J. Appl. Res Plant Sci. Vol. 4(2), 582-592, 2023, https://doi.org/10.38211/joarps.2023.04.02.175

Research Article

OPEN ACCESS

Available on https://www.joarps.org
Journal of Applied Research in Plant Sciences
(JOARPS)
ISSN: 2708-3004 (Online), 2708-2997 (Print)

Varietal Performance of Maize (*Zea mays* L.) Strains Under Saline Conditions

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Article Received 26-10-2022, Article Revised 02-03-2023, Article Accepted 10-04-2023

Abstract

Crop yields are highly affected due to physiochemical properties of soil and climatic conditions of the region. The yield of the crop is drastically impacted in terms of final economic product due to problems which occurs in life cycle of the plant under the stress conditions like, stunted growth, permanent wilting, and delay in leaf initiation as well as oxidative stresses at molecular level. Maize *(Zea mays* L.), widely used as staple food has an ample amount of fats and fibres. Salt stress decreases maize yield and, in this regard, a hydroponic study was carried out to screen maize genotypes against two salinity stress levels i.e., 10 mol m^{-3} NaCl and 100 mol m^{-3} NaCl under hydroponic conditions. Nine (09) hybrid genotypes, i.e., Pioneer 3335 (V_1), Pioneer 32F10 (V_2), Syngenta 8441 (V_3), Pioneer: 33H25 (V_4), Pioneer: 3233 (V_5), Monsanto 6142 (V_6), Syngenta 8711 (V_7), Monsanto 6528 (V_8), Pioneer 31P41 (V_9) were selected for experiment. Statistically, the analysis showed the highest root-shoot length, root fresh-dry weight, and shoot fresh-dry weight with V_3 (Syngenta 8441) and the minimum with V_1 (Pioneer 3335). The results showed that root length increased by 35% shoot length increased by 34% while total length was enhanced by 34% in syngenta 8441. The results clearly depicted that the best suited variety for salt affected areas can be recommended as Syngenta 8441 whereas the least tolerant was Pioneer 3335 in terms of physiological, physical, and growth characteristics.

Keywords*: salinity, sodicity, gypsum, degraded lands, genetic variation*

Introduction

Maize (*Zea mays* L.) is one of the supreme dynamic cereal crops both for human and animals (Tiwari and Yadav, 2019). It is utilized as staple food in many countries due to high fat and protein contents present in its grain, while its fodder also have high protein contents (10-12%). In Pakistan, Maize stands at third position with respect to its importance after wheat and rice. It contributes about 0.5% in gross domestic product (GDP) of the country. of GDP (Rehman *et al.*, 2020). The recent data revealed that Maize was cultivated on 1418 thousand hectares during 2020-21 and its production was estimated as 8.47 million tons (GOP,2022). Recently, the availability of high quality of maize varieties, market prices and land shift towards maize are certain factors which contributed to its annual yield, however the problem of growth in saline soils still prevails, thus posing threats to the normal seedling germination, growth and development, Being a versatile crop, maize is utilized as food, animal fodder and feed (Shaukat *et al.*, 2020). Previous researchers have identified a disruption in metabolic, physiological and biochemical processes in plants which activates during salt stress (Parida and Das, 2005; Zafar *et al.*, 2019; Naz and Perveen, 2021). Likewise, crop production success in salt-affected soils is determined by the continuation of these processes throughout the plant life cycle (Ijaz *et al.*, 2021; Zafar *et al.*, 2019). Soil salinity is becoming threatful day by day due to unavailability of fresh surface water, excessive underground water pumping and exploitation of agricultural lands without considering their sustainability. Excess of salts (soluble and/or exchangeable) both in soil and irrigation groundwater are potential threats for propagation of glycophytes over the globe, especially in arid and semi-arid regions due to low rainfall, high temperature, very high rates of evapotranspiration resulting in upward movement of salts, salts enriched parent material, brackish groundwater, and poor management practices (Azevedo Neto *et al*., 2006). Unfortunately, these glycophytes contribute, almost, the whole of the world's food, feed, and fiber demands. So, fighting against salinity is inevitable for the sustainability of human life. Almost more than 800 m ha of land throughout the world is salt-affected by either cause (Munns, 2005). According to another estimate, 20 % of the total irrigated land worldwide is salt-affected (Munns, 2003). So, it is evident that soil salinity was present even before human civilization and agriculture, but now it is still increasing an alarming rate of 10% annually due to natural and anthropogenic activities (Foolad, 2004). In Pakistan, the crops are also affected from salinity issue and is at 8th position among the countries that are prone to salt stress (FAO, 2010). Pakistan has 80 Mha of topographical region, and comprise a complex water channel system (just about 62,400 km long) which is responsible for irrigating 20.4 Mha fields in Indus plain. But unfortunately, the water received by fields is 25% (3.9% of world salt affected lands) due to one or more reasons, while 1.4 million ha has turned out to be unacceptable for productive agribusiness (FAO, 2010). The yield from salt affected soils cause of loss of 15-55 billion rupees (A$ 140 million to A$ 1.2 billion) annually. Normally, yield decrease due to salt-affected soil is Rs.35 billion, compared to 0.6% of the total national output of the nation in the year 2004 (Corbishley and Pearce, 2007). By keeping in view, the above-mentioned problems and concerns, a study has been designed to test different locally developed maize hybrids against salinity stress and to evaluate their stability under such salinity environment so that more adaptable genotypes may further be selected for their sowing in the salt prone areas.

Martials and Methods

Experimental setup*:* The trial was led at glass house of Saline Agriculture Research Center (SARC), Institute of Soil & Environmental Sciences, University of Agriculture, Faisalabad, during the period 2010 (Feb-March). The experiment was laid out in factorial CRD design and was repeated three times. Nine maize (*Zea mays* L.) genotypes were collected from the maize registered companies in Pakistan. The varieties were Pioneer 3335, Pioneer 32F10, Syngenta 8441, Pioneer 33H25, Pioneer 3233, Monsanto 6142, Syngenta 8711, Monsanto 6528 and Pioneer 31P41. The nine genotypes were selected so that comparison between genotypes of different companies can be tested altogether.

Pot Preparation: The pot setup was prepared by adding Hoglands full strength nutrient solution in black colored pots, furthermore in order to supply oxygen to the soil an aeration pump was also fitted. The experiment was arranged according to the prerequisite design and treatments.

Hydroponic Experimental Set Up: After the seedling emergence, one week old seedlings were then transferred to the hydroponic table comprising of 8L tank with nutrient solution. The seedlings were fitted on holes Styrofoam blocks. Three plants in each hole were fitted by the supported with sponge. The solution was renewed with an interval of 8 days.

Plant growth parameters: The succeeding parameters related to maize plant growth were determined from the hydroponic study affected by salinity. The shoot length was measured as: "total length of stem to highest leaf in cm", root length was measured as: "total summation of primary root length in cm", total plant length in cm, shoot fresh weight in g plant^{-1}, root fresh weight in g plant^{-1}, shoot dry weight in g plant^{-1}, root dry weight in g plant^{-1}.

Ionic Parameters: The ionic contents of Na^+ and K^+ were determined by taking the root and shoot dry samples. The seedlings of 21 days old were obtained from the tested genotypes. The elemental analysis for was performed for K^+ and Na^+ through acid digestion method through micro- Kjeldahl digestion system (Thomas *et al*., 1967). For this, 0.5 g of dry material was taken and mixed with 68% of HNO3 (5mL) in a digestion tube. The material was mixed well and tubes were left overnight. Following the boiling, the digestion was performed at 125°C for four hours. After cooling the digested material was taken into a volumetric flask (100 mL) and the volume was made up to 100 mL by using distilled water. After this, the mixture was passed through filter paper and the filtrate was stored in screw cap dry bottle for further analysis. 10 mL of filtrate was taken and added into a volumetric flask and the solution was made up to 50 mL by diluting it with distilled water and was mixed properly. The concentrations of Na^+ and K^+ (mg g^{-1} DW) in three replicates of each treatment were measured by a flame photometer (Jenway-PFP7, Cole-Parmer, Staffordshire, UK).

Quality Assurance: Entirely, the salts/chemicals/CRMs were used in this experiment were traceable to NIST while the glassware used in the study was Pyrex (A-class) with little uncertainty value. Considering sensitivity and repeatability, standard solutions were used in the analysis of sample sequence after every eight samples.

Statistical Analysis: A two-way analysis of variance (ANOVA) was carried out for analyzing the significance among the treatments. Least significant difference was used to compare the treatments at 0.01 probability level (Steel *et al*., 1997). The statistical analysis was done by using the software Statistix 10.0 whereas the principal component analysis (PCA) was carried out in software 'STAR' Collected data sets were statistically analyzed using a two-way analysis of variance (ANOVA).

Table 1. The root length, shoot length and the total length of different maize genotypes

Factors	Root Length (cm)	Shoot Length (cm)	Total Length (cm)
Salinity Levels (SL)			
S0 (10 mol m^{-3} NaCl)	41.39 A	72.01 A	113.41 A
S1(100 mol m^{-3} NaCl)	29.52 B	56.77 B	86.44 B
Varieties (V)			
Pioneer 3335 (V1)	29.13±1.5 E	53.68±5.6 F	82.81±7.7 F
Pioneer 32F10 (V2)	33.23±2.2 D	58.18±5.9 EF	91.41±8.2 E
Syngenta 8441 (V3)	39.38±2.7 A	72.11±7.1 A	111.49±9.3 A
Pioneer: 33H25 (V4)	35.54±2.1 BC	64.06±7.0 C-E	99.60±7.1 CD
Pioneer: 3233 (V5)	33.25±2.0 D	60.06±6.5 D-F	92.31±7.9 DE
Monsanto 6142 (V6)	37.65±2.4 A	66.10±6.9 A-D	103.75±8.0 BC
Syngenta: 8711 (V7)	38.94±2.1 A	69.13±6.1 A-C	108.07±7.8 AB
Monsanto 6528 (V8)	34.45±2.3 BC	71.11±7.8 AB	105.57±7.9 ABC
Pioneer 31P41 (V9)	37.53±2.1 AB	65.06±7.6 B-E	102.58±8.2 BC
F-value *(SL)*	624.58**	87.30	261.45
F-value *(V)*	23.43**	6.33	13.39
F-value *(SL × V)*	19.54**	3.05	7.99
LSD *(SL)* $(p \leq 0.05)$	0.95	3.31	3.39
LSD *(V)* $(p \leq 0.05)$	2.02	7.03	7.19
LSD *SL × V* $(p \leq 0.05)$	2.86	9.94	10.17

The different alphabetical letters showed difference between the varieties as per applied salinity levels.

Results

Root Length: The information concerning the root length (RL) of maize genotypes is present in Table 1. The root length was decreased in S_1 (100 mM) among all genotypes as compared to the genotypes tested to their particular control S0 (10 mM). Maximum root length was obtained in Syngenta 8441 (39.38 cm), while the minimum root length was obtained by 3335 (291.13 cm).

Shoot Length: Our results showed that shoot length of maize genotypes presented in Table 1 was also affected under different salinity treatments. The data described that shoot length of all maize genotypes dropped/reduced in S_1 (100 mol m^{-3} NaCl) salinity level as compared to their respective control. Highest shoot length was obtained in Syngenta 8441 (72.11 cm), while the lowest shoot length was obtained by Pioneer 3335 (53.68 cm). Similarly, Pioneer 3233 was also at par to Pioneer 3335. The statistical analysis showed that salinity levels (S_0 and S_1) showed a significant difference among maize genotypes performance and was in the order $V_3 > V_9 > V_7 > V_6 > V_9 > V_4 > V_5 > V_2 > V_1$.

Total Plant Length: The total plant length was also affected under salinity treatments. The maximum total length (111 cm) of the maize plant was obtained in Syngenta 8441 followed by Syngenta 8711 (108.07 cm), while the lowest total length (56.23 cm) was obtained in Pioneer 3335. The statistical analysis (Table 1) showed that all the genotypes under salinity stress, the total length was reduced as compared to their respective control. The trend for total length (cm) of maize genotypes against salinity stress was as $V_3 > V_7 > V_8 > V_6 > V_9 > V_4 > V_5 > V_2 > V_1$.

Shoot Fresh Weight: Our results showed that the shoot fresh weight was significantly affected under salinity stress, moreover genotypes also performed differently (Table 2). It was observed that salt stress caused a huge decrease in the development of maize genotypes. Highest shoot fresh weight was observed in Syngenta 8441 (15.81g) followed by Monsanto 6528 (14.75g) whereas the least fresh weight was present in Pioneer 3335 (3.03). The averaged shoot fresh weight was 10.54 in S_0 which was reduced to 8.81 in S_1.

Root Fresh Weight: The result with respect to Root Fresh weight is present in Table 2. The Root Fresh Weight of tested maize genotypes was decreased at 100 mol m^{-3} NaCl. Syngenta 8441 (V3) was the most tolerant genotype as it has the maximum root fresh weight. Contrarily, V1 (Pioneer 3335) was identified as the most sensitive genotype against saline treatment and it showed a decreased Root Fresh Weight. The general trend observed was V3 > V6 > V7 > V8 > V9> V4 > V5 > V2 > V1

Total Fresh Weight: The total fresh weight of the plant was measured and it was revealed that the total fresh weight was maximum in Syngenta 8441 (34.43 g) whereas the minimum was observed in Pioneer 3335 (10.38 g). It was also noted that total fresh weight of Pioneer 32F10, Pioneer:33H25 and Pioneer 3233 were also less in total fresh weight and were statistically at par to V1 (Pioneer 3335).

Shoot Dry Weight: The data about the shoot dry weight of maize genotypes are present in Table 2. The results depicted that shoot dry weight was reduced in S_1 (100 mol m^{-3} NaCl) salinity level as compared to their respective control. The highest shoot dry weight was attained by Syngenta 8441 (V3), while the lowest shoot length was obtained by Pioneer 3335 (V_1). The statistical analysis showed that salinity levels (S_0 and S_1) significantly differ among maize genotypes, although genotypes themselves also showed significant differences (Table 2). The salinity tolerance level of maize genotypes against S_1 was as $V_3 > V_6 > V_7 > V_6 > V_9 > V_4 > V_5 > V_2 > V_1$.

Root Dry Weight: Root dry weight was decreased significantly, in the increased salinity level as compared to control. The maximum root dry weight was of Syngenta 8441 (6.73 g) whereas the least value was observed in Pioneer 3335 (1.35), Pioneer 32F10 was also statistically at par to the least value. Whereas Monsanto 6242 and Syngenta 8711 also showed good results as 5.01 g.

Total Dry Weight: The total dry weight of the plants was also measured and the details are shown in Table 2. The maximum dry weight (11.75 g $plant^{-1}$) of the maize plant was obtained with V_3 (Syngenta 8441), while the lowest total length (3.34 g $plant^{-1}$) was observed in V_1 (Pioneer 3335). The interactions were also significant within and among the genotypes/varieties as well as between salinity levels. The trend for total length (cm) of maize genotypes against salinity stress was as $V_3 > V_8 > V_7 > V_6 > V_9 > V_4 > V_5 > V_2 > V_1$

Sodium (Na^+) and Potassium (K^+) concentration: The information with respect to the Na^+ focus (mol m^{-3}) after analysis of the leaf sap of maize genotypes is exhibited in Figure 1 & 2. V3 gave the minimum Na+ concentration and maximum were observed in V1 and V9, whereas V2, V4 and V5 gave average concentration and were also statistically at par to each other. Results showed that maximum concentration of Na^+ in leaf sap was measured in V_1 (Pioneer 3335) followed by V9 (Pioneer 31P41), V2 (Pioneer 32F10), V4 (Pioneer: 33H25), and V5 (Pioneer 3233). While the minimum was measured in leaf sap of V_3 (Syngenta 8441). On the other hand, the lowest Na^+ was found with V3 (Syngenta 8441) as it showed the most resistant/tolerant to salinity stress as related to all varieties.

Both the levels of salinity applied behaved varied significantly in their outcome on K^+ concentration in maize leaves. The highest K^+ accumulation was found with V3 (Syngenta 8441), as salinity was minimum with this variety. The lowest K^+ accumulation was detected with V_1 (Pioneer 3335).

Potassium/Sodium ratio: The K^+: Na^+ proportion dropped altogether because of salt stress, and decrease was more with the expansion in salinity concentration (Table 3). The most prominent decline was found at 100 mol m^{-3} NaCl treatments. A higher decline was seen on account of half-breed V_1 (Pioneer 3335). Genotypes when contrasted with different genotypes. The hereditary variety under various conditions was likewise critical with respect to K^+: Na^+ proportion of leaf sap.

Pearson Correlation Analysis: The Pearson correlation analysis exposed a negative relationship between Na^+ and K^+ (Figure 3). As the concentration of Na^+ in leaf sap has been increased and antagonistically, the concentration of K^+ decreased. Similar results were found between root dry weight, fresh root weight, root length, shoot dry weight, shoot fresh weight, shoot length, total dry weight, total fresh weight, and Na^+. While on the further indicator, all the parameters showed a positive correlation concerning K^+.

Table 2. Effect of salinity stress on different growth attributes of Maize crop.

Factors	Shoot Fresh Weight	Root Fresh Weight	Total Fresh Weight	Shoot Dry Weight	Root Dry Weight	Total Dry Weight
	(g plant^{-1})					
Salinity Levels (SL)						
S_0 (10 mol m^{-3} NaCl)	10.54±0.5 A	14.30±0.6 A	24.85±0.7 A	4.67±0.2 A	5.5±0.4 A	10.16±0.5 A
S_1 (100 mol m^{-3} NaCl)	8.81±0.4 B	11.09±0.4 B	19.96±0.5 B	3.94±0.1 B	3.68±0.2 B	7.62±0.2 B
Varieties (V)						
Pioneer 3335 *(V1)*	3.03±0.4 G	7.33±0.9 F	10.38±0.9 F	1.35±0.1 G	3.05±0.2 D	4.38±0.3 E
Pioneer 32F10 *(V2)*	7.96±0.7 E	8.92±0.9 E	16.88±1.3 E	3.51±0.2 E	3.30±0.2 D	6.83±0.4 D
Syngenta 8441 *(V3)*	15.81±0.9 A	18.67±1.5 A	34.43±1.8 A	7.03±0.5 A	6.73±0.5 A	13.75±0.9 A
Pioneer: 33H25 *(V4)*	6.30±0.6 F	10.82±1.1 D	17.11±0.9 E	2.80±0.2 F	4.41±0.4 C	7.21±0.5 D
Pioneer: 3233 *(V5)*	6.15±0.7 F	10.28±1.0 D	16.43±1.5 E	2.73±0.2 F	4.16±0.5 C	6.9±0.5 D
Monsanto 6142 *(V6)*	10.9±0.8 D	16.73±1.4 B	27.61±1.2 B	4.80±0.4 D	5.01±0.5 B	9.81±0.8 C
Syngenta: 8711 *(V7)*	11.68±0.7 C	14.25±1.2 C	25.91±1.6 C	6.18±0.6 C	5.01±0.5 B	10.2±0.8 C
Monsanto 6528 *(V8)*	14.75±0.9 B	13.75±1.2 C	28.51±1.2 B	6.5±0.6 B	4.65±0.4 BC	11.20±0.7 B
Pioneer 31P41 *(V9)*	10.81±0.7 D	13.57±1.2 C	24.38±1.1 D	4.78±0.4 D	4.96±0.4 B	9.75±0.5 C
F-value (SL)	*100.9***	*162.3***	*293.6***	*74.22***	*241.1***	*323.3***
F-value (V)	*286.27***	*94.40***	*317.2***	*215.4***	*37.87***	*176.3***
F-value (SL × V)	*3.93***	*10.83***	*14.88***	*2.98***	*1.72***	*3.58***
LSD (SL) ($p \leq 0.05$)	*0.33*	*0.51*	*0.57*	*0.17*	*0.23*	*0.28*
LSD (V) ($p \leq 0.05$)	*0.71*	*1.08*	*1.22*	*0.36*	*0.50*	*0.61*
LSD SL × V ($p \leq 0.05$)	*1.00*	*1.53*	*1.73*	*0.51*	*0.71*	*0.86*

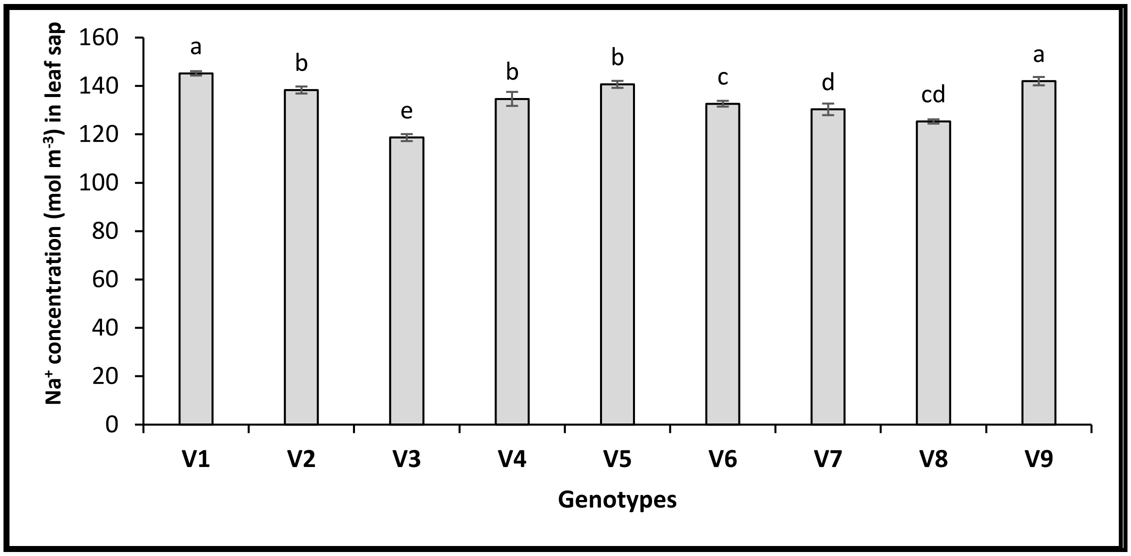

Figure 1 Sodium (Na^+) concentration (mol m^{-3}) In maize leaf sap (harvested at 4 weeks age).

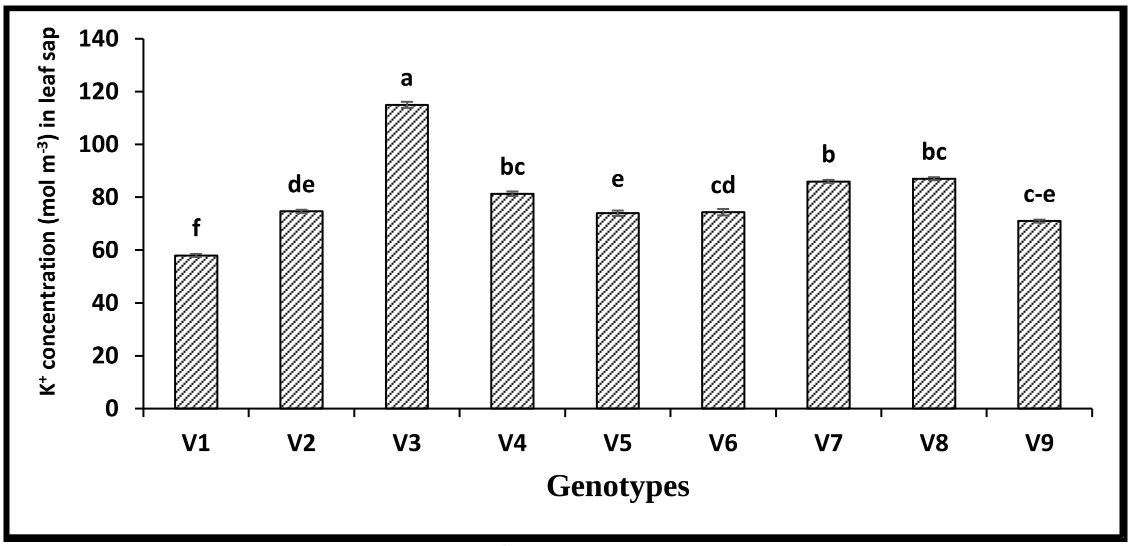

Figure 2: Potassium (K^+) concentration (mol m^{-3}) In maize leaf sap (harvested at 4 weeks age). ***V1: Pioneer 3335, V2: Pioneer 32F10, V3: Syngenta 8441, V4: Pioneer: 33H25, V5: Pioneer: 3233, V6: Monsanto 6142, V7: Syngenta: 8711, V8: Monsanto 6528, V9: Pioneer 31P41***

Table 3. The K:Na ratio of leaf sap affected by two salinity levels.

Genotypes	K:Na ratio	
	S_0	S_1
Pioneer 3335 *(V1)*	1.22 ± 0.10	0.40 ± 0.03
Pioneer 32F10 *(V2)*	1.72 ± 0.12	0.54 ± 0.06
Syngenta 8441 *(V3)*	2.90 ± 0.15	0.97 ± 0.07
Pioneer: 33H25 *(V4)*	1.88 ± 0.13	0.60 ± 0.04
Pioneer: 3233 *(V5)*	1.64 ± 0.14	0.53 ± 0.05
Monsanto 6142 *(V6)*	2.03 ± 0.17	0.56 ± 0.06
Syngenta: 8711 *(V7)*	2.34 ± 0.14	0.66 ± 0.04
Monsanto 6528 *(V8)*	2.03 ± 0.15	0.69 ± 0.05
Pioneer 31P41 *(V9)*	1.72 ± 0.12	0.50 ± 0.03

S_0: 10 mol m^{-3} NaCl, S_1: 100 mol m^{-3} NaCl

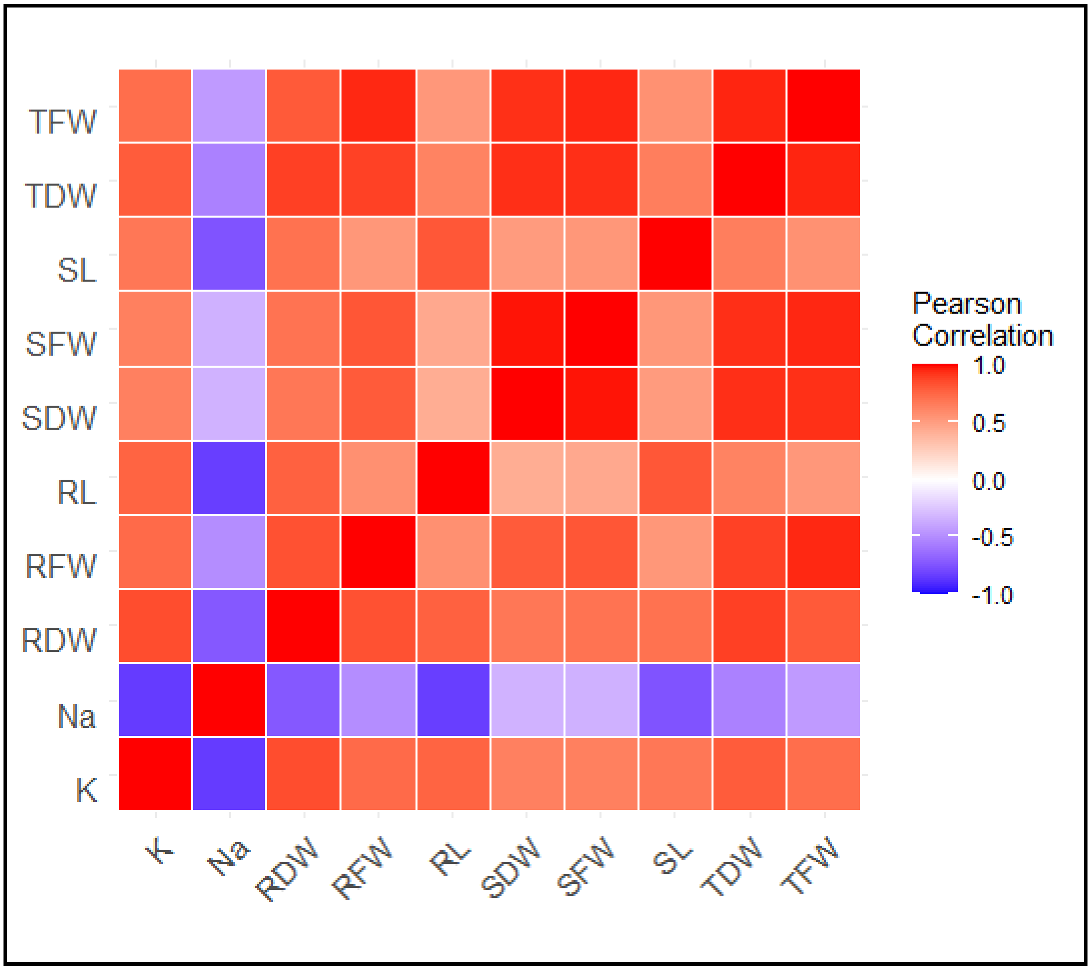

Figure 3. Pearson Correlation for different parameters

Principal Component Analysis: The result of principal component analysis is depicted in the biplot graphs below. The results from the angles between the vectors show correlation of the variables in their space. For example, the smaller the angle is, the more positive high correlation exists between the two variables. In our case shoot wt. and total weight were highly correlated to each other positively whereas, as the angle between the root length and shoot wt. is larger hence there exists least correlation between these two factors. The length of the vectors shows the variability of the variables. In our data there was no significant difference in the length of vectors, however all the vectors length was longer showing more variability of the variables.

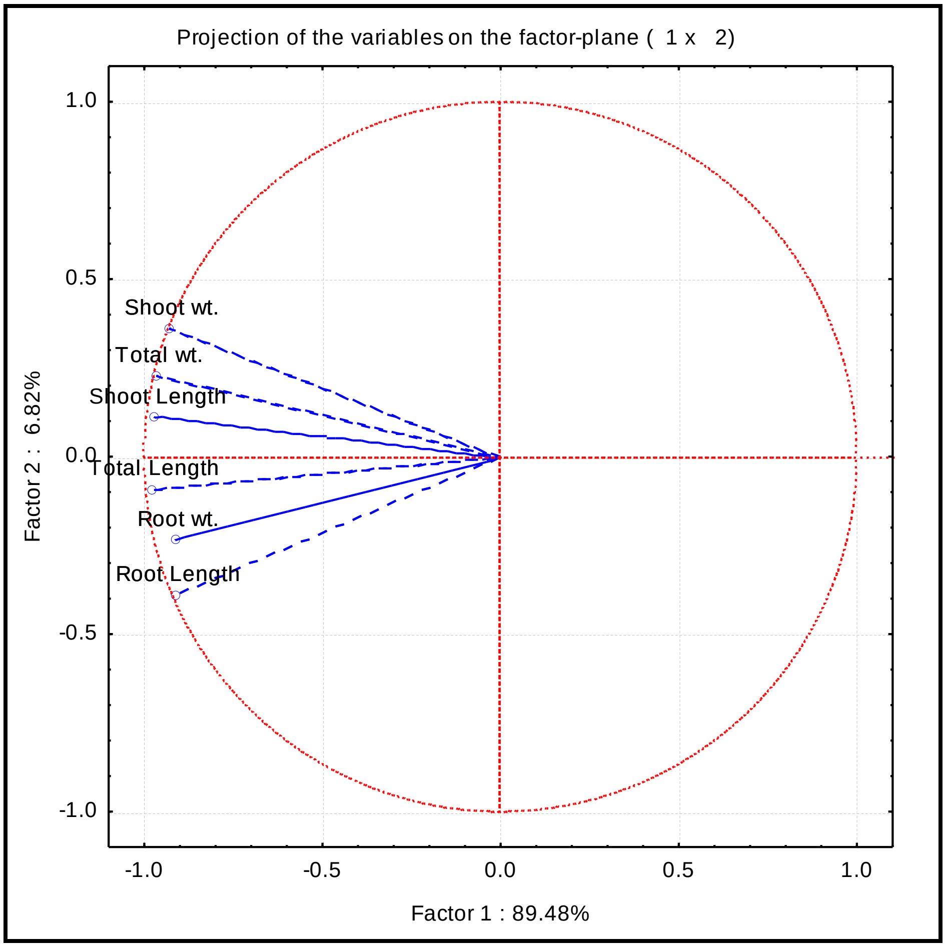

Figure 4: PCA biplot (a)

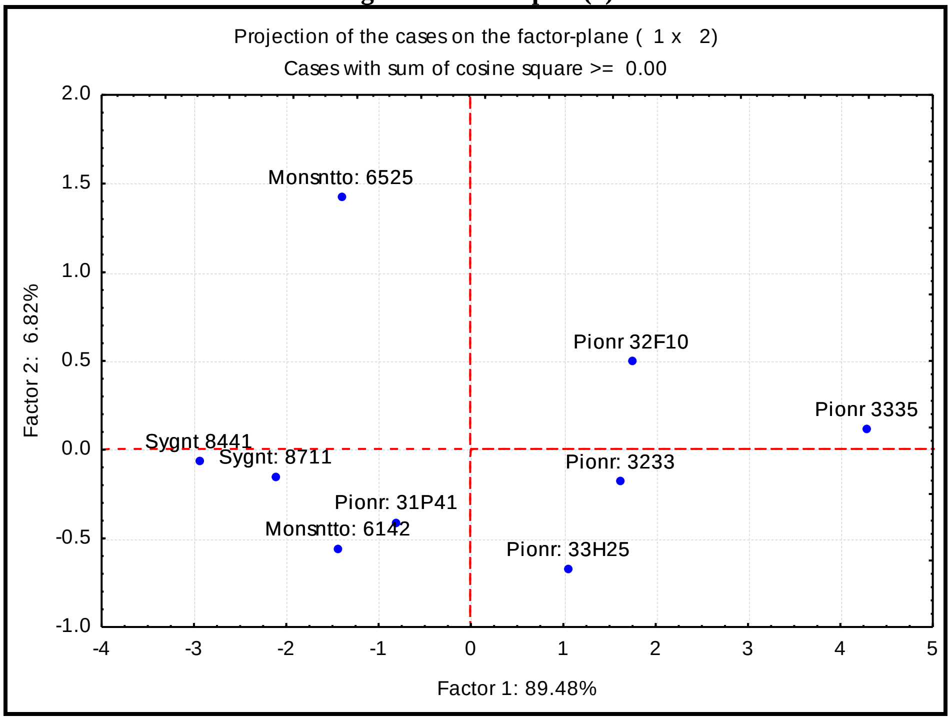

Figure 5: PCA biplot (b)

Discussion

The basic target of this investigation was to examine the plant growth constraints of maize genotypes going to hybrid line/varieties of maize genotypes under the salinity stress. Results demonstrated that the salt stress has non-favorable impact to all-maize genotypes. A few genotypes showed resistance, and some were sensitive to the salt stress. The impact of high salt stress (100 mol m^{-3} NaCl) was increasingly expressed when contrasted with control (10 mol m^{-3} NaCl).

Root is the basic plant organ responsible for supplying the nutrients from growth medium to the plant parts and is in direct contact with the medium, hence the rooting behavior is most important for studying the information regarding salt stress on the plant metabolic system and plant salt tolerance potential. Table 1 shows that root growth was affected drastically under saline conditions; previous research has also shown that roots are severely affected due to higher salt contents in the medium (Ashraf *et al*., 2005). In the same way, increased salt contents tend to lower the shoot length, fresh and dry biomass of the plant (Table 1). Mohammad *et al*., (1998) reported the similar results in tomato. In our present study, all maize genotypes responded differently to the salinity levels. Maize hybrids Syngenta 8441 and Monsanto 6528 showed overall better performance by yielding higher plant fresh and dry weights, thus showing their strength to tolerate the saline stress. Similar results were reported by Meloni *et al*., (2001) for cotton and Sarwar & Ashraf (2003) for wheat.

The Na+ contents in leaves increased in the both salinity levels but more were observed in S1 whereas K+ fixation and K^+: Na^+ proportion was decreased. This difference might be attributed to the altered/disturbed osmatic parity of the cells thus inducing water content reduction. Higher Na+ proved to be lethal and were basic reason for the salt damage (Tavakkoli *et al*., 2010). Particle toxicity also resulted displacement of K^+ thus causing cytotoxicity in biochemical processes. Conformational changes and the loss of elements of proteins as Na^+ particles entered the hydration shells and meddled with non-covalent associations between their amino acids. Ashraf (2002) stated that dry matter production in different genotypes were due to their selectivity for K+ over Na+ while Bastias *et al.,* (2004) showed a significant decrease in dry weight (40%) in maize cultivars 100 and 430 mM NaCl. It has been expressed that maize cultivar with low centralizations of Na^+ in the shoot are progressively salt tolerant, meaning that Na^+ rejection might be emphatically connected with salt resistance. Various screening procedures/criteria have been anticipated for the screening of genotypes against salt stress, however nobody has all the earmarks of being immaculate or all around substantial. Shoot new/dry weight and Na^+, K^+, and K^+: Na^+ proportions are commonly estimated as choice criteria. Distinctive physiological attributes, for example, K selectivity, prohibition, and compartmentation of sodium, osmotic modification, and the aggregation of natural solutes have all been identified with salt resistance of cultivars of various species. Jamil *et al*. (2005) found a significant impact of salt stress (0, 4.7, 9.4 and 14.1 dS m^{-1}) on germination, shoot length, shoot and root new weight of canola, cabbage, and cauliflower. It has been accounted for that the decreases in the rate of leaf and root development are most likely because of variables related with water pressure as opposed to a salt-explicit impact (Munns, 2002). Cicek and Cakirlar (2008) found a significant decrease brought about by salt pressure medicines in K^+: Na^+ proportion, plant stature, new and dry biomass of the shoot in soybeans cultivars. The present study results showed that the concentration of Na^+ increased in all tested genotypes, although least with V_3 (Syngenta 8441) and maximum with V_1 (Pioneer 3335). These results are similar to Cuin *et al*., (2003); Tester and Davenport, (2003) and Khadri *et al*., (2007). Regularization of adequate K^+ in plant tissue under salt stress appears to be reliant on upon selective K^+ uptake and selective cellular K^+ and Na^+ compartmentation and circulation in the shoots (Munns *et al*., 2008; Carden *et al.,* 2003). The maintenance of calcium acquisition and transport under salt stress is an essential determinant of salinity tolerance (Soussi *et al*., 2001)

In this investigation, higher K^+ and K^+: Na^+ proportion and lower Na^+ fixation helped maize genotype, V3 (Syngenta 8441) in keeping up generally higher a moderately higher development. The better execution of V3 (Syngenta 8441) under saline conditions and K expansion may be because of confined take-up and transport of Na^+ and better guideline of K^+ take-up. High K^+: Na^+ proportion was seen in bean plants that appear to restrain sodium translocation to shoot (Khadri *et al.,* 2007). Asch *et al.,* (2000) revealed similar outcomes in the rice crop. Indeed, it is conceivable that high K^+: Na^+ proportion is more significant for some species than just keeping up a low conjunction of Na^+ (Cuin *et al.*, 2003; Tester and Davenport, (2003). Tester and Davenport, (2003). This demonstrated tolerant genotype figured out how to confine the section of Na^+ into the roots and keep up higher substance of K^+ and K^+: Na^+ in the leaf sap. The supported substance of these supplements seemed to cushion the danger of Na^+ and support the tolerant genotype to show better development regarding plant height and shoot fresh weight (Mohammadkhani and Abbaspour, 2018).

Conclusion

In this study, maize (*Zea mays* L.) genotypes were screened, and then each the most tolerant and the most sensitive genotypes were chosen for further investigations. The hydroponic experiment was conducted on nine (09) different hybrid genotypes of maize crop. These genotypes were exposed to 100 mol m^{-3} NaCl along with control treatment (10 mol m^{-3} NaCl). The results showed that maximum root and shoot length, shoot, and root fresh/dry weight was attained by V_3 (Syngenta 8441), and the minimum was with V_1 (Pioneer 3335). Highest Na^+ concentration was accumulated in V_1 (Pioneer 3335) and the lowest with V_3 (Syngenta 8441) and vice versa with K^+. The Pearson correlation analysis showed a negative relation between Na^+ and K^+ in leaf sap. It is concluded that with the exposure to salinity, the growth of all genotypes reduced as compared to control. The most tolerant genotype concerning all tested parameters was V_3 (Syngenta 8441), and the most sensitive was V_1 (Pioneer 3335).

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