The effect of different salt concentrations on the root and stem nutrient contents of pea (Pisum sativum L. cv. Jofs)

Article *in* Journal of Food Agriculture and Environment · January 2012

Mustafa Yorgancilar
Selcuk University

WFL Publisher
Science and Technology

Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.10 (1): 605-607. 2012

www.world-food.net

The effect of different salt concentrations on the root and stem nutrient contents of pea (*Pisum sativum* L. cv. Jofs)

Mustafa Yorgancilar * and Zeynep Gül Yeğin

*Selçuk University, Faculty of Agriculture, Department of Field Crops, 42075, Campus, Konya, Turkey. *e-mail: myorg@selcuk.edu.tr*

Received 20 September 2011, accepted 6 January 2012.

Abstract

The aim of this study was to determine the effects of different salt proportions in the irrigation water (0, 25, 50, 100 mM NaCl) on pea plant's (*Pisum sativum* L. cv. Jofs) macro and micro elements involved in its growth. It has been observed that statistically the different salt proportion affects significantly the quantities of some nutritional elements. The essential elements proportions in roots (P, Mg, S, B, Cu, Mn and Zn) and in stem (K, Ca, Mg, Na, B, Fe, Mn, and Zn) are different. Common essential elements in roots and stem are Mg, B, Mn and Zn.

Key words: Pea, salt, nutritional elements.

Introduction

More and more worldwide researches are made on the effects of low quality irrigation waters, mean on salty tendencies lands, on high economic value plants [4]. It is important to determine when to irrigate the plant in regards of the potential damages of the salt [6]. There are big differences between one plant to other in resistance to salt. Even variant genomes of the same plant can show different resistances. For this reason, in the salty areas, the selection of salt resistant plants or genomes are important [7-10].

Salt stress is a complex fact. It is not only osmotic but, at the same time, it includes toxic ion effect and the disorder of the nutritional elements [1]. The negative effect of salt depends on time of exposure to salt, plant variety, growth period of plants and ions concentration in the environment [7]. The salt negative effects are not only osmotic but also disturbing the absorption of ions by the plant and making the proportion of the nutritional elements unstable [7, 11]. The researches on salt effects on micronutrents are rare. The unstability of macronutrient absorption affects the composition of micronutrients. Usually, excessive absorption of some ions has the effect of diminution of basic nutritional elements in the plant that causes lack and unstability [11]. The plants grown in cultural solution are not absorbing the ions as per their present proportions in the solution; some ions are absorbed more than the others. These ions selection depends on the plant species [2]. Toxic ions accumulation takes time and appearance effects may be slower. The damage grade depends on time of toxic exposure, toxic ions concentration, plant sensibility and, finally, evaporation in the plant [14]. The aim of the present study was to investigate the effects of different salt concentrations in irrigation water on vegetative development and nutrient content of the pea,

Materials and Methods

Pea (*Pisum sativum* L. cv. Jofs) was used as material in the experiment, where beside water, four different levels of salt were applied (0, 25, 50, 100 mM NaCl). The experiment was made in S. Ü. Agricultural Faculty's Biotechnology Lab. The experimental conditions were as follows: 24±2ºC, 60% humidity, 16 hours of light and 8 hours of dark. The grains used in the experiment were washed in 15% sodium hypochlorite for 15 min. Later, grains were rinsed 3 times with pure water for 5 min each. The sterilized seeds, after being dried, were sown in pots. After sowing for 12 days, only pure water was used for irrigation. Later on, for each pot, 250 ml of nutrient solution (Half Hoagland + NaCl) was applied every two days. The experiment was stopped after 4 weeks of application from the solution. The plants were harvested and the elements (P, K, Ca, Mg, Na, S, B, Cu, Fe, Mn, and Zn) on the roots and the stem were analyzed separately.

Element analysis: Dried plant material was weighed (0.2 mg) and put in tubes. On each tube, 5 ml of nitric acid (HNO_3) and 2 ml of hydrogen peroxide (H_2O_2) were added. Digesting process was made in micro oven. Once digested the material was transferred to glass tubes of 25 ml and the volume of the sample was filled with 25 ml pure water. Afterwards, the solution obtained was filtered. Each sample was transferred to a tube and analyzed in ICP-AES, capable of analyzing 28 different elements at the same time. The stem and root results were studied statistically by MSTAT-C software. Significant differences were statistically classified by LSD (Least Significant Differences).

Results and Discussion

The study, aiming to investigate the effects of different salt concentrations in irrigation water on vegetative development and nutrient content of the pea, revealed statistically significant differences (Table 1).

Root nutrients: While the effect of salt concentration in irrigation water on P, Mg, S, B, Cu, Mn and Zn contents was statistically significant at 1% level, but there was no effect on Ca, K, Na, and

Table 1. The variance analyses and CV % results of the irrigation water salt levels on the mineral concentrations in pea roots and stem (means and LSD groups).

Elements	Root		Stem	
	F	% CV	F	% CV
P	41.3965 **	2.6	0.8844	5.79
K	1.8106	5.74	205.6386 **	1.07
Ca	2.9967	19.83	31.8546 **	4.47
Mg	107.2002 **	1.69	63.9999 **	2.04
Na	3.7416	6.43	584.9402 **	1.66
S	59.1351 **	4.41	2.6154	9.44
B	59.4439 **	7.72	30.7659 **	6.59
Cu	120.05 **	3.64	3.8982	10.33
Fe	0.7105	6.65	10.2515 **	4.43
Mn	287.7575 **	0.88	6.7904 *	3.38
Zn	941.5483 **	0.8	16.2175 **	4.75

*5%.
**1%.

Fe contents (Table 1). As represented in Table 2, the control (0 mM NaCl) and 25 mM NaCl had no significant effect; but 50 mM NaCl and 100 mM salt concentrations in irrigation water affected the nutrients in roots. This may be a result for the bean tolerability of 25 mM NaCl salt. The minimum concentration for the change in Mg, S, B, Cu and Mn concentrations was at 50 mM NaCl level of irrigation water. It was found to be significant and the cluster of 50 mM NaCl level had two groups. For the same salt concentration, the change of P and Zn was also significant and formed the last cluster. At the level of 100 mM NaCl salt content of irrigation water, no effect was detected by the increase of the salt concentration (Table 2).

Table 2. The effect of irrigation water salt levels on the mineral concentrations of pea roots (means and LSD groups).

Points	Treatment (mM)				Mean	LSD
	0	25	50	100		
Ca (%)	1.01	0.82	0.85	0.61	0.82	
K (%)	3.88	3.88	4.18	3.78	3.93	
Mg (%)	0.21 b	0.21 b	0.25 a	0.20 b	0.22	0.09573 **
Na (%)	4.04	4.04	4.50	3.79	4.09	
P (%)	1.77 a	1.77 a	1.44 b	1.77 a	1.68	0.1354 **
S (%)	0.35 b	0.35 b	0.51 a	0.38 b	0.39	0.09573 **
B (mg kg^{-1})	64.92 b	64.92 b	119.98 a	66.89 b	79.17	18.51 **
Cu (mg kg^{-1})	14.53 b	14.53 b	22.63 a	15.79 b	16.87	1.861 **
Fe (mg kg^{-1})	48.46	48.46	46.59	45.34	47.21	
Mn (mg kg^{-1})	176.22 b	176.22 b	208.86 a	178.93 b	185.05	4.92 **
Zn (mg kg^{-1})	243.76 a	243.76 a	178.73 b	240.16 a	226.60	5.461 **

*5%. **1%.

Table 3. The effect of irrigation water salt levels on the concentration of minerals in pea stems (means and LSD groups).

Points	Treatment (mM)				Mean	LSD
	0	25	50	100		
Ca (%)	0.76 b	0.76 b	1.01 a	0.79 b	0.83	0.09573 **
K (%)	4.06 b	4.06 b	4.82 a	4.10 b	4.26	0.1354 **
Mg (%)	0.27 b	0.27 b	0.32 a	0.27 b	0.28	0.3027 **
Na (%)	3.80 a	3.80 a	2.24 b	3.87 a	3.42	0.1658 **
P (%)	0.64	0.64	0.68	0.66	0.65	
S (%)	0.17	0.17	0.17	0.20	0.18	
B (mg kg^{-1})	126.79 b	126.79 b	186.66 a	126.79 b	141.75	28.3 **
Cu (mg kg^{-1})	12.67	12.67	16.12	14.18	13.91	
Fe (mg kg^{-1})	63.07 a	63.07 a	52.77 b	61.09 a	60.00	8.04 **
Mn (mg kg^{-1})	120.86 a	120.86 a	108.54 b	120.86 a	117.78	8.181 *
Zn (mg kg^{-1})	69.08 ab	58.39 c	62.24 bc	74.86 a	66.14	9.508 **

*5%.**1%.

Stem nutrients: While the effect of salt concentration in irrigation water on K, Ca, Mg, Na, B, Fe and Zn contents was found to be statistically significant at 1% level, there was no effect on P, S and Cu contents (Table 3). The control (0 mM NaCl) and 25 mM NaCl had no significant effect, but 50 mM and 100 mM salt concentrations in irrigation water affected the nutrients in stem.

As a result of LSD test (Table 3), in the control (0 mM NaCl) and 25 mM NaCl there was almost no difference in stem nutrients. At 50 mM NaCl concentration, K, Ca, Mg and B formed the first and Na, Fe and Mn the last group. Zn content took place at the first group with 100 mM NaCl. As with the root, increasing salinity level of 100 mM NaCl, did not appear in a parallel domain.

The elements in the root and stem also showed some differences. For example, while K, Ca, Na and Fe are unimportant in the root, they are important for the stem. On the other hand, P, S and Cu are unimportant in the stem but they are important for the root. Mg, B, Mn and Zn are important in both root and stem. Mg and B elements formed the first group in the root and stem with the salinity of 50 mM; however, in this level, while Mn element took place in the first group in the root, it appears in the last group in the stem.

These results showed us the similarities and differences in the contents of elements of the root and stem in different levels of salinity in irrigation water.

Discussion

Salt sensitivity in plant species varies, even between the ecotypes of the species, the sensitivity is different. Different kinds of plants are affected in different levels of salt concentration. The resistance to salt varies with the growth period of the plant. That is why the choice of the plant, according to the salt level of the soil, is important for the productivity [13].

The different reaction of the plants to salt concentrations does not permit us to make a common comment. The limits of some elements in the peas' leaf at beginning of blossoming are stated as below [8]: P (%) low 0.25-0.29, sufficient 0.30-0.80, excessive >0.80; K (%) low 1.80-1.90, sufficient 2.00-3.50, excessive>3.50; Ca (%) low 1.00-1.10, sufficient 1.20-2.00, excessive>2.00; Mg (%) low 0.22-0.29, sufficient 0.30-0.70, excessive>0.70; Fe (mg kg^{-1}) low 40-49, sufficient 50-300, excessive>300; Mn (mg kg^{-1}) low 25-29, sufficient 30-400, excessive<400; Zn (mg kg^{-1}) low 20-24, sufficient 25-100, excessive>100; Cu (mg kg^{-1}) low 4-6, sufficient 7-25, excessive>25 and B (mg kg^{-1}) low 20-24, sufficient 25-60, excessive>60. In the fodder of pea Ca and P concentrations were 1.62% and 0.130% before the flowering and at the flowering these levels were 1.71% for Ca and 0.125% for P [5]. S in plants was from 0.50% to 0.15%[8].

The results of our study are similar to

other researchers' results on account of the contents of P, Fe, Mn, Zn and Ca, but we have some differences regarding K and B levels. This is because our study was on root and stem contents; while the others worked on leaf contents.

There are differences related with the salt strength between legumes [9]. Na content in roots and stems of plants varies according to the plants. As well as depending on the variety of plant reactions to sodium, it is also closely related to the particular environment in the absence of potassium. According to this, plants are classified in four groups in terms of salt strength. First group absorbs less Na when there is an adequate level of potassium in the plant growing condition. Pea plant is a good example for this group. The reverse can also be seen in the beet [8]. Excessive sodium intake reduces K and Mg, and Ca ion uptake leads to imbalances. Na damage occurs when they come together with Cl [7-11]. Unlike with this case, Ca, Mg and Zn composition at 75 mM NaCl increases in the pea root; Fe and Mn were reduced and Cu did not cause any change regarding the salt-free environment. At the same time, Ca, Mg and Zn in the stem increased, leaf Ca, Mg increased and decreases in other nutrients were reported [15]. Availability in iron uptake by plants was affected. Sodium intake showed important differences between plant genotypes. These differences are especially important for plants in pasture grass harvested as green fodder [8].

Conclusions

Application of nutrient elements solely affect the accumulation of organic sugars, starch, protein, oil, vitamin, *etc.* that determine the quality. On the other hand, several other elements have vital role. Excessive salt concentration around the root rhizosphere hinders many physiological reactions responsible for plant development [3]. The results presented in this study indicated that plant nutrient contents changed with different salt treatments. However, the magnitude and the course of such differences were not clearly understood as previously indicated by several researchers [2-12] and the topic should be further evaluated.

Acknowledgment

We would like to thank Assistant Professor Ramazan Acar for contribution in this research.

References

[1]Ashraf, M. 2004. Some important physiological selection criteria for salt tolerance in plants. Flora **199**:361-376.

[2]Black, C. A. 1970. Soil Plant Relations (trans. Ogus, L.). Ataturk Univ. Publication No. 75 (in Turkish).

[3]Çağatay, M. 1970. Affinity Effect on Quality of Plant Nutrition and Enzymes. Ankara Univ. Faculty of Agriculture, Publication No. 410 (in Turkish).

[4]Çizikci, S 1998. Different salinity, SAR and Ca:Mg ratio and yield effects of irrigation water spinach and germination. Soil and Water Resources Research Yearbook 1997. General Directorate of Rural Services. Publication No. 106, pp. 205-219 (in Turkish).

[5]Deniz, O. 1967. Cynical, Crude and Digestible Forage Peas Nutrients Ca, P Research on Values. Ayyildiz Printing Co. (in Turkish).

[6]Erözel, Z. and Ağar, A. 1992. Possibilities of Use of Saline Water for Irrigation. Ankara Univ. Faculty of Agriculture, Publication No. 1255 (in Turkish).

[7]Güneş, A., Alpaslan, M. and Inal, A. 2000. Plant Nutrition and Fertilization. Ankara Univ., Faculty of Agriculture, Publication No. 1514 (in Turkish).

[8]Kacar, B. and Katkat, A. V. 2007. Plant Nutrition. 3rd edn. Nobel Publishing, Publication No. 849 (in Turkish).

[9]Lauchli, A. 1984. Salt exclusion: An adaptation of legume for crops and pastures under saline conditions. In Staples, R. C. and Toenniessen, G. H. (eds). Salinity Tolerance in Plant. John Wiley & Sons Inc., pp. 171-187.

[10]Mengel, K. 1984. Nutrition and Metabolism of the Plant (trans. Ozbek, H., Kaya, Z. and Tamcı, M.). CU Faculty of Agriculture. Publication No. 162 (in Turkish).

[11]Munsuz, N., Çaycı, G. and Sözüdoğruok, S. 2001. Land Rehabilitation and Regulators. Ankara Univ., Faculty of Agriculture. Publication No. 1518 (in Turkish).

[12]Nat, N., Kav, V., Sanjeeva, S., Laksiri, G. and Stanford, F. B. 2004. Roteome-level changes in the roots *of Pisum sativum* in response to salinity. Annals of Applied Biology **145**(2):217-230.

[13]Strogonov, B. P. 1971. Physiological Principles of Salt Tolerance in Plants (trans. Guner, H.). Ege University Press, 190 p. (in Turkish).

[14]Yurtseven, E. 2004. Salinity management in irrigated areas, concepts and principles. Proceedings of Salinity in Irrigated Areas Management Symposium, General Directorate of State Hydraulic Works, pp. 17-48 (in Turkish).

[15]Yıldırım, B., Yaşar, F., Terzioğlu, Ö., Tamkoç, A. and Türközü, D. 2008. Effect of salinity stress on nutrient composition of field pea genotypes (*Pisum sativum* sp. *arvense* L.). Journal of Animal and Veterinary Advances **7**(8):944-948.