Middle East Journal of Agriculture Research, 2(4): 152-158, 2013
ISSN 2077-4605

Influence of Mono Potassium Phosphate Fertilizer on Mitigate The Negative Effects of High Saline Irrigation Water on Onion Crop

[1]Camilia, Y. El-Dewiny, [2]Hussein, M.M. and [1]Awad F.

[1]Soil & Water Use Dept., and [2]Water Relations & Irrigation Dept. National Research Centre, Dokki, Cairo, Egypt.

ABSTRACT

A greenhouse experiment was conducted to investigate the effects of foliar application of mono potassium phosphate (MKP) in 3 levels; Blank (0), 100 and 200 ppm on onion plants grown under saline irrigation water containing two salt concentrations (2000 and 4000 ppm) as compared to tap water (300 ppm). The results showed that irrigation of onion crop with saline water decreases plant growth and biomass production compared to those irrigated by tap water. The most serious effect was observed for the plants under higher salinity of irrigation water (4000 ppm) as compared to that of the plants under moderate salinity level (2000 ppm). In addition, increasing the salinity of irrigation water from 2000 to 4000 ppm caused a reduction, with different magnitudes, in the contents of N, P, K, Ca and Mg nutrients as a result of competition between Na^+, Cl^- from high saline water and these nutrients. Whereas, the sodium contents in onion plants were increased by increasing the salinity of irrigation water. Irrigation with tap water combined with foliar application of mono potassium phosphate (MKP) at either 100 or 200 ppm increased the plant growth. This positive effect of MKP was minimized by using higher concentration of saline irrigation water. Irrespective to the salinity of irrigation water, the concentration of potassium and phosphorus in onion plant tissues increased significantly with foliar application of (MKP) in the two levels, while the sodium content was decreased. Foliar application of MKP in two levels has different positive effect on the other nutrients under investigation. This study demonstrated that foliar application of (MKP) mitigated to some extent the negative effects of salts in irrigation water on onion plant growth and quality.

Key words: Diluted sea water, mono potassium phosphate fertilizer (MKP), nutrients contents, and Onion (*Allium cepa, L.*) crop.

Introduction

Water, the most important component of life, is rapidly becoming a critically short commodity for humans and crop production. Limited fresh water supply is one of the major biotic factors that adversely affect agricultural crop production worldwide. Salinity of arable land is a problem that is becoming more and more important in many areas where irrigation is a regular agro-technical measure, and in semi-arid and arid regions in the world where atmospheric precipitations are not sufficient to flush the salts from the root zone. Soil salinity is a major environmental factor causes reduction in plant growth and productivity in arid and semiarid areas of the world. Approximately, 20% of the world's cultivated area and about half of the world's irrigated lands are reported to be seriously affected by salinity and water logging (Munns, 2002; Viswanathan *et al*., 2005 and FAO, 2008). The ability of vegetation to survive under high salinity conditions is important for the distribution of plants and agriculture around the world. One of the major effects of salt stress in plants is nutritional disorder; which may result from the effect of salinity on nutrient availability, competitive uptake and transport or partitioning within the plant (Bartels and Sunkar, 2005 and Munns and Tester, 2008). In greenhouse conditions, Gunes *et al.* (1996) reported that onion plants grown under water deficit with excess fertilizers accumulate large amounts of sodium (Na), potassium (K), phosphors (P), and chloride (Cl). This leads to an excess ion uptake and an imbalance of various mineral elements. Grattan and Grieve (1998) stated that the physiological effects of interactions between salinity and mineral nutrition in horticultural crops are extremely complex. Crop performance may be adversely affected by salinity-induced nutritional disorders. These disorders may result from the effect of salinity on nutrient availability, competitive uptake and transport or partitioning of nutrients within the plant. Salinity can also cause a combination of complex interactions that affect plant metabolism, nutrient requirement, and susceptibility to injury.

In Egypt, onion (*Allium cepa, L.*) is one of the most important vegetable crops. The total grown area is about 87.47 thousands feddan, produced about 1147.6 thousands ton with an average 13.12 tons/fed. (AERI, 2006). Onion has a shallow rooting depth (<60 cm) and requires frequent irrigation to maintain market grade and quality (Schwartz and Bartolo, 1995). Rhoades *et al.* (1992) and Lee (2006) stated that Onion *(Allium Cepa L.*) crops are sensitive to drought stress and moderately sensitive to salt stress.

Corresponding Author: Camilia, Y. El-Dewiny, Soil & Water Use Dept., and Water Relations & Irrigation Dept. National Research Centre, Dokki, Cairo, Egypt.

Haifa MKP™ as a nitrogen-free fertilizer is the preferred source of phosphorus and potassium when nitrogen fertilization should be limited. A common case is at early growing season, when phosphorus and potassium are needed at high rates for the establishment of root system. Moreover, it is very beneficial when applied before harvesting in the time which plants needed more supply from these two major nutrients. Recent research works by Jefon and Lester (2008) and Hussein, *et al.* (2012) indicate that foliar application of mono potassium phosphate (MKP) at 200 ppm concentration increased the plant growth, biomass production, and fruit yield of pepper crop. They added that chlorophyll content and total phenols increased significantly with foliar application of 100 ppm MKP. Whereas, further increase in foliar MKP concentration to 200 ppm had no significant effect on photosynthetic pigments and total phenolic content. The objective of this study was to investigate the effects of foliar application of potassium mono phosphate fertilizer in mitigating the negative effects of salt stress on plant growth and nutrients concentrations of onion plants.

Materials And Methods

Pot experiments were conducted in the greenhouse of the National Research Centre, Dokki, Cairo, Egypt during two winter seasons of 2011-2012 and 2012-2013 to evaluate the effect of spraying onion crop with mono potassium phosphate MKP and irrigated with saline water on growth and composition yield of onion plants. The following treatments were investigated with six replications in each treatment:

A- The salinity of irrigation water was; 2000 and 4000 ppm from diluted seawater. Table (1) shows the chemical analysis of sea water used, while tap water (300 pm) was used as a control treatment.

B- Spraying of mono potassium phosphate (MKP) at levels; 0, 100 and 200 ppm.

Thus, metallic tin pots 35 cm diameter and 50 cm depth were used and the inner surface of the pots was coated with three layers of bitumen to prevent direct contact between the soil and metal. Every pot contained 30 kg of air dried soil and the physical and chemical characterizations of the soil are presented in Table (2). Calcium super phosphate (6.8% P) and potassium sulfate (40.3% K) were added (broadcasted on the soil surface) to the soil in the pot at 4.5 and 2.5 g/pot, respectively.

Table 1: Chemical analysis of sea water used in irrigation of onion crop.

Source	pH	EC dSm^{-1}	Soluble cations (mM)				Soluble anions (mM)				Total soluble salts mg/L
			Na^+	K^+	Mg^{++}	Ca^{++}	CO^{--}	HCO_3^{--}	Cl^-	SO_4^{--}	
Sea water	7.94	50	475	9.7	56	10	2.5	2.3	536	28	32000

Table 2: Physical and chemical analysis of the soil used in this study.

A- Particle size distribution as percent.

Course sand >200 µ	Fine sand 200-20 µ	Silt 200-2 µ	Clay <2µ	Soil texture
9.7	16.8	35.2	38.3	Clay loam

B- Soil chemical analysis

pH 1:2.5	EC dSm^{-1}	$CaCO_3$ %	OM %	Soluble cations Meq/100g soil				Soluble anions Meq/100g soil			
7.50	1.45	2.65	1.4	Na^+	K^+	Ca^{++}	Mg^{++}	$CO^{=}_3$	HCO^-_3	Cl^-	$SO^{=}_4$
				1.95	0.36	2.68	1.57	0.0	0.90	1.8	3.79

Available macro-nutrients%			Available micro-nutrients ppm			
N	P	K	Fe	Zn	Mn	Cu
0.49	0.27	0.93	5.4	3.5	7.8	4.2

Onion seedlings were transplanted on 15 November, 2011, and thinned to 3 plants per pot after two weeks. Nitrogen was applied as ammonium sulfate (20.5% N) in three applications of 9.0 g/pot each, at 2, 4, and 6 weeks after planting. Diluted seawater, to attain two salinity levels (2000 and 4000 ppm), were used for high salinity irrigation began two weeks after planting. The pots were irrigated on three days frequency. Foliar application MKP was done twice, i.e. 35 and 42 days after planting. At the completion of the experiment (120 days after planting), the fresh weights of whole plant were recorded. These plants were dried at 70°C for 72 h and the dry weights were also recorded. The digestion and determination of the concentration of nutrients N, P. K, Ca, Mg, and Na in plant samples were done according to the methods described by Cottine *et al.* (1982). All collected data were subjected to the proper statistical analysis according to Snedecor and Cochran (1980).

Middle East j. Agric. Res., 2(4): 152-158, 2013

Result and Discussion

Plant Growth:

The data in Figure (1) show the effect of saline irrigation water and application rate of MKP fertilizer on the dry weight of onion plants (120 days old). It is clear that the plant growth of onion plants as indicated by the dry weight per plant is decreased by increasing salinity of irrigation water. These adverse effects

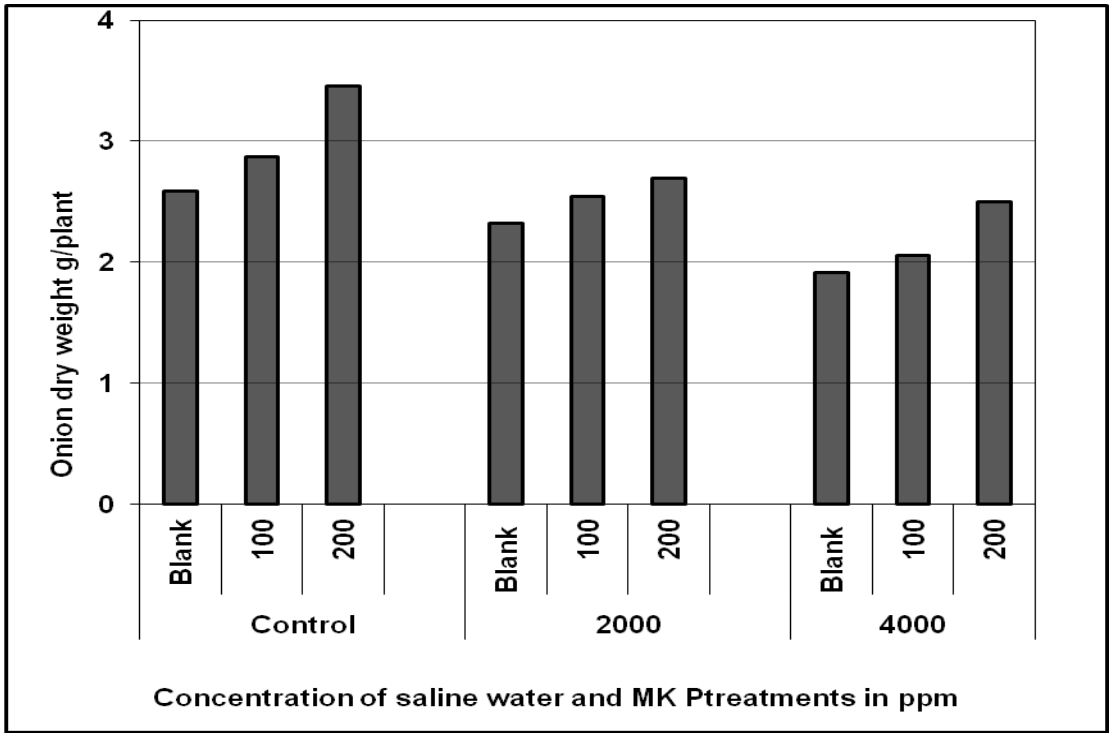

Fig. 1: The effect of saline irrigation water and mono potassium phosphate on onion dry weight.

of salt stress may be due to the effects of salts on the availability and uptake of water leading to a decreased water content in the plant tissues which altered the metabolic processes inside the cells. Furthermore, increased salt content in the irrigation water may cause direct and indirect effects on leaf water relations and stomata closure which influence CO_2 exchange and photosynthetic rate. Increasing salt content in irrigation water may be directly toxic to plants, which in turn, lowered carbohydrate accumulation in the plants; Morales-Garcia, *et al.* (2008), protein assimilation, Zafar, *et al*. (2005), mineral uptake and distribution; Hussein, *et al.* (2004), activities of growth hormones; Kaya *et al.* (2009) and enzymes activities Hussein and Oraby (2008).

Foliar application of (MKP) significantly increased the plant growth as indicated by dry weights of onion plants. Moreover, foliar application of MKP fertilizer reduced the hazard effect of salts on plant growth. Similar results with different vegetables crops were reported by; Fawzy, *et al.* (2005); Fawzy, *et al.* (2007). Hussein, *et al.* (2008) and Hussein, *et al.* (2012).

Mineral Nutrition:

The data in Table (3) show that the salinity of irrigation water affected nutrient contents in onion plant tissues. In general, irrigated onion plant with saline water with 2000 ppm salt concentration slightly increased the contents of most nutrients under investigation. The contents of investigated nutrients in onion tissues were decreased in case of using higher salinity dose increment i.e. 4000 ppm. At this high salt concentration (4000 ppm), the most affected nutrients were potassium, phosphorus, calcium, manganese and nitrogen. Osmotic potential, created by saline ions at the root medium, restricted water and nutrient elements flow into roots. Marschner (1995) stated that accumulation of Na^+ in roots reduced K^+ absorption and translocation from root to shoot. He added that calcium, magnesium and nitrogen transport was also found to be inhibited due to salinity. Due to nutrient deficiency and/or harmful effects of the saline toxic ions, onion plant growth was negatively affected as indicated by dry weight results.

Middle East j. Agric. Res., 2(4): 152-158, 2013

Table 3: Effect of saline irrigation water and mono potassium phosphate on some nutrients contents in onion plant.

Treatments		Nutrients Contents in %					
Salinity in ppm	MKP in ppm	N	P	K	Ca	Mg	Na
300	0	2.03a	1.23a	1.35a	1.59a	1.04a	1.46a
	100	2.13a	1.75b	1.97b	1.85a	1.18a	1.40a
	200	2.24b	2.12c	2.26c	2.20b	1.34b	1.27b
Mean		2.09	1.70	1.86	1.88	1.19	1.42
2000	0	2.24a	1.41a	1.61a	1.67a	0.99a	2.80a
	100	2.44b	1.82b	2.16b	2.05b	1.23b	2.54b
	200	2.56b	2.21c	2.96c	2.17b	1.41c	2.13c
Mean		2.41	1.81	2.24	1.96	1.21	2.49
4000	0	1.98a	1.05a	1.42a	1.19a	0.91a	3.69a
	100	2.03a	1.54b	2.00b	1.40b	1.08b	3.20b
	200	2.21b	2.08c	2.46c	1.62c	1.36c	2.87c
Mean		2.07	1.56	1.96	1.40	1.12	3.25

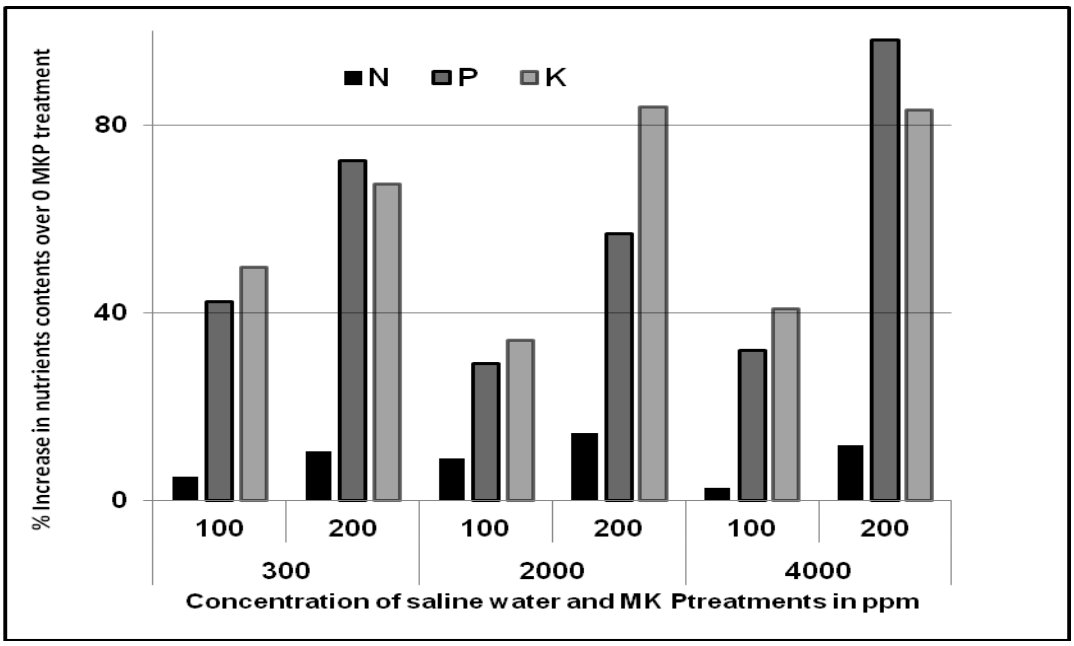

Fig. 2: Percent increase in N, P, and K contents in onion plants, over non MKP treatment, as affected by two rates of this fertilizer and irrigating with saline irrigation.

Nitrogen is the mineral nutrition that plants require in the largest amounts and is a constituent of many plant cell components. Data in Table (3) showed that regardless the effect of MKP, increasing the salinity of irrigation water from tap water to 2000 ppm increases slightly the mean N contents from 2.09 to 2.41 ppm. While, further increase in the concentration of salts in irrigation water to 4000 ppm decreases the mean N content in plant to 2.07 ppm. This reduction in nitrogen contents in onion plants irrigated with high saline water may be due to an interactive effect between Na^+ and NH_4^+ and/or between Cl^- and NO_3^-. The negative effects of salinity have been attributed to disturbance in protein assimilation (Hussein, *et al.*, 2004 and Zafar, *et al.*, 2005), mineral uptake and distribution Hussein and El-Greatly (2007).

The data in Figure (2) indicated that application of MKP in either 100 or 200 ppm increased N content in onion plant tissues. This positive effect was pronounced, with lower magnitudes, under higher concentration of salinity. With regard to the phosphorus and potassium contents in onion plant, the data in the Table (3) and the calculated percent increase over non (MKP) treatmentsas indicated in Figure (2), water to 2000 ppm caused slightly increase in the two nutrients contents in onion crop. The data illustrated in Figure (2) show that the amounts of either P or K contents in onion plants were decreased as a result of increasing the salt concentration in irrigation water up to 4000 ppm without potassium foliar fertilizer treatment. In case of using fresh water and foliar application of MKP in 2 levels, the P and K contents in plant materials were increased. The application of 200 ppm MKP under irrigation of 2000 and 4000 ppm salt solution showed highest P and K contents if compared with 100 ppm or without MKP treatments. These disorders may result from the effect of salinity on

nutrient availability, competitive uptake and transport or partitioning of nutrients within the plant materials. Grattan and Grieve (1998) and Rogers *et al.* (2003) stated that salinity reduces phosphate uptake in crops grown in soils primarily by reducing phosphate availability. Marschner (1995), reported that addition of K fertilizer such as MKP via leaves enhanced the content of K so plants irrigated by fresh or saline water. Because both drought and salinity affect plant growth similarly through water deficit, K^+ is equally important for maintaining the turgor-pressure in plants under either stress.

The data in Table (3) and the calculated percent increase in Ca and Mg contents in onion plants over non MKP treatment, Figure (3), indicated that calcium and magnesium contents were pronouncedly increased by increasing salt level in irrigated diluted seawater. Addition of K fertilizer via leaves enhanced the contents of either Ca or Mg in plants irrigated by fresh or moderated saline water.

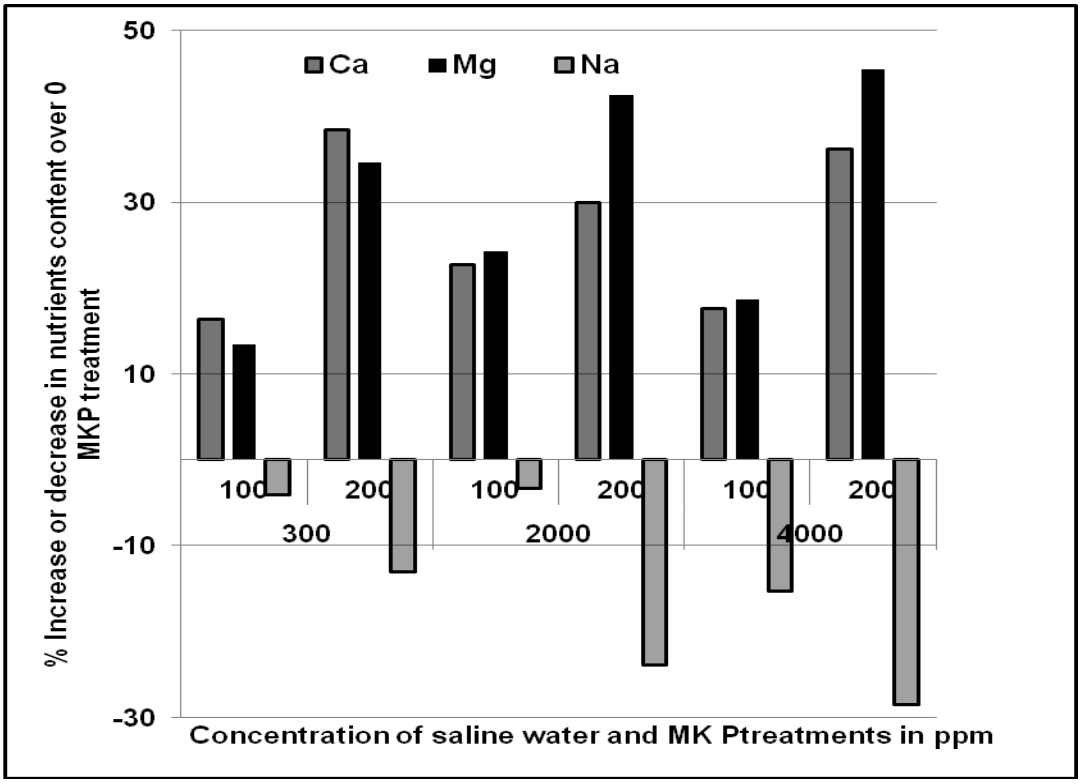

Fig. 3: Percent increase in Ca and Mg, and percent decrease in Na content in onion plants, over non MKP treatment, as affected by two rates of this fertilizer and irrigating with saline irrigation.

Data in Table (3) showed that regardless the effect of MKP, increasing the salinity of irrigation water from tap water to 2000 ppm increase slightly the mean of Ca and Mg contents from 1.88 and 1.19 ppm to 1.96 and 1.21 ppm for the two cations respectively. While, further increase in the concentration of salts in irrigation water to 4000 ppm decrease the mean Ca and Mg contents in plant to 1.40 and 1.12 ppm. This reduction in Ca and Mg contents in onion plants irrigated with high saline water may be due to that calcium plays a vital role in regulating many physiological processes that influence both growth and responses to environmental stresses. Included among these are water and solute movement as influenced through the effects of Ca^{2+} on membrane structure and stomata function, cell division and cell-wall synthesis, direct or signaling roles in systems involved in plant defense and repair of damage from biotic and abiotic stress, and rates of respiratory metabolism and translocation (McLaughlin and Wimmer, 1999). A recent review (Cramer, 2002) summarizes the research on Na^+/Ca^{2+} interactions under salinity stress from a physiological perspective. Because Na^+ readily displaces Ca^{2+} from its extra cellular binding sites, Ca^{2+} availability could be seriously reduced under salinity, especially at low Ca^{2+}: Na^+ ratios. Furthermore, the decreased in Ca^{2+} content under high saline irrigation water (4000 ppm) might be due to its precipitation and the increase in ionic strength that reduces its activity.

The values in Table (3) indicate that irrigation with diluted seawater markedly increased Na content in the onion leaves and regardless the effect of MKP, increasing the salinity of irrigation water from tap water to 2000 and 4000 ppm increases the mean Na content from 1.42 to 2.49 and 3.25 ppm respectively. Sodium content slightly decreased with MKP in the rate of 100 ppm and tended to decrease with 200 ppm application to be less than the control when plants regularly irrigated by fresh water.

Conclusions:

Irrigation of onion crop with saline water has an osmotic effect, which means that the amount of water accessible for plants is reduced. Yield losses due to osmotic stress can be very significant before toxicity symptoms on plants become apparent. The high concentration of salts in the soil solution may reduce the absorption of nitrogen, phosphorus and potassium so it is necessary to add these elements in the form of fertilizers. Understanding the mechanisms by which salinity affects photosynthesis and other physiological processes would help to improve conditions for growing vegetables and increase their yield and quality, and would provide a useful tool for future genetic engineering.

Both drought and salinity disturb the mineral-nutrient relations in plants through their effects on nutrient availability, transport, and partitioning in plants. Additionally, salinity stress also induces ion deficiency or imbalance due to the competition of nutrients such as K^+, Ca^{2+}, and NO^-_3 with the toxic ions Na^+ and Cl^-. Mineral nutrients play a vital role in determining plant resistance to drought or salinity. Because both drought and salinity cause a similar effect on plant growth through a water deficit, K^+ is equally important to maintain the turgor pressure of the plant under either stress. High K^+: Na^+ ratios will also improve the resistance of the plant to salinity. Although Ca^{2+} is a key signal messenger for regulating plant resistance to both drought and salinity, the interaction between Ca^{2+} and each stress has been studied more intensively for salinity than for drought stress.

References

AERI., 2006. Agricultural Economic Research Institute (AERI).

Bartels, D. and R. Sunkar, 2005. Drought and salt tolerance in plants. Crit. Rev. Plant Sci., 24: 23-58.

Cottenie, A., M. Verloo, G. Velghe and R. Comerlynk, 1982. Chemical analysis of plant and soil. Laboratory Analytical and Agro-Chemistry. State Univ., Ghent, Belgium.

Cramer, G.R., 2002. Sodium-calcium interactions under salinity stress. In Läuchli, M., Lüttge, U. Salinity: Environment-Plants-Molecules. Kluwer Acad. Pub., London, pp: 205-228.

FAO, 2008. Land Resources, Management, Planning and Use. Accessed 25 April. Available online at: [http://www.fao.org/ag/agl/agll/spush/].

Fawzy, Z.F., A.G. Behairy and S.A. Shehata, 2005. Effect of potassium fertilizer on growth and yield of sweet pepper plants (Capsicum annuum, L.). Egypt. J. Agric. Res., 2: 599-610.

Fawzy, Z.F., M.A. El-Nemr S.A. and M. Saleh, 2007. Influence of levels and methods of potassium fertilizer application on growth and yield of eggplant. J. Appl. Sci. Res., 3: 42-49.

Grattan, S.R. and C.M. Grieve, 1998. Salinity-mineral nutrient relations in horticultural crops. Sci. Hort., 78: 127-157.

Gunes, A., A. Inal, and M. Alpaslan, 1996. Effect of salinity on stomatal resistance, praline and mineral composition of pepper. J. Plant Nutr., 19: 389-396.

Hussein, M.M. and N.H. El-Greatly, 2007. Influences of Alph-tochopherol and potassium dihydrogen phosphate on growth and endogenous phytohormones of onion plants grown under salinity stress. J. Agric. Sci., 32: 9141-9151.

Hussein, M.M. and S.H. Oraby, 2008. Growth and anti-oxidant enzymes activity in onion plants as affected by thiamine and salinity. Plant Nutrition Management under Water Stress Conditions. 17th Inter. Symp. CIEC, Cairo, pp: 260-278.

Hussein, M.M., S.Y. El-Faham and A.K. Alva, 2012. Pepper plants growth, yield, photosynthetic pigments, and total phenols as affected by foliar application of potassium under different salinity irrigation water. Agric. Sci., 3: 241-248.

Hussein, M.M., M.S. Gaballah, and S.Y. El-Faham, 2004. Amino acids in grains of barley as affected by benzyl adenine and salinity from diluted seawater. J. Appl. Sci., 5: 655-658.

Hussein, M.M., M.M. Shaaban and A.M. El-Saady, 2008. Response of cowpea plants grown under salinity stress to PK-foliar application. Amer. J. Plant Physiol., 3: 81-88.

Jefon, J.L. and G.E. Lester, 2008. Effect of foliar potassium fertilization on muskmelon fruit quality and yield. Proc. of Fluid Form, Feb., 2008, Scotsdale AZ; Fluid Fertilizer Foundation Manhattan, K.CD ROM Publications.

Kaya, C., A.L.Tuna and I. Yoka, 2009. The role of plant hormones in plants under salinity stress tasks for vegetation science. Salinity and Water Stress, 44: 45-50.

Lee, S.K.D., 2006. Hot pepper response to interactive effects of salinity and boron. Plant Soil Environ., 52: 227-233.

Marschner, H., 1995. Mineral Nutrition of Higher Plants. 4th Edition, Academic Press, London.

McLaughlin, S.B. and R. Wimmer, 1999. Transley Review No. 104 – Calcium physiology terrestrial ecosystem processes. New Phytol.,142: 373-417.

Morales-Garcia; K.A. Stewart, and P. Seguin, 2008. Effects of saline water on growth and physiology of bell pepper seedlings. Inter. J. Vegetable Sci., 14: 121-138.

Munns, R., 2002. Comparative physiology of salt and water stress. Plant Cell Env., 25: 239-250.

Munns, R. and M. Tester, 2008. Mechanisms of salinity tolerance. Plant Biol., 59: 651-681.

Rhoades, J.D., A. Kandiah and A.M. Mashali, 1992. The use of saline waters for crop production. FAO Irrigation and Drainage. Rome, 48.

Rogers, M.E., C.M. Grieve, and M.C. Shannon, 2003. Plant growth and ion relations in lucerne (*Medicago sativa* L.) in response to the combined effects of NaCl and P. Plant and Soil, 253: 187-194.

Schwartz, H.F., and M.E. Bartolo, 1995. Colorado onion production and integrated pest management. Ext. Bull. 547A. Colorado State Univ., Fort Collins, USA.

Snedecor, G.W. and W. G. Cochran, 1980. Statistical Methods. 8th Edition, Iowa State University Press, USA.

Viswanathan, C., I. Andreand and J.K. Zhu, 2005. Understanding and improving salt tolerance in plants. Crop Sci., 45: 437-448.

Zafar, S., M.Y. Ashraf and M. Ashraf, 2005. Protease activity and associated changes during germination and early seedling stages of cotton grown under saline conditions. Inter. J. Biol., 1: 103-107.