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RESEARCH ARTICLE

Seedling Stage Screening of Maize (Zea mays L.) Hybrids Against Salinity Stress

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Abstract

Salinity is a stress factor and hot issue for the agriculture globally. Increasing population is an alarming for crop production. Therefore, considerable attention is present in salt tolerance mechanism and enhanced the performance of plant under soil salinity. Maize (*Zea mays* L.) is 3rd imperative cereal crop and is grown under wide-ranging of soil and climate condition. A hydroponic experiment was carried out in green house of Institute of Soil and Environmental Science, University of Agriculture Faisalabad (UAF) to screening out Maize genotypes under different salinity levels. Nineteen maize cultivars (Pioneer 32F10, Pioneer 33H25, Pioneer 32B33, Pioneer 30Y87, ICI-8288, ICI-339, FH-1012, FH-1360, FH-1471, FH-1280, KALAK, MALKA, Monsanto-6714, Monsanto-661, UAF DH 17/21, UAF DH 32/1, UAF DH 40/3, UAF DH 29/36) were grown under 2 levels of salinity (50 mM and 100mM) with control treatment. Crop duration was six weeks and growth parameters (root and shoot length, fresh and dry weights), chlorophyll contents, Na^+/ K^+ conc. in leaves were observed. Complete randomized design with factorial following four replications was used and found that plant growth, physiological factors and chlorophyll contents significantly reduced with increase in salt stress. Among nineteen cultivars FH-1280, UAF DH 32/1 and UAF DH 17/21 were found salt tolerant, While FH-1012, Pioneer 30Y87 and FH-1360 were found most susceptible. The selected cultivars could be grown under natural atmosphere in saline soil to get better yield.

KEYWORDS
Salinity, Maize, hydroponic, genotypes, tolerant

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1 | INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal and cash crops globally, valued for its high nutritional content and versatile uses. Its grains are rich in protein and fats, while green fodder contains 10–15% protein, making it an essential crop for both human consumption and livestock feeding. In Pakistan, maize ranks third after wheat and rice, cultivated on approximately 1 million hectares, producing about 3.13 million tons annually (Anonymous, 2010). Beyond its role as a fodder crop, maize contributes significantly to various processed food products and daily dietary requirements, with annual consumption reaching 600 million tons and total production of 1.3 million tons. Despite its relative tolerance to salinity compared to other cereals, maize remains moderately susceptible to salt stress, which can adversely affect its growth, development, and yield (Mass and Niemon, 2009; Mehdi and Ahsan, 2000).

Soil salinity is a major environmental constraint affecting agriculture worldwide. Globally, around 800 million hectares of land are salt-affected, primarily in arid and semi-arid regions, where high temperatures, low rainfall, and poor soil management exacerbate the problem (Qadir *et al*., 2014; Meloni *et al*., 2003). In Pakistan, approximately 6.35 million hectares of irrigated land are affected by salinity, particularly in the Indus Basin, where waterlogging, rising water tables, and continuous surface irrigation have altered soil hydrology and increased salt accumulation (Ahmad, 2010; Nabati *et al*., 2011). In Punjab alone, approximately 1 hectare of well-irrigated land is lost every five minutes due to salinity, posing serious challenges for food security and the national economy (Qin *et al*., 2010).

Salinity affects plant growth and productivity through multiple mechanisms, including osmotic stress, ionic imbalance, reduced nutrient uptake, and oxidative damage caused by reactive oxygen species (ROS) (Zhu, 2002; Borsani *et al*., 2003; Pitman and Lauchli, 2002). ROS accumulation damages cellular structures, reduces photosynthesis, disrupts membrane stability, and ultimately leads to cell death if not effectively regulated (Mittler, 2002; Gara *et al*., 2003). Plants have evolved enzymatic antioxidant systems, including superoxide dismutase (SOD), catalase (CAT), and peroxidase (POD), to neutralize ROS and maintain physiological and biochemical homeostasis (Scandalios, 1993; Beak and Skinner, 2003). Salinity tolerance is largely genotype-dependent, as differences in metabolic and ionic regulation determine the plant's ability to maintain growth and yield under stress conditions (Khan *et al*., 2003a, b; Munns *et al*., 2006). Maize, being cross-pollinated and highly adaptable, offers opportunities for the selection and breeding of salt-tolerant cultivars suitable for affected areas (Muranaka *et al*., 2002; Davenport *et al*., 2005).

Given the increasing salinity challenges in irrigated and arid regions, identifying maize genotypes that can withstand salt stress is essential for sustainable crop production and food security. The present study was designed to screen different maize cultivars at the seedling stage under controlled hydroponic conditions to evaluate their tolerance to salinity. This research aims to determine the relative performance of maize varieties under saline conditions, identify genotypes with enhanced resistance, and provide baseline information for future breeding programs targeting salt-affected areas. By integrating physiological, morphological, and biochemical assessments, the study seeks to highlight key traits associated with salt tolerance, offering practical insights for improving maize cultivation in saline environments.

2 MATERIALS AND METHODS

Experimental Location

An experiment was performed at experimental area of Institute of Soil and Environmental sciences, University of Agriculture, Faisalabad. Experiment was conducted in wire hose under controlled environmental conditions.

Seed Source

Seeds of 19 varieties of maize (*Zea mays L.)* which were taken from Ayub Agriculture Research Institute and University of Agriculture, Faisalabad which are given below.

Establishment of nursery and Transplantation

Iron trays were used for the sowing of seeds of maize which have size (12×18 cm) by using the line sowing method having 5cm sand layer. Distilled water was used for the maintaining of moisture content in the seeds.

Pioneer 32F10	FH-1280
Pioneer 32B33	KALAK
Pioneer 30Y87	MALKA
ICI-8288	Monsanto-6714
ICI-339	Monsanto-661
FH-1012	UAF DH 17/21
FH-1360	UAF DH 32/1
FH-949	UAF DH 40/3

After7 days of nursery established it was shifted to an iron tube which have volume of 200 L having polystyrene sheet floating over water in the tube which have hole in it which have concentration of half strength Hoagland nutrients solution (Hoagland. and Arnon, 1950). This experiment was comprising of 4 replications of each variety under complete randomized design (CRD) having factorial arrangement. The Concentrated HCL and 1 N NaOH was used regularly to maintain the solution pH around 6.0 to 6.5. An artificial aeration was given to the plant regularly for 6 to 8 hours by aeration pump.

Treatment Plan and Salinity Imposition

Three treatments were used in the experiment that was control, 50mM NaCl stress and 100mM NaCl stress**.** Salts concentration was imposed after 7 days of nursery shifted and NaCl salts was used and calculated by the following formula.

$$Amount\ of\ NaCl\ (g\ L^{-1}) = TSS \times Eq.weight\ of\ NaCl\ /1000$$

Salts were applied to the solution in 3 terms and salinity developed. (Hand book 60: U.S. Salinity Lab. Staff, 1954).

Plant sample collection

After 5 weeks of salinity imposition prior to the harvesting full developed leaves cut from the plants for the determination of Sodium and Potassium conc. in the leaf sap. These samples were kept in freezing temperature.

Harvesting and Biomass Measurement of Maize Seedlings

After harvesting the plants root and shoot were cut with sharp iron cutter and separated. After measuring shoot length, shoot fresh weight, length of root and fresh weight of root the samples were stored in each paper bags having one sample in it and kept for sun drying. These samples of plants kept in oven and dried and obtained 65±5 ^{o}C of temperature. And then shoot and root dry weight was recorded.

Measurements
Physical parameters

The nineteen varieties of maize after 5 weeks of salinity imposition were harvested and data was recorded for the following parameters. Length of shoots of plants was checked by meter rod. The average of four replications of shoot length was obtained. Shoot fresh weights was achieved by electrical weighing scale and their average were recorded. Dry weight of shoots of all genotypes were sited in an electrical drying oven at 65±5^{o}C till persistent weight obtained. Then an electrical weight balance was used to determine dry weight of shoots. Length of roots of all the plants was determined by meter rod and plant samples were measured in centimeters. Then mean values were calculated. Weight of roots of harvested plants was taken by electrical weight balance. Then means of the data was calculated for each treatment. After sun drying of plant root samples, root samples were dried at 65±5 ^{o}C till constant weight obtained to get dried weight of roots by using an electrical weight balance.

Chlorophyll contents (SPAD value)

The Chlorophyll meter (Minolta SPAD. 502 Meter) was used for the determination of chlorophyll content which were measured prior to harvesting and reading was recorded form the measures (from leaf tip to leaf blade).

Ionic parameters

Maize plant leaf samples were collected prior to harvesting. Leaf samples were washed with distilled water. Then the supernatant sap of leaves was collected in tubes to check sodium and potassium concentration and kept at freezing temperature for one week.

Na^{+} and K^{+} determination in leaf sap

A leaf of each genotype of each replication were collected and stored at freezing temperature for 10 days. After 10 days leaves were crushed in tubes by crusher to get leaf sap and leaf sap was again stored at freezing temperature to avoid fungal attack. After one-week tubes of sap were picked from freezer and kept them at normal room temperature for some time and then these tubes were placed in electrical centrifuge machine for 20 minutes at 6500 rpm, 12 tubes of sap were centrifuged at a time. After 20 minutes tubes were taken, and 1 mL of centrifuged sap was taken through micropipette from the tube and diluted 50 times by increasing distilled water and samples were saved for ionic parameters. Na^+ and K^+ were analyzed by flame photometer. Working standards of i.e.; 2, 4, 6, 8, and 10 mM of K^+ and Na^+ were made, and for the removal of error these standards were run on the flame photometer. Sherwood 410 flame photometer method which is used to analysis of Na^+ and K^+.

Statistical Analysis

Data collected from above parameters were processed with statistical analysis under CRD with two-way factorial arrangements. Due to salt stress changes occur in maize varieties was evaluated by (ANOVA) analysis of variance technique. To check the interactive effects of significantly different means of treatments LSD test was used with the help of Statistics software 8.1. Substantial variances between treatments were checked at the $P<0.05$ levels (Steel *et al*., 1997).

3 RESULTS

Shoot fresh weight

The shoot weight for different varieties of maize against various salt stress concentrations showed in (Fig. 1). The shoot fresh weight was significantly affected by salt stress and concentration of salts increases shoot fresh weight of maize genotypes decreases. However maize genotypes showed variability responses with respect to shoot length under salt stress.

At control condition FH-1280, UAF DH 32/1 and UAF DH 29/36 showed maximum shoot fresh weight of 68.93g,67.18g and 66.27grespectively, while minimum weight was observed in FH-1012, Pioneer 30Y87 and Monsanto-6714that was,39.44g, 45.12g and 46.10g respectively. At salt concentration 50 mM growth of maize genotypes UAF DH 32/1, FH-1280 and FH-1471 respectively 59g, 57.8g and 54.7g were maximum while FH-1012, Pioneer-30Y87 and FH-1360 showed minimum shoot fresh weight21.1g, 19.2g and 19.7g as compared to other maize genotypes. At 100 mM NaCl stress UAF DH 32/1, FH1280 and UAD DH 17/21 genotypes showed maximum shoot fresh weight45.24g, 42.55g and 39.02g as compared to other genotypes while FH-1360, FH-1012 and Pioneer 30Y87 showed minimum shoot fresh weight 9.66g, 11.52g and 12.62g as compared other maize genotypes.

These results show that with increasing salt stress the shoot fresh weight of maize reduced because the cell turgidity decrease when salt concentration increase and due to salt stress water deficit occur which ultimately leads to osmotic pressure which is a cause of reduction in shoot weight of maize (Rashid *et al*., 1999 and Akhtar *et al*., 2005). Specific ion toxicity is also a cause of decrease in shoot fresh weight Li *et al*., (2006). These results can be related to finding of some previous studies in which it was concluded that with increasing salt stress shoot weight decrease. (Munns *et al*., 1995; Ashraf *et et al.,*1999; Akhtar *et al*., 2005)

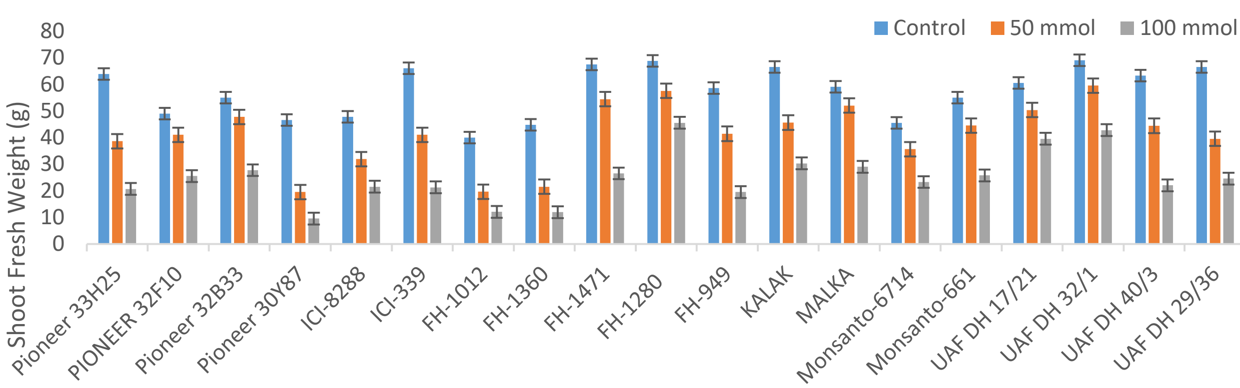

Fig. 1: Effects of salts concentration on Shoot fresh weight (g) of different Maize (*Zea mays* L.) genotypes.

Root fresh weight

The results compiled in Fig. 2 expose that root fresh weight was severe affected with application of salt stress. It was observed that with increasing salt stress the root fresh weight was significantly decreased. However remarkable variation was found in different maize genotypes with application of salt stress. The data root fresh weight of different maize genotypes explained that root fresh weight significantly reduced with increasing salt stress.

At control condition UAF DH 29/36, UAF DH 32/1 and UAF DH 17/21 performed better 21.5 g, 19.78 g and 15.5 g than other genotypes. While FH-1012, Pioneer 30Y87 and ICI-339 showed 8.1g, 10.9g and 11.1g minimum growth. While with application of 50 mM NaCl stress UAF DH 32/1, UAF DH 17/21 and FH-1280genotypes showed maximum root fresh weight 20.1g, 15.4 g and 15.1g while genotypes FH-1360, FH-1012 and Pioneer 30Y87showed minimum root fresh weight6g, 5.2g, 6.9 and 7.2 g as compared other maize genotypes. At 100 mM maize genotypes showed good results in UAF DH 17/21, FH-1280 and UAF DH 32/1 respectively 13.94 g, 12.18 g and 11.26 g while FH-1012, FH-1360 and Pioneer 30Y87 showed minimum root fresh weight2.31g, 3.42g and 3.8g as compared to other maize genotypes.

The results are according to (Levitt, 2004) who observed that reduced root fresh weight under saline conditions may be due to the decrease in water availability, osmotic potential at root surface or due to specific ion toxicity and nutrient imbalance. The reduced root fresh weight under saline conditions might be due to the decrease in water availability, osmotic potential at root surface, nutrient imbalance. And osmotic stresses are responsible for both inhibition or delayed seed germination and seedling establishment, under these stresses there is decrease in water uptake during imbibition's and salt stress may cause excessive uptake of ions stated by Demiral *et al*., (2005). Zynali and Hamdi (2002) also reported that addition of NaCl in the rooting medium caused reduction in root fresh weight. Due to reduction of root weight it caused substantial reduction in photosynthetic rate in both of barley cultivars under saline conditions. Different levels of salinity had significant effects on plant growth and resulted in decrease in root fresh weight. Similar results have been reported by Kingsbury *et al*., (1984) that reduction in plant roots fresh weight by means of salt stress.

Shoot length

Data summarized in Fig. 3 explained the effect of salt stress on the shoot length of several maize genotypes. Shoot length was considerably influenced with application of salt stress and it was found that with increasing salt stress shoot length of maize genotypes significantly reduced. However, there was considerable variation with respect to response in different maize genotypes was found with application of salt stress. The data shoot length of different maize genotypes explained that shoot length significantly reduced with increasing salt stress.

At control condition where no salt stress was applied the maize genotypes UAF DH 32/1, UAF DH 17/21 and ICI-8288 showed maximum shoot length of122.66 cm, 119 cm and 117 cm respectively, while FH-1360, FH-1471 and Pioneer 32F10 as 92.15 cm, 95.5 cm and 98.5 cm showed minimum shoot length respectively. In the second treatment with increasing salt stress to50 mM NaCl UAF DH 32/1, UAF DH 17/21 and FH-1280 genotypes showed better results114 cm, 110.5 cm and 89 cm while FH-1012, Pioneer 30Y87 and FH-1471 showed minimum shoot length 59 cm and 61.5 cm and 69 cm respectively. While in the last treatment where salt stress was applied at the rate of 100 mM NaCl growth of maize genotypes were severely affected.

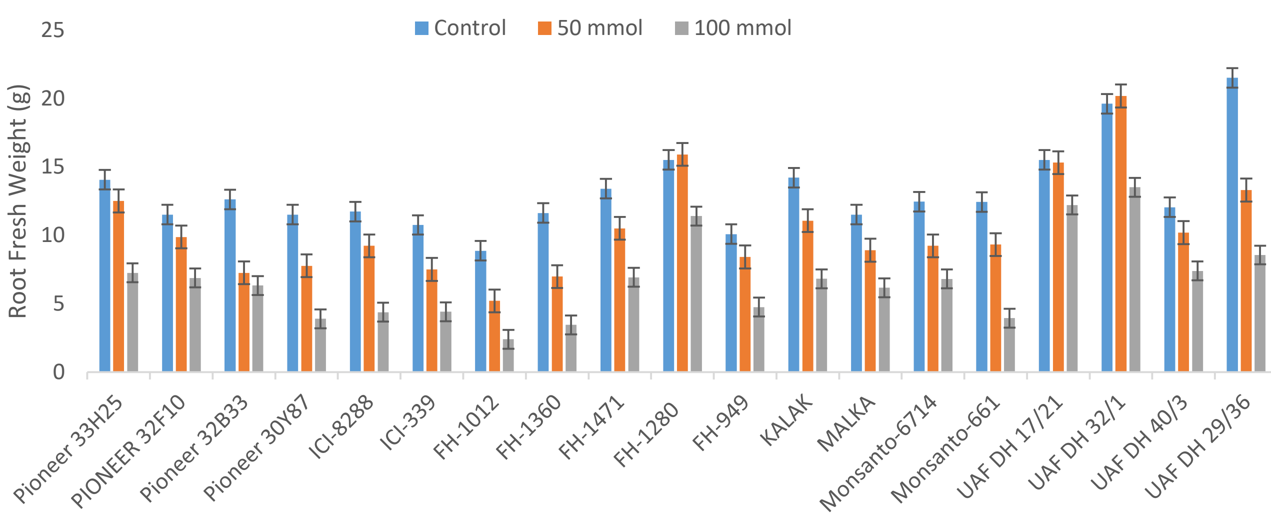

Fig. 2: Effects of Salts concentration on the Root fresh weight (g) of different Maize (*Zea mays L.*) genotypes.

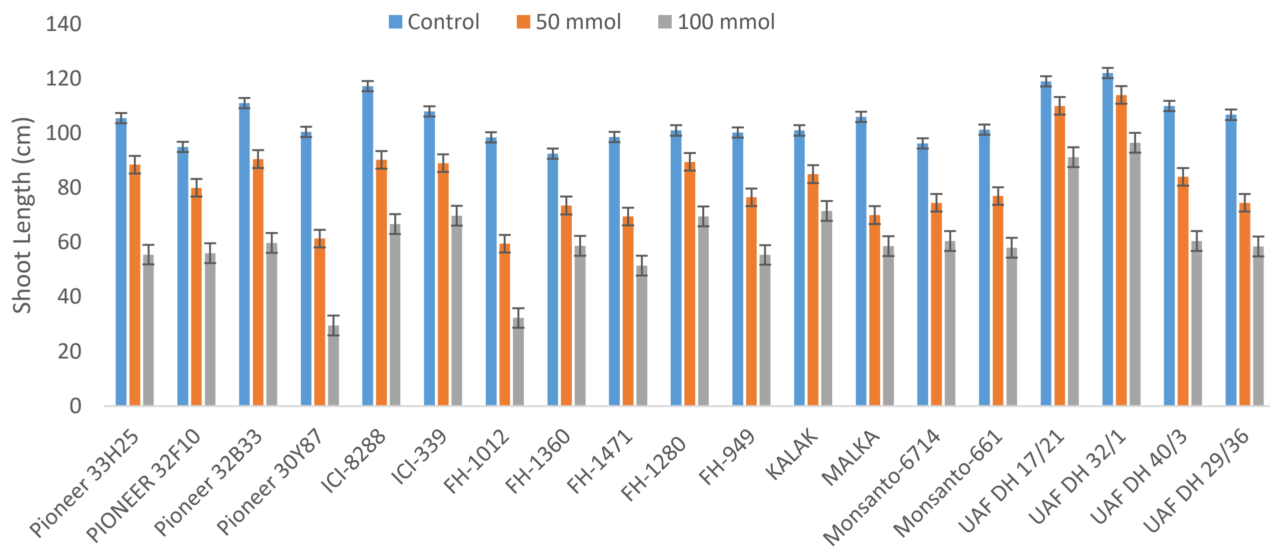

Fig. 3: Effects of Salts concentration on shoot length (cm) of different Maize (*Zea mays L.*) genotypes.

However, genotypes UAF DH 32/1, UAF DH 17/21 and FH-1280 have maximum shoot length 96.25 cm, 91.25cm and 69 cm respectively while Pioneer 30Y87, FH-1012 and FH-1471showed minimum shoot length 29.33 cm,32 cm and 51cm as compared to other maize genotypes.

Such reduction in shoot might be due to the water stress and salt toxicity caused by higher salinity concentrations as reported by Illahi *et al*., (2001). Under salinity extensibility of cell and growth factors are significantly reduced as explained by Sharma and Garg (2000). Higher salinity levels effect the metabolic processes of plants turgor pressure was decreased which ultimately cause reduction in enlargement of cell and reduction takes place in the growth-related parameters as explained by Mahmood *et al*., (2009).

Root Length

Fig. 4 describes the root length for different varieties of maize against various salt stress concentrations. The root length was significantly affected by salt stress and concentration of salts increases root length of maize genotypes decreases. However maize genotypes showed variability responses with respect to root length under salt stress. The mean data root length justifies that it was considerably decreased with enhancing NaCl stress in different maize genotypes.

The maize genotypes UAF DH 17/21, MALKA and Pioneer-33H25 have maximum root length 61.33 cm, 59 cm and 57.5 cm comparatively with other genotypes, While minimum root length was observed in FH-1471, Monsento-6714 and UAF DH 40/3 which was 38.66 cm, 40.75 cm and 44 cm at control conditions.At50 mM NaCl stress UAF DH 17/21, FH-1280 and UAF DH 32/1genotypesperformedbetter66.6 cm, 62.5 cm and 53.25 cm while FH-1360, FH-1012 and Pioneer 30Y87 showed minimum results33.66 cm, 29 cm and 27.5 cm. With increasing salt stress to100 mM maize genotypes were most affected. At 100 mM maximum root length was observed in FH-1280, UAF DH 17/21 and UAF DH 32/1 were 51.66 cm, 49.5 cm and 39.33 cm while FH-1360, Pioneer 30Y87 and FH-1012 showed minimum root length 16.33 cm, 19 cm and 19.5 cm as compared to other maize genotypes.

The results are according to Jamil *et et al.,* (2005) who observed that under higher salinity levels canola varieties showed decrease in the root length. Jeannette (2002) observed that length of root decreased under higher salt stress levels because it delays seedling emergence and germination. The decrease in root length with increase in salinity may be due to the reduction in growth rate and imbalanced nutrition. Sun *et al*., (2011), described that because of higher salt stress and imbalance in composition of nutrients considerably decreased the length of roots. Under high salt stress conditions, the first emergence stage was affected. Due to higher salinity concentration seedling roots were affected that's way length of roots are decreased so elongation of roots does not take place described by Warner *et al*., (2004). This reduction is due to increase in soil solution Osmotic pressure and the imbalances in needed elements. Higher salinity levels in rooting medium cause stress and thus elements required by plants becomes unavailable hence cause decrease in plant's roots and shoots length indicated by Lopez *el at*., (2002).

Shoot dry weight

The results in Fig. 5 revealed that shoot dry weight. It was observed that with increasing salt stress the shoot dry weight was significantly decreased. With increase in concentration of salts all growth parameters were decreased. Shoot dry weight of all genotypes of maize depends upon the concentration of salts. The data shoot dry weight of different maize genotypes explained that shoot dry weight significantly reduced with increasing salt stress.

Maximum shoot dry weight was observed in UAF DH 17/21, UAF DH 32/1 and FH-949 5.4 g, 5.12g and 5.08 g as related to genotypes. While less weight was observed in FH-1012, FH-1360 and Pioneer 32F10 which was 2.95 g, 3.44g and 3.73g respectively. With increasing salt concentration to50 mM, maize genotypes UAF DH 17/21, UAF DH 29/36 and UAF DH 40/3 genotypes showed maximum shoot dry weight 4.77g,4.56g and 3.98g as compared to other genotypes while Pioneer 30Y87, FH-1012 and FH-1360showed minimum shoot dry weight 198g, 1.83 g and 2.21 g as compared other maize genotypes. At 100 mM NaCl stress shoot dry weight of maize genotypes UAF DH 17/21, UAF DH 32/1 and UAF DH 29/36 respectively 3.12 g, 2.88 g and 2.57 g was maximum while Pioneer 30Y87, FH-1012 and FH-1360 showed minimum shoot dry weight 0.99 g, 1.02 g and 1.19g as compared to other maize genotypes.

In the same way Shoukat *et al*., (2025) examined that salt stress and osmotic stress significantly decrease the dry weight of shoot in the plants. Under salinity plant cell turgor pressure is decreased and stomatal closure took place resulting in decreased photosynthesis and ultimately low dry weight. The reduction in dry weight is due to less production of leaf area and leaf number described by Farouk (2000). Reduced dry weight is due to a lesser amount of uptake of CO_2 in leaves because of high salt treatment reported by the Yadiv *et al*., (2001). Salinity decrease availability of water and mineral nutrients hence decreased water potential of rooting medium and growth inhibition reported by Lessani and Marschner (2004). Decrease in weight may be due to decrease in photosynthetic process due to increased specific ion toxicity of salts, and reduced turgor pressure under salinity described by Tevitt (1998). Decrease in plant germination and loss of weight may be attributed to osmotic stress.

Root dry weight

Data summarized in Fig. 6 explore the effect of salt stress on the root dry weight of several maize genotypes. Root dry weight was considerably influenced with application of salt stress and it was found that with increasing salt stress root dry weight of maize genotypes significantly reduced. However, there was considerable variation with respect to response in different maize genotypes was found with application of salt stress.

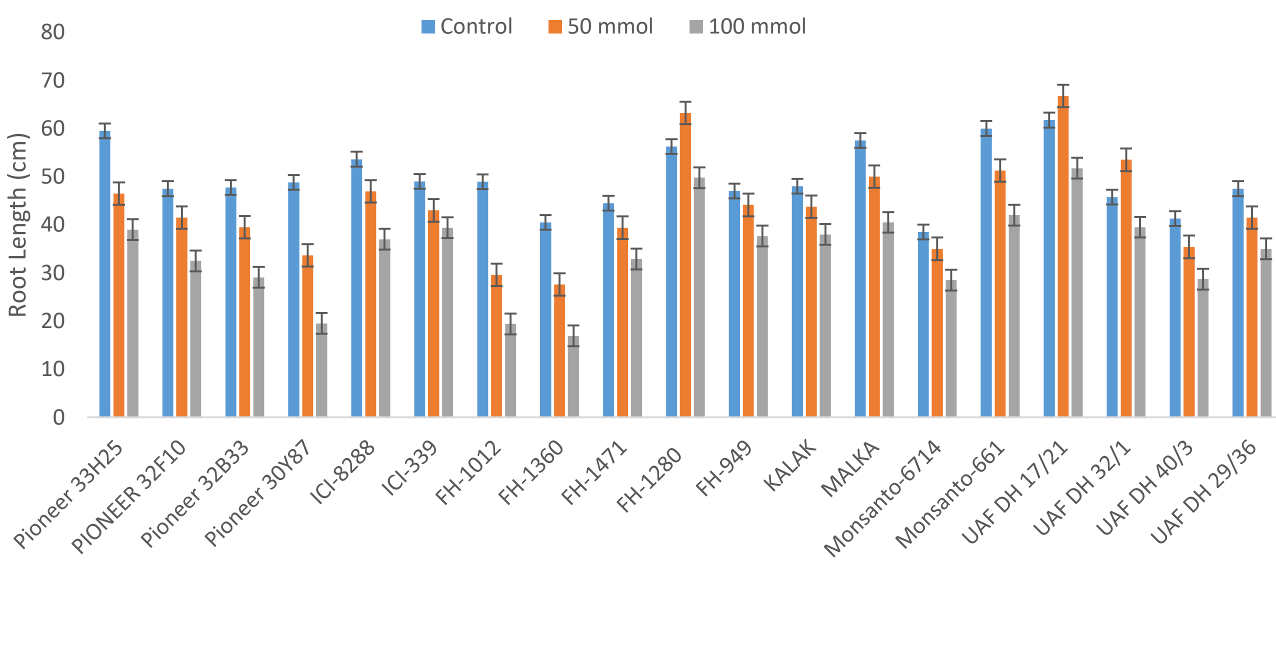

Fig. 4: Effects of Salts concentration on root length (cm) of different Maize (*Zea mays L.*) genotypes.

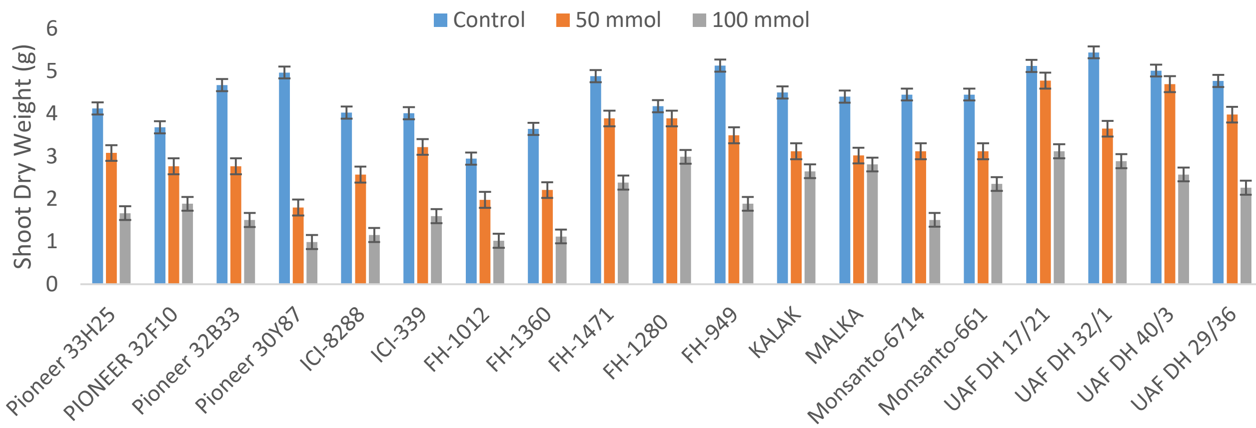

Fig. 5: Effects of Salts concentration on the shoot dry weight (g) of different Maize (*Zea mays L.*) genotypes.

At control condition where no salt stress was applied maize genotypes UAF DH 32/1, UAF DH 17/21 and FH-1280 showed maximum root dry weight 1.66 g, 1.45 g and 1.42g While lessroot weight was detected inMonsanto-6714, FH-1360 and FH-1280 which was 0.98g, 0.87 g and 0.75g respectively. In second treatment where50 mM salt stress was applied maize genotypes UAF DH 17/21, UAF DH 32/1 and FH-1280genotypes showed maximum root dry weight 1.35g, 1.32 g and 1.21g while less dry weight of root were found in FH-1012, FH-1360 and Monsanto-6714 which were 0.45g, 0.63g and 0.65grespectively. At 100 mM salt stress maize genotypes UAF DH 17/21, UAF DH 32/1 and FH-1280 respectively 1.07g, 0.96 g and 0.95 gperformed better while Pioneer 30Y87, FH-1360 and FH-1012 showed minimum root dry weight 0.27g, 0.30 g and 0.31 g as compared to other maize genotypes.

Similar results were reported by Neuman (2001) in which he observed that canola species showed decrease in seedling emergence and less weight of roots. Likewise, trend was found in which salinity reduced the weight of root due to presence of higher salt concentration described by Huang and Redman (2010). High salt stress concentration cause water deficiency, turgidity of cells is all effected which ultimately causes reduction in rate of photosynthesis and dry weight of roots stated by Ashraf *et al*., (2008). Hameed *et al*., (2006) reported that under higher salt stress improves rate of evapo-transpiration in varieties of canola because of salt concentration in root zone ultimately reduce dry weight of root. Against higher salinity cell division greatly affected because of less carbon mobility in leaves which also cause reduction in in rate of photosynthesis and dry weight of shoot stated by Farhoudi (2010). Salt stress concentration influence turgidity of cells and ultimately causes reduction in rate of photosynthesis and dry weight of root stated by Mass and Niemon (2009). Increased transport of toxic ions and imbalanced nutrition also affect the reproductive process because of their effect on metabolic processes reported by He and crammer (2010).

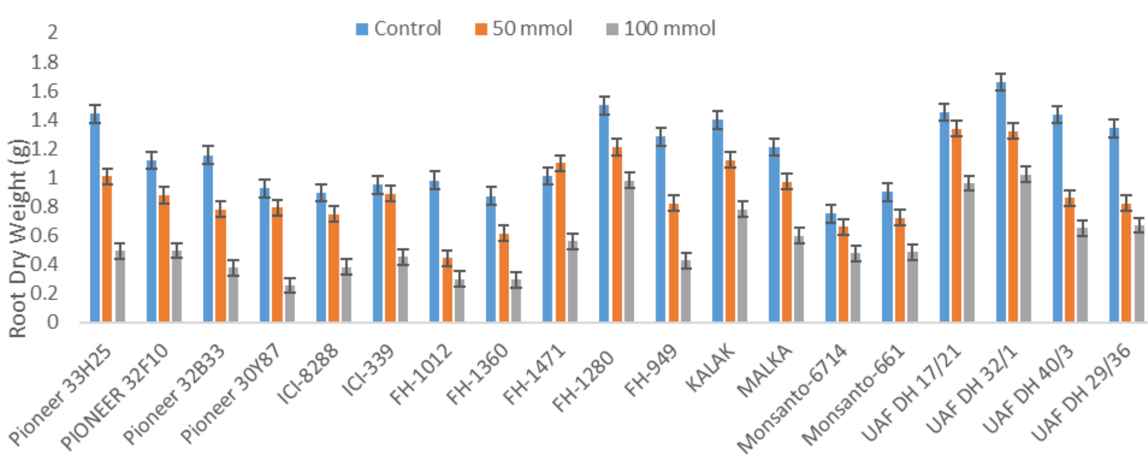

Fig. 6: Effects of Salts concentration on the Root dry weight (g) of different Maize (*Zea mays L.*) genotypes.

Chlorophyll contents

Data summarized in Fig. 7 explore the effect of salt stress on the chlorophyll contents of several maize genotypes. Chlorophyll contents was considerably influenced with application of salt stress. However, there was considerable variation with respect to response in different maize genotypes was found with application of salt stress.

At control condition where no salt stress was applied the maize genotypes KALAK, FH-1471 and ICI-8288 showed maximum chlorophyll contents 37.5, 35.4and 34.5as compared to other genotypes. While minimum chlorophyll contents were observed in FH-1360, Pioneer 32B33 and FH-1471 which was 28.5, 26.4and 20.5. At50 mM salt stress maize genotypes Kalak, FH-949 and Monsento-661 had higher chlorophyll contents33.5,32.75and 30.5 while FH-1360, Pioneer 32B33 and UAF DH 32/1 showed minimum chlorophyll contents 19.5, 19.8and 26.6. At 100 mM maximum chlorophyll contents of maize genotypes was observed in UAF DH 40/3, UAF DH 32/1 and FH-949 respectively 26.45, 24.85 and 22.9 while Pioneer 32B33, Pioneer 32F10 and FH-1360 had minimum chlorophyll contents15.75, 16.65 and 17.75 as compared to other maize genotypes.

The outcomes of study are according to Zhao *et al.,* (2007) who showed that rate of germination varied greatly among the oat genotypes. Reduction in chlorophyll contents, dry biomass, reduced leaf area, More Na^+ and less K^+ was observed. All parameters reduced by application of salt treatment. Under high salt stress conditions all metabolic functions of plant are affected. Higher salinity levels cause stomata closing which effects gases exchange, water stress in plants and hence effects the photosynthetic rate of plant. Chlorophyll contents reduced gradually as concentration of salts increased. Chlorophyll contents decreased by increased salinity levels in tomato plants reported by Al-aghabary *et al.,* (2005).

Maize (*Zea mays L.*) genotypes

Na^+ Concentration in shoot

Fig. 8 explore the Na^+ concentration of different varieties of maize against various salt stress concentrations. With increasing salt stress, Na^+ concentration of maize genotypes also increases. Na^+ uptake increased by potassium transport channel and ultimately Na^+ contents improved in the plant.

At control condition maize genotypes UAF DH 32/1, UAD DH 40/3 and Kalak showed minimum Na^+ concentration 38.38 moles per m^3, 39.91 moles per m^3 and 40.76 moles per m^3 While higher Na^+ concentrations were observed on FH-1012, Pioneer 32F10 and Monsento-6714 which was 56.55 moles per m^3, 55.53 moles per m^3 and 52.72 moles per m^3. With enhancing NaCl stress to 50 mM maize genotypes UAF DH 32/1, FH-1280 and FH-1471 indicated minimum Na^+ Concentration 48.53 moles per m^3, 50.53 moles per m^3 and 51.26 moles per m^3 While higher Na^+ concentrations were observed on Pioneer 33H25, FH-1360 and Pioneer 32B33 which was 89.78 moles per m^3, 88.33 moles per m^3 and 79.85 moles per m^3. In the last treatment where salt stress was increased to 100 mM maize genotypes FH-1280, FH-1471 and ICI-339 showed minimum Na^+ concentration 70.46 moles per m^3, 78.47 moles per m^3 and 79.25 moles per m^3 as compared to other varieties. While the higher Na^+ Concentrations were observed on UAF DH 40/3, UAF DH 29/36 and FH-1360which was 108.58 moles per m^3, 107.88 moles per m^3 and 100.37 moles per m^3.

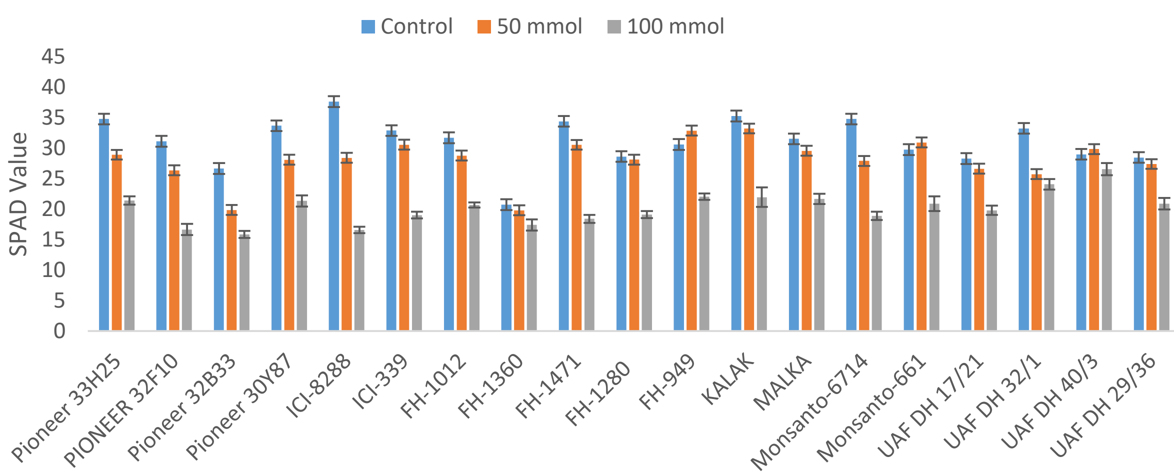

Fig. 7: Effects of Salt concentration on the Chlorophyll Contents (SPAD Value) of different Maize (*Zea mays L.*) genotypes.

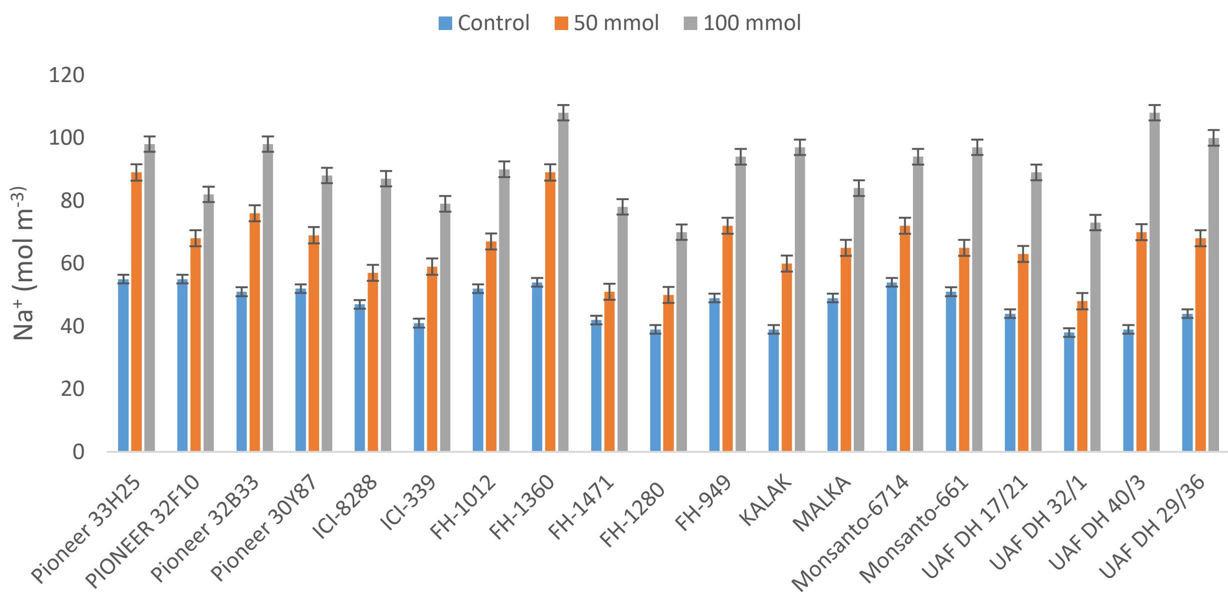

Fig. 8: Effects of Salinity concentration on the Na^+ Concentration in shoot of different Maize (*Zea Mays* L.) genotypes.

The outcome of this study is according to Tavakoli *et al.,* (2011) and Shoukat *et al*., (2024) who stated that most plants accumulate Na^+ in their tissues of shoot when grown in salt stress conditions. Ainnie and Staden (2010) noted that salt tolerance is related to exclusion of Na^+ ion and maintenance of almost uniform concentration of this ion in leaves of all ages. Yadav and Singh (2004) reported that salt tolerance is related to exclusion of Na^+ ion and maintenance of almost uniform concentration of this ion in leaves of all ages. High sodium content generally disrupted the nutrient balance, thereby causing, specific ion toxicity despite disturbing the osmotic regulation stated by Tiessen (1994).

K^+ Concentration in shoot

In contrast to the Na^+, K^+ concentration in the root of different maize genotypes were remarkably reduced under salt stress (Fig. 9). As concentration of salts increases K^+ Concentration of maize genotypes decreases. However, each maize genotype showed various responses with respect to measured parameters. Na^+ and K^+ has antagonistic effect between them, thus at control conditions maximum K^+ concentration in maize genotypes were determined and minimum K^+ concentration was observed at high salinity as K^+ Concentration decreased with increase salt concentration.

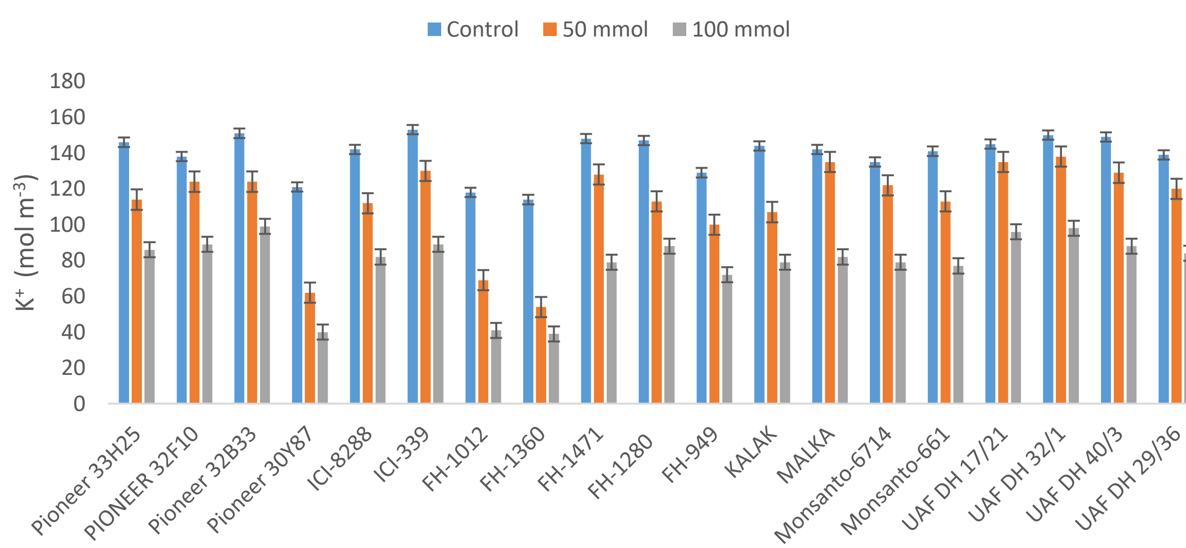

Fig. 9: Effects of Salinity concentration on the K^+ Concentration in the shoot of different Maize (*Zea Mays* L.) genotypes

At control condition maize genotypes ICI-339, UAF DH 32/1 and UAF DH 40/3 showed maximum concentration of K^+153 moles per m^3, 150 moles per m^3 and 149 moles per m^3 While Minimum K^+ contents were observed in FH-1360, FH-1012 and Pioneer 30Y87 which was 114.94 moles per m^3,118.11 moles per m^3 and 121.01 moles per m^3. In the second treatment where50 mM salt stress was applied, maize genotypes UAF DH 32/1, UAF DH 17/21 and MALKA showed higher K^+ Concentration 138.59 moles per m^3, 135.68moles per m^3 and 134.71 moles per m^3 when related with other varieties of maize. While minimum K^+ contents were observed in FH-1360, Pioneer 30Y87 and FH-1012which was 69.64 moles per m^3,62.34 moles per m^3 and 54.36 moles per m^3. In the last treatment where100 mM NaCl stress was applied, maize genotypes Pioneer 32B33, UAF DH 32/1 and UAF DH17/21showed maximum K^+ Concentration 99.92 moles per m^3,98.56moles per m^3 and 96.67 moles per $m^3$when related to other varieties of maize. While minimum K^+ levels were observed in FH-1360, FH-1012 and Pioneer 30Y87which was 39.17 moles per m^3,40.16 moles per m^3 and 41.51 moles per m^3.

The present results of study are according to Sairam *et al*., (2002) and Shoukat *et al*., (2024) who stated that Na^+ content increased and K^+ contents increased in various wheat cultivars at increased salt stress. Sodium and Potassium has antagonistic effect present between them and has more ratio of sodium and potassium. At increased salinity concentration the levels Na^+ and Cl^- concentration higher in roots and plants aerials parts are affected most while potassium concentration is less at high salinity levels reported by Chartzoulakis *et al*., (2002) in six olive cultivars.

Conclusion

Salinity stress significantly impaired the growth, physiological traits, and ionic balance of maize seedlings, with adverse effects intensifying at higher NaCl concentrations. The reduction in biomass, shoot and root length, and chlorophyll content was primarily associated with osmotic stress and ionic toxicity, particularly increased Na^+ accumulation and decreased K^+ uptake. Notable genotypic variation was observed among the tested hybrids, indicating differential tolerance mechanisms. Genotypes FH-1280, UAF DH 32/1, and UAF DH 17/21 consistently exhibited superior performance under saline conditions, maintaining relatively better growth and ionic homeostasis, while FH-1012, Pioneer 30Y87, and FH-1360 were identified as highly susceptible. These findings highlight the potential of tolerant genotypes for cultivation in salt-affected soils and provide valuable baseline information for breeding programs aimed at improving salinity tolerance in maize.

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