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EFFECT OF SALINITY STRESS ON GROWTH AND MACRONUTRIENTS UPTAKE OF SOME EGYPTIAN BARLEY LANDRACES ((*Hordeum vulgare* L.).

Abdeen ,S.A.[1]; A.H. Rizk [1]and S. M. El-Hamamsy [2]

[1] Department of Soils and Water, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.

[2] Department of Biochemistry , Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.

ABSTRACT

In this study the effect of salinity stress on growth and macronutrient uptake of some barley landraces ((*Hordeum vulgare* L.) grown in sandy loam soil were investigated. The main purpose of this study was carried out to evaluate three Egyptian barley landraces i.e. (L2, L6 and L10) for salinity tolerance. The plants were irrigated by using saline water with different concentration (0, 50.100 and 150 mM NaCl) for 60 days. A pot experiment was conducted to achieve this study. Results indicated that increased salinity caused a significant reduction in percentage of fresh and dry weights of barley plants. Soil pH and EC values were increased as a salinity level of irrigation water increased. Soluble Na^+ concentration were increased with increasing NaCl levels, whereas Ca, Mg and K in soil were decrease as a result of increasing the concentration of NaCl in irrigation water. That is true for all landraces. In addition, the values of N, P and K content in barley landraces were decreased with increasing salinity levels. Also the N, P and K uptake were significant decreased by increasing salinity levels. Generally, the results clearly showed that landrace L2 had the highest salt tolerance compared with landraces L6 and L10.

Keywords: Saline stress, barley, macronutrient uptake.

INTRODUCTION

Salinity is one of the most important problem affecting seed germination and plant growth especially in many area of the world. Barley (*Hordeum vulgare L.)* is considered to be the most salinity tolerant among cereals (Belaid and Morris, 1991). Salinity stress affects nutrient uptake and metabolic activities in plant (Singh and Hoque, 2001). Plant growth usually decreases by increasing NaCl concentration in the medium. Naseer *et al*., (2001) reported that the germination percentage, root and shoot length and fresh and dry weights were decreased in barley cultivars by increasing salinity levels. According to Grattan and Grieve (1999) that the direct effect of salts on plant growth may be divided into three broad categories: (i) a reduction in the osmotic potential of the soil solution that reduces plant available water, (ii) a deterioration in the physical structure of the soil such that water permeability and soil aeration are diminished, and (iii) increase in the concentration of certain ions that have an inhibitory effect on plant metabolism (specific in toxicity and mineral nutrient deficiencies). It is also known that high salt concentrations are toxic and limit growth because nutrients are proportionally less available or create physiological drought as a consequence of the high osmotic pressure of the soil solution (Fageria, *et al.,* 1991). Salinity generally inhibits plant growth and productivity (Al-Karaki, 2000).More precisely, detrimental effects of salinity on plant growth result from direct effects of ion toxicity or indirect effects of saline ions on soil water potential, which cause soil/ plant osmotic imbalances. Several authors summarized that salt stress significantly decreased shoot, root and total dry matter of corn plants, and noticed an increasing degree of reduction in dry matter production with increasing salinity levels (Bar-Tal, *et al.,* 1991). Salinity reduces plant growth and yield by two mechanisms, osmotic stress and ion cytotoxicity (Munns and Tester 2008). Munns *et al*. (1995) proposed a two-phase model of salt injury where growth is initially reduced by osmotic stress and then by Na^+ toxicity. However, some uncertainty exists regarding the relative importance of the two mechanisms. This is due to the difficulty in separating the osmotic effect from specific ion effects because of the overlap in the development of the two types of stresses during the development of salinity stress.

The saline growth medium causes many adverse effects on plant growth, which are due to a low osmotic potential of soil solution (osmotic stress), specific ion effects (salt stress), nutritional imbalances, or a combination of these factors (Marschner 1995). The deleterious effects of salinity on plant growth is attributed to the decrease in osmotic potential of the growing medium, specific ion toxicity and nutrient ion deficiency by disrupting potassium (K+) nutrition, which can be a result of inorganic ion (Na^+, Cl^-, and K^+) and compatible organic solute accumulations (soluble carbohydrates, amino acids, proline, betaines, etc.) (Luo et al., 2005). Plants require macro and micro elements to grow. In soil, micronutrients are not always present in the solution and their availability is limited due to several factors, which mainly limit their solubility. Reduced growth under saline conditions is a common response of many plant species including barley (Mahmood *et al.,* 1996). Salt stress had a negative effect on plant growth and caused reduction of dry weight in all maize cultivars. Reduction in growth is one of the potential criteria, as indicated in some earlier studies (Hichem *et al*., 2009). The main objective of this study is to evaluate growth and macronutrient uptake of some three Egyptian Barley landraces for salt tolerances.

MATERIAS AND METHODS

In order to study the effect of salinity on growth and macronutrient uptake of three barley landraces (*Hordeum vulgare L*.) (L2, L6, L10), a Pot experiment was carried out at the farm of soils and water department, Faculty of Agriculture, Al- Azhar University, Nasr city Cairo Egypt. Barley landraces were obtained from Field Crops Research Institute and National Gene Bank (NGB), Agricultural Research Center (ARC), Giza, Egypt. The landraces were analyzed in biochemistry department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt. Four NaCl concentrations (0, 50, 100 and 150 mM) were added. Plastic pots filled with 7 kg sandy loam soil. 10 seeds of all landraces were planted in every pot and moisture content of pots was kept approximately at field capacity. The cultivated plants were fertilized with ammonium sulfate, super phosphate and K- sulfate according to the general recommendation dose of Ministry of Agriculture. After 60 days from planting, barley shoots of each treatment were cut just one cm above the soil surface and prepared for analysis. Soil samples from each pot were taken after harvesting, air- dried, crushed and passed through a 2 mm sieve and kept for soil analysis. The characteristics of the investigated soil, i.e. Particle size distribution, Soil pH, EC, soluble cations and anions, available N, P, K were determined (Page *et al.,* 1982 and Klute, 1986). N, P and K were estimated in the plant digest, Cottenie *et al*. (1982). Total seeds storage protein, carbohydrate and ash were determined by near infra analyzer (NIR), according to Zhao *et al.* (2005).Total lipids and the moisture content were determined as recommended the proceeding outline by A.O.A.C. (1990). The statistical analysis for all data, which obtained was carried out and differences between means were calculated using L.S.D test according to Steel and Torrie (1980). Some physical and chemical properties of the studied soil are presented in Table 1.

Table 1 Some physical and chemical properties of the studied soil

Parameters	pH	EC dS.m^{-1} (1:2.5)	Soluble cations meq.L^{-1}				Soluble anions meq.L^{-1}				Available macronutrients mg .kg^{-1}			Field capacity %	Particle size distribution %			Textural class
			Ca^{++}	Mg^{+}	Na^{+}	K^{+}	$CO_3^{=}$	$HCO_3^{=}$	Cl^{-}	$SO_4^{=}$	N	P	K		Sand	Silt	Clay	
Value	7.5	3.2	6.6	5.9	14.6	0.9	0.0	10.26	12.6	5.14	44.0	13.5	65.0	18.5	53.5	32.0	14.5	Sandy loam

RESULTS AND DISCUSSION

Chemical composition of three Egyptian barley landraces

Grain proteins content and carbohydrates are considered the most important characteristics determining grain quality landraces. **(Gooding *et al*., 2003)**. Data in Table 2 show that the highest value of total carbohydrate content was recorded in landrace 2. The increment was highly significant compared with other landraces. On the other hand the lowest value was found in landrace 10. Also, data revealed that the highest value of fiber content noticed in L6 while the lowest value found in L10.Addition that L10 had the highest value of crude proteins and L 6 had the lowest value. Concerning of Lipids content, L6 recorded the highest value while the lowest recorded in L2.

Table 2 Chemical composition of used barley landraces.

Barley landraces	Total Carbohydrates	Fiber	Ash	Proteins	Moisture	Lipids
L2	43.06	5.08	2.19	12.84	10.21	0.85
L6	40.75	5.26	2.26	12.43	9.82	0.91
L10	36.13	4.89	2.34	13.50	9.96	0.87
LSD at 5%	3.69	N.S	N.S	0.45	N.S	N.S

Soil chemical properties after barley harvest

Soil pH is the most important parameter which shows the over all changes in soil chemical properties. The data in Table 3 show that pH values increased as a salinity level of irrigation water increased. The maximum value of pH (7.4) was recorded under the higher levels of saline irrigation water (150 NaCl mM) while, minimum pH (7.11) was noted at control. The values of soil pH ranged from 7.11 to 7.4 with all landraces. In this concern Magdi *et al.,* (2010) found that irrigation with saline water (NaCl at 50 or 100 mM) significantly increased the values of pH in the soil samples compared with the control. Also the analysis of soil showed that irrigation with saline water increase the total soluble salts in the soil samples after barley harvest. Soil electrical conductivity increased as a result of increasing salinity levels of irrigation water. This finding is in agreement with those obtained by Ragab (2001) He observed that, there was a progressive and significant increase in soil salinity values as the salinity of irrigation water increases. The highest value recorded 12.2 dSm^{-1} for salinity level 150 mM NaCl treatment, and the lowest value was obtained 3.5 dSm^{-1} for salinity level control treatment for L10. Also the same trend was found for all landraces.

Table 3 Some soil properties as affected by levels of saline irrigation water (NaCl) after barley harvest.

Landraces	NaCl mM	pH	EC $dS.m^{-1}$	Cations $meq.L^{-1}$				Anions $meq.L^{-1}$			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO^{=}_3$	$HCO^{=}_3$	Cl^{-}	$SO^{=}_4$
L2	0.0	7.11	3.60	8.50	4.60	16.50	2.80	0.00	8.20	15.50	8.70
	50	7.20	6.90	5.60	3.50	44.70	2.00	0.00	5.11	43.50	7.09
	100	7.35	9.70	4.20	2.60	76.50	1.50	0.00	4.30	74.70	5.80
	150	7.40	11.80	2.80	1.80	90.50	0.90	0.00	3.20	87.20	5.60
L6	0.0	7.14	3.50	8.80	4.70	15.00	3.90	0.00	8.40	16.00	8.00
	50	7.25	7.10	6.40	4.11	48.00	3.00	0.00	7.20	46.50	7.81
	100	7.40	9.60	4.00	2.30	73.00	2.00	0.00	6.50	68.00	6.80
	150	7.40	11.40	3.50	1.50	98.40	1.40	0.00	5.40	93.00	6.40
L10	0.0	7.13	3.50	7.80	5.00	16.10	3.20	0.00	9.11	15.70	7.29
	50	7.20	8.10	7.11	4.20	49.60	3.00	0.00	7.90	49.20	6.51
	100	7.40	10.20	5.20	2.90	76.3	2.11	0.00	6.90	74.00	5.61
	150	7.40	12.20	4.20	2.00	97.00	1.80	0.00	5.60	96.00	3.40

Concerning soluble cations and anions data show that the concentration of soluble Ca^{++}, Mg^{++} and K^{+} in soil decreased as a result of increasing the concentration of NaCl in irrigation water. That is true for all landraces. The highest values of Ca^{++}, Mg^{++} and K^{+} for L2. were 8.5 ,4.6 and 2.8 meq. L^{-1}, respectively. While the lowest values were 2.8, 1.8 and 0.9 $meq.L^{-1}$, respectively. In L6. The highest values of Ca^{++}, Mg^{++} and K^{+} were 8.8, 4.7 and 3.9 $meq.L^{-1}$, respectively. While the lowest values were 3.5, 1.5 and 1.4 meq/L, respectively. In L10. The highest value of Ca^{++}, Mg^{++} and K^{+} were 7.8, 5 and 3.2 meq/L, respectively. While the lowest value were 4.2, 2 and 1.8 meq/L, respectively. But soluble sodium content in the studied soil for all landraces increased by increasing sodium content in irrigation water; this could be attributed to the higher adsorption capacity of sodium. Regard to soluble HCO^{-}_3 and $SO^{=}_4$, generally, increasing salinity levels of irrigation water effected on sulphat and bicarbonate content in the studied soil, the highest value were found in control while the lowest one was found for salinity level 150 mM NaCl treatment. The precedent data are in agreement with those obtained by Magdi *et al.,* (2010) who found that irrigation with saline water (NaCl at 50 or 100 mM) significantly reduced Ca^{++}, Mg^{++}, K^{+}, HCO_3^{-} and $SO_4^{=}$, while significantly increased the contents of Na^{+}, Cl^{-}, pH, and EC in the soil samples compared with the control.

Fresh and dry weight

Generally, plant growth and development are adversely affected by salinity. Data in Table 4 show that the reduction in fresh and dry weight of barley plant was significantly increased with increasing salinity levels in irrigation water. In this concern, Shafi *et al.,* (2009) found that salinity lead to disturbances in plant metabolism, which consequently led to reduction of plant growth. The results clearly showed that increases in salinity were significantly decreased growth of barley plants.

Table (4)Effect of saline irrigation water on fresh and dry weight(g. pot^{-1}) of barley plant

Landraces	NaCl m M	Fresh weight		Dry weight	
		g.pot^{-1}	Decrease* %	g.pot^{-1}	Decrease** %
L2	0.0	41.55	-	7.80	-
	50	40.00	3.73	7.44	4.62
	100	34.65	16.61	6.95	10.9
	150	29.33	29.41	6.22	20.26
mean		36.38	-	7.10	-
L6	0.0	38.62	-	7.43	-
	50	38.00	1.61	7.00	5.79
	100	35.70	7.56	7.00	5.79
	150	24.42	36.77	5.75	22.61
mean		34.18	-	6.79	-
L10	0.0	40.22	-	7.36	-
	50	37.54	6.66	6.94	5.71
	100	32.41	19.42	6.22	15.49
	150	22.63	43.73	5.40	26.63
mean		33.20	-	6.48	-
LSD at 5%	A	0.15	-	0.22	-
	B	0.18	-	0.26	-
	AB	0.31	-	N.S	-

A = Landraces and B =NaCl mM

*** Fresh weight decrease % = 100 x [1 - (fresh weight *treated with NaCl*/ fresh weight control)]**

**** Dry weight decrease% = 100 x [1 - (dry weight *treated with NaCl* / dry weight control)]**

These results are in agreement with those obtained by Sayed (2015) found that fresh and dry weight gradually decreased as the salt concentration increased. However, barley cultivars differ in their sensitivity or tolerance to salts. The percentages of fresh and dry weight were significantly decreased as a result of salt stress in all barley landraces. The maximum percentage was recorded under control level and minimum at the highest salinity level. However, maximum percentage of fresh and dry weight was recorded in L2 in all salinity levels. Also, minimum percentage was recorded in L10 under the same levels. The highest decreasing percentage of fresh and dry weight recorded 43.74 and 26.63%, respectively.

On the other hand the best landrace to tolerance salinity was L2. The highest decreasing percentage of fresh and dry weight recorded 29.41 and 20.26 % respectively. These results are in agreement with those obtained by Hichem *et al*., (2009) who found that growth reduction as associated with salt stress in different maize cultivars at different growth stages. Furthermore, growth reducing effects of different saline regimes in hydroponic culture system were also observed by Chen *et al*., (2007) in different bean cultivars and they reported that different cultivars showed differential response to salt stress. Generally, the maximum percentage of fresh and dry weight recorded under control level and minimum at the highest salinity level of all landraces. According to Haggi *et al.,* (1999) the depressive effect of salt on the growth is related to the osmotic potential of the soil solution around the roots, an increase in the accumulation of some ions in harmful concentrations in tissues and a modification of the nutritional statute of the essential ions to the growth and the development. The increase of soil salinity is translated by an immediate reduction of shoot growth. This is may be due to salinity reduces the water potential of soil solution, which prevents the efficient water supply to the plants. Therefore, saline habitats receiving large amounts of salts in root cells that limit the germination, seedling growth and establishment. (Jamian et al., 2014).

NPK content and uptake

Generally, data in Table 5 show that the N, P and K content were decreased with increasing the concentration of NaCl. Also the uptake of NP and K were significantly decreased with increasing the concentration of NaCl. This is may be due to higher salinity may affect different metabolic processes. The concentrations of soluble salts through their high osmotic pressures affect plant growth by restricting the uptake of water by plant roots. High salinity can also cause nutrient imbalances. In this concern Grattan and Grieve (1999) revealed that the content of some macro nutrients in plant tissue depend on the level of salinity, plant species (cultivar) and developmental stage of plant. The data indicated that both barley landraces grown in sandy loam soil affected by the high levels of salinity. Various authors have attributed this reduction to Cl^- antagonism of NO_3^- (Bar *et al.,* 1997) while others attributed the response to salinity's effect on reduced water uptake (Lea-Cox and Syvertsen**,** 1993). The nitrate influx rate or the interaction between NO_3^- and Cl^- has been reported to be related to the salt tolerance of the species under investigation. In most cases, salinity decreased the concentration of P in plant tissue (Kaya *et al.,* 2001), but the results of some studies indicate salinity either increased or had no effect on P uptake (Ansari, 1990). The reduction in P availability in saline soils was suggested by Sharkey *et al.,* (1992) to be a result of ionic strength effects that reduce the activity of phosphate. In L2 the lowest values of NP and K content were observed in the highest levels of NaCl (150 mM). The values recorded: 1.55, 0.20, and 1.11 %, compared with 1.65, 0.32 and 1.5 as control, respectively. Also, the same trend observed by the uptake of these elements. Concerning of L6, the data in table 3 also revealed that the lowest values of NP and K content and uptake were recorded at 150 mM of NaCl compared with other treatments. The values recorded, 1.4, 0.2 and 1.2%, compared with 1.6, 0.25 and 1.41% as control, respectively. Regarding to L10, the lowest values of N, P and K content were recorded 1.3, 0.2 and 1.10 %compared with 1.6, 0.3 and 1.35 % as control respectively. The mean values of NP K uptake for L6 and L10 were recorded 10.41, 1.58, 8.95 $mg.plant^{-1}$ and 9.31, 1.6 8.12 $mg.plant^{-1}$, respectively, compared with L2 which recorded 11.62, 1.86 and 9.46 mg/ plant. These data are in agreement with those obtained by Mer *et al.,* (2000) who found that macronutrients uptake by barley plants were decreased as a result of high concentrations of salts.

Table 5 NPK content and uptake of barley plant as affected by salinity levels in irrigation water.

Landraces	NaCl m M	N		P		K	
		Content %	Uptake $mg.plant^{-1}$	Content %	Uptake $mg.plant^{-1}$	Content %	Uptake $mg.plant^{-1}$
L2	0.0	1.65	12.87	0.32	2.50	1.50	11.70
	50	1.73	12.87	0.29	2.16	1.39	10.34
	100	1.60	11.12	0.22	1.53	1.28	8.90
	150	1.55	9.64	0.20	1.24	1.11	6.90
mean		1.63	11.62	0.26	1.86	1.32	9.46
L6	0.0	1.60	11.89	0.25	1.86	1.41	10.48
	50	1.60	11.20	0.27	1.89	1.33	9.31
	100	1.50	10.50	0.20	1.40	1.30	9.10
	150	1.40	8.05	0.20	1.15	1.20	6.90
mean		1.53	10.41	0.23	1.58	1.31	8.95
L10	0.0	1.60	11.78	0.30	2.21	1.35	9.94
	50	1.40	9.72	0.25	1.74	1.30	9.02
	100	1.40	8.71	0.22	1.37	1.22	7.59
	150	1.30	7.02	0.20	1.08	1.10	5.94
mean		1.43	9.31	0.24	1.60	1.24	8.12
LSD at 5%	A	0.12	0.21	N.S	0.06	0.06	0.19
	B	0.14	0.34	0.04	0.07	0.07	0.22
	AB	N.S	0.41	N.S	0.11	N.S	0.38

A= Landraces
B=NaCl mM

CONCLUSION

In general, it can be concluded that salinity of irrigation water negatively affected growth and macronutrient uptake of the barley landraces. The maximum percentage of fresh and dry weight recorded under control level and minimum at the highest salinity level. However, maximum percentage of fresh and dry weight recorded in L2 in all salinity levels followed with L 6 and L10. Also pH values increased as a salinity level of irrigation water increased compared with the control. In addition to soluble cations and anions in soil after harvest decreased as a result of increasing the concentration of NaCl in irrigation water. The result also pointed out clearly that salinity changed ion uptake in barley shoots. Salinity caused a significant decreasing in N, P and K uptake. Also, the results showed that L 2 has the highest tolerance compared with landraces L6 and L10 under the same condition of salt stress. Also, it is the best landraces to NP and K uptake under salinity levels compared with other landraces.

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تأثير الإجهاد الملحى على نمو وامتصاص المغذيات الكبرى لبعض سلالات الشعير المصرى

سيد عبدالرحمن عابدين[1] , احمد حمدى رزق[1]و سام محمد امين الحمامصى[2]
[1] قسم الاراضى والمياه– كلية الزراعة بالقاهرة – جامعة الأزهر –القاهرة – مصر
[2] قسم الكيمياء الحيوية – كلية الزراعة بالقاهرة – جامعة الأزهر –القاهرة – مصر

تم اجراء البحث فى مزرعة قسم الاراضى والمياه- كلية الزراعة – جامعة الازهر – مدينة نصر بالقاهرة وذلك لتقييم بعض سلالات الشعير(سلالة 2, سلالة 6 و سلالة 10) تحت مستويات ملوحة مختلفة من تركيز كلوريد الصوديوم (0, 50, 100 و 150 ملليمول /لتر).تم تنفيذ التجربة فى اصص بحيث كل اصيص يحتوى على 7 كجم تربة منزرع به 10 بذور شعير من السلالات المختلفة ,وتم حصاد النباتات بعد 60 يوم من الزراعة.

وقد اوضحت النتائج ما يلى:

- انخفاض ملحوظ فى الوزن الجاف والرطب لنباتات الشعير نتيجة لزيادة مستويات الملوحة من كلوريد الصوديوم مقارنة بالكنترول.
- زيادة تركيز الاملاح الذائبة ورقم الـpH نتيجة الرى بماء مالح فى التربة بعد حصاد الشعير.
- زياده فى تركيز كاتيونات الصوديوم وانخفاض فى تركيز كاتيونات الكالسيوم والماغنيسيوم والبوتاسيوم
- زيادة فى انيون الكلوريد وانخفاض فى انيونات البيكربونات والكبريتات فى التربة بعد الزراعة .
- لوحظ نقص معنوى فى امتصاص العناصر الغذائية الكبرى(النيتروجين – الفوسفور والبوتاسيوم) لنباتات الشعير نتيجة للرى بتركيزات عالية من املاح كلوريد الصوديوم.

عموما أظهرت النتائج بوضوح أن السلالة 2 كانت اكثر السلالات تحملا للملوحة مقارنة بالسلالات 6 و10.