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Influence of Salt Stress and Variety on some Characteristics of Corn

Mohammad Mahdi Akbari, Hamid Reza Mobasser and Hamid Reza Ganjali
Department of Agronomy,
Islamic Azad University, Zahedan Branch, Zahedan, Iran

(Corresponding author: Hamid Reza Mobasser)
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ABSTRACT: Salinity is one of the serious environmental problems that cause osmotic stress and reduction in plant growth and crop productivity in irrigated areas of arid and semiarid regions. The agricultural areas affected by salt need amendment and determination of the most suitable plant species able to grow in these areas. High salinity levels caused significant reduction in growth parameters like leaf area, leaf length, root and shoot dry weights. Maize (*Zea mays* L.) is in the third rank after wheat and rice and is grown all over the world in a wide range of climatic condition. Being highly cross pollinated, maize has become highly polymorphic through the course of natural and domesticated evolution and thus contains enormous variability in which salinity tolerance may exist. The field experiment was laid out in randomized complete block design with factorial design with four replications. Treatments included salt stress (NaCl: 1, 2.3, 3.6, 4.9 gr/lit) and variety (540, 610). Analysis of variance showed that the effect of salt stress and variety on all characteristics was significant.

Key words: corn, salt stress, variety

INTRODUCTION

The rapid increase in the world population demands an expansion of crop areas to raise food production. In this context, a significant fraction of agricultural crops are cultivated on low quality soils, sometimes affected by salinity (Allen *et al.,* 1983). According to Steppuhn and Wall (1999), salinity could be defined as a water property that indicates the concentration of dissolved solutes. Soil salinity refers to the state in which dissolved constituents concentrate beyond the needs of plant roots. It is well-known that salinity is a common stress factor in agricultural areas as a result of extensive irrigation with saline water and fertilizer application (McKersie and Leshem 1994). Salinity is one of the serious environmental problems that cause osmotic stress and reduction in plant growth and crop productivity in irrigated areas of arid and semiarid regions. The agricultural areas affected by salt need amendment and determination of the most suitable plant species able to grow in these areas. Tolerances to environmental stresses as salinity of plants can be determined by using different parameters. Plants need to have special mechanisms for adjusting internal osmotic conditions and changing of osmotic pressure in the root environment. Stressed plants diminish osmotic potential by accumulating free amino acids, ions and dissolvable substances. In this way, osmotic adjustment is ensured (Salama *et al.,* 1994; Weimberg, 1986, 1987). Measurement of proline accumulation is also an important criterion for determination of plant tolerance to salt stress (Palfi and Juhasz, 1971). In salt stressed plants osmotic potential of vacuole decreased by proline accumulation (Yoshiba *et al.,* 1997). It was thought that accumulated proline under environmental stress do not inhibit biochemical reactions and plays a role as an osmoprotectant during osmotic stress (Yoshiba *et al.,* 1997). In addition, several possible roles have been attributed to supraoptimal levels of proline; osmoregulation under drought and salinity conditions, stabilization of proteins, prevention of heat denaturation of enzymes and conservation of nitrogen and energy for a post-stress period (Aloni and Rosenshtein, 1984). It is suggested that the low osmotic potential may cause proline accumulation in tissues (Buhl and Stewart, 1983; Sing *et al.,* 1973). Halophytes are reported to keep the cellular levels of these potentially damaging ROS within a narrow, functionally important range under optimum growing conditions by utilizing a coordinated antioxidant system consisting of enzymes like superoxide dismutases (SOD), catalases (CAT) and peroxidases (POD) and non-enzymatic antioxidants like ascorbate (ASA) and glutathione (GSH) (Jithesh *et al.,* 2006; Shabala, and Mackay, 2011).

Therefore, at the whole plant level, a strong antioxidant defense system along with efficient ion regulation, production of compatible solutes and the maintenance of photosynthesis is attributed to salt tolerance in halophytes (Flowers and Colmer, 2008; Guan *et al.,* 2011; Jithesh *et al.,* 2006; Shabala and Mackaym, 2011; Song *et al.,* 2006). However, these defense mechanisms would become inadequate under high saline conditions leading to growth inhibition and/or death (Flowers and Colmer, 2008; Jithesh *et al.*, 2006; Munns and Tester, 2008). High salinity levels caused significant reduction in growth parameters like leaf area, leaf length, root and shoot dry weights (Ashrafuzzaman *et al.,* 2002). Maintaining a better nutrition with K and Ca, while limiting Na uptake, is a highly important trait contributing to high salt stress tolerance in plants. Consequently, higher K/Na or Ca/Na ratios are typical in the tissues of salt-tolerant varieties, and are often used as a screening parameter for identification of salt stress-tolerant varieties (Gorham, 1990; Dasgan *et al.,* 2002; Munns and James, 2003; Poustini and Siosemardeh, 2004; Song *et al.,* 2006). 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). The osmotic adjustment, *i.e.*, reduction of cellular osmotic potential by net solute accumulation, has been considered an important mechanism to salt and drought tolerance in plants. This reduction in osmotic potential in salt stressed plants can be a result of inorganic ion (Na^+, Cl^-, and K^+) and compatible organic solute (soluble carbohydrates, amino acids, proline, betaines, etc) accumulations (Hasegawa *et al.,* 2000). The osmotic adjustment in both roots and leaves contribute to the maintenance of water uptake and cell turgor, allowing physiological processes, such as stomatal opening, photosynthesis, and cell expansion (Serraj and Sinclair, 2002). In addition to their role in cell water relations, organic solute accumulation may also help towards the maintenance of ionic homeostasis and of the C/N ratio, removal of free radicals, and stabilization of macromolecules and organelles, such as proteins, protein complexes and membranes (Bohnert and Shen, 1999, Bray et al., 2000). Although the relationship between osmoregulation and salt tolerance is not clear, there is evidence that the osmotic adjustment appears, at least partially, to be involved in the salt tolerance of certain plant genotypes (Richardson and McCree, 1985). Maize (*Zea mays* L.) is in the third rank after wheat and rice and is grown all over the world in a wide range of climatic condition. Being highly cross pollinated, maize has become highly polymorphic through the course of natural and domesticated evolution and thus contains enormous variability in which salinity tolerance may exist (Paterniani, 1990). Maize, which belongs to the plants with C4 metabolism, is also classified as moderately sensitive to salinity (Mass and Hofffman, 1977; Katerji *et al.*, 1994; Ouda *et al.,* 2008). For maize grown under salinity, reduction in growth characters and yield were observed (Ouda *et al.,* 2008). Hussain *et al.* (2010) reported that changes in morphological attributes of Maize (*Zea mays* L.) under NaCl salinity. Bojovic *et al.* (2010) was conducted an experiment to determine the effects of NaCl on seed germination in some species from families Brassicaceae and Solanaceae. The ability of seeds to germinate at high salt concentration in the soil is crucial importance for the survival and perpetuation of many plant species. Khatoon *et al.* (2010) determined the morphological variations in maize (*Zea mays* L.) under different levels of NaCl at germinating stage. Perti dishes experiments were conducted at Botany lab of University of Gujrat-Pakistan during 2010 for the study of NaCl effect on maize (*Zea mays* L.) at germinating stage. There were three levels of NaCl applied on growth medium of germinating seeds. All the growth attributes such as germination %, root and coleoptile lengths and plant fresh weight reduced with increase in salinity levels. It was concluded that salinity had adverse effect on growth of maize. NaCl concentrations at germinating stage could have much adverse effects on maize than later stages of growth. Usman *et al.* (2012) found that Effect of NaCl on Morphological Attributes of Maize (*Zea mays* L.) Checking out the response of maize (*Zea mays* L.) to the salt NaCl, the experiments being conducted at research Centre of Hafiz Hayat Campus University of Gujrat. The outdoor CRD experiments were used for this purpose. It was observed that maize show sensitive response against NaCl, as the salinity levels goes on increasing gradually; it greatly reduces the growth parameters. The morphological responses against the NaCl treatments are studied. These morphological parameters included Shoot, Root Length, Fresh and Dry Weight etc. There is a great variation exists for the morphological attributes. The reduction in different growth parameters results gradually from T1 to T2 (20mM to 40 mM), as compared to the control group. It is the clear indication that the plants which are salt sensitive do show reduced yield under the high salinity conditions. The Morphological changes do indicate the fact that the plant is suffering in its metabolic activities which clearly makes a guess towards the disturbance. Drought is a worldwide problem and dangerous for arable field crops growth and subsequently for food security (Jaleel *et al.,* 2009). Currently selection criteria are applied for good variety selection as compare to breeding techniques which are time consuming (Zhu, 2002). Drought stress or water deficit stress is globally renowned feature of climate, also an alarming threat to our agriculture which could be unavoidable.

Kramer (1980) studied that one third part of arable land of the world faces the water shortage which also disturb the crop production. Water is an integral part of plant body plays an important role in growth initiation, maintenance of developmental process of plant life and hence has pivotal function in crop production. Grzesiak (2001) reported the soil drought effect on growth in experiment done in glass house and concluded that genetic makeup of maize show variation in drought tolerance and is better manipulated under severe conditions of drought. Drought is still a serious agronomic problem and one of the most important factors contributing to crop yield loss. For maize grown in Northern China, water resources are very limited with drought stress often occurring during the growth season. Water shortages and soil water losses due to environmental change (Xia, *et al.*, 2005) and land use change (Li *et al.*, 2002) are challenges to maize production. Actually, maize consumption has continued to rise steadily with demand outstripping supply in China. Maize is very sensitive to water stress during the growing season, and is especially vulnerable to soil drought during the flowering and grain-filling periods. As past research has shown, environmental drought stress has caused oxidative damage in plants (Larson, 1995). The antioxidant system including antioxidant enzymes such as superoxide dismutase (SOD), peroxidase (POD), and catalase (CAT) as well as other compounds such as carotenoids and ascorbate were the principal defenses against oxidants (Larson, 1988; Burke and Mahan, 1991).

MATERIAL AND METHODS

A. Location of experiment

The experiment was conducted at the zahedan which is situated between 29° North latitude and 60° East longitude.

B. Composite soil sampling

Composite soil sampling was made in the experimental area before the imposition of treatments and was analyzed for physical and chemical characteristics.

C. Field experiment

The field experiment was laid out in randomized complete block design with factorial design with four replications.

D. Treatments

Treatments included salt stress (NaCl: 1, 2.3, 3.6, 4.9 gr/lit) and variety (540, 610).

E. Data collect

Data collected were subjected to statistical analysis by using a computer program MSTATC. Least Significant Difference test (LSD) at 5 % probability level was applied to compare the differences among treatments` means.

RESULTS AND DISCUSSION

A. Dry weight (t/ha)

Analysis of variance showed that the effect of salt stress on dry weight was significant (Table 1). The maximum of dry weight (0.44) of treatments 0.5 was obtained (Table 2). The minimum of dry weight (0.05) of treatments 8 was obtained (Table 2). Analysis of variance showed that the effect of variety on dry weight was significant (Table 1). The maximum of dry weight (0.27) of treatments 540 was obtained (Table 2). The minimum of dry weight (0.24) of treatments 610 was obtained (Table 2).

B. Number of leaf

Analysis of variance showed that the effect of salt stress on number of leaf was significant (Table 1). The maximum of number of leaf (10.5) of treatments 0.5 was obtained (Table 2). The minimum of number of leaf (2.6) of treatments 8 was obtained (Table 2).

Table 1. Anova analysis of the corn affected by salt stress and variety.

S.O.V	**df**	**Dry weight (t/ha)**	**Number of leaf**	**Plant height (cm)**	**Biomass (t/ha)**
salt stress (s)	4	0.19^{**}	82.58^{**}	4436.18^{**}	6.15^{**}
Variety (v)	1	0.011^{**}	14.4^{**}	252.9^{**}	0.3^{ns}
S*V	4	0.014^{**}	2.46^{**}	259.46^{**}	0.07^{ns}
Error	30	0.0006	0.35	17.2	0.04
CV (%)	-	9.69	10.47	12.10	18.92
*, **, ns: significant at p<0.05 and p<0.01 and non-significant, respectively.					

Analysis of variance showed that the effect of variety on number of leaf was significant (Table 1). The maximum of number of leaf (6.25) of treatments 610 was obtained (Table 2). The minimum of number of leaf (5.05) of treatments 540 was obtained (Table 2).

C. Plant height (cm)

Analysis of variance showed that the effect of salt stress on plant height was significant (Table 1). The maximum of plant height (64.75) of treatments 0.5 was obtained (Table 2). The minimum of plant height (2.6) of treatments 8 was obtained (Table 2). Analysis of variance showed that the effect of variety on plant height was significant (Table 1). The maximum of plant height (38.1) of treatments 610 was obtained (Table 2). The minimum of plant height (30.4) of treatments 540 was obtained (Table 2).

Biomass: Analysis of variance showed that the effect of salt stress on biomass was significant (Table 1). The maximum of biomass (2.4) of treatments 0.5 was obtained (Table 2). The minimum of biomass (0.48) of treatments 6 was obtained (Table 2). Analysis of variance showed that the effect of variety on biomass wasn't significant (Table 1). The maximum of biomass (1.181) of treatments 540 was obtained (Table 2). The minimum of biomass (1.005) of treatments 610 was obtained (Table 2).

Table 2: Comparison of different traits affected by variety and salt stress.

Treatment	Dry weight (t/ha)	Number of leaf	Plant height (cm)	Biomass (ton/ha)
Variety				
540	0.27a	5.05b	30.4b	1.181a
610	0.24b	6.25a	38.1a	1.005b
salt stress (s)				
0.5	0.44a	10.5a	64.75a	2.4a
2	0.34b	7b	50.12b	1.42b
4	0.3	5c	28.25c	0.99c
6	0.14b	3.12d	25.5c	0.48d
8	0.05e	2.6d	2.6d	0.75
Any two means not sharing a common letter differ significantly from each other at 5% probability				

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