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EFFECT OF SALINITY ON SOME WHEAT (TRITICUM AESTIVUM) CULTIVARS

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Abstract

Four wheat cultivars of Giza 9, Giza 7, Sakha 94 and Sakha 61 were cultivated under increasing NaCl levels (0.0, 50, 100, 150 and 200 mM NaCl). The tested morphological characters of shoot and roots (fresh and dry weights as well as, shoot height of the cultivars indicated that as the salinity stress increased lower values of the tested characters elucidated. The tested cultivars showed different capacities toward salt stress, and they can be arranged in the following order according to their efficiency toward salt stress: Sakha 94> Sakha 61> Giza 9 > Giza 7. Under the same conditions the cultivars showed decreased values of P, K, Ca and increased Na accumulation in their shoots and roots. As for cultivar more tolerant to salt stress lower decreases of all the tested elements were determined in their shoot. However, their roots showed adverse results lower values of P, K, and Ca than the less salt tolerant cultivar. These indicate lower translocation of P, K, and Ca from the root to the shoot of the more tolerant cultivars as compared to less tolerant cultivars. The less tolerant cultivars accumulate more Na in their roots and shoots than do the more tolerant cultivars.

Introduction

World population is increasing at an alarming rate and is expected to reach about six billion by the end of the year 2050. On the other hand productivity of food is decreasing due to the effect of various abiotic stresses; therefore minimizing these is a major area of concern for all nations to cope with the increasing food requirements. Salinity and drought are among the major stresses, which adversely affect plants growth and productivity, hence it is important to develop stress tolerant crops. Salinity and drought exerts their malicious effect mainly by disrupting the ionic and osmotic equilibrium of the cell (Bray *et al*. 2000; Mahajan and Tuteja, 2005).

Salinity is a major environmental stress and a substantial constraint to crop production (Allakhverdiev *et al*. 2006). Increase salinization of arable land is expected to have devasting global effects (Wang, 2003). High salinity causes both hyperionic and hyperosmotic stress and can lead to plant demise. Salinity in a given land area depends upon various factors like the amount of evaporation, and the amount of precipitations. Weathering of rocks also affects salt concentration. This leads to large losses in terms of arable land productivity as most of the economically important crop species are very sensitive to soil salinity (Mahajan and Tuteja, 2005).

High salt concentration (Na in particular) which deposit in the soil can alter the basic texture of the soil resulting in decreased soil porosity and consequently reduced soil aeration and water conductance. The basic physiology of high salt stress and drought stress overlaps with each other. High salt depositions in the soil generate a low water potential zone in the soil making it increasingly difficult for the plant to acquire both water as well as nutrients. The major ions involved in salt stress signaling include Na. K, H and Ca. The inter play of these ions, which brings homestasis in the cell (Zhu, 2003. Mahajan and Tuteja, 2005).

Grain germination and seedling growth of wheat (Triticum aestivum L.), like other crops, were negatively affected by drought and salinity stresses(Ashraf and McNeily, 1988; Passioura, 1988, Soltani *et al*. 2006, Song *et al* 2008).Salt stress resulted in poor germination, decreased seedling growth, retarded root and shoot growth, leaf growth, leaf area and affects the plants at all growth stages resulting in poor establishment and occasionally crop failure (Soltani and Galeshi, 2002; Quissible *et al*. 1992; Cramer *et al*. 2001; Bernardo *et al*. 2000; Parida and Das, 2005; Soltani *et al*. 2006; Zheng *et al*. 2008). The present work aimed to compare between four wheat cultivars, Giza 7, 9, Sakha 61 and Sakha 94, to resist increasing levels of NaCl through their effects on some morphological characters as shoot and root fresh and dry weights as well as shoot height and some ions content of P, K, Na, and Ca in their root and shoots.

Material and methods

The grains of four wheat *Triticum aestivum* L.cultivars (Giza 9 and 7, Sakha 94 and 61) were kindly provided from Agriculture Research Centre of Egypt. Grains were sowed in small pots containing clay soil presented from some farms around Khulais village close to Jeddah. The experiment consisted of four saline treatments and tap water as a control. The saline treatments used during this experiment were as a follows: 50,100,150 and 200 mM NaCl. The pots were arranged in randomized block design with four replications. The grains were irrigated with tap water until the first true leaf stage appeared. The seedlings were grown in growth cabinet with a 12- h photoperiod, the temperature ranging between $26C^0$ during the day and $20C^0$ during night periods and the relative humidity of about 70%. Salinity treatments were imposed by adding salt (NaCl) gradually at the rate of 50mM or less per day up to the specific level of each treatment. The seedlings were harvested after one month of adding salinity treatments, five replicates were taken for each measurement.

Physical characteristics, plant height, fresh and dry weights for the shoot and root tissue documented at the end of the experiment. Determine of phosphate, potassium, sodium and calcium concentration of the plant shoots and roots were calculated for plants growing under the various saline treatments according to the method described by Fiske and Subba Row (1952), Jackson (1962) and Piper (1950).

Results and Discussion

Genotype variation of some morphological parameters of wheat cultivars:

Wheat seedlings grown in the presence of increasing NaCl levels (0.0-200 mM) in hydroponic medium during twenty one days showed a noticeable reduction in fresh and dry weights of shoots and roots, as well as shoot heights of the tested wheat cultivars (Giza 7, 9 and Sakha 61 and 94) as given in (Figures 1, 2, 3, 4, 5, 6, 7, 8 and 9). The results showed a detec decrease in all the tested parameters as the salinity increased from 0.0 up to 200 mM NaCl. Under these conditions Giza 9, 7, Sakha 94 and 61 cultivars showed decrease percentages of 8.46, 24.71, 13.68 and 19.89 %, respectively, of shoot fresh weight and 36.4%, 22.2%, 20.0%, 12.5% decreases of shoot dry weight, respectively. While, the roots showed fresh and dry weight decreases of 28.8%, 35.5%, 27.5%, 14.4% and 44.4%, 33.3%, 37.5%, 23.3%, respectively. On the other hand, shoot height for the same cultivars showed decreases of about 27.0, 27.6, 25.9 and 24.1 %, respectively. The deleterious effect of increasing salinity was clearly attained in the root especially in its dry weight outputs. Thus, the mean loss in root dry weight of the four cultivars was about 34.6% and it was about 26.5 % for root fresh weight. On the other hand, shoot fresh and dry weights showed lower mean decreases of about 23.6, 22.8 %, respectively. While shoot height showed mean decrease (26.1 %) parallel to that of root fresh weight (25.5 %). According to the mean of average of decreases of fresh and dry weights (of shoot and root) and shoot height, the cultivars can be arranged in ascending order according to tolerance to salinity as Giza 7 > Giza 9 > Sakha 61 > Sakha 94. Where the means of average of decrease of fresh and dry weights of shoot and root were 24.34, 20.13, 16.23 and 12.16 % respectively, and for shoot height the mean averages were 20.13, 16.95, 15.65 and 12.88 %, respectively. These indicates that Sakha 94 was the most tested wheat cultivar that tolerate salinity and Giza 7 cultivar was the most salt sensitive wheat cultivar.

In accordance with these findings it was reported that salt stress results in a considerable decrease in fresh and dry weights of leaves, stems and roots (Hernandez *et al*. 1995; Ali Dinar *et al*. 1999; Chartzoulakis and Kalapaki, 2000; Sagib *et al*. 2000). It was also reported that the effect of salinity may vary depending on the type of cultivar and different wheat cultivars with different abilities in tolerating salinity might show various behaviours, with some good features can be achieved through breeding (Zheng *et al*. 2008).

Genotypic variation in some ion contents:

The results of element content of P, K, Na and Ca of shoots of wheat cultivars (Giza 7, 9, Sakha 61, 94) as in (Figures 10, 11, 12, 13, 14, 15, 16 and 17) as influenced by increasing salinity level (0.0- 200 mM NaCl) indicated that the salinity increase was concomitant with parallel decrease in wheat cultivars shoot content of P, K and Ca and as the cultivar was more tolerant to salinity, as indicated before, the average of decrease of P, K and Ca was more than the less tolerant cultivar (Giza 7). On the hand, the Na content of the shoots showed adverse picture, where as the salinity level increased Na content was increased and as the cultivar was more tolerant to salinity (Sakha 94) lower Na accumulation was assayed than the less salinity tolerant cultivar (Giza 7). Thus, as the wheat cultivar is more sensitive to salinity its shoot accumulates more Na and lower amount of P,K and Ca. Where, Sakha 94, 61, Giza 9,7 showed decrease of 28.85, 31.25, 36.67 and 40.0%, respectively for P ions, 30.95, 41.86, 43.75, and 48.89% , respectively for K ions and for Ca ions decreases of 12.5, 25.0, 28.57, and 34.29%, respectively were recorded. However, adverse results for Na ions were estimated. Thus, increase of 61.54, 68.4, 100.0, and 120%, respectively, for Sakha 94,61, Giza 9,7. According to the mean of average of decrease of P, K and Ca and increase of Na ions the wheat cultivars can be arranged in ascending order as, Sakha 94 > Sakha 61 > Giza 9 > Giza 7. Where the mean average of decrease of P, K and Ca were 16.63, 19.12, 26.48, and 30.26 % respectively, and Na increases were 34.62, 38.16, 47.22 and 50.0 %, respectively.

As the element content of P, K, Na and Ca of roots of Giza 7, 9, Sakha 61, 94 wheat cultivars were considered, the results clearly indicated that as the salinity increases the element contents of P, K, and Ca of the roots of the four cultivars show detec parallel decreases. However, Na showed parallel increase under the same conditions. The pattern of Na increase in roots was in harmony with the figure of the shoot, i.e., Both Na percentage of increase and mean average of increase are arranged in the following order Giza 7 > Giza 9 >Sakha 61 > Sakha 94. Where 75.0, 66.67, 59.09 and 50.0 increase were respectively detected and mean average percentages of 40.63, 38.89, 31.82, and 29.17, respectively, were calculated. On the other hand, P, K, and Ca decreases in roots were vice versa to that assayed in shoots of the tested cultivars. Thus, as Giza 7 shoot contained the highest average content of P, K, and Ca (30.22%) and Sakha 94 cultivar has the lowest average (16.65%.

The average decrease percentage of P, K, and Ca upsets in their roots. It was the lowest for Giza 7 (20.89) and the highest for Sakha 94 (34.64%). These can be summarized as the decrease P, K, and Ca in the shoots arranged in ascending order as Sakha 94 > Sakha 61 > Giza 9 > Giza 7. In their roots they arranged as Giza 7 > Giza 9 > Sakha 61 > Sakha 94.

The previous results of elements content indicated that P, K, and Ca were translocated from roots to shoots and as the wheat cultivar was more tolerant to increasing salinity level, less element translocation (P, K, and Ca) from the root to the shoot and vice versa, i.e., as the plant less tolerant to salinity the translocation of P, K and Ca increased from the roots to the shoot. This may indicate that as the plant cultivar more tolerant to salinity it accumulates the salt in its root in order to increase its osmotic pressure than the surrounding atmosphere and hence increase its efficiency to absorb water. However, Na showed pattern similar to P, K, and Ca, thus as the plant cultivar was less salinity tolerant more accumulation of Na in both its roots and shoot and as the plant more tolerant less accumulation of Na in its root and shoot. This may indicate that accumulation of lower amount of Na in both roots and shoot of the cultivar could be considered as indication to its more salt stress tolerance as compared to the other cultivars of the same species. In accordance with these results, it was reported that increased treatment of NaCl induced increase in Na and Cl and decrease in Ca, k, Mg levels in a number of plants (Khan *et al*. 1999, 2000, Khan, 2001). It was also reported that increasing NaCl stress significantly elevated Na and Cl in root and shoot tissues of the plant species (Li *et al*. 2008). The effect of salinity on the nutrient composition of plant tissues, especially concentration of Ca and K, has been extensively investigated, and several researchers have confirmed that the determined effects of salinity on plant growth may occur through an ionic imbalance (Essa, 2002).

Conclusion

The tested four plant cultivars, Sakha 94, Sakha 61, Giza 9, and Giza 7 showed different capacities to resist salt stress (increasing NaCl). The more salt resistant cultivar accumulates lower Na in its both roots and shoot as compared with the less tolerant cultivar. Also, it has been shown that lower element decrease of P, K and Ca in its shoot as compared to the less tolerant cultivar with higher element decrease. However, more salt resistant cultivar root showed higher decrease of the elements as compared to the less tolerant one. This means that more translocation of P, K, and Ca from roots to shoot of less salt tolerant cultivars and vice versa in more tolerant cultivars. The four wheat plant cultivars can be arranged in the following order according to their salt tolerance (increasing NaCl levels). Sakha 94> Sakha 61> Giza 9> Giza 7.

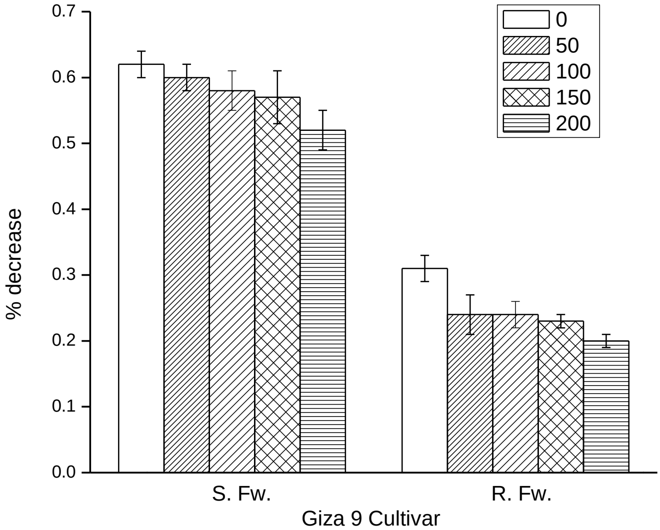

Fig. (1): The fresh weight (g) of shoot (S. Fw.) and root (R. Fw.) of Giza 9 cultivar grown at different concentrations of NaCl (mM)

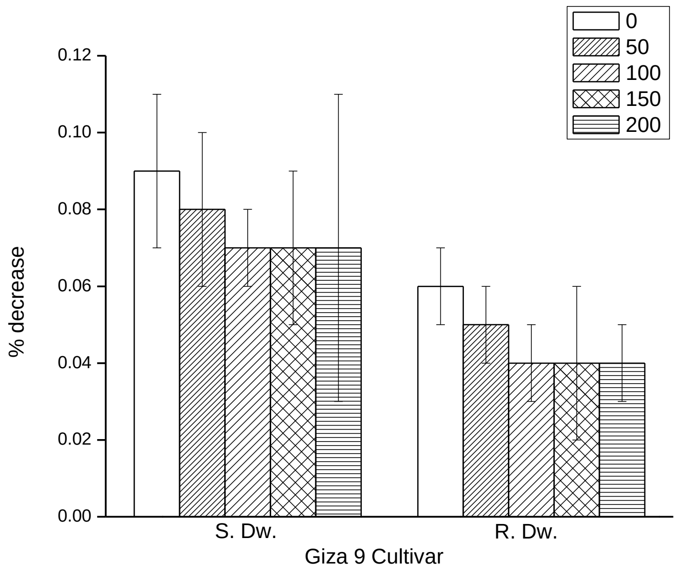

Fig. (2): The dry weight (g) of shoot (S. Dw.) and root (R. Dw.) of Giza 9 cultivar grown at different concentrations of NaCl (mM)

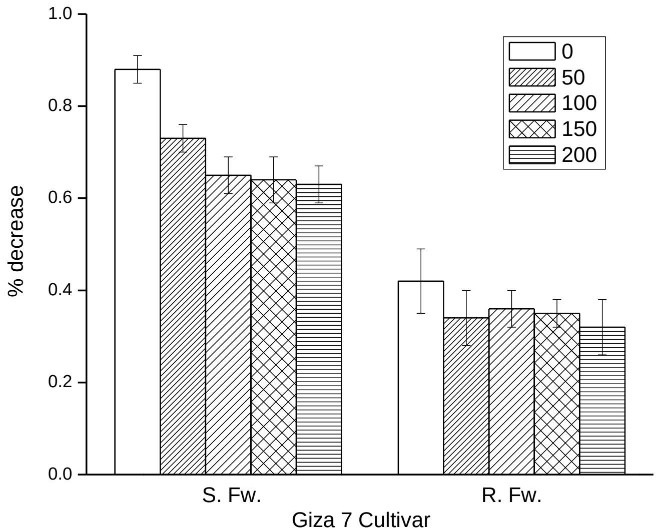

Fig. (3): The fresh weight (g) of shoot (S. Fw.) and root (R. Fw.) of Giza 7 cultivar grown at different concentrations of NaCl (mM)

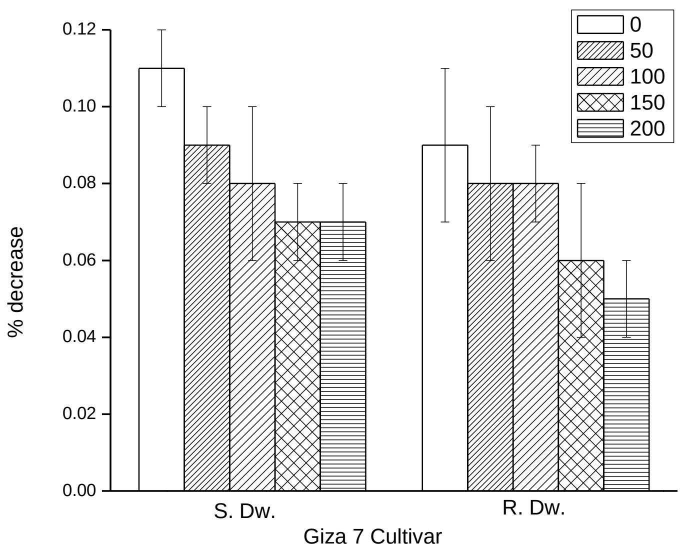

Fig. (4): The dry weight (g) of shoot (S. Dw.) and root (R. Dw.) of Giza 7 cultivar grown at different concentrations of NaCl (mM)

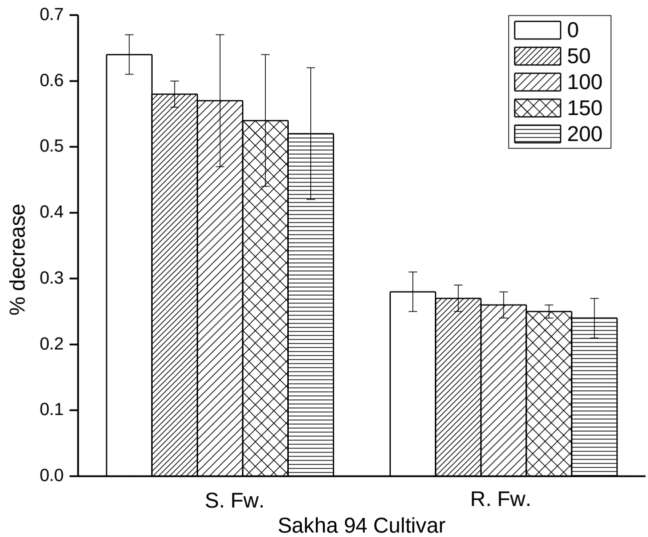

Fig. (5): The fresh weight (g) of shoot (S. Fw.) and root (R. Fw.) of Sakha 94 cultivar grown at different concentrations of NaCl (mM)

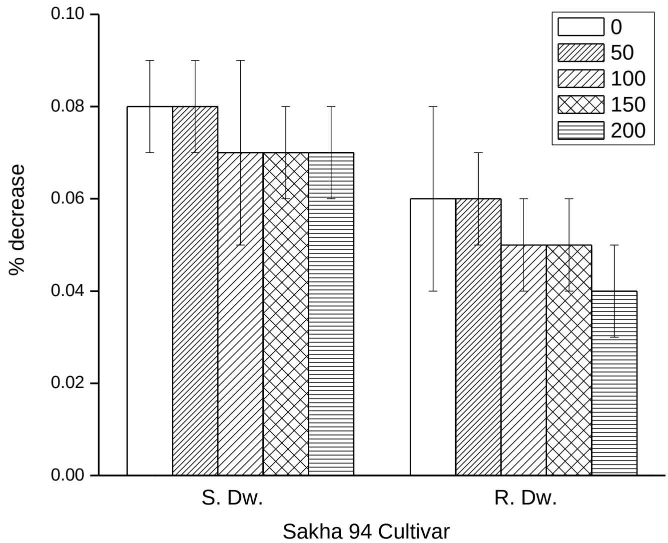

Fig. (6): The dry weight (g) of shoot (S. Dw.) and root (R. Dw.) of Sakha 94 cultivar grown at different concentrations of NaCl (mM)

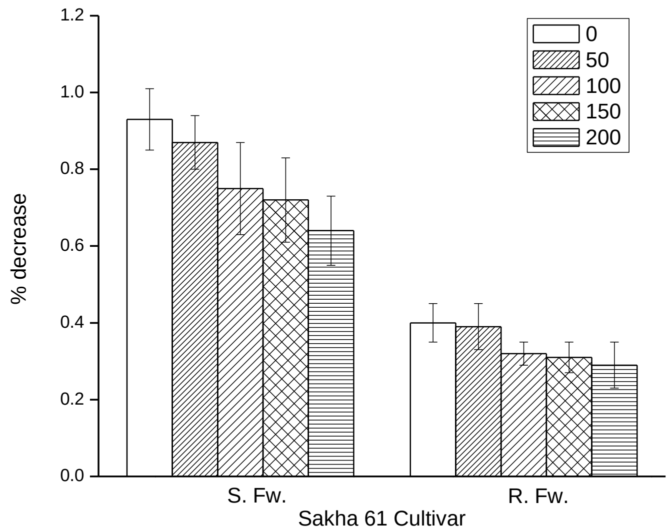

Fig. (7): The fresh weight (g) of shoot (S. Fw.) and root (R. Fw.) of Sakha 61 cultivar grown at different concentrations of NaCl (mM)

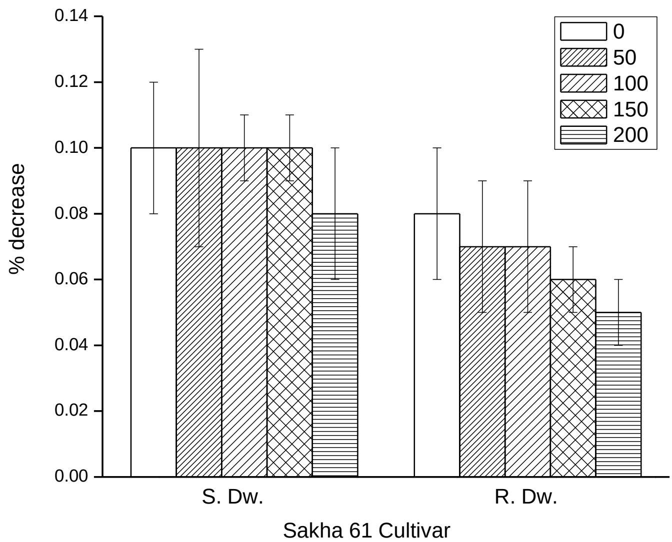

Fig. (8): The dry weight (g) of shoot (S. Dw.) and root (R. Dw.) of Sakha 61 cultivar grown at different concentrations of NaCl (mM)

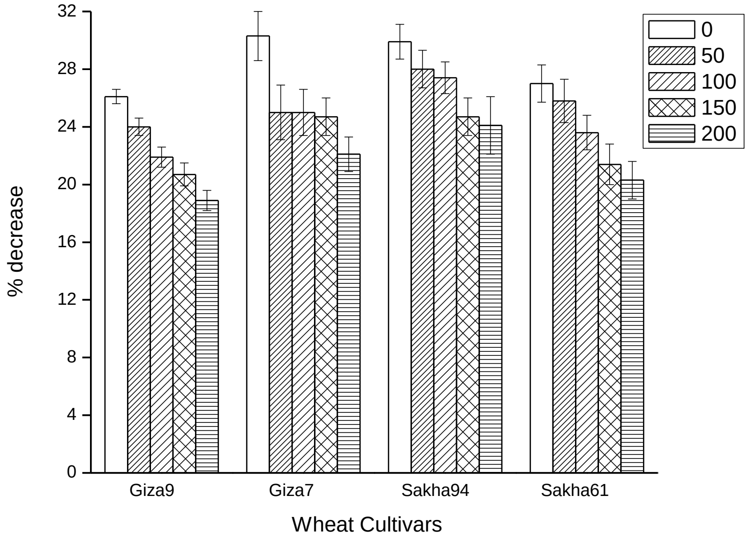

Fig. (9): The shoot heights (cm) of four wheat cultivars grown at different concentrations of NaCl (mM).

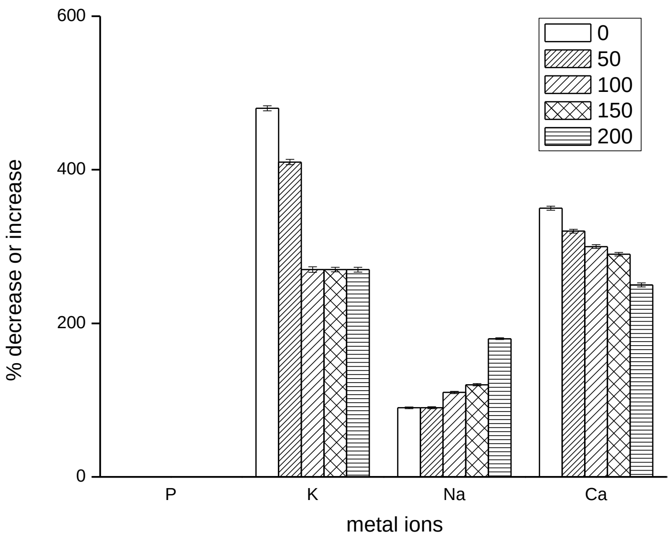

Fig. (10): Phosphate (g/100g) , potassium, sodium, and calcium (ppm) of shoots dry weights of Giza9 wheat cultivar grown at different concentrations of NaCl (mM).

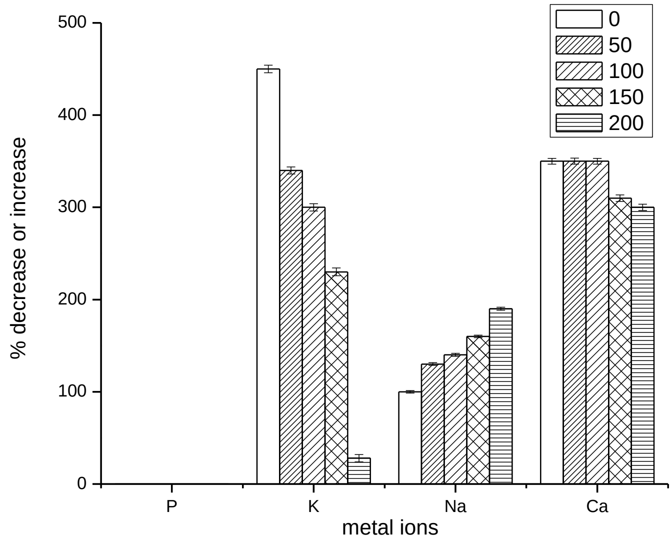

Fig. (11): Phosphate (g/100g) , potassium, sodium, and calcium (ppm) of shoots dry weights of Giza7 wheat cultivar grown at different concentrations of NaCl (mM).

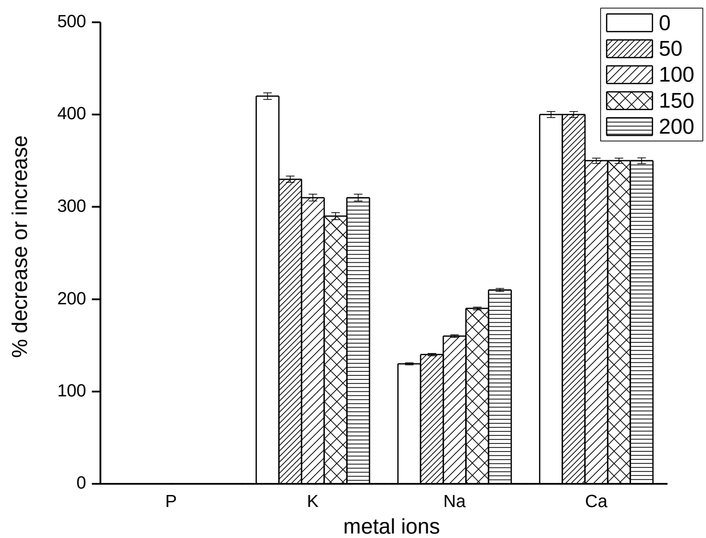

Fig. (12): Phosphate (g/100g) , potassium, sodium, and calcium (ppm) of shoots dry weights of Sakha 94 wheat cultivar grown at different concentrations of NaCl (mM).

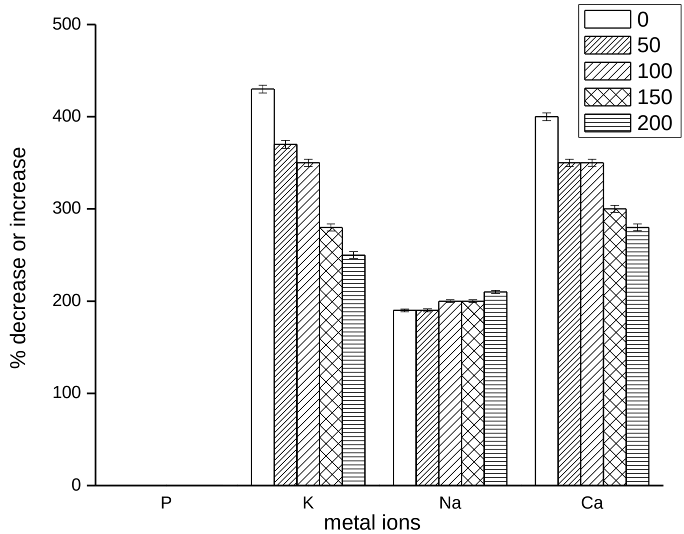

Fig. (13): Phosphate (g/100g) , potassium, sodium, and calcium (ppm) of shoots dry weights of Sakha 61 wheat cultivar grown at different concentrations of NaCl (mM).

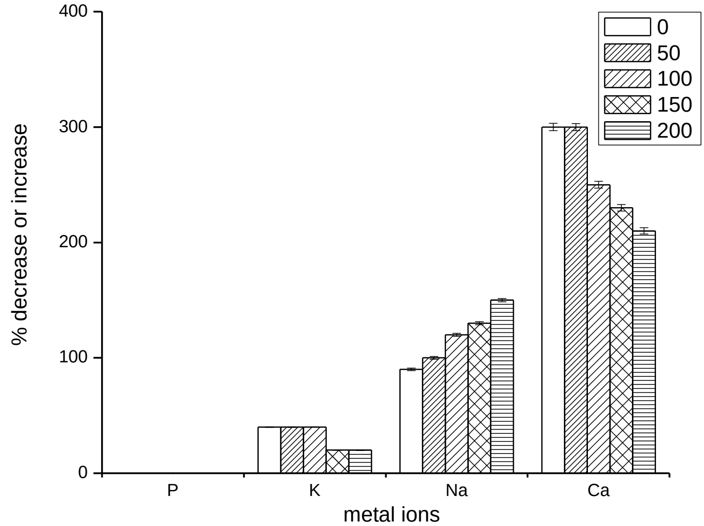

Fig. (14): Phosphate (g/100g) , potassium, sodium, and calcium (ppm) of roots dry weights of Giza9 wheat cultivar grown at different concentrations of NaCl (mM).

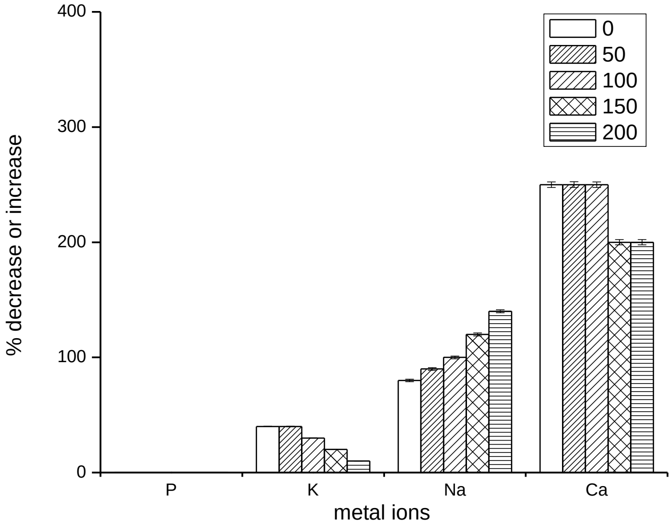

Fig. (15): Phosphate (g/100g) , potassium, sodium, and calcium (ppm) of roots dry weights of Giza7 wheat cultivar grown at different concentrations of NaCl (mM).

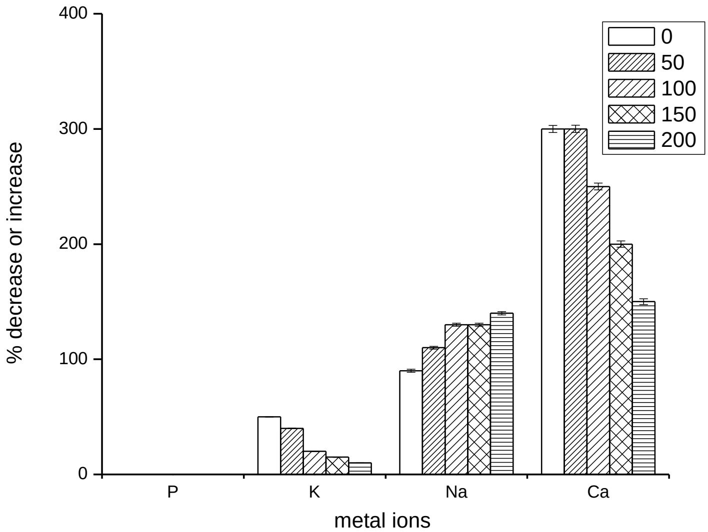

Fig. (16): Phosphate (g/100g) , potassium, sodium, and calcium (ppm) of roots dry weights of Sakha 94 wheat cultivar grown at different concentrations of NaCl (mM).

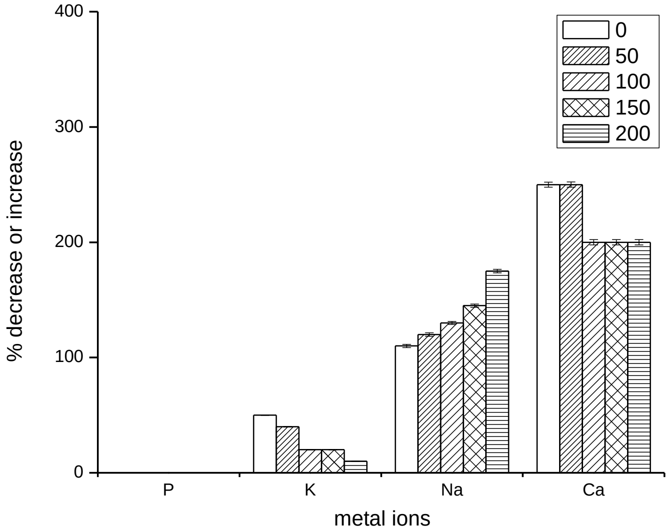

Fig. (17): Phosphate (g/100g) , potassium, sodium, and calcium (ppm) of roots dry weights of Sakha 61 wheat cultivar grown at different concentrations of NaCl (mM).

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تأثير الملوحة على بعض أصناف القمح
(Triticum aestivum)

عمر عبد الحكيم المغربي

قسم العلوم ، كلية المعلمين – جامعة الملك عبد العزيز – جدة– المملكة العربية السعودية

المستخلص

لقد تمت دراسة تأثير الملوحة على أربعة أصناف من القمح هي (جيزة 9, جيزة 7, سخا 94 و سخا 61) وكانت المعاملات الملحية المستخدمة من كلوريد الصوديوم هي (50, 100, 150 و 200 ملليمول) بالإضافة للمعاملة الضابطة وهي الماء العادي. وقد تبين من نتائج الدراسة أن الصفات الظاهرية المدروسة (الوزن الغض والجاف للمجموع الخضري والجذري وارتفاع النبات تناقصت فيها القيم تبعا لارتفاع تراكيز الملوحة وأن الأصناف ظهرت باستجابات متفاوتة تأثرا بالملوحة وكانت على النحو التالي سخا 94> سخا91> جيزة 9> جيزة 7. وفي بعض الحالات كان هناك نقص في العناصر (فوسفور, بوتاسيوم وكالسيوم) وزيادة في تراكم الصوديوم وذلك في المجموع الخضري والجذري. أما الصنف الأكثر مقاومة للإجهاد الملحي فأظهرت النتائج نقصا أقل لكل العناصر المختبرة في المجموع الخضري ولكن الجذور أعطت نتائج مغايرة من حيث النقص الأقل للفوسفور والبوتاسيوم والكالسيوم عن الصنف الأقل مقاومة للأملاح, مما يدل على انتقال أقل للفوسفور والبوتاسيوم والكالسيوم من الجذر إلى المجموع الخضري لمعظم الأصناف الأكثر مقاومة, إذا تم مقارنتها بالصنف الأقل مقاومة, حيث أن الأقل مقاومة بتراكم فيه الصوديوم في الجذور والمجموع الخضري.