TRENDS IN ANIMAL AND PLANT SCIENCES
https://doi.org/10.62324/TAPS/2023.003
www.trendsaps.com; editor@trendsaps.com

RESEARCH ARTICLE

Screening of Maize Germplasm on the base of Morphological andPhysiological Parameters under Salinity Stress

[1]Amtulmunim Latif, and Ayesha Farooq Cheema[2]

[1]Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan
[2]Department of Plant Breeding & Genetics, College of Agriculture, University of Sargodha
***Corresponding author:** amtul1383@gmail.com

Article History: 23-006 Received: 02-Feb-2023 Revised: 17-Apr-2023 Accepted: 24-May-2023

ABSTRACT

Drought and salinity are two major environmental factors that reduce plant productivity. Many factors interrelate and alter the effect of salinity such as soil fertility, humidity, ambient temperature, light, irrigation, and so on. Generally, the survival and growth of plants are measured to determine the tolerance of plants to salinity. The current experimental study was executed to identify the best suitable maize germplasm for salt affected areas based on their performance. This experiment was conducted at the weir house of Department of Plant Breeding and Genetics, The Islamia University of Bahawalpur using the CRD with their replications to determine the selection criteria for salt tolerant maize genotypes at the seedling stage using Chlorophyll Content, Root length, Shoot length, Root fresh weight, shoot fresh weight, Root dry weight, Shoot dry weight andRoot shoot ratio. The 06 genotypes were assessed under normal and heat stress using factorial Complete Randomized design. Analysis of variance showed a significant and non-significantvariation among the studied germplasms. The root fresh weight and shoot fresh weight were correlatedwith root dry weight and shoot dry weight under both normal and stress conditions. So, selection onthe base of these traits enhances the performance of other traits. The root length and chlorophyll content were non-significant and negatively associated with all other studied characters. The results recommended that selection for root length and chlorophyll content could not be suitable for salinity tolerance. The genotypes which performed good under salinity stress conditions can be useful in future maize breeding programs, and evaluation of salinity stress tolerant germplasm on the base ofstudied traits.

Key words: Salt-tolerant maize, Germplasm selection, Salinity stress, Growth parameters, Selection criteria.

INTRODUCTION

Maize, often known as corn, is a cereal grain that is widely grown as a food crop around the globe. *Zea mays* is its scientific name (Alam *et al*., 2021). It is a member of the grass family *Poaceae*. The taxonomy of maize has been the topic of extensive dispute throughout the years due to its complexity (SHAH *et al*., 2023). Four species make up the genus *Zea*: *Zea diploperennis*, *Zea luxurians*, *Zea perennis*, and *Zea mays (Kamal et al., 2019; Razzaq et al., 2020)*. The subspecies of *Zea mays* include *Zea mays ssp. mays*, *Zea mays ssp. parviglumis*, *Zea mays ssp. huehuetenangensis*, *Zea mays ssp. mexicana*, and *Zea mays ssp. mays* L (Hanway and Ritchie, 2019).

Maize is thought to have come from Mesoamerica, more specifically the southwest of Mexico, more than 8,000 years ago. *Zea mays sp. parviglumis*, a grass that still grows in Mexico as well as Central America, is the wild ancestor of maize (Piperno and Flannery, 2001). Over time,people made this plant their own by choosing for desirable traits like bigger kernels and a higher yield (Khalid, 2022). The native peoples of the Americas ate a lot of maize, and it was a big part of how their cultures and societies grew and changed. Columbus introduced maize to Europe in the late 1400s. Ever since, it has become an important crop in many parts of the world (Goodman and Galinat, 1988).

Maize is a very significant crop that can be used in many different ways, both in terms of business and in day-to-day living (abu Haraira et al., 2022; Hamza et al., 2018; Zafar et al., 2020). Because of its value in the food and animal feed industries, as well as in the production of processed foods and products not related to food, it is sometimes referred to as "yellow gold" (BABAR *et al*., 2022). Starch derived from maize is frequently utilized as a sizing componentin both the textile and paper

Cite This Article as: Latif A and Cheema AF, 2023. Screening of maize germplasm on the base of morphological and physiological parameters under salinity stress. Trends in Animal and Plant Sciences 1: 13-21. https://doi.org/10.62324/TAPS/2023.003

manufacturing sectors (Khalid and Amjad, 2018b). In the culinary world, cornmeal is utilized in the making of desserts and savory dishes such as pies, puddings, salad dressings, and confections.In addition to being utilized in the manufacturing of food and industrial goods, maize is also put to use in the manufacture of starch, sweeteners, oil, drinks, adhesives, and industrial alcohol by a number of different businesses (Jin *et al*., 2021).

In addition to its usage as a food crop, maize has a variety of industrial applications. It is employed in the production of biofuel ethanol, which is used to power cars (Chang *et al*., 2017).

By fermenting corn with yeast, ethanol is generated, and it is considered a cleaner and more sustainable alternative to fossil fuels. Maize is also used to produce a wide range of chemicals, including the food industry sweetener dextrose and the biodegradable plastic-making chemical polylactic acid(Fatima et al., 2022; Imtiaz et al., 2022; IQBAL et al., 2023).

In Pakistan, insufficient research and development, restricted extension services, and a lack of suitable storage and processing facilities are other factors that limit maize output (Khalid, *et al*., 2021). To address these concerns, the government has established a number of projects, such as the Prime Minister's National Agricultural Emergency Program, which aims to increase agricultural production and encourage sustainable agricultural methods (Khalid and Amjad, 2018a).

The salinity stress is the most important abiotic factor affecting crop development and yield, including maize. The crop experiences salinity stress when the concentration of soluble salts, typically sodium chloride (NaCl), exceeds its tolerance limit. Reduced germination, delayed emergence, and poor seedling development can be caused by salt stress in maize, resulting in decreased yields. In several ways, maize production is affected by salinity. First, it can inhibit photosynthesis by inhibiting chlorophyll production and photosynthetic enzyme activity (Ahmad *et al*., 2021). Second, salinity stress can result in ion toxicity, which disturbs the ion balance an impairs the function of cellular membranes and enzymes (Tuteja, 2007). Thirdly, salt stress can impair root water intake, leading to water stress and exacerbating the salinity stress's consequences.

The effects of salinity stress on maize seedling characteristics include shoot and root development, biomass accumulation, and nutrient absorption. Research have demonstrated that maize seedlings exposed to salt stress exhibit diminished shoot and root development, as well as decreased biomass accumulation (Khalid, *et al*., 2021). In addition, salinity stress can influence nutritional absorption and utilization, resulting in nutrient imbalances and deficiency (Shahani *et al*., 2021). The adoption of salt-tolerant cultivars, irrigation management, and soil amendments are among the measures that have been developed to enhance maize yield under salinity stress (Bano et al., 2023; BASHIR et al., 2023; Chaudhry et al., 2022). In addition, maize lines with enhanced salt tolerance have been created using genetic engineering techniques (Kamal et al., 2019; Zafar et al., 2022). Understanding the effects of salt stress on maize yield and seedling characteristics is crucial for establishing effective measures to reduce its detrimental effects and ensuring sustainable maize production. This study was conducted to assess six maize genotypes at the seedling stage under varied salt levels (Khalid, *et al*., 2021).

MATERIALS AND METHODS

Six genotypes were provided by Store House of Islamia University of Bahawalpur. The seed wasstored in plastic bag under room temperature 25C°. The experiment was conducted at the wire house of Department of Plant breeding and Genetics, Islamia University of Bahawalpur. On 10, 2, 2023, 06 maize genotype were sown using Complete Randomized design with 4 treatments. Out of 4 treatments 1 treatment is normal and 3 treatments in controlled conditions under salinity stress. Thedoses of controlled treatment are 2.9 NaCl per liter, 5.85 NaCl per liter and 8.75 NaCl per liter respectively. Each treatment was consisting of 3 replications.

Statistical Analysis

Analysis of Variance

The methodology given by Steel *et al*., (1997) was used for statistical analysis to calculate variance from data collected for different traits to determine the variation among various genotypes for variability. Total variance was partitioned into genotypic and phenotypic components. Statistics 10.0was used to find the analysis of variance.

Pearson's Correlation

Karl Pearson's correlation coefficient was estimated to find the linear association between various morphological and physiological parameters using the following formula:

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Where, r is the Pearson's correlation coefficient, X and Y are tahe variables for which the correlation has been estimated, and n is the number of observations.

RESULTS AND DISCUSSION

Screening of Germplasm

Six genotypes of maize (Table 1) were screened in green house using factorial under completely randomized design. Highly significant differences were exhibited among all accessions and traits under normal and salinity conditions (Table 2). All the studied characters exhibited fluctuations in mean value under salinity conditions for most of the genotypes. Mean values for seedling traits in maize were decreased under

Table 1: Genotypes Names

Serial no.	Genotypes	Serial no.	Genotypes
1	G-1	4	G-4
2	G-2	5	G-5
3	G-3	6	G-6

Table 2: Analysis of variance (ANOVA) mean squares of 06 genotypes at the seedling stage under normal and salinity stress conditions

	Replication	Genotypes	Treatment	G*T	Error	Total
SOV/DF	2	5	3	15	46	71
CC	2.027	1.0115*	56.0768**	1.6450*	44.961	
RDW	0.0638	0.21153*	8.66512**	0.17199*	3.2768	
SDW	0.0553	0.08734ns	4.43576**	0.10345ns	2.6664	
RFW	0.158	0.57237ns	0.54969ns	1.87123**	27.7744	
SFW	0.0378	0.8928*	10.6897**	0.5298ns	17.2179	
RL	124.11	37.822*	793.815**	35.993*	699.22	
SL	19.84	71.6868**	88.7998**	34.7720*	874.99	
RSR	0.3236	0.09572ns	0.54962**	0.10418ns	4.3947	

salinity conditions. Similar findings have been reportedby Ahmad *et al*. (2022). Such kind of information was also observed by Mukul *et al*. (2023). Those accessions resist in variation of performance for studied characters under salt environments which were considered as salt tolerant.

Shoot Fresh Weight

Several studies have investigated the effect of salt stress on fresh shoot weight in maize seedlings, and the results suggest that exposure to NaCl can lead to a significant reduction in fresh shoot weight. For example, a study by Li *et al*. (2015) found that maize seedlings exposed to salt stress had a lower fresh shoot weight than non-stressed plants, indicating a negative effect of salt stress on shoot growth. Data collected for shoot fresh weight of maize varied significantly (Table 3a, 3b, 3c and 3d) ranging from 4.39 to 5.63 g under normal conditions, in salinity level 1 ranging from 2.78 to 3.48 g, under salinity level 2 ranging from 3.16 to 4.14 g and in salinity stress level 3 ranging from 2.93 to 4.48 g. The G2 and G4 has minimum and maximum fresh weight with the values of 4.39 and 5.63 g under normal, in salinity stress level 1 G4 and G6 has minimum and maximum fresh weight with the values of 2.78 and 3.48 g, under salinity stress level 2 G3 and G4 has minimum and maximum fresh weight with the values of 3.16 and 4.14 g and in salinity stress level 3 G1 and G3 has minimum and maximum fresh weight with the values of 2.93 and 4.48 g conditions respectively.

Root Fresh Weight

Data collected for root fresh weight of maize varied significantly (Table 3a, 3b, 3c and3d) ranging from 3.75 to 5.22 g under normal conditions, in salinity level 1 ranging from 3.65 to 5.25 g, under salinity level 2 ranging from 3.53 to 5.35 g and in salinity stress level 3 ranging from 2.61 to 5.08 g. The G3 and G2 has minimum and maximum fresh weight with the values of 3.75 and 5.22 g under normal, in salinity stress level 1 G3 and G1 has minimum and maximum fresh weight with the values of 3.65 and 5.25 g, under salinity stress level 2 G1 and G4 has minimum and maximum fresh weight with the values of 3.53 and 5.35 g and in salinity stress level 3 G2 and G3 has minimum and maximum fresh weight with the values of 2.61 and 5.08 g conditions respectively.For instance, Li *et al*. (2019) found that 100 mM NaCl treatment significantly reduced fresh root weight in maize seedlings by 43.6%. Similarly, (AFZAL et al., 2023) reported a significant reductionin fresh root weight in maize seedlings under NaCl stress.

Root Length

Several studies have investigated the effect of salt stress on root length in maize seedlings, and the results suggest that exposure to NaCl can lead to a significant reduction in root length. For example, a study by (AFZAL et al., 2023)found that maize seedlings exposed to salt stress had a shorter root length than non-stressed plants, indicating a negative effect of salt stress on root growth. Similarly, the study by Li *et al*. (2019) found that salt stress significantly reduced root length in maize seedlings, which was accompanied by a decrease in biomass production. Data collected for root length of maize varied significantly (Table 3a, 3b, 3c and 3d) ranging from 29 to 45.33 g under normal conditions, in salinity level 1 ranging from 22.33 to 26.33 g, under salinity level 2 ranging from 22 to 24.33 g and salinity stress level 3 ranging from 24.66 to 29 g. The G4 and G2 hasminimum and maximum fresh weight with the values of 29 and 45.33 g under normal, in salinity stress level 1 G4 and G2 has minimum and maximum fresh weight with the values of 22.33 and 26.33 g, under salinity stress level 2 G4 and G3 has minimum and maximum fresh weight with the values of 22 and 24.33 g and in salinity stress level 3 G1 and G5 has minimum and maximum freshweight with the values of 24.66 and 29 g conditions respectively.

Shoot Length

Data collected for shoot length of maize varied significantly (Table 3a, 3b, 3c and3d) ranging from 39.66 to 46.83 g under normal conditions, in salinity level 1 ranging from 38 to 45.33g, under salinity level 2 ranging

Table 3a: Mean data of maize seedling traits of 06 genotypes under Normal conditions

Genotypes	RFW	SFW	RDW	SDW	RSR	RL	SL	CC
G1	4.68	4.56	1.29	1.44	1.26387	42.33	42.6667	8.18
G2	5.22	4.39	1.08	0.96	1.21521	45.33	46.8333	4.68667
G3	3.75	4.46	0.90	1.01	0.89371	42.00	44.6667	6.76
G4	4.08	5.63	0.90	0.80	1.19445	29.00	45	5.09667
G5	4.91	5.21	0.67	0.87	0.78687	31.33	39.6667	6.43667
G6	4.35	4.99	0.46	0.58	0.79254	35.67	34.3333	5.79

Table 3b: Mean data of maize seedling traits of 06 genotypes under salinity level 1

Genotypes	RFW	SFW	RDW	SDW	RSR	RL	SL	CC
G1	5.25	2.87667	2.73333	1.69	1.61795	23.6667	45.3333	3.96667
G2	3.77	2.89667	2.34667	2.01667	1.16589	26.3333	40.6667	4.66667
G3	3.65	2.88667	1.77667	1.57333	1.12523	23	38	4.63333
G4	4.8	2.78333	2.59667	1.6	1.62355	22.3333	40.3333	4.36667
G5	4.08	3.27333	2.22333	1.88333	1.18295	24.6667	44.3333	4.8
G6	4.45	3.48333	2.05333	1.79667	1.13935	24	38	5.03333

Table 3c: Mean data of maize seedling traits of 06 genotypes under salinity level 2

Genotypes	RFW	SFW	RDW	SDW	RSR	RL	SL	CC
G1	3.53333	3.24667	2.16667	1.81667	1.19279	23.3333	41	3.23333
G2	3.68333	3.82	2.2	1.57	1.40543	23	40.6667	2.43333
G3	4.5	3.16667	2.13333	1.51667	1.40681	24.3333	39.6667	3.2
G4	5.35	4.14	2.16667	1.7	1.29279	22	40.6667	2.96667
G5	4.9	3.89333	2.41667	1.46333	1.64723	24	40.3333	2.26667
G6	4.16667	3.4	2.25	1.65333	1.36172	22.6667	37.6667	3.5

Table 3d: Mean data of maize seedling traits of 06 genotypes under salinity level 3

Genotypes	RFW	SFW	RDW	SDW	RSR	RL	SL	CC
G1	4.61	2.93333	2.36333	2.09	1.12891	24.6667	37.3333	1.8
G2	2.61667	4.28	2.1	2.15667	0.97966	26.6667	49	2.1
G3	5.08333	4.48333	2.46667	2.16333	1.13694	26.3333	46	2.2
G4	4.48	3.56667	2.35667	2.07667	1.133	27	48.3333	2.43333
G5	3.18333	4.31	2.11667	2.07	1.02771	29	50	2.36667
G6	4.51667	4.21667	2.36333	2.23	1.06272	28	40.3333	2.33333

from 37.66 to 41 g and salinity stress level 3 ranging from 37.33 to50 g. The G5 and G2 has minimum and maximum fresh weight with the values of 39.66 and 46.83 g under normal, in salinity stress level 1 G3 and G1 has minimum and maximum fresh weight with the values of 38 and 45.33 g, under salinity stress level 2 G6 and G1 has minimum and maximum fresh weight with the values of 37.66 and 41 g and in salinity stress level 3 G1 and G5 has minimumand maximum fresh weight with the values of 37.33 and 50 g conditions respectively.

Several studies have investigated the effect of salt stress on shoot length in maize seedlings,and the results suggest that exposure to NaCl can lead to a significant reduction in shoot length. For example, a study by Khayatnezhad *et al.* (2012) found that maize seedlings exposed to salt stress hada shorter shoot length than non-stressed plants, indicating a negative effect of salt stress on shoot growth. Similarly, the study by Wang *et al.* (2019) found that salt stress significantly reduced shootlength in maize seedlings, which was accompanied by a decrease in biomass production.

Shoot Dry Weight

Data collected for shoot Dry weight of maize varied significantly (Table 3a, 3b, 3c and3d) ranging from 0.58 to 1.44 g under normal conditions, in salinity level 1 ranging from 1.57 to 2.01 g, under salinity level 2 ranging from 1.46 to 1.81 g and salinity stress level 3 ranging from 2.07to 2.23 g. The G6 and G1 has minimum and maximum fresh weight with the values of 0.58 and 1.44 g under normal, in salinity stress level 1 G3 and G2 has minimum and maximum fresh weight with the values of 1.57 and 2.01 g, under salinity stress level 2 G5 and G1 has minimum and maximum fresh weight with the values of 1.46 and 1.81 g and in salinity stress level 3 G5 and G6 has minimum and maximum fresh weight with the values of 2.07 and 2.23 g conditions respectively. Several studies have investigated the effect of salt stress on shoot dry weight in maize seedlings, and the results suggest that exposure to NaCl can lead to a significant reduction in shoot dry weight. For example, a study by Tuna *et al.* (2008) found that maize seedlings exposed to salt stress had a lower shoot dry weight than non-stressed plants, indicating a negative effect of salt stress on shoot growth.

Root Dry Weight

Several studies have investigated the effect of salt stress on root dry weight in maize seedlings, and the results suggest that exposure to NaCl can lead to a significant reduction in root dry weight. For example, a study by Tuna *et al.* (2008) found that maize seedlings exposed to salt stress had a lower root dry weight than non-stressed plants, indicating a negative effect of salt stresson root growth. Similarly, the study by (AFZAL et al., 2023) found that salt stress significantly reduced root dry weight in maize seedlings, which was accompanied by a decrease in root length and surfacearea. These findings suggest that salt stress can have a negative impact on root growth in maize seedlings by inhibiting root development and reducing water uptake.

Data collected for Root Dry weight of maize varied significantly (Table 3a, 3b, 3c and3d) ranging from 0.46 to 1.29 g under normal conditions, in salinity level 1 ranging from 1.77 to 2.73 g, under salinity level 2 ranging from 2.13 to 2.41 g and salinity stress level 3 ranging from 2.10to 2.46. The G6 and G1 has minimum and maximum fresh weight with the values of 0.46 and 1.29 g under normal, in salinity stress level 1 G3 and G1 has minimum and maximum fresh weight with the values of 1.77 and 2.73 g, under salinity stress level 2 G3 and G5 has minimum and maximum fresh weight with the values of 2.13 and 2.41 g and in salinity stress level 3 G2 and G3 has minimumand maximum fresh weight with the values of 2.10 and 2.46 g conditions respectively.

Root Shoot Ratio

Data collected for root shoot ratio of maize varied significantly (Table 3a, 3b, 3c and 3d) ranging from 0.78 to 1.26 g under normal conditions, in salinity level 1 ranging from 1.12 to 1.64 g, under salinity level 2 ranging from 1.19 to 1.64 g and salinity stress level 3 ranging from 0.97 to 1.13 g. The G5 and G1 has minimum and maximum fresh weight with the values of 0.78 and 1.26 g under normal, in salinity stress level 1 G3 and G4 has minimum and maximum fresh weight with the values of 1.12 and 1.64 g, under salinity stress level 2 G1 and G5 has minimum and maximum fresh weight with the values of 1.19 and 1.64 g and in salinity stress level 3 G2 and G3 has minimum and maximum fresh weight with the values of 0.97 and 1.13 g conditions respectively. (Mehboob et al., 2020)investigated the effects of salinity stress on maize growth and physiology. The researchers found that salinity stress caused a decrease in the root-to-shoot ratio in maize plants, which was associated with a decrease in shoot biomass and leaf chlorophyll content. These studies suggest that salinity stress can cause a reduction in the root-to-shoot ratio in maize plants, which can ultimately lead to a decrease in yield. Salinity stress can also cause a decrease in shoot biomass and leaf area, which may be related to the decrease in the root-to-shoot ratio. These findings highlight the importance of developing salt-tolerant maize varieties to mitigate the effects of salinity stress on maize production.

Chlorophyll Content

Salt stress can reduce chlorophyll content in plants by disrupting the photosynthetic process,reducing the absorption of light energy, and damaging the photosynthetic apparatus. Various studies have investigated the effect of salt stress on chlorophyll content in maize seedlings, and the results suggest that exposure to NaCl can lead to a significant decrease in chlorophyll content. For example, a study by Li *et al*. (2015) found that maize seedlings exposed to salt stress exhibited a significant reduction in chlorophyll content, indicating a decrease in the plant's photosynthetic capacity. Data collected for Chlorophyll Content of maize varied significantly (Table 3a, 3b, 3c and 3d) ranging from 4.68 to 8.18 g under normal conditions, in salinity level 1 ranging from 3.96 to 5.03 g,under salinity level 2 ranging from 2.43 to 3.50 g and salinity stress level 3 ranging from 1.80 to 2.43. The G2 and G1 has minimum and maximum fresh weight with the values of 4.68 and 8.18 g under normal, in salinity stress level 1 G1 and G6 has minimum and maximum fresh weight with thevalues of 3.96 and 5.03 g, under salinity stress level 2 G2 and G6 has minimum and maximum freshweight with the values of 2.43 and 3.50 g and in salinity stress level 3 G1 and G4 has minimum andmaximum fresh weight with the values of 1.80 and 2.43 g conditions respectively.

Correlation

Correlation coefficients define the level of relationship between two variables or factors. It is valuable in plant breeding since it can show a foretelling association that can be exploited in practice, and it offers evidence about the relationship between several preferred traits. It offers a core concept of the association among various yield-contributing traits, which is beneficial for plant breeders in choosing varieties having desired attributes (Ghafoor *et al*., 2013). In this experiment, evidence of the correlation of seedling traits in non-stress and stress conditions may help advance strategies for the assortment of required varieties with preferred traits under normal and salinity stress condition (Table 4a, 4b, 4c and 4d).

Fresh Weight

Fresh root weight is an important trait that determines the belowground biomass of maize plants. The data in a given table conclude that root fresh weight is negatively associated with chlorophyll content and non-significant correlation with root dry weight under normal environment, salinity stress level 1, 2and significant association between root dry weight and non-significant relationship between chlorophyll content similar results was reported by Ahmad *et al*., (2022). According to given data of Shoot fresh is negatively associated with root dry weight under normal environment and under salinity stress level 1, 2 and 3 significant correlated with chlorophyll content similar findings was reported by Din *et al*., (2019), and also correlated with root fresh weight, root shoot ratio and shoot dry weight similar results were also reported by Chen *et al*., (2022).

Root Length and Shoot Length

Shoot length is an important parameter for assessing plant growth and development. It is an indicator of the plant's ability to produce new tissues

Table 4a: Correlation Analysis of Seedling Traits under Normal Condition

	CC	RDW	RFW	RL	RSR	SDW	SFW
RDW	0.3367*P-VALUE 0.05141						
RFW	-0.1544ns0.7703	0.2149ns 0.6826					
RL	0.2138ns0.6842	0.5708* 0.02368	0.2473ns 0.6366				
RSR	-0.0332ns0.9502	0.8685* 0.0248	0.2528ns 0.6288	0.3433ns 0.5052			
SDW	0.7125*0.01121	0.8908* 0.0172	0.1748ns 0.7405	0.5462ns 0.2622	0.5948ns 0.2130		
SFW	-0.2982ns 0.5659	-0.4704* 0.03464	-0.2186ns 0.6773	-0.9799** 0.0006	-0.1713ns 0.7455	-0.5228ns 0.2872	
SL	-0.1789ns 0.7345	0.7576ns 0.0810	0.0430ns 0.9356	0.3706* 0.04695	0.7047ns 0.1179	0.4782* 0.03374	-0.2735ns 0.6000

Table 4b: Correlation Analysis of Seedling Traits under Salinity Stress level 1

	CC	RD	RF	RL	RSR	SD	SF
RD P-VALUE	0.2549ns 0.6260						
RF	-0.1398ns 0.7917	0.7839* 0.0506					
RL	0.5299ns 0.2796	-0.0245ns 0.9633	-0.4341* 0.0389				
RSR	-0.1188ns 0.8226	0.8656* 0.0259	0.8628* 0.0270	-0.5068ns 0.3049			
SD	0.7055ns 0.1173	0.0464ns 0.9305	-0.3374* 0.0513	0.9627** 0.0021	-0.4595ns 0.3593		
SF	0.2571ns 0.6229	-0.4222ns 0.4043	-0.1093ns 0.8367	0.2407ns 0.6459	-0.5661* 0.02416	0.3764* 0.04621	
SL	0.2865ns 0.5820	0.6774* 0.0139	0.4878ns 0.3263	0.1910ns 0.7169	0.4803* 0.0335	0.2108ns 0.6885	-0.1332ns 0.8013

and respond to environmental stimuli. Under normal and salinity stress level 1, 2 and 3 shoot length positively associated with shoot dry weight, root dry weight and root fresh weight similar findings was reported by (AFZAL et al., 2023) and non- significant association with chlorophyll content and root length many scientists finding the similar results Kapadia *et al*., (2021). Root length is another important parameter for assessing plant growth and development. It is an indicator of the plant's ability to acquire water and nutrients from the soil and respond to environmental stimuli. Salt stress can have a significant impact on root length in maize seedlings, as it can inhibit root growth, reduce water uptake, and affect the overall growth rate of the plant. Root length was positively associated with root dry weight, root fresh weight and chlorophyll contents and non- significant with chlorophyll content, root dry weight and root fresh weight under normal and all three levels of salt stress. These types of results were also reported by (AFZAL et al., 2023).

Root Shoot Ratio

The root has a fundamental role in taking nutrients, water, agricultural production and stresstolerance. The trait root: Shoot "ratio is a very complex unlike some partial problems, it is a problemof plant integrity, where each species, every crop or variety represents a specific original solution. Under normal and salinity stress level 1, 2 and 3 root shoot ratios were significantly associated with root dry weights and non-significantly interlinked with root length and chlorophyll contents, similarresults were reported by (Bochicchio *et al*., 2023; Azeem *et al*., 2023).

Conclusion

Those accessions who performed well were consider as salt tolerant, and those who does not performed under salt stress environment were consider as salt susceptible. Then using those criteria, the 03 genotypes were selected as salt tolerant under salinity stress level 1, 2 and 3 (G-3, G-4 and G-6) and 03 genotypes were selected as salt -susceptible from all three level of

Table 4c: Correlation Analysis of Seedling Traits under Salinity Stress level 2

	CC	RD	RF	RL	RSR	SD	SF
RDW	-0.5789ns						
P-VALUE	0.2286						
RFW	-0.1736ns	0.2600*					
	0.7423	0.0188					
RL	-0.2086*	0.2221ns	-0.1548ns				
	0.0317	0.6723	0.7696				
RSR	-0.6874ns	0.7954*	0.3720ns	0.5083ns			
	0.1313	0.0585	0.4678	0.3032			
SD	0.5806ns	-0.5153ns	-0.3454ns	-0.5644*	-0.9269**		
	0.2270	0.2955	0.5025	0.0243	0.0078		
SF	-0.6464*	0.3742ns	0.5862*	-0.5258ns	0.3087ns	-0.1840ns	
	0.0165	0.4649	0.0214	0.2840	0.5516	0.7271	
SL	-0.5519*	-0.1111ns	-0.0110ns	0.0602ns	-0.1102ns	0.1625*	0.3578ns
	0.0262	0.8340	0.9835	0.9098	0.8354	0.7585	0.0462

Table 4d: Correlation Analysis of Seedling Traits under Salinity Stress level 3

	CC	RDW	RFW	RL	RSR	SDW	SFW
RDW	-0.0741ns						
P-VALUE	0.8890						
RFW	0.3752ns	-0.4569*					
	0.4636	0.0324					
RL	0.8371*	-0.4416ns	0.5898ns				
	0.0377	0.3807	0.2179				
RSR	-0.1257ns	0.8962*	-0.7239ns	-0.5032*			
	0.8124	0.0156	0.1038	0.0308			
SD	0.0588ns	0.2259ns	0.5599*	0.0946*	-0.2289ns		
	0.9120	0.6669	0.0279	0.0585	0.6626		
SF	0.5553*	-0.2423ns	0.9391**	0.6588ns	-0.4836ns	0.4884ns	
	0.0527	0.6436	0.0055	0.1548	0.3312	0.3256	
SL	0.6131*	-0.5342ns	0.5136*	0.5556ns	-0.4203ns	-0.2965ns	0.5800ns
	0.01956	0.2749	0.02973	0.2524	0.4067	0.5682	0.2276

salt stress (G-1, G-2G-5). The present studies also showed a pure identity of genotypes for selection criteria on the base of preferred traits such as root length, shoot length, root/shoot ratio, shoot fresh weight, shoot dry weight, root fresh weight, root dry weight and chlorophyll content which would be of great utility in maize breeding programs for developing salt-tolerant maize genotypes.

REFERENCES

abu Haraira, A., Ahmad, A., Khalid, M. N., Tariq, M., Nazir, S., & Habib, I. (2022). Enhancing health benefits of tomato by increasing its antioxidant contents through different techniques: A review. Advancements in Life Sciences, 9(2), 131-142.

AFZAL, M., KHALID, M., IMTIAZ, M., NASIR, B., SHAH, S., NAWAZ, M., NAYAB, S., MALIK, S., MAJEED, T., & MAQBOOL, R. (2023). SELECTION OF DROUGHT TOLERANT WHEAT GENOTYPES BASED ON MEAN PERFORMANCE AND BIPLOT ANALYSIS. Biological and Clinical Sciences Research Journal, 2023(1), 188-188.

Ahmad, K, Aslam, M., Saleem, M. H., Ijaz, M., Ul-Allah, S., El-Sheikh, A. H. M. A. and Ali, S. (2022). Genetic diversity and characterization of salt stress tolerance traits in maize (Zea Mays L.) under normal and saline conditions. *Pakistan Journal Bot*, 54(3), 759-769.

Ahmad, S., Cui, W., Kamran, M., Ahmad, I., Meng, X., Wu, X. and Han, Q. (2021). Exogenous application of melatonin induces tolerance to salt stress by improving the photosynthetic efficiency and antioxidant defense system of maize seedling. *Journal of Plant Growth Regulation*, *40*, 1270-1283.

Alam, S., Khalid, M. N., Ijaz, M., Akram, M. S., Irfan, M. and Hassan, M. (2021). Rearing Of Maize Stem Borer, Chilo Partellus (Lepidoptera: Crambidae) Under Laboratory Conditions.

Azeem, M., Pirjan, K., Qasim, M., Mahmood, A., Javed, T., Muhammad, H. and Rahimi, M. (2023). Salinity stress improves antioxidant potential by modulating physio-biochemical responses in Moringa oleifera Lam. *Scientific Reports*, *13*(1), 1-17.

Babar, M., Nawaz, M., Shahani, A., Khalid, M., Latif, A., Kanwal, K., Ijaz, M., Maqsood, Z., Amjad, I. and Khan, A. (2022). Genomic Assisted Crop Breeding Approaches For Designing Future Crops To Combat Food Production Challenges. *Biological And Clinical Sciences Research Journal* 2022.

Bano, M., Shakeel, A., Khalid, M. N., Ahmad, N. H., Sharif, M. S., Kanwal, S., Bhutta, M. A., Bibi, A., & Amjad, I. (2023). Estimation of Combining Ability for Within-Boll Yield Components in Upland Cotton (Gossypium hirsutum). Sarhad Journal of Agriculture, 39(1).

BASHIR, H., ZAFAR, S., REHMAN, R., HUSSAIN, M., HARIS, M., KHALID, M., AWAIS, M., SADIQ, M., & AMJAD, I. (2023). IMPACT OF POTENTIALLY SOIL MINERALIZABLE NITROGEN (PMN) ON SOIL HEALTH AND CROP PRODUCTION. Biological and Agricultural Sciences Research Journal, 2023(1).

Bochicchio, R., Labella, R., Rossi, R., Perniola, M. and Amato, M. (2022). Effects ofSoil Water Shortage on Seedling Shoot and Root Growth of Saragolle Lucana Tetraploid Wheat (Triticum durum Desf.) Landrace. *Plants*, *11*(24), 3492.

Chang, W. R., Hwang, J. J. and Wu, W. (2017). Environmental impact and sustainability studyon biofuels for transportation applications. *Renewable and Sustainable Energy Reviews*, 67,277-288.

Chaudhry, U. F., Khalid, M. N., Aziz, S., Amjad, I., Khalid, A., Noor, H., & Sajid, H. B. (2022). Genetic studies in different F2 segregating population for yield and fiber quality traits in cotton (Gossypium hirsutum L.). Journal of Current Opinion in Crop Science, 3(3), 135-151.

Chen, Q., Hu, T., Li, X., Song, C. P., Zhu, J. K., Chen, L. and Zhao, Y. (2022). Phosphorylation of SWEET sucrose transporters regulates plant root: shoot ratio under drought. *Nature Plants*, *8*(1), 68-77.

Din, B. U., Sarfraz, S., Xia, Y., Kamran, M. A., Javed, M. T., Sultan, T. and Chaudhary, H. J. (2019). Mechanistic elucidation of germination potential and growth of wheat inoculated with exopolysaccharide and ACC-deaminase producing Bacillus strains under induced salinity stress. *Ecotoxicology and Environmental Safety*, *183*, 109466.

Fatima, A., Saeed, A., Ullah, M., Shah, S., Ijaz, M., Anwar, M., Khaliq, A., Chohan, S., Khalid, M., & Khan, A. (2022). Estimation of gene action for the selection of superior parents and their cross combinations for yield and fiber associated attributes in american cotton (Gossypium hirsutum L.). Biological and Clinical Sciences Research Journal, 2022(1).

Ghafoor, G., Hassan, G., Ahmad, I., Khan, S.N., Suliman, S. (2013). Correlation analysis for different parameters of F2 bread wheat population. *Pure Appl. Biology*, 2013, 2, 28–31

Goodman, M. M. and Galinat, W. C. (1988). The history and evolution of maize. *Critical Reviews in Plant Sciences*, *7*(3), 197-220.

Hamza, M., Tahir, M. N., Mustafa, R., Kamal, H., Khan, M. Z., Mansoor, S., Briddon, R. W., & Amin, I. (2018). Identification of a dicot infecting mastrevirus along with alpha-and betasatellite associated with leaf curl disease of spinach (Spinacia oleracea) in Pakistan. Virus Research, 256, 174-182.

Hanway, J. J. and Ritchie, S. W. (2019). Zea mays. In *CRC Handbook of Flowering* (pp. 525-541). CRC Press.

Imtiaz, M., Shakeel, A., Nasir, B., Khalid, M., & Amjad, I. (2022). HETEROTIC POTENTIAL OF UPLAND COTTON HYBRIDS FOR EARLINESS AND YIELD RELATED ATTRIBUTES. Biological and Clinical Sciences Research Journal, 2022(1).

IQBAL, J., KHALID, M., RIAZ, S., RAZAQ, A., SHAKOOR, A., KARIM, A., RAZZAQ, B., GOHAR, M., AQEEL, M., & MAJEED, T. (2023). DISSECTION OF YIELD AND FIBER QUALITY TRAITS UNDER DROUGHT CONDITION IN GOSSYPIUM HIRSUTUM L. Biological and Clinical Sciences Research Journal, 2023(1), 330-330.

Jin, C., Hu, J., Wu, J., Liang, H. and Li, J. (2021). Innovativeand economically beneficial use of corn and corn products in electrochemical energy storage applications. *ACS Sustainable Chemistry & Engineering*, *9*(32), 10678-10703.

Kamal, H., Minhas, F.-u.-A. A., Farooq, M., Tripathi, D., Hamza, M., Mustafa, R., Khan, M. Z., Mansoor, S., Pappu, H. R., & Amin, I. (2019). In silico prediction and validations of domains involved in Gossypium hirsutum SnRK1 protein interaction with cotton leaf curl Multan betasatellite encoded βC1. Frontiers in Plant Science, 10, 656.

Kapadia, C., Sayyed, R. Z., El Enshasy, H. A., Vaidya, H., Sharma, D., Patel, N. and Zuan, A. T. K. (2021). Halotolerant microbial consortia for sustainable mitigation of salinity stress, growth promotion, and mineral uptake in tomato plants and soil nutrient enrichment. *Sustainability*, *13*(15), 8369.

Khalid, M. and Amjad, I. (2018a). The Application Of Mutagenesis In Plant Breeding Under Climate Change. *Bulletin Of Biological And Allied Sciences Research* 2018, 15-15.

Khalid, M. and Amjad, I. (2018b). Study Of The Genetic Diversity Of Crops In The Era Of Modern Plant Breeding. *Bulletin Of Biological And Allied Sciences Research* 2018, 14-14.

Khalid, M. N. (2022). *Fundamentals Of Agriculture* (Vol. 1). Vital Biotech Publications.

Khalid, M. N., Amjad, I., Hassan, A., Ajmal, U., Ammar, A., Rasheed, Z. and Qasim, M. (2021). Genetics Of Inter Cropping For Crop Productivity Enhancement.

Khalid, M. N., Amjad, I., Nyain, M. V., Saleem, M. S., Asif, M., Ammar, A. and Rasheed, Z. (2021). A Review: Tilling Technique Strategy For Cereal Crop Development. *International Journal Of Applied Chemical And Biological Sciences* 2, 8-15.

Khalid, M. N., Tahir, M. H., Murtaza, A., Murad, M., Abdullah, A., Hundal, S. D., Zahid, M. K. and Saleem, F. (2021). Application And Potential Use Of Advanced Biotechnology Techniques In Agriculture And Zoology. *Ind. J. Pure App. Biosci* 9, 284-296.

Khayatnezhad, M., Asadi-Samani, M., Moradi, M. T. and Gholampoor, A. (2012). The effect of salinity stress on yield, proline and chlorophyll contents in maize (Zea mays L.) cultivars. *African Journal of Agricultural Research,* 7(11), 1727-1730. doi: 10.5897/AJAR11.1416

Li, X., He, J., Zhao, X. and Li, Y. (2015). Effects of salt stress on growth, chlorophyll content, and leaf area of maize seedlings. *Acta Agriculturae Scandinavica, Section B - Soil & Plant Science*, 65(3), 236-246. doi: 10.1080/09064710.2014.1000304

Li, X., He, J., Zhao, X. and Li, Y. (2015). Effects of salt stress on growth, chlorophyll content, and leaf area of maize seedlings. *Acta Agriculturae Scandinavica, Section B - Soil & Plant Science*, 65(3), 236-246. doi: 10.1080/09064710.2014.1000304

Li, X., Wang, L. and Jia, Y. (2019). Effects of NaCl stress on growth, photosynthesis, and ion balance of maize seedlings. *Acta Physiologiae Plantarum*, 41(2), 1-12. doi: 10.1007/s11738-019-2809

Mehboob, S., Kashif, M., KHALID, M., & Amjad, I. (2020). ASSOCIATION STUDY OF ASSORTEDYIELD LINKED COMPONENTS IN WHEAT CROSSES BY INVOLVING EXOTIC GENOTYPES. Bulletin of Biological and Allied Sciences Research, 2020(1), 18-18.

Mukul, M. M. (2023). Genetic analyses of morphological traits, and phenotypic screening of tossa jute germplasm grown under salinity stress. *Heliyon*, 9(1).

Piperno, D. R. and Flannery, K. V. (2001). The earliest archaeological maize (Zea mays L.)from highland Mexico: new accelerator mass spectrometry dates and their implications. *Proceedings of the National Academy of Sciences*, *98*(4), 2101-2103.

Razzaq, A., Ali, A., Safdar, L. B., Zafar, M. M., Rui, Y., Shakeel, A., Shaukat, A., Ashraf, M., Gong, W., & Yuan, Y. (2020). Salt stress induces physiochemical alterations in rice grain composition and quality. Journal of food science, 85, 14-20.

Shah, J., Ramzan, U., Naseer, S., Khalid, M., Amjad, I., Majeed, T., Sabir, W., Shaheen, M., Ali, B. and Shahmim, F. (2023). Chemical Control Of Southern Leaf Blight Of Maize Caused By Helminthosporium Maydis. *Biological And Clinical Sciences Research Journal* 2023, 225-225.

Shahani, A. A. A., Yeboah, E. O., Nadeem, M., Amjad, I., Ammar, A., Rehman, A. U., Awais, M. and Khalid, M. N. (2021). Cytogenetics, Types And Its Application In Crop Improvement. *International Journal Rec. Biotechnology* 9, 9-14.

Tuna, A. L., Kaya, C. and Higgs, D. (2008). The combined effects of gibberellic acidand salinity on some antioxidant enzyme activities, plant growth parameters and nutritional status in maize plants. *Environmental and Experimental Botany*, 62(1), 1-9. doi: 10.1016/j.envexpbot.2007.06.002

Tuteja, N. (2007). Mechanisms of high salinity tolerance in plants. *Methods in Enzymology*, *428*, 419-438.

Wang, J., Liu, H., Zhang, T., Zhang, Y. and Chen, S. (2019). Physiological and transcriptomic responses of maize seedlings to salt stress at different time points. *PLoS One*, 14(7),e0219975. doi: 10.1371/journal.pone.0219975

Zafar, M. M., Razzaq, A., Farooq, M. A., Rehman, A., Firdous, H., Shakeel, A., Mo, H., & Ren, M. (2020). Insect resistance management in Bacillus thuringiensis cotton by MGPS (multiple genes pyramiding and silencing). Journal of Cotton Research, 3(1), 1-13.

Zafar, M. M., Rehman, A., Razzaq, A., Parvaiz, A., Mustafa, G., Sharif, F., Mo, H., Youlu, Y., Shakeel, A., & Ren, M. (2022). Genome-wide characterization and expression analysis of Erf gene family in cotton. BMC Plant Biology, 22(1), 134.