# Growth and Yield Responses of Libyan Hard Wheat (*Triticum durum* Desf ) Genotypes to Salinity Stress

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## Abstract

*A pots experiment was conducted to evaluate salinity tolerance during vegetative and flowering stages for nine hard wheat genotypes (Triticum durum Desf ) in four treatments of salinity including (0 (control), 50, 100, and 150mM NaCl) with 4 replicated RCD. Results indicated that salinity stress caused a marked decrease in growth and yield-related parameters of wheat genotypes. However, few genotypes were superior to other genotypes in maintaining good growth under salinity stress. The study pointed out that plant height, tiller number,*

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*spike number plant$^{-1}$, dry weight plant$^{-1}$, grain yield plant$^{-1}$ and harvest index per plant were substantially reduced due to salinity stress. During vegetative and flowering growth stages, the application of NaCl salinity significantly affected the tiller and spike number of wheat genotypes, mainly at 100 and 150 mM NaCl but there was no significantly difference at the low salinity treatments. Spike number plant$^{-1}$ was more affected by salinity as compared to tiller number at all salinity levels. Grain yield showed considerable decrease with increasing salinity up to 150 mM NaCl. This reduction was more in Alkrm genotype as compared to Aboshock and Homera genotypes. Harvest index was significantly reduced by salinity stress. Nevertheless, the reduction was more pronounced in Alkrm than Aboshock. Among the 9 genotypes, (Aboshock, Jliledeep and Breka) were the most tolerant genotypes and (Alkrm and Mergawe) were the most sensitive genotypes. The study concludes that the effect of salinity on growth traits varied according to the salt tolerance of the genotypes. Yet, more experimental studies are still needed to obtain reliable data under filed condition for different growth stages.*

***Key words:*** *Hard wheat, salinity stress; grain yield, harvest index and salt tolerance index.*

## 1. Introduction

Soil and irrigation water salinity is a growing problem in agriculture causing a reduction of land area used for crop growing and decrease in crop yield [1, 2, 3]. Soil and irrigated water salinity are a worldwide problems that influences about 20 % of irrigated land and reduces crop yields significantly [4, 5]. In North Africa region particularly in Libya owing to an irrigation water shortage and a shallow underground water table in coastal zones, soil salinity is becoming a serious and complicated problem. Irrigation is considered to be an important sources of salinity, as it transports additional salts and releases immobilized salts into the soil through mineral dissolution and weathering [6, 7]. Salinity affects almost all stages of plant development including germination, vegetative growth and reproductive development [8, 9, 10]. Plant productivity is dependent on the availability of soil water, in terms of both quantity and quality. Also, salinity has a negative effect on soil physical properties and plant production [11]. Excess of salt concentrations in the root zone results in an increased osmotic stress in the soil solution and causing decrease in water availability to the plant [12, 13]. Soil salinity reduces the ability of water uptake of crop plants, due to increased amounts of $Na^+$ and $Cl^-$ in roots [14, 15]. Salinity, through reduction of soil water potential and ionic toxicity, dramatically reduces the photosynthetic rate [9], decreases in chlorophyll content [16], change in transpiration rate, and stomata conductance [17, 18]. Also, excess of salt concentrations around the root lead to considerable changes in different morphological and physiological traits at different stages of plant growth [18]. The adverse effects of salinity on plant development are more reflective during the reproductive stage [10]. Wheat plants stressed at 100-175 mM NaCl showed a significant reduction in spikelets per spike, delayed spike emergence and reduced fertility, which results in poor grain yields [19].

Hard wheat (*Triticum durum Desf* ) is an important crop cultivated in many arid and semi-arid areas across the world including North Africa. Currently, about 65 % of the wheat crop is used for food, 17 % for animal feed, and 12 % in industrial applications, including biofuels [20, 21]. To meet the demand, 40 percent more grain in 2020 is required [22]. Therefore, improvements in crop yields will be required to bring about the necessary production increases. Flowering stage (Feekes growth stage 10.5.1, Zadoks 62) initiates just a few day after heading is finished. When flowering begins, pollination will be completed in about four or five days [23]. Flowering stage is usually noted by extrusion of the anthers from each floret [24]. During this stage the spikelet per spike are determined by the number of flowers that are pollinated [25]. Flowering stage is extremely sensitive to abiotic stresses such as drought and salinity. Under severe stress, all of the florets in each spikelet of the head may terminate prior to flowering [26]. Salinity accelerates all phonological stages [27], decreases number of fertile tillers [28, 29], reduces the number of spikelet number per spike [30], kernel weight [29]. As a result, grain yield and plant biomass are reduced due to salinity stress. Also, the number of valuable ears per plant is the most critically affected yield component in wheat under saline conditions [31, 32]. Higher plants, such as wheat and barley have developed some survival mechanisms to enhance their tolerance to salinity stress [9, 33, 34]. High salinity resistant genotypes can retain a better water status and reduce the effects of salt induced osmotic stress by control of ion uptake by roots [35].One of the most effective and practical ways to maintain wheat production under salinity conditions is to improve the tolerance of wheat genotypes to salt stress [9]. Therefore, this experiment was conducted to appraise variation in the salinity tolerance potential of nine wheat genotypes at different growth stages and to test the comparative performance of multivariable growth and yield parameters as screening criteria for evaluating the salinity tolerance of wheat genotypes.

## 2. Materials and Methods

This study was conducted in semi-controlled environment facilities at Joddam farm in Zawia city and lab work was done at plant science department, university of Az Zawia. Experiment was conducted in fall of 2018 to determine the effect of salinity stress on plant growth and yield.

### 2.1. Plant Materials

Seeds of nine Libyan hard wheat genotypes including: (Alqara, Mrjawy, Aboshock, Berka, Homera, Jlildeeb, Bohot 107, Alneaama, and Alkrm) obtained from Libyan National GenBank in Tajoura were used in this study.

### 2.2. Experimental and Treatment Conditions

A pots experiment based on randomized complete design (RCD) with four replications was employed. The experiment was conducted in field with rainfall shelter. The experiment consisted of nine hard wheat genotypes and four salinity treatments (0, 50, 100 and 150mM NaCl) with electric conductivity [EC] value of < 0.7, 4.8, 10.6 and 15.9 $dSm^{-1}$). Sandy -loamy soil was collected from the soil surface (0-10 cm). The soil was passed through a 2-mm mesh screen, and thoroughly mixed and filed in 15L pots, 14kg of soil in each pot (**36**). Twenty healthy seeds of wheat were sown in each pot and irrigated with tap water as needed. After seedling establishment, seedlings were thinned to 14 seedlings per pot.

Pots were divided into four sets each set represent a treatment. At the jointing stages, one set of plants were irrigated with fresh water (no added NaCl) (500mL/ pot) and served as absolute control and the other three sets served as salinity treatments (50, 100 150mM NaCl). Salinity stress was induced by irrigating with saline solution prepared with fresh water and NaCl. Salinity treatments were applied by irrigating each pot with 500mL of NaCl solution to all treated plants and as mentioned above for 15days (3 times). 5 days of salinity stress imposition four plants from each pot were harvested for data collection and the rest of plants were irrigated with fresh water as needed till plants attained booting stage. At the onset of booting stages (Feekes growth stage 10.0), the same set was served as absolute control was irrigating with fresh water (no added NaCl) (500mL/ pot) and the other three sets served as salinity treatments (50, 100 and 150mM NaCl) as mentioned above. Salinity stress was induced by irrigated with saline solution. Salinity treatments were applied by irrigating each pot with 500mL of NaCl solution to all treated plants and as mentioned above for 15days (3 times). After that, all plants were irrigated with fresh water as needed till plants attained flowering stage. At the onset of flowering stages (Feekes growth stage 10.51), salinity treatments were applied the same way as treated at booting stage for 15 d. Subsequently, after 15 days of salinity stress imposition (3 times) the plants were irrigated with fresh water till plants attained physiological maturity. The N, P. K 20,19,19 fertilizer was applied as7g/ per pot at tillering, booting, and flowering stages, Di-Ammonium phosphates ($P_2O_5$) 46P, 18N was also added around jointing stage (37). During the period of experiment, the pots were kept under semi-controlled condition and water applied as needed. Grain maturity was visually estimated according to the complete loss of green color from grains.

## 2.3. Data Collection

At maturity, four plants from each pot were hand-harvested by cutting them at the soil level. Data on plant height, number of tillers plant$^{-}$

$^{1}$, number of spike plant$^{-1}$, spike length were recorded at the day of harvesting on four plants from all salinity levels. Plant height was determined as the distance between base of the plant to the tip of the main stem spike excluding awns. Tiller number plant$^{-1}$ contained both fertile (with spikes) and non-fertile (without spike) tillers. For vegetative dry weight measurements, plant parts: leaves, stems, and spikes (main spike and other spikes separately) were collected and dried at 45 °C for 5 d. Vegetative dry weight was determined as the weight of leaves, stems, and spikes per plant. After drying for 5 d, spikelet number spike$^{-1}$ was counted for main spike, then main spikes were hand threshed to separate grains, and grain number per spike was counted manually. Grain yield for main spike and per plant were calculated and individual grain weight was calculated by dividing grain yield per spike by grains number per spike. Harvest index was calculated as the ratio of grain yield to the total vegetative dry weight for each plant (38).

**2.4. Experiment Design and Data Analysis:**

The experimental design was a randomized complete design (RCD) with four replications. Salinity was the main plot factor (four levels 0, 50, 100, 150 mM NaCl), genotype was assigned to sub plots (nine levels).. Data were analyzed using GLM procedure in statistical software SAS 9.4 (SAS Institute Inc., Cary, NC, USA) for mean and standard error estimation. Separation of means was carried out using the least significant differences (LSD; $P < 0.05$). The means were compared using Duncan's multiple range test.

## 3. Result

In Tables ()1,2) the result for growth and yield traits obtained are presented. Highly significant differences among salinity concentrations and genotypes in agronomic parameters were observed in this study. The independent effect of salinity stress was significant ($P < 0.0001$) for plant height, tiller number, spike number, spike length, spikelet number, dry weight, grain number, grain yield, individual grain weight and harvest index. The independent effect of genotype was significant ($P < 0.001$) for plant height, tiller number, spike number, spikelet number, dry weight, grain number, grain yield, individual grain weight and harvest index. The interaction effects of salinity and genotype were significant ($P < 0.05$) for plant height, tiller number, spike number, spike length, spikelet number, dry weight, grain number, grain yield, individual grain weight and harvest index. Salinity and genotype interaction had significant ($P < 0.05$) effect on all yield traits.

**Table 1. Probability values of the effects of salinity (S), genotype (G), and S x G interaction on various growth and yield traits.**

| Traits | Salinity (S) | Genotype (G) | S x G |
|---|---|---|---|
| Plant height (cm) | <.0001 | 0.0012 | 0.0486 |
| Tiller number plant$^{-1}$ | <.0001 | <.0001 | 0.0501 |
| Spike number plant$^{-1}$ | <.0001 | <.0001 | 0.0467 |
| Spike length (cm) | <.0001 | 0.0055 | 0.0477 |
| Spikelet number spike$^{-1}$ | <.0001 | <.0001 | 0.0458 |
| Grain number spike$^{-1}$ | <.0001 | 2.0000 | 0430.0 |
| Grain number plant$^{-1}$ | <.0001 | <.0001 | 2250.0 |
| Grain yield spike$^{-1}$ (g) | <.0001 | 00010. | 0.0507 |
| Grain yield plant$^{-1}$ (g) | <.0001 | <.0001 | 860.00 |
| Individual grain weight (mg) | <.0001 | .00140 | 3620.0 |
| Dry weight plant$^{-1}$ (g) | <.0001 | <.0001 | 5060.0 |
| Harvest index (%) | <.0001 | <.0001 | 1650.0 |

The relative salt tolerance indexes for some of the measured traits include spike number plant$^{-1}$, spikelet number spike$^{-1}$, grain number spike$^{-1}$, grain yield spike$^{-1}$ (g), individual grain weight (mg), dry weight plant$^{-1}$ (g) and harvest index varied among genotypes (Table 3). The salt tolerance index of spike number plant$^{-1}$ ranged from 0.69 to 0.94 at moderate salinity level 100mM NaCl and from 0.38 to 0.76 at high salinity level 150mM NaCl among genotypes. Also; the salt tolerance index of grain yield spike$^{-1}$ (g) ranged from 0.58 to 0.92 at moderate salinity level 100mM NaCl and from 0.32 to 0.63 at high salinity level 150mM NaCl among genotypes. However, the salt tolerance index of harvest index ranged from 0.49 to 0.91 at moderate salinity level 100mM NaCl and from 0.22 to 0.62 at high salinity level 150mM NaCl among genotypes.

Although; the low salinity treatment (50mM NaCl) reduced growth and yield traits to a lesser degree than moderate (100mM NaCl) and high salinity level (150mMNaCl). However; all agronomic traits included in this study were reduced under moderate and high salinity levels (100, 150mM NaCl) treatment (Table 3). The reduction in all parameters included in this study at both salinity levels (100, 150mM NaCl) from that of the control was lower in some genotypes which seemed to be salt tolerant genotypes.

**Table 2. The effect of salinity on various growth and yield traits of 9 wheat genotypes. Data are averaged across nine genotypes, four replications of each genotype and four salinity levels. Means was estimated using the GLM procedure in SAS.**

| Traits | 0mM NaCl | 50mM NaCl | 100mM NaCl | 150mM NaCl |
|---|---|---|---|---|
| Plant height (cm) | 71.8$^{a}$ | 68.3$^{b}$ | 63.3$^{c}$ | 42.3$^{d}$ |
| Tiller number plant$^{-1}$ | 5.4$^{a}$ | 5$^{b}$ | 4$^{c}$ | 2.8$^{d}$ |
| Spike number plant$^{-1}$ | 4$^{a}$ | 3.8$^{b}$ | 3.2$^{c}$ | 2.3$^{d}$ |

| Traits | 0mM NaCl | 50mM NaCl | 100mM NaCl | 150mM NaCl |
|---|---|---|---|---|
| Spike length (cm) | 7.4[a] | 7.1[a] | 6.1[b] | 4.6[c] |
| Spikelet number spike$^{-1}$ | 17.1[a] | 16.7[a] | 15.6[b] | 12.2[c] |
| Grain number spike$^{-1}$ | 39.1[a] | 37.6[a] | 32[b] | 22.6[c] |
| Grain number plant$^{-1}$ | 157[a] | 141[b] | 104[c] | 56[d] |
| Grain yield spike$^{-1}$ (g) | 1.9[a*] | 1.8[a] | 1.4[b] | 0.83[c] |
| Grain yield plant$^{-1}$ (g) | 7.4[*] | 6.7[b] | 4.5[c] | 2.1[d] |
| Individual grain weight (mg) | 47.4[a*] | 47.3[a] | 42.2[b] | 36.7[c] |
| Dry weight plant$^{-1}$ (g) | 21.1[a*] | 20.4[b] | 18.2[c] | 14.4[d] |
| Harvest index (%) | 0.35[a*] | 0..33[b] | 0..24[c] | 0.14[d] |

[*] Individual value is the mean of **9** genotypes under different salinity levels. Values followed by different letters are significantly different according to Duncan's multiple range test (*$P < 0.05$*).

The results of this study showed that Hmoera, Aboshock, Berka and Jlildeeb were affected the least by increasing salinity from 0-150mM NaCl. Salinity stress effected plant growth and performance, which caused by reducing shoot length and reduction in above ground biomass.

**Table 3. Salt tolerance indexes of some agronomic parameters in hard wheat genotypes under different salinity levels.**

| Genotypes | Salinity levels (mM NaCl) | Spike number plant$^{-1}$ | Spikelet number spike$^{-1}$ | Grain number spike$^{-1}$ | Grain yield spike$^{-1}$ (g) | Individual grain weight (mg) | Dry weight plant$^{-1}$ (g) | Harvest index |
|---|---|---|---|---|---|---|---|---|
| Alqara | 50 | 0.96 | 1.01 | 0.99 | 1.02 | 1.03 | 1.01 | 0.95 |
| | 100 | 0.75 | 0.95 | 0.76 | 0.67 | 0.87 | 0.86 | 0.57 |
| | 150 | 0.48 | 0.67 | 0.47 | 0.38 | 0.79 | 0.65 | 0.28 |
| Merjawy | 50 | 0.88 | 0.99 | 0.98 | 0.96 | 0.98 | 0.94 | 0.89 |
| | 100 | 0.75 | 0.94 | 0.79 | 0.68 | 0.85 | 0.75 | 0.67 |
| | 150 | 0.44 | 0.61 | 0.48 | 0.35 | 0.74 | 0.66 | 0.23 |
| Aboshock | 50 | 0.95 | 1.01 | 0.99 | 1.02 | 1.03 | 0.95 | 1.01 |
| | 100 | 0.89 | 0.95 | 0.92 | 0.90 | 0.97 | 0.87 | 0.91 |
| | 150 | 0.76 | 0.87 | 0.74 | 0.60 | 0.82 | 0.74 | 0.62 |

| Genotypes | Salinity levels (mM NaCl) | Spike number $plant^{-1}$ | Spikelet number $spike^{-1}$ | Grain number $spike^{-1}$ | Grain yield $spike^{-1}$ (g) | Individual grain weight (mg) | Dry weight $plant^{-1}$ (g) | Harvest index |
|---|---|---|---|---|---|---|---|---|
| Berkra | 50 | 1.00 | 0.97 | 0.96 | 0.95 | 0.98 | 0.96 | 1.01 |
| | 100 | 0.88 | 0.93 | 0.90 | 0.84 | 0.94 | 0.88 | 0.85 |
| | 150 | 0.69 | 0.80 | 0.72 | 0.55 | 0.79 | 0.71 | 0.54 |
| Homera | 50 | 0.94 | 0.96 | 0.98 | 0.99 | 1.01 | 1.03 | 0.89 |
| | 100 | 0.94 | 0.93 | 0.91 | 0.92 | 1.01 | 0.95 | 0.91 |
| | 150 | 0.75 | 0.80 | 0.70 | 0.58 | 0.83 | 0.85 | 0.53 |
| Jlildeeb | 50 | 0.94 | 0.98 | 0.96 | 1.01 | 1.05 | 0.94 | 1.01 |
| | 100 | 0.88 | 0.95 | 0.90 | 0.87 | 0.96 | 0.93 | 0.82 |
| | 150 | 0.69 | 0.83 | 0.75 | 0.63 | 0.84 | 0.75 | 0.59 |
| Bhoot107 | 50 | 0.90 | 0.98 | 0.94 | 0.94 | 0.99 | 0.94 | 0.87 |
| | 100 | 0.71 | 0.87 | 0.76 | 0.61 | 0.80 | 0.82 | 0.54 |
| | 150 | 0.48 | 0.64 | 0.49 | 0.35 | 0.72 | 0.57 | 0.30 |
| Alneama | 50 | 0.94 | 0.99 | 0.97 | 0.94 | 0.97 | 1.00 | 0.89 |
| | 100 | 0.75 | 0.90 | 0.79 | 0.67 | 0.85 | 0.91 | 0.56 |
| | 150 | 0.56 | 0.59 | 0.46 | 0.35 | 0.75 | 0.68 | 0.28 |
| Alkrm | 50 | 0.94 | 0.98 | 0.97 | 0.94 | 0.97 | 0.97 | 0.90 |
| | 100 | 0.69 | 0.87 | 0.75 | 0.58 | 0.77 | 0.83 | 0.49 |
| | 150 | 0.38 | 0.62 | 0.45 | 0.32 | 0.71 | 0.59 | 0.22 |

The result clearly showed a reduction in plant height as compared to the control. Simultaneously; the result indicated that under salt stress, plant dry weight was reduced. However; this study indicated a diverse response across the studied nine hard wheat genotypes and that high level of salinity had significant effects on plant height and plant biomass (Fig. 1).

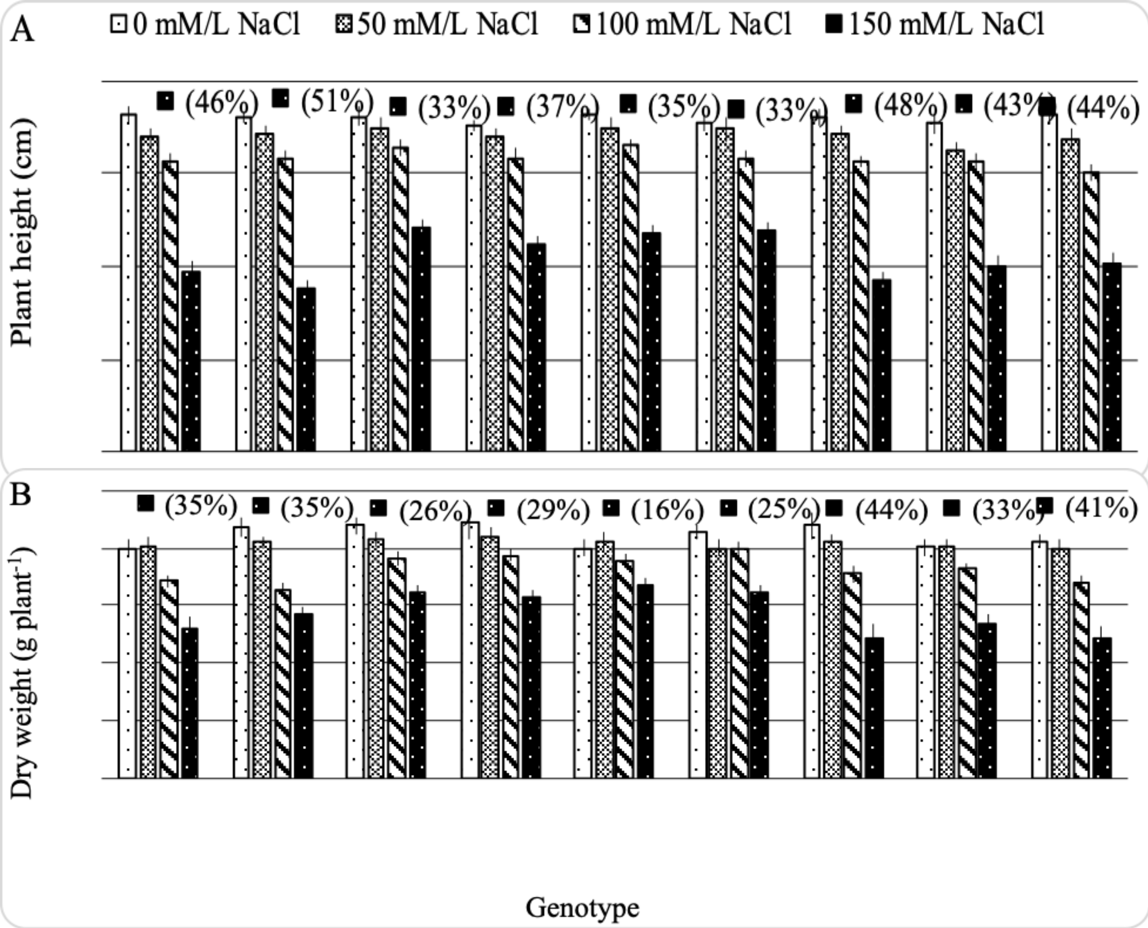


**Figure 1: Effect of salinity on (A) plant hight (cm) and (B) total dry weight (g plant$^{-1}$) of 9 hard wheat genotypes.Values shown are mean ± SE. Values in parenthesis indicates the percent differences from 0mM NaCl to 150mM NaCl salinity treatment.**

The result illustrated that plant height varied among genotypes and the reduction of plant height at 150mM NaCl ranged between 33% in Aboshock and Jlildeeb genotypes and 51% in Merjawy genotype (Fig. 1A). In regard to plant biomass (dry weight) the result indicated that genotypes had diverse response to salt stress. For example, the per cent decrease in plant dry weight at 150mM NaCl was by 16% in genotypes

Homera and by 44 % in genotype Bhoot 107 (Fig 1B). A significant difference was observed between salinity stress and control conditions and between genotypes for tillers number plant$^{-1}$. Tillers number plant$^{-1}$ reduced due to high level of salinity (150 mM NaCl), as the results showed that the reduction in tiller number at 150mM NaCl ranged between 27% in Homera genotype and 68 % in Merjawy genotype (Fig. 2A). Also, spike number per plant was affected by high level of salinity, and the reduction of spikes number plant$^{-1}$ at 150mM NaCl ranged between 24 in Aboshock genotype and 63 % in Alkrm genotype (Fig. 2B).

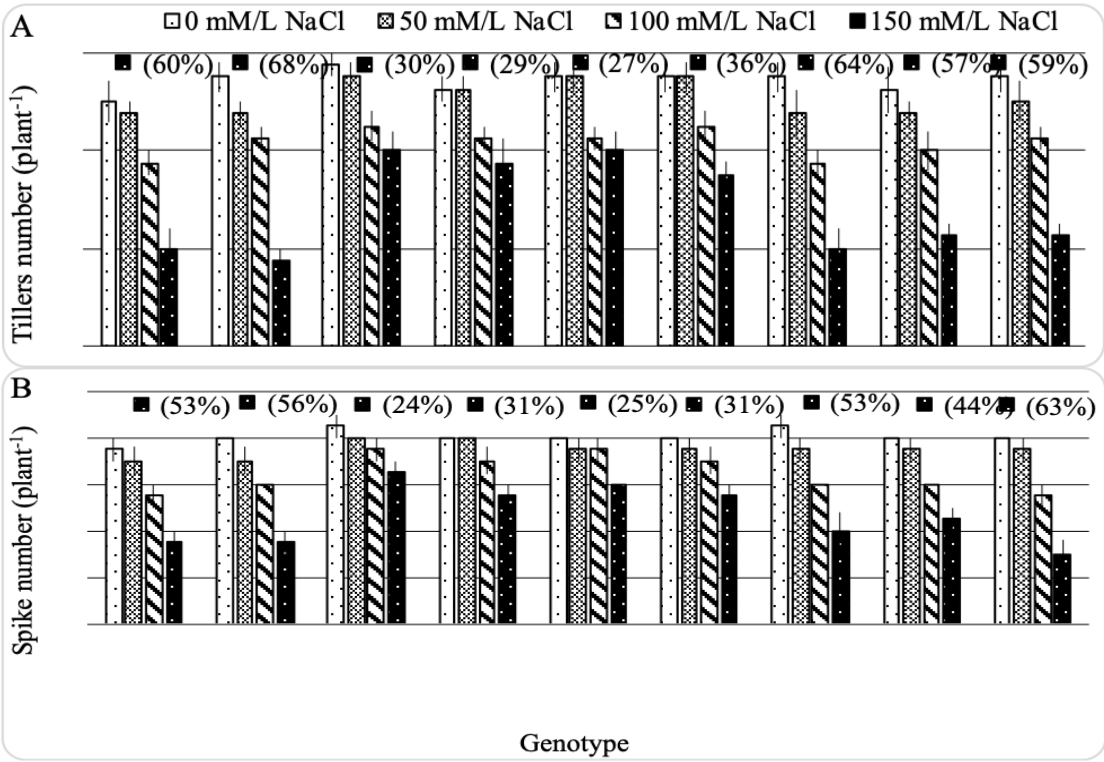


**Figure 2: Effect of salinity on (A) tiller number (plant $^{-1}$) and (B) spike number (plant $^{-1}$) of 9 hard wheat genotypes.Values shown are mean ± SE. Values in parenthesis indicates the percent differences from 0mM NaCl to 150mM NaCl salinity treatment.**

The same trend was seen with other agronomic traits such as spike length (cm) and spikelet number spike$^{-1}$. The result pointed out that spike length decreased due to salt stress and the reduction in spike length at 150mM NaCl ranged between 21% in Jlildeeb genotype and 54% in Alqara genotype (Fig.3A). In addition; high level of salinity (150mM NaCl) also significantly ($P < 0.0001$) affected number of spikelet spike$^{-1}$. Figure (3B) shows that reduction in spikelet number spike$^{-1}$ at 150mM NaCl ranged between 13% in Aboshock genotype and 40 % in Alneaama genotype (Fig. 3B).

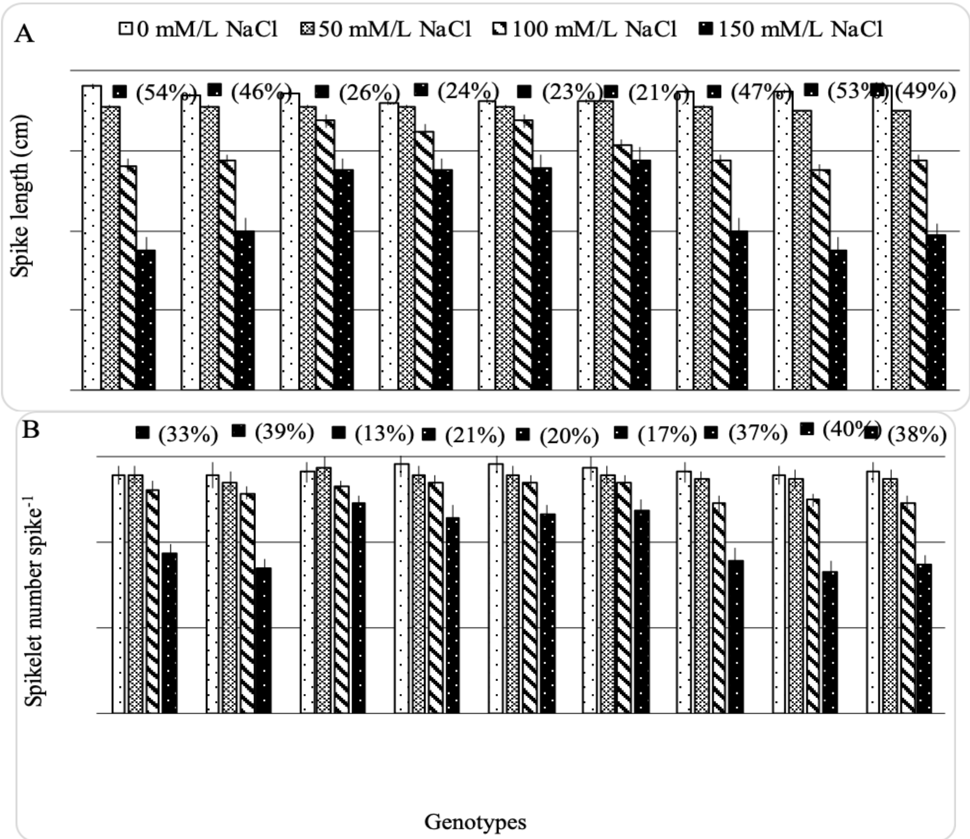


**Figure3 : Effect of salinity on (A) spike length (cm) and (B) spikelet number (spike $^{-1}$) of 9 hard wheat genotypes.Values shown are mean ± SE. Values in parenthesis indicates the percent differences from 0mM NaCl to 150mM NaCl salinity treatment.**

The grain number spike$^{-1}$ and grain yield spike$^{-1}$varied significantly among the genotypes and a significant genotype × salinity interaction showed that the genotypes acted differently in grain number spike$^{-1}$ and grain yield spike$^{-1}$under salt stress. Salinity at 150mM NaCl decreased grain yield spike-$^{1}$ by 55%  in Alkrm genotype and by 26 % in Jlildeeb genotype (Fig. 4A). Also the effect of salinity at 150mM NaCl on grain yield spike$^{-1}$  was the lowest in Jlildeeb genotype 38% decline as compared to control; and the highest in Alkrm genotype which decreased by 68% (Fig. 4B).

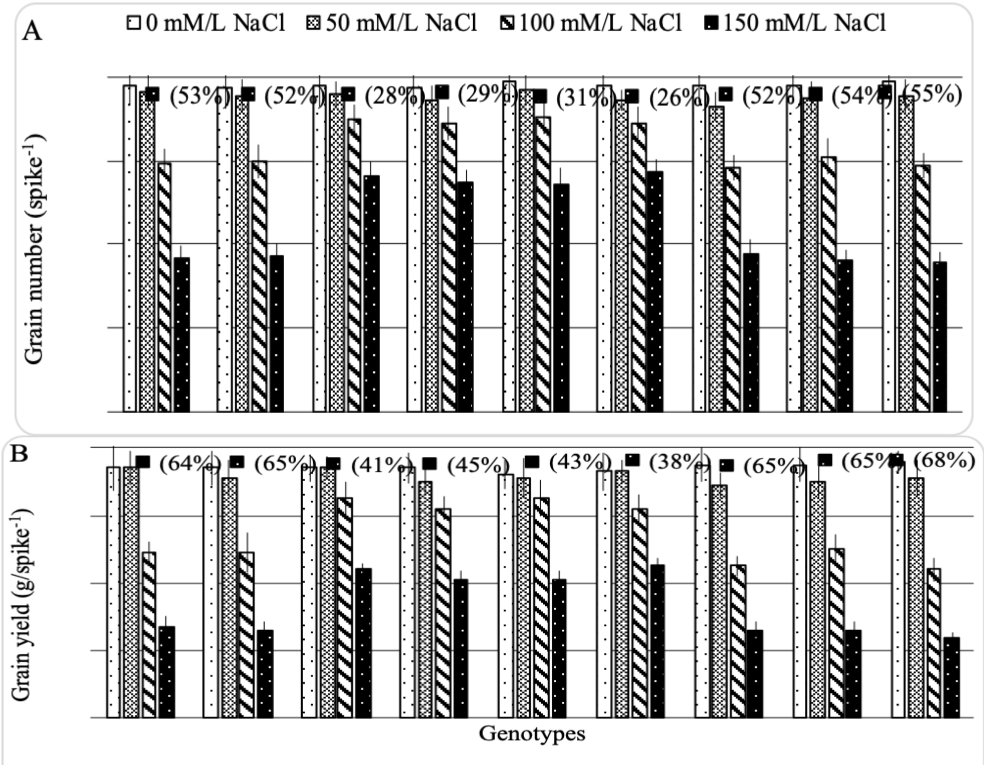


**Figure 4: Effect of salinity on (A) grain number (spike$^{1}$), and (B) grain yield (g/spike$^{1}$) of 9 hard wheat genotypes.Values shown are mean ± SE. Values in parenthesis indicates the percent differences from 0mM NaCl to 150mM NaCl salinity treatment.**

Analysis of variance indicated that individual grain weight (mg) and harvest index of all the genotypes decreased significantly with an increase in salinity. Also, genotypes responded differently to the stresses in term of individual grain weight (mg) and harvest index (Fig 5). Genotypes such as Aboshock and Jlildeeb had the highest value of individual grain weight (mg) under high level of salinity 150mM NaCl, and genotypes such as Alkrm had the lowest value at 150mM NaCl (Fig. 5A). Moreover; harvest index was also affected due to salinity stress. The results illustrated significant decrease in harvest index, which decreased at 150mM NaCl by 38 % in Aboshock genotype and by 79 % in Alkm genotype (Fig. 5B).

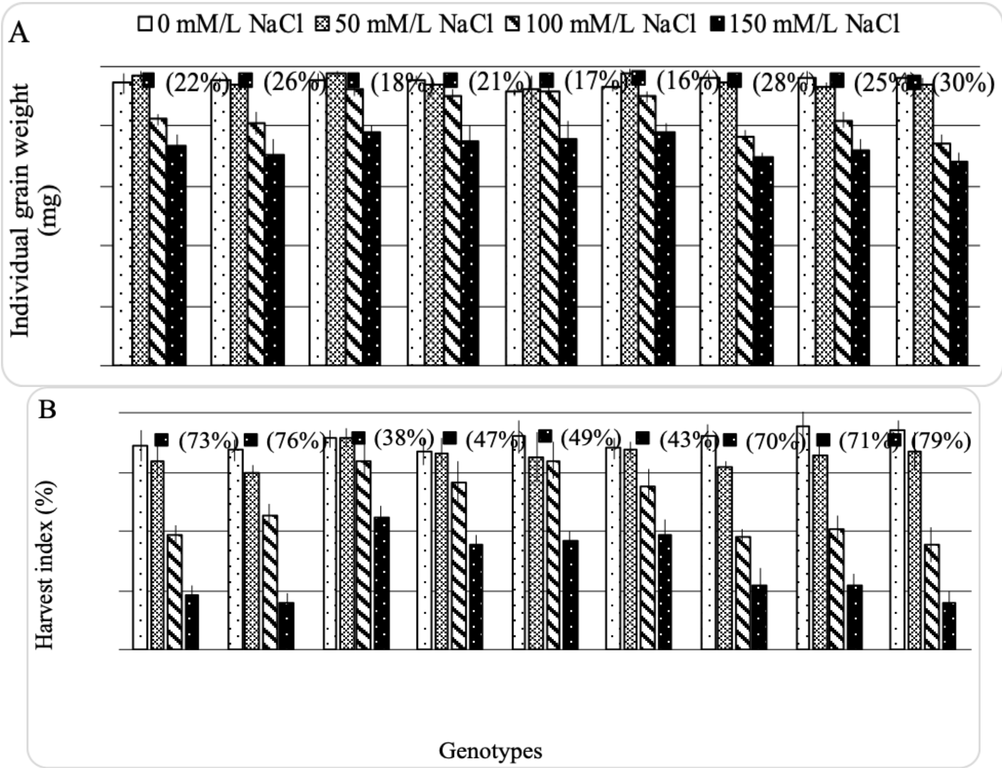


**Figure 5: Effect of salinity on (A) individual grain weight (mg) and (B) ) harvest index (%) of 9 hard wheat genotypes.Values shown are mean ± SE. Values in parenthesis indicates the percent differences from 0mM NaCl to 150mM NaCl salinity treatment.**

## 4. Discussion

This study was conducted to evaluate the response of different hard wheat genotypes to salinity stress. All wheat genotypes exposed to 100 and 150mM NaCl salt concentration showed that salinity stress highly influenced growth and yield traits. Plants growing under saline condition are subjected to suffer from drought stress, ion toxicity, and nutrient imbalance which may lead to reduced growth and productivity. In wheat, yield is determined by the number of spikes per plant and yield components such as spikelet number, grain number and grain weight [39, 40, 41]. The study pointed out that salinity stresses had significant effect on growth and yield traits of wheat genotypes. These findings are in agreement with other studies that have been done on the effect of salinity on plant growth and yield [42, 43]. Salinity stresses affect plant growth and development at all growth stages [8]. However; exposure to salinity stress may vary with the stage of plant development, but all vegetative and reproductive stages are affected by salinity stress [44, 12]. Flowering stage in wheat is the transition between two growth stages, which are the vegetative stage and the grain filling stage. During vegetative the reproductive initiation, and reproductive development occur and determine the final yield potential and provide the photosynthetic factory essential for maximum yield [45]. Salinity stress reduces plant growth by increasing water deficits, ion toxicity, and nutritional imbalance [18, 46]. At flowering stage, fertilization has been shown to be highly sensitive to water stress in various wheat [47]. Therefore, stress in these stages mostly result in yield decrease. Some studies showed that the reduction of leaf area is often the first indication of salinity stress (25, 48, 49, 50, 51]. Shoot and root growth also are reduced by salinity, but the shoot is usually more sensitive due to the inhibitory effect of salt on cell division and enlargement in growing point, which, in turn, affects the normal growth of wheat and the viability of tillers and decreases the number of primary and secondary tillers [31, 32, 52]. salinity causes reduction in the number of leaves in the main shoot and reduction of the number of spikelet in the main spike, which result in reduction of seed set and grain yield [30, 53]. The result from this study showed that spikelet number per spike had a positive and highly significant relationship with grain yield under high salinity stress. This result agrees with other studies, which concluded that there was a reduction of spikelet number and grain number under salinity condition [42, 43]. Our study reported that spikelet number per spike was reduced due to salinity stress. This could be due to the fact that spikelet number initiation occurs at the vegetative stage and stress may have resulted in shortening the vegetative stage, in turn causing a reduction in number of spikelet per spike. This agreed with the earlier study which showed a positive correlation between the length of the vegetative stage and the number of spikelet number and that the increase in the duration of the vegetative stage of the apex induces more spikelet numbers [54, 55, 56]. Nevertheless, another study showed that the actual number of spikelet is determined by the length of the reproductive stage and reveled that short days from double ridge to terminal spikelet initiation stimulate a large number of spikelet [57]. In addition; harvest index had very significant relationship with grain yield under stress condition. The study found that grain yield and harvest index of wheat genotypes tested in this research significantly decreased with increasing salinity level. These results were similar to the results reported from other studies, which reported that grain yield and harvest index were reduced under stress [56, 59]. Although most crops' sensitivity to salinity is high during early seedling stage and reproductive stage, crops need to maintain functions at all stages of their life cycle to increase their ability to maintain yield under high salinity. The study reported that at flowering stage of the wheat growth, grain number was the main determinant of grain yield under salinity stress. In this study and based on harvest index reduction genotypes Aboshock was the most tolerant to salinity stress (38 % decline ) Fig.5B.

## 5. Conclusion

In conclusion, salinity100 and 150mM NaCl at booting and flowering stages were negatively influenced wheat growth and yield-related parameters. Also, the study suggests that there is genetic variability among what genotypes so that some genotypes were capable of adapting to salinity stress. Genotypes Homera, Aboshock, Berka and Jlildeeb were the more tolerant ones. There were some traits that can be selected for breeding programs such as grain number and weight. However, the screening for wheat genotypes can be based on traits related to high yields under stress condition. These criteria better be firm and simple to evaluate especially with the need to screen a high number of genotypes. Yet, further research is needed to confirm these effects with other wheat genotypes and under field condition.

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