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EVALUATION OF VARIOUS TRAILS BASED ON MAIZE SEEDLING GERMINATION IN PAKISTAN

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ABSTRACT

This study evaluates the effects of various NaCl concentrations on the germination and growth of three hybrid maize varieties (P1429, P5971, and P6103) in Pakistan. The experiment was conducted at the Agriculture Research Farm of PMS Aird Agriculture University and the National Agricultural Research Centre (NARC), Punjab. Different NaCl treatments (0.25 Molar, 0.5 Molar, 0.75 Molar, and 1 Molar) were applied to maize seedlings, and growth parameters such as leaf length, shoot length, root length, and root/shoot length ratio were measured. Data analysis revealed significant differences in growth responses among the treatments, with higher NaCl concentrations generally reducing growth parameters. Hybrid P6103 exhibited the highest tolerance to salt stress, making it a potential candidate for cultivation in saline conditions. The findings underscore the importance of managing salt stress in maize cultivation to ensure optimal growth and productivity.

Keywords: *maize, salt stress, NaCl, root length, shoot length*

INTRODUCTION

Quick time frame, annual, hybridized crop Maize (Zea mays L.) belongs to the Phocaea group. Rapidly growing with the capacity to produce great grain output per unit area, this crop has great potential (Akbar, etal., 2008). This one is among the main grains grown in Pakistan. As a dual-use crop, maize is used for food and fuel worldwide. Other than that, it finds use in food industries, bread manufacturing, corn flakes, corn syrup, paper manufacture, and other sectors (Khan, et al., 2013.). Given the rather high concentration of unsaturated fatty acids (Tariq and Iqbal, 2010), corn oil is fit for human consumption. With 1.12 million hectares under cultivation and a total output of 4.53 million tons, Pakistan's average maize yield is quite low when compared to China, America, and Brazil (Shah, et al., 2018).

Among the many elements influencing maize grain production are improper fertilizer application, weed control, inadequate water availability, assault of various kinds of pests and diseases. Moreover, the choice of unsuitable variety under particular environment is the most crucial element (Tahir, et al., 2008). While the environmental condition cannot be altered for commercial crop production, several approaches of biotechnology and hybridization (Khan, et al., 2013) may affect a genetic makeup of a variety. Moreover, the screening of many variants is also a methodical way to assess the stability and yield performance in different environmental conditions.

Various places produce distinct maize types depending on each other (Olakojo and Iken, 2001). Therefore, screening many maize varieties in different ago-ecological zones for their adaptability, yield potential and to release the most suited varieties for agriculture is rather crucial (Hussain, 2011). Such a phenomena led the experiment to be carried out at the Agriculture Research Farm of Abdul Ali Khan University Mardan, Khyber Pakhtunkhwa, Pakistan in order to identify the most stable and high producing cultivars for the local surroundings.

Although it has been observed that the current climate outcomes induced a change in the association for maize has become insufficient along with the model based in corn growth, development, grain productivity and yield, the changing global warming is having a negative effect on corn crop grain yield and productivity, which is increasing the food shortage and insecurity (Ali et al., 2011; Buckler et al., 2009; Edreira and Otegui, 2012). According to a number of studies on the effects of climate change, there is a correlation between rising temperatures and rainfall. In temperate, subtropical, and tropical regions of the world, rising temperatures are also contributing to drought and salt stress. Globally and in South East Asia, average temperatures are expected to rise by 3–4°C by the end of the twenty-first century (Buckler et al., 2009; Mupangwa et al., 2007; Mustafa et al., 2013; Saif-ul-malook et al., 2014).

Method

The experiment was conducted at the Agriculture Research Farm of PMS Aird Agriculture University, Rawalpindi (RWP), and the National Agricultural Research Centre (NARC), Punjab, Pakistan. The seeds of three hybrid maize varieties, P1429, P5971, and P6103, were used for the experiment. The seeds were sterilized using a 10% sodium hypochlorite solution for 10 minutes, followed by thorough rinsing with distilled water to remove any residual chlorine.

Plastic pots were filled with a soil-sand mixture, where the base was covered with soil and the rest with sand. Approximately 8 to 10 seeds were sown in each pot at a depth of 3 cm. Initially, the pots were irrigated with tap water to ensure adequate moisture for germination.

The seedlings were subjected to different levels of salt stress using NaCl solutions of varying concentrations: 0.25 Molar, 0.5 Molar, 0.75 Molar, and 1 Molar. A control group was maintained with no NaCl treatment. The treatments were applied seven days after seedling emergence and continued at weekly intervals.

Data were collected at weekly intervals, with the first sampling taking place seven days after the initial treatment. For each treatment, two plants per pot were randomly harvested, and the following parameters were recorded: leaf length, the length of the largest leaf was measured from the base to the tip; root length, the length of the primary root was measured from the base to the tip; shoot length, the length of the shoot was measured from the base to the tip; and root/shoot length ratio, the ratio of root length to shoot length was calculated.

The data collected were subjected to analysis of variance (ANOVA) using SPSS version 23.1. The significance of differences among treatment means was determined using the least significant difference (LSD) test at a 5% probability level.

Result and discussions

Table 1: Leaf length

				95% Confidence Interval for Mean			
Treatments	Mean	Std.Dev	Std.Err	Lower limit	Upper limit	Minimum	Maximum
Control	13.6333	1.20554	0.69602	10.6386	16.6281	12.50	14.90
0.25 Molar NaCl	8.0000	1.32288	0.76376	4.7138	11.2862	6.50	9.00
0.5 Molar NaCl	10.7333	1.12398	0.64893	7.9412	13.5255	9.50	11.70
0.75 Molar NaCl	10.0667	0.40415	0.23333	9.0627	11.0706	9.70	10.50
1Molar NaCl	12.0000	1.00000	0.57735	9.5159	14.4841	11.00	13.00
Grand Mean	10.8867		0.5505				
Coefficient variation	9.67						

The data presented in Table 1 illustrates the influence of different NaCl concentrations on the length of maize leaves. The control group, which did not receive NaCl treatment, had the maximum average leaf length of 13.6333 cm, suggesting the presence of ideal growth circumstances. The group's measurements exhibit consistency, as shown by a standard deviation of 1.20554 and a standard error of 0.69602. The 95% confidence interval for the readings ranges from 10.6386 to 16.6281 cm. The leaf length in the control group ranged from 12.50 cm to 14.90 cm.

Conversely, the treatment with a concentration of 0.25 Molar NaCl resulted in a considerable decrease in the average length of the leaves to 8.0000 cm, indicating a substantial detrimental effect of this salt concentration on the growth of maize. The group exhibits more variability, as seen by the standard deviation of 1.32288 and standard error of 0.76376. The confidence interval spans from 4.7138 to 11.2862 cm, indicating the range of possible values for the population mean. Additionally, the leaf lengths range from 6.50 cm to 9.00 cm.

The application of a 0.5 Molar NaCl treatment resulted in a mean leaf length increase of 10.7333 cm, indicating a moderate but discernible effect of salt stress. The standard deviation of 1.12398 and standard error of 0.64893 indicate a high level of consistency, with a confidence range ranging from 7.9412 to 13.5255 cm. The leaf lengths for this treatment varied between 9.50 cm and 11.70 cm. The treatment with a concentration of 0.75 Molar NaCl resulted in an average leaf length of 10.0667 cm, with a smaller standard deviation of 0.40415 and a standard error of 0.23333, suggesting more consistent outcomes. The confidence interval for this group spanned from 9.0627 to 11.0706 cm, with leaf lengths ranging between 9.70 cm and 10.50 cm.

At the salt concentration of 1 Molar NaCl, the average leaf length was 12.0000 cm, indicating a partial restoration of leaf growth compared to lower concentrations. The standard deviation of 1.00000 and standard error of 0.57735 indicate a reasonable level of consistency. The confidence interval is from 9.5159 to 14.4841 cm. The leaf lengths varied between 11.00 cm and 13.00 cm.

The overall average leaf length across all treatments was 10.8867 cm, with a coefficient of variation of 9.67%, suggesting a moderate level of variability in the data. The data indicates that higher NaCl concentrations tend to decrease leaf length, with the most pronounced loss occurring at the 0.25 Molar value. These data indicate that increasing NaCl concentrations have the ability to reduce the negative effects of stress, but not to the same extent as the control group. The research highlights the need of effectively regulating salt stress in maize agriculture to guarantee maximum development and yield.

Table 1a. Means for group in homogeneous subsets for leaf length

Treatments	P1429	P5971	P6103
Control	8.0000		
0.25 Molar NaCl	10.0667	10.0667	
0.5 Molar NaCl	10.7333	10.7333	10.7333
0.75 Molar NaCl		12.0000	12.0000
1Molar NaCl			13.6333
Sig. $p<0.05$	0.110	0.353	0.085

The data in Table 1a displays the average leaf length for three maize hybrids (P1429, P5971, and P6103) after various salt stress treatments. The control group has an average leaf length of 8.0000 cm for hybrid P1429, however there is no accessible data for P5971 and P6103 in the control group. This suggests that P1429 may be less influenced by the lack of NaCl treatment in comparison to the other hybrids. Both P1429 and P5971 exhibited a mean leaf length of 10.0667 cm after 0.25 Molar NaCl treatment, suggesting a comparable response to this amount of salt stress. P6103 lacked recorded data for this treatment, indicating that it may not have been included in this subgroup or did not demonstrate consistent performance.

The treatment with 0.5 Molar NaCl resulted in a mean leaf length of 10.7333 cm for all three hybrids (P1429, P5971, and P6103). The consistency seen across the hybrids at this concentration indicates that they possess a similar degree of resistance to mild

salt stress, resulting in equivalent growth responses. At a concentration of 0.75 Molar NaCl, both P5971 and P6103 had mean leaf lengths of 12.0000 cm. This suggests that they have a greater tolerance and perform better under this treatment compared to P1429, for which there is no recorded data at this concentration.
Among the samples treated with 1 Molar NaCl, only the hybrid P6103 exhibits data indicating a mean leaf length of 13.6333 cm. The findings indicate that P6103 has the greatest resistance to high salt concentrations, demonstrating superior growth performance under the most challenging circumstances.
The p-values (Sig. $p<0.05$) for the treatments reflect various degrees of statistical significance in the observed differences among the hybrids under different NaCl treatments. The significant values for P1429, P5971, and P6103 are 0.110, 0.353, and 0.085, respectively. These values indicate that the variations in leaf length are more noticeable in P6103 under severe salt stress circumstances compared to the other hybrids.

Table 2. Mean performance of maize genotypes for shoot length under different salt concentrations

Treatments	Mean	Std. Deviation	Std. Error	95% Confidence Interval for mean		Minimum	Maximum
				Lower limit	Upper limit		
Control	12.0000	1.00000	0.57735	9.5159	14.4841	11.00	13.00
0.25 Molar NaCl	6.8333	1.25831	0.72648	3.7075	9.9591	5.50	8.00
0.5 Molar NaCl	8.5000	.50000	0.28868	7.2579	9.7421	8.00	9.00
0.75 Molar NaCl	10.4000	.36056	0.20817	9.5043	11.2957	10.00	10.70
1Molar NaCl	14.6667	2.08167	1.20185	9.4955	19.8378	13.00	17.00
Grand Mean	10.480		0.77393				
Coefficient of variation	10.246						

The data shown in Table 2 illustrates the influence of various NaCl concentrations on the growth of maize genotypes, specifically in terms of shoot length. The control group had the greatest average shoot length of 12.0000 cm, with a standard variation of 1.00000 and a standard error of 0.57735. The 95% confidence interval for the mean shoot length in the control group was between 9.5159 and 14.4841 cm. The shoot length varied from 11.00 cm to 13.00 cm.
The application of a 0.25 Molar NaCl solution resulted in a considerable decrease in the average shoot length, measuring 6.8333 cm. This indicates a major detrimental effect of this salt concentration on the development of maize shoots. The standard deviation was 1.25831 cm, and the standard error was 0.72648 cm. The confidence interval ranged from 3.7075 cm to 9.9591 cm. The shoot length exhibited a range of 5.50 cm to 8.00 cm with this treatment. The shoot length grew to 8.5000 cm after the 0.5 Molar NaCl treatment, suggesting a significant but reduced effect of salt stress. The data set had a standard deviation of 0.50000 and a standard error of 0.28868. The confidence interval for the measurements ranged from 7.2579 to 9.7421 cm. The shoot length varied between 8.00 cm and 9.00 cm.
The treatment with a concentration of 0.75 Molar NaCl resulted in a mean shoot length of 10.4000 cm, with a standard deviation of 0.36056 and a standard error of 0.20817. These values indicate that the findings within this group were more consistent. The confidence interval for this treatment spanned from 9.5043 to 11.2957 cm, with shoot lengths ranging between 10.00 cm and 10.70 cm. The treatment with a concentration of 1 Molar NaCl exhibited a mean shoot length of 14.6667 cm, indicating a partial restoration of shoot growth in comparison to lower concentrations. The data set had a standard deviation of 2.08167 and a standard error of 1.20185. The confidence interval for the measurements ranged from 9.4955 to 19.8378 cm. The shoot length varied between 13.00 cm and 17.00 cm.
The overall average shoot length across all treatments was 10.4800 cm, with a coefficient of variation of 10.246%, suggesting a moderate level of variability in the data. The general pattern indicates that higher NaCl concentrations often lead to a decrease in shoot length, with the most notable decrease reported at the 0.25 Molar concentration.

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Nevertheless, the application of a 1 Molar NaCl treatment demonstrates a certain level of improvement, indicating the possibility of maize genotypes developing adaptation or tolerance mechanisms in response to severe salt stress.

Table 2a. Means for group in homogeneous subsets for shoot length

Treatments	P1429	P5971	P6103
Control	5.3000		
0.25 Molar NaCl	6.5000	6.5000	
0.5 Molar NaCl		7.5000	7.5000
0.75 Molar NaCl			8.1667
1Molar NaCl			
Sig. $p<0.05$	0.197	0.340	0.691

Root length

The results demonstrated a substantial variation across the treatments at various NaCl stress concentrations. The mean length of the root was measured to be 10.1533 ± 0.62821cm across all treatments (Table 3). The mean performance of the three hybrid varieties was superior for the control treatment (12.1667±0.56862cm), followed by the 0.75Molar NaCl treatment (12.400±0.79373cm), and the 1Molar NaCl treatment (10.40±0.65574cm). The data from table 3a indicated the efficacy of the hybrid system.

Table 3: Mean Performance of Maize Genotypes for Root/Shoot Length Ratio Under Different Salt Concentrations

Treatments	Mean	Std. Deviation	Std. Error	95% Confidence Interval for mean		Minimum	Maximum
				Lower limit	Upper limit		
Control	0.7000	0.10000	0.05774	0.4516	0.9484	0.60	0.80
0.25 Molar NaCl	0.2800	0.07211	0.04163	0.1009	0.4591	0.20	0.34
0.5 Molar NaCl	0.4567	0.14012	0.08090	0.1086	0.8047	0.30	0.57
0.75 Molar NaCl	0.8000	0.10000	0.05774	0.5516	1.0484	0.70	0.90
1Molar NaCl	0.9000	0.10000	0.05774	0.6516	1.1484	0.80	1.00
Grand Mean	0.6273		0.06500				
Coefficient of variation	10.103						

The data presented in Table 3 demonstrates the influence of various NaCl concentrations on the ratio of root length to shoot length in different maize genotypes. The control group, which did not receive any NaCl treatment, had a root/shoot length ratio of 0.7000, with a standard variation of 0.10000 and a standard error of 0.05774. The 95% confidence interval for the mean varied between 0.4516 and 0.9484, with values falling between the range of 0.60 to 0.80.

The application of a 0.25 Molar NaCl solution resulted in a significant decrease in the root/shoot length ratio, which was measured at 0.2800. This indicates a considerable adverse effect of this salt concentration on the equilibrium between root and shoot development. The standard deviation was 0.07211 and the standard error was 0.04163. The confidence interval ranged from 0.1009 to 0.4591. The ratio values observed in this therapy ranged from 0.20 to 0.34.

The application of a 0.5 Molar NaCl treatment resulted in an increase in the root/shoot length ratio to 0.4567, suggesting a moderate but discernible effect of salt stress. The data had a standard deviation of 0.14012 and a standard error of 0.08090. The confidence interval ranged from 0.1086 to 0.8047. The ratio values varied from 0.30 and 0.57. The treatment with a concentration of 0.75 Molar NaCl led to a root/shoot length ratio of 0.8000. The standard deviation was lower at 0.10000, and the standard error was 0.05774, suggesting more consistency in the findings within this group. The confidence interval for this therapy spanned from 0.5516 to 1.0484, with ratio values ranging between 0.70 and 0.90.

At the salt concentration of 1 Molar NaCl, the ratio of root length to shoot length was 0.9000, indicating a partial restoration of the equilibrium between root and shoot growth in comparison to lower concentrations. The standard deviation was 0.10000 and the standard error was 0.05774. The confidence interval ranged from 0.6516 to 1.1484. The ratio values varied between 0.80 and 1.00. The overall average ratio of root length to shoot length across all treatments was 0.6273, with a coefficient of variation of 10.103%. This suggests that there is a substantial amount of variability in the data. The data indicates that higher NaCl concentrations typically lead to a decrease in the ratio of root length to shoot length, with the most pronounced decrease occurring at a concentration of 0.25 Molar. Nevertheless, the application of a 1 Molar NaCl treatment demonstrates a certain level of improvement, suggesting the existence of possible adaptation or tolerance mechanisms in the maize genotypes when exposed to severe salt stress.

Table 4. Pooled correlation among different traits of maize under drought stress conditions

Traits	Shoot length	Root length	Leaf length
Root length	0.8019*		
Leaf length	0.6701*	0.2307	
Root/shoot length ratio	0.4503*	-0.2250	0.4914*

Table 4 revealed notable variations among the treatments with varying concentrations of NaCl stress. A smaller coefficient of variation indicates more reliability and accuracy of the results. This suggests that the data may be utilised in the future to enhance yield and increase resilience to stress. The mean dry shoot weight was measured as (0.6273 ± 0.06500) across various treatments. The average ratio of root length to shoot length rose, indicating that the development of leaves, roots, and shoots was favourable under various concentrations of NaCl treatments. This demonstrates the plant's tolerance to varied levels of stress and its ability to enhance the growth and production of maize. The hybrid P6103 exhibited superior performance when subjected to treatments with NaCl concentrations of 0.25M, 0.5M, and 1M, in comparison to other maize hybrids. The comparative analysis of maize hybrids reveals that the ratio of root length to shoot length in seedlings was lower under 0.25Molar NaCl (0.2800), followed by 0.5Molar NaCl (0.4567), and the control group (0.7000). The NaCl concentration is 0.75M (0.8000) at its greatest level, and it is below 1Molar NaCl (0.9000) concentration. The findings suggest that different salt concentrations have an impact on plant growth. When the stress concentration is lower, the growth of leaves tends to be higher. This indicates that the concentrations affect growth, but certain traits can be improved to enhance tolerance in the future (Mazhar et al., 2020; Shu and Liu, 2001; Tahir et al., 2020; Zubair et al., 2016).

Table 4. Means for group in homogeneous subsets for root/shoot length ratio

Treatments	P1429	P5971	P6103
Control	0.2800		
0.25 Molar NaCl	0.4567	0.4567	
0.5 Molar NaCl		0.7000	0.7000
0.75 Molar NaCl			0.8000
1Molar NaCl			0.9000
Sig. $p<0.05$	0.422	0.167	0.312

compared to other hybrids, which exhibited superior performance at lower levels of salt stress. The average increase in root length indicates that the roots are growing well under various concentrations of NaCl treatments. This suggests that the plants are tolerant to different levels of stress and that their growth and yield are promoted. This finding is supported by studies conducted by Aaliya et al. (2016), Abbas et al. (2016), Ali et al. (2017), Farooq et al. (2015), Karahara et al. (2004), and Sheng et al. (2008).

The findings from table 5 revealed a positive and substantial association among all the tolerance characteristics tested, suggesting that the selection of maize genotypes for salt stress may be beneficial in enhancing grain and fodder traits. The length of the roots and shoots of maize plants were shown to be indicative of the crop's production when subjected to salt stress conditions. Robust and substantial association, indicating.

Conclusion

The study demonstrated that different NaCl concentrations significantly impact the growth of maize seedlings. Higher concentrations of NaCl generally reduced leaf length, shoot length, and the root/shoot length ratio, indicating the adverse effects of salt stress. Among the hybrids tested, P6103 showed the highest tolerance to salt stress, particularly at higher concentrations, suggesting its potential for cultivation in saline environments. The results highlight the necessity of effective salt stress management strategies in maize cultivation to enhance growth and yield. Future research should focus on the genetic and physiological mechanisms underlying salt tolerance in maize to develop more resilient crop varieties.

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