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## Nutritional Status in Shoots of Barley Genotypes as Affected by Salinity of Irrigation Water

<sup>1</sup>Mahmoud M. Shaaban, <sup>2</sup>Mohamed M. Housein and <sup>1</sup>Abdel-Kareem M. El-Saady

<sup>1</sup>Department of Fertilization Technology,

<sup>2</sup>Department of Water Relations and Field Irrigation, National Research Centre,  
Dokki, Cairo, Egypt

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**Abstract:** Pot experiment was conducted in the greenhouse of National Research Centre with 6 barley (*Hordeum vulgare* L.) genotypes (Giza 123, Giza 124, Giza 125, Giza 126, Giza 127 and Giza 128) to investigate the effect of different salinity levels (250, 2000, 4000 and 6000 mg L<sup>-1</sup>) in the irrigation water on the nutrient status (uptake, concentrations and balance) in the shoot tissues. Variations in genotypic tolerance to salinity stress were also under investigation. Uptakes of N, P, K, Mn and Cu were significantly declined as salinity dose in the irrigation water increased. The most affected nutrient ratios were N/P, P/Mn and P/Zn. Concentrations of nutrients in all studied genotypes were disturbed and N-concentration was deficient in the shoot tissues of all genotypes grown under salinity stress, except of Giza 127. Nutrient balances in all genotypes under investigation were also disturbed. Giza 127 was the only genotype which nutrient ratios in its shoot tissues were near to the sufficient ranges.

**Key words:** Barley, salinity stress, genotypes, nutritional status

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### INTRODUCTION

Salinity is one of the most challengeable problems faced agricultural productivity. About 20% of the world's cultivated area and nearly half of the irrigated lands are saline affected (Zhu, 2001). Soil salinity affects plant growth and development by way of osmotic stress, injurious effects of toxic Na<sup>+</sup> and Cl<sup>-</sup> ions and nutrient imbalance caused by the excess of these elements (Sairam and Tyagi, 2004; Backhousen *et al.*, 2005). Salt tolerance is assessed as the percent biomass production in saline versus control over a period of time. Dramatic differences are found between plant species regarding their tolerance to saline stress conditions (Greenway and Munns, 1980). Salinity stress response is multigenic, as a number of processes involved in the tolerance mechanism are affected such as various compatible solutes/osmolytes, polyamines, reactive oxygen species and antioxidant defence mechanism, ion transport and compartmentalization of the injurious solutes (Sairam and Tyagi, 2004; Brenant *et al.*, 2007). Thus, varieties of higher salt tolerance may expose better nutritional status than less-tolerant varieties.

Barley (*Hordeum vulgare* L.) is widely grown in the Mediterranean region as a grain crop and forage purposes (Al-Karaki, 2001). It has been rated as one of the most salt-tolerant crop species among glycophytes (Maas, 1986). Barley genotypes (*Hordeum vulgare* L. var. Giza) are the genotypes developed by the Agronomy Research institute, Ministry of Agriculture, Giza, Egypt. They are commonly cultivated in Egypt and the surrounded countries, where many problems of water deficit and salinity stress.

Numerous traits were used to screen barley genotypes for salt tolerance (Munns *et al.*, 1995). Screening genotypes under field conditions is the best, however it is confused and more expensive than

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**Corresponding Author:** Mahmoud M. Shaaban, Department of Fertilization Technology, National Research Centre, Dokki, Cairo, Egypt

screening under controlled conditions (Shannon and Noble, 1990). The relation between mineral status and irrigation saline water was physiologically studied by some investigators (Grieve and Poss, 2000; Hussein *et al.*, 2006). The present work studied the nutrient concentrations, uptake and balance in 6 barley genotypes grown under different levels of salinity stress in irrigation water in order to assign the most tolerant varieties.

## MATERIALS AND METHODS

Pot experiment was conducted in the greenhouse of the National Research Centre, Dokki, Cairo Egypt during the winter season 2004/2005 to study the shoot nutritional status of six barely (*Hordeum vulgare* L.) genotypes (Giza 123, Giza 124, Giza 125, Giza 126, Giza 127 and Giza 128) grown under different levels of salinity stress.

Barley cultivars were sown in December, 20 in metallic tin pots 35 cm diameter and 50 cm depth. The inner surface of the pots was coated with three layers of bitumen to prevent direct contact of the metal with soil. Every pot contained 30 kg clay loam soil (Table 1). Two kilograms of gravel (particles 2-3 cm in diameter) were placed in the bottom to make the movement of water from the base upward. Plants were thinned twice (10 days after sowing and two weeks later) to leave 3 plants per pot. Calcium super phosphate (15.5% P<sub>2</sub>O<sub>5</sub>) potassium sulfate (48.5% K<sub>2</sub>O) in the rate of 3.0 g and 1.5 g pot<sup>-1</sup>, respectively were added before sowing. The pots received N-fertilization in the rate of 6.86 g pot<sup>-1</sup> ammonium sulfate (20.6% N) in two equal splits (2 weeks after sowing and 2 weeks later).

### Treatments

Irrigation with Strogonov chloride solution (Table 2) in three concentrations (3.0, 6.0 and 9.0 dS m<sup>-1</sup>) started at 30 days after sowing, while tap water (0.4 dS m<sup>-1</sup>) is considered as control. Every treatment contained 6 replicates.

Table 1: Soil chemical and physical characteristics

Physical characteristics		Nutrient concentrations	
pH	8.3	<b>Exchangeable macronutrients</b>	
EC (dS m <sup>-1</sup> )	0.8	<b>(mg 100 g<sup>-1</sup> soil)</b>	
CaCO <sub>3</sub> (%)	1.6	P	5.2*
OM (%)	0.1**	K	37.9*
Sand (%)	14.0	Mg	30.7*
Silt (%)	28.0	<b>Available micronutrients</b>	
Clay (%)	58.0	<b>(mg kg<sup>-1</sup> soil)</b>	
Texture	Clay loam	Fe	11.0*
		Mn	9.0*
		Zn	3.3*
		Cu	10.2*

\*Adequate; \*\*Low

Table 2: Chemical composition of Strogonov chloride solution

<b>Salt mixture components (%)</b>	
MgSO <sub>4</sub>	10
CaSO <sub>4</sub>	1
NaCl	78
MgCl <sub>2</sub>	02
CaCO <sub>3</sub>	9
<b>Milliequivalents of specific anions and cations (%)</b>	
Na <sup>+</sup>	38
Mg <sup>++</sup>	6
Ca <sup>++</sup>	6
SO <sub>4</sub> <sup>--</sup>	5
Cl <sup>-</sup>	40
CO <sub>3</sub> <sup>--</sup>	5

## Sampling and Analysis

### Soil

A representative soil sample was taken just before sowing, air dried, ground and sieved through 2.0 mm sieve and analyzed. Mechanical analysis was carried out using the hydrometer method (Bauyoucos, 1951), pH and Electric Conductivity (EC): Water extract (1 soil: 2.5 water) method (Jackson, 1973), CaCO<sub>3</sub>: Calcimeter method (Black, 1965), Organic Matter (OM): potassium dichromate method (Walkley and Black, 1947). Phosphorus (P) was extracted using sodium bicarbonate (Olsen *et al.*, 1954). Potassium (K) and Magnesium (Mg) were extracted using ammonium acetate method (Chapman and Pratt, 1978). Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) were extracted using DTPA method (Lindsay and Norvell, 1978).

### Shoots

Shoot samples were taken 45 days after sowing. The complete shoots were washed with tap water, 0.01 N HCl and bi-distilled water, respectively, dried at 70 °C for 24 h, weighed and ground. A part of the plant material was dry-ashed in a Muffel furnace at 550 °C for 6 h. The ash was digested in 3 N HNO<sub>3</sub> and the residue was then suspended in 0.3 N HCl (Chapman and Pratt, 1978). A part of the sample was weighed and oven dried at 105 °C for 24 h, then weighed again and the dry weight was calculated.

### Nutrient Measurements

Nitrogen was determined using Kjeldahl-method; phosphorus was photometrical determined using the molybdate-vanadate method according to Jackson (1973). Potassium, Ca<sup>++</sup> and Na<sup>+</sup> were measured using Dr. Lang -M8D Flame-photometer. Magnesium, Fe<sup>++</sup>, Mn<sup>++</sup>, Zn<sup>+</sup> and Cu<sup>+</sup> were determined using the Perkins-Elmer Atomic Absorption Spectrophotometer.

### Evaluation of the Nutrient Status

Soil nutrient status was evaluated according to the sufficient concentrations of Ankerman and Large (1974) and plant tissues nutrient status according to Reuter (1988).

### Statistical Analysis

Data were statistically analyzed using the method described by Snedecor and Cochran (1980)

## RESULTS AND DISCUSSION

### Effect of Salinity Degree

Nutrient uptake by different barley genotypes were dramatically affected with salinity dose increment in the irrigation water (Table 3). Concentrations of such nutrients were consequently affected (Fig. 1). N-concentration was declined with all salinity doses to fall in the deficient level. Concentrations of other nutrients were also declined even so they still in the sufficient range, except

Table 3: Mean values of nutrient uptakes by barley shoots as affected by different salinity levels in the irrigation water (n = 6)

Salinity level dS m <sup>-1</sup> )	Macronutrients (mg plant <sup>-1</sup> )						Micronutrients (µg plant <sup>-1</sup> )		
	N	P	K	Mg	Ca	Na	Mn	Zn	Cu
0.4	64.80	6.64	17.1	2.24	54.0	115	350	522	64.3
3.0	49.50	5.92	15.6	3.33	52.3	118	336	491	58.7
6.0	43.60	5.53	15.8	2.51	54.4	133	329	429	56.7
9.0	45.50	4.67	14.6	1.93	49.5	153	289	424	61.6
LSD <sub>(0.05)</sub>	08.59	1.26	04.0	NS	NS	19.2	NS	34.2	3.77

Ns: Non significant

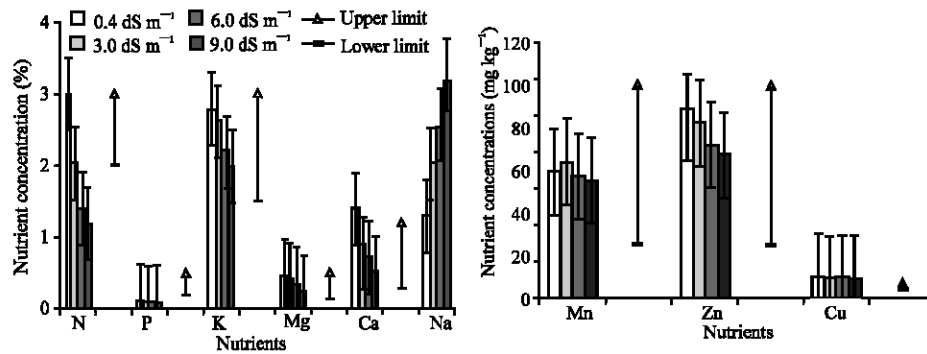


Fig. 1: Nutrient concentrations in barley shoot as affected by salinity dose increment in the irrigation water (n = 6)

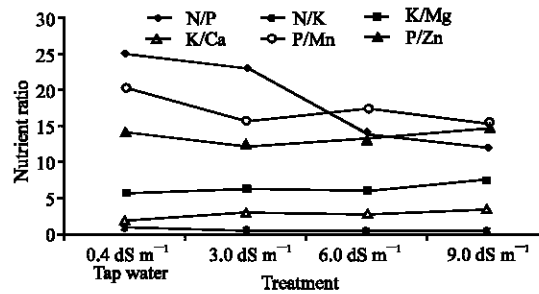


Fig. 2: Nutrient ratio in barley shoots as affected by salinity dose increment in the irrigation water

of phosphorus which was always in the deficient level. Plants irrigated with saline water characterized by low growth (Meiri and Shalhevet, 1973; Izzo *et al.*, 1991; Munns, 1993). Uptake of nutrients is restricted due to reduction of root volume, high pH values and antagonism between nutrients (Yahya, 1998; Salama and Shaaban, 2000). Salinity dose increment in the irrigation water led to increased levels of toxic elements such as  $\text{Na}^+$  and  $\text{Cl}^-$  which are absorbed by plant roots. Osmotic potential created by saline ions at the root medium restricted water and nutrient elements flow (Munns, 2002). Due to growth inhibition caused by the harmful effects of  $\text{Na}^+$  and  $\text{Cl}^-$ , concentrations of K, Mg, Ca, Mn, Zn and Cu, in barley shoot tissues may give a false impression that they are in the sufficient range, but in reality the amount of nutrient is concentrated in a retarded tissue weight (Shaaban *et al.*, 2004).

As nutrient concentrations are altered by uptake disturbance, nutrient ratio balances within shoot tissues ought to be affected by salinity level increment. The ratios N/P, P/Mn and P/Zn were the most affected (Fig. 2). These ratios found to be decline with the salinity dose increment while N/K showed a flat curve. This means that both N- and K-uptake processes were highly inhibited followed by P-uptake and N-, K- and P-uptake processes were severely inhibited than uptake processes of other nutrients. Graboov (2007) came to similar conclusion with potassium.

### Genotypic Variations

Barley genotypes grown under salinity stress were differed significantly regarding to nutrient uptakes. The best for N, P and Zn-uptakes was the genotype Giza 127 followed by Giza 123 for N

Table 4: Mean values of nutrient uptakes by shoots of barley genotypes grown under salinity stress conditions (n = 6)

Genotypes	Macronutrients (mg plant <sup>-1</sup> )					Micronutrients (µg plant <sup>-1</sup> )			
	N	P	K	Mg	Ca	Na	Mn	Zn	Cu
Giza 123	125.9	7.5	17.3	2.2	69.0	152	331	328	88.9
Giza 124	104.2	5.0	17.5	1.5	92.3	113	372	622	34.9
Giza 125	67.7	5.5	14.9	2.2	42.3	99	239	306	78.5
Giza 126	83.1	7.1	18.9	3.4	75.8	166	379	391	67.6
Giza 127	166.3	9.7	17.2	1.9	38.5	134	238	803	44.7
Giza 128	65.7	8.2	9.0	4.0	43.1	89	341	349	80.0
LSD <sub>(0.05)</sub>	25.15	0.82	3.18	2.38	13.0	48.3	64.3	114.7	24.17

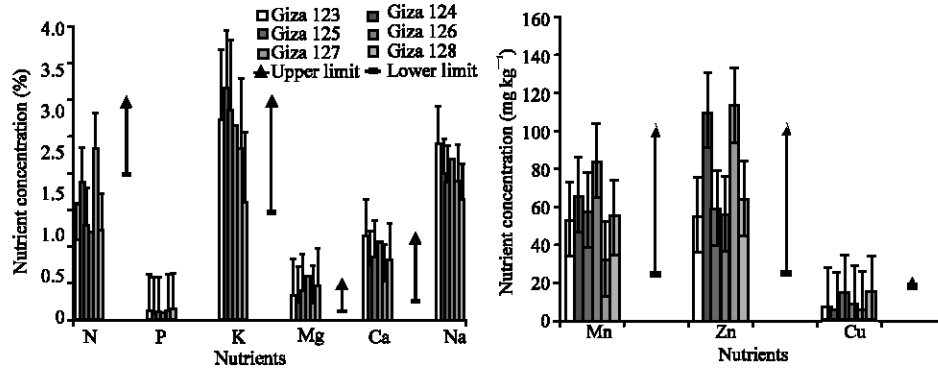


Fig. 3: Nutrient concentrations in barley shoot tissues as affected by genotypic tolerance to salinity stress (n = 6)

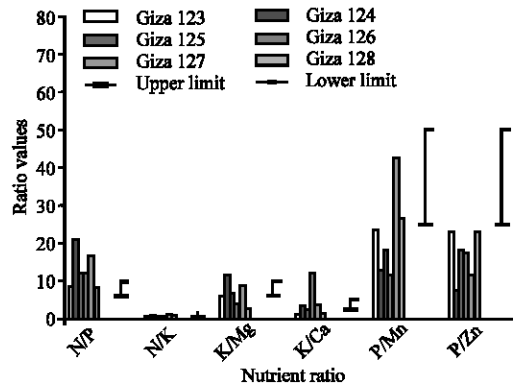


Fig. 4: Nutrient ratio in barley shoot tissues as affected by genotypic tolerance to salinity stress

and P (Table 4). This was directly translated to concentration of nutrients in the shoot tissues where the only N-concentration in the shoot tissues fall in the sufficient range was for the genotype Giza 127 (Fig. 3). Concentrations of all other determined nutrients for all genotypes were more or less in the sufficient range or even in the excess ranges, except of phosphorus which was nearly in the deficient level. The best nutrient ratios which are near to sufficient ranges came for the genotype Giza 127 (Fig. 4).

Barley genotypes which could keep a good NPK uptake and sufficient concentrations may have more ability to exclude Na<sup>+</sup> and Cl<sup>-</sup> ions to be transported to shoot tissues. Munns (1985) concluded that about 95% of Na<sup>+</sup> and Cl<sup>-</sup> in xylem of some barley genotypes are excluded and not reached to

leaves. On the other hand, sufficient concentrations of nutrients, especially nitrogen enabled the plant mechanism regulations to synthesize reasonable concentrations of metabolites required to reduce the harmful effects of the saline ions (Kao, 1997).

### CONCLUSIONS

Salinity in the root medium stresses nutrient uptake, concentrations and balance in barley shoots. The stress degree increased with salinity level increment. Out of the 6 genotypes under investigation, only the genotype Giza 127 proved to be the best regarding nutrient uptake, concentrations in shoot tissues and nutrient ratios which suggests that such cultivar has a better genotypic base to tolerate salinity stress conditions. More genetic studies should be done to recognize its genetic characteristics.

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### REFERENCES

- Al-Karaki, G.N., 2001. Germination, sodium and potassium concentrations of barley seeds as influenced by salinity. *J. Plant Nutr.*, 24 (3): 511-522.
- Ankerman, D. and L. Large, 1974. *Soil and Plant Analysis*. A and L Agric. Lab. Inc. New York, USA.
- Backhausen, J.E., M. Klein, M. Klocke, S. Jung and R. Scheibe, 2005. Salt tolerance of potato (*Solanum tuberosum* L. var. Desire'e) plants depends on light intensity and air humidity. *Plant Sci.*, 169 (1): 220-237.
- Bauyoucos, G.J., 1951. A recalibration of the hydrometer for making mechanical analysis of soil. *Agron. J.*, 43 (9): 434-438.
- Black, C.A., 1965. *Methods of Soil Analysis*. No. 9, Part 2, Am. Soc. Agron. Inc., Madison, Wisconsin, USA.
- Brenant, T.F., A. Fowzio and M.R. Kessler, 2007. Modulation of spermidine and spermine levels in maize seedlings subjected to long term salt stress. *Plant Physiol. Biochem.*, 43 (10-11): 812-821.
- Chapman, H.D. and P.F. Pratt, 1978. *Methods of analysis for soils, plants and waters*. Division of Agric. Sci. Univ. California, Berkeley, USA., pp: 309.
- Graboov, A., 2007. Plant KT/KUP/HAK Potassium transporters: Single Family-Multiple Functions. *Ann. Bot.*, 99 (6): 1035-1041.
- Greenway, H. and R. Munns, 1980. Mechanisms of salt tolerance in nonhalophytes. *Ann. Rev. Plant Physiol.*, 31(6): 149-190.
- Grieve, C.M. and J.A. Poss, 2000. Wheat response to interactive effects of boron and salinity. *J. Plant Nutr.*, 23 (9): 1217.
- Hussein, M.M., A.A. Abd El-Kadier, M.S.A. Abo El-Kheir and O.M. Kassab, 2006. Effects of diluted sea water and benzyl adenine on macro and micronutrients content of barley shoots. *Egypt. J. Agron.*, 28 (2): 47-56.
- Izzo, R., F. Navari-Izzo and M.F. Quartacci, 1991. Growth and mineral absorption in maize seedlings as affected by increasing NaCl concentration. *Egypt. J. Physiol. Sci.*, 14 (10): 687-699.
- Jackson, M.L., 1973. *Soil Chemical Analysis*. Prentice-Hall of India Private Limited, New Delhi, India.
- Kao, C.H., 1997. Physiological significance of stress-induced changes in polyamines in plants. *Bot. Bull. Acad. Sin.*, 38 (3): 141-144.

- Lindsay, W.L. and W.A. Norvell, 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Am. J.*, 42 (3): 421-428.
- Maas, E.V., 1986. Salt tolerance of plants. *Applied Agric. Res.*, 1 (1): 12-26.
- Meiri, A. and J. Shalhevet, 1973. *Crop Growth Under Saline Conditions*. Ecological Studies, Vol. 5, Springer-Verlag Berlin, Heidelberg, New York, pp: 277-290.
- Munns, R., 1985.  $\text{Na}^+$ ,  $\text{K}^+$  and  $\text{Cl}^-$  in xylem sap flowing to shoots of NaCl treated barley. *J. Exp. Bot.*, 36 (7): 1032-1042.
- Munns, R., 1993. Physiological processes limiting plant growth in saline soils: Some damages and hypotheses. *Plant Cell Environ.*, 16 (1): 15-24.
- Munns, R., D.P. Schachtman and A.G. Condon, 1995. The significance of a two-phase growth response to salinity in wheat and barley. *Aust. J. Plant Physiol.*, 22: 561-591.
- Munns, R., 2002. Comparative physiology of salt and water stress. *Plant Cell Environ.*, 25 (2): 239-250.
- Olsen, S.R., C.W. Cole, S.S. Watanabe and L.A. Dean, 1954. Estimation of available phosphorus in soil by extraction by sodium bicarbonate. *USDA Agric. Circ.* 939, pp: 19.
- Reuter, D.J., 1988. Temperate and Subtropical Crops. In: *Plant Analysis*, Reuter, D.J. and J.B. Robenson (Eds.). An Interpretation Manual, pp: 40-41.
- Sairam, R.K. and A. Tyagi, 2004. Physiology and molecular biology of salinity stress tolerance in plants. *Curr. Sci.*, 86 (3): 407-421.
- Salama, Z.A. and M.M. Shaaban, 2000. Growth, nutrient status and some oxidases enzyme activity of cucumber plants as affected by sodium chloride salinity. *J. Agric. Sci. Mansoura Univ.*, 25 (4): 2065-2074.
- Shaaban, M.M., M.M. El-Fouly, E.A.A. Abou El-Nour and A.A. Abdel-Maguid, 2004. Halophytes and foliar fertilization as useful techniques for growing processing tomatoes in the saline affected soils. *Pak. J. Biol. Sci.*, 7 (4): 503-507.
- Shannon, M.C. and C.L. Noble, 1990. Genetic approaches for developing economic salt-tolerant crops. In: *Agricultural Salinity Assessment and Management*, Tanji, K.K. (Ed.). Am. Soc. Civil. Eng. New York, pp: 161-185.
- Snedecor, G.W. and W.G. Cochran, 1980. *Statistical Methods*. 7th Edn. Iowa State Univ., Iowa, USA.
- Walkley, A. and I.A. Black, 1947. Determination of organic matter in the soil by chromic acid digestion. *Soil Sci.*, 63 (c): 251-264.
- Yahya, H., 1998. Salinity effects on growth and on uptake and distribution of sodium and some essential mineral nutrients in sesame. *J. Plant Nutr.*, 21 (7): 1439-1451.
- Zhu, J.K., 2001. Over expression of a delta-pyrroline-5-carboxylate synthetase gene and analysis of tolerance to water and salt stress in transgenic rice. *Trends Plant Sci.*, 6 (2): 66-71.