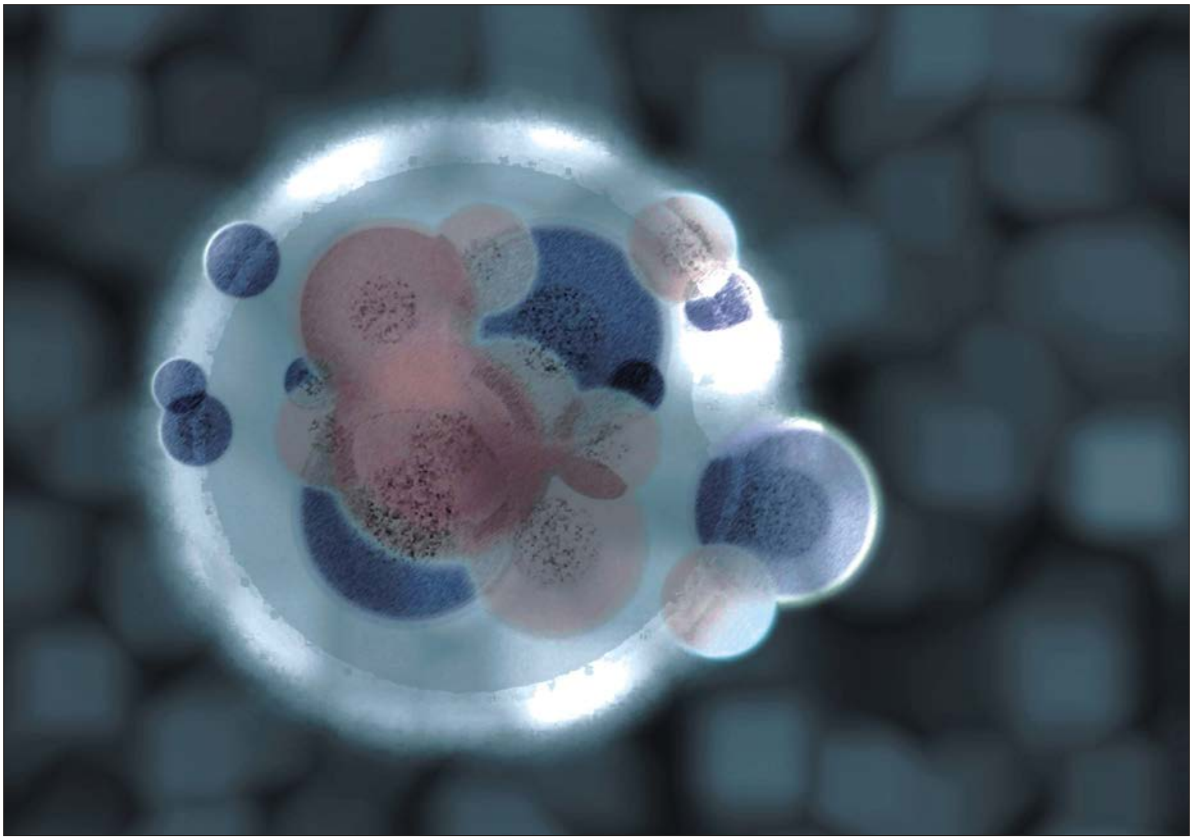

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Comparative Performance of Wheat (*Triticum aestivum* L.) Genotypes under Salinity Stress II: Ionic Composition

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Abstract: The concentration of sodium and chloride ions in leaf sap increased while that of potassium decreased under salinity as compared to control. Among the genotypes, Pb-25, Pb-28, SARC-6, KLR-1-4 and Bakhtawar restricted the uptake of Na^+ and preferred K^+ and thus maintained high K^+:Na^+ ratio, while Pb-39 and SARC-1 behaved conversely.

Key words: Comparative performance, ionic composition, salinity, wheat genotypes

Introduction

In saline environment, 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). Membrane depolarization caused by excess NaCl leads to the loss of membrane and cytosolic K^+ and inner pool of Ca^{2+} through displacement of Ca^{2+} by Na^+ (Cramer *et al.*, 1984, 1985).

Different physiological traits such as potassium selectivity, exclusion and/or compartmentation of Na^+ and Cl^- ions, osmotic adjustments and accumulation of organic solutes have all been related to the salt-tolerance of cultivars of different species (Wyn Jones and Storey, 1981). Exclusion of Na^+ and Cl^- at leaf or cellular level is an important physiological process conferring salt-tolerance in wheat and perhaps many other crop species (Schachtman and Munns, 1992; Rashid *et al.*, 1999). Moreover, salt-tolerant plants can compartmentalize the toxic concentrations of the salts in their tissues (older leaves) and cells (vacuoles) and osmotic adjustments are accomplished by the synthesis of sugars in the cytoplasm (Gorham and Jones, 1993; Munns *et al.*, 1995; Fricke *et al.*, 1996). The present study aims to compare the performance of wheat genotypes under salinity with special reference to ion accumulation as a criterion for salt -tolerance.

Materials and Methods

The experiment was conducted in pots filled with 10 kg of soil each. There were two treatments, i.e. control (non-saline) and salinity (EC_e = 15.0 dS m^{-1}) each replicated thrice. Normal soil with salinity of EC_e 1.13 dS m^{-1} was used as control treatment. In salinity treatment, soil was salinized prior to filling in the pots by mixing calculated amount of NaCl and a final level of salinity in the range of EC_e 14.82-15.18 dS m^{-1} was achieved. Seeds of eleven wheat genotypes (Pb-25, Pb-28, Pb-35, Pb-36, Pb-39, SARC-1, SARC-5, SARC-6, Inqlab, KLR-1-4 and Bakhtawar) were imbibed in continuously aerated water for 48 hours before sowing. Fertilizers were applied at 120: 60:60 kg ha^{-1} NPK as Urea, SSP and K_2 SO_4. Half N and whole P and K were applied at sowing, while ½ N was applied at booting stage. At booting stage fully expanded second to flag leaf was sampled, washed, blotted and stored in the Eppendorf tube at freezing temperature. Frozen samples were thawed and leaf sap was extracted by crushing with a metal rod (Gorham *et al.*, 1984). Extracted sap was centrifuged at 6500 rpm for 10 minutes and was diluted as required by adding distilled water. Then sodium and potassium concentration in sap was determined by Flame Photometer (Jenway PFP-7) and chloride by Chloride Analyzer (Corning 926). The data thus obtained were analyzed statistically using completely randomized design (Steel and Torrie, 1980) and treatment means were compared by using Duncan's Multiple Range Test (Duncan, 1955).

Results

Sodium concentration: Root zone salinity increased the sodium concentration in the expressed leaf sap. Genotypes differed significantly for Na^+ accumulation both under control and saline conditions. Under saline conditions maximum accumulation of Na^+ was observed in the case of Pb-36, while minimum in the case of SARC-5. Rest of all the genotypes were statistically at par with one another (Fig. 1a). On relative basis accumulation of Na^+ by Pb-39 was maximum when compared with that under control, followed by Pb-36. Minimum relative accumulation (w.r.t. control) was observed in the case of SARC-6, Bakhtawar and Inqlab.

Potassium concentration: As regards K^+ accumulation significant differences were observed among various genotypes. Figure 1b shows that salinity reduced the K^+ concentration in all the genotypes except Pb-25, Pb-28 and Pb-36. Potassium concentration in these genotypes under salinity treatment was higher than that under their respective controls. Under saline conditions genotype Pb-28 accumulated the highest while SARC-1 the lowest K^+ concentration. Potassium concentration in SARC-1 under control treatment was also the lowest, while in Bakhtawar the highest concentration was observed. Under salinity stress, K^+ concentration in Pb-25, Pb-36, KLR-1-4 and Bakhtawar was high while in Pb-39 and SARC-5 low, as compared with rest of the genotypes.

Chloride concentration: Chloride concentration (Fig. 2a) in the expressed leaf sap of all the genotypes under salinity stress was high as compared to that under their respective controls. Genotypes among themselves did not differ significantly for Cl^- accumulation under both the treatments. Under salinity stress SARC-6 accumulated the highest Cl^- concentration followed by Pb-39. while Cl^- concentration of rest of the genotypes was more or less similar. But under control treatment Cl^- concentration in all the genotypes was statistically similar.

K^+ : Na^+ Ratio: Salinity reduced the K^+:Na^+ ratio in all the genotypes (Fig. 2b). The highest K^+:Na^+ ratio was recorded in Pb-25 and the lowest in Pb-39 and SARC-1 under salinity stress. The values for K^+:Na^+ ratio for Pb 28, SARC-6, KLR-1-4 and Bakhtawar were also high and differed non significantly from the highest one. The lowest values of K^+:Na^+ ratio were found for the genotypes Pb-39 and SARC-1 under salinity stress, but the same genotypes showed the highest values under their respective controls.

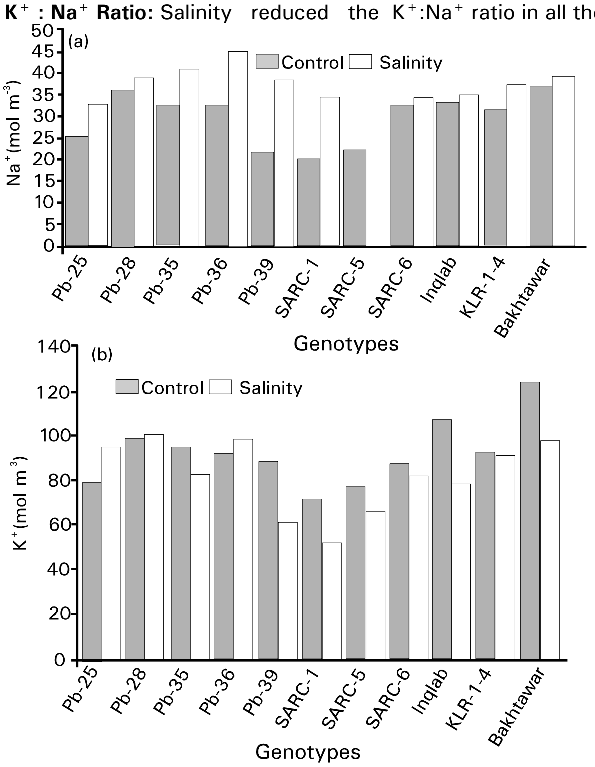

Fig.1(a-b): Concentration of sodium and potassium in the tissue sap of fully expanded second to flag leaf collected at booting stage

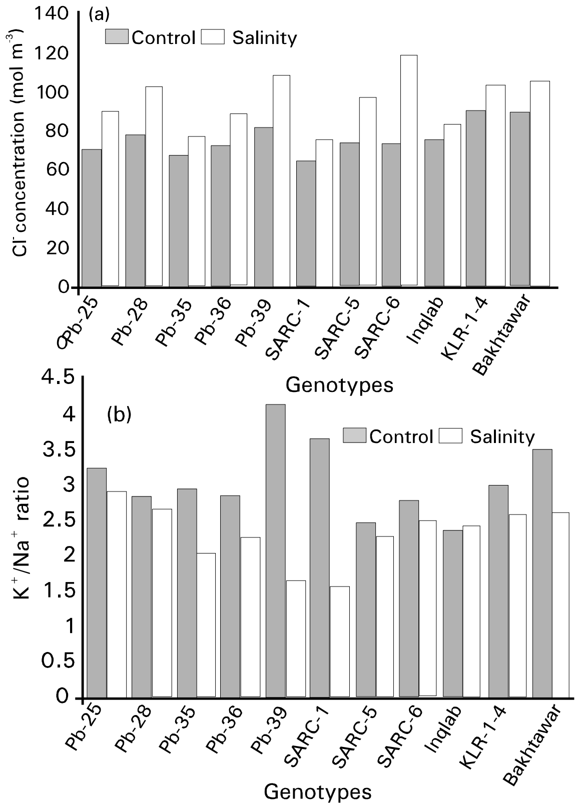

Fig. 2(a-b): Concentration of chloride and potassium sodium ratio n the tissue sap of fully expanded second to flag leaf collected at booting stage

Discussion

The increased Na^+ concentration in leaf sap under salinity could be due to high NaCl 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 waterlogging. Increased Cl^- concentration in leaf sap under salinity stress might have resulted from excessive chloride concentration in nutrient medium that resulted in more uptake of Cl^- by plants (Shah and Wyn Jones, 1988). Decreased K^+ concentration in leaf sap under salinity could be attributed to high external Na^+ concentration, which inhibited K^+ absorption. Also high Na^+ concentration in plants displace Ca^{2+} from the plasmalemma resulting in loss of membrane integrity and efflux of cytosolic K^+ and consequently the K^+ concentration in leaf sap is decreased (Cramer *et al.*, 1985). 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 of the genotypes under salinity stress could be due to efficient potassium absorption by selective inclusion of sodium by cortical cells (Schachtman and Munns,1992).

A positive correlation exists between Na^+ and Cl^- exclusion and relative salt-tolerance in many crops including wheat (Torres and Bingham, 1973). Efficient Na^+ exclusion is a good selection criterion for salt-tolerance in wheat and many other crops (Greenway and Munns, 1980). Figure 1 shows that sodium concentration in the leaf sap of genotypes Pb-28, SARC-6, Inqlab and Bakhtawar under salinity treatment was close to that under their respective controls. This explains that these genotypes under salinity stress either restricted the absorption of Na^+ or excluded Na^+ from leaves. Comparing sodium concentration in expressed leaves of Pb-36, Pb-39 and SARC-1 under salinity stress with that under the control treatment of the same genotypes, higher values were observed in the former case. This indicates that these genotypes could not exclude/restrict the accumulation of Na^+ in their leaves. Higher concentration of Na^+ in the leaf sap of Pb-39, SARC-1 and SARC-5 might have inhibited K^+ uptake (Fig 1a-b, 2b), hence these genotypes accumulated low concentration of K^+ in leaves. Under salinity stress sodium concentration in genotype Pb-25 was low while that of K^+ 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

Pb-25, Pb-28, Pb-36, SARC-6, KLR-1-4 and Bakhtawar under salinity stress was also high and consequently these genotypes maintained a good K^+/Na^+ ratio possibly due to the presence of K^+/Na^+ selectivity characteristic. The K^+/Na^+ ratio of genotypes Pb-39 and SARC-1 was low, might be due to the absence of selective absorption of K^+. These declarations have been made on the recommendations of Ponnamperuma (1984), who reported that the concentration of K^+ in shoot and root of plants plays an important role in activating the enzymes for stomatal functioning which is known to be related to salinity tolerance. Potassium/sodium selectivity is an important criterion of salt-tolerance (Lauchli and Stelter, 1982), because tolerant varieties maintain high K^+:Na^+ ratio (Akhtar *et al*., 1994; Muhammad and Aslam, 1998). However, the mechanism that control the K^+:Na^+ ratio in wheat shoot are complex and not clearly understood (Akhtar *et al*., 1998). The genotypes Pb-25, Pb-28, SARC-6, KLR-1-4 and Bakhtawar retained low Na^+ concentration and maintained better K^+:Na^+ ratio and thus could be declared as salt-tolerant, while Pb-39 and SARC-1 as sensitive for accumulating high Na^+ concentration and low K^+:Na^+ ratio.

References

Akhtar, J., J. Gorham and R.H. Qureshi, 1994. Combined effect of salinity and hypoxia in wheat (*Triticum aestivum* L.) and wheat-*Thinopyrum amphiploids*. Plant Soil, 166: 47-54.

Akhtar, J., R.H. Qureshi, M. Aslam and S. Nawaz, 1998. Performance of selected wheat genotypes grown under saline and hypoxic environment. Pak. J. Soil Sci., 15: 146-153.

Cramer, G.R., A. Lauchli and V.S. Polito, 1984. Na^+-Ca^{2+} interactions in cotton root hair membranes. Plant Physiol., 75: 237-237.

Cramer, G.R., A. Lauchli and V.S. Polito, 1985. Displacement of Ca^{2+} by Na^+ from the plasmalemma of root cells: A primary response to salt stress? Plant Physiol., 79: 207-211.

Duncan, D.B., 1955. Multiple range and multiple F tests. Biometrics, 11: 1-42.

Flowers, T.J., M.A. Hagibagheri and A.R. Yeo, 1991. Ion accumulation in the cell wall of rice plants growing under saline conditions: Evidence for *Oertill hypoptesis*. Plant Cell Environ., 14: 319-325.

Fricke, W., R.A. Leigh and A.D. Tomos, 1996. The intercellular distribution of vacuolar solutes in the epidermis and mesophyll of barley leaves changes in response to NaCl. J. Exp. Bot., 47: 1413-1426.

Gorham, J. and R.G.W. Jones, 1993. Utilization of Triticeae for Improving Salt Tolerance in Wheat. In: Towards the Rational Use of High Salinity Tolerants Plants, Leith, H. and A.A. Massoum (Eds.). Kluwer Academic, The Netherlands, pp: 27-33.

Gorham, J., E. McDonnell and R.G.W. Jones, 1984. Salt tolerance in the triticeae: *Leymus sabulosus*. J. Exp. Bot., 35: 1200-1209.

Greenway, H. and R. Munns, 1980. Mechanisms of salt tolerance in nonhalophytes. Annu. Rev. Plant Physiol., 31: 149-190.

Lauchli, A. and W. Stelter, 1982. Salt Tolerance of Cotton Genotypes in Relation to K^+/Na^+ Selectivity. In: Biosaline Research: A Look to the Future, Pietro, A.S. (Ed.). Plenum Press, New York, pp: 511-514.

Muhammad, S. and M. Aslam, 1998. Screening of rice for salt-tolerance. Pak. J. Soil Sci., 14: 96-98.

Munns, R., D.P. Schachtman and A.G. Condon, 1995. The significance of a two-phase growth response to salinity in wheat and barley. Aust. J. Plant Physiol., 22: 561-569.

Nawaz, R.H. Qureshi, M. Aslam, J. Akhtar and S. Parveen, 1998. Comparative performance of different wheat varieties under salinity and waterlogging II: Ionic relations. Pak. J. Biol. Sci., 1: 357-359.

Ponnamperuma, F.N., 1984. Role of Cultivar Tolerance in Increasing Rice Production in Saline Lands. In: Salinity Tolerance in Plants: Strategies for Crop Improvement, Staples, R.C. and G.H. Toenniessen (Eds.). Wiley Interscience, New York, USA., pp: 255-271.

Qureshi, R.H., A. Aslam, G. Mustafa and J. Akhtar, 1991. Some aspects of physiology of salt tolerance in wheat. Pak. J. Agric. Sci., 28: 199-206.

Rashid, A., R.H. Qureshi, P.A. Holington and R.G.W. Jones, 1999. Comparative responses of wheat (*Triticum aestivum* L.) cultivars to salinity at the seedling stage. J. Agron. Crop Sci., 182: 199-208.

Schachtman, D.P. and R. Munns, 1992. Sodium accumulation in leaves of *Triticum* species that differ in salt tolerance. Aust. J. Plant Physiol., 19: 331-340.

Shafqat, M.N., G. Mustafa, S.M. Mian and R.H. Qureshi, 1998. Evaluation of physiological aspects of stress tolerance in wheat. Pak. J. Soil Sci., 14: 85-89.

Shah, S.H. and R.G. Wyn Jones, 1988. Effect of different salinities on successive growth and ionic composition of tetra and hexaploid wheats. Proceedings of the 2nd National Congress on Soil Science, December 20-22, 1988, Islamabad, Pakistan, pp: 12.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics: A Biometrical Approach. 2nd Edn., McGraw Hill Book Co., New York, USA., ISBN-13: 9780070609266, Pages: 633.

Torres, C.B. and F.T. Bingham, 1973. Salt tolerance of Mexican wheat: 1. Effect of NO_3 and NaCl on mineral nutrition, growth and grain production of four wheats. Soil Sci. Soc. Am. J., 37: 711-715.

Wyn Jones, R.G. and R. Storey, 1981. Betains. In: Physiology and Biochemistry of Drought Tolerance, Paleg, L.G. and D. Aspinal (Eds.). Academic Press, Sydney, pp: 204.