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MINERAL CONTENT IN THE LEAVES OF SWEET PEPPER PLANT IN RESPONSE TO CERTAIN BIO-STIMULANTS UNDER SALT STRESS CONDITIONS

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ABSTRACT

N, P, K+ and Mg_2+ concentration as well as K+/Na+ ratio in sweet pepper root, shoot, and fruits were significantly increased at the low salinity level NaCl+$CaCl_2$ (2000 mg/L) followed by $CaCl_2$. In addition, increasing salinity levels led to a decrease in this respect. Meanwhile, $CaCl_2$ or NaCl+$CaCl_2$ increased significantly the Ca_2+ concentration with increasing salinity levels from 2000 to 4000 mg/L as compared to control. On the other hand, calcium concentration was decreased significantly with increasing NaCl salinity level to 4000 mg/L.

With increasing salinity levels, both Na+ and Cl- concentration were increased as compared with control. The highest value of Na+ was obtained by NaCl followed by NaCl+$CaCl_2$. In addition, pre-soaking seeds in SA, AsA, α-tocopherol and yeast extract at both levels significantly increased N, P, K+, Ca_2+ and Mg_2+ concentrations as well as K+/Na+ ratio whereas decreased Na+ and Cl- under non-saline and saline conditions. In addition, AsA at 50 mg/L and SA at 75 mg/L were more effective as compared with the other treatments.

INTRODUCTION

Sweet pepper (*Capsicum annuum* L.) is among the most important crops for the world human nutrition and its fruits have a good nutritional value in respect to antioxidant compounds, such as vitamin C and carotenoids (Navarro *et al*., 2006).

It is a moderately-sensitive to salt stress (Lycoskoufis *et al.,* 2005). It is cultivated under open field and greenhouses conditions. In Egypt,the cultivated area is around 71428.57 feddan in 2008, yielded 475000 tones (FAO, 2008)*[1]. In addition, productions throughout the world are around over 24 million tons every year (Casado-Vela *et al*., 2007). Soil salinity is one of the major environmental stresses affecting over 20% of the world's irrigated area (Etehadnia, 2009) and 2.1% of the dry-land agriculture existing on the globe (Khosravinejad *et al.*, 2009) and extent throughout the world is increasing regularly (Schwabe *et al.,* 2006). It has now become a very serious problem for crop production (Munns and Tester, 2008), particularly in arid and semi-arid regions. However, the intensity of salinity stress varies from place to place. Irrigated land produces one-third of the world's food

*** FAO: Food and Agriculture Organization of the united nation, Statistical agricultural database sector.**
www.http:// faostat.fao.org/site/567/

approximately (Munns, 2002) so its salinization, often due to poor irrigation practices, is particularly critical. Dry land salinity is also an important, and increasing, problem in some areas of the world (Tester and Davenport, 2003).

Salinity is a common problem for agricultural productivity as a condition where the salts in solution within the crop root zone accumulate in concentration which decrease crop yield . the plant growth is ultimately reduced by salinity stress but plant species differ in their salinity tolerance (Jamil et al., 2005). It is well known that salinity retards plant growth through its influence on the osmotic adjustment , reducing nutrient uptake (Greenway and Munns, 1980).

Therefore, the present investigation was carried out to clarify the influence of two types of salinity on the mineral uptake in the leaves of sweet pepper plant and the possibility of alleviating the harmful effects of salinity by application of certain bio-stimulants.

MATEREIALS AND METHODS

The experiment was carried out in the glasshouse of the Agricultural Botany Dept., Fac. of Agriculture, Mansoura Univ. during the growing season of 2008, to study the response of mineral contents in the leaves of sweet pepper to different sources of salinity i.e. NaCl, $CaCl_2$ and its combination (1:1 w/w); and how to minimize its harmful effects through pre-soaking seeds in vitamins (Ascorbic acid or α-tocopherol) or bio-regulator (Salicylic acid) or Yeast extract.

Plant materials

The seeds of sweet pepper (*Capsicum annuum* L. cv. Orlando), a hybrid 'California Wonder' used in this investigation were secured from the Gohara Co. Cairo, Egypt.

Chemicals:-

1. Vitamins, ascorbic acid Vit. C (AsA) and α-tocopherol Vit. E (α-toco.) were supplied by Sigma Chemicals Co., USA and used at the concentration of 50 or 100 mg/L each.
2. Bio-regulator, salicylic acid (SA) (2-hydroxybenzoic acid) was obtained from Sigma Chemicals, Co., USA. and initially dissolved in 100 µL dimethyl sulfoxide and used at the concentrations of 75 and 150 mg/L,
3. Yeast extract, active dry yeast (*Saccharomyces cervisiae*) was applied at the concentration of 1000 or 2000 mg/L.
4. Salts:

Sodium Chloride (NaCl) from EL-Gomhoria Co., Egypt and was used at the concentrations of 2000 and 4000 mg/L.

Calcium Chloride ($CaCl_2$) from EL-Gomhoria Co., Egypt and was used at the concentrations of 2000 and 4000 mg/L.

Their combination, NaCl: $CaCl_2$ 1:1 (w/w) was used at the concentrations of 2000 and 4000 mg/L.

Table (1): The Molarity (Mol), Electrical Conductivity (E.C.) and pH values for different nutrient solutions.

Nutrient solution (N.S.) mg/L	N.S.	N.S.+ NaCl		N.S.+ $CaCl_2$		N.S.+ {NaCl+$CaCl_2$} (1:1) w/w			
		2000 NaCl	4000 NaCl	2000 $CaCl_2$	4000 $CaCl_2$	2000(NaCl+$CaCl_2$)		4000 (NaCl+$CaCl_2$)	
						1000 NaCl	1000 $CaCl_2$	2000 NaCl	2000 $CaCl_2$
Mol (M)	0 (Control)	3.4×10^{-2}	6.9×10^{-2}	2.0×10^{-2}	3.6×10^{-2}	1.7×10^{-2}	0.9×10^{-2}	3.4×10^{-2}	2.0×10^{-2}
Ec dSm^{-1}	2.00	5.42	8.42	4.59	7.60	5.08		8.08	
pH	5.50	5.77	5.80	5.19	5.30	5.45		5.34	

Table (2):Weights (g) of pure substances to be dissolved in 1000 liters of water to give the theoretically ideal concentrations (Cooper, 1979).

Substance	Formula	Weight
Potassium dihydrogen Phosphate	KH_2PO_4	263
Potassium Nitrate	KNO_3	583
Calcium Nitrate	$Ca(NO_3)_2$. 4H2O	1003
Magnesium Sulphate	$MgSO_4$. $7H_2O$	513
EDTA Iron	$CH_2.N(CH_2.COO)_2]_2$ Fe Na	79.0
Manganous Sulphate	$MnSO_4.H_2O$	6.10
Boric Acid	H_3BO_3	1.70
Copper Sulphate	$CuSO_4.5H_2O$	0.39
Ammonium Molybdate	$(NH_4)_6Mo_7O_{24}.4H_2O$	0.37
Zinc Sulphate	$ZnSO_4.7H_2O$	0.44

After soaking, the sterilized seeds (25 seeds/dish) were placed in glass Petri dishes (11 cm) with a double layer of Whatman No. 1 filter paper. The dishes were left in an incubator in the dark for seed germination at 25 ± 2^0C and 90% relative humidity, and then dishes were covered with aluminum foils for darkness. In order to avoid water losses, 5 ml of the nutrient solution were added to Petri dishes, every 5 days. Thiram was added to the solution at a concentration of 2% (w/v) to control the fungi infection.

The following experiment was carried out in the glasshouse of the Agric. Bot. Dept., Fac. of Agric., Mansoura Univ. during the spring–summer period of 2008 in a glasshouse under conditions of ambient light during winter, spring and early summer, with 10/14 light/dark period at 800–1100 µmol m^{-2s-1} PPFD, a day/night average temperature cycle of 26/15 ^{o}C and 65±5% relative humidity.

The target of the current experiment was to provide fundamental biological understanding and knowledge on sweet pepper plants growing in nutrient film technique (NFT), under different sources of salinity NaCl, $CaCl_2$ and their combinations 1:1 (w/w); and how to minimizing the harmful effects through pre-soaking seeds in vitamins (Ascorbic acid, α-tocopherol) or bio-regulator (Salicylic acid), or Yeast extract. The seeds of sweet pepper were sown on January, 13, 2008. A homogenous sweet pepper seeds were placed in 100 ml beakers and 20 ml of 1% sodium hypochlorite was added for sterilization. These were left in the solution for 5 min followed by washing under running tap water and ionized water twice. Then divided into 9 sets.

The first set was soaked (24hours) in distilled water as control and the remaining sets (8) were separately soaked for 24 h in aqueous solution of AsA or α–toco. at (50 or 100 mg/L) each or SA at (75 or 150 mg/L) or Yeast extract at (1000 or 2000 mg/L). Then germinated in seedling trays (209 eye) containing peat moss and perlite (1:1) as a rooting medium moistured by nutrient cooper solution (Cooper, 1979). Trays containing the seeds were placed in a glasshouse at 28 $\pm 2^0$C to germinate.

The experimental layout consisted of 7 automatic hydroponic units (groups) (experimental plots). Each hydroponic unit comprised of two plastic channels (4 m long * 10 cm in diameter) placed on one side of the holder (4m length * 1.5 m height). Each channel had 40 pores (6 cm diameter). Every unit was provided by an electric pump representing seven groups (Table, 1) nutrient solution (2.0 dSm^{-1} as a control), 2000 mg/L NaCl (5.42 dSm^{-1}), 4000 mg/L NaCl (8.42 dSm^{-1}), 2000 mg/L $CaCl_2$ (4.59 dSm^{-1}), 4000 mg/L $CaCl_2$ (7.60 dSm^{-1}), 2000 mg/L NaCl+$CaCl_2$ (1:1) (5.08 dSm^{-1}) and 4000 mg/L NaCl+$CaCl_2$ (1:1) (8.08 dSm^{-1}).

The seedlings were transplanted to the experimental installation on Feb, 26 , 2008 (after 45 days from pre-soaking) at the stage of four/five true leaves. Two uniform seedlings were transplanted to 6 cm perforated pots (reticulated) containing peat moss and perlite (1:1) as a rooting medium.

Every two channels was divided into 9 sets, the first set was soaked in distilled water (control), AsA, α–tocopherol at (50 or 100 mg/L) each, SA at (75 or 150 mg/L), and Yeast extract at (1000 or 2000 mg/L). Each set contained (8 replicates) 16 seedlings (two seedling/pot) spaced 10 cm representing a Nutrient Film Technique (NFT).

To keep the concentrations of sodium chloride and mineral nutrients constant, the solution was changed every 7 to 10 days and the volume of the solution was maintained by adding distilled water as required after measuring the electrical conductivity by digital conductivity meter Lutron CD-4301. A nutrient solution was pumped into the channels at a flow rate of one liter per minute from a reservoir containing 10 liters.

Sampling dates:

Two fresh leaf samples were taken at 30 and 45 days after transplanting (75 and 90 days from sowing) to study the following measurements.

For determination of Ca_2+, Mg_2+, N, P, K+, Na+, and Cl the dried samples (roots, shoots and fruits) were digested with HClO3/H2SO4 until the solution was clear, cooled, and brought to volume at 100 ml using deionized water (Peterburgski ,1968).

Total nitrogen concentration was determined according to "Nessler's" method which was described by A.O.A.C. (1975).

Phosphorus was determined by the methods described by Cooper (1977) using ammonium molybdate and ascorbic acid.

Potassium and Sodium concentrations were determined using a Flame photometer (Peterburgski, 1968).

Magnesium and Calcium were determined using versenate methods according to Richard (1954).

Chloride was extracted from dried plant materials using deionized water, then determined by volumetric titration with 0.001 N $AgNO_3$ using potassium dichromate as an indicator (Hanson and Munns, 1988).

Table (3): Composition of yeast extract (according to, Nagodawithana, 1991)

Constituents	**Value (%)**		
Protein	47		
Carbohydrates	33		
Minerals	8		
Nucleic acids	8		
Lipids	4		
Approximate composition of vitamins			
Vitamines	**Value (µg/g)**		
Cholin	4000		
Niacin	300-500		
Thiamine (B_1)	60-100		
Pantorhenate (B_5)	70		
Riboflavin (B_2)	35-50		
Pyridoxine HCL (B_6)	28		
Folic acid	5-13		
Biotin	1.3		
Vit. B_{12}	0.001		
Approximate composition of minerals			
Minerals	**Value (mg/g)**	**Minerals**	**Value (µg/g)**
K	21	Cu	8.00
P	13.50	Ni	3.00
S	3.90	Sn	3.00
Mg	1.65	Cr	2.20
Ca	0.75	Mo	0.40
Zn	0.17	Se	0.10
Na	0.12	Li	0.17
Si	0.03	Va	0.04
Fe	0.02	Mn	0.02

Statistical analysis:

The obtained data were subjected to statistical analysis of variance according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Data presented in Tables (4-7 and 11) revealed that low salinity level (2000 mg/L) significantly increased N, P, K+ and Mg_2+ concentrations as well as K+/Na+ ratio in the sweet pepper shoot, root and fruit. The highest value was obtained under NaCl+$CaCl_2$ followed by $CaCl_2$ and NaCl. In addition, these concentrations were decreased with increasing salinity levels especially under NaCl and NaCl+CaCl2 at 4000 mg/L as compared with the untreated plants. On the other hand, calcium concentration was increased significantly in sweet pepper shoot, root and fruit, under low salinity level of NaCl thereafter significantly decreased with increasing salinity level to 4000 mg/L (Table, 8).

Meanwhile, under $CaCl_2$ salinity or NaCl+$CaCl_2$ the Ca_2+ concentration was significantly increased with increasing salinity levels from

2000 to 4000 mg/L as compared to control. Moreover, both Na+ and Cl- concentrations (Tables 9-10) were increased with increasing salinity levels as compared with control plant. The highest value of Na+ was obtained under NaCl stress followed by NaCl+$CaCl_2$.

Concerning pre-soaking seeds in SA, AsA, α-tocopherol and yeast extract at both levels N, P, K+, Ca_2+ and Mg_2+ concentrations as well as K+/Na+ ratio were significantly increased under non-saline conditions but that of Na+ and Cl- were decreased. In addition, AsA at 50 mg/L or SA at 75 mg/L was more effective as compared with the other treatments.

As for the interactions between salinity and the applied bio-stimulants used (A*C), data in the same tables show that nitrogen, phosphorous, potassium, magnesium, and calcium concentrations as well as K+/Na+ ratio were significantly increased as compared to the untreated plants. While, sodium and chloride concentrations were decreased especially under high salinity level of all tested salinity types at 4000 mg/L.

Data in Tables (9, 10) show that sodium and chloride concentrations in the shoot, root and fruits were increased under the high salinity level whereas; nitrogen, phosphorus, potassium, calcium and magnesium (Tables 4-8) were decreased. Therefore, K+/Na+ ratio (Table 11) was decreased due to the increase in Na+ influx.

Salt stress inhibits the uptake and transport of magnesium (Pascale *et al.,* 2000), phosphorous (Parti et al., 2002), potassium (Rashid et al., 2004) as well as nitrogen and calcium (Jeong et al., 2006). In addition, exposure plants to salinity affects transport processes in the plant and can be alternations of nutritional status and tissue ion balance. Generally, uptake of nutrient ions affected by salinity depends on plant species, age and level of salinity as well as its concentration. Nutrient deficiency is the most crucial factor that reduces plant growth and crop productivity because both macro- and micronutrients are important constituents of enzymes, hormones, and cellular structures. However, nutrient uptake by the plants from soil is influenced by the activity of membrane transporters that mediate their intra- and inter-cellular distribution (Epstein and Bloom, 2005), inward- and outward-rectifying K channels for Na and K (Maathuis and Amtmann, 1999) and transporters for nitrate and ammonium (Epstein and Bloom, 2005) and salt-induced blockage or reduced activity of these transporters and/or uptake of N, P, K, Ca_2+ and Mg_2+ through the roots and its supply to the growing regions of shoots is considerably impaired (Munns, 2005) and the plasmalemma has been shown to lose its specific permeability (Helmy, 2008).

Nitrogen

From the obtained data it could be mentioned that low salinity level significantly increased nitrogen content in the roots and shoots as well as fruits of sweet pepper plant (Table, 4). This increase may be due to limited utilization of nitrogenous substances and consequently their accumulation is more rapid than their utilization for formation of new cells and tissues (Strogonov and Ostopnke, 1946). The reduction in nitrogen under saline conditions may be due to the suppressing effect of salinity on reduced water uptake (Lea-Cox and Syvertsen, 1993) and/or an increase in chloride uptake

and accumulation accompanied by a decrease in shoot nitrate concentrations of plants due to the competition between chloride and nitrate which decreases nitrate content (Khan and Srivastava, 1998). Furthermore, Silberbush and Ben-Asher (1987) observed that despite drastic reductions in leaf nitrate concentrations in response to salinity, other nitrogen containing fractions either increased (proline, soluble protein).

Table (4) Effect of pre-soaking seeds in SA, AsA, α-tocopherol or Yeast extract on nitrogen concentration (mg/g DW) of sweet pepper root, shoot and fruit grown under non-saline and saline conditions using NFT.

Salinity (A) / Treatment (C) mg/L		N.S.	N.S.+ NaCl			N.S.+ $CaCl_2$			N.S.+ ($NaCl+CaCl_2$) (1:1) w/w			Mean (C)
			Conc. (B)		Mean	Conc. (B)		Mean	Conc. (B)		Mean	
			2000	4000	(A*C)	2000	4000	(A*C)	2000	4000	(A*C)	
Root												
Water		11.99	13.40	6.85	10.75	14.41	10.47	12.29	15.91	9.63	12.51	11.85
SA 75		13.16	14.33	9.58	12.36	15.65	11.97	13.59	20.82	10.40	14.79	13.58
SA 150		12.56	14.08	9.17	11.93	14.95	11.19	12.90	17.51	10.15	13.41	12.75
AsA 50		13.12	14.27	9.49	12.29	15.54	11.86	13.51	19.59	10.36	14.36	13.39
AsA 100		12.83	14.04	9.29	12.05	15.16	11.58	13.19	18.16	10.30	13.76	13.00
α-toco 50		12.70	14.15	9.24	12.03	15.08	11.39	13.06	17.78	10.24	13.57	12.89
α-toco 100		12.95	14.22	9.41	12.19	15.32	11.80	13.36	18.57	10.33	13.95	13.17
Yeast 1000		12.16	13.24	7.65	11.02	14.50	10.52	12.39	16.32	9.78	12.75	12.05
Yeast 2000		12.48	13.74	8.94	11.72	14.68	10.93	12.70	16.69	9.94	13.04	12.49
Mean	A	12.66	11.82			13.00			13.57			
	B		15.63	10.09								
	A*B		13.94	8.85		15.03	11.30		17.93	10.13		
LSD at 0.05		A; 0.04	B; 0.04		C; 0.07	A*B; 0.07		A*C; 0.13	B*C; 0.13		A*B*C; 0.22	
Shoot												
Water		14.99	16.75	8.57	13.44	18.02	13.09	15.37	19.89	12.04	15.64	14.81
SA 75		16.45	17.91	11.97	15.44	19.56	14.96	16.99	26.02	13.00	18.49	16.97
SA 150		15.70	17.60	11.46	14.92	18.70	13.99	16.13	21.88	12.69	16.76	15.93
AsA 50		16.40	17.84	11.87	15.37	19.43	14.82	16.88	24.49	12.95	17.95	16.73
AsA 100		16.03	17.55	11.62	15.06	18.96	14.48	16.49	22.70	12.88	17.20	16.25
α-toco 50		15.88	17.69	11.55	15.04	18.85	14.24	16.32	22.22	12.81	16.97	16.11
α-toco 100		16.19	17.78	11.77	15.24	19.14	14.75	16.69	23.20	12.92	17.44	16.46
Yeast 1000		15.21	16.54	9.56	13.77	18.12	13.15	15.50	20.40	12.22	15.94	15.07
Yeast 2000		15.61	17.18	11.17	14.65	18.36	13.67	15.88	20.86	12.42	16.30	15.61
Mean	A	15.83	14.77			16.25			16.96			
	B		19.54	12.61								
	A*B		17.43	11.06		18.79	14.13		22.41	12.66		
LSD at 0.05		**A; 0.05**	**B; 0.05**		**C; 0.09**	**A*B; 0.09**		**A*C; 0.16**	**B*C; 0.16**		**A*B*C; 0.28**	
Fruit												
Water		16.62	17.93	10.52	15.03	19.02	15.42	17.02	20.90	14.27	17.27	16.44
SA 75		17.77	18.87	14.16	16.93	20.76	16.49	18.34	32.68	15.32	21.92	19.06
SA 150		17.28	18.54	13.63	16.49	19.90	16.05	17.74	22.91	15.02	18.40	17.54
AsA 50		17.64	18.77	13.95	16.79	20.63	16.42	18.23	27.09	15.28	20.00	18.34
AsA 100		17.45	18.47	13.78	16.57	20.07	16.19	17.91	24.12	15.12	18.90	17.79
α-toco 50		17.39	18.61	13.72	16.57	20.01	16.08	17.83	23.48	15.10	18.65	17.68
α-toco 100		17.56	18.69	13.84	16.69	20.37	16.24	18.06	25.15	15.20	19.30	18.02
Yeast 1000		16.71	17.90	11.89	15.50	19.18	15.51	17.13	21.07	14.49	17.42	16.68
Yeast 2000		17.18	18.25	13.26	16.23	19.49	15.89	17.52	22.22	14.63	18.01	17.25
Mean	A	17.29	16.31			17.75			18.88			
	B		20.93	14.72								
	A*B		18.45	13.20		19.94	16.03		24.40	14.94		
LSD at 0.05		**A; 0.22**	**B; 0.22**		**C; 0.38**	**A*B; 0.38**		**A*C; 0.65**	**B*C; 0.65**		**A*B*C; 1.13**	

N.S.= Nutrient Solution (Control) **SA = Salicylic acid**

AsA = Ascorbic acid **α-toco. = α-tocopherol**

Yeast = Yeast extract

Phosphorus

The influence of salinity on phosphorous accumulation in plants is variable and depends upon the plant. The obtained results in Table (5) indicate that increasing salinity level promoted a reduction of phosphorous concentration in sweet pepper tissue. In general, this close negative relationships between phosphorous and salinity level may be due to a decrease in the root absorption potential and to a decrease in the translocation of phosphorous upward through the root as a result of the increase in the osmotic pressure of the root medium (Greenway *et al.,* 1969).

Table (5) Effect of pre-soaking seeds in SA, AsA, α-tocopherol or Yeast extract on phosphorus concentration (mg/g DW) of sweet pepper root, shoot and fruit grown under non-saline and saline conditions using NFT.

Salinity (A) / Treatment (C) mg/L		N.S.	N.S.+ NaCl			N.S.+ $CaCl_2$			N.S.+ ($NaCl+CaCl_2$) (1:1) w/w			Mean (C)
			Conc. (B)		Mean	Conc. (B)		Mean	Conc. (B)		Mean	
			2000	4000	(A*C)	2000	4000	(A*C)	2000	4000	(A*C)	
Root												
Water		1.35	1.51	0.83	1.23	1.59	1.16	1.37	1.73	1.07	1.38	1.33
SA 75		1.48	1.59	1.07	1.38	1.72	1.33	1.51	2.24	1.15	1.62	1.50
SA 150		1.42	1.57	1.04	1.34	1.65	1.24	1.43	1.91	1.11	1.48	1.42
AsA 50		1.46	1.58	1.06	1.37	1.71	1.31	1.49	2.09	1.15	1.56	1.47
AsA 100		1.44	1.56	1.05	1.35	1.67	1.27	1.46	1.98	1.12	1.52	1.44
α-toco 50		1.43	1.57	1.04	1.35	1.66	1.25	1.45	1.96	1.12	1.50	1.43
α-toco 100		1.45	1.58	1.05	1.36	1.70	1.29	1.48	2.01	1.13	1.53	1.46
Yeast 1000		1.36	1.50	0.87	1.24	1.60	1.16	1.38	1.80	1.08	1.41	1.34
Yeast 2000		1.41	1.53	1.01	1.32	1.63	1.21	1.42	1.85	1.10	1.45	1.39
Mean	A	1.42	1.33			1.44			1.50			
	B		1.72	1.12								
	A*B		1.55	1.00		1.66	1.25		1.95	1.11		
LSD at 0.05		**A; 0.003**	**B; 0.003**		**C; 0.006**	**A*B; 0.006**		**A*C; 0.009**	**B*C; 0.009**		**A*B*C; 0.016**	
Shoot												
Water		2.16	2.33	1.37	1.95	2.47	2.00	2.21	2.72	1.85	2.24	2.13
SA 75		2.31	2.45	1.84	2.20	2.70	2.14	2.38	4.25	1.99	2.85	2.48
SA 150		2.24	2.41	1.77	2.14	2.59	2.08	2.30	2.98	1.95	2.39	2.28
AsA 50		2.29	2.44	1.81	2.18	2.68	2.13	2.37	3.52	1.98	2.60	2.38
AsA 100		2.27	2.40	1.79	2.15	2.61	2.10	2.33	3.13	1.96	2.45	2.31
α-toco 50		2.26	2.42	1.78	2.15	2.60	2.09	2.32	3.05	1.96	2.42	2.30
α-toco 100		2.28	2.43	1.79	2.17	2.65	2.11	2.35	3.27	1.97	2.51	2.34
Yeast 1000		2.17	2.32	1.54	2.01	2.49	2.01	2.22	2.74	1.88	2.26	2.17
Yeast 2000		2.23	2.37	1.72	2.11	2.53	2.07	2.28	2.89	1.90	2.34	2.24
Mean	A	2.24	2.12			2.31			2.45			
	B		2.72	1.91								
	A*B		2.40	1.71		2.59	2.08		3.17	1.94		
LSD at 0.05		A; 0.03	B; 0.03		C; 0.05	A*B; 0.05		A*C; 0.08	B*C; 0.08		A*B*C; 0.15	
Fruit												
Water		4.16	4.51	2.71	3.79	4.82	3.80	4.26	5.17	3.40	4.24	4.10
SA 75		4.50	4.82	3.36	4.22	5.10	4.13	4.57	7.14	3.77	5.13	4.64
SA 150		4.34	4.72	3.26	4.11	5.01	3.99	4.45	5.57	3.63	4.52	4.36
AsA 50		4.46	4.80	3.33	4.20	5.07	4.11	4.55	6.17	3.75	4.79	4.51
AsA 100		4.40	4.70	3.30	4.13	5.03	4.06	4.50	5.82	3.70	4.64	4.42
α-toco 50		4.37	4.76	3.28	4.14	5.02	4.01	4.47	5.71	3.68	4.59	4.40
α-toco 100		4.42	4.78	3.31	4.17	5.05	4.07	4.51	5.89	3.72	4.68	4.45
Yeast 1000		4.20	4.50	2.96	3.89	4.84	3.87	4.30	5.26	3.47	4.31	4.17
Yeast 2000		4.32	4.60	3.21	4.04	4.96	3.97	4.42	5.38	3.52	4.41	4.29
Mean	A	4.35	4.08			4.45			4.59			
	B		5.16	3.61								
	A*B		4.69	3.19		4.99	4.00		5.79	3.63		
LSD at 0.05		A; 0.02	B; 0.02		C; 0.03	A*B; 0.03		A*C; 0.06	B*C; 0.06		A*B*C; 0.10	

N.S.= Nutrient Solution (Control) **SA = Salicylic acid**

AsA = Ascorbic acid **α-toco. = α-tocopherol**

Yeast = Yeast extract

On the contrary, Papadopoulos and Rendig (1983) concluded that chloride may have suppressed phosphorous uptake and accumulation in tomato shoot and reduced activity of phosphorous in the soil solution due to the high ionic strength of the media (Awad et al., 1990) and/or phosphate availability in soil solution are tightly controlled by absorption process and the low solubility of calcium-phosphorous mineral (Grattan and Grieve, 1994).

Table (6) Effect of pre-soaking seeds in SA, AsA, α-tocopherol or Yeast extract on potassium concentration (mg/g DW) of sweet pepper root, shoot and fruit grown under non-saline and saline conditions using NFT.

Salinity (A) / Treatment (C) mg/L		N.S.	N.S.+ NaCl			N.S.+ $CaCl_2$			N.S.+ ($NaCl+CaCl_2$) (1:1) w/w			Mean (C)
			Conc. (B)		Mean (A*C)	Conc. (B)		Mean (A*C)	Conc. (B)		Mean (A*C)	
			2000	4000		2000	4000		2000	4000		
Root												
Water		22.10	25.50	14.10	20.57	27.30	20.40	23.27	28.60	18.30	23.00	22.28
SA 75		24.70	27.30	18.00	23.33	28.40	21.90	25.00	46.30	20.30	30.43	26.26
SA 150		23.10	26.40	16.80	22.10	27.70	21.30	24.03	35.40	19.50	26.00	24.04
AsA 50		24.40	27.10	18.00	23.17	28.20	21.80	24.80	42.90	20.10	29.13	25.70
AsA 100		23.80	26.70	17.30	22.60	27.90	21.60	24.43	36.50	19.80	26.70	24.58
α-toco 50		23.40	27.00	17.10	22.50	27.90	21.40	24.23	34.60	19.50	25.83	24.19
α-toco 100		24.30	26.90	17.60	22.93	28.20	21.60	24.70	37.80	20.00	27.37	25.00
Yeast 1000		22.20	25.00	14.50	20.57	27.40	20.60	23.40	29.40	18.60	23.40	22.46
Yeast 2000		22.90	25.80	15.90	21.53	27.60	21.10	23.87	30.80	18.90	24.20	23.20
Mean	A	23.43	22.14			24.19			26.23			
	B		30.02	19.11								
	A*B		26.41	16.59		27.84	21.30		35.81	19.44		
LSD at 0.05		A; 0.07	B; 0.07		C; 0.12	A*B; 0.12		A*C; 0.21	B*C; 0.21		A*B*C; 0.36	
Shoot												
Water		18.20	20.70	7.20	15.37	24.00	15.10	19.10	27.80	12.00	19.33	17.93
SA 75		20.10	23.80	11.90	18.60	27.20	17.90	21.73	36.70	15.00	23.93	21.42
SA 150		19.40	22.00	10.20	17.20	26.30	17.10	20.93	32.90	13.80	22.03	20.06
AsA 50		20.10	23.50	11.50	18.37	26.80	17.70	21.53	34.80	14.90	23.27	21.06
AsA 100		19.80	22.20	10.90	17.63	26.70	17.40	21.30	33.20	14.30	22.43	20.46
α-toco 50		19.50	22.80	10.50	17.60	26.40	17.20	21.03	32.30	13.90	21.90	20.18
α-toco 100		20.00	22.50	11.30	17.93	26.70	17.70	21.47	33.70	14.50	22.73	20.71
Yeast 1000		18.60	20.50	7.50	15.53	24.50	15.30	19.47	28.50	12.10	19.73	18.24
Yeast 2000		19.20	21.00	8.90	16.37	26.00	16.70	20.63	30.40	13.30	20.97	19.32
Mean	A	19.43	17.18			20.80			21.81			
	B		26.81	13.55								
	A*B		22.11	9.99		26.07	16.90		32.26	13.76		
LSD at 0.05		A; 0.06	B; 0.06		C; 0.10	A*B; 0.10		A*C; 0.18	B*C; 0.18		A*B*C; 0.31	
Fruit												
Water		20.20	23.40	9.10	17.57	25.20	17.70	21.03	29.60	14.70	21.50	20.03
SA 75		23.10	24.90	14.40	20.80	29.30	20.00	24.13	47.20	17.70	29.33	24.76
SA 150		22.50	24.40	13.30	20.07	27.20	18.90	22.87	34.70	16.50	24.57	22.50
AsA 50		23.00	24.90	14.10	20.67	28.90	19.80	23.90	46.20	17.50	28.90	24.49
AsA 100		22.80	24.60	13.90	20.43	28.00	19.40	23.40	40.40	16.80	26.67	23.50
α-toco 50		22.50	24.70	13.60	20.27	27.80	19.10	23.13	33.40	16.60	24.17	22.52
α-toco 100		22.80	24.60	14.10	20.50	28.20	19.80	23.60	45.10	17.10	28.33	24.14
Yeast 1000		20.40	23.40	9.90	17.90	25.50	17.90	21.27	30.80	15.00	22.07	20.41
Yeast 2000		22.40	23.70	11.90	19.33	26.90	18.60	22.63	32.10	15.80	23.43	21.80
Mean	A	22.19	19.73			22.89			25.44			
	B		29.82	16.04								
	A*B		24.29	12.70		27.44	19.02		37.72	16.41		
LSD at 0.05		A; 0.06	B; 0.06		C; 0.11	A*B; 0.11		A*C; 0.19	B*C; 0.19		A*B*C; 0.33	

N.S.= Nutrient Solution (Control) **SA = Salicylic acid**

AsA = Ascorbic acid **α-toco. = α-tocopherol**

Yeast = Yeast extract

and K+ homeostasis between cytoplasm and vacuole, (Epstein and Bloom, 2005; Helmy, 2008). In addition, K+ activates more than 50 enzymes and is an essential element in protein synthesis as it binds tRNA to the ribosomes (Blaha et al., 2000). In the present study, salinity significantly decreased potassium concentration in sweet pepper roots, shoots and fruits (Table, 6) and this decrease was accompanied by an increase in sodium concentration in roots, shoots and fruits (Table, 9). The decreases of endogenous K+ levels induced by high external NaCl concentrations may be attributed to a transmembrane competition between K+ and Na+ (Meloni et al., 2008). In addition, the antagonism between Na+ and K+ at the site of their uptake in roots and Na+ is frequently accumulated in the vacuoles where it can replace k+ both quantitively and qualitatively (Hatung, 2004).

Magnesium and Calcium

The increase in Mg_2+ and Ca_2+ (Tables 7-8) contents under low salinity level applied in this study may indicate that Mg_2+ and Ca_2+ may play a role in the response of sweet pepper plants to saline condition. Calcium is widely recognized to play an important role in regulating the passive entry of sodium and potassium/sodium selectively and involved in signaling pathway leading to induction of antioxidant enzymes (Agarwal *et al.,* 2005) and/or reduces permeability of sodium through the plasma membrane; prevent potassium/sodium selectivity (He and Cramer, 1992) and increase the rigidity of plant cell walls by complexly into polysaccharides (Cleland *et al.,* 1990). Moreover, Ca_2+ concentration declined with increasing salinity (Table, 8). These decreases may be due to the high sodium levels in the external media reduced the activity of calcium in the solution and/or decrease the amount of Ca_2+ available for uptake by the plant (Alam, 1994). On the other hand, Ca_2+ increased in leaf as salinity levels increased (Ramoliya *et al.,* 2004).

Salinity affected magnesium accumulation in plant organs similar to calcium (Tables, 7 and 8). The decrease in magnesium content seems to be due mainly to ion competition between sodium and magnesium. These results are in agreement with Neveen, Shawky, 2003. They found that with increasing salinity levels a reduction in N, P, K+, Ca_2+ and Mg_2+ concentrations was recorded as compared to non-salinized *Capsicum annuum* L. plants. In addition, Lycoskoufis et al. (2005) on sweet pepper reported that salinity reduced significantly the leaf K, Ca, and Mg uptake but not to levels that could cause nutrient deficiencies. On the contrary, Aktas et al. (2005) revealed that the fruit calcium concentration was not affected by salinity, but manganese concentrations in both leaves and fruits were significantly reduced under these conditions.

Na+ and Cl-

The applied NaCl into nutrient solution induced Na+ and Cl- accumulation in shoots and roots (Tables, 9 and 10). The alternations in distribution and accumulation of mono- and divalent cations in the different organs of salt stressed plants may be an indication of the role of these cations in regulating the physiological activities of these plants (Benzioni *et al.,* 1992). In addition, high Na+ concentration strongly inhibited uptake and

accumulation of K+ by roots. Because K+ is a macronutrient involved in turgor control, inhibition of potassium uptake (Renault *et al.,* 2001).

Table(7):Effect of pre-soaking seeds in SA, AsA, α-tocopherol or Yeast extract on magnesium concentration (mg/g DW) of sweet pepper root, shoot and fruit grown under non-saline and saline conditions using NFT.

Salinity (A) / Treatment (C) mg/L		N.S.	N.S.+ NaCl			N.S.+ $CaCl_2$			N.S.+ ($NaCl+CaCl_2$) (1:1) w/w			Mean (C)
			Conc. (B)		Mean	Conc. (B)		Mean	Conc. (B)		Mean	
			2000	4000	(A*C)	2000	4000	(A*C)	2000	4000	(A*C)	
Root												
Water		4.75	5.33	2.64	4.24	5.75	4.10	4.87	6.36	3.74	4.95	4.69
SA 75		5.24	5.73	3.71	4.89	6.25	4.73	5.41	8.41	4.07	5.91	5.40
SA 150		5.01	5.65	3.58	4.75	5.97	4.38	5.12	7.02	3.94	5.32	5.06
AsA 50		5.19	5.72	3.68	4.86	6.21	4.70	5.37	7.85	4.04	5.69	5.31
AsA 100		5.12	5.63	3.62	4.79	6.07	4.62	5.27	7.30	4.00	5.48	5.18
α-toco 50		5.06	5.68	3.61	4.78	6.02	4.47	5.18	7.14	3.97	5.39	5.12
α-toco 100		5.15	5.70	3.65	4.83	6.11	4.65	5.30	7.47	4.02	5.54	5.23
Yeast 1000		4.86	5.29	2.90	4.35	5.80	4.12	4.93	6.55	3.80	5.07	4.78
Yeast 2000		4.98	5.49	3.51	4.66	5.87	4.27	5.04	6.73	3.87	5.20	4.96
Mean	A	5.04	4.68			5.16			5.39			
	B		6.26	3.94								
	A*B		5.58	3.43		6.01	4.45		7.20	3.94		
LSD at 0.05		**A; 0.02**	**B; 0.02**		**C; 0.03**	**A*B; 0.03**		**A*C; 0.05**	**B*C; 0.05**		**A*B*C; 0.09**	
Shoot												
Water		3.99	4.61	1.67	3.42	5.16	3.27	4.14	5.72	2.82	4.18	3.91
SA 75		4.48	5.12	2.76	4.12	5.68	3.94	4.70	7.49	3.22	5.06	4.63
SA 150		4.20	5.02	2.46	3.89	5.49	3.63	4.44	6.27	3.02	4.50	4.28
AsA 50		4.47	5.08	2.68	4.08	5.62	3.91	4.67	6.94	3.17	4.86	4.54
AsA 100		4.37	4.98	2.58	3.98	5.56	3.75	4.56	6.48	3.11	4.65	4.40
α-toco 50		4.35	5.05	2.54	3.98	5.54	3.68	4.53	6.40	3.10	4.62	4.37
α-toco 100		4.38	5.06	2.63	4.03	5.59	3.89	4.62	6.69	3.13	4.74	4.46
Yeast 1000		4.02	4.58	1.91	3.50	5.18	3.36	4.19	5.82	2.92	4.25	3.98
Yeast 2000		4.17	4.83	2.19	3.73	5.36	3.50	4.34	6.05	2.96	4.39	4.16
Mean	A	4.27	3.86			4.47			4.58			
	B		5.61	3.03								
	A*B		4.93	2.38		5.47	3.66		6.43	3.05		
LSD at 0.05		**A; 0.003**	**B; 0.003**		**C;0.004**	**A*B; 0.004**		**A*C; 0.008**	**B*C; 0.008**		**A*B*C; 0.011**	
Fruit												
Water		3.54	3.97	2.13	3.22	4.20	3.21	3.65	4.52	2.94	3.67	3.51
SA 75		3.92	4.18	2.92	3.67	4.49	3.52	3.98	5.55	3.18	4.22	3.96
SA 150		3.72	4.11	2.70	3.51	4.39	3.38	3.83	4.84	3.06	3.87	3.74
AsA 50		3.89	4.17	2.90	3.65	4.48	3.50	3.96	5.23	3.13	4.09	3.90
AsA 100		3.80	4.09	2.77	3.56	4.43	3.44	3.89	4.97	3.09	3.96	3.80
α-toco 50		3.76	4.12	2.74	3.54	4.41	3.41	3.86	4.91	3.08	3.92	3.77
α-toco 100		3.85	4.14	2.83	3.61	4.46	3.46	3.92	5.09	3.11	4.02	3.85
Yeast 1000		3.58	3.94	2.30	3.28	4.24	3.23	3.68	4.58	2.98	3.71	3.56
Yeast 2000		3.69	4.03	2.59	3.44	4.36	3.35	3.80	4.73	3.01	3.81	3.68
Mean	A	3.75	3.50			3.84			3.92			
	B		4.47	3.04								
	A*B		4.09	2.65		4.39	3.39		4.94	3.06		4.09
LSD at 0.05		**A; 0.008**	**B; 0.008**		**C; 0.013**	**A*B; 0.013**		**A*C; 0.023**	**B*C; 0.023**		**A*B*C; 0.040**	

N.S.= Nutrient Solution (Control) **SA = Salicylic acid**

AsA = Ascorbic acid **α-toco. = α-tocopherol**

Yeast = Yeast extract

In addition, Cl- is a more sensitive indicator of salt damage than Na+, since it is stored by the plant (Alam, 1994). Cl- accumulates in roots, shoots and fruits (Table, 10) with increasing salinity levels. This accumulation may result from the reduction in the availability of calcium causing an increase in root permeability (Grattan and Grieve, 1994) and Na+ and Cl- are energetically efficient osmolytes for osmotic adjustment and are

Table(8): Effect of pre-soaking seeds in SA, AsA, α-tocopherol or Yeast extract on calcium concentration (mg/g DW) of sweet pepper root, shoot and fruit grown under non-saline and saline conditions using NFT.

Salinity (A) / Treatment (C) mg/L		N.S.	N.S.+ NaCl			N.S.+ $CaCl_2$			N.S.+ ($NaCl+CaCl_2$) (1:1) w/w			Mean (C)
			Conc. (B)		Mean	Conc. (B)		Mean	Conc. (B)		Mean	
			2000	4000	(A*C)	2000	4000	(A*C)	2000	4000	(A*C)	
Root												
Water		1.93	2.13	1.36	1.80	3.06	3.37	2.78	2.51	2.83	2.42	2.34
SA 75		2.11	2.49	1.92	2.17	3.33	4.50	3.31	2.77	3.06	2.65	2.71
SA 150		2.04	2.28	1.85	2.06	3.15	3.74	2.98	2.66	3.01	2.57	2.54
AsA 50		2.10	2.48	1.91	2.16	3.28	4.18	3.19	2.74	3.04	2.62	2.66
AsA 100		2.08	2.41	1.88	2.12	3.25	3.90	3.07	2.69	2.98	2.58	2.59
α-toco 50		2.05	2.33	1.88	2.09	3.18	3.81	3.02	2.68	3.02	2.58	2.56
α-toco 100		2.08	2.44	1.90	2.14	3.27	3.99	3.11	2.70	3.03	2.61	2.62
Yeast 1000		1.97	2.14	1.47	1.86	3.07	3.49	2.84	2.57	2.80	2.45	2.38
Yeast 2000		2.00	2.22	1.82	2.01	3.12	3.63	2.91	2.64	2.92	2.52	2.48
Mean	A	2.04	2.05			3.02			2.56			
	B		2.73	2.86								
	A*B		2.33	1.78		3.19	3.84		2.66	2.96		
LSD at 0.05		A; 0.01	B; 0.01		C; 0.02	A*B; 0.02		A*C; 0.03	B*C; 0.03		A*B*C; 0.05	
Shoot												
Water		2.59	2.81	1.84	2.41	3.87	4.28	3.58	3.22	3.60	3.14	3.04
SA 75		2.79	3.22	2.57	2.86	4.21	5.59	4.20	3.54	3.85	3.39	3.48
SA 150		2.73	3.01	2.46	2.73	4.02	4.71	3.82	3.38	3.78	3.30	3.28
AsA 50		2.79	3.18	2.55	2.84	4.18	5.26	4.08	3.53	3.83	3.38	3.43
AsA 100		2.77	3.11	2.50	2.79	4.08	4.88	3.91	3.45	3.77	3.33	3.34
α-toco 50		2.75	3.06	2.48	2.77	4.05	4.78	3.86	3.41	3.80	3.32	3.32
α-toco 100		2.78	3.17	2.53	2.83	4.12	4.99	3.96	3.48	3.82	3.36	3.38
Yeast 1000		2.63	2.83	2.06	2.50	3.90	4.39	3.64	3.27	3.56	3.15	3.10
Yeast 2000		2.67	2.94	2.40	2.67	3.95	4.49	3.70	3.35	3.69	3.24	3.20
Mean	A	2.72	2.71			3.86			3.29			
	B		3.49	3.65								
	A*B		3.04	2.38		4.04	4.82		3.40	3.75		
LSD at 0.05		A; 0.01	B; 0.01		C; 0.02	A*B; 0.02		A*C; 0.03	B*C; 0.03		A*B*C; 0.06	
Fruit												
Water		3.10	3.39	2.34	2.94	4.24	4.59	3.97	3.65	4.00	3.58	3.50
SA 75		3.38	3.64	3.07	3.36	4.57	6.67	4.87	3.96	4.20	3.84	4.03
SA 150		3.25	3.52	2.94	3.23	4.41	5.04	4.23	3.84	4.14	3.74	3.74
AsA 50		3.34	3.62	3.05	3.34	4.53	5.62	4.50	3.93	4.18	3.82	3.88
AsA 100		3.28	3.58	3.00	3.29	4.50	5.43	4.41	3.87	4.13	3.76	3.82
α-toco 50		3.26	3.53	2.98	3.26	4.47	5.22	4.32	3.85	4.16	3.76	3.78
α-toco 100		3.29	3.60	3.02	3.30	4.51	5.56	4.45	3.91	4.18	3.79	3.85
Yeast 1000		3.11	3.40	2.70	3.07	4.26	4.74	4.04	3.68	3.98	3.59	3.57
Yeast 2000		3.15	3.47	2.91	3.18	4.36	4.85	4.12	3.81	4.09	3.68	3.66
Mean	A	3.24	3.22			4.32			3.73			
	B		3.93	4.10								
	A*B		3.53	2.89		4.43	5.30		3.83	4.12		
LSD at 0.05		A; 0.04	B; 0.04		C; 0.07	A*B; 0.07		A*C; 0.12	B*C; 0.12		A*B*C; 0.21	

N.S.= Nutrient Solution (Control) — **SA = Salicylic acid**

AsA = Ascorbic acid — **α-toco. = α-tocopherol**

Yeast = Yeast extract

Table(9):Effect of pre-soaking seeds in SA, AsA, α-tocopherol or Yeast extract on sodium concentration (mg/g DW) of sweet pepper root, shoot and fruit grown under non-saline and saline conditions using NFT.

Salinity (A) / Treatment (C) mg/L		N.S.	N.S.+ NaCl			N.S.+ $CaCl_2$			N.S.+ ($NaCl+CaCl_2$) (1:1) w/w			Mean (C)
			Conc. (B)		Mean	Conc. (B)		Mean	Conc. (B)		Mean	
			2000	4000	(A*C)	2000	4000	(A*C)	2000	4000	(A*C)	
Root												
Water		0.97	1.21	2.04	1.41	0.90	0.80	0.89	1.09	1.26	1.11	1.13
SA 75		0.90	1.10	1.26	1.09	0.81	0.62	0.78	0.98	1.21	1.03	0.97
SA 150		0.93	1.15	1.36	1.15	0.86	0.72	0.84	1.00	1.22	1.05	1.01
AsA 50		0.91	1.13	1.29	1.11	0.82	0.64	0.79	0.98	1.21	1.03	0.98
AsA 100		0.91	1.14	1.31	1.12	0.83	0.70	0.81	0.98	1.22	1.04	0.99
α-toco 50		0.93	1.15	1.33	1.14	0.85	0.69	0.82	0.99	1.22	1.05	1.00
α-toco 100		0.91	1.13	1.30	1.11	0.82	0.67	0.80	0.98	1.22	1.04	0.98
Yeast 1000		0.95	1.19	1.67	1.27	0.88	0.77	0.87	1.07	1.23	1.08	1.07
Yeast 2000		0.94	1.15	1.53	1.21	0.83	0.73	0.83	1.02	1.22	1.06	1.03
Mean	A	0.93	1.18			0.83			1.05			
	B		1.00	1.13								
	A*B		1.15	1.46		0.84	0.70		1.01	1.22		
LSD at 0.05			**A; 0.003**	**B; 0.003**	**C; 0.005**	**A*B; 0.005**		**A*C; 0.026**	**B*C; 0.026**		**A*B*C; 0.046**	
Shoot												
Water		0.88	1.10	2.09	1.36	0.78	0.64	0.77	1.02	1.30	1.07	1.06
SA 75		0.78	1.03	1.31	1.04	0.65	0.40	0.61	0.89	1.11	0.93	0.86
SA 150		0.82	1.06	1.42	1.10	0.71	0.55	0.69	0.98	1.18	0.99	0.93
AsA 50		0.79	1.03	1.33	1.05	0.66	0.44	0.63	0.90	1.13	0.94	0.87
AsA 100		0.81	1.05	1.38	1.08	0.69	0.52	0.67	0.92	1.14	0.96	0.90
α-toco 50		0.81	1.06	1.39	1.09	0.70	0.49	0.67	0.95	1.16	0.98	0.91
α-toco 100		0.80	1.05	1.36	1.07	0.68	0.44	0.64	0.90	1.14	0.95	0.89
Yeast 1000		0.86	1.09	1.99	1.31	0.76	0.61	0.74	1.01	1.24	1.03	1.03
Yeast 2000		0.83	1.07	1.47	1.12	0.70	0.57	0.70	0.99	1.19	1.00	0.94
Mean	A	0.82	1.14			0.68			0.98			
	B		0.90	1.07								
	A*B		1.06	1.53		0.70	0.52		0.95	1.18		
LSD at 0.05			**A; 0.003**	**B; 0.003**	**C; 0.005**	**A*B; 0.005**		**A*C; 0.008**	**B*C; 0.008**		**A*B*C; 0.014**	
Fruit												
Water		0.79	1.05	1.59	1.15	0.66	0.53	0.66	0.89	1.20	0.96	0.92
SA 75		0.67	0.90	1.23	0.93	0.53	0.32	0.50	0.81	1.06	0.84	0.76
SA 150		0.74	0.94	1.34	1.01	0.60	0.42	0.59	0.84	1.14	0.90	0.83
AsA 50		0.68	0.91	1.24	0.94	0.53	0.33	0.51	0.82	1.08	0.86	0.77
AsA 100		0.69	0.93	1.28	0.97	0.57	0.39	0.55	0.83	1.12	0.88	0.80
α-toco 50		0.72	0.93	1.30	0.98	0.60	0.36	0.56	0.83	1.13	0.89	0.81
α-toco 100		0.69	0.92	1.26	0.96	0.55	0.34	0.52	0.82	1.10	0.87	0.78
Yeast 1000		0.77	0.99	1.49	1.08	0.64	0.48	0.63	0.88	1.18	0.94	0.89
Yeast 2000		0.76	0.95	1.43	1.04	0.59	0.44	0.60	0.86	1.15	0.92	0.85
Mean	A	0.72	1.01			0.57			0.90			
	B		0.79	0.96								
	A*B		0.95	1.35		0.59	0.40		0.84	1.13		
LSD at 0.05			**A; 0.003**	**B; 0.003**	**C; 0.006**	**A*B; 0.006**		**A*C; 0.009**	**B*C; 0.009**		**A*B*C; 0.016**	

N.S.= Nutrient Solution (Control) | **SA = Salicylic acid**

AsA = Ascorbic acid | **α-toco. = α-tocopherol**

Yeast = Yeast extract

Table(10): Effect of pre-soaking seeds in SA, AsA, α-tocopherol or Yeast extract on chloride concentration (mg/g DW) of sweet pepper root, shoot and fruit grown under non-saline and saline conditions using NFT.

Salinity (A) / Treatment (C) mg/L		N.S.	N.S.+ NaCl			N.S.+ $CaCl_2$			N.S.+ ($NaCl+CaCl_2$) (1:1) w/w			Mean (C)
			Conc. (B)		Mean	Conc. (B)		Mean	Conc. (B)		Mean	
			2000	4000	(A*C)	2000	4000	(A*C)	2000	4000	(A*C)	
Root												
Water		0.62	1.33	2.17	1.37	0.93	1.75	1.10	1.01	1.54	1.06	1.18
SA 75		0.47	1.11	1.77	1.12	0.71	1.55	0.91	0.95	1.39	0.94	0.99
SA 150		0.52	1.14	1.87	1.18	0.78	1.64	0.98	0.99	1.44	0.98	1.05
AsA 50		0.49	1.11	1.79	1.13	0.74	1.57	0.93	0.96	1.40	0.95	1.00
AsA 100		0.50	1.12	1.83	1.15	0.76	1.60	0.95	0.98	1.42	0.97	1.02
α-toco 50		0.51	1.12	1.85	1.16	0.77	1.62	0.96	0.98	1.43	0.97	1.03
α-toco 100		0.50	1.11	1.81	1.14	0.75	1.58	0.94	0.96	1.40	0.95	1.01
Yeast 1000		0.62	1.31	2.01	1.32	0.92	1.72	1.09	1.00	1.51	1.04	1.15
Yeast 2000		0.61	1.26	1.92	1.26	0.82	1.66	1.03	0.99	1.48	1.03	1.11
Mean	A	0.54	1.20			0.99			0.99			
	B		0.99	1.66								
	A*B		1.18	1.89		0.80	1.63		0.98	1.45		
LSD at 0.05		**A; 0.002**	**B; 0.002**		**C; 0.004**	**A*B; 0.004**		**A*C; 0.007**	**B*C; 0.007**		**A*B*C; 0.012**	
Shoot												
Water		0.58	1.24	2.03	1.28	0.87	1.64	1.03	0.95	1.44	0.99	1.10
SA 75		0.44	1.04	1.66	1.05	0.66	1.45	0.85	0.89	1.30	0.88	0.93
SA 150		0.49	1.06	1.76	1.10	0.73	1.54	0.92	0.93	1.35	0.92	0.98
AsA 50		0.46	1.04	1.68	1.06	0.70	1.47	0.88	0.90	1.31	0.89	0.94
AsA 100		0.47	1.05	1.71	1.08	0.72	1.50	0.89	0.92	1.34	0.91	0.96
α-toco 50		0.48	1.05	1.74	1.09	0.72	1.52	0.90	0.92	1.34	0.91	0.97
α-toco 100		0.46	1.04	1.70	1.07	0.71	1.48	0.88	0.90	1.32	0.89	0.95
Yeast 1000		0.58	1.23	1.89	1.23	0.86	1.62	1.02	0.94	1.42	0.98	1.08
Yeast 2000		0.57	1.18	1.81	1.19	0.77	1.56	0.97	0.93	1.38	0.96	1.04
Mean	A	0.50	1.13			0.93			0.93			
	B		0.92	1.55								
	A*B		1.10	1.77		0.75	1.53		0.92	1.35		
LSD at 0.05		**A; 0.002**	**B; 0.002**		**C; 0.004**	**A*B; 0.004**		**A*C; 0.007**	**B*C; 0.007**		**A*B*C; 0.01**	
Fruit												
Water		0.63	1.19	1.86	1.23	0.87	1.53	1.01	0.94	1.36	0.97	1.07
SA 75		0.51	1.02	1.54	1.02	0.70	1.37	0.86	0.89	1.24	0.88	0.92
SA 150		0.54	1.04	1.63	1.07	0.76	1.44	0.91	0.92	1.28	0.92	0.97
AsA 50		0.52	1.02	1.56	1.03	0.73	1.38	0.88	0.89	1.25	0.89	0.93
AsA 100		0.53	1.02	1.59	1.05	0.74	1.41	0.89	0.91	1.27	0.90	0.95
α-toco 50		0.54	1.03	1.61	1.06	0.75	1.42	0.90	0.92	1.27	0.91	0.96
α-toco 100		0.53	1.02	1.58	1.04	0.73	1.39	0.88	0.90	1.25	0.89	0.94
Yeast 1000		0.62	1.18	1.74	1.18	0.86	1.51	1.00	0.93	1.34	0.96	1.05
Yeast 2000		0.62	1.14	1.67	1.14	0.79	1.46	0.96	0.93	1.31	0.95	1.02
Mean	A	0.56	1.09			0.92			0.92			
	B		0.92	1.45								
	A*B		1.07	1.64		0.77	1.43		0.91	1.29		
LSD at 0.05		**A; 0.002**	**B; 0.002**		**C; 0.003**	**A*B; 0.003**		**A*C; 0.006**	**B*C; 0.006**		**A*B*C; 0.01**	

N.S.= Nutrient Solution (Control) | **SA = Salicylic acid**

AsA = Ascorbic acid | **α-toco. = α-tocopherol**

Yeast = Yeast extract

In the present study, sodium accumulated in the root more than the shoot and fruits. The preferential accumulation in root over shoots may be interpreted as a mechanism of tolerance by maintenance of a substantial potential for osmotic water uptake into the roots and/or restricting the spread of Na+ to the shoots (Renault et al., 2001). Moreover, the high accumulation of Na+ and Cl- in plant roots (Tables, 9, 10) may be due to a regulatory

mechanisms located within the roots that prevent translocation of cations such as Na+ from the root to shoot (Adams, 1994). In addition, the accumulation of Na in roots provides a mechanism for pepper to cope with salinity in rooting medium and/or may indicate the existence of an inhibition mechanism of Na transport to leaves. Moreover, Zandstra-Plom et al. (1998) found that sodium is preferably accumulated in sweet pepper roots and in pith cells in the lower part of the stem, which play a decisive role in the re-circulation of sodium throughout the plant. On the other hand, Tester and Davenport (2003) pointed out that leaves are more vulnerable than roots to Na+ simply because Na+ and Cl– accumulate to higher levels in shoots than in roots. Though Na+ is transported to shoots through the rapidly moving transpiration stream in the xylem, it can only return to roots via the phloem. There is limited evidence of extensive recirculation of shoot Na+ to root, suggesting that Na+ transport is largely unidirectional and results in progressive accumulation of Na+ as leaves age (Tester and Davenport, 2003).causes a disturbances in the ion balance in plants by an increase in the Na+ uptake (Table, 9). Excessive amount of Na+ and Cl- in the media may be attributed to low accumulation of K+ in the plant organs (root, shoot and fruits) which, in turn, impairs the selectivity of the root membrane (Table, 6; Misra and Gupta, 2006) and/or lower K+/Na+ ratios which may unpaired the selectivity of the root membrane (Gadalla, 2009b) and/or excess of Na+ in the root media results in a passive accumulation of this ion in the root and shoot lead to a high Na+/K+ ratio and reduced plant growth (Helmy, 2008).

K+/Na+ Ratio

The present study, revealed that salinity reduced the ratio of K+/Na+ in the roots, shoots and fruits of sweet pepper plant (Table, 11) which may be due to the fact that Na+

The ratio K+/Na+ (Table 11) is often found to be important for salt tolerance (Schachtman et al., 1989). The promotion of Na+ uptake in the presence of NaCl was accompanied by a corresponding decrease of K+ influx showing an apparent antagonism between K+ and Na+.

Application of the applied bio-stimulants used helped plants to limit toxic ion as sodium and chloride (Tables, 9 and 10) and significantly increased nitrogen, phosphorous, potassium, calcium, magnesium concentration in the roots and fruits of sweet pepper plants under non-saline or saline conditions (Tables, 4-8). The role of ascorbic acid on mineral content of plants has been revealed by Neveen, Shawky, 2003 and El-Banna, 2006 on sweet pepper and Gadalla, 2009a on wheat. Applications of ascorbic acid help plants to limit toxic ion (Na+) and increased potassium concentration in the roots and shoots of sweet pepper plant growing under non-saline and saline conditions and affected indirectly as a result of its effect on N, P, K+, Ca2+ and Mg2+ uptake which plays an essential role in many metabolic (Neveen, Shawky, 2003). In addition, Hanafy-Ahmed et al. (1995) showed that ascorbic acid caused favorable effect on the content of N, P+ and K+ in the different faba bean plant organs. Ascorbic acid is mitigating partially or completely the adverse effects of salt stress which may be one aspect of the role of the vitamin C in the activation of some enzymatic reactions (Al-Hakimi and Hamada, 2001) and stabilizing and protecting the

photosynthetic pigments and the photosynthetic apparatus from being oxidized (Hamada, 1998). Furthermore, the main function of anti-oxidants is their protective effect of cell membranes and their binding transport proteins (H+-ATP-ase membrane pumps), maintained their structure and function against the toxic destructive effect of ROS during stress, in turn more absorption and translocation of minerals (Dicknson et al., 1991) and increased N, P and K contents in leaves (El-Shazly and El-Masri, 2003), and (El-Gabas, 2006).

Table (11):Effect of pre-soaking seeds in SA, AsA, α-tocopherol or Yeast extract on potassium/sodium ratio of sweet pepper root, shoot and fruit grown under non-saline and saline conditions using NFT.

Salinity (A) / Treatment (C) mg/L		N.S.	N.S.+ NaCl			N.S.+ $CaCl_2$			N.S.+ ($NaCl+CaCl_2$) (1:1) w/w			Mean (C)
			Conc. (B)		Mean	Conc. (B)		Mean	Conc. (B)		Mean	
			2000	4000	(A*C)	2000	4000	(A*C)	2000	4000	(A*C)	
Root												
Water		22.85	21.15	6.89	16.96	30.45	25.66	26.32	26.22	14.59	21.22	21.50
SA 75		27.41	24.72	14.25	22.13	35.14	35.18	32.58	47.43	16.84	30.56	28.42
SA 150		24.79	22.90	12.35	20.01	32.16	29.77	28.91	35.31	16.00	25.37	24.76
AsA 50		26.82	24.06	13.96	21.61	34.33	34.04	31.73	43.76	16.61	29.06	27.47
AsA 100		26.03	23.43	13.23	20.90	33.42	30.76	30.07	37.06	16.24	26.44	25.80
α-toco 50		25.23	23.51	12.82	20.52	32.90	31.06	29.73	34.82	16.00	25.35	25.20
α-toco 100		26.58	23.79	13.55	21.31	34.15	32.41	31.04	38.55	16.41	27.18	26.51
Yeast 1000		23.27	21.04	8.69	17.67	31.02	26.96	27.08	27.39	15.09	21.92	22.22
Yeast 2000		24.34	22.38	10.41	19.04	33.06	28.96	28.79	30.19	15.50	23.34	23.72
Mean	A	25.26	20.02			29.58			25.60			
	B		30.53	19.42								
	A*B		23.00	11.80		32.96	30.53		35.64	15.92		
LSD at 0.05		A; 0.09	B; 0.09		C; 0.15	A*B; 0.15		A*C; 0.25	B*C; 0.25		A*B*C; 0.44	
Shoot												
Water		20.60	18.82	3.45	14.29	30.70	23.74	25.01	27.25	9.27	19.04	19.45
SA 75		25.71	23.03	9.10	19.28	41.90	44.54	37.38	41.14	13.48	26.78	27.81
SA 150		23.62	20.67	7.19	17.16	37.22	31.23	30.69	33.71	11.75	23.02	23.62
AsA 50		25.42	22.74	8.65	18.94	40.45	40.48	35.45	38.62	13.23	25.76	26.72
AsA 100		24.64	21.21	7.91	17.92	38.75	33.14	32.18	36.14	12.50	24.43	24.84
α-toco 50		24.00	21.51	7.55	17.69	37.59	35.10	32.23	33.86	11.97	23.27	24.40
α-toco 100		25.16	21.50	8.30	18.32	39.26	40.08	34.83	37.40	12.78	25.11	26.09
Yeast 1000		21.71	18.87	3.77	14.78	32.44	24.92	26.36	28.30	9.79	19.93	20.36
Yeast 2000		23.00	19.57	6.03	16.20	37.26	29.31	29.86	30.59	11.19	21.60	22.55
Mean	A	23.76	17.17			31.55			23.22			
	B		30.76	17.42								
	A*B		20.88	6.88		37.28	33.62		34.11	11.77		
LSD at 0.05		A; 0.09	B; 0.09		C; 0.16	A*B; 0.16		A*C; 0.28	B*C; 0.28		A*B*C; 0.48	
Fruit												
Water		25.55	22.26	5.72	17.84	38.04	33.68	32.42	33.35	12.24	23.71	24.66
SA 75		34.64	27.51	11.73	24.63	55.28	62.95	50.96	58.72	16.70	36.69	37.42
SA 150		30.50	25.94	9.91	22.12	45.28	45.08	40.29	41.35	14.48	28.78	30.39
AsA 50		34.03	27.24	11.36	24.21	54.08	59.77	49.30	56.55	16.17	35.58	36.36
AsA 100		32.88	26.52	10.85	23.42	48.77	49.36	43.67	48.40	14.98	32.09	33.06
α-toco 50		31.45	26.63	10.44	22.84	46.62	52.19	43.42	40.01	14.74	28.73	31.67
α-toco 100		33.31	26.65	11.20	23.72	51.50	58.24	47.68	54.90	15.61	34.61	35.33
Yeast 1000		26.55	23.55	6.65	18.92	39.82	37.19	34.52	34.87	12.72	24.71	26.05
Yeast 2000		29.66	24.96	8.34	20.99	45.80	42.54	39.33	37.46	13.76	26.96	29.09
Mean	A	30.95	22.08			42.40			30.21			
	B		39.34	24.39								
	A*B		25.69	9.58		47.24	49.00		45.07	14.60		
LSD at 0.05		A; 0.17	B; 0.17		C; 0.29	A*B; 0.29		A*C; 0.50	B*C; 0.50		A*B*C; 0.87	

N.S.= Nutrient Solution (Control) **SA = Salicylic acid**

AsA = Ascorbic acid **α-toco. = α-tocopherol**

Yeast = Yeast extract

Concerning the beneficial effects of the applied SA in imitative partially the adverse effects of salinity stress on ion uptake in sweet pepper plants might be attributed to effect of on producing healthy plants and enhancing the plants to have great ability for elements uptake as well as their roles on regulation ions and may modifying the movement of nutrients within the plant tissues and play an important role to enhance the activity of enzymes (Cherki *et al.,* 2002).

The beneficial effects of the applied yeast on mineral content of plants has been revealed by many authors i.e. Eata (2001) and Abou-Aly (2005) on tomato. Moreover, Abou-Aly (2005) found that inoculation with yeast enhanced activities of dehydrogenase and nitrogenase. Moreover, application of yeast either foliar or seedlings inoculation enhanced the tested strains of N_2–Fixer and P-Solubilizer, which led to increases in mineral content as well as carbohydrates concentration of tomato.

It could be concluded that pre-soaking sweet pepper seeds in AsA at 50 mg/L or SA at 75 mg/L could alleviate the harmful effect of salinity on the leaves mineral content .

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محتوى العناصر فى أوراق الفلفل الحلو إستجابة لبعض المحفزات الحيوية تحت ظروف الملوحة

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أدي التركيز المنخفض من مخلوط الملحين معاً أو كلوريد الكالسيوم فقط إلي زيادة تركيز النيتروجين، الفوسفور، والبوتاسيوم، والمغنسيوم وكذلك نسبة البوتاسيوم/الصوديوم في المجموع الخضري والجذري وكذلك ثمار نبات الفلفل الحلو. ولقد أدت زيادة تركيز الملح إلي حدوث نقص معنوي في تركيز هذه العناصر. كما وجد أن زيادة تركيز كلوريد الكالسيوم أو مخلوط الملحين من ٢٠٠٠ إلي ٤٠٠٠ جزء في المليون يؤدي إلي حدوث زيادة في تركيز الكالسيوم وذلك مقارنة بالنباتات الغير معاملة، علي العكس من ذلك كان للتركيز المرتفع من كلوريد الصوديوم (٤٠٠٠ جزء في المليون) أثراً سلبياً علي تركيز الكالسيوم.

أدت زيادة تركيز كل من كلوريد الصوديوم أو مخلوط الملحين إلي زيادة تركيز كل من الصوديوم والكلوريد. بالإضافة إلي ذلك، أدي نقع البذور في أي من حمض الأسكوربيك أو الألفاتوكوفيرول أو حمض السالسليك أو مستخلص الخميرة إلي حدوث زيادة معنوية في تركيز كل من النيتروجين، الفوسفور، والكالسيوم، والمغنسيوم، وكذلك نسبة البوتاسيوم/الصوديوم ، ونقص تركيز كل من الصوديوم والكلوريد تحت الظروف العادية وظروف الملوحة. كما وجد أن حمض الأسكوربيك بتركيز ٥٠ جزء في المليون أو حمض السالسليك بتركيز ٧٥ جزء في المليون الأكثر تأثيراً وذلك مقارنة بباقي المعاملات.

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