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A study of germination traits and seedlings growth of Wheat (*Triticum aestivum*) Barley (*Hordeum vulgare*) compared with Triticale (*×Triticosecale* Wittmack) under salinity stress.

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Abstract

Cereals crop production are challenged by some biotic and abiotic stresses such as pests, pathogenic, heat, drought, and salinity. This study was conducted to assess and compare the effect of salinity stress on germination and seedlings growth of wheat (*Triticum aestivum* L., cv. Salambo), and barley ((*Hordeum vulgare* L., cv Rihan 03), with triticale (×*Triticosecale Wittmack, cv. line 3(cume).* Seeds of each plant species were treated with 0mM NaCl (control), 80mM NaCl and 160mM NaCl at germination and early growth stage. A complete randomized design (CRD) experimental layout was used with four replications. The results indicated that the independent effect of salinity treatment was extremely significant (P <.0001) for all investigated traits. The independent effect of plant species was extremely significant (P <.0001) for all investigated traits excluding germination percentage. Also, the study revealed that there was a statistically significant two-way interaction salinity stress and plant species (P< 0.05) for all investigated traits excluding final germination percentage. Results showed that under high salinity stress condition (160mM NaCl), barley and triticale had the highest germination speed compared with bread wheat. The results indicated that salinity significantly decreased water uptake percentage, shoots and roots length, fresh and dry weights of seedlings. However; barley proved to be the most salinity efficient cereal, had the highest dry matter production followed by triticale and bread wheat had the last seedlings dry weight. This study concluded that under salinity stress, barley followed by triticale demonstrates a promising salt tolerant cereals crops that can be cultivated in dry, saline and degraded lands with the same experiment situation.

Keywords: Salinity stress, Germination, *Triticum aestivum*, *Hordeum vulgare*, *Triticosecale Wittmack,* seedlings growth

Introduction

United Nations reported that the existing world population is about 7.7 billion and is predicted to be about 9.7 billion in 2050 and by 2100 is expected to rise to 11 billion (United Nations, 2019). To meet the need for food security, crops production including rice, wheat, maize, and barley are required to increase worldwide. These crops are influenced by many climatic and environmental factors which can be of abiotic and biotic. These crops respond directly to changes in temperature, CO2 concentration, moisture, salinity, light intensity, condition of the soil, and so on. Salt stress is one of the most important abiotic stresses casing reduction of plant yield by effecting many of plant traits like growth, development and productivity. Worldwide, it is estimated that around 950 million hectares of arable land is affected by salinity stress (Kiani-Pouya, 2020). Salinity stress could be typically viewed as the toxicity to the plants due to development of salinity resulting from higher salt concentration which is adequate to lower the water potential (Yadav *et al*., 2019). Salinity problems became increasingly severe as the rising sea level from global warming and inappropriate irrigation practice (Deng *et al*., 2020). About 20% of the global land area and over 50% of agricultural irrigated land is salt-affected soils (Cheng *et al*., 2016). In Libya, precisely in the North close to the coast of Mediterranean Sea, the problem of salinity in agriculture becomes gradually severe because of too much irrigation water is applied for crop production. Salinity stresses are becoming increasingly important because of the declining availability of good quality water.

Salinity stress effects plant as it reduces water potential, cause ions imbalance, disturbances in ion homeostasis, and toxicity (Maas, and Grattan. 1999). Salinity decreases seed ability to absorb water and causes a decrease in germination and seedlings growth as well as changing plant metabolic processes (Pearson and Bernstein, 1959; Munns, 2002). Salinity is known to not only/delays, but also decreases seed germination of many crops. Germination of seeds is controlled by some physiological mechanisms, which are necessary for the growth and development of the embryo. Seeds germination and seedlings growth are the most sensitive stages to salt stress (Bhattacharjee, 2008; Hubbard *et al*., 2012). During germination stage, salinity stress may result in embryonic damage due to ionic toxicity which is linked with reduced and inhibited germination and seedlings growth (Munns and Tester, 2008; Majeed *et al*., 2019). Also many studies reported that crops in saline condition may be subjected to infection by soil pathogens (MacDonald, 1982; Snapp *et al*. 1991; Chang *et al*., 2018; Pye et al., 2018).

Cereal crops are grown worldwide for grains, food, and feed. In the field, cereals are challenged with some environmental stresses that severely affect their growth, yield and overall production. Some cereals are moderately tolerant to salinity stress (Shannon, 1997). Plants respond to salinity differently, so wheat, triticale and barley have different salt tolerances capabilities and may grow as grain crops in saline and non-saline condition. Wheat production generally varied due to interaction with environmental conditions. Besides, it is well known as moderately tolerant to saline condition (Rajendran *et al*., 2009; Panhwar *et al*., 2021). However, wheat is the most salt-sensitive species among cereals (Zeeshan *et al*., 2020). Triticale is an amphiploid species bearing the genomes of wheat (*Triticum*) and rye (*Secale*), which is mainly grown as feed grain and biomass production (Blum, 2014, Mergoum *et al*., 2019). Triticale is tolerant of many abiotic stresses and may grow in marginal fields with higher stress conditions (Yagmur and Kaydan, 2008; Shreidi *et al*., 2019). Because it is derived from rye, triticale has always been expected to be somewhat resistant to both biotic and some abiotic stresses such as salinity (Blum, 2014).

Barley is adapted to different conditions and is considered as one of the best adapted cereals because of its tolerance to salinity stress (Munns and Tester, 2008). However, its adaptation to salinity varies between barley genotypes and growth stages (Munns, 2005; Ferreira *et al*., 2016; El-Esawi et al., 2018).

Finding methods that may alleviate salinity stress on crop yield production is of outermost importance. There are many methods and approaches to overcome the adverse effects of salinity on plants growth and productivity. One approach is the selection of cultivars and species that tolerant or/and resistant to salinity stress (Sallam *et al*., 2019). Extensive genetic studies and investigations of landrace and wild germplasm have indicated extensive variation for abiotic stress tolerance in different crops (Langridge *et al*., 2006). Up to our knowledge, no study has been conducted to evaluate the effect of salinity on triticale and no work has been done to compare the effect of salinity stress on germination and seedlings growth of Libyan wheat, barley and triticale. Therefore, it would be imperative to investigate the effect of salinity stress on germination and seedlings growth parameters of those three cereals crpos. Thus, this study is the first to compare both of wheat and barley with triticale for salinity tolerance.

Material and Methods

This study was conducted in semi-controlled environment facilities at the Plant Science Department, University of Az Zawia, Libya. Experiments were conducted in fall of 2021 to compare the impact of salinity stress on germination and some important seedlings characteristic of wheat, barley and triticale.

Plant Material: Barley, wheat and triticale seeds were used in this study obtained from National Libyan GenBank(NLGB) in Tripoli. The cultivars of the three spices were (Salambo) bread wheat, (Rihan 03) barley and line 3(cume) triticale.

Experimental details

Three different concentrations of saline solution (NaCl) prepared with fresh water (0, 80 and 160 mM NaCl with electric conductivity [EC] value of (0.7, 6.3 and 15.5 dSm^{-1}) were used for salinity treatments. Healthy seeds of each cereal spices were surface sterilized with sodium hypochlorite solution (5 %) for three minutes, washed with distilled water, air dried and used for the experiment. Then seeds were weighted (5g) and subjected to corresponding treatment as following: (0mM NaCl) value of < 0.7 dSm^{-1} control), 80 mM NaCl [EC] value of 6.3 dSm^{-1}) and 160 mM NaCl [EC] value of 15.5 dSm^{-1}. Seeds allowed for water imbibitions for 20h. During the imbibitions period (20h) water uptake was calculated after 3, 6, 12 and 18h (Aghamir et al., 2016). Each time the seeds were removed from the water solutions, followed by draining and blotting dry with a paper towel for 1 min and reweighed. Water uptake percentage (WUP) was calculated. After that. a set of 20

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seeds from each cereal were placed in a petri dish with Whatman no. 1 filter paper discs; and it was moisturized 5 mL of the different saline solutions (0, 80, and 160 mM NaCl). The filter paper was moisturized on daily basis till the end of experiment and filter papers were changed once in every two days to prevent salt accumulation. The seeds moisturized with fresh water instead of NaCl solution saved as absolute control treatment for the experiment. A total of four replications used for control and NaCl treatments for each cereal. All the petri dishes were placed in the dark throughout the germination period (total 10 days) at room temperature 22±2°C. Seeds were considered germinated when both shoots, and roots extended more than 2 mm from the seeds (Islam *et al*., 2012). Germination traits data was recorded during germination period of 10 days after sowing.

Data collection

Water uptake percentage

During the first 20h of seed socking water uptake was calculated after 3, 6, 12 and 18h water uptake percentage (WUP) was determined as following the equation (Aghamir *et al*., 2016). The increase in weight of the soaked beans was considered as result of water absorption.

WUP = W2-W1/W1 x100

Where W1= initial weight of seed, and W2= weight of seed after absorbing water in a particular time.

Germination traits

Germination percentage (*G %*) was expressed according to the following formula (Nasri et al., 2011). $G\,\% = (NSG \div TNSS) \times 100$

Where *NSG* is the number of seeds germinated at the end of the experiment (8 days after sowing). *TNSS* is the total number of seeds sown.

The germination speed (GS) was calculated according to the equation given by Rubio-Casal *et al*. (2003). The number of germinated seeds was recorded every day from the start of sowing and last for 10 days and used to calculate GS. The following formula was used to calculate GS:

$$GS = n1/d1 + n2/d2 + n3/d3 + \cdots$$

Where n_1 is the number of seeds germinated in day one of sowing, d_1 is the number of days taken for germination from day of sowing.

Mean daily germination (MDG) was calculated using the following formula (Gairola *et al*., 2011). $MDG = TNGS \div TNDG$

Where *TNGS* is total number of germinated seeds and *TNDG* is total number of days taken for final germination.

Seedlings growth

Morphological traits viz., shoots, roots length, fresh and dry weight were subsequently measured for 4 healthy uniform seedlings from each treatment at seedling stage (0.0-0.9) Zadok's scale. Selected seedlings were dissected and shoot, and root length were recorded. The length from the seed to the tip of the root and leaf blade was calculated and expressed in cm to measure the root length and shoot length, respectively. The fresh weight of shoots and roots was recorded using a weighing balance, and then dried in an oven maintained at 50 °C till it attains stable weight. After that, shoots and roots dry weights were recorded. Using the morphological traits, the salinity tolerance index (STI) and Seedlings vigor index (SVI) were calculated. The following formula was used to calculate STI (Tsegay, and Gebreslassie, 2014).

STI = (SdwTrt/ SdwCon) x 100

Where *SdwTrt* is dry weight of seedlings from priming treatment, *SdwCon* is dry weight of seedlings from control treatment.

The following formula was used to calculate SVI (Majid *et al*., 2013). *SVI* = (SL x G%) x 100

Where *SL* is seedlings length and *G%* is germination per cent.

The relative water content was estimated according to Turner (1981) and was evaluated from the equation:

RWC = (FW – DW)/ (TW – DW) X100

Where FW is the fresh weight of the shoots, TW is the weight at full turgid taken after floating the shoots for 24 h distilled water in the light at room temperature ++and DW is the weight measured after drying the shoots at 50C° until a constant weight is achieved.

Statistical analysis:

The experimental design was a randomized complete design with a split-plot treatment structure in four replications. plant species was the main plot factor; salinity was assigned to sub-plots. For the treatments, plant species had three levels (wheat, barley and triticale), salinity had three levels (0, 80 and 160mM NaCl). Data were analyzed using GLM procedure in statistical software SAS 9.4 for mean and standard error estimation. Separation of means was carried out using the Duncan's multiple test ($P < 0.05$).

Results

The P-values for relative water content, water uptake percentage, germination traits, germination speed and seedlings growth traits obtained with SAS PROC GLM are presented in (Table 1). The independent effect of salinity treatment was extremely significant (P <.0001) for all investigated traits. The independent effect of plant species was extremely significant (P <.0001) for all investigated traits excluding germination percentage (which was not significant) and mean daily germination which was very significant (P < 0.01). Also, the study revealed that there was a statistically significant two-way interaction salinity stress and plant species (P< 0.05) for all investigated traits excluding final germination percentage (Table 1).

Table 1. Probability values of the effect of salinity (S), plant species (PS), and S x PS interaction on various germination and seedlings growth traits.

	Variables		
Traits	Salinity (S)	Plant Species (PS)	(S x PS)
Germination percent (%)	<.0001	0.6941	0.4964
Mean daily germination	<.0001	0.0086	0.0405
Germination Speed	<.0001	<.0001	0.0439
Shoots length (cm)	<.0001	<.0001	0.0485
Roots length (cm)	<.0001	<.0001	0.0384
Seedlings length (cm)	<.0001	<.0001	0.0286
Seedlings fresh weight (g)	<.0001	<.0001	0.0490
Seedlings dry weight (g)	<.0001	<.0001	0.0258
Seedlings vigor index	<.0001	<.0001	0.0460
Salinity tolerance index	<.0001	<.0001	0.0046
Water uptake percentage (%)	<.0001	<.0001	0.0472
Relative water content	<.0001	<.0001	0.0463

Results of the independent effect of salinity treatment on germination and seedlings growth traits are presented in (Tables 2). The result showed that relative water content, water uptake percentage, germination traits and seedlings growth traits were reduced under high saline condition (160mM NaCl) as compared with the control. However; this reduction was less pronounced under low salinity level (80mM NaCl).

Table 2. The main effect of salinity (S) on seed germination and their speed and seedlings growth traits of three plant species. Data are averaged across three plant species, and four replications.

Traits	0mM NaCl	80mM NaCl	160mM NaCl
Germination percent (%)	98.[a*]	92[b]	82[c]
Mean daily germination	9.8[a]	5.9[b]	4[c]
Germination Speed	15.9[a]	12[b]	9[c]
Shoots length (cm)	10.4[a]	8.6[b]	5.5[c]
Roots length (cm)	9.9[a]	7.8[b]	5[c]
Seedlings length (cm)	20.3[a]	16.4[b]	10.6[c]
Seedlings fresh weight (g)	1.63[a]	1.45[b]	1.26[c]
Seedlings dry weight (g)	0.47[a]	0.30[b]	0.14[c]
Seedlings vigor index	19.9[a]	15[b]	8.8[c]
Salinity tolerance index	100[a]	64[b]	29[c]
Water uptake percentage (%)	71.2[a]	66.2[b]	52.5[c]
Relative water content	90[a]	78[b]	72[c]

[*]Values followed by different letters are significantly different according to Duncan's multiple range test ($P < 0.05$).

The results of different plant species response to salinity stress treatments are presented in (Tables 3). The result revealed that plant species responded differently to salinity treatments in terms of relative water content, water uptake percentage, germination traits, germination speed, and seedlings growth traits.

Table 3. The main effect of plant species on seeds germination and seedlings growth traits of three plant species. Data are averaged across three salinity treatment and four replications.

Traits	Barley	Triticale	Wheat
Germination percent (%)	91.7[a*]	90.4[a]	89.6[a]
Mean daily germination	7[a]	6.6[ab]	6.2[b]
Germination Speed	13.6[a]	12.9[a]	10.7[b]
Shoots length (cm)	9.3[a]	8.7[b]	6.6[c]
Roots length (cm)	8.7[a]	7.8[b]	6.3[c]
Seedlings length (cm)	18[a]	16.4[b]	12.9[c]
Seedlings fresh weight (g)	1.51[a]	1.48[a]	1.36[b]
Seedlings dry weight (g)	0.34[a]	0.31[b]	0.26[c]
Seedlings vigor index	16.7[a]	15.1[b]	12[c]
Salinity tolerance index	72[a]	65[b]	56[c]
Water uptake percentage (%)	53.3[c]	72.2[a]	64.3[b]
Relative water content	82[a]	81[a]	77[b]

[*]Values followed by different letters are significantly different according to Duncan's multiple range test ($P < 0.05$).

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The result presented that water uptake percentage in all plant species was low under salinity condition as compared to control. After 3h, the seed water uptake of non- saline water (control) was greater than the saline water. When the NaCl level increased, water uptake of the seeds decreased. Seeds absorbed water much faster during the first 6 h. Also, the result indicated that water uptake of plant species varied with increasing NaCl levels at each measurement time (Figre 1).

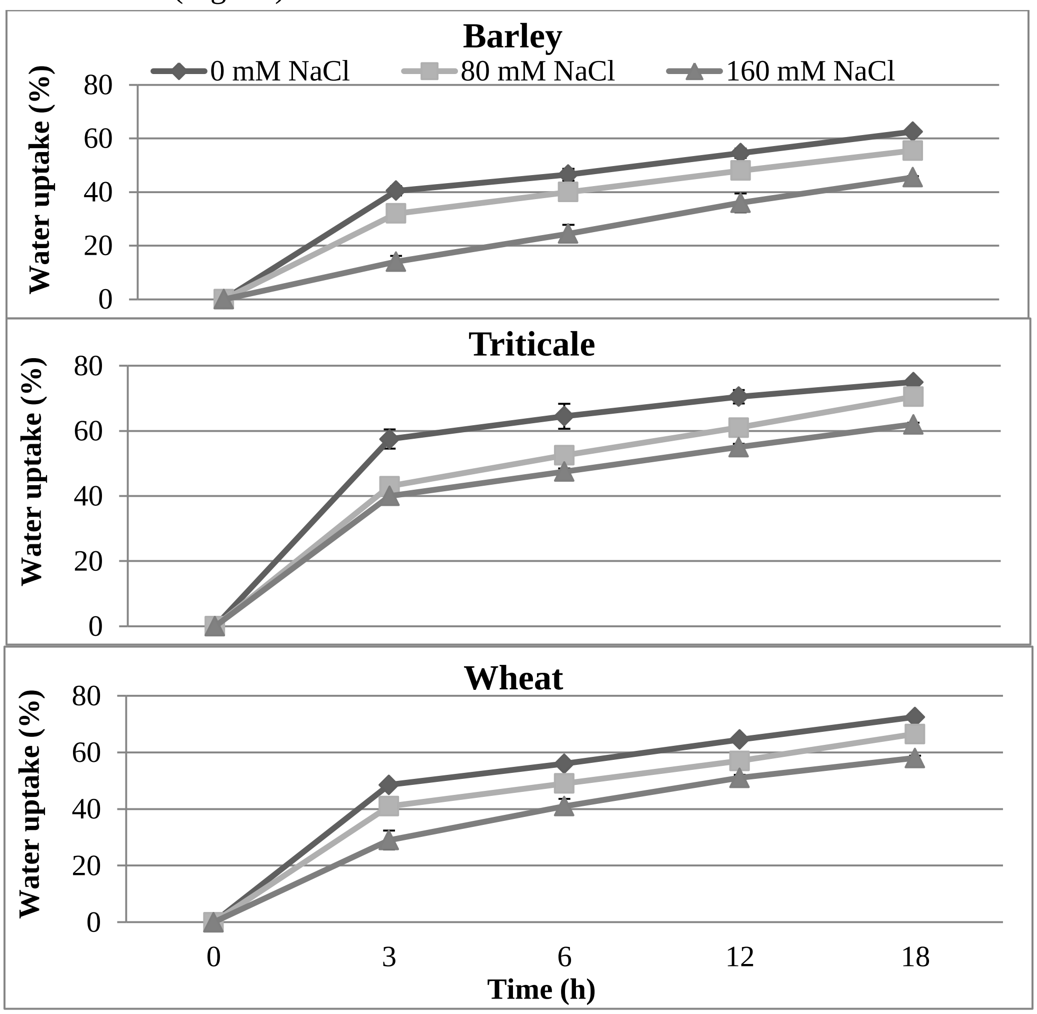

Figure 1. Water uptake percentage of three plant species as affected by salinity treatments.

In regard to seeds germination traits, the result showed that in low concentration of NaCl (0 and 80mM NaCl), 90-98% final germination was observed for all plant species (Table 2). The effect of increasing NaCl concentration on final germination percentage was essentially almost the same for all species. All plant species germinated at low levels of

NaCl, but at high level of salinity 160mM NaCl the seed germination percentage (GP) of barley, triticale, and wheat was reduced by 13%. 14% and 22% respectively with respect to control (Figure 2a). Also mean daily germination (MDG) differed relative to plant species and NaCl concentration. Increasing NaCl level delayed germination rather than affecting the final germination percentage. At high level of salinity mean daily germination of barley, triticale, and wheat was decreased by 55%, 59%, and 63% respectively compared to control (Figure 2b). Also, speed of germination decreased with the increasing of NaCl concentration. So, germination process initiated at different times with different NaCl concentrations and with different plant species. The result found that speed of germination of barley, triticale, and wheat was delayed by 33%, 41%, and 52% respectively as compared to control (Figure 2c).

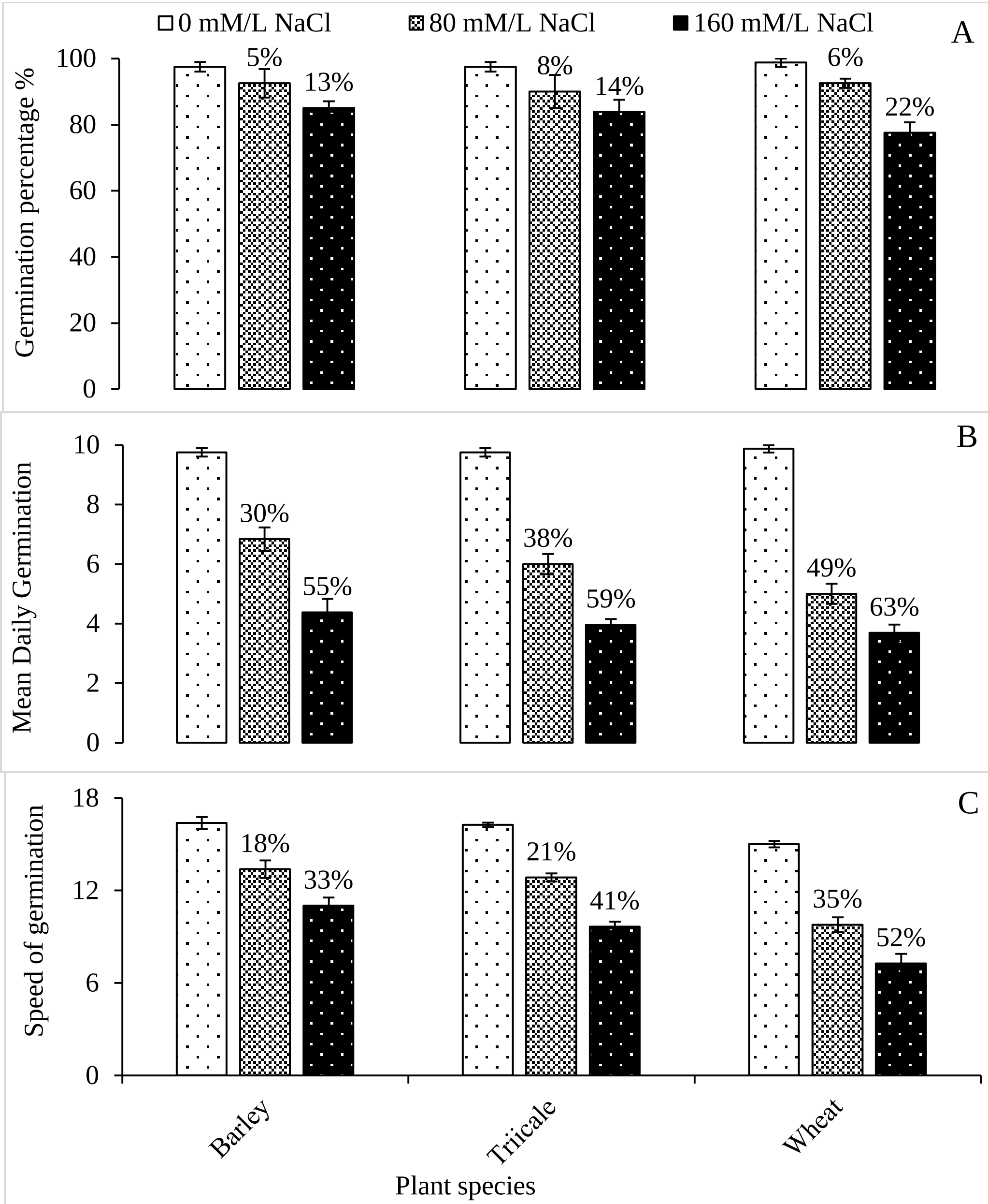

Fig 2. The effects of salinity on (A) germination percentage, (B) mean daily germination and (C) speed of germination of three plant species. Each datum indicates mean value and vertical lines on top of bars indicate standard error of means (n = 4). Values on top of bars indicates the percent reduction from control.

With respect to seedlings growth traits, the result indicated that salinity negatively affected all seedlings growth traits of all plant species tested in this study. The shoots length of the seedlings differed under the different NaCl levels and also shoots length differed with plant species depending on stress levels. In normal condition, as well as in low level of salinity (0 and 80mM NaCl) the seedlings of all plant species had higher shoots length compared to those in high level of salinity (160mM NaCl). The result illustrated that at 160mM NaCl, shoots length reduced by 36%, 49% and 57% in barley, triticale, and wheat respectively (Figure 3a).

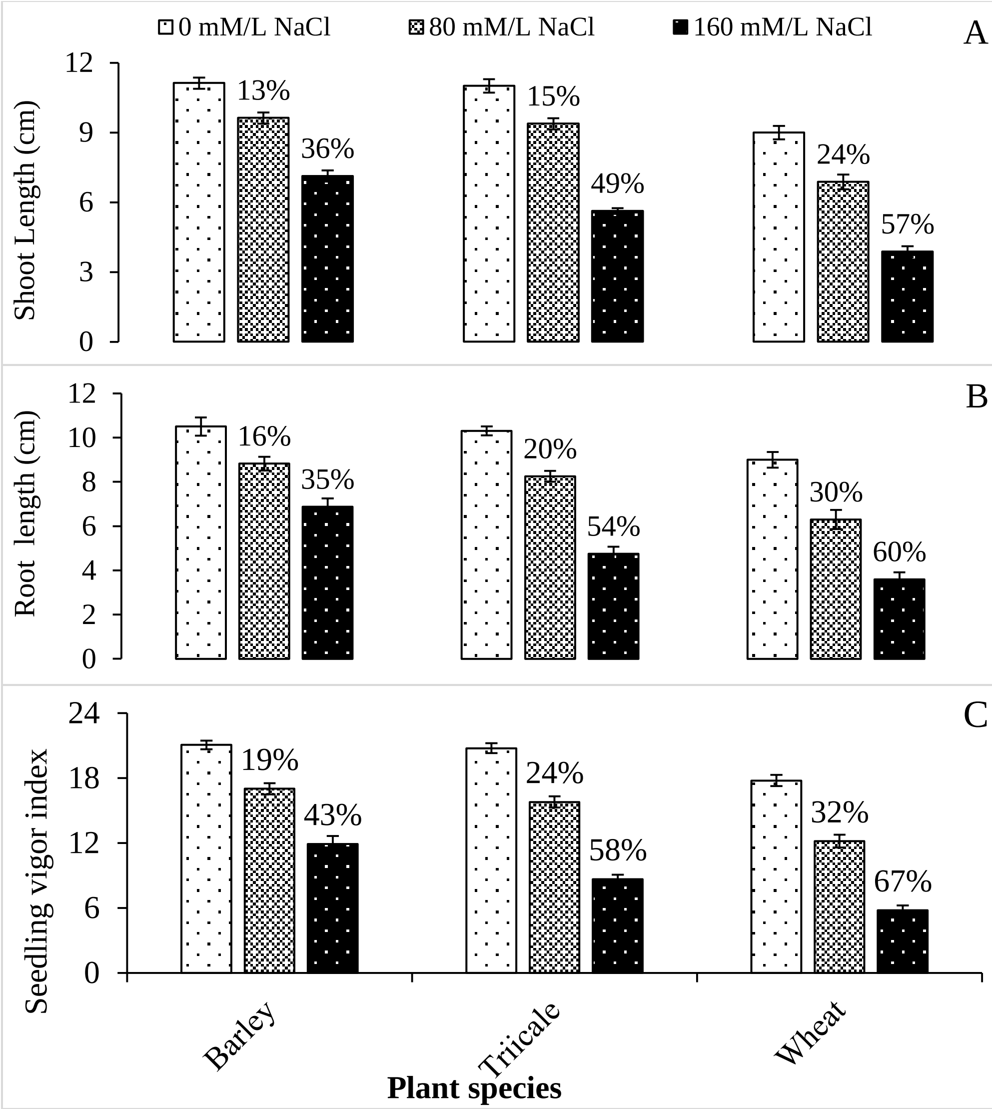

Fig 3. The effects of salinity on (A) shoots length, (B) roots length and (C) seedlings vigor index of three plant species. Each datum indicates mean value and vertical lines on top of bars indicate standard error of means (n = 4). Values on top of bars indicates the percent reduction from control.

In addition, roots length of all plant species differed at different NaCl concentrations. The increasing of NaCl level decreased roots length compared to control. Likewise, roots length differed by plant species in various NaCl concentrations. The result showed that the roots length of barley, triticale, and wheat roots reduced by 16%, 20%, and 30% at 80mM NaCl and by 35%, 54%, and 60% at 160mM NaCl respectively (Figure 3b). Moreover, the results indicated that seedlings vigor index decreased with the increasing NaCl concentration. But greater decrease in seedlings vigor index was seen at high level of salinity (16mM NaCl). And different plant species significantly had different response to salinity. At 160mM NaCl seedlings vigor index of barley, triticale and wheat reduced by 43%, 58%, and 67% respectively (Figure 3c)

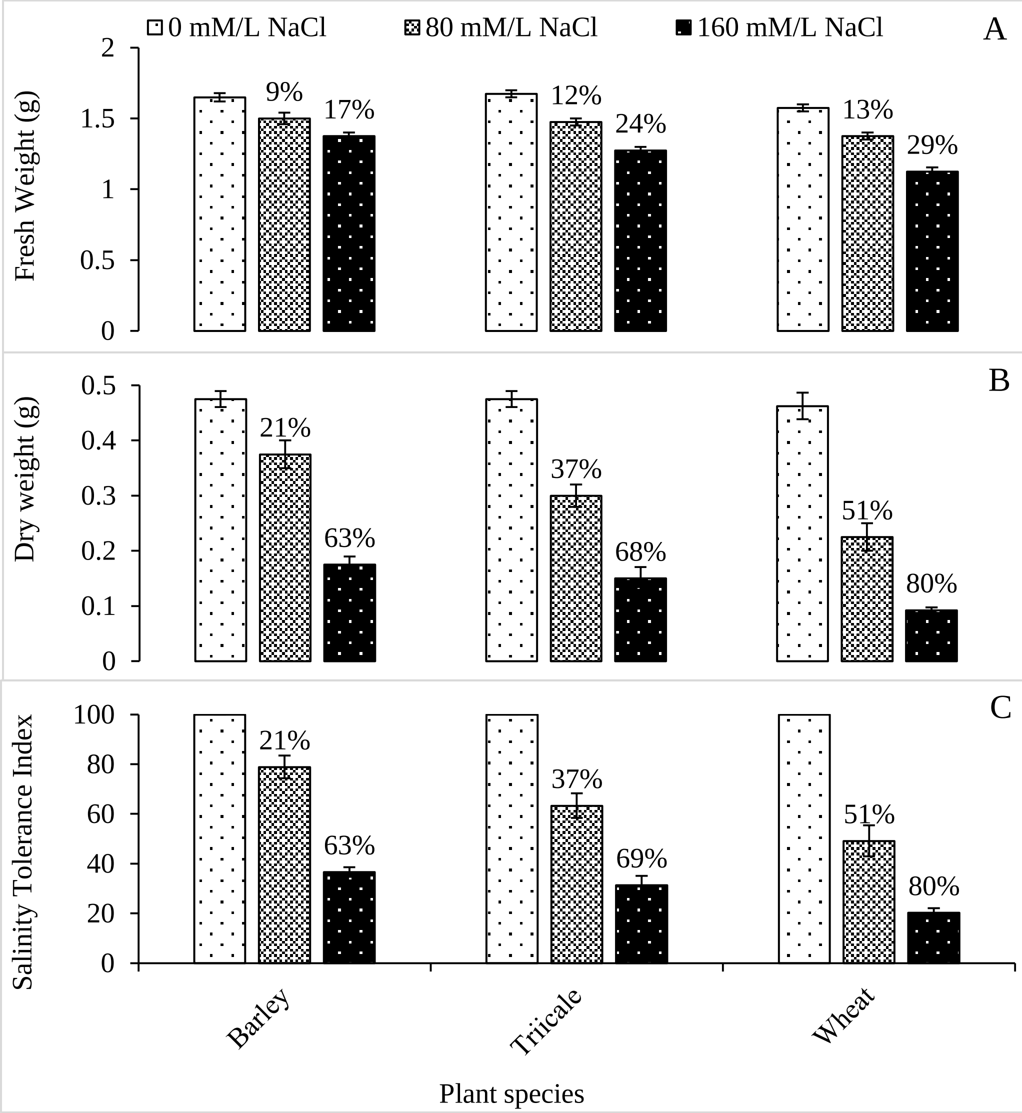

Fig 4. The effects of salinity on (A) seedlings fresh weigh, (B) seedlings dry weigh and (C) salinity tolerance index of three plant species. Each datum indicates mean value and vertical lines on top of bars indicate standard error of means (n = 4). Values on top of bars indicates the percent reduction from control.

Generally, salinity adversely affected seedlings growth as indicated by changes in fresh and dry weights. The decrease in plant fresh and dry weight was proportional to the level of salinity stress conditions imposed on the seedlings. Plant responded differently to salinity stress. NaCl solution did not affect much the fresh weight of seedlings at low concentrations (80mM NaCl), but fresh weight of seedlings decreased at higher NaCl concentrations (160mM NaCl) compared to control. The result showed that the fresh weight if barley, triticale, and wheat seedlings was decreased by 17%, 24%, and 25% respectively as compared with control (Figure 4a). In fact, the negative effect of salinity stress on seedlings growth was pronounced more on seedlings dry as compared to fresh weight. The dry weight of seedlings decreased sharply at higher NaCl concentrations (160mM NaCl) compared to control. The result showed that the dry weight if barley, triticale, and wheat seedlings was decreased by 63%, 68%, and 80% respectively as compared with control (Figure 4b). the same trend was seen with salinity tolerance index, which indicated that barley was the most tolerant to salinity stress followed by triticale, whereas wheat was the most sensitive to salinity (Figure 4c).

The result showed that plant species varied in their response to salinity treatments in term of water up uptake. In barley, triticale, and wheat plants the reduction of water uptake under high salinity level was 35 %, 20%, and 26 % respectively as compared to control treatment (Figure 5a). Also, salinity stress significantly reduced relative water content of shoots compared to control. Depending on decrease in shoots growth, relative water content gradually declined with the increasing of concentration of NaCl. Furthermore, greater reduction in relative water content was obtained in high level of NaCl concentration compared to control. Relative water content was in barley and triticale higher than those of wheat under both salinity level. relative water content decreased by 18% in barley and triticale seedlings whereas it decreased by 24% in wheat at 160mM NaCl (Figure 5b).

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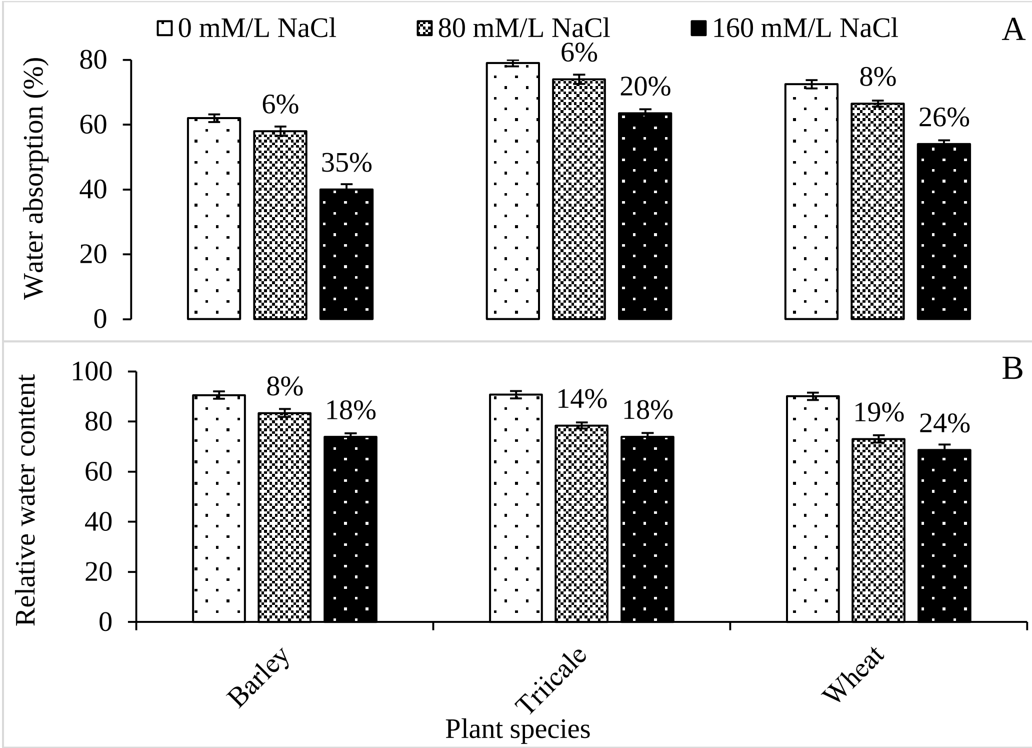

Fig 5. The effects of salinity on (A) Water uptake percentage (%)and (B) relative water content of three plant species. Each datum indicates mean value and vertical lines on top of bars indicate standard error of means (n = 4). Values on top of bars indicates the percent reduction from control.

Discussion

Salinity is the major abiotic stress that reduces plant growth and crop productivity worldwide. Salinity usually causes an individual and synergistic effects of osmotic, ionic toxicity, nutritional imbalances, and water stress which may affect plant productivity (Munns, 1993). plant's response to salinity is associated with its stage of development, and many studies indicated that the most salt-sensitive stages of crop growth are seeds germination as it affects seedlings establishment (Ashraf and Foolad, 2005; Ehtaiwesh and Rashed, 2019; Kankarla *et al.*, 2020). 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. Differences in salt tolerance of wheat and barley have been well documented but knowledge of such differences in triticale species is important. The results indicated that there were differences in germination traits of plant species depending on stress intensity. However, the result indicated that barley were the less effected plant species by salinity stress followed by triticale, whereas; wheat plants were the most effected plant species. In this study high salinity level (160mM NaCl) reduced relative water content, seeds water absorption, seed germination traits, and seedlings growth traits in all plant species. These results were similar to many previous studies with different plant species in wheat (Borlu *et al*, 2018; Rashed and Ehtaiwesh, 2019), in barley (Niazi *et al*., 1992), in triticale (Kaydan and Yagmur, 2008; Wang *et al*., 2019), and in rye (Bishnoi and Pancholy, 1980). This was because the increase of NaCl concentrations lowered water uptake by seeds, and resulted in decreases of germination and seedlings growth traits. However, plant species responded differently to high level of salinity. The result showed that mean daily germination and germination speed were the highest for barley followed by triticale and were lowest for wheat table 3. This result agreed with early study (Pagliarini *et al*., 2021). Roots and shoots length as well as seedlings vigor index are important traits against salinity stress in different plant genotypes; in general, plant genotypes with longer roots growth have resistant ability for salinity (Shafi *et al*., 2010). In this study, increase in salinity level caused a reduction in seedlings growth in term of shoots and roots length, but the extent of reduction in roots growth was more than that for shoots. In addition, these reductions in roots and shoots length as well as seedlings vigor index were lower in barley followed by those of triticale then wheat, which had the shortest shoots and roots length table 3. Similar results were obtained when comparing triticale, wheat and barley growth under saline condition (Pagliarini *et al*., 2021). Similar results were reported by Darko et al., (2015) that barley seedlings under salinity stress performed better than those of wheat. Therefore, barley seeds had an advantage of seedlings establishment under salinity condition. In addition, high level of salinity caused a growth reduction in growth of barley, triticale and wheat seedlings in term of seedlings fresh and dry weight. Similarly, Rawson et al (1988) and Bağci et al (2007) reported that seedlings fresh and dry weights of wheat declined when salinity level increased, but the extent of reduction in fresh weight was less than that for dry weight. Even though the seedlings weights decreased with the effects of NaCl, barley seedlings had higher fresh and dry weights compared to wheat and triticale, however, the triticale showed less reduction in growth compared to the wheat which agreed with the finding of early study (Shalaby *et al*., 1993). Even in NaCl increased concentrations, Karim et al (1994) indicated that barley was the most tolerant to salinity among all the crops, followed by triticale. Therefore, heavier seedlings weights protected seedlings from salinity injuries. Moreover, the results of this study presented in table 3 showed that salinity tolerance of triticale is basically better than that of wheat and might even approach that of barley, this finding was similar to that indicated in previous study (Blum, 2014; Shreidi *et al*., 2019). Furthermore, Relative water content was used as a measure of drought induced by salinity, and it is useful for determining seedlings water status. The relative water content of the shoots has been proposed as a better indicator of water stress. This study revealed that drought induced with salinity decreased shoots water status, which was in agreement with (Kaydan and Yagmur, 2008; Agami, 2014; Charushahi *et al*., 2015). Yet, seedlings of barley and triticale had higher relative water content than that of wheat table3. This result indicated that barley seedlings having longer roots had more water uptake abilities resulting in higher shoots relative water content. Almost all germination and seedlings growth traits included in this study indicated that barley appeared to be more tolerant followed by triticale and wheat was the most sensitive to salinity stress. The study recommended that the all studied traits can be used as selection criteria for cereal breeding programs.

Conclusion

Environmental stresses are the most contributive factors which controlling crops yield resulting in declining agricultural productivity. In North Africa, 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. Previous studies have focused on salinity stress in either triticale, barley or wheat alone, with little inter specific comparison. So, this study aimed to compare the salinity tolerance in these three crop species. The results revealed that the values for the examined traits such as water uptake, relative water content, germination speed, shoots and roots length, fresh and dry weight were significantly affected with the increasing levels of salinity, but varied depending on crop species and levels of salinity. This study conclude that barley may be considered the most tolerant to salinity followed by triticale and wheat was the most sensitive to salinity stress. However; more research and further investigation are needed to compare the effect of salinity on growth and yield at different growth stages of these three cereals crops as well as diverse crops. The results of this study was very useful to use as selections criterion for improving grain yield in those cereal species.

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دراسة صفات الإنبات ونمو البادرات لنباتات القمح (*Triticum aestivum*) والشعير (*Hordeum vulgare*) مقارنة مع نبات الشقم (*Triticosecale Wittmack* ×) تحت الإجهاد الملحي

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الملخص

إنتاج محاصيل الحبوب كغيره من المحاصيل تواجه العديد من الضغوط الحيوية كالآفات والكائنات الممرضة ،والغير حية مثل الحرارة والجفاف والملوحة. أجريت هذه الدراسة لتقييم ومقارنة تأثير إجهاد الملوحة على إنبات ونمو بادرات القمح (*Triticum aestivum* L) صنف سلامبو، والشعير (*Hordeum vulgare* L) صنف ريحان 03 مع الشيقم (*Triticosecale Wittmack* ×) صنف (cume) line 3 . تمت معالجة بذور كل الأنواع النباتية بثلاثة معاملات (تركيزات)من الملوحة : (0 مجموعة الشاهد و80 و 160 ملي مول كلوريد الصوديوم في مرحلة الإنبات ونمو البادرات..نفذت التجربة بالتصميم العشوائي الكامل في أربعة مكررات.

أشارت النتائج إلى أن التأثير المستقل للملوحة كان معنوياً جدا ($P < .0001$) بجميع الصفات التي تم دراستها، كما كان التأثير على الأنواع النباتية معنوياً أيضا ($P < .0001$) لجميع الصفات التي تم درستها باستثناء نسبة الإنبات. وكذلك أوضحت الدراسة وجود علاقة ذات دلالة إحصائية بين تداخل إجهاد الملوحة مع نوع النبات ($P < 0.05$) لجميع الصفات التي تم دراستها باستثناء نسبة الإنبات، وأظهرت النتائج أنه في ظل ارتفاع تركيز الملوحة (160 ملي مول كلوريد الصوديوم) فان نباتات الشعير و الشيقم كانت أعلى سرعة في الإنبات. كما أشارت النتائج إلى أن الملوحة أدت إلى انخفاض معنوي في كلا من نسبة امتصاص البذور للماء وطول الجذور و وزن البادرات الحي (الرطب) والجاف. وبذلك؛ اكدت الدراسة ان نبات الشعير هو أكثر الأنواع كفاءة تحت ظروف الملوحة فقد سجل اعلى إنتاج للمادة الجافة يليه نبات الشيقم، بينما سجل نبات القمح الطري أقل وزن جاف للبادرات.

خلصت هذه الدراسة إلى أنه في ظل الإجهاد الملحي، يُظهر أن كل من نبات الشعير والشيقم محاصيل حبوب واعدة تتحمل الملوحة ويمكن زراعتها في الأراضي الجافة والمالحة والتي تتشابه وظروف الدراسة وخاصة من حيت تركيز الملوحة .

الكلمات المفتاحية: الإجهاد الملحي، الإنبات، *Triticum aestivum*، *Hordeum vulgare*، *Triticosecale* × *Wittmack* ، نمو البادرات،الملوحة