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Growth and Ion Accumulation in Some Wheat Genotypes under NaCl Stress

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Abstract: There was a gradual decrease in germination of all the wheat varieties with the increase in NaCl concentrations. Anmole was the least affected by NaCl salinity at germination stage. However, the performance of Sursabz were better during early seedling growth. The better performance of Sarsabz might be due to its better osmotic adjustment.

Key words: Growth and ions accumulation, early seedling stage, salinity, wheat varieties

Introduction

Wheat is the major food crop for one third of the world population. The total production area in Pakistan is 8.2 mha and the average yield is 2170 kg ha^{-1} or 23.53 mds/ acre (Anonymous, 1999). It is considered to be a crop moderately tolerant to salinity. The relative salt tolerance of wheat crop is 7.0 dS/m and its yield reduced to 25% at 9.0 dS/m and remains only 50 % at 13.0 dS/m (Mohammad, 1996). The possible cause of varietal difference most likely involve ion transport properties and cellular compartmentation (Munns, 1988). Schachtmann and Munns (1992) reported that Na exclusion was a general characteristic of salt tolerance in wheat lines, whereas salt tolerant lines display much higher shoot Na levels than sensitive lines. On the other hand, Kingsbury *et al*. (1984) have the opinion that varietal differences in growth response to salinity in wheat leaves were not related to differences in salt accumulation n leaves, but to differences in osmotically induced reduction in water availability under salinity stress.

Germination and early seedling growth are critical phases in the development of plant, which play an important role in getting a good crop stand for subsequent growth. Therefore the present study was conducted to study the growth and ion accumulation of five wheat varieties, under NaCl stress at early seedling stage.

Materials and Methods

The experiment was conducted in the laboratory, using five wheat (*Triticum aestivum,* L) varieties viz.: Sursabz, Kiran-95, Mehran-89, Anmole and Pasban-90. Healthy seeds were surface sterilized for 10 minutes with 5% sodium hypochlorite and were thoroughly washed with distilled water. Thirty seeds were planted on molded plastic sieves in a plastic jar with sufficient ¼ Hoagland solution (control). Four salt treatments (50, 100, 150 and 200 mM NaCl) were given. The jars were placed in growth cabinet maintained at 25/20°C day/ night temperature and 12 hours photoperiod (irradiance 22Wm^{-2}). Germination percentage was recorded after 72 hours and the seedlings were harvested 10 days after planting. Early growth observations i.e. shoot/ root length, shoot/ root fresh and dry weight (oven dried at 70°C for 48 hours) were recorded.

Ionic concentrations (Na, K and Ca) in plant shoot were determined by flame photometer (Model PFP 7), after extracting in 1.0 M acetic acid according to the method given by Ansari (1986). The experiment was replicated thrice and in a randomized manner. The data was subjected to analysis of variance (ANOVA) and Duncan's New Multiple Range Test (DMRT).

Results

Germination: Salt tolerance at germination stage is an important factor, where soil salinity is mostly dominated at surface layer. The overall germination of all the five varieties tested, was good i.e. above 75% (Fig. 1). However, there was a gradual decrease in germination percentage with the increase in NaCl concentration and the maximum decrease in germination was recorded under highest salinity treatment. Among the individual varieties, least affected variety at the highest salinity level was Anmol followed by Kiran-95, Pasban-90, Mehran-89 and Sarsabz. However, the difference among the varieties was non- significant.

Seedling growth: Seedling growth was recorded in terms of shoot/root length and shoot/ root fresh and dry weight. Increasing concentrations of NaCl has reduced shoot and root length of all the wheat varieties (Fig. 2a and 2b). All the varieties responded quite fairly up to 100 mM NaCl, but at high salinity treatments, shoot length decreased considerably. Maximum reduction was recorded at the highest salt treatment, where the reduction in growth was above 50% in all the varieties. At the highest salinity treatment, maximum shoot length was observed in Sarsabz. The difference among the varieties was significant for shoot length and non-significant for root length.

Plant biomass in terms of fresh and dry weight was also reduced gradually with increasing NaCl salinity (Fig 2c and 2d). Like in shoot length, shoot fresh and dry weight of Sarsabz variety were also maximum at the highest salt treatment, while the variety, Pasban-90 showed maximum reduction at that concentration. However, the difference among the varieties was non-significant.

Similar to the above parameters, the variety Sarsabz had maximum root fresh weight in all the salinity treatments (Fig. 2e). While in case of root dry weight, there is a slight change in situation with Kiran-95 having maximum root dry weight, at highest salinity treatment (Fig. 2f). However, the average, root dry weight of Sarsabz remained high.

Ions accumulation: Ionic contents determined in plant shoot showed that there was a gradual increase in sodium (Na) ion, with the increase in NaCl concentrations in the root medium. Pasban-90 was the only variety, where the

Table 1: Ions accumulation in wheat shoot at different NaCl concentrations

Varieties	Control	50mmole	100mmole	150mmole	200mmole	Mean
Sodium						
%Sarsabz	0.467a	1.68a	1.723a	1.72a	1.81a	1.48 A
Kiran-95	0.4a	1.263a	1.447a	1.25ab	1.807a	1.233 AB
Mehran-89	0.367a	1.583a	1.64a	1.277ab	1.673a	1.308AB
Anmole	0.39a	1.51a	1.66a	1.283ab	1.577a	1.28 AB
Pasban-90	0.49a	1.343a	1.32a	1.123b	1.26a	1.107B
Mean	0.423C	1.476AB	1.558AB	1.331B	1.625A	
Calcium %						
Sarsabz	1.66	1.25	1.323	0.82	0.967	1.024
Kiran-95	1.27	1.067	1.037	1.017	0.75	1.028
Mehran-89	1.48	1.083	1.117	0.84	0.703	1.045
Anmole	1.607	1.283	1.283	1.09	0.683	1.189
Pasban-90	1.37	1.15	1.203	1.25	0.517	1.098
Mean	1.477A	1.167B	1.193B	1.003B	0.74C	NS
Potassium %						
Sarsabz	2.673	2.070	2.047	1.587	1.400	1.955
Kiran-95	2.030	1.510	1.450	1.750	0.900	1.528
Mehran-89	1.893	1.510	1.640	1.700	1.007	1.646
Anmole	2.313	1.990	1.817	1.720	2.410	2.047
Pasban-90	2.700	1.967	1.697	2.050	1.530	1.915
Mean	2.322A	1.593B	1.73B	1.763B	1.45 B	NS

Values in the column and rows having similar alphabets are statistically non-significant. LSD = 0.23 (Na) = overall 0.21 (Ca) = Treatment 0.48 (K) = Treatment

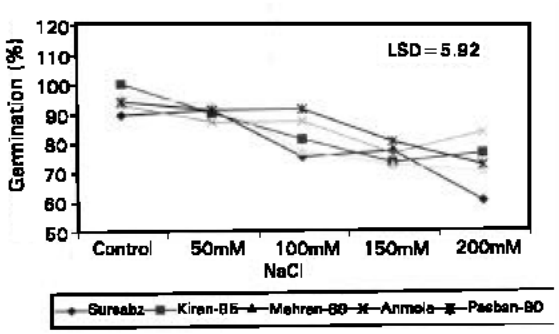

Fig. 1: Germination percentage recorded under different salt (NaCl) concentrations

increase in Na content in plant shoot was lowest, while Na content in Sarsabz was maximum. The average values recorded in Sarsabz were 1.48% followed by Mehran-89 1.31, Anmol 1.28, Kiran-95 1.23 and Pasban-90 1.10%. Increasing concentrations of NaCl in the rooting medium have depressed calcium (Ca) content. Maximum reduction in Ca content was observed at the highest NaCl treatment. Among the varieties tested, Sursabz had the maximum Ca content in plant shoot, while Pasban-90 had the lowest Ca value at highest salinity level. However, the difference non-significant.

Response of varieties with respect to potassium (K) content was also similar to that of calcium (Ca). Potassium content was decreased with increasing salinity level. Maximum reduction in K content was observed in variety Kiran-95. On the other hand, Mehran-89 had maintained its K level quite satisfactorily.

Discussion

Wheat varieties responded differently under various NaCl salinity treatments. Among the varieties tested, Sarsabz appeared to be more sensitiv at germination stage than others. This sensitivity was also reported earlier (Khanzada *et al.*, 1990). Sarsabz variety although, had comparatively low germination percentage at higher NaCl salinity levels, but had performed quite satisfactorily during early seedling stage. At highest salinity treatment, it had outclassed all the other four varieties with maximum shoot and root length i.e. 7.15 and 3.41cm, respectively. The performance of Kiran-95 was also satisfactory up to150mM of NaCl treatment, but at highest salinity treatment it could not compete with Sarsabz. On the other hand, the two varieties i.e. Pasban-90 and Anmole, having highest germination percentage at maximum salt treatment, were found to be more sensitive during early seedling stage. This indicates that species/ varieties can never be selected simply on the basis of high germination percentage. According to Mass and Grieve (1990), the ability of seed to germinate and emerge in saline soil not only depends upon the concentration of salts, but also upon various other biological factors i.e. viability of seed, seed age, dormancy, seed coat permeability and internal inhibitors. While, George and William (1964) have the opinion that greater tolerance of barley to salinity during germination is associated with lower respiration rate and greater reserve of respiratory substances. Maqsood *et al.* (2000) suggested that soaking of wheat seed in water as pre-sowing treatment and subsequent drying is a simple, rapid and economical methode of improving germination under saline conditions.

The variation in shoot fresh and dry weight was found non-significant among varieties. While the results with respect to root fresh and dry weight showed significantly higher values of Sarsabz variety. This indicates, its good growth even under highest salinity treatment.

Good performance of Sarsabz variety at seedling stage might be due to its better osmotic adjustment (i.e. by high Na absorption in its shoots), which is considered to be an

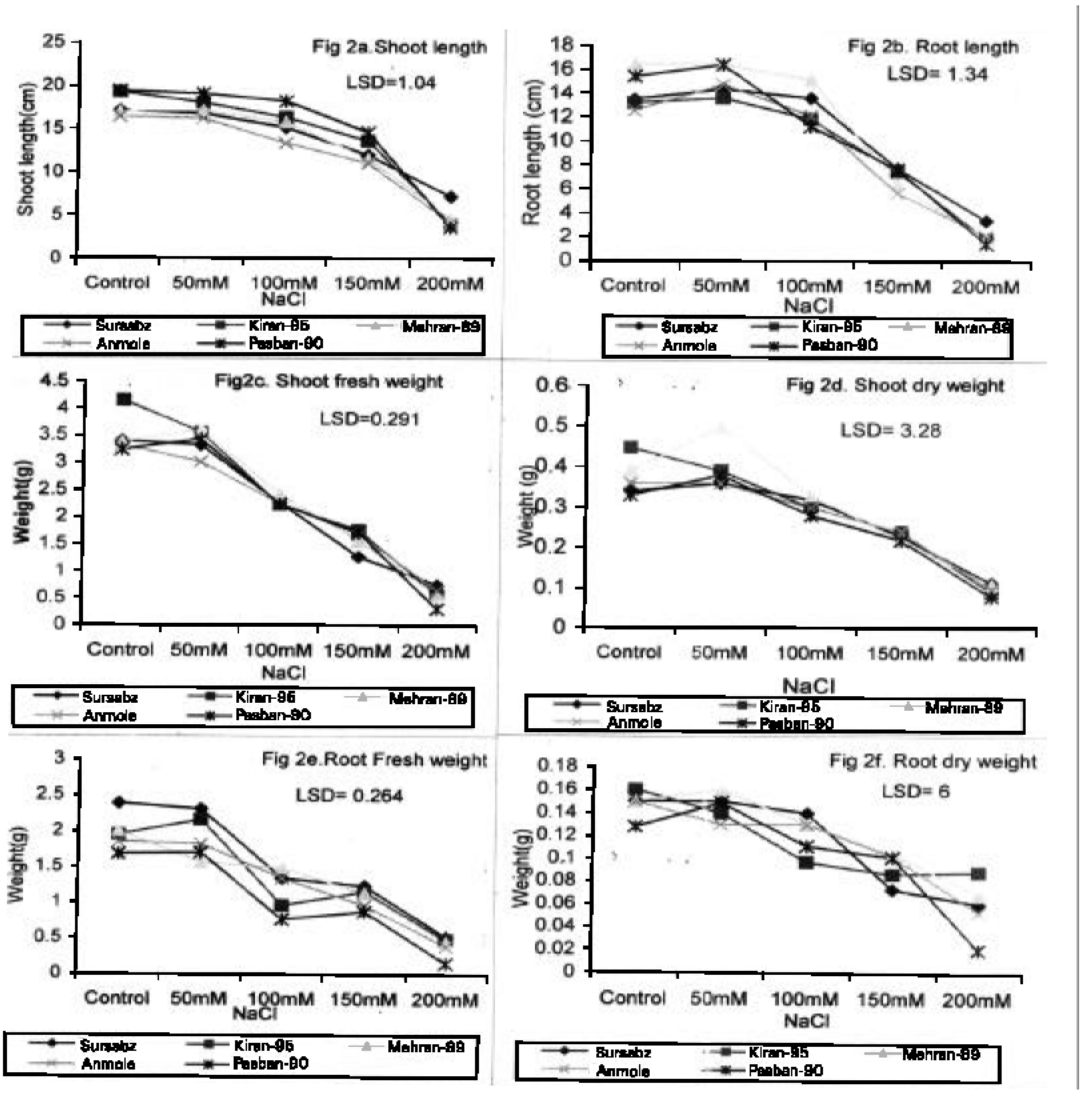

Fig. 2: Different growth parameters recorded at early seedling stage

important adaptation of plant to salt stress because, it contributes to the maintenance of turgor and cell volume (Yeo, 1994). On the other hand, the variety Pasban-90, with comparatively lower growth performance, also had low Na content in plant shoot. The other varieties were in between the Sarsabz and Pasban-90. The results are in accord with that of Schahtmann and Manna (1992), who reported higher shoot Na levels in salt tolerant wheat lines, as compared to sensitive lines. Similarly, Greenway and Munns (1980) suggested that salt sensitivity of some non-halophytes may be due to insufficient uptake of electrolytes for turgar pressure and volume maintenance, particularly in the expending tissues. The presence of significant Calcium(Ca), in growth medium is essential to prevent toxic effect of sodium(Na), because Na uptake by Plant is strongly regulated by Ca. According to Maqsood *et al.* (2000) Ca enrichment enables the plant cell to maintain ion selectivity of their membrane to cope with harmful effects of higher Na levels and restrict their influx. This was true in the present findings. Pasban-90 and Kiran-95, which had higher Ca content, also had good seedling growth up to 150mM NaCl and then decline at high salinity level due to widening of Na/Ca ratio. While the variety Anmole, which also had high Ca content up to 150mM NaCl treatment did not showed better response at highest salinity treatment. On the other hand Sarsabz which although had comparatively low Ca content, but had quite satisfactorily maintained its Ca level at highest salinity treatment, resulting in good seedling growth.

Decrease in K content in plant shoot, with the increase in NaCl salinity is a general trend as K and Na often compete for Uptake (Schachtman and Liu, 1999). However, comparatively high K content in sensitive varieties might be due to some other mechanism, as the plant roots have a number of independent K uptake mechanisms that operate in parallel to ensure plants to have an adequate supply of this essential macronutrient (Sally and Schachtman, 2000). Yet, a mere increase in rate of uptake of ions by wheat

shoot would not remedy the situation as shown for several species by the salt sensivity of those varieties, which have a high rate of uptake to shoots. Therefore, integration of all different facets of adaptations, such as salt-excreting mechanisms and increase in wall flexibility is also needed. On the basis of growth parameters and high sodium uptake for the adjustment of osmo -regulation, the variety Sarsabz appeared to be the most tolerant among the varieties tested, at seedling stage.

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