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Effect of NaCl Salinity on the Growth and Yield of Inqlab Wheat (*Triticum aestivum* L.) Variety

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Abstract: Investigating the tolerance of crop species and varieties to NaCl may contribute to develop practical and cost-effective solutions for managing salt-affected soils. A pot experiment involving addition of different NaCl concentrations was conducted in a wire-house with the aim to investigate the impact of 2, 4, 6, 8 and 10 EC_e (dS m^{-1}) on the wheat (cv. Inqlab) growth, yield and yield components. It was observed that increasing soil salinity progressively decreased plant height, spike length, number of spikelets $spike^{-1}$ and grain and straw yield. With increase in EC_e of the soil, the concentrations of Na^+ increased and that of K^+ decreased, which led to lower down the K^+/Na^+ ratio in the flag leaf sap, grains and straw. The effects of salinity were greater at EC_e 10 than at 2, 4, 6 and 8 (dS m^{-1}). The results obtained from this study suggest that the cv. Inqlab may particularly be considered for cultivation on non-saline and/or saline soils with an EC_e up to 6 (dS m^{-1}).

Key words: Soil salinity, Na^+, K^+, K^+/Na^+

Introduction

Soil salinity is the oldest soil pollution problem. The collapse of the Babylonian Empire is considered to be partly the result of failure of irrigated crops due to the accumulation of salts (Rowell, 1994). Salt-affected soils are commonly found in all the continents and under almost all types of climate. However, their distribution is extensive and wide spread in arid and semi-arid compared to humid regions of the World (Ghassemi *et al.,* 1995; Gupta and Sharma, 1990). Soil salinity is considered as one of the serious soil problems of Pakistan. About 6.3 m ha land is affected by salinity in Pakistan (Sial, 1985). Salt-affected soils with high Na^+ and Cl^- concentrations are widespread in the Sindh (Sial, 1985), particularly in the lower and upper regions.

Soil salinity directly affects plant growth through osmotic stress and ionic toxicity caused by Na^+, Cl^- and SO_4^{2-} which may promote imbalance in plant nutrient metabolism (Rowell, 1994; Ghafoor, 2004). Salt-affected soils can be managed by reclamation, but due to scarcity of good quality water, low soil permeability and high cost of amendments this approach is not feasible on large scale (Qureshi *et al.,* 1990). Bio-saline agriculture technology is an alternative approach for effective utilization of salt-affected soils (Qureshi and Barrett-Lennard, 1998), which involves the integrated use of genetic resources (plants, animals, fish, insects and microorganisms). Identifying genotypes and

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cultivars that are tolerant to salinity and/or sodicity is a practical and relatively simple way of improving crop yield and profitability on salt-affected soils (Grewal *et al.*, 2005).

A lot of effort has gone into selecting salt-tolerant genotypes and varieties of wheat by various agricultural institutions in Pakistan and other countries. With the result several wheat genotypes, varieties and selections including, SARC-I, SARC-II, SARC-III, SARC-IV, Blue Silver, LU-26S and Kharchia-65 are now considered as salt-tolerant cultivars. However, identification of new crop varieties that may out perform the currently prevalent varieties is growing need of the Saline Agriculture technology. Farmers in Sindh, most commonly cultivate the Inqlab wheat variety. Since studies on its performance under saline conditions are limited. This study thus describes the effect of NaCl salinity on the growth, ions uptake and yield of Inqlab wheat variety.

Materials and Methods

The sandy clay soil (plough layer) with 0.95% organic matter, 7.0 pH, 2.16 electrical conductivity (EC_e dS m^{-1}) and 8.1 Exchangeable Sodium Percentage (ESP) was collected from the cultivated field of Latif Experimental Farm of Sindh Agriculture University, Tando Jam. The soil was air-dried and passed through 1/4 cm garden sieve. There were three replications of each five saline soil treatments namely: T_1 (control), T_2 (4 dS m^{-1}), T_3 (6 dS m^{-1}), T_4 (8 dS m^{-1}) and T_5 (10 dS m^{-1}). The method suggested by Rowell (1994) was used to calculate the quantity of NaCl required for the preparation of each saline soil treatment. The NaCl was directly mixed to the dry soil. The soil (8 kg pot^{-1}) of each treatment was placed in black painted plastic pots with drainage holes in the bottom. The pots were arranged on wooden benches of the wire-house.

The seed of Inqlab wheat variety was sown in soil filled pots, with 4 cm plant to plant and row to row spacing. The plants were watered regularly to reduce losses by evapo-transpiration. To provide sufficient nutrients to plants, urea and a compound fertilizer named Engro NPK containing 10% N: 23% P_2O_5: 15% K_2O were applied to each pot. Before sowing, soil samples were collected and analyzed for soil texture using Bouyoucos hydrometer method, organic matter by Walkley Black method, pH and EC_e with digital meters and Na^+ and K^+ by Flamephotometer. Exchangeable Sodium Percentage (ESP) was calculated following the formula of Rowell (1994).

When they became fully expanded the flag leaves of three plants from each pot were randomly sampled, placed in Eppendorf tubes and stored in a freezer at -10°C. The lamina of the leaves was removed and sap was extracted following the method of Gorham *et al.* (1997) and analyzed for Na^+ and K^+. At maturity all plants were harvested by cutting at soil level. The ears were separated from straw, placed in separate paper bags and oven dried for 48 h at 82 ^{0}C. Threshing was done by hand. Grain and straw samples were prepared by ash digestion (MAFF, 1985) method for the analysis of Na^+ and K^+. To perform ANOVA, all plant data were analyzed statistically using MINITAB-12 computer package. Differences between means were tested by calculating Least Significant Differrence (LSD) values at the 5% probability level.

Results

Increasing soil EC_e (dS m^{-1}) progressively decreased plant height (Fig. 1), spike length (Fig. 2), number of spikelets $spike^{-1}$ (Fig. 3) and grain and straw yield (Fig. 4). Compared to the control, salt-affected plants were significantly ($P<0.05$) shorter, produced significantly ($P<0.05$) smaller spikes with fewer spikelets, lighter grains and gave significantly ($P<0.05$) lower grain and straw yield

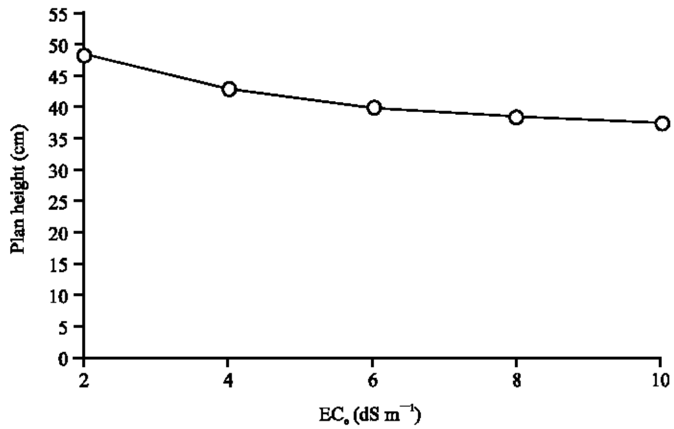

Fig. 1: Effect of different salinity levels on plant height (cm) recorded at flag leaf stage
SED = 3.267, LSD = 7.279**

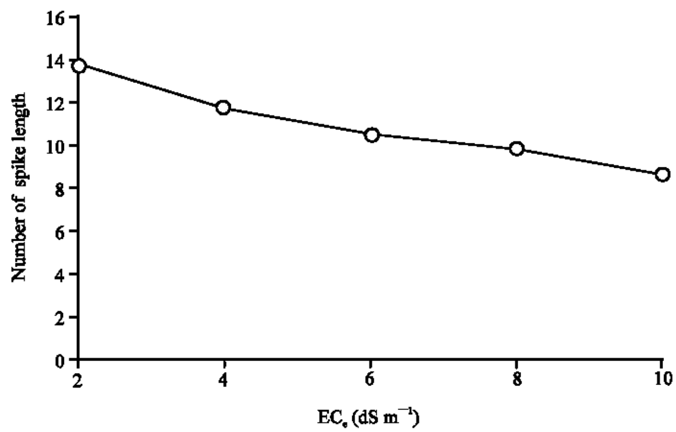

Fig. 2: Effect of different salinity levels on spike length (cm). SED = 0.456, LSD = 1.016***

(Fig. 4). The effect of soil salinity on all measured characters was greater at EC_e 10 (dS m^{-1}) where higher concentration of NaCl was added to the soil. At soil EC_e of 4, 6, 8 and 10, the grain yield was decreased by 29.45, 57.98, 58.25 and 76.42%, respectively over control. The reduction in straw yield was also greater (38%) at EC_e 10 (dS m^{-1}) over control. The adverse effects of NaCl salinity were associated with significantly ($P<0.05$) higher concentration of Na^+ and lower concentration of K^+ determined in the flag leaf sap (Fig. 5), grains and straw dry matter (Fig. 6). The high Na^+ and low K^+ resulted in lower K^+/Na^+ ratio in the flag leaf sap, grains and straw dry matter of plants grown under saline conditions (Fig. 7). Compared to EC_e 4 and 6, the plants grown at EC_e 10 (dS m^{-1}) had higher Na^+ and lower K^+ and K^+/Na^+ ratio in flag leaf sap, grains and straw.

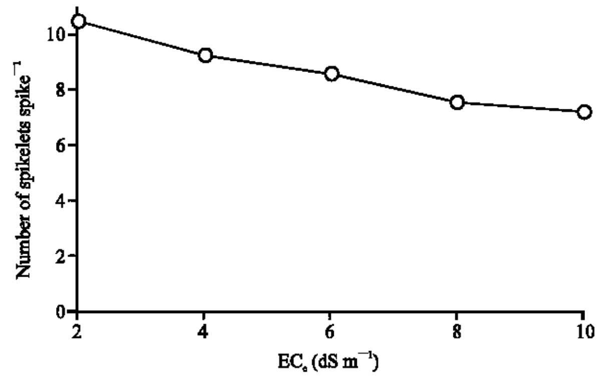

Fig. 3: Effect of different salinity levels on number of spikelets spike^{-1}. SED = 0.288, LSD = 0.643***

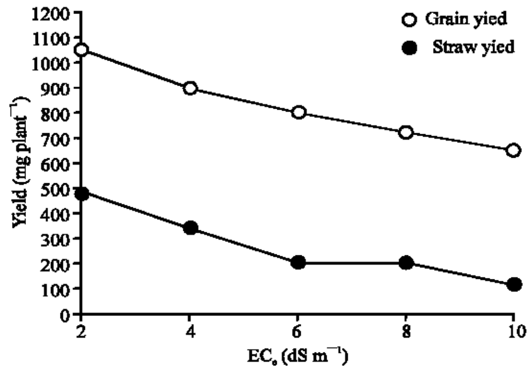

Fig. 4: Effect of different salinity levels on grain and straw yield.

SED (Grains) = 28.763 LSD (Grains) 64.08***

SED (Straw) = 39.471 LSD (Straw) 87.94***

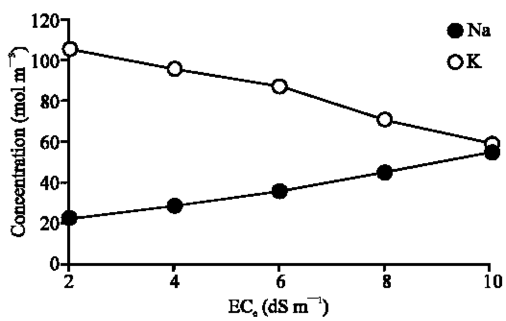

Fig. 5: Effect of different salinity levels on Na and K concentration determined in the falg leaf sap. SED (Na) = 6.855, LSD = (Na) 15.274**. SED (K) = 1.507. LSD = (K) 3.676**

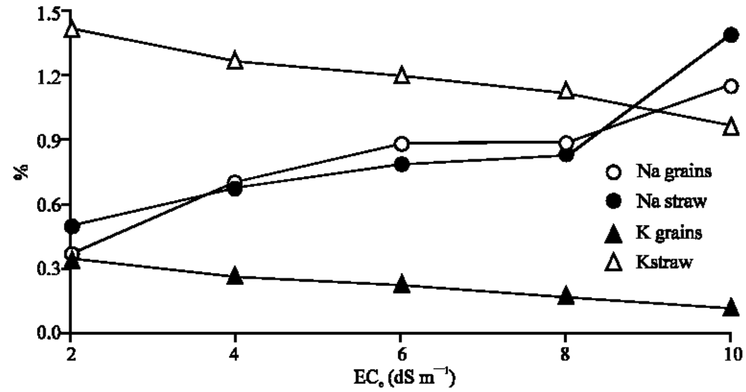

Fig. 6: Effect of different salinity levels on Na and K contents in grain and straw. SED (Na) = 0.310**. SED (K) = 0.03, LSD (K) = 0.067***

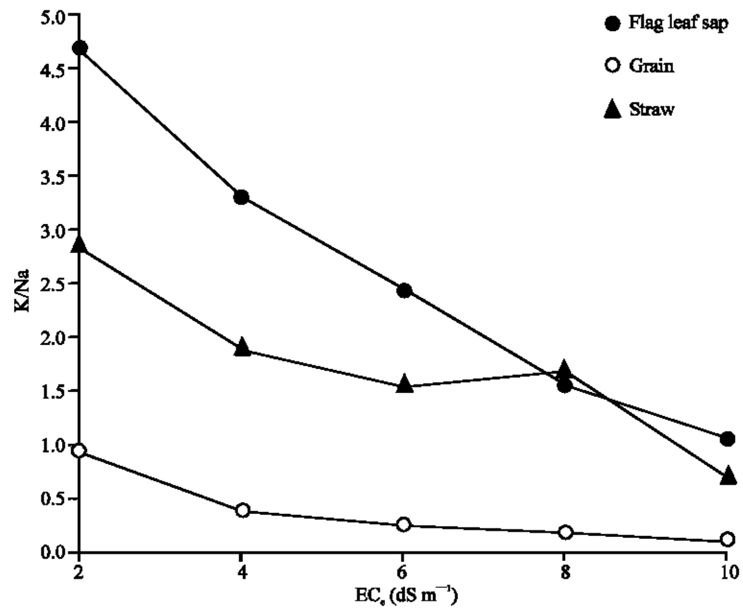

Fig. 7: Effect of different salinity levels on K/Na ratio determined in the flag leaf sap, grains and straw. SED (Grain) = 0.070, LSD (Grains) = 0.156***, SED (Straw) = 0.463, LSD (Straw) = 1.032*, SED (Sap) = 1.058, LSD = (Sap) = 2.357**

Discussion

The production of shorter plants with small and empty spikes might have affected the grain and straw yield in saline soil treatments. Several authors (Rajpar, 1999; Grewal *et al*., 2005) have also observed the similar effects of NaCl salinity on wheat. The higher concentration of Na^+ displayed by plants in flag leaf sap, grains and straw dry matter under saline conditions was due to higher soil EC_e (dS m^{-1}) reflected by the addition of higher concentration of NaCl to the soil during preparation. The lower concentration of K^+ in flag leaf sap, grains and straw was possibly due to the negative effect of higher concentration of Na^+ on ionic balance. Higher K^+/Na^+ ratio is considered as the base of salt-tolerance in wheat under saline conditions (Chippa and Lal (1995). Grewal *et al*. (2005) and Rowell (1994) have also concluded that nutrient deficiencies and/or direct toxicities due to high concentration of Na^+ and Cl^- in soil can reduce growth and yield of crops.

Conclusions

The results obtained from this experiment showed that NaCl salinity particularly, beyond EC_e 6 (dS m^{-1}) had detrimental effect on the cv. Inqlab. Furthermore, this study suggests that, cultivar Inqlab may be recommended for cultivation on saline soils with an EC_e up to 6 (dS m^{-1}).

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