Research Article

Evaluation of Non-Aromatic Rice (*Oryza sativa* L.) Cultivars for NaCl Tolerance under Hydroponic Conditions

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Abstract | Rice (*Oryza sativa* L.) is the most important cereal crop in the world and it is used as a staple food for over one-third world's population. Salinity is one of the major abiotic stresses, which is reducing the yield of rice crop in the world. The tolerance level of five native non-aromatic, coarse rice cultivars (IR-6, IR-8, DR-82, DR-83 and DR-92) was tested in the current study. A local nursery was established for each cultivar and healthy seedlings were shifted in isolated hydroponic plastic tubs containing the Hoagland solution and 0 (control), 40, 80, 120 and 160 mM of NaCl concentrations. Amongst the five rice cultivars, DR-92 performed better in terms of survival percentage, average plant height, shoot dry weight, percent reduction over control (PROC) for plant height and shoot dry weight, the accumulation of less Na^+ and more K^+ as well as the higher K^+/Na^+ ratio in shoot dry matter, than rest of the cultivars at low to high salt-stress (NaCl) conditions. The results show that the non-aromatic rice cultivar DR-92 can survive and give better yield in moderately (40-120 mM NaCl) saline soils.

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Introduction

Rice (*Oryza sativa* L.) is used as a staple food by half of the world's population. It is cultivated in many parts of the world including Asia, America, Africa, Europe and Oceania. Asia contributes 676.61 million tonnes of the total global (756.74 million tonnes) rice production as compared to 38.11, 37.89, 4.07 and 0.062 million tonnes rice production by America, Africa, Europe and Oceania respectively (FAO, 2020). The rice is generally grouped into aromatic or non-aromatic cultivars depending on the presence or absence of aroma (Verma and Srivastav, 2020). As compared to non-aromatic rice, aromatic rice comprises small portion of the global rice production, nevertheless it is regarded as unique due to the presence of aroma (Dias *et al*., 2022). According to Prodhan and Qingyao (2020) most aromatic rice cultivars have comparatively low yields than non-aromatic rice cultivars due to their low adaptability to changed environmental conditions. However, the price of aromatic rice cultivars is two to three times higher than the non-aromatic rice cultivars (Cavin *et al*., 2018).

Pakistan is the 13th largest producer (8.42 million tonnes) and the 16th largest exporter (13600 tonnes) of rice in the world (FAO, 2020). Rice in Pakistan is cultivated from 2500-meter-high altitude to sea level and from hot arid plains to coastal tropical humid areas (Shahzadi *et al*., 2018). However, its production is under threat due to several factors including the soil salinity. In arid and semiarid regions of the world, the soil salinity is a major environmental problem that affect the agricultural productivity and sustainability of the crops (Hussain *et al*., 2019). According to Syed *et al*. (2021) approximately 831 Mha of the land is salt affected worldwide. In only Pakistan, the salt-affected land is approximately 4.5 Mha (Aslam, 2016). The soil salinity produces adverse effects on the growth, development, and yield of rice crop (Heenan *et al*., 1988). It inhibits the ability of the plants to uptake water by decreasing the osmotic potential of the soil solution, causes premature aging and reduces the photosynthetic leaf area of the plants to a level where sustainable growth is stunted (Munns, 2002; Munns and Tester, 2008; Nemati *et al*., 2011; Horie *et al*., 2012). Its impact on the rice crop is seen at almost all growth and developmental stages (Khatun *et al*., 1995), however at its early growth stage the impact is much adverse (Rad *et al*., 2011). Generally, the response of plant to soil salinity is seen in morphological, physiological, biochemical or molecular makeups (Rhodes *et al*., 2002). Among the early developmental stages, seed germination is the most negatively affected stage under saline conditions (Azza *et al*., 2007). According to Heenan *et al*. (1988) the seed germination is an extremely sensitive stage of the plant to saline conditions in most plant species. Previous studies show that the germination percentage, root and shoot length, and total dry weight of rice were reduced with an increase in NaCl levels (Abbas *et al*., 2013).

The survival of plant and completion of its life cycle under saline conditions depends upon its ability to tolerate salt stress at its various growth stages from (Akbari *et al*., 2007). The development and/or screening of the salt tolerant cultivars is the best choice to increase rice production in salt affected areas of the world. There are two main methods of screening crop species including screening under controlled environment (in pots, in hydroponics or inside greenhouse) and the field evaluation (Singh *et al*., 2009). The screening under controlled environments is more effective than field evaluation in maintaining light conditions, soil composition, temperature and relative humidity (Gregoria *et al*., 1997).

Very few studies are reported on evaluating non-aromatic rice cultivars for salt tolerance. In current study five non-aromatic rice cultivars of Sindh, Pakistan were grown under hydroponic conditions to screen their salt (NaCl) tolerance level.

Materials and Methods

An experiment was conducted in hydroponic at the Centre for Biosaline Agriculture (CBA), Soil Science Department, Sindh Agriculture University, Tandojam, Pakistan. Aim of the study was to test the tolerance level of five high yielding non-aromatic local rice cultivars (IR-6, IR-8, DR-82, DR-83 and DR-92) in four NaCl treatment solutions (40, 80, 120 and 160 mM) against a control treatment (0 mM).

Seeds of the five cultivars were received from Rice Research Centre (RRC) Dokri, Sindh. The germination of seeds of each cultivar in a separate nursery were observed in first week of June 2017. Twenty-five days old plants were shifted to tubs in first week of July 2017. The measurements were taken after 35 days of transplantation into tubs. Twenty-five (25) days older seedlings were shifted to hydroponic plastic tubs of size 26 × 55 cm, using thermocol sheets (expanded polystyrene foam). For each treatment, including control, three tubs were used. Each tub contained 25 liters of Hoagland solution. The composition of Hoagland solution per liter was as per Hoagland and Arnon (1950) (NO_3^- 14.0, NH_4^+ 1.0, P 1.0, K^+ 6.0, Ca^{2+} 4.0, Mg^{2+} 2.0, S 2.0 mM) and (Mn^{2+} 9.1, Zn^{2+} 0.8, Cu^{2+} 0.3, B 46.3, Mo 0.1, Fe^{2+} 32.0 μM). The pH of the solution was set to 6.3 (Alexander, 2000). The hoagland solution of the tubs was changed every 10 days. Electrical conductivity was maintained in each tub as per the treatment. The experiment was completely randomized design (CRD) with five replicate per treatment. The nursery was grown in open field conditions and the hydroponics experiments were conducted in a wire-house. The average relative

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humidity recorded from April to August was 119 to 160%. The average maximum and minimum temperature recorded from April to August was 36 to 42 °C and 26 to 29 °C, respectively. The average light hours per day counted from April to August were 12 to 14 and the average dark hours were 12-10.

The response of each cultivar was recorded in term of phenotypic traits and biochemicals contents. The percent reduction over control (PROC) was attained with the following formula as per Ali *et al*. (2004).

$$PROC = \frac{Value\ in\ Control - Value\ in\ NaCl\ solution}{Value\ in\ control} x\ 100$$

Plant height (cm) and dry shoot weights (g) per plant were noted at the time of harvesting. The contents of Na^+, K^+ and Cl^- in dry shoot matter was obtained through Dry Ash Processing Technique as per Chapman (1965). The contents of Na^+ and K^+ were determined using flame photometry (Model PFP 7, Jenway, Staffordshire, United Kingdom). The Cl^- contents were determined through titration method as per Richards (1954). The obtained data was analyzed using two-way ANOVA (p<0.05) using Statistix software (version 8.1, Miller Landing Rd, Tallahassee) and the differences among the means were calculated through LSD at <0.05 level of significance.

Results and Discussion

Survival rate (%)

Data presented in Table 1 shows the survival rate of five non-aromatic rice cultivars grown under different hydroponics conditions. The maximum mean survival rate of 100% was seen in control (0 mM NaCl) which was decreased up to 8% with an increase in salt concentration from 40 mM NaCl to 160 mM NaCl. Of the four NaCl concentrations, 40 mM NaCl concentration revealed 52% mean survival rate as compared to 32% survival on 80 mM and 20% survival on 120 mM concentration. The lowest mean survival rate (8%) was recorded on 160 mM NaCl concentration.

Of the five non-aromatic rice cultivars tested, DR-92 revealed 100% survival on 40 mM NaCl concentration which was followed by IR-6 with 60% survival and, DR-82 and DR-83 with 40% survival rate on 40 mM NaCl concentration (Table 1). The survival rate was decreased in each cultivar with an increase in NaCl concentration from 40 mM to 160 mM. Cultivar DR-92 was found better amongst all the five cultivars in terms of survival on all the four NaCl concentrations and control. The survival rate in DR-92 was however decreased up to 40% on 160 mM NaCl concentration which was however higher than survival rate found in rest of the cultivars. In IR-6 the survival rate of 60% on 40 mM concentration was decreased to 40% and 20 % on 80 mM and 120 mM and 160 mM NaCl concentrations respectively. Cultivar DR-83 could only survive in control treatment and on 40 mM NaCl concentration. Whereas, cultivar IR-8 and DR-82, both revealed 20% survival on 80 mM concentration which was decreased to 0% survival on 120 mM and 160 mM NaCl concentrations in both the cultivars.

Table 1: *Survival % of rice cultivars grown in hydroponics.*

Treatment NaCl (mM) (A)	Cultivar (B) IR-6	IR-8	DR-82	DR-83	DR-92	Mean (A)
Control	100	100	100	100	100	100
40	60	20	40	40	100	52
80	40	20	20	0	80	32
120	40	0	0	0	60	20
160	20	0	0	0	40	8
Mean (B)	52	28	32	28	76	

Table 2: *Effect of different NaCl salinity levels on plant height (cm) of five non-aromatic coarse rice cultivars in hydroponic condition.*

Treatment NaCl (Mm) (A)	Cultivar (B) IR-6	IR-8	DR-82	DR-83	DR-92	Mean (A)
Control	35.00	41.80	39.80	38.20	52.20	41.40
40	32.40	36.00	34.80	35.00	48.60	37.60
80	31.60	34.80	32.80	32.80	46.60	35.72
120	30.00	31.60	29.60	30.00	45.00	33.24
160	27.20	27.00	28.20	29.00	42.80	30.84
Mean (B)	31.24	34.24	33.04	32.24	47.040	
	Treatment	Cultivar		Treatment × Cultivar		
S.E.D	0.58	0.58		1.31		
L.S.D (0.05%)	1.16***	1.16***		NS		

****Highly Significant (P < 0.05) ns= non-significant.*

Salinity responses on phenotypic traits

The effect of different NaCl concentrations on plant height of five non-aromatic rice cultivars is presented in Table 2. The results show that NaCl concentration significantly (p<0.05) effected plant height of the plants in all cultivars. As compared to four NaCl treatments, control (0 mM) showed the maximum mean plant height of 41.40 cm, which was followed by 37.60 cm on 40 mM NaCl concentration and 35.72 on 80 mM NaCl treatment. The minimum mean plant height was recorded on 160 mM NaCl treatment (30.84 cm). Amongst the five cultivars, the highest mean plant height of 47.04 cm was seen in cultivar DR-92 which was followed by 34.24 cm in cultivar IR-8, 33.04 cm in cultivar DR-82 and 32.24 cm in cultivar DR-83. The lowest mean plant height was recorded in cultivar IR-6 (31.24cm).

Table 3: *Effect of different NaCl concentrations on plant shoot dry weight (g) per plant of five non-aromatic coarse rice cultivars under hydroponic condition.*

Treatment NaCl (mM) (A)	Cultivar (B)					Mean (A)
	IR-6	IR-8	DR-82	DR-83	DR-92	
Control	0.38	0.19	0.20	0.30	0.54	0.32
40	0.35	0.14	0.15	0.22	0.51	0.27
80	0.32	0.10	0.13	0.20	0.49	0.25
120	0.29	0.08	0.101	0.16	0.44	0.22
160	0.23	0.06	0.08	0.12	0.34	0.17
Mean (B)	0.31	0.12	0.13	0.20	0.47	
	Treatment	Cultivar	Treatment × Cultivar			
S.E.D	0.01	0.01	0.02			
L.S.D (0.05%)	0.02***	0.02***	NS			

****Highly Significant (P < 0.05) ns= non-significant.*

The addition of NaCl in the water as compared no NaCl (Control) also significantly reduced the shoot dry weight of rice cultivars (Table 3). The results revealed that both, NaCl concentration (A) and cultivar type (B) produced the significant (P<0.05) impact on plant shoot dry matter however the interaction of both A × B remained non-significant. It can be seen in Table 3 that the least mean dry shoot weight of 0. 0.17 g per plant was recorded at 160 mM NaCl concentration. The results shows that the maximum mean dry shoot weight of 0.32 g per plant was achieved in control treatment which was followed by 0.27 g on 40, 0.25 g on 80 and 0.22 g dry shoot weight on 120 mM NaCl concentration. The minimum mean dry shoot weight (0.17) per plant was recorded on 160 mM NaCl concentration. Amongst the five non-aromatic rice cultivars, DR-92 produced the maximum mean dry shoot weight of 0.47 g per plant, which was followed by 0.31 g in cultivar IR-6, 0.20 g in DR-83 and 0.13 g dry shoot weight in cultivars DR-82, respectively. The minimum mean dry shoot weight (0.12 g) per plant was recorded in cultivar IR-8. It can also be seen from the data that cultivar DR-92 performed better than all other cultivars in control and all NaCl concentrations.

Percent reduction over control

The percent reduction over control (PROC) was recorded for all five cultivars and NaCl treatments (Table 4). On average, the maximum PROC of 22.60% was recoded in cultivar IR-8 in terms of plant height, which was followed by 21.22% in DR-82, 17.01% in DR-83 and 13.42% in IR-6. The minimum average PROC (12.35%) was recorded in cultivar DR-92. Amongst the four NaCl concentrations, 40 mM revealed the lowest PROC of 9.82%, which was increased with an increase in concentration of NaCl from 80 mM (13.77%) to 120 mM (19.91%). The highest PRCO (25.92%) was recorded on 160 mM NaCl concentration.

Table 4: *PRCO Plant height.*

NaCl (mM) (B)	Cultivars (A)					Mean (B)
	IR-6	IR-8	DR-82	DR-83	DR-92	
40	7.42	13.87	12.56	8.37	6.89	9.82
80	9.71	16.74	17.58	14.13	10.72	13.77
120	14.28	24.40	25.62	21.46	13.79	19.91
160	22.28	35.40	29.14	24.80	18.00	25.92
Mean (A)	13.42	22.60	21.22	17.01	12.35	

Table 5: *PRCO Shoot dry weight.*

NaCl (mM) (B)	Cultivars (A)					Mean (B)
	IR-6	IR-8	DR-82	DR-83	DR-92	
40	7.89	26.31	25.00	26.66	5.55	18.28
80	15.78	47.36	35.00	33.33	9.25	28.14
120	23.68	57.89	50.00	46.66	18.52	39.35
160	39.47	68.42	60.00	60.00	37.03	52.98
Mean (A)	21.70	49.10	43.80	39.58	17.59	

In terms of shoot dry weight (Table 5) the maximum PROC of 49.10% was recoded in cultivar IR-8, which was followed by 43.80% in DR-82 and 39.58% in DR-83. The minimum average PROC (17.59%) was recorded in cultivar DR-92 followed by (21.70%) in cultivar IR-6. Amongst the four NaCl concentrations, 40 mM concentration revealed the lowest PROC of 18.28%, which was increased with an increase in concentration of NaCl from 80 mM (28.14%) to 120 mM (39.35%). The highest PRCO (52.98%) was recorded on 160 mM NaCl concentration.

Effect of NaCl treatments on Na^+, K^+ and Cl^- contents

The data present in Table 6 shows the Na^+ contents in shoot of five rice cultivars grown under different NaCl solutions. The content of Na^+ in shoot was significantly increased with an increase in NaCl concentrations from 40 mM to 160 mM. As compared to an average 0.64% of Na^+ accumulation in control, 0.78% Na^+ content was found on 40 mM NaCl solution, which increased up to 1.69% in plants grown on 160 mM NaCl solution. Amongst the five non-aromatic rice cultivars, DR-92 and IR-6 accumulated the lowest Na^+ of 0.97% and 0.98% respectively, while IR-8 accumulated the highest (1.40%) Na^+ followed by DR-83 (1.19%) and DR-82 (1.08%).

Table 6: *Effect of different NaCl salinity levels on Na^+ content (%) in shoot of five non-aromatic coarse rice cultivars in hydroponic condition.*

Treatment NaCl (mM) (A)	Cultivar (B) IR-6	IR-8	DR-82	DR-83	DR-92	Mean (A)
Control	0.60	0.78	0.65	0.63	0.54	0.64
40	0.78	0.88	0.71	0.82	0.69	0.78
80	1.07	1.20	1.13	1.19	0.96	1.11
120	1.14	1.80	1.28	1.62	1.14	1.40
160	1.32	2.34	1.62	1.68	1.50	1.69
Mean (B)	0.98	1.40	1.08	1.19	0.97	
	Treatment		Cultivar	Treatment × Cultivars		
S.E.D	0.043		0.043	0.097		
L.S.D	0.087***		0.087***	0.195***		

***Highly Significant ($P < 0.05$).

Table 7: *Effect of different NaCl salinity levels on K^+ content (%) in shoot of five non-aromatic coarse rice cultivars in hydroponic condition.*

Treatment NaCl (mM) (A)	Cultivar (B) IR-6	IR-8	DR-82	DR-83	DR-92	Mean (A)
0	3.60	2.64	2.55	2.74	4.32	3.17
40	3.00	2.54	2.43	2.64	3.96	2.91
80	2.76	2.52	1.92	2.40	3.84	2.69
120	2.64	1.27	1.68	2.28	2.90	2.15
160	2.52	0.95	1.56	1.80	2.88	1.94
Mean (B)	2.90	1.98	2.03	2.37	3.58	
	Treatment		Cultivar	Treatment × Cultivar		
S.E.D	0.090		0.090	0.201		
L.S.D	0.181***		0.181***	0.205***		

***Highly Significant ($P < 0.05$).

On the contrary, K^+ contents in shoot reduced with an increase in NaCl levels (Table 7). In general, the maximum mean K^+ content of 3.17% was recorded in control, which decreased to 2.91% in plants grown on 40 mM NaCl solution, and 2.69% and 2.15% in plants grown on 80 and 120 mM NaCl solution, respectively. The minimum K^+ content accumulation percentage (1.94%) in rice plants was recorded on 160 mM NaCl solution. Amongst the five non-aromatic rice cultivars, DR-92 accumulated the highest K^+ content percentage of 3.58, which was followed by IR-6 (2.90%) and DR-83 (2.37%). The lowest K^+ content accumulation percentage (1.98%) was found in IR-8 cultivar.

Table 8: *Effect of different NaCl salinity levels on K^+/Na^+ ratio in shoot of five non-aromatic coarse rice cultivars in hydroponic condition.*

Treatment NaCl (mM) (A)	Cultivar (B) IR-6	IR-8	DR-82	DR-83	DR-92	Mean (A)
0	6.06	3.40	3.95	4.43	7.95	5.16
40	3.87	2.99	3.41	3.23	5.80	3.86
80	2.56	2.10	1.69	2.02	4.00	2.47
120	2.33	0.70	1.35	1.41	2.54	1.67
160	1.90	0.40	0.96	1.07	1.93	1.26
Mean (B)	3.34	1.92	2.27	2.43	4.44	
	Treatment		Cultivar	Treatment × Cultivar		
S.E.D	0.129		0.129	0.288		
L.S.D	0.259***		0.259***	0.589***		

***Highly Significant ($P < 0.05$).

The accumulation of K^+/Na^+ ratio in shoot was also found inversely proportional to the NaCl concentrations. It can be seen from the data presented in Table 8 that with an increase in NaCl concentration from 40 mM to 160 mM, the K^+/Na^+ ratio was decreased from 3.86 to 1.26. The maximum mean K^+/Na^+ ratio of 5.16 was recorded in control, which was decreased to 3.86 with the addition of 40 mM NaCl. The K^+/Na^+ ratio in shoot was further decreased on 80 mM solution to 2.47 and 1.67 on 120 mM NaCl solution. The minimum mean K^+/Na^+ ratio in shoot (1.26) was noted in plants grown on 160 mM NaCl solution. Amongst the five non-aromatic rice cultivars, DR-92 showed the highest mean K^+/Na^+ ratio of 4.44 in shoot, which was followed by 3.34 in IR-6, 2.43 in DR-83 and 2.27 ratio in DR-82. The minimum mean K^+/Na^+ ratio (1.92) was noted in cultivar IR-8.

The results regarding accumulation of Cl^- content in rice shoot are present in Table 9. The data shows an increase in Cl^- content with an increase in NaCl concentration from 40 mM to 160 mM. The minimum mean accumulation of Cl^- content (0.19%)

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was recorded in control, whereas the maximum mean accumulation of Cl^- content (0.32%) was noted in plants grown on 160 mM NaCl solution. Amongst the five rice cultivars, the minimum mean accumulation of Cl^- content (0.20%) was recorded in DR-92, which was followed by IR-6 cultivar (0.23%) DR-83 cultivar (0.25%) and DR-82 cultivar (0.26%) The maximum mean accumulation of Cl^- content (0.30%) in plant shoot was recorded in cultivar IR-8.

Table 9: *Effect of different NaCl salinity levels on Cl^- content (%) in shoot of five non-aromatic coarse rice cultivars in hydroponic condition.*

Treatment NaCl (mM) (A)	Cultivar (B)					Mean (A)
	IR-6	IR-8	DR-82	DR-83	DR-92	
0	0.16	0.23	0.16	0.22	0.15	0.19
40	0.23	0.24	0.26	0.23	0.17	0.23
80	0.25	0.26	0.27	0.25	0.21	0.25
120	0.26	0.33	0.28	0.26	0.23	0.27
160	0.28	0.45	0.36	0.27	0.25	0.32
Mean (B)	0.23	0.30	0.26	0.25	0.20	
	Treatment		Cultivar	Treatment × Cultivar		
S.E.D	0.012		0.012	0.028		
L.S.D	0.025***		0.025***	0.056**		

****Highly significant (P < 0.05).*

Soil salinity is a prominent factor in halting and reducing the total productivity of a crop. It is not only associated with reduction in total productivity and yield of the crop but also, affect the usage of cultivated lands. In present study the influence of NaCl concentrations on five non-aromatic rice cultivars was tested under hydroponic conditions. The rice plants revealed salt stress-related phenotypic symptoms including white leaf tip, drying of the older leaves and slow growth (Sen and Chandrasekhar, 2014) which may be associated with Na^+ and Cl^- toxicity. An increase in concentration of the specific ion at certain level may become toxic resulting increase in the thresholds (Batool *et al*., 2014). The reduction in plant growth and development under saline environments is reported to be caused by osmotic stress and toxic effects of salts (Munns, 2002; Munns and Tester, 2008; Nemati *et al*., 2011; Horie *et al*., 2012). In current study the NaCl salts may have decreased plant growth by diminishing the water potential, increasing specific ion toxicity (Na^+ and Cl^-) and interfering with the essential nutrient absorption (Akram *et al*., 2007).

Under current saline conditions cultivar DR-92 performed better than rest of the four other cultivars in terms survival percentage, plant height, shoot dry weight, PROC (both in plant height and shoot dry weight), and ion contents. Out of all the five non-aromatic rice cultivars tested, cultivar IR-6, IR-8, DR-82 and DR-83 showed unsatisfactory response under all salinity treatments. Present findings are in close confirmation with the findings of Zeng and Shannon (2000) and Zeng *et al*. (2001) that salinity influences altogether on seedling development and biomass production of rice. Our findings may also be supported by the findings of Castillo *et al*. (2003) that salt-stress given to rice plants at its vegetative stage is more adverse that prolongs the crop growth duration.

A typical mechanism of salinity tolerance in rice has been described as the Na^+ exclusion or take-up diminishment, while increment in accumulation of K^+ to keep up a decent and adjusted Na^+/K^+ ratio in the shoot. The characterization of crop for susceptibility to and moderately tolerant or absolute tolerant to salinity stress is based on field trials, research facility and nursery tests, and is generally identified with the accumulation ratio of Na^+ and K^+. The Na^+/K^+ ratio, which is the balance between Na^+ and K^+ in shoot, is also a substantial standard in estimating valid criterion in measuring salinity tolerance of rice (Gregoria *et al*., 1997). Present results suggested that with an increase in NaCl concentration, the K^+ content (%) and K^+/Na^+ ratio in the shoot was decreased, while on the contrary, the contents of Na^+ and Cl^- were increased. According to Al- Karaki (2000) the specific impacts of salt stress on plant digestion, particularly on leaf senescence, has been identified under the accumulation of Na^+ and Cl^- and to K^+ and Ca^{2+} consumption. The high Na^+ accumulation under various salinity levels may cause declining of growth essentially because of Na^+ lethality. Such lethality which is associated with high NaCl concertation, interrupts vital metabolic activity in plants, especially in nutrient uptake (Castillo *et al*., 2003).

In current study the findings shows that cultivar DR-92 was better than rest of the cultivar, IR-6, IR-8, DR-82 and DR-83 under all NaCl concentrations. The ion contents noted in the shoots of all five rice cultivars at different NaCl concentrations suggested that the better performance of cultivar DR-92 was perhaps associated with accumulation of less Na^+ and Cl^-, and more K^+ content as well as K^+/Na^+ ratio in shoot.

Conclusions and Recommendations

It can be concluded from the study that yield was generally decreased by exposing young rice plants to different NaCl concentrations under hydroponic conditions at vegetative growth. However, the rice cultivar DR-92 was found more tolerant to the NaCl concentrations and performed better than rest of the tested rice cultivars in terms of all the tested traits. Hence, DR-92 cultivar may be recommended to growers for further trials and cultivation on saline soils where other intolerant rice cultivars have failed to survive.

Novelty Statement

Soil salinity is a major environmental problem that has affected the agricultural productivity and sustainability of the rice crop. In current study non-aromatic rice cultivars were screened for salt tolerance to increase the rice production in salt affected areas.

Author's Contribution

Ghulam Sarwar Channa, **Abdul Razak Mahar** and **Inayatullah Rajpar:** Designed the study.
Ghulam Sarwar Channa, **Muneer Ali Bhagat** and **Wazir Ali Maitlo:** Performed the field work and collected the data.
Ghulam Sarwar Channa and **Abdul Aziz Mirani:** Analyzed the data and drafted the manuscript.
All the authors read and approved the final manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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