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Growth and Inorganic Solute Accumulation of Two Barley Varieties in Salinity

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Abstract: Salinity (NaCl stress) was applied with 50, 100, 200, 300 and 400 mM NaCl. The shoot and root length, fresh and dry weight, sodium and potassium content of two barley varieties (*Hordeum vulgare* L. var. Afzal and var. EMB82-12) were determined in various concentrations of NaCl. Root and shoot length, fresh and dry weight were decreased in two barley varieties in response to increased salt concentration, but the decrease was more significant in the root. Sodium content was increased and potassium content was decreased in two barley varieties in response to different salt regimes, but in general, these changes were more significant in the root.

Key words: NaCl stress, biomass, inorganic solute, *Hordeum vulgare*

INTRODUCTION

The effects of salinity on plant growth have extensively been a focus of research because of salt response of plants is a complex phenomenon that involves several physiological and biochemical changes (Hasegawa *et al*., 2000; Ghoulam *et al*., 2002). Ionic imbalance occurs in the cell due to excessive accumulation of Na^+ and Cl^- and reduces the uptake of other mineral nutrients such as K^+ and NO_3^- (Viégas *et al*., 2001). It has been suggested that Na^+ and Cl^- accumulation in root over shoot could be useful as indicator of salinity tolerance of plants (Silveira *et al*., 2001). The best manifestation of this is exemplified by those cases in which gain in dry mass were associated with decreased accumulation of Na^+ and Cl^- in shoot of some woody plants in the early seedling phase (Taleisnik and Grunberg, 2006). The exclusion of Na^+ from shoot and its preferential accumulation in root has been observed in cashew (Viégas *et al*., 2001). In the later case, Na^+ exclusion occurs from young to either old leaves or root but only in the earlier stages of salinity stress. According to Viégas *et al*. (2001), this process is disrupted in cashew plants due to displacement of root-Ca^{2+} by Na^+, resulting in a change of plasma membrane permeability (Debouba *et al*., 2007). The Ca^{2+} displacement by Na^+ at plasma membrane may constitute a primary response to salinity stress. Under this condition K^+/Na^+ selectivity may substantially be altered (Serrano and Rodriguez-Navarro, 2001). It has been suggested that the interaction between K^+ and Na^+ might represent a key factor in determining the salinity tolerance of plants (Buschmann *et al*., 2000). At the whole plant level, it is generally accepted that increased K^+/Na^+ selectivity during uptake and reduced Na^+ translocation from the root to the shoot contribute to the salt tolerance of glycophytes (Rascio *et al*., 2001). Recent research with mutants of *Arabidopsis* has shown that the integrity of the K^+ uptake system plays a role to salt tolerance (Zhu *et al*., 1998). Higher level of K^+ in leaf tissue is associated with salt tolerance in cowpea (Silveira *et al*., 2001). The role of K^+ is vital for osmorregulation and protein synthesis, maintaining cell turgor and stimulating photosynthesis (Buschmann *et al*., 2000). At salt stress plants more suffer from high accumulation of Na^+. Instead of taking up suitable amount of K^+ which is necessary for plant's normal growth and development they accumulate Na^+ to toxic level. Therefore it is need how can plants mange k+/Na^+ imbalance properly.

MATERIALS AND METHODS

Plant materials and growth conditions: Two genotypes of barley (*Hordeum vulgare* L.) were used: var. Afzal and var. EMB82-12 which these seeds were obtained from the Agricultural Research Center of Karaj, Iran. Seeds were surface sterilized in 0.5% sodium hypochloride solution for 20 min and grown in pots containing Vermiculite. Plants were watered every second day using half strength of Hoagland nutrient solution in controlled growth room for 4 days, then seedlings were subjected to treatment with 50, 100, 200, 300, 400 mM NaCl for 3 days. Shoot and root to be used for biochemical determinations were frozen and stored in liquid nitrogen immediately after harvest.

Measurement of items: Lyophilized plant tissue was powdered and subjected to wet digestion with (4:1) HNO_3: $HClO_4$ (Yilmaz *et al*., 2004). The resulting solutions were properly diluted and analyzed for K^+ and Na^+ by flame photometer. Root and shoot weight was determined by weighing tissue before and after complete lyophilization using an analytical balance (Coombs and Hall, 1982).

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Statistical analysis: Mean values were calculated from measurements of four replicates and the SE of the means were determined. One-way ANOVA and Tukey HSDs multiple range test ($p<0.05$) was applied to determine the significance of the result between different treatments. All statistical analysis were done using the Statistical Package for Social Sciences (SPSS) for Windows (version 13.0.0).

RESULTS AND DISCUSSION

Salinity caused a reduction in shoot and root length, fresh and dry weight in both varieties, but the decrease in EMB82-12 variety was higher than Afzal var. In 400 mM NaCl, shoot length reduction was 39.51% in EMB82-12 var. and 29.03% in Afzal var. and root length reduction was 39.72% in EMB82-12 var. and 29.72% in Afzal var., as compared to control plants (Fig. 1a, b). In highest salinity, shoot fresh weight reduction was 50.64% in EMB82-12 var. and 28.69% in Afzal var. as compared to control plants and the decrease in Afzal var. was gradually and in EMB82-12 var. in 400 mM NaCl was enormous. Root fresh weight reduction was 71.71% in EMB82-12 var. and 68.96% in Afzal var. as compared to control plants (Fig. 2a, b). Shoot dry weight decreased in both varieties and in 400 mM NaCl, reduction of this factor was 76% in EMB82-12 var. and 48.14% in Afzal var., root dry weight reduction was 64.70% in EMB82-12 var. and 59.45% in Afzal var. as compared to control (Fig. 3a, b). It means that Afzal plants have lower growth reduction than

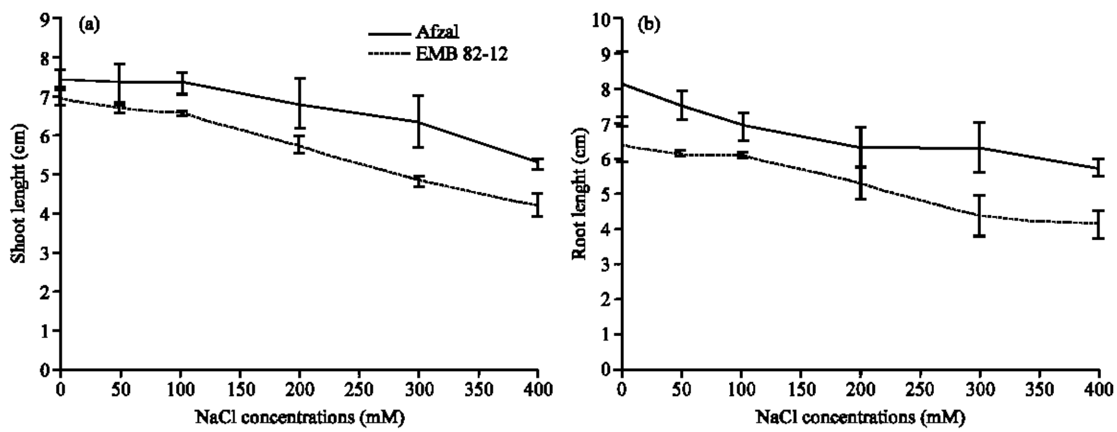

Fig. 1: Effects of different NaCl concentrations on (a) shoot and (b) root length in two barley varieties. Results are shown as Mean±SE ($p<0.05$), obtained from four replicates

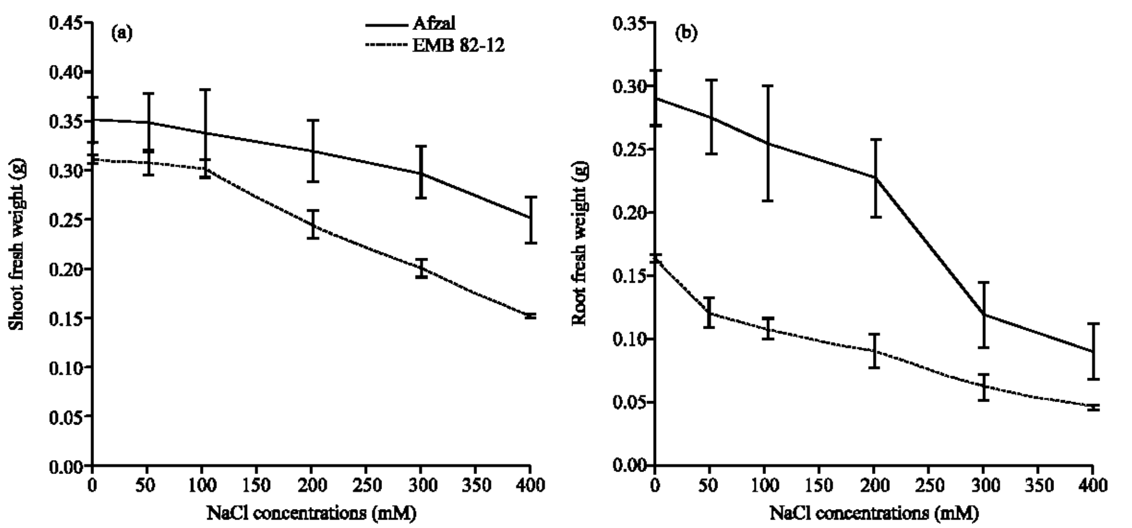

Fig. 2: Effects of different NaCl concentrations on (a) shoot and (b) root fresh weight in two barley varieties. Results are shown as Mean±SE ($p<0.05$), obtained from four replicates

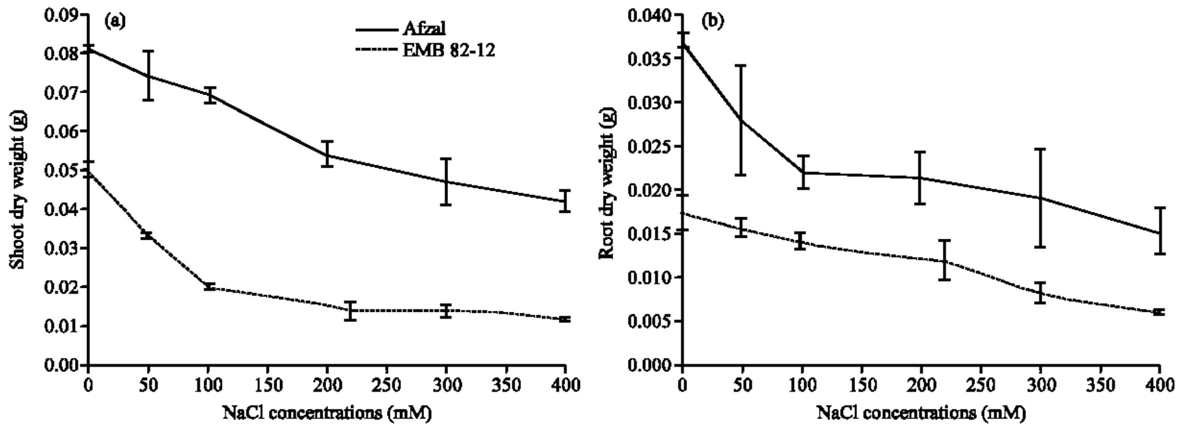

Fig. 3: Effects of different NaCl concentrations on (a) shoot and (b) root dry weight in two barley varieties. Results are shown as Mean±SE ($p<0.05$), obtained from four replicates

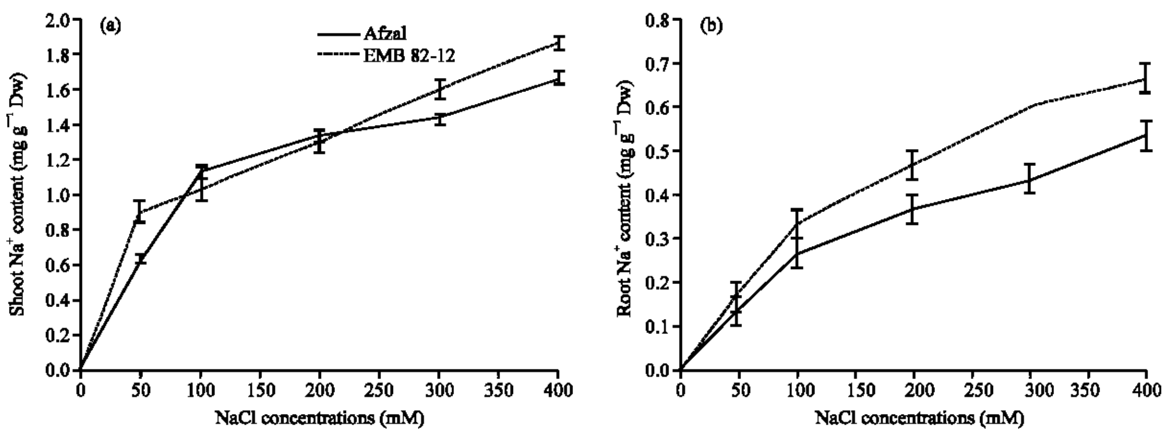

Fig. 4: Effects of different NaCl concentrations on (a) shoot and (b) root Na^+ content in two barley varieties. Results are shown as Mean±SE ($p<0.05$),obtained from four replicates

EMB82-12 var. when salt stressed. Shoot and root Na^+ content in both varieties increased, but the increase in EMB82-12 var. was higher than Afzal plants. In 400 mM NaCl, shoot Na^+ content was 1.82 mg g^{-1} Dry weight (DW) in EMB82-12 var. and 1.60 mg g^{-1} DW in Afzal var. and root Na^+ content was 0.60 mg g^{-1} DW in EMB82-12 var. and 0.47 mg g^{-1} DW in Afzal var. as compared to control plants (Fig. 4a, b). Shoot and root K^+ content in both varieties decreased, but the decrease in EMB82-12 var. was higher than Afzal plants. In 400 mM NaCl, shoot K^+ content reduction was 80% in EMB82-12 var. and 61.53% in Afzal var. and root K^+ content reduction was 66% in EMB82-12 var. and 56.52% in Afzal var. as compared to control plants (Fig. 5a, b).

Salt stress may reduce plant growth by causing ion toxicity, ion imbalance, or a combination of any of these adverse factors (Greenway and Munns, 1980). In this investigation, it was determined that the salinity caused loses of growth characteristics of barley varieties, that were negatively affected by increasing NaCl. Results were agreed earlier investigations by Kaya *et al.* (2008) and Yilmaz *et al.* (2004). When salinity increased, loses were observed in germination and growth stage and these loses varied in similar manner to varieties tested and cited above. This differences among the varieties observed in this study are describe below. Afzal plants were found more tolerant to increasing salinity concentrations in various growth stage characteristics. The results supported other studies that plant show various adaptation to salinity in different growing stages. This was explained as differences of Na^+ and K^+ uptake among varieties. The K^+ uptake were affected negatively by increasing Na^+ as demonstrated elsewhere (Alpaslan *et al.*, 1999). In addition, there is accumulation of a controlled amount of salt as an osmoticum, which is different for different cell of plants (Lerner, 1985). There

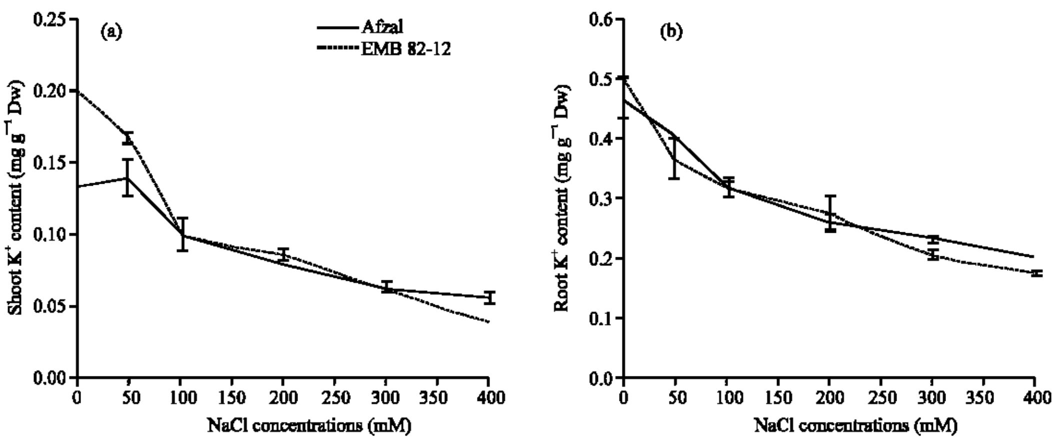

Fig. 5: Effects of different NaCl concentrations on (a) shoot and (b) root K^+ content in two barley varieties. Results are shown as Mean±SE ($p<0.05$),obtained from four replicates

is a significant correlation between salt tolerance and K^+ uptake of plant varieties and species (Gorham *et al*., 1984). It is reported that salt tolerance of species and varieties can balance osmoticum and adjust Na^+ and K^+ levels (Matthew *et al*., 2007). In this study, the Na^+ content increase with increasing salt concentration and the K^+ content decreased. The increasing salt stress prevented K^+ uptake of plants. According to growth stage characteristics, Afzal showed the higher tolerance to salt than the other varieties. While Na^+ content of this variety was lower and K^+ content were significantly higher than the other varieties, in especially 400 mM NaCl. The data indicated that salt tolerance of tolerant varieties in barley related to mechanism of Na^+ uptake under control or ability of regulation of K^+ levels. At the plant cell level, a few strategies can be suggested for the plants survival in the saline conditions. Salt may be taken up by the cells and used as a major osmoticum and ion toxicity could be prevented by compartmentation or by some other mechanism of protecting enzyme and ribosomal activities (Shennan, 1987). It has been benefited from genotypes balanced to uptake of Na^+ and K^+ levels to structure at the agricultural as economical. Determining of varieties to salt tolerance in early growth stages is very important in determining produce commercial crops (Goertz and Coons, 1991).

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