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EFFECT OF DIFFERENT Ca/Na RATIOS IN SALINE SOILS ON THE GROWTH AND YIELD COMPONENTS OF WHEAT

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Abstract

A pot study was undertaken to monitor the response of wheat (Var.Inqlab-91) to 1:1, 3:1 and 1:3 Ca/Na ratios, maintained under salinity levels of 6 and 12 dS m^{-1} in the original soil having ECe of 2.4 dS m^{-1}. Salinity levels were developed by adding salt mixture of NaCl, Na_2SO_4, $CaSO_4$, $CaCl_2$ and $MgSO_4$ to 12kg of normal soil filled in glazed pots. The results indicated that all the plant characteristics studied were affected significantly with salinity except plant height. Maximum grain yield per pot was obtained with 3:1 ratio of Ca/Na and it was minimum with 1:3 ratio. Different Ca/Na ratios and ECe level showed a significant interaction (Ca/Na X ECe) for grain yield. It was concluded that spikes length, 1000-seed weight and grain yield all decreased considerably with the decreasing Ca/Na ratios and increasing salinity levels.

Introduction

Soil salinity reduces crop yield by adversely affecting the water and nutritional balances of plants. Above a critical threshold salinity, salts enter the root and shoot passively and result in plant mortality (Kramer *et al.*, 1977). Specific ion effect may also deteriorate metabolic activities in the plants and ultimately the plants may die. Actually, plants take up excessive amounts of Na^+ at the cost of K and Ca (Kuiper, 1984) in a saline environment. The accumulation of Cl^- also parallels that of Na^+ (Yeo and Flowers, 1985). These Na^+ and Cl^- ions besides exerting ion specific effect on plants, disturb their osmoregulatory mechanism (Richards, 1954). The higher salt concentration outside root zone sometime may cause physiological drought by ex-osmosis due to highly negative osmotic potential in the external environment of the roots.

To counterbalance the detrimental role of Na^+ and Cl^- ions in saline soils, the Ca^{++} is considered to be the effective remedy. It is also reported that the soils receiving water of low Na/Ca ratios perform better than the soil with high Na/Ca ratio (Javaid, 1998a). The role of Ca is multifold when added to saline soils. It may act as a macro-plant nutrient and also improve physical soil characteristics. It is reported that use of high Ca/Mg or Ca/Na water gave a linear trend with exchangeable Ca/Na ratio of the soil exchange complex(Marlet,1997). Hence it favours the crop growth in a soil enriched with soluble or available Ca, especially under saline soils.

The role of Ca becomes even more important in a saline environment (Rains, 1972). This is because Ca is required in the root medium to maintain the selectivity and integrity of cell membrane (Wyn Jones and Lunt, 1967; Fageria, 1983). On the other hand saline soils are deficient in K and available Ca in a stable proportion.

Some trials on rice crop with different Na/Ca and Na/K ratios have shown the favourable effect of low Na/Ca ratios on grain yield. Generally, the reduction in grain yield is greater than the straw yield of rice under high Na/Ca ratio in a saline medium (Panaullah and Ponnampesruma, 1980; Muhammad, 1986). The high Ca/Na levels thus, under different salinity levels are also important. However crop performance also depends upon its degree of salt tolerance.

On the other hand, the threshold salinity for grain yield of any crop depends upon soil fertility, type of salts causing salinity and cultivar etc. About 50% reduction in rice grain yield is reported at ECe 7.0 dS m^{-1} (Bresler *et al*., 1982). Similarly 50% reduction in wheat grain is reported to occur at ECe of 13.0 dS m^{-1} (Ayers and westcot, 1985). However wheat is sodicity sensitive but salinity tolerant (Kuper, 1997). Therefore with the above situation in view, the experiment was carried out to evaluate crop growth and yield performance of wheat crop at different Ca/Na ratios in soils with low (6.0 dS m^{-1}) and high (12 dS m^{-1}) salinity status.

Materials and Methods

A pot experiment was conducted during Rabi 1995-96 in the Directorate of Land Reclamation (DLR), Lahore. Composite soil samples from the DLR experimental fields were collected from the upper 0-15 cm soil depth, mixed thoroughly and analysed for soil texture (Moodie et al., 1959), pHs, ECe and SAR as per procedure described by Richards (1954). Three Ca/Na ratios 1:1, 3:1 and 1:3 were developed under two salinity levels of 6.0, 12.0 dS m^{-1} using salt mixture of NaCl, Na_2SO_4, $CaSO_4$, $CaCl_2$, and $MgSO_4$ following the procedure described by Richard (1998). Both the salinity levels with the mentioned Ca/Na ratios were developed in the original soil (12 kg) having pHs = 8.0, ECe = 2.0 dS m^{-1} and SAR = 6.1 $(mmol_c\ L^{-1})^{0.5}$.

Wheat crop (Inqlab-91) was grown as test crop in a Completely Randomized Design (CRD) with four repeats in glazed pots. Nitrogen, phosphorus and potassium were applied @ 130, 75 and 100 kg ha^{-1} as Urea, DAP and SOP (sulphate of potash) respectively. Eight seeds were sown in each pot and thinned out to three few days after germination when plants were well established. Keeping in view the sensitivity of seedlings, the salinity levels were developed when seedlings were well anchored after thinning out process.

At maturity crop was harvested and data on plant height, grain yield, spike length and seed index weight were recorded and statistically analyzed using CRD-factorial (Ca/Na ratios and ECe level) according to the statistical procedure described by Steel and Torrie, (1980). However, to avoid complication in CRD data manipulation for Ca/Na ratios developed, the control is excluded and it is assumed that one treatment acts as a control for the other.

Results and Discussion

Grain Yield: The data (Table 1) depict that different growth parameters studied were significantly affected by salinity levels and different Ca/Na ratios developed with the salt mixture. It was noted that maximum grain yield (16.6 g pot^{-1}) was recorded where Ca/Na ratio of 3:1 was maintained. The lowest yield of wheat crop was obtained where sodium exceeded three times to the Ca (i.e. Ca/Na ratio of 1:3). Similarly, mean values in respect of salinity levels indicated a substantive decrease in grain yield under high salinity stress (ECe = 12.0 dS m^{-1}). As for as yield performance of wheat under individual Ca/Na ratios are considered, it was maximum (17.4 g pot^{-1}) at 3:1 ratio of Ca/Na under salinity level of 6.0 dS m^{-1}. Not only the effect of Ca/Na ratio and salinity levels (ECe) was statistically significant (P=0.01) but interaction between the Ca/Na ratios and salinity levels (ECe) i.e. Ca/Na x ECe was also highly significant at P=0.01.

Seed Index Weight: It is also evident from the data of Table 1 that grain weight of 1000 wheat grains correlated with the sequence observed in case of grain yield. The maximum seed index weight of 52.3 g was recorded under ECe of 6.0 dS m^{-1} with Ca/Na ratio of 3:1.

As for as mean values are considered, a grain weight of 48.8 g (per 1000 seeds) was recorded with Ca/Na ratio of 3:1, which statistically differed from all other treatments. Minimum seed index weight of 36.3 g was obtained under Ca/Na ratio of 1:3. The statistical analysis of the data reveals that the salinity stress also had a pronounced effect on seed index weight. Lower seed index weight (40.5 g) was recorded at higher salinity level (ECe 12.0 dS m^{-1}). However, the interaction between Ca/Na and ECe levels in case of seed index weight was statistically non-significant.

Spike Length Data displayed via Fig. 1 indicate that both Ca/Na ratios and ECe levels had a significant effect on spike length. The maximum spike length of 13.1 cm was recorded under Ca/Na ratio of 3:1 with ECe level of 6.0 dS m^{-1}. However, mean values indicate a spike length of 11.9 cm under 3:1 Ca/Na ratio followed by 10.5 and 9.9 cm for Ca/Na ratios of 1:1 and 1:3, respectively. However, interaction between Ca/Na ratios and ECe levels was statistically non-significant.

Salinity also affected the spike length of the wheat (Inqlab-91). If we look, at the data of aforementioned parameters, a fare sequence among the parameters becomes clear. It reveals that when spike length is greater, the more grains it will contain and consequently more grain yield would be the result.

Plant Height: The bar diagram (Fig. 2) indicates that in contrast to the other growth parameters, the effect of different Ca/Na ratio on plant height was different (statistically non-significant). However, the effect of salinity levels on plant height was statistically significant. The Ca/Na x ECe interaction was also not statistically significant.

It is clear from the aforementioned results that all the growth characteristics studied are seriously affected by the salinity levels. The decrease in plant height, seed index weight and grain yield at higher salinity level may be ascribed to the salt concentration in the soil solution. These salt concentrations decreased the water potential of the soil solution. Consequently, physiological drought occurred because plants were unable to take up water. To overcome this problem, plant used metabolic energy at the expense of growth and yield reductions which ultimately decreased the plant height and spike length in addition to grain yield of wheat crop, (Javaid et al., 1998). The decrase in paddy and wheat yield with the increasing salinity level has also been attributed to the accumulation of certain toxic ions (Na^+, Cl^-) which besides having a specific ion effect (Richards, 1954) could also affect the plants metabolic system (Girdhar, 1988). Soil salinity reduces crop yield by adversely affecting the water and nutritional balances of plants. (Muhammed, 1986). However, the type of salts in growth medium are very important for crop growth. At comparable EC values, injury was less to rice crop in sea water than in solutions of NaCl (Ponnamperuma, 1984).

As for as Ca/Na ratios are concerned, better results obtained under higher Ca/Na ratio (under different salinity levels) highlighted the importance of Ca in salt-affected soils. Beneficial effects of Ca additions to growth medium have been observed for many crops (Marcar, 1986). Addition of Ca to growth medium improves the growth, yield and chemical composition of rice and other crops (Kawasaki and Moritsugu, 1978). Actually the Ca in the growth medium is required to maintain selectivity and integrity of cell membrane. Calcium is also required for selective transport of ions like K^+ across membranes (Wyn Jones and Lunt, 1967). Thus, low Ca/Na ratio or in otherwords high Na/Ca ratio in the external solutions besides impairing selectivity of the cell membrane and leading to passive uptake of Na^+ in root and shoot (Kramer et al., 1977) also affects stomatal movement and photosynthesis (Beringer, 1980). Perhaps this is the reason that higher Ca/Na ratio under different salinity levels reduced the salinity effect (to some extent) on wheat yield and other growth characteristics.

Table 1. Effect of different Ca/Na ratios on grain yield and seed index weight in saline soils of different ECe (dS m^{-1}).

	Ca/Na Ratio			
ECe	1:1	3:1	1:3	Mean
		Grain Yield g pot^{-1}		
6.0	15.5 b	17.4 a	14.5 c	15.8 A
12.0	3.6 d	15.7 b	12.5 e	13.9 B
Mean	14.6 B	16.6 A	13.5 C	-
		10^3 -Grain Weight (g)		
6.0	47.0	52.3	39.0	46.1 A
12.0	42.8	45.3	33.5	40.5 B
Mean	44.9 B	48.8 A	36.3 C	-

Coefficient of variation (COV) for grain yield = 3.40%, COV for grain weight = 2.51%.

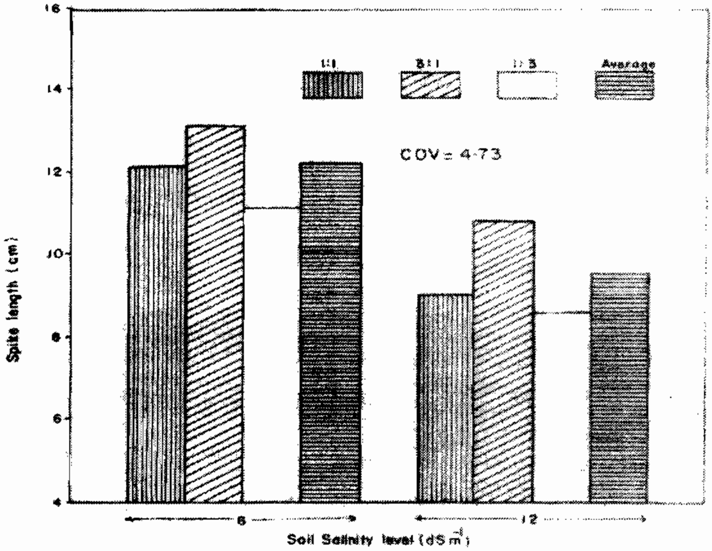

Figure I. Effect of different Ca/Na ratios and salinity levels on spike length.

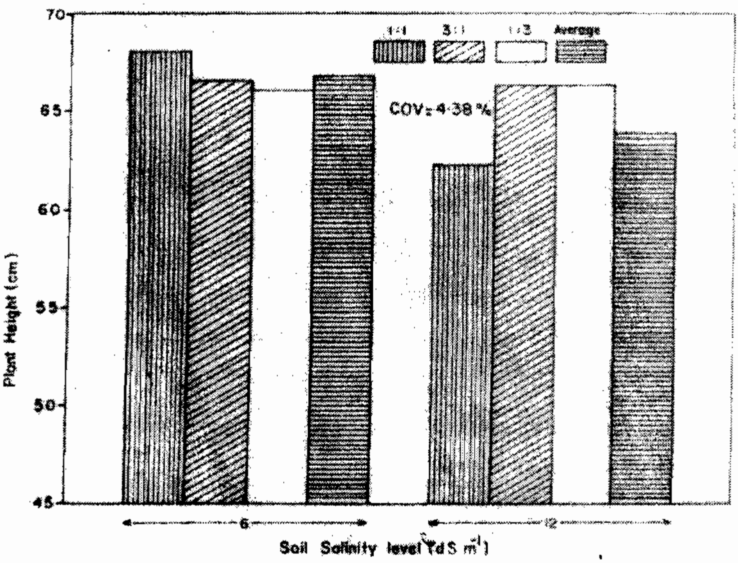

Figure 2. Effect of different Ca/Na ratio and salinity levels on plant height.

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