# COMPARATIVE RESPONSE OF WHEAT (*Triticum aestivum* L.) GENOTYPES TO BRACKISH WATER AT SEEDLING STAGE

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Seedling growth and ionic composition of different wheat genotypes was assessed in solution culture at different concentrations of brackish water to determine the tolerance of genotypes. Growth was recorded as shoot fresh / dry weight, root fresh/dry weight, root/shoot length and leaf analysis for major inorganic ions ($Na^+$, $K^+$ & $Cl^-$). Results showed a reduction in growth parameters was observed in all treatments but it was greatest in $T_5$ which contain combination of highest EC, SAR and RSC. The concentration of sodium and chloride ions in leaf sap increased while that potassium decreased by application of brackish water as compared to fit water. Among genotypes SARC-1 and 8670 restricted the uptake of $Na^+$ and preferred $K^+$ uptake and thus maintained high $K^+$: $Na^+$ ratio and performed better in all types of brackish water.
**Keywords:** Wheat, brackish water tolerance, ion content, seedling growth

## INTRODUCTION

Salinization of soil is a major environmental, agricultural and community problem throughout the Indus Basin of Pakistan. Irrigation systems are particularly prone to salinization, with about half the existing irrigation systems of the world now under the influence of salinization or water logging, due to either low quality irrigation water, or to excessive leaching and subsequent rising water tables. Under agro-climatic conditions of Pakistan, evapo-transpiration is several times higher than rainfall (2025 and 150 mm, respectively), which is responsible for net upward movement of salts through capillary action. The shortfall in irrigation water requirement is likely to reach 107 MAF by 2013 (Ghafoor *et al.*, 2002b). In order to supplement the present canal water availability at farm-gate (43 MAF), 0.565million tube wells are pumping underground water to fulfill the crop water requirement (Kahlown and Azam, 2003). Estimates show that about 70–80% of pumped water in Pakistan (67,842 million $m^3$) contains soluble salts and/or sodium ions ($Na^+$) levels above the permissible limits for irrigation water (Latif and Beg, 2004). Rafiq (1990) estimated development of surface salinity and/or sodicity on an area of about 3 m ha in the country as a result of using marginal-quality drainage and groundwater without appropriate management practices. Growth of most agricultural crops irrigated with poor quality water suffers adversely (Minhas *et al.*, 1996; Chaudhry *et al.*, 2001; Murtaza *et al.*, 2005).

When salts are present in higher concentrations plant growth is affected negatively in various ways i.e. osmotic effects, specific ion effect and nutritional imbalance probably all occurring simultaneously (Flowers *et al.*, 1991). Initial growth inhibition in saline environment is induced by the decreased water potential of rooting medium due to higher salt concentrations (Munns *et al.*, 1995). A secondary effect of high concentrations of $Na^+$ and $Cl^-$ in the root medium is the suppression of uptake of essential nutrients such as $K^+$, $Ca^{2+}$, $NO_3^-$ etc. (Gorham and Wyn Jones, 1993). Such practices will be relying on plants that have higher degree of salt tolerance. Salt tolerance in crops will also allow the more efficent use of poor quality irrigation water. Many investigators have reported retardation of germination and growth of seedlings at high salinity. However, plant species differ in their salt tolerance.

Wheat is the most important and widely adapted food cereal in Pakistan. Therefore, it is necessary to increase wheat production in Pakistan by raising the wheat grain yield. The most efficient way to increase wheat yield is to improve the salt tolerance of wheat genotypes (Epstein *et al.*, 1980; Shannon, 1997; Pervaiz *et al.*, 2002) because increasing the salt tolerance of wheat is much less expensive for poor farmers in developing countries than using other management practices (e.g. leaching salt from the soil surface etc., Qureshi and Barrett-Lennard, 1998). Test on wheat cultivars have shown that there are interavarietal differences for salt tolerance (Kingsbury and Epstein 1984, Rashid *et al.*, 1999). Salt tolerance of crops may vary with their growth stage (Mass and Grieve, 1990). In general, cereal plants are the most sensitive to salinity during the vegetative and early reproductive stages and less sensitive during flowering and during the grain filling stage (Mass and Poss, 1989). However, a difference in the salt tolerance among genotypes may also occur at different growth stages. Zeng *et al.* (2002) reported that various responses of different rice genotypes to salt tolerance exist at different growth stages. The objective of the present investigation was therefore to asses the response of different wheat genotypes to brackish water (different salts combinations) at seedling stage.

## MATERIALS AND METHODS

### Raising of nursery

The present investigation was carried in solution culture conducted in wire house of Institute of Soil & Environmental Sciences, University of Agriculture, Faisalabad. Seeds of seven wheat genotypes were sown in gravels contained in iron trays and irrigated with water daily. When nursery was germinated, a small amount of ½ strength Hoagland nutrient solution was applied to supply the essential nutrients for the establishment of nursery seedlings.

### Nursery transplantation

At 2-3 leaf stage, plants were transferred to foam plugged holes in polystyrene sheet, floating over 200 L capacity iron tubs lined with polyethylene sheet, containing ½ strength Hoagland's nutrient solution. After two days different amount of salts ($Na_2SO_4$, $NaHCO_3$, $CaCl_2.2H_2O$ and $MgSO_4.7H_2O$) calculated by using quadratic equation were added to develop five treatments as $T_1$ fit water **(**EC=1.3, SAR=2.59, RSC= 0.60); $T_2$ High EC water **(**EC=10, SAR=8.0, RSC= 0.80) ; $T_3$ High SAR water **(**EC=3.0, SAR=20.0, RSC= 1.0);$T_4$ High RSC water **(**EC=3.0, SAR=8.5, RSC= 5.4) and $T_5$ high EC- SAR-RSC water **(**EC=10, SAR=20.0, RSC= 5.40). Aeration was provided with air pump 8 hours a day. Seedlings were arranged according to Completely Randomized Design (CRD) factorial arrangement. The pH was maintained daily at 6.0-6.5, and nutrient solution was changed after 15 days. After 30 days of stress plants were harvested and data were collected for growth parameters [Shoot/root length (cm plant$^{-1}$); Shoot/root fresh weight (g plant$^{-1}$) were recorded after oven drying. The leaf samples were collected for ionic analysis of $Na^+$, $K^+$, $Cl^-$ shoot/root dry weight (g plant$^{-1}$)] and leave sap analysis for $Na^+$, $K^+$ and $Cl^-$.

## RESULTS

Growth of wheat genotypes in terms of shoot and root length, shoot fresh and dry weight and root fresh and dry weight was observed in different brackish water treatments. The effect of brackish water on plant growth and ionic concentration in leaf sap of wheat genotypes is explained as under.

### Shoot and root length (cm plant$^{-1}$)

The data regarding root and shoot length as affected by brackish water application is presented in Fig. 1. Root and shoot length of all wheat genotypes was adversely affected with brackish water treatments. There were significant differences in shoot/root length among wheat genotypes under different concentration as well as at the same concentration of brackish water. The maximum shoot root length of all genotypes was obtained under fit water treatment ($T_1$) and minimum was in EC-SAR-RSC water application ($T_5$). In EC-SAR-RSC water treatment, comparison of genotypes showed that maximum root and shoot length was obtained by SARC-1 (34.0 and 34.8 cm plant$^{-1}$) followed by V-8670 (30 & 29.6 cm plant$^{-1}$) and WC-78 (27.5 & 25.0 cm plant$^{-1}$) and lowest was in SQ-78 (22.0 & 23.0 cm plant$^{-1}$), while CIM-31 could not survive.

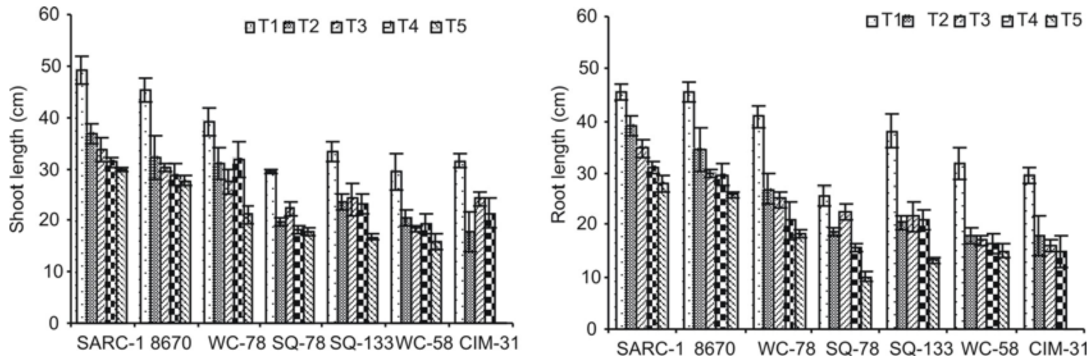
### Shoot and root fresh weight (g plant$^{-1}$)

Significant difference in shoot and root weight were observed among the wheat genotypes under different brackish water treatments (Fig. 2). The maximum shoot and root fresh weight of all genotypes was obtained under fit water treatment ($T_1$) and minimum was in EC-SAR-RSC water application ($T_5$).Wheat genotypes showed significant variation under each treatment. The reduction in growth parameters occurred in all treatments but maximum reduction was recorded in T5. At highest salt level ($T_5$) SARC-1 and 8670 performed better and maximum shoot fresh weight was obtained (2.52 and 2.55 g plant$^{-1}$) and lowest was obtained by SQ-133 (1.6 g plant$^{-1}$) but CIM-30 could not survive. The reduction in shoot fresh weight also varied between wheat genotypes and minimum reduction was found in 8670 (53.21%) followed by SARC-1 (56.9 %) and maximum was in WC-78 (80%) at highest level of EC, SAR and RSC. Similar trend was observed in root fresh weight.

### Ion accumulation in leaf sap

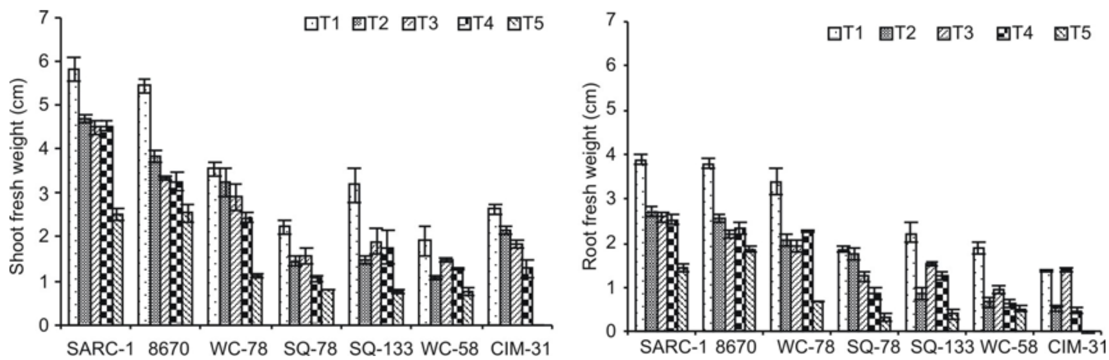
Ionic contents determined in leaf sap showed that there was a gradual increased in sodium ($Na^+$) and chloride ($Cl^-$) ions, with increase in salt concentration in brackish water. However, potassium ($K^+$) concentration and $K^+$:$Na^+$ ratio decreased (Fig. 3) with increase in salt concentration. Maximum sodium ($Na^+$) accumulations was observed at higher salt concentration and among the genotypes SQ-78 accumulate highest $Na^+$ (4.24 mol m$^{-3}$) as compared to others and minimum was in SARC-1 (1.2 mol m$^{-3}$). Similarly, significant differences were observed for $K^+$ among various genotypes. Data showed that brackish water reduced $K^+$ concentration in all treatments for all genotypes. Maximum $K^+$ accumulated in SARC-1 (4.67 mol m$^{-3}$) and minimum was in SQ-133 (2.71mol m$^{-3}$). Similarly $Cl^-$ concentration increased in all genotypes as the salt concentration increased in brackish water. The highest $K^+$: $Na^+$ ratio was recorded in SARC-1 followed by 8670 and minimum in SQ-78 at $T_5$ containing combination of highest levels of EC, SAR and RSC.

**Fig. 1. Effect of brackish water on shoot and root length (cm plant$^{-1}$)**



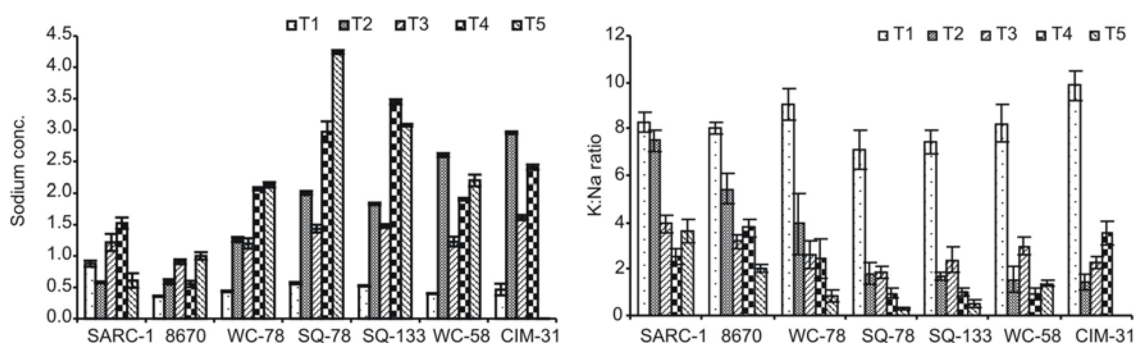

$T_1$ [Fit Water] $T_2$ [EC (10.0 dSm$^{-1}$) Water]
$T_3$ [SAR (20.0(m mol L$^{-1}$)$^{1/2}$) Water] $T_4$ [RSC (5.4 me L$^{-1}$) Water]
$T_5$ [EC (10 dSm$^{-1}$) + SAR (20(m mol L$^{-1}$)$^{1/2}$) + RSC (5.4 me L$^{-1}$) Water]

**Fig. 2. Effect of brackish water on shoot and root fresh weight (g plant$^{-1}$)**




$T_1$ [Fit Water] $T_2$ [EC (10.0 dSm$^{-1}$) Water]
$T_3$ [SAR (20.0(m mol L$^{-1}$)$^{1/2}$) Water] $T_4$ [RSC (5.4 me L$^{-1}$) Water]
$T_5$ [EC (10 dSm$^{-1}$) + SAR (20(m mol L$^{-1}$)$^{1/2}$) + RSC (5.4 me L$^{-1}$) Water]

**Fig. 3. Ionic concentration in leaf sap of wheat genotypes**




$T_1$ [Fit Water] $T_2$ [EC (10.0 dSm$^{-1}$) Water]
$T_3$ [SAR (20.0(m mol L$^{-1}$)$^{1/2}$) Water] $T_4$ [RSC (5.4 me L$^{-1}$) Water]
$T_5$ [EC (10 dSm$^{-1}$) + SAR (20(m mol L$^{-1}$)$^{1/2}$) + RSC (5.4 me L$^{-1}$) Water]

## DISCUSSION

Young seedling of wheat genotypes exhibited a gross ability to adjust osmotically in response to high salt stress. Growth parameters measured were adversely affected by salt concentration in brackish water. This is in good agreements with results observed by others that brackish water reduced the wheat growth (Sharma *et al.*, 2001; Minhas, *et al.*, 1996; Chaudhry *et al.*, 2001; Murtaza *et al.*, 2005). The reduction in shoot fresh weight and other growth parameters were less in SARC-1 and 8670 genotypes as compared to others in all brackish water treatments. So that these genotypes had ability to perform better under different types of brackish water treatments.

The increased $Na^+$ concentration in leaf sap under salinity could be due to high salt concentration in the rooting medium (Shafqat *et al.*, 1998) and passive sodium diffusion through damaged membranes, i.e. leakiness resulting in decreased efficient exclusion of $Na^+$. Nawaz *et al.* (1998) reported increased $Na^+$ concentration in leaf sap due to enhanced inward movement and inhibited outward active exclusion of this ion under the combined stress of salinity and water logging. Serraj and Sinclair (2002) reported that accumulation of $Na^+$, $Cl^-$ and organic solute caused reduction in osmotic potential and due to osmotic adjustment plants maintained water uptake. Higher concentration of $Cl^-$ become toxic in same range as that $Na^+$, if $Na^+$ and $Cl^-$ are sequestered in the vacuoles of cell, $K^+$ should accumulate in cytoplasm (Hasegawa *et al.*, 2000). Increased $Na^+$ and $Cl^-$ concentration and decreased $K^+$ concentration in expressed leaf sap under salinity was also reported by Qureshi *et al.* (1991), Akhtar *et al.* (1994) and Rashid *et al.* (1999). The increased potassium in leaf sap of some genotypes under salinity stress could be due t o efficient potassium absorption by selective inclusion of sodium by cortical cells (Schachtman and Munns, 1992).

## CONCLUSION

Under brackish water salinity stress sodium concentration in genotype SARC-1 was low while that of $K^+$ was high and resultantly a high $K^+$:$Na^+$ ratio was observed. It can be inferred that the genotype possess $K^+$:$Na^+$ selectivity characteristic of salt tolerance. The $K^+$ concentration of 8670 under brackish water salinity stress was also high and consequently these genotypes maintained a good tolerance in non-halophytes selectivity characteristic.

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