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ORIGINAL ARTICLE

MORPHOLOGICAL VARIATIONS IN MAIZE (*ZEA MAYS* L.) UNDER DIFFERENT LEVELS OF NA_2SO_4 AT GROWTH STAGE

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ABSTRACT: Pot experiments were done at Nursery of University of Gujrat, Pakistan in 2011 for the study of Na2SO4 effect on maize (Zea mays L.) at growth stage. 32-B-33 Pioneer variety of maize was used. The pot experiment was arranged in a completely randomized design with four salt concentrations and four replicates under the greenhouse condition. Sulfate treatments were applied to maize by dissolving Ammunion sulphate salts in distilled water. There were four levels of Na2SO4 (0, 50 mM, 100 mM and 150mM) used on growth of plant. The experimental soil was salinized with Na2SO4 at the rates of 0, 50, 100 and 150mM Na2SO4. Growth of the maize plants was inhibited by salinity. Enhancements of growth were observed at 50mM Na2SO4 in maize. The strongest inhibition of growth occurred at the high salt concentration (150mM). Applied Na2SO4 significantly decreased dry mass of maize plants. All the growth attributes such as root and shoots lengths and plant fresh weight decreased with increase in salinity levels. It was observed that salinity had adverse effect on growth of maize. It was concluded that water potential changes caused reduction of root length and leaf area in maize under salt stress. Water potential changes caused by salt concentrations in growth medium and salinity had adverse effect in growth.

INTRODUCTION

Maize (Zea mays L.) is largely grown in many parts of the world where soil salinity is one of the major agricultural threats to its productivity. While comparing different crops for their response to salinity stress this crop is very sensitive to high concentrations of salts in soil solution (Maas and Hoffman, 1977).

Maize (*Zea mays* L.) is an important crop in Pakistan, which is used as food and corn oil for human consumption, feed for livestock and poultry and raw material for agro-based industries. In Pakistan, maize is the third most important crop after wheat and rice. Being an important crop, maize is grown on about one million hectares with a total yield of about 2 million tones and an average yield of 1882 kg ha^{-1} (Anonymous, 2005). In view of its increasing importance, improvement in agronomic characteristics of maize has got considerable attention in Pakistan (Mehdi and Ahsan, 2000).

More than 800 million hectares of land throughout the world are salt-affected, either by salinity or the associated condition of sodicity by FAO, (2005). Soil salinity is one of the major abiotic stresses which badly affect crop growth and productivity. In Pakistan, about 6.30 Mha of land are salt affected (Alam *et al.,* 2000). In the province of Punjab, an estimated 1 hectare of irrigated land is being lost every five minutes to salinity by Rahman, (1998).

Marschner, (1986) observed salt stress causes various effects on plant physiology such as increased respiration rate, ion toxicity, changes in plant growth, mineral distribution, and membrane instability resulting from calcium displacement by sodium and salt stress cause membrane permeability which observed by Gupta *et al.,* (2002).

Maize is a highly sensitive to saline irrigation water showing 50 % decrease in yield at EC 3.9 dS mX^1, Ayres and Westcot, (1985). Salinity has a two-fold effect on plants, the salt in the soil solution reduces the availability of water to the roots (osmotic stress) and the salt taken up by the plant can accumulate to toxic levels in certain tissues (ionic stress), Munns *et al.,* (1995). Reduction in growth under saline conditions is a reason of several physiological responses, including modification of ionic balance, water status, mineral nutrition, stomatal behavior, photosynthetic efficiency and carbon allocation and utilization, Munns and Termaat, (1986).

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Salt sensitivity of maize plants has been found to be due to high accumulation of Na^+ in the leaves (Munns, 1993).
Wyn Jones, (1981) was observed that soil salinity developed due to high amount of chloride or sulfate salts of sodium. Salt stress reduced the plant growth because plant might suffer different types of stresses (Greenway and Munns, 1980).
Osmotic effects are due to salt-induced decrease in the soil water potential. Salinity results in a reduction of K+ and Ca2+ content and an increased level of Na^+ and SO_4^{2-}, which forms its ionic effects (Mansour *et al.*, 2005). Reduction in biomass, photosynthetic capacity changes in leaf water potential and leaf turgor have been reported to have a cumulative effect attributed to salinity stress (Tourneux and Peltier, 1995; Gama, 2007), it is also clear that several soil and other environmental factors do influence plant growth under salinity conditions.
Hussain *et al.*, (2010) was observed that many species of higher plants including most crops was showed to growth inhibition under high salinity conditions. The salt stress induced of plant growth was caused not only by osmotic effects on water uptake but also by variable effects on plant cell metabolism under salt stress.
Reduction in growth of plants was mainly due to the adverse effects of salinity on various biochemical and physiological processes by Majeed *et al.*, (2010). It was due to the salt induced osmotic and toxic effects which minimize the uptake of other mineral nutrients such as N, K and Ca^{+2}, Ashraf, (2004). The ion concentrations in roots, shoots and leaves are maintained by regulating ion transport to acclimatize salt stress, Tester and Davenport, (2003).
The principal objective of the present study was to determine the effects of Na_2SO_4 on the growth and ion composition of maize (*Zea mays* L.) plant at growth stage. The hypotheses that Na_2SO_4 effects on plant growth are more severe compared with the Control treatment (Distilled water).

MATERIALS AND METHODS

Seeds of maize (*Zea mays* L.) were obtained from Murjan seeds Corporation, Gujranwala, Pakistan. One variety of maize was used in this 4 experiment i.e. 32-B-33 Pioneer. Seeds were surface sterilized by dipping in water for 3 hours and air-dried at an ambient temperature of 32 C in the laboratory. Ten seeds were put in each pot with four replicates. Following treatments of Na_2SO_4 salinity were applied.
T_0 = Control (Distilled water)
T_1 = Na_2SO_4 50-mM
T_2= Na_2SO_4 100-mM
T_3= $Na_2SO_4$150-mM
The experiment was laid out as Completely Randomized Design (CRD) with four replicates. Four levels of Na_2SO_4 salt (0, 50, 100 and 150 mM Na_2SO_4) were applied after 20-days of germination. Plants were treated after 20-days of germinating the seeds and following studies were made. Plants were harvested at maturity. Plants were uprooted carefully and washed in distilled water. After 15-days of treatment, root and shoots lengths (cm) were measured with the help of scale meter. Plant fresh weight (g) was noted by electric balance. Shoot and root length was measured with the help of scale meter in cm at final harvest. Plant samples were placed in oven at 65 C. After 7-days shoot and root dry weight (g/pot) was calculated with the help of electric balance at final harvest (23-days after treatment).

2.1. Leaf area per plant (cm^2)

Leaf area per plant was determined following the formula of Carleton and Foote, (1965).
Leaf area (cm^2) = maximum leaf length x maximum leaf width x 0.75 (0.75 = Correction factor)
The correction factor (C.F.) of family Graminae is also 0.75.

RESULT AND DISCUSSION

Salinity had highly significant effect on growth attributes of maize in pots under different levels of Na_2SO_4 stress.

3.1. Shoot Length (cm)

Shoot lengths significantly decreased with increasing Na_2SO_4 levels in maize (Fig. 1).The maximum reduction was observed at Na_2SO_4 level of 150 mM. Data regarding of shoot length is given in Table (1). In control shoot length was 25.5 cm while it decreased up to 20.8 cm at Na_2SO_4 level of 150 mM.

It is generally accepted that plant growth at all stages of development and sensitivity to salinity varies from one growth stage to another, Ashraf *et al.*, (1994), Hussain *et al.*, (2008).
According to many reports maize is sensitive at early stages but could withstand at later growth stages to saline conditions, Shirazi *et al.*, (1971).

Table 1: Effect of different salinity levels on Maize

Parameters	T_o=Control	T_1(50 mM)	T_2(100 mM)	T_3(150 mM)
Shoot length (cm)	25.50	21.73	21.38	20.83
Root length (cm)	20.50	15.45	15.25	14.33
Leaf area (cm^2)	18.30	15.75	14.94	12.40
Shoot fresh weight (g)	1.90	1.22	1.21	1.14
Root fresh weight(g)	0.79	0.60	0.58	0.50
Shoot dry weight (g)	0.84	0.57	0.54	0.47
Root dry weight (g)	0.39	0.31	0.30	0.28

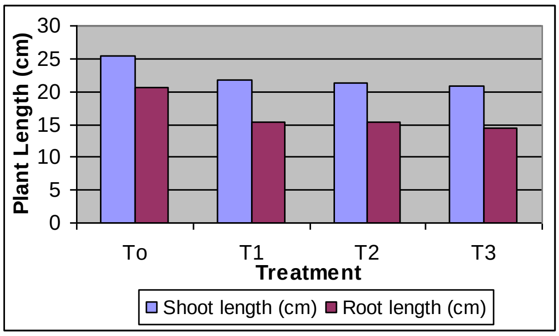

Figure 1: Effect of different concentration of Na_2SO_4 on Root and Shoot length (cm) of maize

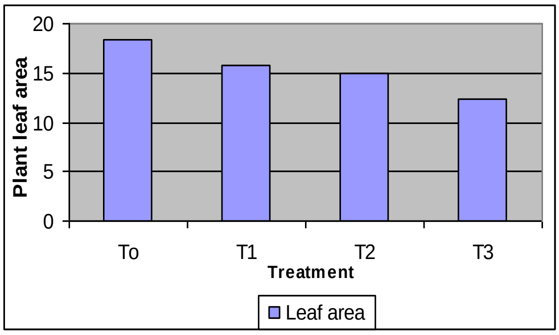

Figure 2: Effect of different concentration of Na_2SO_4 on Plant leaf area (cm^2) of maize

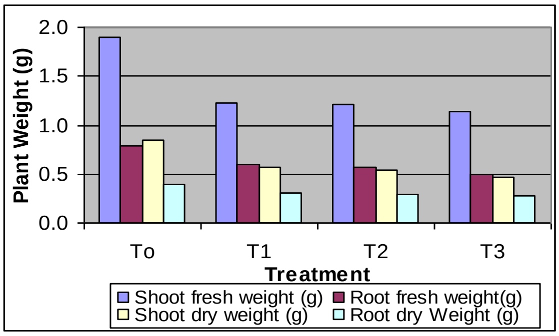

Figure 3: Effect of different concentration of Na_2SO_4 on Plant fresh and dry weight (g) of maize

3.2. Root Length (cm)

Na_2SO_4 severely affected the root length of maize (Fig. 1). Data regarding of root length of maize is given in Table 1. Na_2SO_4 stress has highly significant effect on root length of maize studied. In case of root length it decreased to 14.3cm at 150 mM Na_2SO_4 than control had 20.5 cm root length (Table 1). Root lengths decreased with increasing Na_2SO_4 concentrations. Maximum reduction in root length was noted 14.3cm in 32-B-33 Pioneer at 150 mM Na_2SO_4. Similarly, Hussain *et al.*, (2009a) observed the reduction of root length in black seeds under salt stress. This may due to water potential changes caused by salt concentrations in growth medium.

3.3. Leaf Area (cm_2)

Leaf area also decreased with increasing Na_2SO_4 levels in maize (Fig. 2). Maximum reduction in leaf area was observed in T_3 (150 mM Na_2SO_4) that was 4.90cm_2 of maize variety (32-B-33 Pioneer) while in control, plant leaf area was 1.90cm (Table 1). Growth of leaf area is inhibited by salinity (Brugnoli and Lauteri, 1991; Alberico and Cramer, 1993).High salt in the soil caused osmotic gradient between root and soil and mild osmotic stress leads rapidly to growth inhibition of leaves and stems, whereas roots may continue to grow and elongate (Frensch and Hsiao, 1994; Hsiao and Xu, 2000).

3.4. Plant Fresh Weight (g)

Reduction in plant fresh weight was also noted in maize (Fig. 3). In control shoot fresh weight was 1.90cm while at T_3 (150 mM Na_2SO_4), it decreased up to 1.14cm (Table 1). Maximum reduction was observed in T_3 (150 mM Na_2SO_4) that was 0.76g in maize (32-B-33 Pioneer). The maximum root fresh weight was calculated in control that was 0.79g and the minimum at 150mM Na_2SO_4 was 0.50g in maize (32-B-33 Pioneer). These results are similar with the earlier findings in maize (Izzo *et al.*, 1996).

3.5. Plant Dry Weight (g)

Similar pattern of reduction in shoot and root dry weight was also noted in maize (Fig. 3). Data regarding to plant dry weight showed that shoot and root dry weights were decreased with increasing Na_2SO_4 level in Table 1. The maximum shoot dry weight was calculated in control (0.79g) and the maximum reduction in shoot dry weight was noted (0.50g) in maize variety at T_3 (150 mM Na_2SO_4). In case of root dry weight, the maximum weight was present in control (0.39g), while it decreased up to 13.31g at 150 mM Na_2SO_4 (Table 1). Similarly, Hussain *et al.*, (2009b) found the reduction of growth in Chaksu (*Cassia absus L.*) under salt Stress.

The results of biomass showed that applied Na_2SO_4 inhibited the growth of maize plant, and led to a decrease in biomass. The results of biomass may be related to the effect of salt stress which resulted in the limitation of water absorption and biochemical processes (Cusido *et al.*, 1987; Parida and Das, 2005).

The suppression of plant growth under salt-stress may either be due to osmotic reduction in water availability or to excessive accumulation of ions, known as specific ion effect (Marschner, 1995). There are many reports on osmotic stress and ionic toxicity resulted from salt stress in maize plants (Katerji *et al.*, 2004; Mansour *et al.*, 2005; Eker *et al.*, 2006).

Addition of Na_2SO_4 had an adverse effect on the growth of maize. Salinity caused a significant effect on shoot and root lengths, shoots fresh and dry weight and root fresh weight and dry weight. The reason for growth reduction in maize could be due to water shortage and ionic toxicity caused by salinity. The decrease in plant growth may be due to turgor potential which is decreased by water deficit produced by high concentrations of the salts in the soil, Ashraf and Naqvi, (1996).

The present study showed that the growth processes in the maize plants were suppressed which was a result of the disturbed osmotic processes and the toxic effect of $SO_4^{2-}$and Na^+. Osmotic effects are due to salt-induced decrease in the soil water potential. Salinity results in a reduction of K^+ and Ca^{2+} content and an increased level of Na^+, Cl^- and SO_4^{2-}, which forms its ionic effects (Mansour *et al.*, 2005).

In the present study, accumulation of Na^+ and SO_4^{2-} in maize Plants was significantly increased due to salt stress and the plant growth ratio decreased as increasing amounts of SO_4^{2-} were added to the soils.

CONCLUSION

It was concluded that salinity had severe effect on growth of *Zea Mays*. All the growth parameters including root length, shoot length, leaf area, fresh and dry weight of *Zea Mays* reduced at all levels of added salt. The salt Na_2SO_4 was added in three different concentrations i.e. 50mM to 150mM. There was a significant reduction in growth with increase in salinity levels. The maize variety i.e. 32-B-33 is salt sensitive as the vegetative growth of maize is adversely effected by the addition of salt.

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