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The effect of salinity on the growth , soluble sugar and mineral ions content of barley plant (Hordeum vulgare L.) and soil properties .

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Abstract

An experiment in plastic pots was carried out to know the effect of different salt concentration levels (50 , 100 , 150 and 200) mMol /L of NaCl in addition to distill water as a control treatment on the growth , soluble sugar and mineral ions content of barley plant (cv local) and the arable soil properties . The results of the study shows an increase on salinity causing a decrease on the growth of plant in terms of stems length and their dry matter weight , also a decrease observed on the concentrations of reduced sugar (19.75 , 18.625 , 15.19 and 15.875) mg / gm as compared with the concentration (15.185) mg/gm at a control treatment ; while the concentrations of total sugar (22.30 , 23.35 , 24.085 and 25.99) mg / gm and sucrose (1.25 , 2.315 , 4.335 and 4.925) mg/gm were increased , as compared with their concentrations (16.525 and 0.65) mg /gm respectively , at a control treatment .

The results showed that , the increase of salinity causes an increase on the concentration of mineral ions (Na , Ca , Mg and Cl) on the shoot part of plant whereas (K) ion was decreased , also the values of pH , EC and the concentrations of mineral ions (Na , Ca , Mg , K and Cl) were increased on the arable soil.

Introduction

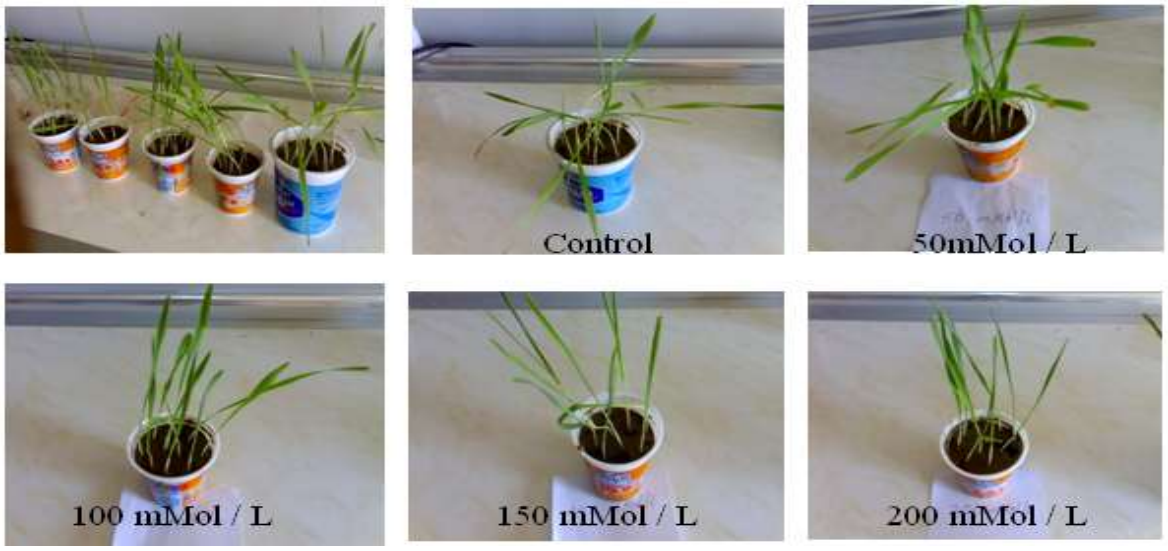
Agriculture at different countries was suffered from the problems of salinity as a result of accumulation high concentrations salts on the soil . There were (400) million hectares of soil affected by salinity (Flowers , 1975) . The united nation environmental program (UNEP) estimated about (%20) of the suitable agriculture regions and (%50) of the arable soils on the world were affected by salt stress (Flowers and Yeo , 1995) . Iraq on forefront of the asian arab countries in the total area that affected by salinity (Batanouny , 1996). The irrigation by using saline water added some of salts to the irrigating soil and changed their physical and chemical properties (Al-Seedi , 1992). Soil salinity was recognized as an important problem on the southern region of Iraq where barley was widely grown (Al-Zubaydi and Al-Seedi , 1999) . A reduction of the plant growth correlated with the increase of salinity which causes a decrease in stem length , shoot dry matter weight of

many wheat varieties (Kumar *et al*.,1987) and a number of branches and spikes of barley (Al-Zubaydi and Al-Seedi , 1999) . Glycophyte vary more in their ability to control ion uptake and translocation than to development metabolic mechanisms of adaptation to saline environment (Rains , 1972) . The differences in ion regulation , mainly of Na and Cl cause specific nutritional imbalance which together with metabolic reactions were associated with salt tolerance of the species (Greenway and Munns , 1980). The ionic content of plant shoot systems depend on the concentration of salts in the external medium in which plants were growing . The increase of ionic content on the shoot system of many plants were reported by many authors (Flowers *et al*., 1991 ; Al-Zubaydi , 1994 ; Hassen , 1999) . The increase of salinity caused an imbalance in metabolic process and inhibition on the invertible process of simple sugar to complicated sugar and the concentration of sugar was increased (Dhingra and Varghese , 1985) . Gill and Singh (1985) observed that an increase at the quantity of sugar on rice plant incurrence to the salt stress . The increase of salinity on the growth medium of plants caused a decrease on the monosaccharide concentration levels and an increase on the concentration of disaccharide especially sucrose (Abo-Zaid , 2000) , also increase of salinity caused a decrease on the concentrations of total sugar and reducing sugar , whereas sucrose was increased (Chang *et al*., 2005) . The objective of this work was to study the effect of sodium chloride salination (Meq / L) on the early growth stages , mineral ions content of tissues , sugar concentrations and the soil properties. There were the essential features on the study of the salt tolerance of barley plant which was cultivated in Iraq .

Materials and Methods

The experiment was carried out in the Bio . Dept. , College of Education , Thi-Qar Univ. in November - 2008 , by using a plastic pots (15 cm. diam) that have drainage out let and filled with (1) kg of thoroughly mixed soil made from sandy loam and manure at the ratio (2:1) . The pH (7.3) and EC (3.8) dS / m were determined from the extract solution (water to soil) on the ratio (2.5 : 1) at the initial time of the experiment . Also , pH , EC and mineral ions content of soils (Meq / L) were determined at the final time . Seeds of barley plant were surface sterilized with (%5) of sodium hypochlorate solution for (10) minutes and washed with distill water before used in the experiment. Salt solution was prepared to give the concentration levels (50 , 100 , 150 and 200) mMol / L , by dissolved (2.925 , 5.85 , 7.80 and 11.70) gm /l of NaCl respectively , and added as an irrigation water to a plastic pots , in addition to distill water treatment applied as a control . Healthy seeds had been chosen and then (10) of them sowed in each pot at a depth (1) cm . Treatments were replicated three times and the experiment continued for (4) weeks . At first of the experiment , pots were irrigated with distill water up to soil field capacity till the seedling reached two weeks old , then these plants were received the salt solutions for the remained period . The average of stem lengths (cm) of (5) plants were measured and harvested , shoot systems of plants washed with distill water and dried in an oven at (65) C for (48) hours . The dry matter of (5) plants was calculated by balance (Precisa Instrument Ltd. XB

220A) and digested according to the procedure described by (Cresser and Parsons , 1979) for analysis of the mineral ions content . Sodium and potassium were determined by flame photometer (Corning M 410) . Calcium , magnesium and chloride were determined by titration after a regulation of the plant extract solution (pH) by buffer solution according to the procedure described by (Al-Musawi , 1977) . Total mineral ions content were calculated by (mg / gm) of the dry matter weight .



* Pictures are illustrates the effect of salinity on the growth of barley plant after (4) weeks of the beginning process of seeds germination

The estimation of sugar

1- **Prepared of sample**

The plant dry matter was ground and (1) gm had been taken and put on the conical flask (250) ml capacity containing (50) ml of distill water . The flask was put on the heat resource (heater) till it reached the boiling point , then removed and let it cool for (15) minutes . The solution was filtered by filter paper (Whitman's No.1) and clearified by addition of a neutral lead acetate (%45) . The residual was removed by the centrifuge at a terminal velocity (3000) round (rpm) for (5) minutes . (3) ml of potassium oxalate (%22) was added to the extract solution and the residual removed at the same procedure .The final volume of the extract solution was completed to (250) ml. by adding distill water .

2 - **Estimation of reducing sugar**

Reducing sugar was estimated according to the procedure described by (Howrtiz , 1975) . (50) ml of the sample extract solution had taken and put on the conical flask (250) ml. capacity , the phenolphthalein indicator (3) droplets were added . The acidity of the extract solution was neutralized by titration via sodium hydroxide solution (1N) till reached to the end point of reaction by appearance of the florid colour . Then the neutralized extract solution was put on the burette (50) ml. capacity . (5) ml of Fehling solution (A) and (5) ml of Fehling solution (B) were put on a conical flask and mixed very well . Then

the mixture solution was heated till it reached the boiling point , then (2) droplets of methylene blue were added to the mixture solution and titrated with the neutralized extract solution for (1) minute till it reached the end point of reaction. The colour of the mixture solution existed a red residual (copper oxide) , then the volume of sugar solution downward of the burette recorded which not decreased down (15) ml or increased above (50) ml .

3 - **Estimation of total sugar**

The same procedure for the reducing sugar was followed to estimate the total sugar according to the procedure described by **(**Abbas and Abbas , 1992).
Reducing and total sugar were estimated as the following : -

$$\text{Reducing sugar} = \frac{\text{mg of sugar (from the table which equate the volume downward of burette)} \times \text{dilutions} \times 100}{\text{Weight of sample} \times 100}$$

$$\text{Total sugar(inverted sugar)} = \frac{\text{mg of sugar} \times \text{dilutions} \times ١٠٠٠}{\text{Weight of sample} \times 1000}$$

Percent of sucrose = Percent of total inverted sugar - percent of reduced sugar × 0.95

Total sugar = The percent of total inverted sugar + the percent of sucrose

The obtained data of the experiment were subjected to statistical analysis of variance and the T- values at ($P < 0.05$) level were calculated . Test of significance was done according to the least significant differences (L.S.D) test for each salt treatment by using the statistical program (Spss - 11 - 2003) .

Results and Discussion

Table (1) illustrates the effect of salinity on the lengths and dry matter weights and sugar of barley plants . Lengths were negatively affected by the increases of salt concentration levels . Salt free solution revealed the highest length (12.30) cm , whereas the lowest length (9.45) cm was observed at salinity treatment (200) Meq / L , also the high value of dry matter weight (0.748) gm occurred at a control in distill water , whereas the low value (0.615) gm was observed at salt treatment (200) Meq / L . There were different patterns of significant differences occurring between salinity treatments . A gradual decrease was obtained in the lengths and dry matter weights with increasing of salinity from (50 - 200) Meq / L . These results were in accordance with many authors (Nasir , 2002 ; Nasir and Abbas , 2006 , Al-Seedi , 2008) , that increasing of salt concentration levels caused decrease on the growth of plants . It was evident that , with increasing salt concentration levels a significant decrease was noticed between treatments . The growth reduction was caused by salinization due to a limitation of water supply (Yeo *et al.* , 1991) . The adverse effect of salinity was due to osmotic and toxic effect . There were significant differences occurring between the

control and another salinity treatments . Increasing osmotic potential on plant cells can cause a change of cell sap as a result of high absorption of salt ions ,

Table (1) the effect of salinity on the lengths and dry matter weights and sugar of barley plant (5 plants / pot)

Salt treatments (Meq / L)	Lengths (cm)	Dry matter weights (gm)	Total sugar (mg / gm)	Reducing sugar (mg / gm)	Inverted sugar (mg / gm)	Sucrose (mg / gm)
Control	a 12.30	a 0.748	c 16.525	d 15.185	c 15.875	c 0.65
50	b 11.52	ab 0.726	b 22.300	a 19.75	a 21.06	c 1.25
100	b 10.95	ab 0.679	b 23.350	b 18.625	a 21.06	b 2.315
150	c 9.87	b 0.637	b 24.085	d 15.19	b 19.75	a 4.335
200	c 9.45	b 0.615	a 25.990	d 15.875	a 21.06	a 4.925
Means	bc 10.818	a 0.681	b 22.450	c 16.925	b 19.760	b 2.695
L.S.D.	0.712	0.111	1.893	0.922	1.037	0.855

- Each number represent the mean of three replications.
- The means have the same alphabetical letters are not significantly different from the each other at ($P < 0.05$) level of significance .

consequently , there will be a reduction in water absorbing capacity and hence a reduction in stem length and dry matter weight occur (Al-Zubaydi , 1994) .

In addition , plants growing in saline medium spend high energy to balance its osmotic potential on the expense of energy required for normal growth and physiological activities (Flowers *et al.* , 1986) . From the table above , it was clear that salinity affected the concentrations of sugar on the plant tissues , a gradual increase occurred with the increasing of salt concentration levels . There were different patterns of significant differences occurring between salinity treatments and the control . The incurrence of plants to salt stress leads to the accumulation of some soluble organic compounds especially sugar , their compounds have an important role on the osmoregulation process . The increase of total sugar concentrations was due to the increase of salt concentration levels . The high concentrations of total sugar and sucrose (25.99 and 4.925) mg / gm , respectively occurred at the salinity treatment (200) Meq / L , whereas the low concentrations (16.525 and 0.65) mg / gm occur at a control on the distill water . These results were in accordance with many authors (Gorham *et al*., 1981 ; Bolarin *et al*., 1995 ; Prado *et al*. 1995 , Abo-Zaid , 2000) , the increasing of salinity causing an increase of the total sugar concentrations on the plant tissues . The increase of the total sugar was one of expedience adaptation for resistant salinity (Gorham *et al.* , 1981) also, to performance the osmoregulation between the cytoplasm and organelles inside the cells , that organic compounds , especially sugar were not toxic and preserve the composition of the cells

(Claes *et al.* , 1990) . The high concentration of sugar on the plants that growing in saline medium due to the decrease on the activity of invertase enzyme under their conditions (Prado *et al*., 1995) . The variation and depression on reducing sugar under salt stress condition and an increase of sucrose concentration due to breakdown of starch and carbohydrates which were used by the plants as dissolved and reducing sugar on the metabolism process (Change *et al*., 2005). The variation between plants on the contents of sucrose is due to the variation on the salinity concentration that were added as irrigation water . The increase of salinity concentration levels caused an increase of sucrose concentrations on the plant tissues , or perhaps the reason belongs to the breakdown of starch and its transform to sugar as a result of the plants osmosis requirement (Dhingra and Varghese , 1985). The increase of salinity concentration caused decrease on the concentration levels of monosaccharide and an increase on the concentration of disaccharide especially sucrose (Abo-Zaid , 2000) . The depression of reducing sugar and the increase of sucrose content under salt stress conditions was due to the breakdown of starch and carbohydrates , which the plants used their resulted materials from the analysis as reduced and dissolved sugar on the osmoregulation process (Chang *et al*., 2005) .

Table (2) demonstrates the effect of salinity on the mineral ions content of barley plant . It was evident that , the increase of salt concentration levels on the irrigating water caused an increase on mineral ions content especially(Na , Ca , Mg and Cl) of the plant tissues , whereas a decrease on the (K) ion was occurred . There were significant differences occurred between salinity treatments in regard to ionic accumulation . These results were in accordance with many authors (Flowers *et al.* , 1991 ; Al-Zubaydi , 1994 ; Hassen , 1999 ; Nasir and Abbas , 2006 ; Al-Seedi , 2008) . An increase in salinity on the growth medium of plants leads to the increase of ions concentration in shoots and roots of plant (Flowers *et al.* , 1991) . The presence of sodium ion on the roots medium leads to increase the membranous permeability of roots (Greenway and Munns , 1980) . The gradual increase of (Na and Cl) ions on the plant tissues was due to the increase of salt concentration levels on the solution that added as irrigation water . The gradual decrease of (K) ion on the plant tissues with increasing salinity was due to the increase of (Na) ion because of the competition effect between them on the absorption sites in roots (Jacobson *et al*., 1961) or perhaps the presence of (Na) ion on the growth

Table (2) the effect of salinity on the mineral ions content (mg / gm) of barley plant (5 plants / pot)

Salt treatments (Meq / L)	Mineral ions content (mg / gm)				
	Na	K	Ca	Mg	Cl
Control	e 14.50	a 14.10	e 10.30	d 11.20	d 9.60
50	de 15.50	a 13.80	d 11.50	d 12.20	d 10.90
100	cd 17.20	b 11.60	c 12.20	c 14.80	c 14.80
150	b 21.30	c 10.20	b 12.90	b 16.30	b 18.50
200	a 26.40	d 8.50	a 13.70	a 18.40	a 22.60
Means	bc 18.98	b 11.64	c 12.12	c 14.58	c 15.28
L.S.D.	2.38	1.12	0.48	1.44	2.60

medium caused an inhibition on ability of the plant to absorb (K) ion . Also , the gradual increase of (Ca and Mg) ions on the plant tissues were due to the increase of salt concentration levels that added as an irrigation water which caused the release of the bound ions from the soil granules . The liberations of ions from the soil granules and increases in their concentrations on the plant growth medium leads to increase on the absorption by plant roots . Table (3) shows the effect of salinity on the final (pH) , (EC) and mineral ions content of the soil extract solutions for the each salinity treatment . It was observed that salinity caused an increase on the (pH) values at all the salinity treatment as compared with a control treatment in distill water. A significant differences on (pH) values between all the salinity treatments and a control occurred except at the treatment (50) Meq / L . The increase on the (pH) values was due to the increase of salinity that caused an increase on the soil alkalinity because of the liberation of mineral and hydrogen ions from the soil granules .There was a gradual increase on the electrical conductivity (EC) of the soil extract solutions with the increase of the salt concentration levels . The high value (7.70) dS / m was observed at salinity treatment (200) Meq / L and the low value (2.90) dS/m at a control in distill water . A significant differences between treatments on the (EC) values were noticed . The decrease of (EC) value on the control treatment was due to the irrigation with distill water that caused leaching of salt ions from soil , whereas the gradual increase on (EC) values at salinity treatments were due to the increase of the salt concentration

Table (3) the effect of salinity on the final pH , EC and mineral ions content of the soil extract for each treatment .

Salt treatments (Meq / L)	pH	EC (dS/m)	Mineral ions content (Meq / L)				
			Na	K	Ca	Mg	Cl
Control	b 7.10	d 2.90	d 17.0	d 6.0	e 11.0	d 9.0	d 22.0
50	b 7.15	c 3.85	d 23.0	d 7.0	de 13.0	c 13.0	d 33.0
100	a 7.52	c 4.20	bc 38.0	c 9.0	cd 15.0	b 17.0	bc 58.0
150	a 7.54	b 5.30	b 46.0	b 12.0	b 19.0	a 21.0	b 67.0
200	a 7.53	a 7.70	a 58.0	a 14.0	a 23.0	a 24.0	a 79.0
Means	a 7.368	bc 4.79	c 36.40	c 9.60	c 16.20	b 16.80	c 51.80
L.S.D.	0.214	0.96	8.20	1.60	2.40	3.0	11.40

levels on the irrigation water which caused a gradual increase on the soil salinity (Al-Saadi *et al.* , 1982). These results were in accordance with many authors (Fowler and Hamm , 1980 ; Al-Seedi , 1992 ; Al-Seedi , 2008) . It was also observed that the increase of salt concentration levels on the irrigating water caused a gradual increase on mineral ions content of the soil extract solutions at all the treatments . A significant differences between salt treatment on mineral ions content occurred . These results were in accordance with many authors (Nukaya *et al*., 1979 ; Kumar *et al*., 1987 ; Al-Seedi , 1992) that , the increase of salinity on the irrigating water caused an increase on the soil salinity and increases on mineral ions content (Na , K ,Ca , Mg and Cl) of the soil extract solutions. The increase of (Na and Cl) ions content on the soil extract solutions was due to the increase of the salt concentration levels that added during the irrigation process , also the increase of (Ca , K and Mg) ions content on the soil extract solutions was due to the dissolve of calcium , potassium and magnesium compounds as a result of the salt increase on irrigation water (Al-Mashhadani , 1978) . The high saline irrigated water caused the release of bound ions of the soil granules (Al-Seedi , 2008) .

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تأثير الملوحة على النمو ومحتوى السكريات الذائبة والأيونات المعدنية في نبات الشعير (*Hordeum vulgaris* L.) وخواص التربة المنزرعة .

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المستخلص

أجريت تجربة في أصص بلاستيكية لمعرفة تأثير مستويات تراكيز مختلفة من الملوحة (٥٠ و ١٠٠ و ١٥٠ و ٢٠٠) مليمول / لتر من كلوريد الصوديوم (NaCl) بالإضافة إلى الماء المقطر كمعاملة سيطرة على النمو ومحتوى السكريات الذائبة والأيونات المعدنية في نبات الشعير (صنف محلي) وخواص التربة المنزرعة .

أظهرت نتائج الدراسة إن زيادة الملوحة سببت إنخفاضاً في نمو النبات كما هو مقاس في أطوال السيقان ووزن المادة الجافة لها ، كما لوحظ الإنخفاض في تراكيز السكريات المختزلة (١٩,٧٥ و ١٨,٦٢٥ و ١٥,١٩ و ١٥,٨٧٥) ملغم / غم بالمقارنة مع تركيزها (١٥,١٨٥) ملغم / غم في معاملة السيطرة ؛ بينما ظهرت زيادة في تراكيز السكريات الكلية (٢٢,٣٠ و ٢٣,٣٥ و ٢٤,٠٨٥ و ٢٥,٩٩) ملغم / غم ، والسكروز (١,٢٥ و ٢,٣١٥ و ٤,٣٣٥ و ٤,٩٢٥) ملغم / غم بالمقارنة مع تراكيز السكريات الكلية والسكروز (١٦,٥٢٥ و ٠,٦٥) ملغم / غم ، على التوالي في معاملة السيطرة . وأظهرت النتائج أيضاً إن زيادة الملوحة سببت زيادة في تراكيز أيونات (Na و Ca و Mg و Cl) في الجزء الخضري للنبات بينما إنخفض تركيز أيون (K) ، كما سببت زيادة في قيم الأس الهيدروجيني والتوصيل الكهربائي وتراكيز الأيونات المعدنية (Na و Ca و Mg و K و Cl) في التربة المنزرعة .