. lagopoides* which reduced to (3976.2 D) at 210 mM NaCl. Na^+ concentrations in the selected halophytes increased with the growing salt levels. Na^+ concentration in leaves were (2331.8 D) and (3834.7 ppm) at 0 mM NaCl level while it was (9078 A) and (7494.3A) in *P. antidotale* and *A. lagopoides* at 210 mM NaCl respectively. Phytoremediation by halophytic grasses is time saving, economically viable and novel approach towards reclaiming saline soils.

Keywords: Salinity, Halophytes, Biomass, Phytoremediation, MSI, Na^+

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INTRODUCTION

Salinity stress is described as factors enforced by the environment on the optimum functions of an organism. Stress factors including salinity, scarcity of water, life-threatening temperature, chemical toxicity and oxidation stresses are severe intimidations of vegetation and cause degradation of land on Earth. Due to salinity stress, the average reduction in biomass for some most important plants has been recorded more than 50%. Aridity and salinization of land is spreading very fast and it has been estimated that in 2050 more than 50% of arable lands could severe salinized (Wang et al. 2003; Jamil et al. 2011). Globally, salinity is reported to affect nearly 20% of cultivated areas and significant reduction in crop yields occurs (Qadir et al. 2014). In Middle East and Africa about 15-million-hectare area is salinized and one third of agriculture land is at risk of it. Estimated 44 countries in Asia and Africa are facing critical shortage of lands due to salinity and about 1830 million ha land consist of saline soils (Khan and Glenn 1996; Meijerink and Roza 2007). In South Asian countries, the salinity was first reported dates back to 1855 in Western-Yamuna in Moonak village (Now in Haryana) (Mann and Tamhane 1910). Sri Lanka accounts 21% of saline soil followed by Bangladesh 12% and India has only 4%. In these countries, about 7% of the total agriculture land is salt affected. Pakistan has 23% of agriculture land which is either saline or sodic soil, nearly 6.70 million ha land is saline out of which 1.89 ha is sodic soil (Gurung and Azad 2013).

Salinity has been considered as the most important factor which adversely affects the plant growth and metabolism in arid and semi-arid areas of the Earth (Munns and Tester 2008). These problems related soil is getting more intention in the whole world because of intense cultivation of crops and global climatic change (Ashraf and Akram 2009). There is a need for prevention of plants production losses and to make good use of saline soils (Yıldıztugay et al. 2011). Several ways have been used for reclamation of saline soils which includes agronomic practices, using of species which are adapted to salinity and phytoremediation. Among these methods' phytoremediation is most effective and economically and environmentally perfect for reclamation of saline soil (Hasanuzzaman et al. 2014). There are three types of adaptations in plants against salinity, one is osmotic stress tolerance second is elimination of Na^+ or Cl^- ion and the last one is tissue accumulated Na^+ or Cl^- tolerance (Munns and Tester 2008). To maintain vegetation cover in arid and semi-arid areas we need to deal with growth parameters that can be caused by salinity. High salinity level reduced the plants cover and decreased the both above and belowground biomass production. Moreover, it leads to wind and water erosion and for further land degradation following the loss of stabilizing soil-plant feedbacks (Okin et al. 2006; Breshears et al. 2009).

In a study conducted by Claeys et al. (2014) on *Arabidopsis* have shown that low concentrations of salts have minimal effect while higher has pronounced effect and quick decline in growth occurs. Future researches are much needed on particular traits that are responsible for inducing salinity tolerance in plants (Negrão et al. 2017).

The identification of native vegetation to different salinity levels is very important for development of affected areas and the reclamation of these soils. Salt tolerant ecotypes provide excellent means for finding the adaptive mechanisms to tolerate different environmental stresses (Ashraf 2003). That's why these plants can be used as a model plants for the reclamation of saline soils (Hameed et al. 2008; Pessarakli and Kopec 2009). The study greatly requires more research on such lands which are saline under critical conditions like Cholistan desert, whose most of the area is saline due to harsh conditions, water scarcity, anthropogenic activities, and exploitation of indigenous flora, change in land use, low precipitation and long and dry summers. Based on above mentioned climatic conditions we used 4 native halophytic grasses *Panicum antidotale*, *Aeluropus lagopoides*, *Cenchrus setigerus* and *Cymbopogon jwarancusa* to check the salinity stress and minimizing it by absorbing in large contents of Na^+ and K^+ for the reclamation of the saline lands in the Cholistan Rangeland, Bahawalpur.

MATERIALS AND METHODS

A hydroponic experiment was accompanied at experimental area of Forestry, Range & Wildlife Management, UCA & ES, The Islamia university of Bahawalpur during the month of September to October 2018. The grass stumps of the *Cymbopogon jwarancusa*, *Panicum antidotale*, *Cenchrus setigerus* and *Aeluropus lagopoides* were collected from the Cholistan Rangeland. The collected stumps were matched with the herbarium collection deposited at the Cholistan Institute of Desert Studies. The plants were trimmed at a uniform size of stump, i.e., 10.16cm. The stumps were placed in the Hoglands solution (1979). The plants were kept under green shed of the research area at 35˚C. The hydroponic medium was changed once a week to maintain the nutrients in proper proportion. Solution pH was maintained at a range of 5.5 to 7.0. Pots were arranged in a Completely Randomized Design (CRD) with four blocks. Each species has the 4 treatments with 4 replications (Kong and Zheng 2014). The solutions were aerated during the whole experiment by using air pumps. A total of 72 plants stumps were tested in the experiment. Four stubbles were grown in each pot which represented one replicate. Different treatments of NaCl 0, 70, 140, 210 mM NaCl were given to the treatments.

Biomass Production

***Fresh and Dry Weight*:** Samples from each species were taken and washed through tape water and then rinsed with deionized water and weighed. After this the samples were air dried. Then these were oven dries at 70˚C for three days and weighed.

***Relative Leaf Water Contents (LRWC)*:** Young leaves were used to measure the leaf relative water contents. For this, young leaves from each treatment of every species were taken. Leaves were separated from the base of lamina and sealed in polythene bags. These were shifted to laboratory just after harvesting. Fresh weight (FW) was measured within 2 hours after harvesting. Thereafter, leaves were soaked in distilled water for 16-18 hours at 25˚C and then carefully dried by using blotting tissue paper. After drying turgid weight (TW) was measured by using electrical weighing balance. Dry weight (DW) was measured after drying the samples in oven at 70˚C for 72 hours. LRWC was calculated in percentage by using the formula as giving by Lazcano-Ferrat and Lovatt (1999).

$$LRWC = (FW-DW) / (TW-DW) \times 100$$

***Membrane Stability Index (MSI)*:** Membrane Stability Index (MSI) was measured using the method of Sairan and Saxena (2000). Leaf disc of 100mg were made and carefully cleaned using tape water followed by washing with distilled water. Washed discs were heated in 10 ml distilled water at 40˚C for 30 minutes. After this,

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Electrical Conductivity (C_1) was measured using EC meter. Then the samples were kept in boiling water at 100°C for 10 minutes. EC (C_2) was also noted at that time. MSI was calculated as:
MSI= [1-(C_1/C_2)] x 100

Determination of Sodium and Potassium in Plants

***Reagent Solutions*:** A) 1:2 Perchloric acid and Nitric acid mixture solution was prepared. For this 500 ml (70%) perchloric acid in 1000 ml HNO3 (69-71%) was mixed well. The solution was kept cool and then stored in glass bottle and kept in dark. B) Standard solutions of potassium and sodium were made for flame photometer.

***Digestion*:** Weighed 1.0 g, ground, sieved and free of contamination plant sample in digestion tube. Added 20 ml acid mixture. Heated at 150-175°C on digestion block till white to slight yellowish plant material color in the digestion tube. Made volume 100 ml with distilled water or as desired for analysis. Made dilution as of the digested material. Determined K (ppm) by flame photometer using standard and graph reading.

Calculations:
K and Na (%) = Na or K ppm x d.f./10000
K and Na ppm = (ppm in extract – blank) x A/Wt.
A is a volume of extract (ml)
Wt. is a weight of sample used (Jones Jr et al. 1991).

RESULTS AND DISCUSSION

Biomass Production

Fresh and Dry Weight: Fresh weight indicates the total biomass production and the vigour of a plant. Healthy plants produce more fresh weight that is necessary for reproductive growth and produce seeds for next generation. Plants show different response against different stresses (Karim et al. 2012). In the present study, results showed that different treatments significantly changed the amount of fresh weight produced by the selected halophytes (Table 1).

Maximum fresh weight was measured at treatment T2 (27.6 A) in *Cymbopogon jwarancusa* while the lowest fresh weight was at T4 (15.6 D). Fresh weight in *Cenchrus setigerus* showed that under treatment T2 was maximum (21.3 A) while it started reduction at elevated NaCl treatment and at T4 it was (9.0 C). *Aeluropus lagopoides* showed that the species is highly salt tolerant and produced high fresh weight at high NaCl concentration T3 (19.3 A) while at very high saline condition T4 showed retarded growth (8.6 C). Table 2 is explaining that fresh weight was significantly affected under different treatments. Overall comparison among four species showed that *Panicum antidotale* produced the highest fresh weight biomass (20.4 A) under high salinity T3 followed by the *Aeluropus lagopoides, Cenchrus setigerus and Cymbopogon jwarancusa* by (19.3 A), (14.6 B) and (19.3 C), respectively.

Table 1. Analysis of variance of halophyte species against salinity stress

Species	DOF	Chlorophyll		Biomass production		RWC		MSI		K		Na+	
		F	P	F	P	F	P	F	P	F	P	F	P
Cymbopogon jwarancusa	3	10.7	0.004	21.6	0.0003	42.7	0.00	62.7	0.00	473	0.00	460	0.00
Aeluropus lagopoides	3	398	0.000	11.7	0.0027	49.1	0.00	69.0	0.00	213	0.00	169	0.00
Panicum antidotale	3	149	0.000	23.5	0.0003	86.5	0.00	63.9	0.00	156	0.00	626	0.00
Cenchrus setigerus	3	159	0.000	9.18	0.0057	67.4	0.00	130	0.00	216	0.00	670	0.00

RWC = relative water contents, MSI = Membrane Stability Index; Significance level (P>0.05). F value is the calculated value of CR design and P is the significant value at 0.05%.

Table 2. Fresh and dry weights in four halophytic grasses against salinity stress

Treatments NaCl mM		*Cymbopogon jwarancusa*		*Aeluropus lagopoides*		*Cenchrus setigerus*		*Panicum antidotale*	
		FW	DW	FW	DW	FW	DW	FW	DW
T1	0	16±1.94	2.1±0.34	10±1.18	2.3±0.26	12.6±0.68	1.8±0.19	15.3±1.12	2.9±0.15
T2	70	27.6±0.25	6.7±0.56	14.6±0.25	2.9±0.12	21.3±1.12	5.3±0.22	19±0.89	3.8±0.11
T3	140	19.3±0.68	3.7±0.11	19.3±0.68	3.6±0.09	14.6±0.68	3.0±0.44	20.4±1.12	4.2±0.17
T4	210	15.6±1.29	3.2±0.08	8.6±1.36	1.8±0.20	9.0±0.44	2.0±0.22	11.5±1.16	2.6±0.13

Fresh Weight = FW; Dry Weight = DW

Dry weight is the total weight after removal of relative water contents from plants or with 5-10% moisture level. Salinity affects the total dry mass of plants. *C. jwarancusa* produced maximum dry weight at medium saline environment T2 (6.7 A). Dry weight of *C. jwarancusa* reduced with the increasing salinity. Dry weight of *Cenchrus setigerus* explained that under normal saline conditions T2; retained the highest dry weight (5.3 A) that reduced with the increasing salt level under T4 (2.0 B). *A. lagopoides* produced more biomass under high salinity T3 (3.6 A) while at highly saline treatment T4 dry weight was lagging behind (1.8 C). *Panicum antidotale* is a halophytic grass and grown well under saline environment. Mean values explained that under saline treatment T3 (4.21 A) dry weight was produced. At highly saline treatment T4 recorded dry weight was (2.6 B).

Salinity has great impact on plants production that not only reduces the total production but may leads to severe damage and even death of the plants. Salt levels have significant consequences on leaves of halophytes. These results correlate the study conducted by Alamgir and Ali (2006), number of leaves decreased with the increasing salinity in *Oryza sativa*. Similar results were also found in wheat crop by Hu and Schmidhalter (2007). Salt toxicity varies with changing ecotype. Karim et al. (2012) described that biomass production in plants decrease with increasing the salinity while it reduced at highly saline conditions. Utilization of the saline soil using ground saline and surface rainwater resources for growing palatable grasses is a sensible thought. Uses of biotic method (growing halophyte species) in the saline soil are very economical and possible way to overcome the scarcity of sweet water for irrigation in saline areas (Ahmad 2010).

Fresh and dry weights of *Aeluropus lagopoides* increased with the increasing salinity level up to 150 mM NaCl while it started decreasing at 600 and 750 mM NaCl (Ahmad 2010). The halophyte species showed optimum growth and productivity at medium salinity stress but suppressed at high NaCl toxicity (Sobhanian et al. 2010; Mohammadi et al. 2019). Similar results were expressed by Boestfleisch and Papenbrock (2017) that in *Crithmum maritimum* L., *Triglochin maritima* L. and *Halimione portulacoides* (L.) biomass reduced with increasing salinity.

Salinity Tolerance

***Relative Leaf Water Contents*:** Relative leaf water contents (RLWC) are the amount of water present in leaf. RLWC describe the vigour and health of plants. Higher the RLWC more will be the vigour and biomass in the plant. RLWC of all species are shown in Table 3 that illustrates that *C. jwarancusa* retain maximum water contents in leaves under treatment T2 (88.7 A). Elevated NaCl treatments T3 and T4 showed the reduction in RLWC (73.6 B) and (64.6 C). *C. setigerus* preserve (88.0 A) percent RLWC at T2 treatment. *Aeluropus lagopoides* at high salt level T3 it conserves the more RLWC (89.6 A) and reduced at very high salinity level T4 (67.3 C). *Panicum antidotale* contains the highest RLWC at T3 (87.3 A) while under very high salt situations T4 RLWC was (64.7 D).

Salinity decreases the relative water contents (RWC) in root or shoot of plants. While in some halophytes RWC increases at some level and finally decrease the RWC at high salinity toxicity. In *Kochia scoparia* species water contents decrease with the increasing salinity (Nabati et al. 2011). Yang et al. (2009) also described the similar effects. Different salts level has significant effect on leaf water contents and at rapid increase RWC reduce water potential of leaf. MSI has positive relations with RWC (Nabati et al. 2011). Our results showed the reduction in RWC at high saline conditions that matched with Munns and Tester (2008) also explained the physiological attributes of halophytes and reported that osmotic pressure of plants reduced with increasing salinity and Jamil et al. (2012) also stated the reduction in RWC with increasing salinity in *Beta vulgarus* and discussed the comparable findings.

Table 3. Relative leaf water contents (%) in four halophytic grasses against salinity stress

Treatments	NaCl mM NaCl	*Cymbopogon jwarancusa*	*Aeluropus lagopoides*	*Cenchrus setigerus*	*Panicum antidotale*
T1	0	69.3±0.93	65±0.89	68.3±0.93	69.3±0.93
T2	70	88.7±1.12	73.7±1.36	88±1.61	75.3±0.68
T3	140	73.6±1.36	89.6±1.125	72.6±0.68	87.3±0.93
T4	210	64.6±1.43	67.3±0.68	64±1.18	64.7±0.68

***Membrane Stability Index (MSI)*:** Membrane stability index (MSI) is the durability of cell membrane against toxicity. Salinity has greatly damaged the cellular membrane and showed significant results (Table 1) that leads to the death of cell. Durability of cellular membrane is the key step toward the healthy growth of plants (Munns and Tester 2008). MSI of *C. jwarancusa* is shown in Table 4. Mean percent values are described that in *C. jwarancusa* cell membrane damage increase with the increasing salinity level at T4, T3 and T2 (26.7 A), (33.3 C) and (52.6 D) accordingly. MSI in *A. lagopoides* increased with the elevated NaCl treatment T1, T2 and T3 (24.0 C), (28.3 B) and (46.3) respectively while under highly saline condition MSI reduced to (19 C). MSI in *C. setigerus* was at the peak value under T2 (50.7 A) and decreased with the increasing NaCl concentrations T3 and T4 (28.6 B) and (18.6 C) respectively. Mean comparison of four species shows that MSI was highest in *P. antidotale* followed by the *A.*

lagopoides under saline treatments T3 (47.3 A) and (46.3 A) accordingly. Under highly saline treatment T4 MSI of all the species were highly sensitive and salinity caused much damage to all the species.

Membrane Stability Index (MSI) is an important parameter in plants growth and development (Füzy et al. 2019). Membrane stability decreases with the increasing abiotic stress. Salinity cause cellular injury that retard the growth and limit the productivity. Membrane stability reflects the salinity tolerance. Nabati et al. (2011) represented the similar results and reported that membrane stability damage increase with the increasing level of salts in soil. Membrane stability in *Beta vulgarus* reduced at higher salinity and expressed the similar results as we did find in our experiment (Jamil et al. 2012). Munns and Tester (2008) also reported and discussed the physiology of halophytes. At high saline conditions plants reduced its water contents that lead to cells injury in halophytes.

Table 4. Membrane Stability Index (MSI) % in four halophytic grasses against Salinity stress

Treatments	NaCl mM NaCl	*Cymbopogon jwarancusa*	*Aeluropus lagopoides*	*Cenchrus setigerus*	*Panicum antidotale*
T1	0	30±0.44	24±1.18	26.6±0.93	29±0.89
T2	70	52.6±1.69	28.3±0.93	50.7±0.93	38.3±0.93
T3	140	33.3±1.13	46.3±1.36	28.6±0.68	47.3±1.57
T4	210	26.7±0.93	19±0.89	18.6±1.25	20.7±0.93

Phytoremediation of K^+ and Na^+ ions

***Na^+ and K^+ Concentration in root/shoot of Halophytes*:** K^+ includes in the macro nutrients of plants. Relative proportions of these nutrients are very important to normalize the physiological functioning of plants, but excessive amount of these macro elements leads to toxicity in plants species (Munns and Tester 2008). Halophytes have been affected by the different concentrations of salinity. Salinity even changed the amount of nutrients absorbed by plants. Results showed that K^+ ions absorption varies under changed NaCl treatments and its values decreased with the increased salt level in all four species. Concentrations of absorbed K^+ ions in roots of *C. jwarancusa* decreased with the increasing salinity T1, T2, T3 and T4 (7689.7 A), (7352.8 A), (4313.1 B) and (3046.3 C) accordingly. K^+ ions absorbed by *Aeluropus lagopoides* under T1, T2, T3 and T4 are (6004.8 A), (5755.5 A), (4245.8 B) and (3578.4 C) respectively. Similar case was happened with *C. setigerus* and *P. antidotale* under saline treatments shown in Table 5 and Table 6. Similar results were measured for the K^+ ions concentration in shoots by *C. jwarancusa*, *A. lagopoides*, *C. setigerus* and *P. antidotale*. Table 4 and Table 5 is clarifying the mean values of K^+ in root of said halophytes. In *C. setigerus* under T1, T2, T3 and T4 K^+ ions are (5822.8 A), (4785 B), (3956.1 C) and (2945.2 D) respectively.

Table 5. Na^+ and K^+ ions Concentrations in Halophytic Grasses against Salinity Stress

Treatments	NaCl Mm	*Cymbopogon jwarancusa*				*Aeluropus lagopoides*			
		Root (ppm)		Shoot (ppm)		Root (ppm)		Shoot (ppm)	
		Na	K	Na	K	Na	K	Na	K
T1	0	3551.6±71.3	7689.7±88.1	2641.8±37.5	5843.1±47.1	4319.9±150	6004.8±93.6	3834.7±129	5088.2±61
T2	70	6348.5±76.5	7352.8±97	5452.2±140	5182.5±90	6442.9±182	5755.5±79	5708.2±135	4778.2±84
T3	140	8080.6±99.2	4313.1±124	6159.9±86	3908.8±145	7595.4±70	4245.8±84.1	6854±122	4124.5±105
T4	210	11632.2±66.3	3046.3±71	8363.7±141	3093.4±110	9900.3±110	3578.4±84	7494.3±105	2486.8±61

Relative proportions of nutrients are very essential for plants. But the availability of these nutrients depends upon the extent of nutrients in soil. Moreover, other biotic and abiotic factors also have great effect in nutrients absorption by plants. Amount of salinity in the root zone of plants has also a significant impact on nutrients absorption (Table 1). Na^+ and Cl^- ions absorption by roots are more in plants under saline environment than the non-saline conditions. Results showed that with the increasing salinity T1, T2, T3 and T4 the amount of Na^+ in shoot of *C. jwarancusa* increased (2641.8 D), (5452.2 C), (6159.9 B) and (8363.7 A) respectively. Under the followed treatments *C. setigerus* and *P. antidotale* also behaved the same absorption ratio and as *P. antidotale* accumulates (2331.8 D), (5829.5 C), (7399.9 B) and (9078 A). Na^+ ions absorbed through roots can be boost up by the increasing NaCl level in soil. In *A. lagopoides* and *C. setigerus* Na^+ accumulation in roots of both species increased with the growing salinity. Under T1, T2, T3 and T4 accumulated Na^+ was (4319.9 D), (6442.9 C), (7595.4 B) and (9900.2 A) respectively in *A. lagopoides* while in *C. setigerus* under the followed treatments Na^+ concentrations were (2790.1 D), (4731.1 C), (6153 B) and (9381.3 A) correspondingly.

Table 6. Na^+ and K^+ ions Concentrations in Halophytic Grasses against Salinity Stress

Treatments NaCl mM		*Panicum antidotale*				*Cenchrus setigerus*			
		Root (ppm)		Shoot (ppm)		Root (ppm)		Shoot (ppm)	
		Na	K	Na	K	Na	K	Na	K
T1	0	3268.6±42	6658.5±71.3	2331.8±17.8	5991.3±68	2790.1±35.6	9327.4±75	2210.5±59.9	5822.8±178
T2	70	6712.4±64	6254.1±147	5829.5±124	5398.3±79	4731±126	8592.8±242	5384.7±128	4785±116
T3	140	8505.2±88	4178.5±64.2	7399.9±68	3416.9±236	6153±135	7069.7±61	5930.6±132	3956.1±61.7
T4	210	9435.3±65	3673±105	9078±68	2635±191	9381.3±77.7	3976.3±117	6988.8±122	2945.2±70.3

Halophytes are plants that can complete their life cycle under saline conditions. These plants bear and store sodium and chloride ions in their vacuoles. *S. maritima* is a halophyte and can store up to 500-600 mM Na^+ ions in its leaves (Yeo and Flowers 1980; Flowers et al. 2014). Under high salinity Na^+ ions increase while K^+, Ca^+ and Mg^+ ions decrease with the increasing salts level. Under saline conditions *Haloxylon recurvum* express the same results (Khan et al. 2000). Na^+ and K^+ ions have great contribution in plants growth. But at high salinity toxicity plants showed retarded growth and bounds the production. Halophytes showed reasonable growth at medium salinity level but at 200 mM NaCl or more salinity, limit their production. Na^+ ions in halophytes root/shoot increases with the increasing salinity that causes the reduction of K^+ ions concentrations respectively. Matoh et al. (1986) and Khan et al. (2000) described the similar results, in *Atriplex gmelini* and *Haloxylon recurvum* respectively. Hameed and Ashraf (2008) described that *Cynodon dactylon* decreases their Na^+ and K^+ ions concentration in leaves and roots with the increasing NaCl level while different ecotypes have also the great effects in the accumulation of these ions. *Cynodon dactylon* collected from Faisalabad region has low tolerance level than the species collected from Salt Ranges of Pakistan (Hameed and Ashraf 2008).

Conclusion: The results showed that all four species are halophytic in nature as these produced well under increasing saline conditions while at highly saline treatments their productivity reduced. Membrane stability in these species increased with elevated NaCl level while reduced at higher saline treatment. RLWC in all species increased with elevated salt toxicity and reduced at higher salinity toxicity. All species are also capable of phytoremediation of Na^+ and K^+ ions because these absorbed more Na^+ as the salt level increased. All species are suitable for reclaiming saline soils.

Contribution of Authors: MR conceived, designed experiments and carried out the supervision of studies. MA and HB performed the experiments. ZA performed statistical analyses of experimental data and MM prepared the draft of the manuscript. MUG provided technical assistance. All authors critically revised the manuscript and approved the final version.

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