Minufiya J. Agric. Res. Vol.40 No. 4(2): 1065 –1083 (2015) **"http://www.mujar.net"**

MONITORING THE IMPACT OF ON-FARM SEED PRIMING WITH MICRONUTRIENTS SOLUTION ON SALINITY TOLERANT OF FABA BEAN (*Vicia faba* L.)

Nieven O. Fathi

Salinity and Alkalinity Soils Research Laboratory, Alexandria. Ministry of Agriculture, (Egypt)

(Received: May. 11, 2015)

ABSTRACT: *A pot experiment was conducted at Soil Salinity and Alkalinity Laboratory, Alexandria, Egypt. The objectives were: to investigate the potential for resource-poor farmers to use 'on-farm' seed priming before sowing to increase the amount of Zn or Fe in and on seeds; to improve the productivity and profitability of the important legume faba bean thereby under salt stress; and to evaluate the most effective method of micronutrients application vs. foliar fertilization for crop growth, yield and grain fortification of faba bean. The results revealed that the greater amount of salts in irrigation water supplied to soil may have increased Na concentrations in soils. So, the sodium adsorption ratio (SAR) values were far above the limit (>13) and pH < 8.50 established to define saline–sodic soils. Nutrient seed priming of faba bean seeds with Fe and Zn significantly increased the concentrations of these elements within the seeds. Corresponding to increases ranged from 22 to 1080 % of the natural seed reserves. A highly significant difference in nutrient concentrations was detected between unprimed and primed seeds. The priming treatment significantly affected total chlorophyll contents in leaves of faba bean plants. The concentrations of Na and K in primed plans were higher than those of salinity treated un-primed plants. There was a significant increase in grain yields per pot with Fe seed priming relative to unprimed seeds . The highest increase for grain yield was obtained in mineral form of Fe primed seeds at 150 ppm priming solution for 12 hours followed by spray treatment of micronutrient at 150 ppm. The overyielding percentages were 227 and 217% for Fe primed seeds at 150 ppm for 12 hours and spray treatment of Fe at the same concentration (150 ppm), respectively. Also, the overyielding percentages or the relative increase in yield were ranged from 30 to 170 % for all other priming treatment or spray. On the other hand, There was a significant increase in grain yields per pot with Zn seed priming relative to unprimed seeds . The results of this study demonstrated that seed priming is a cost-effective method of increasing yield and improving grain quality in these crops and is appropriate for resource poor farmers.*

***Key words**: Priming- salt stress- faba bean-micronutrients*

INTRODUCTION

Since the dawn of civilization legumes, together with cereals, are considered the fundamental source for protein in human diet, edible oils, and fodder and forage for animals. Faba bean (*Vicia faba* L.) is one of the oldest legume crops mainly grown for human and animal dietary needs. Like other grain legumes, faba bean contributes to sustainable agriculture by fixing atmospheric nitrogen in symbiosis with soil bacteria. This unique ability reduces the dependence of farmers on extensive use of chemical fertilizers protecting soil and water quality. In addition, legumes play a critical role in crop rotation, improving soil physical conditions and decreasing the amount of diseases and weed populations which in turn leads to lower consumption of herbicides and fungicides. Salinity is one of the most important problems of farmers in worldwide. Salt and osmotic stresses are responsible for delayed seed germination and seedling establishment (Mohammadi, 2009). Salinity can affect plant physiological processes and reduced growth and yield (Azooz, 2009). One of the methods that could increase the tolerance to salinity in plants is seed priming (Sadeghi *et al.,* 2010) that among different techniques of tolerance to salinity is an easy, low cost and low risk method (Iqbal and Ashraf, 2006). Seed priming improves seed performance under environmental conditions (Tavili *et al.,* 2010) and can reverse some of the aging-induced deteriorative events (Chiu et al., 2002). This technology can increase the range of seed germination and emergence under stress conditions such as drought, salinity, low and high temperatures. One of the most practical and cheapest methods of seed priming is on-farm seed priming using tap water. Research has shown that on-farm seed priming which consists of soaking seeds in water (usually overnight) then surface drying and planting the same day, resulted in yield increases and has already been adopted by thousands of resource-poor farmers for many crops in many countries in both Asia and Africa . Furthermore, seed priming can be used to overcome soil micro- and macro-nutrient deficiencies. Micronutrients are required in very small quantities (Abd El-Wahab 2008). There are mainly three methods of micronutrient application in crops: application to soil, foliar sprays, and seed treatment (Johnson *et al.,* 2005).Harris *et al*. (2002) reported that priming in corn improved seedling establishment, plant growth and caused earlier flowering and increasing yield. In these plants, increased yield was attributed to both priming and zinc (Zn) content. Increasing the Zn and Fe concentration of food crop, resulting in better crop production and improved human health is an important global challenge. Among micronutrients, Zn and Fe deficiencies are occurring in both crops and humans (Welch and Graham 2004). Zn and Fe deficiencies in soils have been reported worldwide, particularly in calcareous soils of arid and semiarid regions. In a global soil survey study, SillanpaÈaÈ (1990) found that 50% of the soil samples collected in 25 countries was Zn deficient. Zinc deficiency is a particularly widespread micronutrient deficiency in wheat, leading to severe depressions in wheat production and nutritional quality of grains (Graham and Welch, 1996). As in soils and plants, Zn deficiency is also a common nutritional problem in humans, predominantly in developing countries where diets are rich in cereal-based foods and poor in animal protein (Welch, 1993). Foods derived from cereals are not only low in Zn, but also rich in compounds depressing bioavailability (utilization) of Zn to humans, such as phytic acid and fibre. Since a wide range of soils in the world are deficient in zinc, seed priming combined with zinc element can be effective for the treatment of zinc deficiency in the soil. Cakmak (2000) reported that zinc has important role in protecting and stabilizing the structure of cell membranes. In barley, seed priming with zinc solution improved seed germination and seedling vigor index. This indicates of important physiological role of zinc during germination process. Since a wide range of soils in the world are deficient in zinc, seed priming combined with zinc element can be effective for the treatment of zinc deficiency in the soil. Ouzturk *et al*. (2006) found that high concentrations of zinc in root and coleoptile represent a critical physiologic role of zinc during early seedling development. Probably, zinc in these tissues is used for membrane protein synthesis, cell elongation and greater resistance to environmental stresses. In maize, priming in 1% $ZnSO4$ solution (for 16 h) substantially improved crop growth, grain yield and grain Zn content (Harris *et al.,* 2007). Results of seven field trials showed yield increase of 27% with seed priming compared with non-priming controls (Harris *et al.,* 2007). It is interesting to note that the benefit: cost value was substantially higher from Zn priming compared to soil application (Harris *et al.,* 2007). Multiple micronutrient deficiencies of Zn, Mn, Cu, B, Fe, and Mo occur in the soils of Egypt, and they are becoming more prevalent as cropping intensity increases. Most of the calcareous soils have Fe and Zn deficiencies. Therefore, it was decided to determine the effects of priming seeds with Fe and Zn to find their proper concentrations. There may be several advantages to this approach: the effects of uneven application of Zn or Fe to the soil are avoided as each seed is exposed to the nutrient; initial uptake is guaranteed; the nutrient is available early in the life of the plant; the amounts required are likely to be orders of magnitude less, and thus less costly, than for soil application. Conversely, optimal use of micronutrients added to seeds depends on the mobility of the element once inside the seed, and risk of toxicity may be increased by priming.

The objectives of this study were: to investigate the potential for resource-poor farmers to use 'on-farm' seed priming before sowing to increase the amount of Zn and Fe in and on seeds; to improve the productivity and profitability of the important legume faba bean thereby under salt stress; and to evaluate the most effective method of micronutrients application vs. foliar fertilization for crop growth, yield and grain fortification of faba bean.

MATERIALS AND METHODS

Soil characteristics:

The agricultural soil used in the study was classified as *Typic calciorthids* .The soil was air-dried and sieved through a 2-mm sieve. Sub-samples of the air-dried soil were used for the following chemical analysis: the pH and the electrical conductivity (EC) were determined in soil-paste extract (Richards, 1954), the organic matter content was determined by dichromate oxidation method (Nelson and Sommers, 1982), cation exchange capacity (CEC) was determined by IM NaOAC method (Rhoades, 1982), the particle size distribution was determined by the hydrometer method (Day, 1965), total calcium carbonate content was determined using calcimeter (Nelson, 1982), the available phosphorus was determined by 0.5 M $NaHCO_3$ test (Olsen and Sommers, 1982),the available nitrogen was determined by 2M KCl method (Bremner and Mulvaney, 1982), and the available potassium was determined by 1N ammonium acetate method (Knudsen and Peterson,1982).The main chemical and physical properties of the soil are shown in Table (1).

Experimental set-up:

The laboratory seed priming tests of faba bean (Giza 716.) were performed in a split plot design, using solutions containing two concentrations of iron and zinc. There were three replications of each priming solution, plus three replications of an unprimed control. Seeds were soaked in the required aqueous solutions of chemicals as $FeSO_4.7H_2O$, Sequstrene 330Fe (chleated iron) , chelated zinc and $ZnSO_4$. The priming solution concentrations were 150 and 300 mgl^{-1} each of Fe and Zn. Each treatment involved weighing approximately 10 g of seeds into a plastic cup, adding 20 ml of the priming solution (sufficient to submerge the seeds), and allowing the seed-and-solution mixture to stay covered with a plastic cup for 12 and 24 h. Seeds, after soaking, were rinsed three times with distilled water to remove excess salts from the seed coat, as described by Johnson *et al.* (2005). A portion of the primed seeds were dried. Another portion of seeds were then ground to a powder in a Wiley micro-mill with stainless steel blades and sifted through a 40-mesh sieve. Seed subsamples were digested and then the Fe and Zn were determined using atomic absorption Spectrophotometer (Issac and Kerber 1971). The seed concentrations of Fe and Zn before and after priming are presented in Table (2). The iron and zinc solutions rates (150 and 300 ppm) were added as a foliar spray twice after four and six weeks of sowing date.

A pot experiment was conducted in the greenhouse of Soil Salinity and Alkalinity Laboratory in Alexandria- Agriculture Research center. Egypt during the winter season of 2013/2014 using faba bean in polyethylene pots, each containing 10 kg calcareous soil. The soil in each pot was irrigated with water of different salinity. The EC of each saline water was obtained by blending tap water with sea water, shaking and then measuring EC. The salinity(S) levels were: (tap water 0.47), and 4 dSm^{-1} representing 50 % from the faba bean yield according to the data outlined by FAO, (1976) in all possible combinations. Pots then left in the greenhouse, receiving only natural light, for 22 weeks, and watered weekly with tap water (EC 0.47 dS m^{-1}) or saline water level. Fertilization with the recommended rates of N, P, and K was accomplished according to Ministry of Agriculture and Land Reclamation (MALR), Cairo, Egypt. The maximum and minimum temperatures in the greenhouse were 28 and 15^0C, respectively. Two seeds of faba bean were sown per pot then thinned to one plant after 7 days of germination. The experimental design was a split plot design with three replicates of each treatment. The layout of the treatments will be conducted in the greenhouse pots as shown in Table (1).

Table (1): Expermintal treatments.

Salinity	Soaking time,hr	Soaking/Spray							
		Iron (ppm)				Zinc (ppm)			
		mineral		chelated		mineral		chelated	
		150	300	150	300	150	300	150	300
S*	0	x		x		x		x	x
	12	x		x		x		x	x
	24	x		x		x		x	x

*: irrigation by 4.0 dS/m water

Table (2): Some physical and chemical characteristics of the experimental soil (means ± SD except for pH) ‡

Characteristics	Unit	Value
EC	dSm^{-1}	6.00±0.72
pH		7.96-8.12
$CaCO_3$	$g\ kg^{-1}$	273.00±13.56
Sand	$g\ kg^{-1}$	629.00±5.29
Silt	$g\ kg^{-1}$	110.54±2.52
Clay	$g\ kg^{-1}$	260.46±4.69
Texture		S.C.L[¶]
O.M[†]	$g\ kg^{-1}$	8.40±0.36
CEC	$Cmol(+)\ kg^{-1}$	17.12±1.63
Olsen-P	$mg\ kg^{-1}$	16.55±1.22
Available-N	$mg\ kg^{-1}$	16.24±1.59
Available-K	$mg\ kg^{-1}$	138.85±7.43

‡Data are the means of 4 samples
S.C.L. Sandy Clay Loam

Soil sampling and analysis:

At harvest, the soil in each pot was mixed and a sample of soil was taken for determination of EC and soluble cations and soluble anions according to Richards (1954).

Plant sampling and analysis:

Samples of plants were collected after 22 weeks from sowing to study the growth characteristics and for chemical analysis of leaves .After sampling of faba bean pods and leaves, immediately triple rinsed in distilled water to remove the adhering soil particles, then oven dried at 65°C for 48 h and the oven-dried matter yield was recorded. The oven-dried plant materials were ground in a stainless steel mill and subsamples were dry-ashed in a muffle furnace at 450°C for 6h. The ash was dissolved in 5 ml of HNO_3 (1: 1), diluted to a constant volume with distilled water and analysed for K, Fe, Zn and Na (Jones, 2001). The dry matter production and plant nutrients concentrations are expressed on oven-dry weight basis.

Chlorophyll content analysis:

The chlorophyll content in faba bean was measured by SPAD 502 plus chlorophyll meter (Spectrum Technologies,Inc).

Statistical and mathematical analyses:

The treatment effects on growth and yield parameters, nutrients concentrations were evaluated by analysis of variance (ANOVA) and also by the least significant difference (LSD) mean separation procedure at the 0.05 level of significance (SAS Institute, 1994).

Overyielding (%) or relative increase in yield was calculated according to the following equation:

$$\text{Overyielding (\%)} = (\text{Yield}_{\text{treatment}} - \text{Yield}_{\text{control}}) \times 100 / (\text{Yield}_{\text{control}})$$

RESULTS AND DISCUSSION

Characteristics of the soil before and after irrigation

The soil studied was a sandy clay loam (*Typic calciorthids*), with low OM and high calcium carbonate contents (Table 2). It was moderately alkaline (pH = 7.96) and classified as a saline soil (EC > 4 dS m^{-1}). The cation exchange capacity (CEC) was 17.12 $cmol_c$ kg^{-1}. The available nitrogen, potassium, and nitrogen were moderate. While after irrigation with tap and saline waters most of the characteristics were considerably affected (Table 3). At harvest, the EC of the soil was significantly ($P < 0.05$) changed by the irrigation treatment compared to the control (Table 3). The K, Cl, and HCO_3 in the soil were significantly affected by irrigation with saline water (Table 2). Continuous flooding or frequent inundation can change these results. However, the value of bicarbonate in soil was 2.20 and 12.50 $meql^{-1}$, no adverse effects on faba bean growth was observed during growth period. However the SAR was greater after irrigation with saline water, a highly significant difference was found between the tap and saline waters (Table 2). Slightly lower SAR value was found in soil irrigated with low level salts-water. While, the higher SAR value were found in soils irrigated with high level salts-water. The greater amount of salts in irrigation water supplied to soil may have increased Na concentrations in soils. So, the SAR values were far above the limit (>15) established to define saline–sodic soils (US Salinity Laboratory Staff, 1954).

Table (3): Concentrations of soluble salts, SAR, and pH in the soil extracts after harvest of faba bean irrigated with tap and saline water.

Soil Characteristics						
	dSm^{-1}		**$meq.l^{-1}$**			
	EC	**pH**	**K**	**Cl**	**HCO_3**	**SAR**
Before	6.00	7.96	1.50	22.00	1.25	11.50
After TW	4.75	7.89	0.61	29.75	2.20	7.30
After SW	26.00	7.72	1.20	215.00	12.50	25.22

Data are the average (n=3).

The two main risks of high sodium levels in soil water are toxic effects and impacts on plant growth as reflection of changes in soil structure. Excess sodium present in soil water can cause soil dispersal, especially in soils with high clay contents. Soil dispersal causes loss of soil structure and surface crusting. Surface crusting leads to reduced hydraulic conductivity, reduced water infiltration, and increased water runoff especially under field conditions. These can make seedling establishment very difficult. Decreased drainage as a result of sodium-induced soil dispersal can also increase the sodicity in the root zone.

If water containing salts is not allowed to drain below the root zone, the salt concentration of soil water will increase as plants take up water by transpiration and as evaporation occurs. Sodium-induced dispersal also makes it difficult for plant roots to get the water and nutrients they need to survive due to osmotic pressure and gradient concentration. This occurs because sodic soils are likely to become and remain water-logged, resulting in anaerobic conditions. If anaerobic conditions persist for more than a few days, roots fail to obtain sufficient oxygen, which reduces plant growth and can cause plant injury and eventually death. Similarly, Walker and Bernal (2004), and Toth *et al*. (2008) found that the irrigation with saline water affected most of soil characteristics.

Nutrient seed priming effects on seed nutrient levels

Nutrient seed priming of faba bean seeds with Fe and Zn significantly increased the concentrations of these elements within the seeds (Table 4). Corresponding to increases ranged from 22 to 1080 % of the natural seed reserves (Table 4). A highly significant difference in nutrient concentrations was detected between unprimed and primed seeds. Similarly, the forms of element significantly affect concentration of element in faba bean seeds before and after priming (Table 4). Seeds with Fe or Zn priming had significantly higher concentrations of these elements compared to unprimed (Table 3). Seed contents of Fe or Zn were highly affected by priming time (Table 3).Seeds Fe or Zn concentrations were considerably higher at 24 hrs priming time compared to the concentrations at 12 hrs priming time (Table 4). In general, the seed contents of Fe and Zn were significantly affected by priming time, element form, element concentrations, and their interactions (Table 4). Based on calculations of nutrient concentrations (Table 4), similar increases have been reported in earlier studies after Zn priming of barley (Ajouri *et al.,* 2004) and maize (Harris *et al.,* 2007).

Total chlorophyll contents

Effect of priming treatments on total chlorophyll contents in plant is shown in Figure (1). The priming treatment significantly affected total chlorophyll contents in leaves of faba bean plants compared to that of the control. It is very obvious that priming treatment, form of element, and element concentration were highly affected chlorophyll contents. Priming treatments significantly protected faba bean plants against the reduction in total chlorophyll content occurred at high salinity levels (Figure 1). Hence, priming treatments stimulated chlorophyll synthesis under salt stress. This could be due to that micronutrients were used as priming agents in association with other components of the system. Also, it is stated that priming in micronutrients protect plants against oxidative damage resulting from aerobic metabolism, photosynthesis and a range of pollutants and salt and drought stresses (Bashan *et al.,* 2004). These results coincided with the results of other researchers (Li *et al.,* 2006; Sharifi *et al.,* 2007; Mahdy and Fathi, 2012). Consistent findings reported the beneficial effects of priming in nutrient solutions in partially mitigating the adverse effects of salt stress on plants growth (Mozafar and Dertli 1992). The obtained results revealed a significant interaction effects between NaCl stress and priming solutions on the chlorophyll content.

Table 4

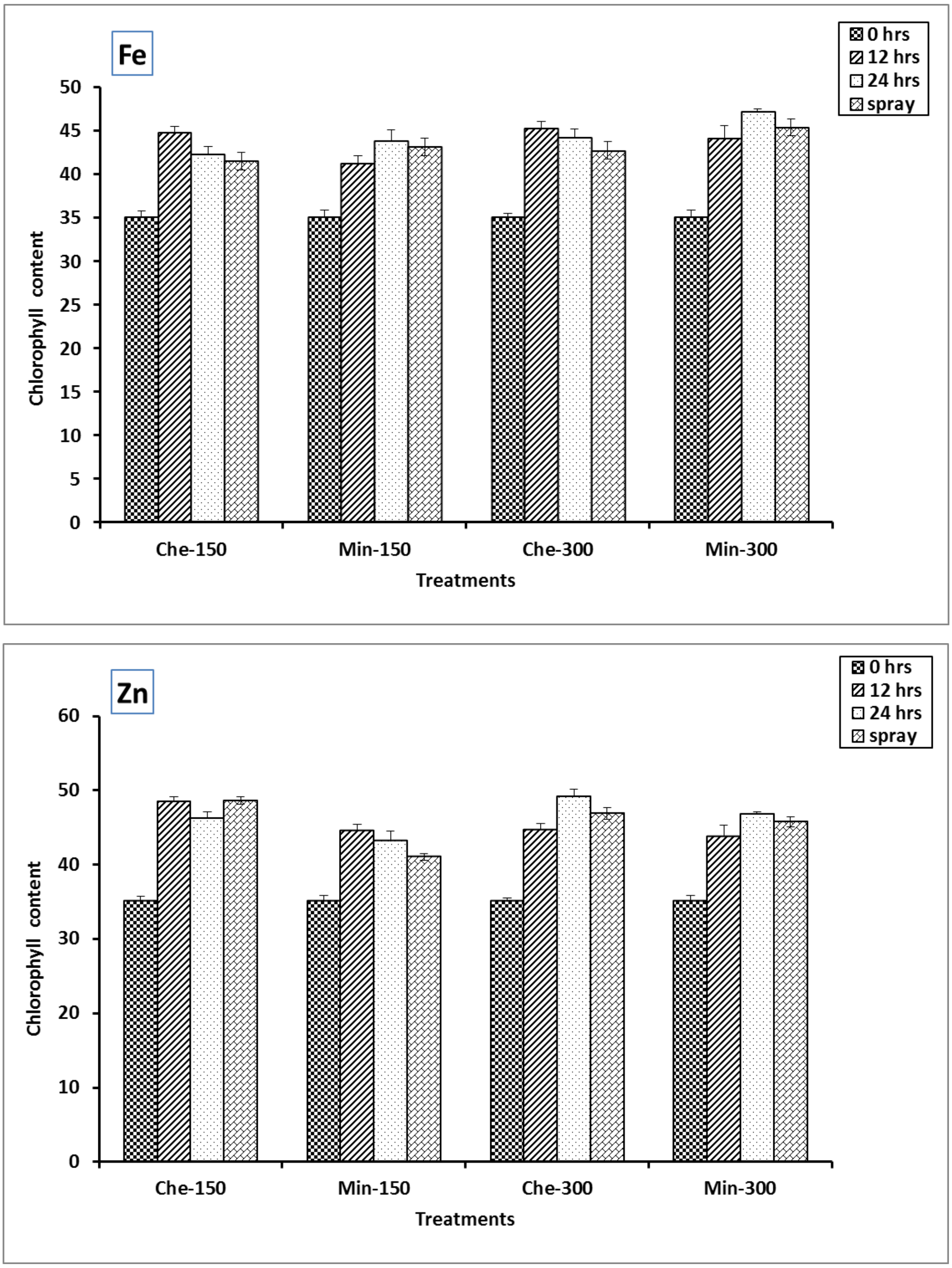

Figure (1): Effect of priming treatments on chlorophyll content of faba bean shoot under saline conditions; bars indicate standard error (*n* = 4).

F-test :priming time(T)** element form (F)* Concentration (C)***

T X F *** C X S *** C X T **** C X F *** T X F X C **

*, **, ***: significant at 0.05, 0.01 and 0.001, respectively

Nutrients content in faba bean

Tables (5-8) show nutrients contents in faba bean as affected by priming treatments. The Na, K, Fe, and Zn, have significantly affected by all priming treatments. With concentration of priming solution increase, the Na and K concentrations in plant tissues increased. Also, Fe and Zn concentrations were significantly increased.

Priming treatments had significant effect on nutrient concentrations in faba bean plant as compared to salinity affected plants (Tables 5-8). The concentrations of Na and K in primed plants were higher than those of salinity treated un-primed plants (Tables 5 and 6). On the other hand, priming for 24 hrs in Fe or Zn solutions significantly increased element concentration higher than that of 12 hrs priming time. Data showed that there is a significant difference in element concentrations between priming and spray of element (Tables 5 &6). However, the priming agents did protect plants against the increase of Na in faba bean plants compared to the concentrations of this element in control plants.

Tables (5&6) showed that salt stress caused significant decrease in the micronutrients content of faba bean plants in comparison to control. It is found also that priming time, element form, element concentration and their interaction significantly affected micronutrients content of faba bean plants in comparison to unprimed plants. Also, foliar application of micronutrients significantly increased Na and K concentrations in plants in comparison to no spray-treated plants (Tables 4&5). It could be concluded that, the priming treatments significantly inhibited the negative effects of salinity levels on micro or macro-nutrients concentrations in plants. wherever, mineral form (150 ppm) treatment was the best followed by (mineral-300 ppm), then (chelated-300 ppm).

These results may be due to some nutritional disturbances that are expected under saline conditions, resulting in high ratios of Na/K. In the presence of excess NaCl in the growth medium, Na and Cl are accumulated in plant organs, and these ions can affect other mineral elements uptake through competition of membranes which causes nutrient deficiencies in plants (Bohra and Doffling 1993). It is clear, therefore, that salt stress had caused ion imbalance in faba bean plant.

Similarly, priming treatments had significant effects on Fe and Zn concentrations in faba bean plant (Tables 7 &8). The concentrations of Fe and Zn in primed plans were higher than those of salinity treated un-primed plants (Tables 7 and 8). On the other hand, priming for 24 hrs in Fe or Zn solutions significantly increased element content higher than that of 12 hrs priming time. Data showed that there is a significant difference in element concentrations between priming and spray of element (Tables 7 & 8). Also, foliar application of micronutrients significantly increased micronutrients concentrations in plants in comparison to no spray-treated plants (Tables 7& 8). In general, the plant shoot contents of Fe and Zn were significantly affected by priming time, element form, element concentrations, and their interactions (Tables 7 & 8).

Grain yield

Effects of priming treatments on yield of faba bean are shown in Figures (2) and (3). Final grain yield was calculated as total fresh grain yield just after harvest. There was a significant increase in grain yields per pot with Fe seed priming relative to unprimed seeds . The highest increase for grain yield was obtained in mineral form of Fe primed seeds at 150 ppm priming solution for 12 hours followed by spray treatment of micronutrient at 150 ppm (Figure 2). The overyielding percentages were 227 and 217% for Fe primed seeds at 150 ppm for 12 hours and spray treatment of Fe at the same concentration (150 ppm), respectively. Also, overyielding percentages were ranged from 30 to 170 % for all other priming treatment or spray. On the other hand, there was a significant increase in grain yields per pot with Zn seed priming relative to unprimed seeds . The highest increase for grain yield was obtained in chelated form of Zn primed seeds at 150 ppm priming solution for 24 hours followed by 150 ppm priming solution for 12 hours, then spray treatment of Zn at 150 ppm (Figure 2). The Overyielding percentages were 397 and 254% for Zn primed seeds at 150 ppm chelated Zn for 24 and 12 hours, respectively. Also, Overyielding percentages were ranged from 56 to 259 % for all other priming treatment or spray. Grain yield was significantly affected by element form, priming time, element concentration, and their interaction (Figure 2).

Table (5): Effects of priming time and spray of different Fe concentrations on sodium and potassium concentrations in plant shoot after harvest of faba bean (± SD).

Element	**Priming**					
	Concentrations,%					
	Priming time, hrs	**Unprimed**	**Chelated**		**Mineral**	
			150	**300**	**150**	**300**
Na	**12**	0.40 ± 0.04	0.70± 0.01	0.78± 0.05	0.66± 0.06	0.65± 0.05
	24		0.71± 0.02	0.88± 0.06	0.86± 0.04	0.92± 0.11
	LSD $_{0.05}$		**0.05**	**0.08**	**0.10**	**0.12**
K	**12**	0.63± 0.05	0.60± 0.03	0.98± 0.02	0.79± 0.07	0.96± 0.12
	24		0.98± 0.02	0.88± 0.10	0.70± 0.08	1.17± 0.13
	LSD $_{0.05}$		**0.16**	**0.07**	**0.06**	**0.08**
Spray						
		No spray	**Chelated**		**Mineral**	
			150	**300**	**150**	**300**
Na		0.40 ± 0.04	0.52± 0.05	0.85± 0.07	0.72± 0.05	0.86±0.04
LSD $_{0.05}$			**0.12**		**0.09**	
K		0.63± 0.05	0.78± 0.07	0.73± 0.06	1.17± 0.04	0.90± 0.03
LSD $_{0.05}$			**0.04**		**0.08**	
F-test						
Priming time(T)		***				
Element form(F)		**				
Concentration(C)		***				
T X F		*				
T X C		*				
F X C		**				
T X F X C		***				

*, **, ***: Significant at 0.05, 0.01, and 0.001 probability levels, respectively.

Table (6): Effects of priming time and spray of different Zn concentrations on sodium and potassium concentrations in plant shoot after harvest of faba bean (± SD).

Element	**Priming**					
	Concentrations,%					
	Priming time, hrs	**Unprimed**	**Chelated**		**Mineral**	
			150	**300**	**150**	**300**
Na	**12**	0.40 ± 0.04	0.79± 0.03	0.72± 0.04	0.88± 0.08	0.87± 0.08
	24		0.88± 0.05	0.67± 0.05	0.81± 0.07	0.97± 0.10
	LSD $_{0.05}$		**0.04**	**0.05**	**0.03**	**0.07**
K	**12**	0.63± 0.05	1.17± 0.11	1.06± 0.12	0.64± 0.04	0.80± 0.10
	24		0.94± 0.12	0.36± 0.01	0.78± 0.05	0.75± 0.07
	LSD $_{0.05}$		**0.06**	**0.14**	**0.10**	**0.03**
Spray						
		No spray	**Chelated**		**Mineral**	
			150	**300**	**150**	**300**
Na		0.40 ± 0.04	0.76± 0.08	0.64± 0.07	0.87± 0.09	0.74±0.04
LSD $_{0.05}$			**0.07**		**0.05**	
K		0.63± 0.05	1.13± 0.11	0.87± 0.10	1.10± 0.13	0.86± 0.05
LSD $_{0.05}$			**0.05**		**0.10**	
F-test						
Priming time(T)		*******				
Element form(F)		******				
Concentration(C)		*******				
T X F		*****				
T X C		*****				
F X C		******				
T X F X C		*******				

*, **, ***: Significant at 0.05, 0.01, and 0.001 probability levels, respectively.

Table (7): Effects of priming time and spray of different Fe concentrations on Fe concentrations in plant shoot after harvest of faba bean (± SD).

Element	**Priming**					
	Concentrations,mg.kg^{-1}					
	Priming time, hrs	**Unprimed**	**Chelated**		**Mineral**	
			150	**300**	**150**	**300**
Fe	**12**	**148.00±6.12**	219.50±12.11	297.50±10.09	225.50±17.12	278.00±23.12
	24		265.00±12.23	313.00±16.21	381.00±9.43	375.00±23.34
	LSD $_{0.05}$		**8.12**	**12.23**	**22.32**	**18.94**
Spray						
		No spray	**Chelated**		**Mineral**	
			150	**300**	**150**	**300**
Fe		**148.00±6.12**	168.00±8.22	207.50±11.98	254.00±18.53	268.00±16.43
LSD $_{0.05}$			**13.12**		**8.76**	
F-test						
Priming time(T)		*****				
Element form(F)		******				
Concentration(C)		*******				
T X F		*******				
T X C		******				
F X C		*******				
T X F X C		*****				

*, **, ***: Significant at 0.05, 0.01, and 0.001 probability levels, respectively.

Table (8): Effects of priming time and spray of different Zn concentrations on Zn concentrations in plant shoot after harvest of faba bean (± SD).

Element	**Priming**					
	Concentrations,mg.kg^{-1}					
	Priming time, hrs	**Unprimed**	**Chelated**		**Mineral**	
			150	**300**	**150**	**300**
Zn	**12**	**78.00±3.32**	105.00±13.22	200.00±28.88	24.50±8.22	134.00±8.22
	24		91.00±11.12	89.00±14.25	100.00±8.22	95.00±8.22
	LSD $_{0.05}$		**9.12**	**18.32**	**25.18**	**14.36**
Spray						
		No spray	**Chelated**		**Mineral**	
			150	**300**	**150**	**300**
Zn		**78.00±3.32**	240.00±34.25	180.00±20.11	160.00±16.52	230.00±26.38
LSD $_{0.05}$			**21.02**		**28.32**	
F-test						
Priming time(T)		*				
Element form(F)		**				
Concentration(C)		***				
T X F		**				
T X C		*				
F X C		**				
T X F X C		**				

*, **, ***: Significant at 0.05, 0.01, and 0.001 probability levels, respectively.

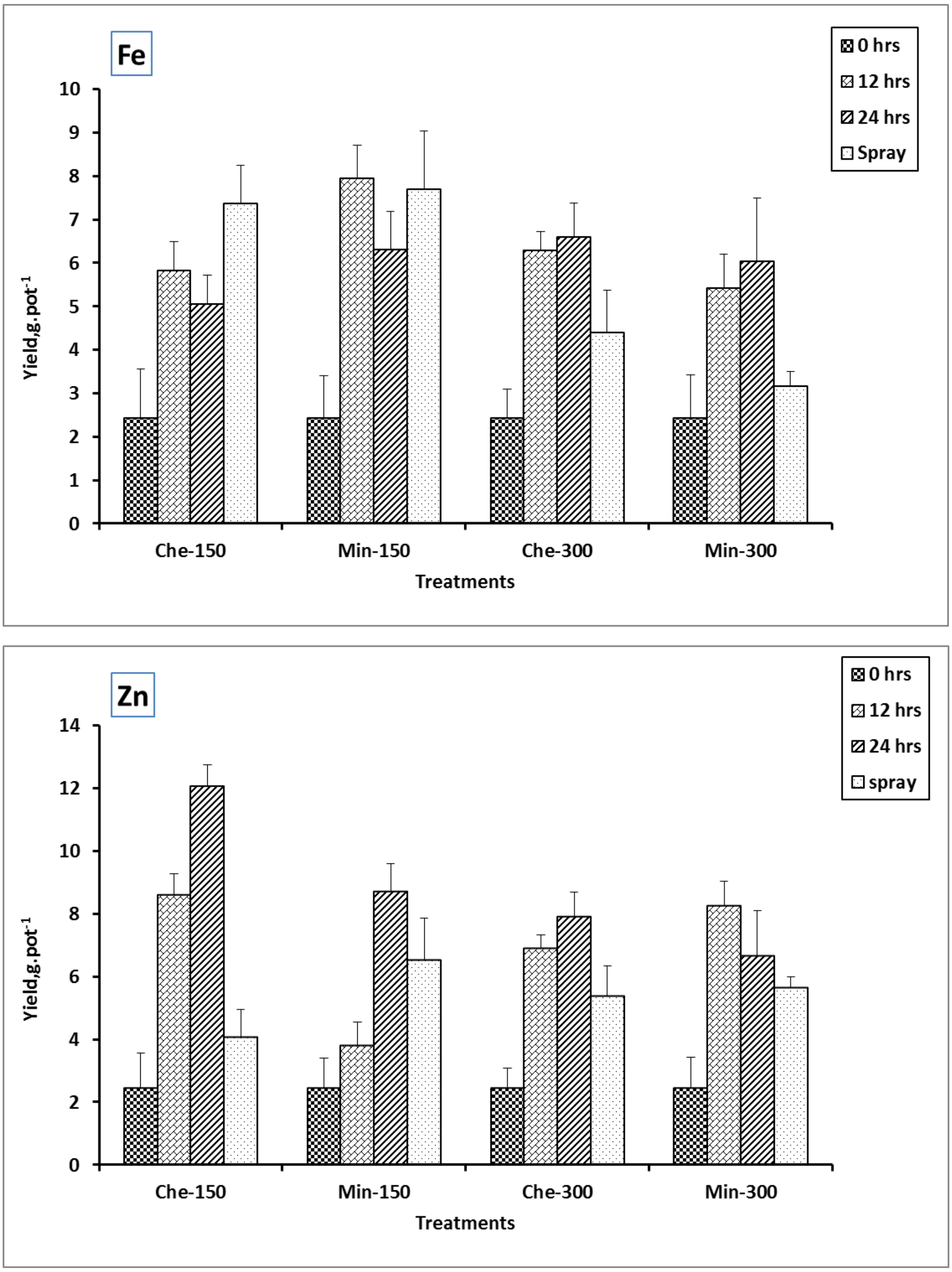

Figure (2): Effect of priming treatments on grain yield of faba bean under saline conditions; bars indicate standard error (*n* = 4).

F-test :priming time(T)* element form (F)* Concentration (C)**
T X F ** C X S *** C X T ** C X F *** T X F X C **
*, **, ***: significant at 0.05, 0.01 and 0.001, respectively

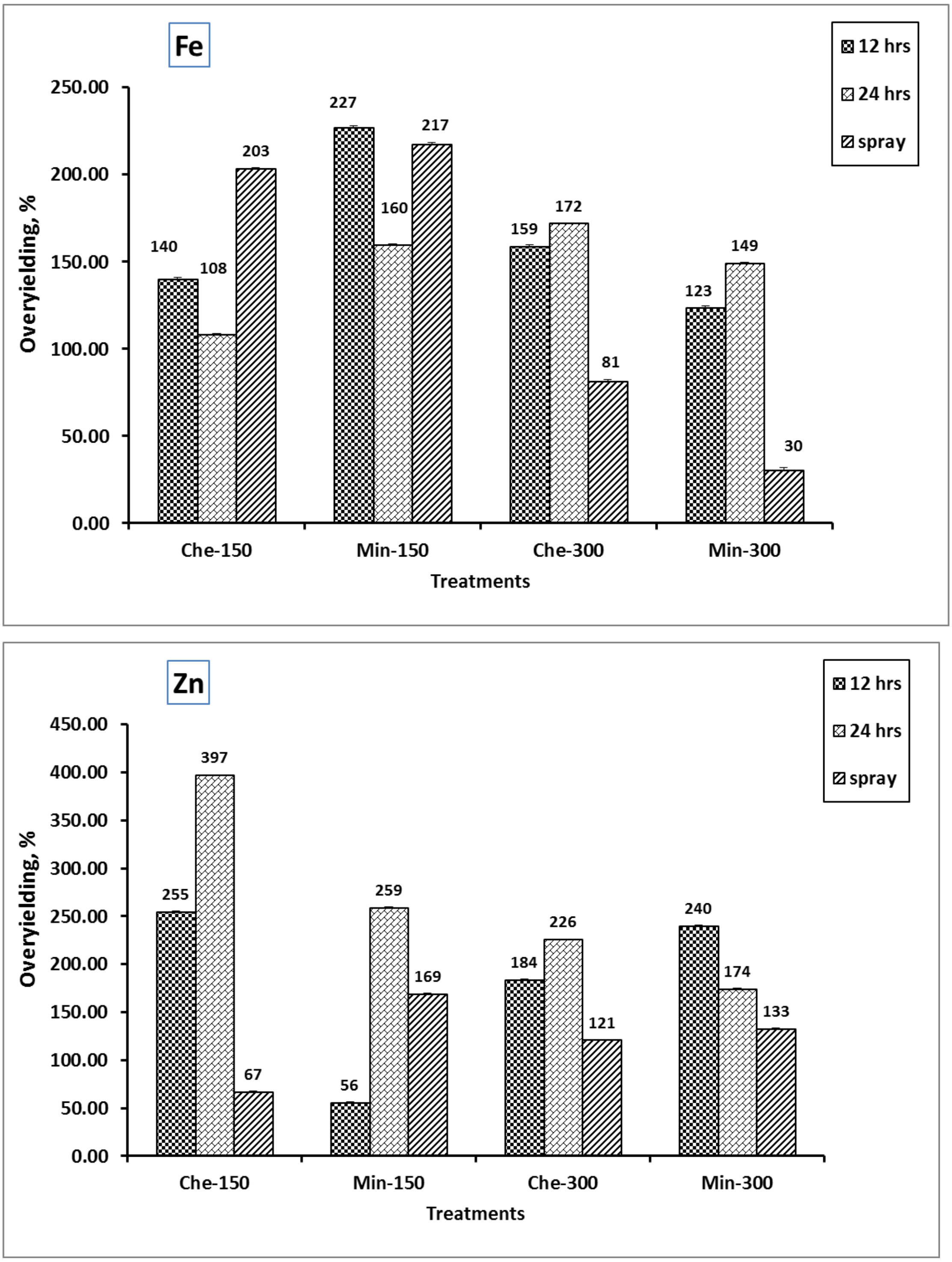

Figure (3): Effect of priming treatments on overyielding percentage (the relative increase in yield) of faba bean under saline conditions; bars indicate standard error (*n*= 4).

F-test :priming time(T)** element form (F)* Concentration (C)**
T X F * C X S *** C X T ** C X F * T X F X C **
*, **, ***: significant at 0.05, 0.01 and 0.001, respectively

In general, seed priming treatments with iron or zinc showed a beneficial effect for grain yield .The beneficial effect of seed priming on grain yield is consistent with farmers' perceptions of its effects on some other medicinal plants, such as cumin and marigold (*Calendula officinalis* L) (Tabrizian and Osareh 2007). Seed priming with Fe and Zn in this study resulted in a total overyielding of 397%. In on-station trials of priming, Harris *et al.* (1999) reported that soaking seeds in priming solution for 12 h decreased the time of emergence by about 50% . Concentrations exceeding 1.5% Fe and 1% B in the priming solutions affected germination negatively. Ajouri *et al.* (2004), similarly investigated studied the effect of seed priming on germination, and showed that priming concentrations exceeded 0.04 M boric acid significantly reduced the germination rate in barley. A reduced germination percentage was also registered for treatment of sweet pepper (*Capsicum annum* L), whenever higher dosages of micronutrients were used for seed priming (Diniz *et al.* 2009) .The importance of seedling vigor on the rapid stand establishment and early growth of medicinal plants to compete for water, light, and nutrients has been stressed by Tabrizian and Osareh (2007). Radpoor and Rimaz (2007), in their study on priming fennel seeds with iron, molybdenum, and boron solutions, came to the same conclusion of the current study that revealed that priming with Fe and Zn resulted in an increase in grain yield. Furthermore, (Karthikeyan *et al.* 2007) verified that the application of very high doses of micronutrients to bean seeds, due to their toxic effects, caused an increase of abnormal and dead seedlings. Significant differences have been observed in the dry matter accumulation of red periwinkle (*Catharanthus roseus* L.) between primed and unprimed seeds .The roles of Fe, Cu, Mn, Zn, Mo, and B on yield and yield components of cumin were studied by Mirshekari *et al.* (2010). They reported that coating seeds with microelements increased the shoot dry weight (SDW) and number of umbels per plant. An increased grain yield in dill is associated with a higher SDW under nutrient priming. The results of this study indicate that seeds enriched with micronutrients caused increase the growth and yield of faba bean. This results is in agreement with that reported by Arshad Ullah *et al.* (2002) on peela raya (*Brassica carianata* L.), Mirshekari *et al* .(2010) on cumin, and Johnson *et al.* (2005) on some cereals and legumes. However, higher doses of Fe and Zn in soil solutions may slow seedling establishment . Priming the seeds with micronutrients makes them able to rapidly imbibe water and revive metabolism and germination. This then results in a higher germination rate (Rowse, 1995), improved stand establishment, increased drought and pest tolerance, and ultimately higher yields (Harris *et al.,* 1999).

CONCLUSIONS

Seed treatment with micronutrients has the potential to meet crop micronutrient requirements and improve seedling emergence and stand establishment, yield, and grain micronutrient enrichment. Seed treatment, by seed priming or seed coating, seems pragmatic, inexpensive and an easy method of micronutrient delivery especially by small landholders in developing countries. Variation exists within crops and varieties/ genotypes/hybrids in their response to various treatments, which will help researchers to identify useful accessions for further work such as: developing techniques using a range of micronutrient sources at varying concentrations and durations, integrating inoculation and micronutrient seed invigoration, storage potential of nutria-primed seeds—prolonged storage of primed seeds may be critical for technology transfer and marketing of primed seeds.

Priming seeds of faba bean with dilute solutions of Fe and /or Zn solutions was effective in raising grain yields by amounts equivalent to those obtained using much larger amounts of soil-applied Zn. About fifty percentage of the increase was due to the effect of priming, and the other fifty percentage was due to the elemental effect of Zn or Fe. It can be concluded that seed priming is a cost-effective method of increasing yield and improving grain quality in these crops and is appropriate for resource poor farmers.

REFERENCES

Abd El-Wahab, A.M. and A. Mohamed (2008). Effect of some trace elements on growth, yield and chemical constituents of *Trachyspermum ammi* L. plants under Sinai conditions. Res J Agric Biol Sci 4: 717-724.

Ajouri, H., H. Asgedom and M. Becker (2004). Seed priming enhances germination and seedling growth of barley under conditions of P and Zn deficiency. Journal of Plant Nutrition and Soil Science 167: 630–636.

Arshad Ullah, M., M. Sarfraz, M. Sadiq, S.M. Mehdi and G. Hassan (2002). Effects of pre-sowing seed treatments with micronutrients on growth parameters of Raya. Asian J Plant Sci 1: 22-23.

Azooz, M.M. (2009). Salt stress mitigation by seed priming with salicylic acid in two faba bean genotypes differing in salt tolerance .Int Agric Biol 11(4):343-350.

Bashan,Y., G. Holguin and L.E. Bashan (2004). Azospirillum-plant relationships: physiological, molecular, agricultural and environmental advances. Can. J. Microbiol.50:521-577.

Bohra, J.S. and K. Doffling (1993). Potassium nutrition of rice varities under NaCl salinity. Plant Soil 152:299-303.

Bremner, J.M. and C.S. Mulvaney (1982). Nitrogen-Total. In: Page A.L., Miller R.H., Keeney D.R. (eds): Methods of Soil Analysis, Am. Soc. of Agron., Madison, Wisconsin, USA.

Cakmak, I. (2000). Role of zinc in protecting plant cells from reactive oxygen species. New Phytol. 146:185–205**.**

Chiu, K.Y., C.L. Chen and J.M. Sung (2002). Effect of priming temperature on storability of primed sh-2 sweet corn seed. Crop Sci. 42:1996-2003.

Day, P.R. (1965). Particle fraction and particle size analysis. In: Black A.C., Evans D.D., Ensminger L.E., White J.L., Clark F.E.(Eds): Methods of Soil Analysis, Part I. Am. Soc. of Agron., Madison, Wisconsin, USA.

Diniz, K.A., P.A. Silva, J.A. Oliveira and JRE Evangelista (2009). Sweet pepper seed responses to inoculation with microorganisms and coating with micronutrients, amino acids and plant growth regulators. Sci Agric 66: 293-297.

FAO (1976). Water quality for agriculture No.29 .FAO,Rome.

Graham, R.D., R.M. Welch (1996). Breeding for staple food crops with high micronutrient density. Working Papers on Agricultural Strategies for Micronutrients, No. 3. International Food Policy Research Institute, Washington, D.C..

Harris, D., A. Joshi, P.A. Khan, P. Gothkar and P.S. Sodhi (1999). On-farm seed priming in semi-arid agriculture: development and evaluation in maize rice and chickpea in India using participatory methods. Experimental Agriculture 35: 15–29.

Harris, D., A. Rashid, P.A. Hollington, L. Jasi and C. Riches (2002). *Proceedings of a maize symposium held, december 3-5, 2001, Kathmandu, Nepal. Kathmandu: NARC and CIMMYT*. pp. 180–185.

Harris, D., A. Rashid, G. Miraj, M. Arif and H. Shah (2007). 'On-farm' seed priming with zinc sulphate solution – a cost-effective way to increase the maize yields of resource-poor farmers. Field Crops Research 102: 119–127.

Iqbal, M. and M. Ashraf (2006). Wheat seed priming in relation to salt tolerance: growth, yield and levels of free salicylic acid and polyamines. Ann. Bot. fennici 43:250-259.

Issac, R.A. and J.D. Kerber (1971). Atomic absorption and flame photometry: techniques and uses in soil, plant and water analysis. In: Instrumental Methods for Analysis of Soils and Plant Tissue, (Ed. LM Walsh), Soil Science Society of America, Madison, Wisconsin, USA, pp. 224-232.

Johnson, S.E., J.G. Lauren, R.M. Welch and J.M. Duxbury (2005). A comparison of the effects of micronutrient seed priming and soil fertilization on the mineral nutrition of chickpea (*Cicer arietinum*), lentil (*Lens culinaris*), rice (*Oryza sativa*) and wheat (*Triticum aestivum*) in Nepal. Exp Agric 41: 427-448.

Jones, J. B. (2001). Laboratory Guide of Conducting Soil Tests and Plant Analysis. CRC Press. New York, Washington D.C., USA.

Karthikeyan, B., C.A. Jaleel, R. Gopi and M. Deiveekasundaran (2007). Alterations in seedling vigor and antioxidant enzyme activities in *Catharanthus roseus* under seed priming with native diazotrophs. Department of Microbiology, Faculty of Agriculture, Annamalai University, Tamilnadu, India.

Knudsen, D., G.A. Peterson and P.F. Pratt (1982). Lithium ,sodium and potassium. *In* :Page, A.L.,Miller R.H., Keeney, D.R.(eds): Methods of soil analysis, Am. Soc. Agron., Madison, Wisconsin, USA. p225--245

Ozturk, L. M.A. Yazici, C. Yuce, A. Torun, C. Cecik, A. Bagcki, H. Ozkan, H J. Braun, Z. Sayens and I. Cakmak (2006). *Plant Physiology*. 144-152**.**

Li, X., P. An, S. Inanaga, A.G. Eneji and K. Tanabe (2006). Salinity and defoliation effects on soybean growth. J. Plant Nutr.29:1499-1508.

Mahdy, A.M. and N.O. Fathi (2012). Interactive Effects between Biofertilizer and Antioxidant on Salinity Mitigation and Nutrition and Yield of Okra Plants (Abelmoschus esculentus L.). J. Soil Sci. and Agric. Eng., Mansoura Univ.,43(2):189-205.

Mirshekari, B., H. Asadi Rahmani, Mirmozaff ari Roudsari A (2010). Effect of seed inoculation with *Azospirillum* strains and coating with microelements on seed yield and essence of cumin (*Cuminum cyminum* L.). Iran J Medic Aromatic Plant 25: 470- 481.

Mohammadi, G.R. (2009). The influence of NaCl priming on seed germination and seedling growth of canola (Brassica napus L.) under salinity conditions. American-Eurasian J Agric & Environ Sci, 5(5): 696-700.

Mozafar, A. and J.T. Dertli (1992). Uptake and transport of thianin (Vitamin B1) by barley and soybean. J. Plant Physiol. 436: 442.

Nelson, D.W. and L.E. Sommers (1982). Total Carbon, Organic Carbon and Organic Matter. In : Page A.L., R.H. Miller, D.R. Keeney (Eds.). Methods of Soil Analysis., Am. Soc. of Agron., Madison, Wisconsin, USA.

Nelson, R.E. (1982). Carbonate and Gypsum. In : Page A.L., R.H. Miller, D.R. Keeney.(Eds.). Methods of Soil Analysis, Am. Soc. of Agron, Madison, Wisconsin, USA, pp: 181-197.

Olsen, S.R. and L.E. Sommers (1982). Phosphorus., *In*: Page, A.L., R.H. Miller, D.R. Keeney eds), Methods of soil analysis, Am. Soc. Agron., Madison, Wisconsin, USA. pp:403—427

Radpoor, R. and A. Rimaz (2007). Rapid germination and higher vigor in seedlings of fennel (*Foeniculum vulgare*) due to seed priming with microelements. Iran J Crop Sci 7: 237-248.

Rhoades, J.D. (1982). Cation Exchange Capacity. In: Page AL, R.H. Miller, D.R. Keeney (Eds.).Methods of Soil Analysis., Am. Soc. of Agron., Madison, Wisconsin, USA.

Richards, L.A. (1954). Diagnosis and Improvement of Saline and Alkaline Soils. USDA Handbook 60.US Government Printing Office, Washington D. C.

Rowse, H.R. (1995). Drum priming: A non-osmotic method of priming seeds. Seed Sci Technol 24: 281- 294.

Sadeghi, M., A. Nemati and B. Esmaielpour (2010). Effect of seed priming on germination and seedling growth of two medicinal plants under salinity. Emir J Food Agric 22(2): 130-139.

SAS Institute (1994). SAS/STAT User's Guide. Version 6.4th Ed. SAS Inst., Cary, N.C.USA.

Sharifi, M., M. Ghorbanli and H. Ebrahimzadeh (2007). Improved growth of salinity-stressed soybean after inoculation with salt pre-treated mycorrhizal fungi. J. Plant Physiol. 164:1144-1151.

SillanpaÈaÈ, M. (1990). Micronutrients assessment at the country level: An international study. FAO Soils Bulletin 63. Food and Agriculture Organization of the United Nations, Rome.

Tabrizian, F. and A.M. Osareh (2007). Improved seed emergence and yield related traits of marigold (*Calendula offi cinalis* L.) by on-farm seed micronutrient treatment trials. Iranian J Crop Sci 9: 124-141.

Tavili, A., S. Zare, S.A. Moosavi and A. Enayati (2010). Effects of priming techniques on seed germination and early growth characteristics of Bromus timentellus L. and Bromus inermis L.Not Sci Biol 2(1):104-108.

Toth, G., L. Montanarella and E. Rusco (2008). Updated Map of Salt Affected Soils in the European Union. *In* Toth, G., Montanarella, L. and Rusco, E. (eds.) Threats to Soil Quality in Europe. Office for Official Publications of the European Communities, Luxem- bourg. pp. 61-74.

U.S. Salinity Laboratory Staff (1954). Diagnosis and Im- provement of Saline and Alkali Soils. USDA Handbook No. 60. U.S. Government Printing Office, Washington D.C.

Walker, D. J. and M. P. Bernal (2004). Plant mineral nutrition and growth in a saline Mediterranean soil amended with organic wastes. *Commun. Soil Sci. Plant Anal.*35: 2495-2514.

Welch, R.M. (1993). Zinc concentrations and forms in plants for humans and animals. In: Robson, A.D. (Ed.), Zinc in Soil and Plants. Kluwer Academic Publishers, Dordrecht, the Netherlands,pp. 183±195.

Welch, R.M. and R.D. Graham (2004). Breeding for micronutrients in staple food crops from a human nutrition perspective. J. Exp Bot 55:353–364.

تأثير نقع البذور فى محلول العناصر الصغرى على مدى تحمل الفول البلدى للملوحة

نيفين عمر فتحى

معمل بحوث الأراضى الملحية والقلوية- مركز الحوث الزراعية- وزارة الزراعة- الإسكندرية

الملخص العربى

أجريت تجربة أصص زراعية فى معمل بحوث الأراضى الملحية والقلوية بالإسكندرية لدراسة أثر تقنية نقع البذور فى المحاليل المغذية كوسيلة فعالة وبسيطة لزيادة محتواها من عناصر الحديد و الزنك وكذلك لدراسة تحسين إنتاجية الفول البلدى تحت الظروف الملحية وأيضاً تقييم أثر إحدى طرق إضافة العناصر الصغرى مقارنة بالتسميد الورقى على نمو النبات والمحصول. أشارت نتائج الدراسة أن زيادة ملوحة ماء الرى أدت إلى زيادة الصوديوم فى الأراضى وإزدادت قيم نسبة الصوديوم المدمص SAR وبالتالى انخفض المحصول فى حالة البذور الغير منقوعة. نقع البذور فى محاليل الحديد والزنك أدت إلى زيادة محتوى البذور من الحديد والزنك حيث ازداد المحتوى بنسبة 22-1080 % مقارنة بالكنترول . إزداد محتوى الأوراق من الكلوروفيل فى حالة النقع مقارنة بمعاملة الكنترول الغير منقوعة. أيضاً ازداد محتوى النبات من الصوديوم والبوتاسيوم فى النباتات المنقوعة المروية بمياة مالحة مقارنة بالغير منقوعة. أشارت النتائج ايضاً الى زيادة محصول الحبوب فى المعاملات المنقوعة فى محاليل الحديد والزنك بالمقارنة بالغير منقوعة. وكانت أعلى قيمة لمحصول الحبوب عند المعاملة نقع لبذور فى محلول 150 جزء فى المليون حديد لمدة 12 ساعة يليها معاملة الإضافة الورقية عند تركيز 150 جزء فى المليون . وكان مقدار الزيادة النسبية فى المحصول تتراوح من 217-227 % عند أحسن المعاملات وهى 150 جزء فى المليون حديد لمدة 12 ساعة يليها معاملة الإضافة الورقية عند تركيز 150 جزء فى المليون. مقارنة بالنباتات الغير معاملة أوضحت نتائج الدراسة الحالية أن تقنية نقع البذور هى طريقة رخيصة الثمن وفعالة فى زيادة المحصول ومناسبة للفلاح البسيط لمقاومة الملوحة وتحقيق محصول جيد.

الكلمات الكشافة: النقع – الملوحة – الفول – العناصر الصغرى