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Original Research

Exploring the Role of Salt on Morpho-Physiological Response of Wheat Genotypes

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Abstract

Wheat (*Triticum aestivum* L.) is the main cereal crop in Pakistan. Wheat is the principal source of food and is extensively grown, consumed, and preferred in Pakistan. But due to the increased use of poor-quality water for irrigation and salinization, their growth and yield are decreasing day by day in Pakistan. Wheat is a salt tolerant cereal crop, and new genotypes of wheat with diverse salt tolerance are being developed continuously to cope with salinity and improve crop productivity. A pot experiment was conducted in the Department of Soil and Environmental Sciences, Ghazi University, Dera Ghazi Khan, to explore the role of salt stress on the morphophysiological response of wheat genotypes. Treatments were T_1: control, T_2: 6 dsm^{-1}, T_3: 9 dsm^{-1}, and T_4:12 dsm^{-1} in a Factorial Completely Randomized Design (CRD). The results showed that salt stress reduced the growth parameters of wheat under a saline condition. Further, the wheat genotype G_2 (108) is a more salt tolerant genotype because it gains the highest shoot fresh weight, plant height, shoot length, number of spikelets, shoot dry weight, root length, 1000 grain weight chlorophyll contents, membrane stability index, and less shoot Na^+, while the

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genotype G_1 (133) is a salt sensitive genotype. Our findings revealed that the genotype (108) is screened for the future to grow on salt affected soils.

Keywords: salt stress, production, wheat

Introduction

Accounting for more than a third of the world's population, wheat is an essential food crop and is a staple in main diets. Wheat accounts for around 35% of the population's primary food (Pakistan Agricultural Statistics 2017-19). Wheat is grown to supply the food demands of Pakistan and other countries. Wheat productivity per hectare is significantly lower than its potential production. This is due to a variety of stresses. The most critical factor is soil salinity (Khan et al., 2006). Wheat is the most common human food, and it is widely farmed in Pakistan as a valuable crop. It has about 2%-3% minerals, 1.5-2% fat, 2%-2.5% glucose, and 60%-80% protein [1]. Wheat (*Triticum aestivum L.*) is a salt-tolerant crop to a certain extent. Soil conditions and water availability have an impact on wheat growth. Wheat is a moderately salt-tolerant crop with significant genotypic differences in salinity tolerance. Wheat output in Pakistan is low in salt-affected areas, with yield losses as high as 65% in moderately saline soils [2].

Salt stress is a severe concern for Pakistani soils, with around 6.3 million hectares of land affected by the problem of salt irrigation. Wheat has a salt tolerance of 7 dsm^{-1}, with a yield loss of 9.0 dsm^{-1} up to 25%. It could be affected by the amount of salt in the soil and the type of farming [3]. Wheat is a tolerant crop that can grow in a variety of environments, allowing for large scale agriculture as well as long-term food storage. Approximately 70% of this crop is utilized for human consumption, 19% for animal feed, and the remaining 11% is used for industrial purposes, including biofuels. Wheat is important because its grains may be processed into flour, semolina, and other items that are used to make bread and other bakery products, as well as pasta. As a result, it serves as the primary source of nutrients for the majority of the world's population. Wheat's nutritional content is very essential because it is one of the few crop species that is widely farmed as a staple food source [4].

This situation causes plants to absorb excessive concentrations of ions, which compete with vital nutrients for uptake. This condition results in plants absorbing high concentrations of ions, which compete with important elements for uptake, resulting in nutrient deficiency. However, wheat productivity per hectare is significantly lower than its potential due to a variety of issues, the most important of which is soil salinity. This may be an enhancement of tolerance in agro-economically important crops [5]. Wheat productivity per hectare is significantly lower than its potential due to a variety of problems, the most important of which is soil salinity. Salt stress is a severe hazard to Pakistani soils, with around 6.3 million hectares of land damaged by salinity issues. Wheat has a salt tolerance of 7.0 dSm^{-1} and there's a yield drop of 9.0 dSm^{-1} up to 25%. It could be influenced by salt medium concentrations in the soil and cultivars. Nearly 70% yield loss has been observed among cereal crops such as wheat, maize, and barley due to soil contamination by salinity and audacity [6].

As a result of the struggle between human and industrial usage, freshwater resources are becoming limited. Furthermore, the kind and quantity of dissolved salts had a major impact on the quality of saline water. Irrigating crops using diluted seawater helps conserve freshwater resources and can be used to successfully grow crops in certain situations. Plants irrigated with saline water had higher salt concentrations in the soil, which harmed plant growth and output. To address this issue, salt-affected soils are being recovered using a variety of inorganic (gypsum, limestone, sulfuric acid, and derivatives of sulfur, synthetic fertilizers) and organic (green and farmyard manure, industrial waste such as press mud) techniques. So far, inorganic (gypsum, limestone, sulfuric acid and derivatives of sulfur, synthetic fertilizers) and organic (green and farmyard manure, industrial waste such as press mud) techniques have been used to reclaim such soils [7]. Plant breeders and biotechnologists are also constantly battling to generate salt-tolerant crop varieties, whether through natural selection, QTL mapping, marker-assisted selection, or genetic modification through the insertion of salt-tolerant genes from other animals [8]. However, due to a variety of circumstances, such biological methods for stress tolerance augmentation in agro-economically important crops have not shown satisfying results at the field level [9].

To manage salt-affected soils, a variety of measures can be applied through well-established procedures, such as sufficient drainage and the application of amendments. Other options include green manuring, mulching, and salt scraping, along with new technologies such as phytoremediation and bio-saline agriculture that offer a way to grow salt-tolerant crops in adverse conditions. Biochar application reduces soil electrical conductivity and exchangeable Na percentages to an acceptable range. The microbial and biological activity of sodic soils has been reported to improve when they are covered by trees, grasses, or any cultivable crops. Those agronomic interventions can improve the biological, physical, and chemical properties of the problem soil, which ultimately leads to an increase in crop productivity and sustainable yield. It is necessary to develop salt stress-tolerant crop varieties through breeding and plant genetic modification, but this is a time-consuming process, while agronomic interventions

to relieve stress might be a more cost-effective and eco-friendly approach that could be framed in a shorter period. Hence, to restore agricultural production under constrained resource conditions, it is necessary to integrate soil, water, forest, and biological resources and adopt these practices in an integrated manner that would be a greater step toward the restoration of problem soils [10].

Material and Methods

Site Description

The research work presented in this thesis has been conducted in the Department of Soil and Environmental Sciences at Ghazi University, Dera Ghazi Khan. This work has been carried out to explore the role of salt stress on the morpho-physiological response of wheat genotypes. A pot experiment was conducted at the experimental site at Ghazi University, Dera Ghazi Khan, during the month of December 2020. The geographical location of Dera Ghazi Khan is 30.060° latitude and 70.63° longitude, with an elevation of 129 meters above sea level. The summer is hot, with the temperature going to 45ºC. whereas the winter is pleasant and mild. The average annual rainfall is 80 mm, and soil varies from sandy loam to loam. A number of experiments are designed to achieve the objectives outlined below. A description of the experimental design is provided below.

Growth Conditions and an Experimental Plan

Seed Source

Four exotic wheat genotypes were used in this trial, obtained from CIMMYT (Mexico) (International Maize and Wheat Improvement Center), and their details are as follows:

G_1: GU0133
G_2: GU0108
G_3: GU0112
G_4: GU0128

Experimental Design

A set of four exotic wheat genotypes was sown in pots (Height-30cm, Diameter-55cm) in three replicates in a Factorial Completely Randomized Design. Sowing was done in the Department of Soil and Environmental Sciences at Ghazi University, Dera Ghazi Khan, in a Factorial Completely Randomized Design (CRD).

Methods to Develop Salinity

Dry soil salinity was developed in the soil with the calculated amounts of Nacl along with the control condition, and 7 kg of soil was filled in each pot. The salt was calculated on the basis of this formula.

$$\text{Amount of NaCl (g)} = \frac{ECe * 10 * Equivalent\ weight\ of\ Nacl * Saturation\ \%}{1000}$$

The amount of NaCl (g) was calculated for the different treatment levels, and their details are as follows:

T_1: Control (without salt)
T_2: 6 dsm^{-1} (4.06g /pot)
T_3: 9 dsm^{-1} (8.54 g /pot)
T_4: 12 dsm^{-1} (12.95 g /pot)

Physical Parameters

Plant Height (cm)

Plant height was determined at the harvesting stage by a meter scale in (cm). At the lower point of the plant/ shoot, the meter scale was adjusted and the length of the plant was measured.

Shoot, Root, and Spike Length (cm)

At the harvesting stage, shoot length was measured in (cm). Root length was measured in (cm) by adjusting the meter scale near the root tip of the plant, and spike length was controlled by utilizing the meter scale.

Shoot and Root Fresh Weight (G $Plant^{-1}$)

Shoot fresh mass was calculated in (g) after the harvesting. With the help of the scissors, the root and shoot portions were cut, and by using the digital weighing balance, the shoot fresh weight was calculated in g $plant^{-1}$. After the shoot fresh weight was calculated, the root fresh weight was recorded by the digital balance in g $plant^{-1}$.

Shoot and Root Dry Weight (G $Plant^{-1}$)

The number of tillers was measured by manually counting the tillers $plant^{-1}$. After keeping the fresh root sample in an oven at a constant temperature 65°C for 72 hours after measuring the fresh weight, the dry weight of the roots was recorded using a digital balance in g plant.

Number of Tillers, Spikelets, Leaves, and Grains Per Plant

Shoot dry weight was recorded by keeping the sample at 65ºC for 72 hours. For this process, the shoots were fully dried until there was no moisture content left. The shoot dry weight was then recorded in g $plant^{-1}$. The number of spikelets in $plant^{-1}$ was counted manually at the growth stage of the plant, and the number

of leaves in plant^{-1} was counted manually. The number of grains was also measured manually by counting every spikelet.

1000 Grain Weight (Plant^{-1})

1000 grain weight was measured by weighing 100 grains of every replicate and then multiplying by 10.

Biochemical Parameters

Chlorophyll Content

Chlorophyll contents were measured using the chlorophyll meter. The final readings were taken in the spade units. For this purpose, the 4th fully extended leaf was selected, and readings were taken (spade value) (Naus et al., 2010, and Uchino et al., 2013).

Membrane Stability Index

According to Sairam et al. 1994, the leaf membrane stability index was measured. For this purpose, leaf discs were cut into pieces (100 mg) and washed carefully in running tap water, followed by washing the leaves with distilled water. In test tubes, 10 ml of double distilled water was added, and leaf discs were placed in them. These test tubes were placed in the water bath for 30 minutes at 40ºC. After this, with the help of an electrical conductivity meter (C_1). Quickly again, Ece was determined by placing the same sample in the water bath at 100ºC for 10 minutes. The following formula was used to calculate the MSI:

$$MSI\ (\%) = [1-(C_1/C_2)] \times 100$$

Plant Chemical Analysis

Potassium Content (m mol g^{-1})

Digestion of the plant sample was taken. A dry sample of 0.1 g was taken from each wheat genotype leaf in an individual digestion tube. In each digestion tube, 10 ml of di-acid (3.33 ml of $HClO_4$ and 6.67 ml of HNO_3) was added and placed overnight at room temperature to facilitate digestion. This tube was shaken for complete dissolution of the parts of the plant. The digestive material was heated at a low temperature on the stove, and smoke was generated. The tube was heated until the material became colorless. The tube was removed from the stove and allowed to cool. To each colorless digestive material, a minimum quantity of distilled water was added so that the filtration process could be performed. The volume of the extract is 100 ml in a volumetric flask for each sample. The filtrate was used to determine the potassium content of the leaf with a flame photometer, according to the ACARDA Manual (2013).

Sodium Content (m mol G^{-1})

The digestion of the plant sample was done. A 0.1 g dry sample was taken from each wheat genotype leaf in an individual digestion tube. In each digestion tube, 10 ml of di-acid (6.67 ml of HNO_3 and 3.33 ml of $HClO_4$) was added and placed overnight at room temperature until digestion. This tube was shaken for complete dissolution of the parts of the plant. The digestive tract was heated at a low temperature on the stove, and smoke was generated. The tube was heated until the material became colorless. The tube was removed from the stove and allowed to cool. A minimum distilled water amount was added to every colorless digestive material so that the filtration process could be performed. The extract volume is 100 ml in a volumetric flask for each sample. The filtrate was used to measure the sodium content of the leaf with a flame photometer, according to the ACARDA Manual, 2013.

K^+ / Na^+ Ratio

The K^+ /Na^+ ratio was determined by dividing potassium over sodium. The K^+ /Na^+ ratio = potassium/sodium.

Soil Analysis

The various analytical procedures used for soil were analyzed based on methods described in the ACARDA Manual (2013). For the determination of the basic analysis of soil, it analyzes soil EC, soil pH, and saturation percentage.

Electrical Conductivity (EC)

For the determination of EC, 5 g soil was taken in the beaker, and 50 ml water was added. On a rotary shaker, shake the contents for one hour. Leave the sample for some time. After the calibration of the electrical conductivity meter, the EC of soil suspension was determined. The cell constant was determined by the following formula:

$$\text{Cell constant (k)} = \frac{1.4118 ds/m}{observed\ Ece}$$

pH of Soil Suspension (1:1)

The pH of the soil water suspension (1:1) was measured by a pH meter after leaving the sample for two hours. 50 g air-dried soil was weighed in a beaker, and 50 ml distilled water was added to form soil suspension. Then, after stirring the suspension, the electrode of the pH meter was inserted to take the reading after 30 seconds. Before taking the reading by pH meter, it was standardized with buffer solutions of pH 7.0, pH, 4.0, and pH 10.0.

Soil Texture

50 g soil was taken in the plastic beaker. After that, a soil paste was made by adding the water with the help of a burette and shaking the contents with the help of a spatula. When the soil paste was prepared, a reading of water was taken using a burette. Multiply the reading of water used by 2. The ml of water used was compared with the criteria that classified the soil into different classes.

Saturation Percentage (%)

A constant and permanent weight was measured with soil saturated pastes after oven drying at 105ºC, and with the use of the below information, saturation % was determined as:

$$\text{Saturation Percentage (\%)} = \frac{oven\ dried\ weight}{Dried\ from\ oven\ of\ soil\ mass} * 100$$

The soil analysis results are shown in Table 1.

Statistical Analysis

Data was analyzed through a Factorial Completely Randomized Design followed by Steel et al. (1997), using statistics software 8.1. Significant variation ($P<0.05$) was recorded at the LSD test by comparing the treatments and genotypes.

Results and Discussion

The results of the morphological and biochemically related parameters of wheat genotypes grown under Nacl stress in a pot study are presented below:

Plant Height (cm)

Plant height is the most important parameter in plant growth. The results showed that there is a significant difference in plant height due to salinity. Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interaction for plant height (Fig. 1). Plant height is significantly reduced under saline conditions as compared to non-saline conditions.

Table 1. Soil analysis results for wheat.

Characteristics	Unit%	Value
Texture	-	Loam
ECE	dS m^{-1}	3.0
pH	-	7.50
Saturation percentage	%	3.6

In controlled conditions, the maximum plant height was measured in genotype G_2 (108) while genotypes G_3 (112) and G_4 (128) got the minimum plant height under non-saline levels. At 6dsm^{-1} saline, the condition genotype (108) achieved the maximum plant height, while the lowest plant height was recorded in genotype (133) at 6 dsm^{-1} as compared to the non-saline condition. At 9 dsm^{-1}, maximum plant height was measured in the genotype (108) while genotype (133) achieved the lowest plant height at 9dsm^{-1} as compared to the non-saline condition. At 12 dsm^{-1}, the maximum plant height was recorded for the genotype (108) while genotype (133) achieved the lowest plant height as compared to the non-saline condition. So, comparing the various salinity levels, there is a decrease of up to 50% in the plant height when exposed to 12 dsm^{-1} as compared to 6 and 9 dsm^{-1} salinity levels.

Shoot, Root, and Spike Length (cm)

Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interaction for the shoot length (Fig. 1). The results showed that there is a significant difference in the shoot length due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype G_2 (108) found the highest shoot length, and the lowest shoot length was recorded in genotype G_1 (133). The other two genotypes, (112 and 128), are found to be less salt sensitive and attain maximum shoot length as compared to the G_1 (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype G_2 (108) attains the maximum shoot length at that level, a little reduced shoot length of G_2 (108) as compared to the non-saline condition. G_1 (133) genotype at that level of salinity found less shoot length. In 9 and 12 dsm^{-1} genotypes, G_2 (108) was reduced in shoot length as compared to the non-saline condition, while G_1 (133) achieved less shoot length. So, the overall results showed the wheat genotype G_2 (108) achieved the maximum shoot length and reduced little spike length at 6, 9, and 12 dsm^{-1} in saline environments. While the genotypes G_3 (112) and G_4 (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1}, at all salinity levels, G_1 (133) was found to be a salt sensitive genotype and reduced shoot length at all these levels at the highest position. Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the root length shown in Fig. 1. Root length decreased when the saline stress increased. The results showed that there is a significant difference in the root length due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype G_2 (108) found a significant root length, and the lowest root length was recorded in genotype G_1 (133). The other two genotypes, G_3 (112) and G_4 (128) are found to be less salt-sensitive and attain maximum root length as compared to the G_1 (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment,

wheat genotype G_2 (108) attains the maximum root length at that level, with a slightly reduced root length of G_2 (108) as compared to the non-saline condition. G_1 (133) genotype at that level of salinity found less root length. In 9 and 12 dsm^{-1} genotype G_2 (108) was reduced in root length as compared to the non-saline conditions, while G_1 (133) achieved root length. So, the overall results showed the wheat genotype G_2 (108) achieved the maximum root length and reduced little root length at 6, 9, and 12 dsm^{-1} in saline environments. While the genotypes G_3 (112) and G_4 (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels,

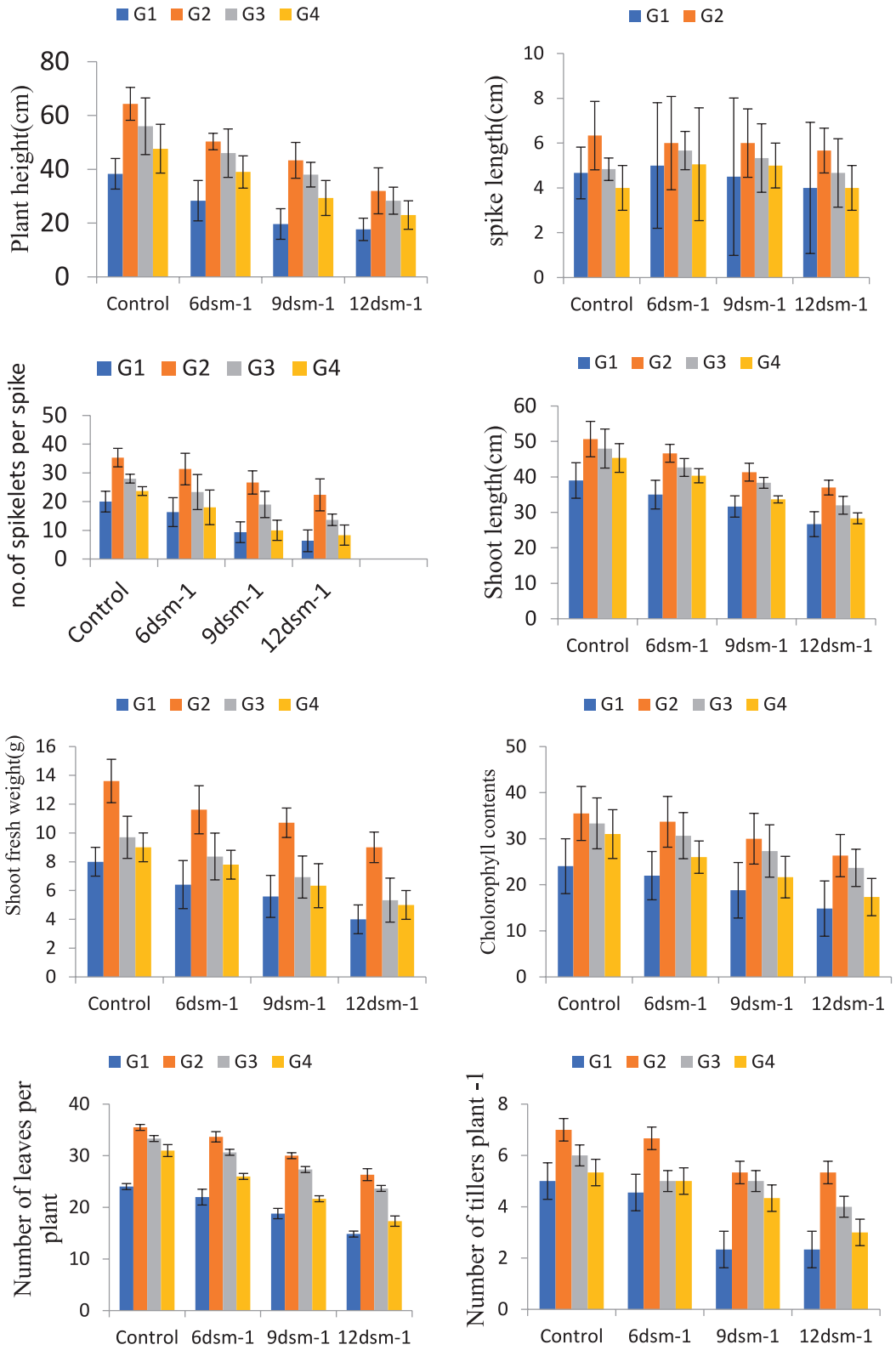

Fig. 1. Effect of Nacl stress on different set of parameters on different wheat genotypes

G_1 (133) was found to be a salt sensitive genotype and reduced root length at all these levels due to a high Na^+ concentration. Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interaction for the spike length (Fig. 1). The results showed that there is a significant difference in the spike length due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt genotype, G_2 (108) found the highest spike length, and the lowest spike length was recorded in genotype G_1 (133). The other two genotypes, G_3 (112) and G_3 (128) are found to be less salt sensitive and attain maximum spike length as compared to the G_1 (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype G_2 (108) attains the maximum spike length at that level, with a little reduced spike length of G_2 (108) as compared to the non-saline condition. G_1 (133) genotype at that level of salinity found less spike length. In 9 and 12 dsm^{-1} genotypes, G_2 (108) has a reduced spike length as compared to the non-saline condition, while G_1 (133) achieved a shorter spike length. So, comparing the overall results, the wheat genotype G_2 (108) achieved the maximum spike length and reduced little spike length at 6, 9, and 12 dsm^{-1} saline stress. While the genotypes G_3 (112) and G_3 (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, G_1 (133) was found to be a salt sensitive genotype and reduced spike length at all these levels up to 50%.

Shoot and Root Fresh Weight (g)

Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the shoot fresh weight shown in Fig. 3. The results showed that there is a significant difference in the shoot fresh weight due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype G_2 (108) found the highest shoot fresh weight, and the lowest shoot length was recorded in genotype G_1 (133). The other two genotypes (112 and 128) are found to be less salt sensitive and

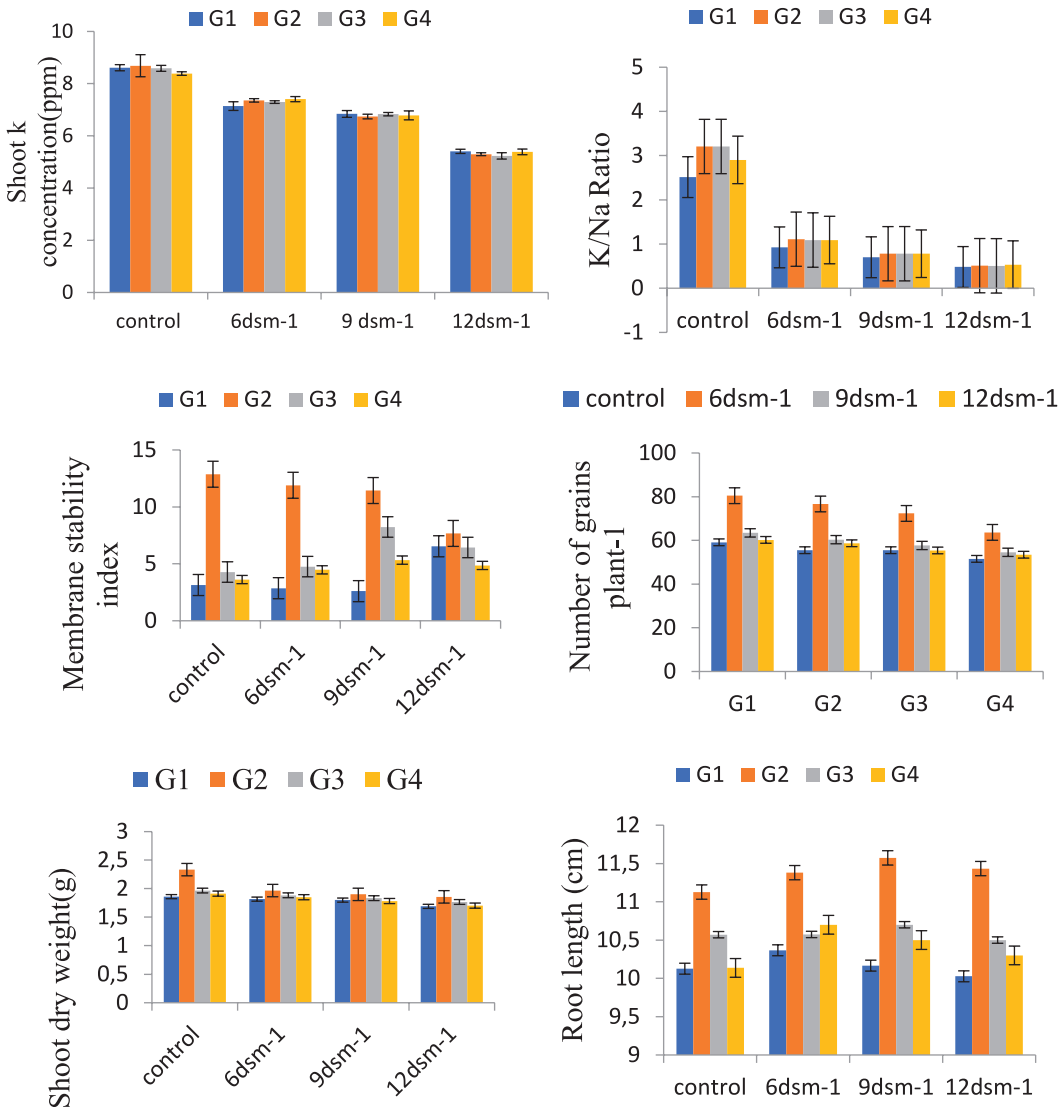

Fig. 2. Effect of Nacl stress on different parameters on wheat genotypes under different salt levels.

attain maximum shoot fresh weight as compared to the G_1 (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype G_2 (108) attains the maximum shoot fresh weight. At that level, a little reduced shoot fresh weight of G_2 (108) is observed as compared to the non-saline condition. G_1 (133) genotype at that level of salinity found less shoot fresh weight. In 9 and 12 dsm^{-1} genotypes, G_2 (108) reduced shoot fresh weight as compared to the non-saline condition, while G_1 (133) achieved less shoot fresh weight. So, the overall results showed the wheat genotype G_2 (108) achieved the maximum shoot fresh weight and reduced little shoot fresh weight at 6, 9, and 12 dsm^{-1} in saline environments. While the genotypes G_3 (112) and G_4 (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, G_1 (133) was found to be a salt sensitive genotype and reduced shoot fresh weight at all these levels at the highest position. Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the root fresh weight are shown in Fig. 1. Shoot fresh weight decreased when the saline stress increased. The results showed that there is a significant difference in the root fresh weight due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype G_2 (108) found the most significant root fresh weight, and the lowest root fresh weight was recorded in genotype G_1 (133). The other two genotypes, G_3 (112) and G_4 (128) are found to be less salt sensitive and attain maximum root fresh weight as compared to the G_1 (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype G_2 (108) attains the maximum root fresh weight. At that level, little reduced root fresh weight of G_2 (108) as compared to the non-saline condition. G_1 (133) genotype at that level of salinity found less root fresh weight. In 9 and 12 dsm^{-1} genotypes, G_2 (108) was reduced in root fresh weight as compared to the non-saline condition, while G_1 (133) achieved root fresh weight. So, the overall results showed the wheat genotype G_2 (108) achieved the maximum root fresh weight and reduced little root length at 6, 9, and 12 dsm^{-1} in saline environments. While the genotypes G_3 (112) and G_4 (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, G_1 (133) was found to be a salt sensitive genotype and reduced root fresh weight at all these levels due to high stress.

Shoot and Root Dry Weight (g)

Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the shoot dry weight (g) (Fig. 1). The results showed that there is a significant difference in the shoot dry weight due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotypes (108) found the highest shoot dry weight, and the lowest shoot dry weight were recorded in the genotype (133). The other two genotypes, (112 and 128), are found to be less salt sensitive and attain maximum shoot dry weight as compared to the (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype (108) attains the maximum shoot dry weight at that level with a slightly reduced shoot dry weight of (108) as compared to the non-saline condition. (133) genotype at that level of salinity found less shoot dry weight. In the 9 and 12 dsm^{-1} genotypes, (108) reduced shoot dry weight as compared to the non-saline condition, while

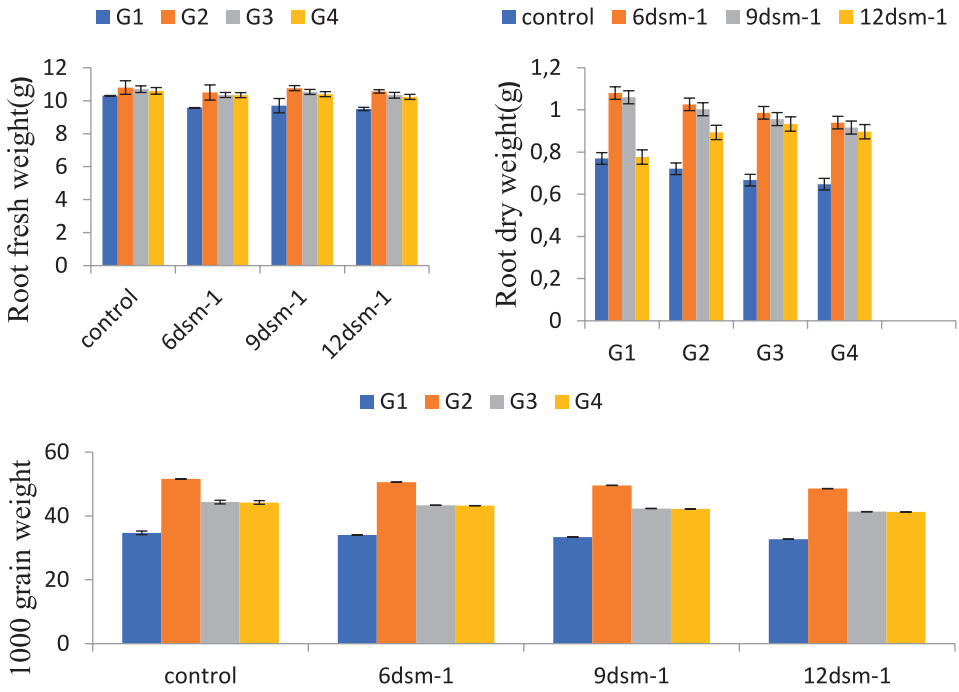

Fig. 3. ANOVA showing the results of effects of salinity on number of leaves ($plant^{-1}$ on wheat genotypes under different saline treatment.

(133) achieved less shoot dry weight. So, comparing the overall results, the wheat genotype (108) achieved the maximum shoot dry weight and reduced little shoot dry weight at 6, 9, and 12 dsm^{-1} saline stress. While the genotypes (112) and (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, (133) was found to be a salt sensitive genotype and reduced shoot dry weight at all these levels up to 50%. Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the root dry weight are shown in Fig. 1. Root dry weight decreased when the saline stress increased. The results showed that there is a significant difference in the root dry weight due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype G_2 (108) found the most significant root dry weight, and the lowest root dry weight was recorded in genotype G_1 (133). The other two genotypes, G_3 (112) and G_4 (128) are found to be less salt sensitive and attain maximum root dry weight as compared to the G_1 (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype G_2 (108) attains the maximum root dry weight. At that level, a little reduced root dry weight of G_2 (108) is observed as compared to the non-saline condition. The G_1 (133) genotype at that level of salinity found less root dry weight. In 9 and 12 dsm^{-1} genotypes, G_2 (108) was reduced in root dry weight as compared to the non-saline condition, while G_1 (133) achieved root dry weight. So, the overall results showed the wheat genotype G_2 (108) achieved the maximum root dry weight and reduced little root dry weight at 6, 9, and 12 dsm^{-1} in saline environments. While the genotypes G_3 (112) and G_4 (128) are less affected by salinity stress at 6, 9, and 12 $dsm^{-1,}$ at all salinity levels, G_1 (133) was found to be a salt sensitive genotype and reduced root dry weight at all these levels.

Number of Tillers, Spikelets, Leaves, and Grains per Plant

Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the number of tillers shown in Fig. 1. The number of tillers decreased when the saline stress increased. The results showed that there is a significant difference in the number of tillers due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype G_2 (108) found the highest number of tillers, and the lowest number of tillers were recorded in genotype G_1 (133). The other two genotypes, G_3 (112) and G_4 (128) are found to be less salt sensitive and attain the maximum number of tillers as compared to the G_1 (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment wheat genotype, G_2 (108) attains the maximum number of tillers at that level, with a slightly reduced number of tillers of G_2 (108) as compared to the non-saline condition. The G_1 (133) genotype at that level of salinity found fewer tillers. In 9 and 12 dsm^{-1} genotypes, G_2 (108) reduced the number of tillers as compared to the non-saline condition, while G_1 (133) achieved the maximum number of tillers. So, the overall results showed the wheat genotype G_2 (108) achieved the maximum number of tillers and reduced tillers at 6, 9, and 12 dsm^{-1} in saline environments. While the genotypes G_3 (112) and G_4 (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, G_1 (133) was found to be a salt sensitive genotype and reduced the number of tillers at all these levels at the highest position. Our data revealed that the number of tillers was lowest due to salt stress, which may limit the production of tillers and cause abortion in later stages of growth. Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the number of spikelets are shown in Fig. 1. There is a significant decrease in the number of spikelets that grow in the saline condition as compared to the non-saline environment. The results showed that under normal saline conditions, 6 and 9 dsm^{-1} genotypes G_1 (108) have the highest number of spikelets as compared to the other genotypes, and the lowest number of spikelets was recorded in genotype G_1 (133) as compared to the non-saline levels. But when increasing the concentration of salinity, there is a decrease in the number of spikelets up to 50% as compared to the non-salinity condition. Under high saline conditions, 12 dsm^{-1} had the lowest number of spikelets in genotype G_1 (133), and the highest was recorded in genotype G_2 (108). The other two genotypes, G_3 (112) and (G_4), have the minimum number of spikelets as compared to the non-saline. The overall results showed that the highest number of spikelets were observed in genotype (G_2) (108), which is the salt tolerant genotype, and the lowest were measured in G_1 (133) up to the highest extent as compared to the non-saline environments. Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the number of leaves shown in Fig. 1. The number of leaves decreased when the saline stress increased. The results showed that there is a significant difference in the number of leaves due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype G_2 (108) found the highest number of leaves, while the lowest number of leaves was recorded in genotype G_1 (133). The other two genotypes, G_3 (112) and G_4 (128) are found to be less salt sensitive and attain the maximum number of leaves as compared to the G_1 (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype G_2 (108) attains the maximum number of leaves at that level, with a slightly reduced number of leaves in G_2 (108) as compared to the non-saline condition. The G_1 (133) genotype at that level of salinity found fewer leaves. In 9 and 12 dsm^{-1} genotypes, G_2 (108) had a reduced number of leaves as compared to the non-saline condition, while G_1 (133) achieved a higher number of leaves. The overall results showed the wheat genotype G_2 (108) achieved the maximum number of leaves and reduced fewer leaves

at 6, 9, and 12 dsm^{-1} in saline environments. While the genotypes G_3 (112) and G_4 (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, G_1 (133) was found to be a salt sensitive genotype and reduced the number of leaves at all these levels at the highest position. Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the number of grains in plant [1] (Fig. 2). The results showed that there is a significant difference in the number of grains $plant^{-1}$ due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype (108) found the highest number of grains in $plant^{-1}$, and the lowest number of grains in $plant^{-1}$ was recorded in genotype (133). The other two genotypes, (112 and 128), are found to be less salt sensitive and attain the maximum number of grains in $plant^{-1}$ as compared to the (133) genotype. At 6 dsm^{-1}, a low salinity treatment wheat genotype (108) attains the maximum number of grains in $plant^{-1}$. At that level, a slightly reduced number of grains in $plant^{-1}$ (108) is observed as compared to the non-saline condition. The (133) genotype at that level of salinity found fewer grains in $plant^{-1}$. In 9 and 12 dsm^{-1} genotypes, (108) reduced the number of grains in $plant^{-1}$ as compared to the non-saline condition, while (133) achieved fewer grains in $plant^{-1}$. So, comparing the overall results, the wheat genotype (108) achieved the maximum number of grains in $plant^{-1}$ and reduced fewer grains in $plant^{-1}$ at 6, 9, and 12 dsm^{-1} saline stress. While the genotypes (112) and (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, (133) was found to be a salt sensitive genotype and reduced the number of grains in $plant^{-1}$ at all these levels by up to 50%.

1000 Grain Weight ($Plant^{-1}$)

Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the 1000 grain weight are shown in Fig. 1. The 1000 grain weight decreased when the saline stress increased. The results showed that there is a significant difference in the 1000 grain weight due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype G_2 (108) found a significant 1000 grain weight, and the lowest 1000 grain \ weight was recorded in genotype G_1 (133). The other two genotypes, G_3 (112) and G_4 (128), are found to be less salt sensitive and attain a maximum 1000 grain weight compared to the G_1 (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype G_2 (108) attains the maximum 1000 grain weight at that level, with a slightly reduced 1000 grain weight of G_2 (108) as compared to the non-saline condition. The G_1 (133) genotype at that level of salinity found less for the 1000 grain weight. In 9 and 12 dsm^{-1} genotypes, G_2 (108) had a reduced 1000 grain weight as compared to the non-saline condition, while G_1 (133) achieved 1000 grain weight. So, the overall results showed that the wheat genotype G_2 (108) achieved the maximum 1000 grain weight and minimally reduced 1000 grain weight at 6, 9, and 12 dsm^{-1} in saline environments. While the genotypes G_3 (112) and G_4 (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, G_1 (133) was found to be a salt sensitive genotype and reduced 1000 grain weight at all these levels due to high saltiness.

Chlorophyll Content

Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the chlorophyll contents shown in Fig. 1. The chlorophyll contents decreased when the saline stress increased. The results showed that there is a significant difference in the chlorophyll contents due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype G_2 (108) found the highest chlorophyll contents and the lowest chlorophyll contents were recorded in genotype G_1 (133). The other two genotypes, G_3 (112) and G_4 (128) are found to be less salt sensitive and attain maximum chlorophyll contents as compared to the G_1 (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype G_2 (108) attains the maximum chlorophyll contents at that level, with little reduced chlorophyll contents of G_2 (108) as compared to the non-saline condition. Then G_1 (133) genotype at that level of salinity found fewer chlorophyll contents. In 9 and 12 dsm^{-1} genotypes, G_2 (108) had reduced chlorophyll contents as compared to the non-saline condition, while G_1 (133) achieved less chlorophyll contents. So, the overall results showed that the wheat genotype G_2 (108) achieved the maximum chlorophyll contents and reduced chlorophyll contents at 6, 9, and 12 dsm^{-1} in saline environments. While the genotypes G_3 (112) and G_4 (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, G_1 (133) was found to be a salt sensitive genotype with reduced chlorophyll content weights at all these levels at the highest position.

Membrane Stability Index (MSI)

Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the membrane stability index (Fig. 1). The results showed that there is a significant difference in membrane stability index due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype (108) found the highest membrane stability index and the lowest membrane stability index was recorded in the genotype (133). The other two genotypes, (112 and 128), are found to be less salt sensitive and attain maximum spike length as compared to the (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype (108) attains the maximum membrane stability index at

that level, with a reduced membrane stability index of (108) as compared to the non-saline condition. The (133) genotype at that level of salinity found less spike length. In 9 and 12 dsm^{-1} genotypes, (108) had a reduced membrane stability index as compared to the non-saline condition, while (133) achieved a lower membrane stability index. So, comparing the overall results, the wheat genotype (108) achieved the maximum membrane stability index and reduced the smaller membrane stability index at 6, 9, and 12 dsm^{-1} in saline stress. While the genotypes (112) and (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, (133) was found to be a salt sensitive genotype and reduced the membrane stability index at all these levels up to a higher level.

Plant Chemical Analysis

Shoot Na^+

Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the shoot Na^+ shown in Fig. 2. Shoot Na^+ increased when the saline stress increased. The results showed that there is a significant difference in shoot Na^+ due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype G_2 (108) found the highest growth, where all genotypes retain normal development. The other two genotypes, G_3 (112) and G_4 (128) are found to be less salt sensitive and attain maximum shoot Na^+ as compared to the G_1 (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype G_2 (108) attains the lowest shoot Na^+ at that level, with a little reduced shoot Na^+ of G_2 (108) as compared to the non-saline condition. The G_1 (133) genotype at that level of salinity found maximum shoot Na^+. In 9 and 12 dsm^{-1} genotypes, G_2 (108) had reduced shoot Na^+ as compared to the non-saline condition, while G_1 (133) achieved the greatest shoot Na^+. So, the overall results showed the wheat genotype G_2 (108) achieved the smallest shoot Na^+ with reduced growth at 6, 9, and 12 dsm^{-1} in saline environments. While the genotypes G_3 (112) and G_4 (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, G_1 (133) was found to be a salt sensitive genotype and increased shoot Na^+ at all these levels at the highest yield loss.

Shoot K^+

Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for shoot k^+ (Fig. 2). The shoot K+ interest in all wheat genotypes decreased because the salinity in the increasing medium increased on this test. The results showed that there is a significant difference in the shoot K+ concentration due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype (108) found the highest shoot K+. The other two genotypes, (112 and 128), are found to be less salt sensitive and attain maximum results compared to the (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype (108) attains the maximum shoot K+ at that level, with a little reduced shoot length of (108) as compared to the non-saline condition. The (133) genotype at that level of salinity found fewer shoots. In 9 and 12 dsm^{-1} genotypes, (108) reduced shoot K+ because when Na is increased in the soil, the K+ concentration decreases in the soil, and plants get less K+ as compared to the non-saline condition. While (133) achieved more K+. So comparing the overall results, the wheat genotype (108) achieved the maximum K+ and reduced K+ concentrations at high salinity induced levels at 6, 9, and 12 dsm^{-1} in saline stress. While the genotypes (112) and (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, (133) was found to be a salt sensitive genotype and reduced K+ at all these levels up to 50%.

Na^+/K^+ Ratio

Significant variation ($P<0.05$) was recorded among the genotypes, treatments, and their interactions for the Na^+/k^+ ratio shown in Fig. 2. The results showed that there is a significant difference in the Na^+/k^+ ratio due to salt stress as compared to the non-saline condition. In the non-saline condition, which contains no salt, genotype (108) found the highest Na^+/k^+ ratio and the lowest Na^+/k^+ ratio was recorded in genotype (133). The other two genotypes, (112 and 128), are found to be less salt sensitive and attain the maximum Na^+/k^+ ratio as compared to the (133) genotype. At 6 dsm^{-1}, which is a low salinity treatment, wheat genotype (108) attains the maximum Na^+/k^+ ratio at that level, with a minimally reduced Na^+/k^+ ratio of (108) as compared to the non-saline condition. The (133) genotype at that level of salinity found less growth. In 9 and 12 dsm^{-1} genotypes, (108) was reduced Na^+/k^+ as compared to the non-saline condition, while (133) achieved less Na^+/k^+ So comparing the overall results, the wheat genotype (108) achieved the maximum Na^+/k^+ and reduced spike length at 6, 9, and 12 dsm^{-1} in saline stress. While the genotypes (112) and (128) are less affected by salinity stress at 6, 9, and 12 dsm^{-1} at all salinity levels, (133) was found to be a salt sensitive genotype and reduced Na^+/k^+ at all these levels up to 50%.

The assumption of the present study related to the adverse effect of salinity on plant biomass was also confirmed by [11]. Similarly, [12] also revealed that under salinity stress, susceptible plants persist in underdevelopment due to a decrease in cell division and elongation and also limit the synthesis of growth hormones (auxin), which leads to a decrease in the total biomass of the affected plant. Furthermore, seed number per spike was calculated among tolerant accessions and varieties only, where we found a significant reduction in this trait. However, for the remaining plants, this value was equal to zero.

These results were explained by the way that NaCl stressed wheat during the apex vegetative stage had a shorter spikelet development stage that resulted in fewer spikelets per spike, which led to a reduced number of grains per spike [13]. The decrease in the number of grains is the major cause of grain yield reduction under salt stress, which may be due to ionic toxicity and osmotic stress created by the excessive salts present in the growth medium [14]. It is well documented that lower Na^+ uptake and higher K^+ uptake are the key indicators of salinity tolerance in higher plants. In the present study, the Na^+ /K^+ ratio in the leaves, roots, and stems of the genotype was significantly lower. When exposed to salinity stress, K^+ concentration in the leaves, roots, and stems of both genotypes decreased significantly, whereas Na^+ concentration significantly increased, ultimately causing an increase in the ratio of Na^+/K^+, which resulted in a serious deterioration of the ionic homeostasis in the leaves, roots, and stems of affected plants. Among the genotypes, the K^+ concentration was not changed, but the Na^+ concentration and the Na^+/K^+ ratio were changed, and a higher change was found in one genotype than the other. It is indicated that the genotype is sensitive to salinity stress as a result of a greater accumulation of Na^+ concentration and the Na^+/K^+ ratio, causing serious visible injury signs in the leaves, roots, and stems of affected plants, whereas the genotype was found to be tolerant and did not show any signs of injury under salinity stress. The shoot K+ activity in all wheat genotypes was reduced as the salinity in the growth medium was raised in this test. Due to an ionic interaction between K^+ uptake in crops and external Na^+ content, the concentration of K^+ was lowered due to the presence of excessive Na^+ in the growth medium [15]. In plants, K^+ uptake could be associated with the salinity tolerance mechanism [16], especially as K^+ is used in the osmotic regulation of plants and with the competition of Na^+ [17].

When present in high concentrations, Na+ is harmful to plants and affects a variety of metabolic activities. Resistance was discovered in genotypes that could retain Na+ in their roots. Plants' ability to control Na+ transport into shoots is necessary for maintaining growth rates and protecting the metabolic process in elongating cells from oxidative stress, Na+ has an influence. The findings of this study confirm those of [18] and [19], who showed that poor Na+ uptake and transport, as well as the retention of high K^+ /Na^+ in wheat shoots and leaves, are linked to salt resistance in wheat and other plant species. Wherever Na+ levels were present, they had a deleterious impact on grain yield. In wheat and other plant species, having a high K+/Na+ ratio in shoots or leaves is associated with salt tolerance. Although Na+ levels had a serious effect on grain yield, K+ values and the K+/Na+ ratio had a largely favorable impact on grain yield. The study findings are also similar to those of [20].

In our findings, the number of tillers was the lowest because of salt stress that may restrict the formation, and later stages of growth can cause the abortion of tillers. At 7.5dsm-1 salinity increases, most of the vegetative tillers of moderate salt tolerant genotypes were reduced, and the number of tillers was also the lowest at the highest level [21]. The number of tillers was greatly related to the salt stress levels. The reduction of aerial and root biomasses under the effect of high salt concentrations has been reported in both varieties by several authors [22]. We can explain the reduction of stalks and leaves under saline conditions in terms of the increase in temperature and the lack of water at the time of growth, which acts at the height of the stalks of wheat; or maybe the different populations tested have differences in the accumulation of mineral ions between different parts of the plant. Concerning plant growth, the general effect of salinity is reflected in the reduction of biomass, and it can be explained by ionic problems [23]. Observation of the chlorophyll contents (a), (b), and carotenoids showed that both varieties were negatively affected by salt stress. Indeed, the highest applied dose of NaCl (6 g/l, severe stress) reduced the chlorophyll content (a) in both varieties studied. Concerning chlorophyll (b) and carotenoids pigments, an identical effect was also noted, i.e., a decrease in their contents in both varieties treated. These results are in line with another study reported by [4]. On the other hand, the application of a moderate level of NaCl stress (6 g/l) induced a significant increase in the content of chlorophyll (a) in Viton and Gta varieties. The data showed that at a low level, there was a greater number of spikelets, but when Ece increased (12 dsm^{-1}) there was a greater reduction in the number of spikelets as compared to low salinity. During the vegetative growth of wheat, salinity caused shorter spikelets that resulted in the lower spikelets $plant^{-1}$, which is a reduction in the number of grains per spike [24]. The results showed that there is a significant difference in spike length among all genotypes. The effects of high salt stress caused a reduction (23.73%) in spike length compared to the low and medium stress conditions, as also described in [25]. There is no significant difference between the genotypes because wheat is a salt tolerant crop. Different morpho-physiological parameters in wheat show different responses, like plant height, which showed a crop salt tolerance response at the initial growth stages of wheat and can also be used for screening selection for salinity tolerance. The wheat genotypes showed a different response when exposed to varying salinity treatments [26]. It was concluded that the salt stress affected the plant height significantly.

Our results showed that root growth in length appears to be indifferent to salt stress, and it did not show a significant difference with salinity level, although the roots are the first contact site between the plant and the strong one. The emergence of the radical during germination would be controlled by the osmolality of the medium, while the subsequent growth of the seedlings would be limited by the mobilization and transport of the reserves towards the embryonic axis [27].

The growth parameters, including shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, and root dry weight, are more closely correlated with crop salt tolerance at the initial stages of growth and can serve as screening/selection criteria for salinity tolerance [28]. The growth, physiological, and ionic data of the current study indicated that genetic variation existed in the tested wheat genotypes for salt tolerance. The wheat genotypes responded differently to varying NaCl salinity levels. [29] reported that salinity affected plant growth processes, including reductions in plant height and fresh and dry weights of roots, stems, and leaves; lowered yield; and caused deterioration of the quality of the product. The increasing concentration of NaCl from 100 to 200 mM also significantly changed the shoot biomass of the used wheat genotypes. The reduction in fresh and dry biomass with increasing salinity can be attributed to a reduced photosynthesis rate and other physiological functions. The results are in agreement with [30]. The wheat genotypes showed a differential response to salt stress, which might be due to their differential genetic potential for salt tolerance. Under salt stress, variation in biomass production by different varieties has also been reported for other crops such as sunflower, maize, and barley [31]. It is well known that Na+ is toxic to plants and disrupts different metabolic activities when present at high concentrations. The genotypes that were able to retain Na+ in their roots were found to be tolerant. In the present study, with increasing salinity in the growth medium, the leaf K+ concentration decreased in all wheat genotypes. The concentration of K+ was decreased due to the presence of excessive Na+ in the growth medium because an antagonistic effect is found between K+ uptake in plants and external Na+ contents. Salt tolerance is reported to be associated with K+ contents in plants because of the involvement of K+ in osmotic regulation and competition with Na+ [32]. In the same concept, it was found that salt stress during tiller emergence can inhibit their formation and cause their abortion at later stages. Furthermore, when salinity levels are greater than 7.5 dSm^{-1} or 50 mM NaCl, most of the secondary tillers of moderately tolerant genotypes are eliminated, and their number is greatly reduced [4]. Furthermore, this trait was highly correlated with the number of tillers. Based on the results revealed in our work, we can conclude that the number of seeds per spike increased with the acuteness of salt stress. Furthermore, the seed's number per spike was calculated only among tolerant accessions and varieties, where we noticed a great reduction in this trait; however, for the remaining, this value was equal to zero.

These results were explained by the way that NaCl stressed wheat during the apex vegetative stage had a shorter spikelet development stage that resulted in fewer spikelets per spike, which led to a reduction in the number of grains per spike [33]. The results of this study mentioned that thousand kernel weight (TKW) is more affected by salt stress among sensitive genotypes than tolerant ones. In our work, we concluded that TKW was strongly reduced among different genotypes. Furthermore, according to this trait, it is essentially related to the duration of grain development.

In this study, the work on barley that reduced the grain yield under salt stress could be due to reduced efficiency per day to fill the grains and consequently more effective days and also to disturbed starch-sugar balance. Reduction in plant growth (plant height) due to salinity is commonly reported by many workers and most recently supported by [34], who also reported that the presence of salinity in the growth medium significantly decreased dry weight and plant height.

The decrease in plant height in wheat genotypes may be due to the presence of excessive salts in the root zone, which reduced water and essential nutrient uptake. The salinity stress adversely affected the number of grains per spike, grain weight per plant, and 1000 grain weight in all wheat genotypes. It seems that the growth and yield processes are very sensitive to salinity, and similar findings are also noted by [35], who all reported that salinity stress reduces growth, yield, and yield components. The decrease in the number of grains is the major cause of grain yield reduction under salt stress, which may be due to ionic toxicity and osmotic stress created by the excessive salts present in the growth medium. Salinity stress induced significant changes in Na+, K+ contents, and the K^+ /Na^+ ratio in all wheat genotypes. In the present study, K+ /Na+ were greater in the wheat genotype, followed by Bakhtawar, then others. Reduced Na+ uptake and improved K+ uptake are the key indicators of salinity tolerance in higher plants [36]. The ability of plants to limit Na+ transport into shoots is important for the maintenance of growth rates and protection of the metabolic process in elongating cells from the toxic effect of Na+. The results of this study were strengthened by the outcome of and who suggested that uptake and transport of low Na+ and maintenance of high K+ /Na+ in shoots or leaves are related to salt resistance in wheat and in some other plant species. Na+ contents showed a negative effect on grain yield wherever K+ contents and the K+ /Na+ ratio had a significant positive correlation with grain yield. The results of this study are also in accordance with the findings of [37].

The chlorophyll contents of genotypes were found to be negatively affected by salt stress. The highest applied dose of NaCl (12 dsm^{-1}, severe stress) did indeed reduce the chlorophyll content of the varieties studied. An identical effect was observed for chlorophyll (b) and carotenoids pigments, namely a decrease in their contents in both varieties. An identical effect was observed for chlorophyll, namely a decrease in their contents in both varieties treated. These findings are consistent with those of another study published by [38, 39]. The application of a moderate level of NaCl stress (12 dsm^{-1}) on the other hand, resulted in a significant increase in the content of chlorophyll in the plants.

Conclusions

The current study described that the plant height, shoot length, shoot fresh weight, shoot dry weight, root length, number of spikelets, number of grains (plant^{-1}), root fresh weight, root dry weight, 1000 grain weight chlorophyll contents, membrane stability index, shoot Na^+, and shoot K^+ are good parameters for the screening of the wheat genotypes for NaCl stress. According to all the above-determined data, it was concluded that genotype G_2 (108) is a salt tolerant genotype and can survive in a saline condition, while genotype G_1 (133) is a salt sensitive genotype to NaCl stress. These findings are a good source for plant breeders and plant physiologists engaged in the development of wheat salt tolerance genotypes. These salt tolerant genotypes should be used by breeding programmers for the development of the best genotype with the highest salt tolerance ability and the potential to grow on naturally salt affected soils.

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Conflict of Interest

The authors declare no conflict of interest.

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