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Effects of Salinity Stress on Germination Characters of Two Corn Varieties

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ABSTRACT

Sustained and profitable production of crops on salt-affected soils requires appropriate on-farm management decisions. Growers must know how plants respond to salinity, the relative tolerances of different crops and their sensitivity at different stages of growth, and how different soil and environmental conditions affect salt-stressed plants. For investigating of salinity stress on germination characters of two corn varieties a factorial experiment in a completely randomized design with three replications was conducted in 2010. The experimental factors were corn cultivars, including two conventional sweet corn cultivars (merrit and Ksc403su) and one super-sweet corn cultivar (Abcsion), and five levels of salinity (0, 3, 6, 9, and 12 ds/m). The results showed that with increasing the salinity levels, all the measured parameters including the percentage of germination, speed of germination, and radical and plumule length decreased. Among the cultivars studied, Ksc403su cultivar (Golden Seed, Iranian) showed higher tolerance to salinity in the traits measured compared to the other two cultivars. In all the mentioned cultivars, the highest values for the measured traits were obtained from the control treatment.

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INTRODUCTION

Soil salinization is one of the major factors of soil degradation. It has reached 19.5 % of the irrigated land and 2.1 % of the dry-land agriculture existing on the globe (FAO, 2000). Salinity effects are more conspicuous in arid and semiarid areas where 25 % of the irrigated land is affected by salts. (Lira *et al*., 1982). Salinity inhibition of plant growth is the result of osmotic and ionic effects and the different plant species have developed different mechanisms to cope with these effects (Munns, 2002). Since corn is grown in climatically diverse regions and under different production conditions, corn seed is inevitably subject to various stress conditions. These stress conditions affect seed germinability, resulting in poor crop emergence, reduction of plant stand below the optimum, increased presence of weeds and, ultimately, reduced yield and quality of commercial corn Environmental stress, especially salinity stress, can play an important role in the reduction of the plant growth stage especially germination stage. Germination is a critical stage of the plant life and resistance against salinity during the germination is important for stability Salinity is known to cause not only ionic and osmotic stress but also oxidative stress (Zhu, 2001). Osmotic stress is the primary effect of drought, while salinity induces osmotic stress more indirectly through the effect on the ionic homeostasis within the plant (Zhu, 2002).

A large amount of soil salinity can be reduced using the drainage systems as well as watering the saline layer of the soil with adequate amount of water, but these methods are very expensive and sometimes impossible; therefore, it is more appropriate to select varieties that are salinity resistant. Salinity impairs seeding, retards plant development and reduces crop yield; these effects are different during growth stages (Greenway and Munns, 1980). Schachtmann and Munns [10] reported that sodium exclusion was a general characteristic of salt tolerance in wheat lines, where as, salt tolerant display much higher shoot sodium level than sensitive lines. Few studies have been carried out on the relative salt tolerance of various cultivars of agricultural crops of Pakistan (Mer *et al*., 2000) the screening of salt tolerant lines/cultivars has been attempted by many researchers on various species at seedling growth stage (Ashraf, 1999). The relation of various seedling growth parameters to seed yield and yield component under saline conditions are important for the development of salt tolerant cultivar for production under saline conditions. Salinity can also affect plant growth because the high concentration of salts in the soil solution interferes with balanced absorption of essential nutritional ions by plants-(Tester and Devenport, 2003). It is well established that higher plants can withstand high salinity by

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either salt exclusion or salt inclusion (sykes, 1992). Under saline conditions, a reduced plant growth due to specific ion toxicities (e.g. Na+ and Cl^-) and ionic imbalances acting on biophysical and/or metabolic components of plant growth occurs (Grattan and Grieves, 1999). Increased NaCl concentration has been reported to induce increases in Na and Cl as well as decreases in N, P, Ca, K and Mg level in fennel (Abd El-Wahab, 2006). The study presented here deals with the response of two cultivars of corn to NaCl stress at germination and early seedling growth stage.

MATERIAL AND METHODS

A factorial experiment in a completely randomized design with three replications was conducted. The experiment included two conventional sweet corn cultivars (merrit and Ksc403su) and one super-sweet corn cultivar (Abcsion), and five levels of salinity (0, 3, 6, 9, and 12 dS/m). Treatments were 7 salinity levels, i.e. control (tap water), 0, 3, 6, 9, 12 $dS.m^{-1}$ and 3 genotypes of sweet corn; two conventional sweet corn cultivars (merrit and Ksc403su) and one super-sweet corn cultivar (Abcsion). The salinity of culture medium was artificially provided by calcium chloride and sodium chloride with the ratio of $2NaCl:1CaCl_2$ (wt/wt). Seeds were placed on the sterile petri dishes and then added 20 ml of the saline solution. Petri dishes were kept in the dark conditions at the constant temperature of 25 C in the seed germinator. One day later, the germinating seeds were counted until 15 days after establishing the experiment. Seeds on a daily basis and reviewed at a certain time and number of seeds the radicle was visible as they germinated seeds were counted. Final test day (tenth day) as well as root length and shoot in the five randomly selected seedlings were measured. Germination standard level was considered as a 3 mm long radicle and using this specification, the germinated seeds were recorded in daily tables.

The germination rate was calculated by equation:

$$GR = \frac{x_1}{y_1} + \frac{x_2 - x_1}{y_2} + ... + \frac{x_n - x_{n-1}}{y_n}$$

Where "x_n" is the number of the seeds that germinated in the last day, n is number of day, and "y_n" is the number of the days from the beginning of the experiment to the last day of the experiment. T_{50} which is the time required for 50% of the seeds germinated on a daily basis was calculated by the following equation:

$$T_{50} = t_t \times \left(\frac{\frac{N+1}{2} - n_i}{n_j - n_i} \right) \times \left(t_j - t_i \right)$$

Where, N is the seed grown at the end of the experiment, n_i and n_j are the number of the seeds grown during the days, t_i and t_j and t_t is the time required for the maximum germination.

The angular transformation of *Arc sin* $\sqrt{x}$ was used for the normalizing of the data. SAS and Excel were used to analyze the data and to draw the graphs. Mean comparison was performed using Duncan's test at 5% probability level.

RESULTS AND DISCUSSION

The results of this experiment showed that the effects of cultivars and salinity levels on the studied traits were highly significant (P=1%) (Table 1), but the interaction effects of cultivar and salinity were not significant. Mean comparison of the effects of cultivar-salinity showed that with increasing the salt concentrations, the investigated parameters decreased in all three cultivars tested. Therefore, the relationship between the parameters and salinity levels follows a significant negative linear relationship. The results imply that Ksc403su cultivar is more tolerant than the two previously mentioned cultivars in terms of germination percentage, speed of germination and radicle and plumule length. Results of this study showed that among the three cultivars studied, Ksc403su cultivar (Golden Seed) has a more favorable condition in terms of all the components of germination. Moreover, this cultivar has the highest percentage and speed of germination and highest radicle and plumule length under different levels of salinity. These components being higher in Ksc403su cultivar can be very effective in faster and more favorable seedling establishment in saline conditions. As a result, they can guarantee further success of the product. Report of Mass *et al.*, (1983) on relative tolerance of 16 corn cultivars at germination stage showed that corn is moderately tolerant to salinity during the germination stage. Hoffman *et al.*, (1983) investigated the effects of five levels of salinity of irrigation water (0.2, 2, 4, 6, and 8 dS/m) on a grain corn cultivar and found that the salt tolerance of grain corn has a threshold of about 3.7 dS/m and in salinities of higher than the threshold, for each unit increase in salinity, the grain yield decreases by about 14 percent. Mehmet Demir (2003) in the study of 3 varieties of safflower, showed that with the increase of salinity, length of radical, plumule dried weight of radical plumule decreased. Because of salinity increase, germination percentage decreases and germination time increases (Jajarmi. 2007).

Conclusions:

Salt stress causes huge losses of agriculture productivity worldwide. Therefore, plant biologists aimed at overcoming severe environmental stresses needs to be quickly and fully implemented. Together with conventional plant physiology, genetics and biochemical approaches to studying plant responses to abiotic stresses have begun to bear fruit recently. Relevant information on biochemical indicators at the cellular level may serve as selection criteria for tolerance of salts in agricultural crops. Although there were many transgenic plants with high stress tolerance generated, plant abiotic stress tolerance is a complex trait that involves multiple physiological and biochemical mechanisms and numerous genes.

Table 1: Analysis of variance for germination characters on corn

S.O.V	df	Germination percentage	Germination rate	Pulmus length (mm)	Radical length (mm)	Dry weight
Variety	2	11855**	616/525 **	4/951 **	29/95**	0/917 **
Salinity	4	282 **	93/256 **	3/151 **	6/95**	0/002 **
Variety× Salinity	8	340 ns	61/840 ns	0/148 ns	0/638 ns	0/004 ns
Error	30	67/22	2/17	4/808	26/10	0/133

*, ** significantly at the 5% and 1% levels of probability respectively and ns (non significant)

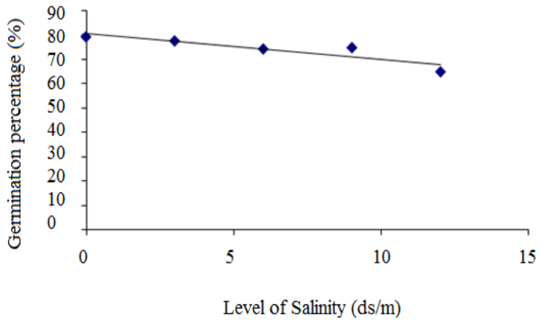

Fig. 1: Effect of salinity on Germination percentage

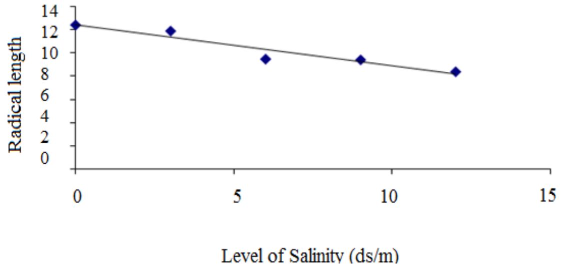

Fig. 2: Effect of salinity on Radical length

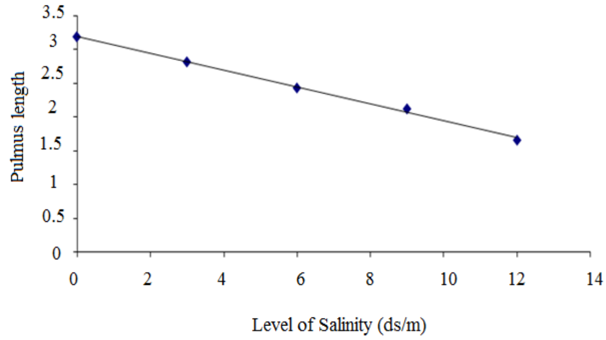

Fig. 3: Effect of salinity on Pulmus length

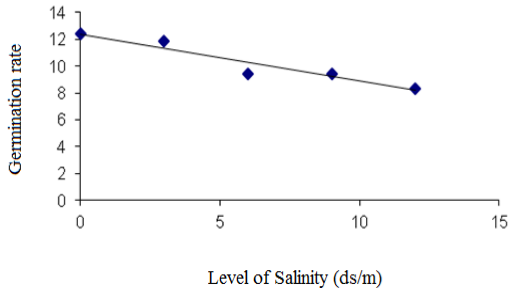

Fig. 4: Effect of salinity on Germination rate

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