Journal of Horticultural Science & Ornamental Plants 2 (2): 93-106, 2010
ISSN 2079-2158

Response of Two Grapevine Rootstocks to Some Salt Tolerance Treatments under Saline Water Conditions

H.T. Mehanna, T.A. Fayed and A.A. Rashedy

Department of Pomology, Faculty of Agriculture, Cairo University, Giza, Egypt

Abstract: A field experiment was carried out at the Agricultural Experiments Desert Station, Faculty of Agriculture, Cairo university in Wadi El-Natroon district, Beheira Governorate, Egypt during the two successive seasons 2007 and 2008. The study had conducted two grapevine rootstocks, Salt Creek (*Vitis champini*) and 1103 Paulsen (V. *berlandieri* × V. *rupestris*) nursling with or without some soil application treatments (humic acid, Uni-Sal, sulphur and mycorrhizae) under saline water irrigation. The obtained results indicated that Salt Creek rootstock recorded the highest significant shoot length, leaf area, leaf number, root length, total plant dry weight, leaf transpiration rate and root Ca content and it had a significant reduction in stomatal diffusion resistance (SDR) compared to 1103 Paulsen rootstock. Whereas, 1103 Paulsen had the highest values of plant survival %, leaf proline content and reduction in leaf and shoot Cl and Na contents. Moreover, Uni-Sal treatment gave the highest significant shoot length, leaf area, root length, plant dry weight, total chlorophylls and transpiration rate, plant K content and reduced significantly SDR and leaf Na content. Furthermore, Salt Creek rootstock with Uni-Sal treatment gave the best results. This study cleared a benefit effect of Uni-Sal treatment in alleviating the adverse effect of salinity on grapevine rootstocks.

Key words: Grapevine · Rootstocks · Salt Creek · 1103 Paulsen · Tolerance · Humic acid · Uni-Sal · Sulphur · Mycorrhizae and Saline water

INTRODUCTION

Grapes ,belong to the genus *Vitis* , rank first among fruit crops in the world in terms of both production and economic importance [1]. In 2010, World grapevine production was 67708587 tons from 7408127 Hectare [2]. Salinity stress is one of the main problems facing vine growers. Salinity of irrigation water can impair the performance of growth and production of grapevines [3, 4]. The adverse effects of salinity either of soil or water on growth were confirmed in different grapevine cultivars [5-9].

Grapevine is considered as moderate sensitive to salinity. However, grapevine response to salinity depends on several factors such as rootstock, scion, irrigation system, soil type and climate or combination between them. Moreover, changing some of these factors with the same irrigation water could produce entirely different results [10].

In Egypt, most of the extensions in vineyard plantations during the last few decades were in the newly reclaimed areas where salinity of soil and irrigation water is a major problem [11]. Kamel *et al.* [12] stated that symptoms of salinity start with leaf burns, shoot die back, leaf fall and finally death of vine. Also, leaf burn in Thompson Seedless grapevine accompanied with salinity appeared after 4-5 weeks from treatment [13]. In general, aerial portion and root system as well as number of roots/vine were gradually decreased as salinity concentration was increased [6].

Certain rootstocks reduce the accumulation of chloride in the scion variety, the high salt concentration in the soil or water cause growth inhibition in most plants. Also, effect of saline conditions affect plant growth in various ways [14,15]. Moreover, salinity can cause decreasing in water uptake in the plants, accumulating ions to toxic levels and reducing nutrient availability [16].

Sensitive *Vitis vinifera* rootstocks can grow normally in soils containing 0.2 to 0.3% NaCl [17]. But *Vitis riparia* and *Vitis rupestris* die above 0.4% NaCl, Salt Creek and 1103 Paulsen are the most resistant rootstocks (0.8 - 1.5% [5 ,18].

Corresponding Author: H.T. Mehanna, Department of Pomology, Faculty of Agriculture, Cairo University, Giza, Egypt

Sulphur has been recently used for reducing soil and water salinity. Also, it is involved in the synthesis of vitamins and amino acids [19]. In addition, it is highly effective in reducing soil pH, salinity and increasing the activity of soil microorganisms [20]. Humic substances (HS) and fulvic acid (FA) are essential in soil organic matter (SOM). Also, the nature stability of these substances affects carbon and nitrogen cycles and carbon sequestration [21]. Humic substances are relatively stable products of organic matter. They accumulate in the environmental systems to increase moisture retention and nutrient supply potentials of sandy soils [22]. Furthermore, it can ameliorate negative soil properties and improve the plant growth and uptake of nutrients in case of the negative effect of salt that would inhibit the plant growth and the uptake of nutrient elements [23, 24]. It is concluded that the application doses are important for taking benefit from humic substances under salt conditions. Economical levels of application should be determinated and should not exceed 1g humus kg^{-1} soil in soil application and 0.1% in foliar application [25].

In recent years, the use of biological methods as a practical way to alleviate saline soil stresses on plant growth has received increased attention [26, 27]. Other researchers have noted that arbuscular miccorhiza can alleviate the stress of salinity on plant growth besides inhibiting high uptake of Na and Cl and their transfer to the plant shoots [26, 28]. To some extent, these fungi have been considered as bio-ameliorators of saline soils [29].

Addition of Calcium ameliorate the adverse effects of salinity on plants [30-32]. Ca is well known to have regulatory role in metabolism [33] and sodium ions may compete with Ca ions in membrane-binding sites. Therefore, it has been hypothesized that high Ca levels can protect cell membrane from the adverse effect of salinity [34]. Furthermore, an adequate supply of Ca maintains membrane integrity and selectivity [35]. The ability of Ca to ameliorate the negative effects through its role in reducing Na uptake and increasing K and Ca uptake resulting in an increase in plant growth [36]. Kaya *et al*. [31] reported that supplementary Ca resulted in increased values for daily water use which were very close to those for unstressed plants. This indicated that this treatment is restoring normal growth by negating the effects of salinity. Beside Ca, applying polyethylene glycol (PEG 2000) or mannitol to the root medium has been often used to submit higher plants to control negative water potentials [37]. In addition, PEG gives more consistent results than mannitol as an external osmotic; to study water relationships in stressed plants. The higher viscosity of PEG solutions, as compared with NaCl, may be the primary factor contributing to a diminution of water flow through roots [38, 39].

Many authors tried to reduce the established adverse effects of water salinity on growth and nutritional status of different grape varieties [4, 40]. They suggested that using materials containing biostimulants, organic matter and sulphur was necessary for alleviating the unfavorable effects of salinity on growth of grapevine rooting.

The target of this investigation was to evaluate the response of two grapevine rootstocks (Salt Creek and 1103 Paulsen) with or without some soil application treatments (humic acid, Uni-Sal, sulphur and mycorrhiza) under saline water irrigation.

MATERIALS AND METHODS

A field experiment was carried out at the Agricultural Experiments Desert Station, Faculty of Agriculture, Cairo University in Wadi El-Natroon District, Beheira Governorate, Egypt during the two successive seasons of 2007 and 2008. Two grapevine rootstocks namely, Salt Creek (*Vitis champini*) and 1103 Paulsen (1103P) (V. *berlandieri* × V. *rupestris*) nurslings were conducted to evaluate growth and chemical compounds under saline water irrigation. All plants received the recommended orchard management according to recommendation of the Ministry of Agriculture, Egypt .Vines were planted at 1 x 3 m in sandy soil under drip irrigation system.

Four soil applications of saline tolerance treatments were used: humic mixture (8% active humic acid, 1% active folvic acid and 72.3% organic matter) at 3 cm per nursling monthly, Uni-Sal (contains 9% PEG, 7.5% calcium, 7% glutaric acid, 5% nitrogen and 1% citric acid) at 5cm monthly, sulphur at 250g added once per nursling during transplanting and mycorrhizae containing *Glomus* spp.; *Gigaspora* spp. and *Acoulaspora* spp. added to each plant at 250 g of mixed dry soil containing 2500 spores/g of mycorrhiza [41] beside control treatment (without any soil application).

Uni-Sal and humic acid were added to the soil in equal doses (monthly at the first week, from June to November) but mycorrhiza and sulphur were added once at planting. The transplanting started in the first week of June in both seasons under study.

Seventy five normal, homogeneous and vigorous plants of one-year-old of each rootstock were planted in sandy soil and then irrigated with saline water (2624 ppm) in the two seasons (Tables 1 and 2). After transplanting, the transplants of each rootstock were pruned to 4 eyes.

Table 1: Chemical analysis of the soil.

			Soluble anions (meq/l)			Soluble cations (meq/l)			
Depth(cm)	pH	EC dS/m	HCO_3	Cl	SO_4^{--}	Na	K	Ca	Mg
0 - 15	7.31	7.75	1.3	68.0	0.5	85.00	1.02	15.0	13.0
15 - 30	7.43	4.54	1.5	32.5	0.3	37.14	0.68	15.0	6.0
30 - 45	7.46	3.79	1.6	20.6	0.2	28.83	0.52	10.2	7.4
45 - 60	7.24	2.77	1.0	4.2	0.2	18.29	0.46	4.8	5.4

Table 2: Chemical analysis of the irrigation water.

		Ions Concentration (meq/l)						
pH	EC dS/m	$HCO_3 + CO_3$	Cl^-	SO_4^{--}	Na^+	K^+	Ca^{++}	Mg^+
7.35	4.1	3.8	27.2	14.58	35.1	0.48	6.0	4.0

Evaluation of the tested rootstocks and treatments under saline water irrigation was carried out in respect of the following:

Survival and Growth Parameters: Survival percentage and vegetative growth parameters included survival (%), plant length (cm), plant diameter at 5cm above soil surface (cm), number of leaves/plant, average leaf area (cm^2) of the basal sixth and seventh leaves from shoot base estimated in mid of August using portable leaf area meter model LI 3000. The dry weight of leaves, shoots and roots were also estimated beside shoot/root ratio at the end of each season. The plants of each treatment were got out of the soil for the estimation of root length using the grid intersection method after dividing them into 3 categories according to their diameter < 2 ml, 2-4 ml and > 4ml [42].

Physiological Parameters: leaf transpiration rate (mg/cm^2) and stomatal diffusion resistance (s/cm) were determined using a portable steady state parameter apparatus (Model LI-1600 LI-COR, INC.). The determination was carried out each season using the basal sixth and seventh leaf from shoot base (10 leaves/replicate) to calculate the average values. Total chlorophylls content was determined in the basal sixth and seventh leaf from the shoot base (10 fresh leaves/ replicate) by using nondestructive chlorophyll meter (Minolta SPAD-502), it determines the relative amount of chlorophyll percent by measuring the transmittance of the leaf in two wave bands (600 to700 and 400 to 500 nm) giving reading in arbitrary units, that are proportional to the amount of chlorophyll content.

Chemical Analysis: Leaf samples were taken from the sixth and seventh leaf on the shoots picked at mid of August. While shoot and root minerals content was determined at the end of October yearly after washing it several times with tap water then dried to a constant weight at 70°C and the following determinations were recorded: Leaves proline content was made using the method outlined by Bates *et al.* [43]. Chloride was estimated by titration method with silver nitrate according to Jackson [44]. Potassium, Sodium and calcium contents were determined by using spectrophotometer according to Brown and Lilleland [45]. All results were expressed as percentage on dry weight basis.

Statistical Analysis: Treatments were laid out as a two-factor experiment involving two rootstocks as a main plot and five salt tolerance treatments in a split plot design with three replications. Each replicate consisted of five vine plants; and LSD method was used to compare the means of results [46].

RESULTS AND DISCUSSION

Survival Percentage: Tabulated results in Table 3 illustrate that survival percentage was increased by different soil application of tested salt tolerance enhancement treatments on the two studied rootstocks in both seasons. 1103Paulsen recorded higher survival value than Salt Creek rootstock in both seasons. Moreover, Uni-Sal or humic acid treatment gave the highest significant survival % followed in descending order by mycorrhizae then sulphur.Control treatment gave the lowest survival value in both seasons. Concerning the interaction between rootstocks and treatments, the highest significant survival % was recorded by Salt Creek and 1103 Paulsen with soil application of humic acid or Uni-Sal treatments beside 1103 Paulsen with mycorrhizae compared to other treatments and control in both seasons.

Table 3: Effect of some saline tolerance treatments on survival percentage of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Survival (%)					
	Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	66.67	73.33	70.00	53.33	60.00	56.67
Humic acid	86.67	93.33	90.00	73.33	80.00	76.67
Uni-Sal	93.33	100.00	96.67	80.00	86.67	83.33
Sulphur	73.33	80.00	76.67	60.00	66.67	63.33
Mycorrhizae	80.00	86.67	83.33	66.67	73.33	70.00
Mean	80.00	86.67		66.67	73.33	
LSD at 5%						
Rootstocks(A)		5.48			4.62	
Treatments(B)		11.82			10.42	
A X B		16.72			14.82	

Table 4: Effect of some saline tolerance treatments on shoot length and diameter (cm) of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Shoot length (cm)						Shoot diameter (cm)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	51.33	33.00	42.17	71.33	55.67	63.50	0.38	0.33	0.36	0.75	0.75	0.75
Humic acid	65.31	41.89	53.60	104.00	75.06	89.53	0.67	0.51	0.59	1.13	1.02	1.08
Uni-Sal	65.83	49.50	57.67	104.50	83.94	94.22	0.71	0.57	0.64	1.27	1.17	1.22
Sulphur	53.11	39.00	46.06	77.06	64.17	70.61	0.66	0.35	0.51	0.82	0.86	0.84
Mycorrhizae	60.57	40.19	50.38	103.50	73.06	88.28	0.71	0.47	0.59	1.09	0.97	1.03
Mean	59.23	40.72		92.08	70.38		0.63	0.45		1.01	0.96	
LSD at 5%												
Rootstocks(A)		1.09			2.73			0.09			0.03	
Treatments(B)		1.72			4.31			0.14			0.05	
A X B		2.44			6.09			0.20			0.08	

These results are in harmony with Sourial *et al.* [11], Abou Sayed *et al.* [6], Ahmed [5] and Ismail [47] on different grape cultivars and rootstocks, as they recorded that there was a reduction of survival percentage under saline conditions. Moreover, salinity decreases water uptake in the plants, accumulates ions to toxic levels and reduces nutrient availability [16]. Other researchers have noted that humic acid, mycorrhizae or Ca can alleviate the stress of salinity on plant growth besides inhibiting high uptake of Na and Cl and their transfer to the plant shoots [24, 26, 28 , 31].

Shoot Length and Diameter: Data in Table 4 indicated that shoot length and diameter were significantly affected by different saline tolerance treatments and the two studied rootstocks during the two seasons. Furthermore, Salt Creek rootstock recorded the highest significant shoot length and diameter than 1103Paulsen rootstock in both seasons.

Soil application of Uni-Sal treatments gave the highest plant length and diameter values compared to other treatments in both seasons. Regarding the interaction, the highest plant length and diameter values were recorded by Salt Creek rootstock with soil application of Uni-Sal compared to the same rootstock and 1103Paulsen with or without other treatments under study in both seasons.

The effect of saline water on reducing plant length were recorded [5,6,8,11,48]. Furthermore, Ahmed *et al.* [40] found that addition of Nile fertile (38% sulphur) as soil conditioner at 1, 2 and 3 g/kg soil with any level of soil salinity improved plant length compared to those irrigated with saline water only, this indicated that this treatment is restoring normal growth by negating the effects of salinity. Beside Ca, applying polyethylene glycol (PEG 2000) or mannitol to the root medium has been often used to submit higher plants to control negative water potentials [37].

Table 5: Effect of some saline tolerance treatments on leaves number/plant and leaf area (cm^2) of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Leaves number/plant						Leaf area (cm^2)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	10.00	9.00	9.50	26.00	17.00	21.50	23.75	21.09	22.42	47.63	38.33	42.98
Humic acid	15.33	14.19	14.76	37.72	29.05	33.39	28.11	22.42	25.27	59.65	51.7	55.67
Uni-Sal	17.33	16.94	17.14	40.17	29.44	34.81	33.68	22.68	28.18	65.06	54.71	59.88
Sulphur	13.03	12.00	12.51	31.83	21.33	26.58	23.83	21.23	22.53	50.06	41.92	45.99
Mycorrhizae	14.00	13.25	13.63	34.00	28.89	31.44	26.89	22.15	24.52	53.75	45.14	49.44
Mean	13.94	13.08		33.94	25.14		27.25	21.92		55.23	46.36	
LSD at 5%												
Rootstocks(A)		0.56			1.10			0.94			0.41	
Treatments(B)		0.89			1.74			1.49			0.64	
A X B		1.26			2.46			2.11			0.91	

In addition, PEG gives more consistent results than mannitol as an external osmotic; to study water relationships in stressed plants. The higher viscosity of PEG solutions, as compared with NaCl, May be the primary factor contributing to a diminution of water flow through roots [38, 39].

Number of Leaves/plant and Leaf Area (cm^2): Data depicted in Table 5 indicated that numbers of leaves per plant and leaf area (cm^2) were significantly affected by different saline tolerance treatments and both studied rootstocks during the two seasons. Also, Salt Creek rootstock recorded the highest number of leaves/ plant and leaf area than 1103Paulsen rootstock in both seasons. In addition, soil application of Uni-Sal treatment gave the highest number of leaves (17.14 and 34.81) and leaf area (28.18 and 59.88 cm^2) in the first and second seasons, respectively .Soil application of humic acid, also, increased number of leaves per plant (33.39) in the second season compared to other treatments under study. Concerning the interaction between rootstocks and treatments, Salt Creek rootstock with soil application of Uni-Sal treatment gave the highest leaves number and area values (17.33- 40.17 and 33.68- 65.06 cm^2) in both seasons under study. Both rootstocks under study without any application treatments (control) gave the lowest number of leaves per plant and leaf area values in both seasons.

In this regard, Kaya *et al.* [31] reported that supplementary Ca resulted in increasing values for daily water use which were very close to those for unstressed plants. This indicated that this treatment is restoring normal growth by negating the effects of salinity. Beside the higher viscosity of Uni-Sal solutions may be the primary factor contributing to a diminution of water flow through roots [39]. Also, Stevenson [21] illustrated that humic acid and fulvic acid are essential part of soil organic matter and the nature and stability of these substances affect carbon, nitrogen cycles and carbon sequestration. Humic substances are relatively stable products of organic matter; accumulate in the environmental systems to increase moisture retention and nutrient supply potentials of sandy soils [22]. Other researchers have noted that arbscular mycorrhizae (AM) can alleviate the stress of salinity on plant growth due to inhibiting high uptake of Na and Cl and their transfer to the plant shoots [26], these fungi have been considered as bio-ameliorators of saline soils [29].

Root Length (cm): Data presented in Tables 6 and 7 indicated that root length was increased significantly by all salt tolerance treatments except for sulphur treatments on roots < 4cm in both seasons and roots 2-4cm in the 1st season only. Also, Salt Creek rootstock recorded the highest significant root length in both seasons compared with 1103Paulsen rootstock. In addition, soil application of Uni-Sal treatment gave the highest significant root length in both seasons compared to other treatments beside soil application of humic acid in second season for roots < 4cm, followed in descending order by mycorrhizae then sulphur and control treatments.

As for the interaction between rootstocks and treatments, Salt Creek rootstock with Uni-Sal treatment gave the highest significant root length in both seasons compared to other treatments on the same rootstock and 1103Paulsen with or without treatments.

Table 6: Effect of some saline tolerance treatments on root length of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Root length <2 cm (cm)						Root length 2-4cm (cm)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	220.10	260.00	240.10	242.70	191.70	217.20	101.70	58.67	80.17	127.80	124.00	125.90
Humic acid	527.20	448.30	487.80	338.00	311.00	324.50	151.60	150.90	151.30	198.20	203.20	200.70
Uni-Sal	652.10	540.60	596.40	524.10	399.60	461.90	227.10	193.60	210.30	247.60	206.90	227.20
Sulphur	227.80	296.00	261.90	259.30	201.80	230.60	102.10	69.40	85.77	157.00	140.20	148.60
Mycorrhizae	393.70	343.70	368.70	273.40	260.20	266.80	104.80	87.86	96.31	197.60	164.10	180.90
Mean	404.19	377.73		327.51	272.84		137.46	112.07		185.63	167.67	
LSD at 5%												
Rootstocks(A)		9.66			10.2			5.90			3.80	
Treatments(B)		15.27			9.56			9.34			7.90	
A X B		21.59			13.51			13.20			11.18	

Table 7: Effect of some saline tolerance treatments on root length of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Root > 4cm (cm)						Total root length (cm)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	20.00	14.00	17.00	18.67	9.33	14.00	341.80	332.70	337.20	389.10	325.00	357.10
Humic acid	49.85	22.26	36.06	56.33	20.27	38.30	728.70	621.40	675.10	592.50	534.40	563.50
Uni-Sal	66.52	23.31	44.92	57.63	22.17	39.90	945.70	757.40	851.60	829.40	628.60	729.00
Sulphur	20.00	18.86	19.43	23.60	12.81	18.20	349.90	384.30	367.10	439.80	354.90h	397.40
Mycorrhizae	26.71	18.86	22.78	32.97	15.70	24.33	525.20	450.40	487.80	504.00	440.00	472.00
Mean	36.617	19.457		37.84	16.06		578.26	509.25		550.98	456.57	
LSD at 5%												
Rootstocks(A)		9.66			2.96			12.58			7.30	
Treatments(B)		4.26			4.68			19.89			12.35	
A X B		6.03			6.62			28.12			17.46	

Table 8: Effect of some saline tolerance treatments on shoot and root dry weight (g) of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Shoot dry weight (g)						Root dry weight (g)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	7.10	3.54	5.32	20.33	9.30	14.82	18.00	15.73	16.86	28.33	24.00	26.17
Humic acid	12.00	10.52	11.26	28.79	24.25	26.52	25.78	27.95	26.87	42.64	42.18	42.41
Uni-Sal	16.95	10.86	13.90	30.85	28.03	29.44	29.36	29.92	29.64	46.34	46.61	46.48
Sulphur	9.97	7.81	8.89	24.83	12.78	18.81	21.28	18.84	20.06	32.15	27.79	29.97
Mycorrhizae	10.92	3.54	9.64	25.85	21.49	23.67	23.60	19.18	21.39	39.45	40.21	39.83
Mean	11.39	8.22		26.13	19.17		23.61	22.33		37.78	36.16	
LSD at 5%												
Rootstocks(A)		0.43			0.68			0.80			1.32	
Treatments(B)		0.07			1.07			1.27			2.09	
A X B		0.97			1.51			1.80			2.95	

Table 9: Effect of some saline tolerance treatments on total plant dry weight and leaf dry weight (g) of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Leaf dry weight (g)						Total plant dry weight (g)					
	Rootstocks (2007)			Rootstocks (2007)			Rootstocks (2007)			Rootstocks (2007)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	5.03	4.74	4.89	13.00	8.33	10.67	30.13	24.01	27.07	61.67	41.63	51.65
Humic acid	8.69	7.16 c	7.93	23.88	18.15	21.02	46.48	45.64	46.06	95.31	84.58	89.94
Uni-Sal	9.89	8.13	9.01	29.99	19.33	24.66	56.19	48.92	52.56	107.20	93.97	100.60
Sulphur	7.85	5.87	6.86	18.58	11.10	14.84	39.10	32.52	35.81	75.56	51.67	63.62
Mycorrhizae	7.96	6.65	7.31	21.78	17.12	19.45	42.48	34.19	38.34	87.08	78.81	82.95
Mean	7.89	6.51		21.45	14.81		42.88	37.06		85.36	70.13	
LSD at 5%												
Rootstocks(A)		0.46			0.92			1.01			1.17	
Treatments(B)		0.73			1.45			1.60			1.85	
A X B		1.03			2.06			2.62			2.62	

The increasing in root length under saline conditions with mycorrhizae treatment was in accordance with Gendiah [49] who found that inoculation of the rooting medium with *Glomus mossae* fungus gave percentage ratios 70.3 and 121.1 for number of roots, root length of rooted Banati cuttings, respectively. The effect of Ca on root growth and length may be attributed to the regulation roles in metabolism [33] and sodium ions may compete with Ca ions for membrane-binding sites. Therefore, it has been hypothesized that high Ca levels can protect cell membrane from the adverse effect of salinity [34]. Furthermore, an adequate supply of Ca maintain membrane integrity and selectivity [35] resulting in increasing in plant growth and root length.

Dry Weight of Leaves, Shoots and Roots (g): Data depicted in Tables 8 and 9 showed that leaves, shoots and roots dry weights were significantly increased by saline tolerance treatments comparing to control treatment during the two seasons of study. In addition, Salt Creek rootstock recorded higher dry weights of different organs, mentioned above, than1103Paulsen rootstock in both seasons. Furthermore, soil application of Uni-Sal gave the highest leaf, shoot, root and total dry weights values, followed in descending order by humic acid, mycorrhizae, sulphur and control in both seasons. Concerning the interaction between the two factors, Salt Creek rootstock treated with Uni-Sal application gave the highest significant values compared to other interactions beside 1103Paulsen with Uni-Sal that also gave the highest root dry weight value in both seasons.

For the effect of treatments and rootstocks, all treatments gave significant increases in shoot/root ratio compared to untreated plants as shown in Table 10. Furthermore, Uni-Sal and sulphur treatments gave the highest values beside mycorrhizae in the first season. In addition, Salt Creek gave a higher shoot/root ratio compared to 1103Paulsen rootstock. Regarding the effect of the interaction, Uni-Sal and sulphur with Salt Creek rootstock gave the highest shoot/root ratio in the two seasons of study.

These results agreed with those of Kaya *et al.* [31] who reported that supplementary Ca resulted in significant increases in dry matter of plants grown at high NaCl and the values obtained from the treatments were almost the same as those for the control treatment. Similar results were observed by Navarro *et al.* [32] on tomato. Also, Casierra-Posada *et al.* [24] reported that leonardite (23.6% humic acid and 1.1% fulvic acid, from leonardite) had alleviated salt-stress in plants receiving 20 mmol NaCl treatment, but in soils subjected to 40 to 80 mmol NaCl an increase of yield and dry matter production per plant was recorded.

Furthermore, Gendiah [9] found that the highest values for shoot and root dry weight were obtained by mycorrhizae combined with SEEADW (sewage effluents-enriched agriculture drainage water) in Banati cultivar. The same result was recorded by Awad [50] on Flame Seedless . With regard to effect of sulphur on plant dry weight, it was in accordance with Rizk-Alla *et al.* [4] on Thompson Seedless, found that irrigation with saline water at 1000 ppm alone or combined with Nile fertile containing 38% sulphur had no significant effect on

Table 10: Effect of some saline tolerance treatments on shoot/root ratio of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Shoot /Root ratio					
	Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	0.67	0.53	0.60	1.17	0.74	0.96
Humic acid	0.80	0.63	0.72	1.24	1.01	1.12
Uni-Sal	0.91	0.64	0.78	1.31	1.02	1.17
Sulphur	0.85	0.73	0.79	1.35	0.86	1.11
Mycorrhizae	0.80	0.79	0.79	1.21	0.96	1.08
Mean	0.81	0.66		1.26	0.92	
LSD at 5 %						
Rootstocks(A)		0.04			0.05	
Treatments(B)		0.07			0.08	
A X B		0.09			0.11	

Table 11: Effect of some saline tolerance treatments on chlorophyll content (SPAD value) and leaf transpiration rate (mg/cm^2) of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Chlorophyll content (spad value)						Leaf transpiration rate (mg/cm^2)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	34.97	36.27	35.62	37.53	27.00	32.27	1.25	1.10	1.18	0.98	0.92	0.95
Humic acid	40.08	37.82	38.95	44.80	34.63	39.72	1.45	1.57	1.51	1.22	1.18	1.20
Uni-Sal	41.02	39.6	40.31	45.70	35.47	40.58	1.69	1.70	1.69	1.47	1.42	1.45
Sulphur	38.32	36.92	37.62	41.30	31.00	36.15	1.34	1.27	1.30	1.10	1.03	1.07
Mycorrhizae	39.63	36.97	38.30	44.23	33.90	39.07	1.42	1.34	1.38	1.18	1.17	1.18
Mean	38.80	37.52		42.71	32.40		1.43	1.40		1.19	1.14	
LSD at 5%												
Rootstocks(A)		1.01			0.34			0.02			0.03	
Treatments(B)		1.59			0.54			0.08			0.04	
A X B		2.25			0.76			0.11			0.05	

the dry weight of shoots and roots. Abou Sayed *et al.* [6, 7] indicated that increasing salinity level caused clear reduction in leaf dry weight. Also, Ismail [47] and Eissa *et al.* [8] indicated that 1500 ppm sodium carbonate treatment significantly increased shoot/root ratio comparing with other treatments (0, 750 and 1500 ppm).

Leaf Chlorophylls Content: Data depicted in Table 11 indicate that leaf total chlorophylls content was significantly affected by different salt tolerance treatments in the two seasons. Salt Creek rootstock recorded higher leaf total chlorophylls content than 1103Paulsen rootstock in both seasons. In addition, soil application of Uni-Sal treatment gave the highest leaf total chlorophylls(SPAD values of 40.31 and 40.58) in the first and second seasons, respectively beside soil application of humic acid in the 1st season compared to the other treatments under study. Salt Creek rootstock with Uni-Sal treatment gave the best result in both seasons (41.02 and 45.7) followed by Salt Creek with humic in both seasons. Both rootstocks under study without application treatments gave the lowest leaf chlorophyll content in both seasons.

Supplementary Ca resulted in significant increases in chlorophyll content of plants grown at high NaCl and the values obtained from Ca treatments were almost the same as those for the control treatment [31]. In this regard, Sourial *et al.* [11] reported the reduction in pigment content under saline conditions. Also, Ismail [47] reported that addition of Nile fertile as natural soil conditioner under salinity conditions was significantly responsible for enhancing plant pigments compared with the control.

Table 12: Effect of some saline tolerance treatments on stomatal diffusion resistance (s/cm) and leaf proline content (%) of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Stomatal diffusion resistance (s/cm)						Leaf Proline (%)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	27.33	28.33	27.83	27.70	30.30	29.00	0.074	0.064	0.069	0.069	0.061	0.065
Humic acid	25.00	25.00	25.00	21.60	26.83	24.22	0.052	0.042	0.047	0.049	0.045	0.047
Uni-Sal	22.00	22.67	22.33	20.50	24.50	22.50	0.041	0.030	0.036	0.037	0.037	0.037
Sulphur	27.13	27.00	27.07	27.10	28.23	27.67	0.060	0.050	0.055	0.057	0.053	0.055
Mycorrhizae	26.67	26.00	26.33	24.73	27.50	26.12	0.054	0.046	0.050	0.048	0.050	0.049
Mean	25.63	25.80		24.33	27.47		0.056	0.046		0.052	0.049	
LSD at 5%												
Rootstocks(A)		0.12			0.04			0.007			0.007	
Treatments(B)		0.99			0.66			0.012			0.012	
A X B		1.41			0.94			0.021			0.021	

Leaf Transpiration Rate (mg/cm^2): Data depicted in Table 11 show that all saline tolerance treatments significantly increased transpiration rate (TR) compared to the untreated plants. Also, Salt Creek rootstock gave the highest significant TR compared to 1103Paulsen in both seasons. Moreover, Uni-Sal treatment gave the highest significant TR followed in descending order by humic acid, mycorrhizae, sulphur then control plants. Concerning the effect of the interaction, the highest TR values were recorded by both rootstocks (Salt Creek and 1103P) with Uni-Sal compared to the other treatments and control plants.The effect of saline water irrigation on TR reduction of grape plants was reported by many researchers [7,11,47,51].

Leaf Stomatal Diffusion Resistance (S/cm): Data depicted in Table 12 present that stomatal diffusion resistance (SDR) was affected by different saline tolerance treatments. Salt Creek rootstock gave the lowest significant SDR values in the two seasons compared to 1103Paulsen rootstock. In addition, soil application of Uni-Sal gave the lowest significant SDR value in both seasons (22.33 and 22.50, respectively) compared to other treatments followed in descending order by humic acid, mycorrhizae, sulphur and control plants. As for the interaction, both Salt Creek and 1103P rootstocks treated with Uni-Sal gave the lowest SDR values in both seasons. The effect of saline water irrigation on increasing SDR was in accordance with Sourial *et al.* [11] who found that the highest values of SDR were obtained by the highest tested salinity levels (2000 and 3000 ppm).

Leaf Proline Content (%): Tabulated results in Table 12 illustrate that proline leaf content was significantly decreased by Uni-Sal treatment in both seasons compared to the untreated plants. Also, 1103P recorded the lowest proline content compared to Salt Creek which was significant in the 1st season. Regarding to the effect of interaction (Rootstock X Treatment), Uni-Sal treatment combined with 1103Paulsen gave the lowest (0.030 and 0.037%) proline content in both seasons followed by Uni-Sal with Salt Creek. On the other hand, control plants gave the highest proline content. Proline accumulation under saline conditions was reported by Gaser [51]; Ismail [47] and Sourial *et al.* [11]. This it may be due to the increase in salinity of water [52].

Chloride and Sodium Contents: Tables 13, 14 and 15 indicate that all salt tolerance treatments significantly decrease plant Cl and Na contents in both seasons. In addition, Uni-Sal and humic acid treatments gave the lowest Cl values in different plant organs compared to other treatments and control plants. Moreover, 1103Palsune rootstock recorded the lowest leaves and shoots Cl and Na values beside root Na content in both seasons. While there is no significant differences in root Cl content in both rootstocks. Regarding the effect of interaction, 1103Pulsen with Uni-Sal and humic acid gave the lowest Cl and Na values in different plant organs compared to other treatments or untreated plants.

Table 13: Effect of some saline tolerance treatments on leaf and shoot Cl content (%) of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Leaf Cl content (%)						Shoot Cl content (%)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	0.29	0.16	0.22	0.38	0.29	0.33	0.27	0.17	0.22	0.36	0.17	0.26
Humic acid	0.19	0.11	0.15	0.32	0.25	0.29	0.21	0.11	0.16	0.21	0.10	0.16
Uni-Sal	0.13	0.10	0.12	0.28	0.22	0.25	0.17	0.11	0.14	0.15	0.09	0.12
Sulphur	0.28	0.15	0.22	0.36	0.26	0.31	0.25	0.15	0.20	0.31	0.14	0.23
Mycorrhizae	0.21	0.12	0.17	0.34	0.26	0.30	0.21	0.12	0.17	0.28	0.14	0.21
Mean	0.22	0.13		0.34	0.26		0.22	0.13		0.26	0.13	
LSD at 5%												
Rootstocks(A)		0.01			0.007			0.007			0.02	
Treatments(B)		0.02			0.01			0.01			0.04	
A X B		0.05			0.02			0.02			0.05	

Table 14: Effect of some saline tolerance treatments on root Cl and leaf Na contents (%) of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Root Cl content (%)						Leaf Na content (%)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	0.35	0.32	0.34	0.19	0.25	0.22	0.32	0.32	0.32	0.68	0.60	0.64
Humic acid	0.19	0.23	0.21	0.12	0.13	0.12	0.29	0.24	0.26	0.55	0.47	0.51
Uni-Sal	0.18	0.19	0.19	0.11	0.13	0.12	0.26	0.16	0.21	0.38	0.44	0.41
Sulphur	0.34	0.31	0.33	0.18	0.17	0.18	0.32	0.29	0.31	0.61	0.57	0.59
Mycorrhizae	0.21	0.24	0.23	0.15	0.19	0.17	0.29	0.25	0.27	0.58	0.47	0.52
Mean	0.26	0.26		0.15	0.18		0.30	0.25		0.56	0.51	
LSD at 5%												
Rootstocks(A)		N.S.			0.024			0.024			0.031	
Treatments(B)		0.04			0.04			0.04			0.09	
A X B		0.05			0.05			0.05			0.13	

Table 15: Effect of some saline tolerance treatments on shoot and root Na (%) of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Shoot Na content (%)						Root Na content (%)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	2.59	3.20	2.89	2.45	1.92	2.18	1.21	1.01	1.11	1.30	1.15	1.23
Humic acid	2.17	0.38	1.28	0.60	0.45	0.52	0.92	0.76	0.84	0.73	0.71	0.72
Uni-Sal	0.47	0.38	0.43	0.39	0.42	0.41	0.88	0.71	0.80	0.62	0.64	0.63
Sulphur	2.50	3.16	2.83	2.38	1.86	2.12	1.16	0.94	1.05	1.18	1.03	1.11
Mycorrhizae	2.38	2.17	2.28	0.81	1.39	1.10	0.92	0.94	0.93	0.83	0.84	0.83
Mean	2.02	1.86		1.32	1.21		1.02	0.87		0.93	0.87	
LSD at 5%												
Rootstocks(A)		0.109			0.09			0.08			0.11	
Treatments(B)		0.17			0.77			0.13			0.18	
A X B		0.24			1.09			0.18			0.26	

Table 16: Effect of some saline tolerance treatments on leaf and shoot K content (%) of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Leaf K content (%)						Shoot K content (%)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	0.88	1.14	1.01	0.90	1.45	1.18	0.56	0.72	0.64	0.35	0.36	0.36
Humic acid	1.33	1.47	1.40	1.32	1.83	1.57	1.11	1.25	1.18	0.55	0.84	0.69
Uni-Sal	1.54	1.53	1.54	1.60	2.20	1.90	1.32	1.46	1.39	0.78	1.04	0.91
Sulphur	0.99	1.19	1.09	1.00	1.65	1.33	1.06	0.97	1.02	0.39	0.39	0.39
Mycorrhizae	1.07	1.45	1.26	1.30	1.79	1.55	1.00	1.20	1.10	0.52	0.43	0.48
Mean	1.16	1.36		1.23	1.78		1.01	1.12		0.52	0.61	
LSD at 5%												
Rootstocks(A)		0.10			0.08			0.08			0.11	
Treatments(B)		0.13			0.13			0.13			0.18	
A X B		0.18			0.18			0.18			0.26	

Table 17: Effect of some saline tolerance treatments on root K and leaf Ca contents (%) of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Root K content (%)						Leaf Ca content (%)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	0.46	0.45	0.45	0.45	0.38	0.42	2.21	1.80	2.01	1.49	1.28	1.39
Humic acid	0.58	0.51	0.54	0.52	0.47	0.50	3.05	2.17	2.61	2.01	2.25	2.13
Uni-Sal	0.62	0.64	0.63	0.54	0.70	0.62	3.37	2.33	2.85	2.09	2.37	2.23
Sulphur	0.46	0.47	0.46	0.48	0.41	0.44	3.05	2.09	2.57	1.77	1.45	1.61
Mycorrhizae	0.47	0.49	0.48	0.48	0.42	0.45	2.33	2.17	2.25	1.77	1.69	1.73
Mean	0.52	0.51		0.50	0.48		2.80	2.11		1.83	1.81	
LSD at 5%												
Rootstocks(A)		0.008			0.008			0.11			0.01	
Treatments(B)		0.07			0.12			0.18			0.32	
A X B		0.09			0.16			0.25			0.46	

Table 18: Effect of some saline tolerance treatments on shoot and root Ca contents (%) of Salt Creek and Paulsen grapevine rootstocks under saline water conditions.

	Shoot Ca content (%)						Root Ca content (%)					
	Rootstocks (2007)			Rootstocks (2008)			Rootstocks (2007)			Rootstocks (2008)		
Treatments	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean	S.Creek	Paulsen	Mean
Control	2.10	1.73	1.92	1.25	1.22	1.23	1.38	1.18	1.28	1.38	1.28	1.33
Humic acid	2.41	3.25	2.83	1.69	2.01	1.85	2.01	1.93	1.97	1.85	1.45	1.65
Uni-Sal	3.37	3.86	3.61	1.93	3.45	2.69	2.25	2.09	2.17	2.09	1.61	1.85
Sulphur	2.17	1.77	1.97	1.45	1.45	1.45	1.61	1.37	1.49	1.61	1.36	1.49
Mycorrhizae	2.37	2.01	2.19	1.48	1.45	1.47	1.85	1.37	1.61	1.81	1.37	1.59
Mean	2.48	2.52		1.56	1.92		1.82	1.59		1.75	1.41	
LSD at 5%												
Rootstocks(A)		0.02			0.16			0.07			0.15	
Treatments(B)		0.27			0.26			0.12			0.25	
A X B		0.38			0.36			0.16			0.35	

Potassium and Calcium Contents: Tables 16, 17 and 18 illustrate that plant K and Ca contents were significantly increased by Uni-Sal treatment in both seasons compared to other treatments. Furthermore, humic acid treatment also significantly increased K content compared to control plants except for root K content in the second season. Also, 1103Palusen rootstock tended to K accumulate more than Salt Creek rootstock which had significant leaf K content in both seasons. Moreover, Uni-Sal treatment gave the best Ca significant value beside humic acid compared to untreated plants. Also, leaf and root Ca contents of Salt Creek rootstock gave the highest significantly values in the first season compared to 1103P rootstock. Concerning the interaction between rootstock and treatments, it was observed that highest K and Ca contents was obtained by 1103Paulsen and Salt Creek rootstocks with Uni-Sal in both seasons.

The obtained results are in agreement with those of Walker *et al.* [18] who concluded that 1103 Paulsen rootstock was the best chloride excluder based on the lowest concentration of accumulated Cl in petioles compared with Salt Creek rootstock. Also, Ahmed [5] mentioned that transplants of 1103 Paulsen appeared to be more tolerated to salinity stress than 5C Teleki and Harmony rootstocks.

Eissa *et al.* [53] reported that 1103 Paulsen contained lower leaf and root chloride and sodium values than Harmony, Dogridge rootstocks and Thompson Seedless. Moreover, Gendiah [9] reported that SEEADW combined with mycorrhizae not only improved vegetative growth but also reduced both sodium and chloride concentrations and their uptake by plants. Kaya *et al.* [31] reported that sodium concentration was increased in leaves and roots in both grapevine cultivars in the presence of NaCl stress. While supplementary Ca lowered Na concentration in all parts of the tested plants, but leaf and root Na concentrations in all cases remained significantly higher than in the controls. They concluded that the decrease in leaf Na may partially be explained by a dilution effect. The ability of Ca to ameliorate the negative effects of salinity is through its role in reducing Na uptake and increasing K and Ca uptake, resulting in increasing plant growth [36]. Furthermore, Kaya *et al.* [31] reported that, supplementary Ca resulted in increased values for daily water use which was very close to those for unstressed plants. This indicated that this treatment is restoring normal growth by negating the effects of salinity. Beside Ca, the higher viscosity of Uni-Sal treatment with irrigation by water containing higher NaCl may be the primary factor contributing to a diminution of water flow through roots [39]. Also, Sanchez *et al.* [54] found a decrease in grape sodium levels when he used humic acid as a chlelate to improve the uptake of iron by plants. Humic substances are relatively stable products of organic matter [55], the accumulation of organic matter increases moisture retention and nutrient supply potentials of sandy soils [22]. The symbiosis of arbuscular mycorrhizae (AM) with the host plant and hence the production of a very extensive network of hypha, improves plant nutrient uptake and photosynthesis in the host plant [56]. Rizk-Alla *et al.* [4] reported that application of Nile fertile containing 35% sulphur caused a pronounced increase in K content in the roots comparing with irrigation with saline water only.

This study showed the benefit effect of Uni-Sal or humic substances treatments in alleviating the adverse effect of salinity on grapevine rootstocks under saline water conditions.

REFERENCES

1. Vivier, M.A. and I.S. Pretorius, 2002. Genetically tailored grapevines for the wine industry. Trends Biotechnol., 20: 472-478.
2. FAO, 2010. FAO stat. data, http://faostat.fao.org
3. Hawker, J.S. and R.R. Walker, 1978. The effect of sodium chloride on the growth and fruiting of *Cabernet sauvignon* vines. Amer. of Enol. and Viticul., 29: 172-176.
4. Rizk-Alla, M.S., M.A. Abd El-Wahab and G.F. Ghobrial, 2006. Alleviating the harmful effects of irrigation water salinity on Thompson Seedless grape rootings through the application of Nile fertile as a neutral soil conditioner. Egypt. J. Appl. Sci., 21: 239-257.
5. Ahmed, O.A., 2007. Studies on salt tolerance and nematode resistance of some grape rootstocks. Ph.D. Thesis, Fac. Agric., Cairo Univ., Egypt.
6. Abou Sayed, A.T. A., A.S. Hassan, S.A. Nomir and I.E. Othman, 2000. Studies on relative salt tolerance of seven grape varieties: II-leaf characteristics. Zagazig J. Agric. Res., 27: 331-351.
7. Abou Sayed, A.T.A., A.S. Hassan, S.A. Nomir and I.E. Othman, 2000. Studies on relative salt-tolerance of seven grape varieties: I- Growth vigor. Zagazig J. Agric. Res., 27: 353-370.
8. Eissa, A.M., M.N. Haggag, M.B. El-Sabrout and M.E. Abd El-Rahman, 2003. Effect of some sodium salts on the growth, miniral composition and organic content of some grape rootstocks: I- the growth. J. Agric. Sci. Mansoura Univ., 28: 6821-6839.

9. Gendiah, H.M., 1998. Growth and nutritional status of grape rooted cuttings as affected by the irrigation sources and mycorrhizal fungi inoculation. Annals of Agric. Sci. Moshtohor, 36: 2487-2502.
10. Fisarakis, I., K. Chartzoulakis and D. Stavrakas, 2001. Response of Sultana vines (*V. vinifera* L.) on six rootstocks to NaCl salinity exposure and recovery. Agricultural Water Manage., 51: 13-27.
11. Sourial, G.F., N.A. Rizk, R.A. Al-Ashkar and G.H. Sabry, 2004. A comparative study on salt tolerance of Dogridge rootstock and Thompson Seedless grape variety. Zagazig J. Agric. Res., 31: 31-60.
12. Kamel, A.M., A.M. Rokba, A.A. Abd El-Kawy and E. El-Menshawy, 1977. Studies on the tolerance of some grape rootstocks and varieties to adverse environmental conditions. Agric. Res. Rev., 55: 31-38.
13. Khanduja, S.D., K.N. Chaturvedi and V.K. Garg, 1980. Effect of exchangeable sodium percentage on the growth and miniral composition of Thompson Seedless grapevines. Sci. Hort., 12: 47-53.
14. Bernstein, L., C.F. Ehlig and R.A. Clark, 1969. Effect of grape rootstocks on chloride accumulation in leaves. J. Amer. Soc. Hort. Sci., 94: 584-590.
15. Sauer, M.R., 1968. Effects of vine rootstocks on chloride concentration in Sultana scions. Vitis., 7: 223.
16. Flowers, T.J., P.F. Troke and A.R. Yeo, 1977. The mechanism of salt tolerance in halophytes. Ann. Rev. Plant Physiol., 28: 89-121.
17. Huglin, P., 1986. Biologie et Ecologie de la Vigne. Payot (Eds.), Lausanne, Paris, pp: 372.
18. Walker R.R., D.H. Blackmore, P.R. Clingeleffer and P.R.L. Correll, 2004. Rootstock effects on salt tolerance of irrigated field-grown grapevines (*Vitis vinifera* L. cv. Sultana) 2. Ion concentrations in leaves and juice. Australian Journal of Grape and Wine Res., 10: 90 - 99.
19. Maas, H. and D. Klambt, 1977. Cytokinin effect on protein synthesis *in vivo* in higher plants. Planta, 133: 117-120.
20. Mostafa, M.A., A.M. El-Gala, M.M. Wassif, S.E. El-Maghraby and M.H. Hilal, 1992. Distribution of some micronutrients through a calcareous soil column under sulphur and saline water application. Soil Dept. Fac. Agric. Ain Shams Univ. Cairo, Egypt. Proceeding Middle East Sulphur Symposium, pp: 263-276.
21. Stevenson, F.J., 1994. Humus Chemistry: Genesis, Composition, Reactions. Wiley, New York, pp: 496.
22. Suganya, S. and R. Sivasamy, 2006. Moisture retention and cation exchange capacity of sandy soil as influenced by soil additives. J. Appl. Sci. Res., 2: 949-951.
23. Demir, K., A. Gunes, A. Inal and M. Alpasan, 1999. Effects of humic acid on the yield and mineral nutrition of cucumber (*Cucumis sativus* L.) grown with different salinity levels. Acta Hort., 492: 95-104.
24. Casierra-Posada, F., C.A. Rodríguez and G. Fischer, 2009. Reducing negative effects of salinity in Tomato (*Solanum lycopersicum* L.) plants by adding leonardite to soil. Acta. Hort., 821: 133-140.
25. Asik, B.B., M.A. Turan, H. Celik and A.V. Katkat, 2009. Effects of humic substances on plant growth and mineral nutrients uptake of wheat (*Triticum durum* cv. Salihli) under conditions of salinity. Asian J. Crop Sci., 1: 87-95.
26. Giri, B. and K.G. Mukerji, 2004. Mycorrhizal inoculant alleviates salt stress in *Sesbania aegyptica* and *Sesbania grandiflora* under field condition: evidence for reduced sodium and improved magnesium uptake. Mycorrhiza, 14: 307-312.
27. Miransari, M., H.A. Bahrami, F. Rejali and M.J. Malakouti, 2008. Using arbuscular mycorrhiza to reduce the stressful effects of soil compaction on wheat (Triticum aestivum L.) growth. Soil Biol. Biochem., 40: 1197-1206.
28. Al-Karaki, G.N., 2006. Nursery inoculation of tomato with arbuscular mycorrhizal fungi and subsequent performance under irrigation with saline water. Sci. Hort., 109: 1-7.
29. Azcon-Aguilar, C. and J.M. Barea, 1997. Applying mycorrhiza biotechnology to horticulture: significance and potentials. Sci. Hort., 68: 1-24.
30. Gaines, A.M. and C. Shennanb, 1999. Interactive effects of Ca^{+2} and NaCl salinity on the growth of two tomato genotypes differing in Ca^{+2} use efficiency. Plant Physiol. Biochem., 37: 569-576.
31. Kaya, C., H. Kirnak, D. Higgs and K. Saltali, 2002. Supplementary calcium enhances plant growth and fruit yield in Strawberry cultivars grown at high NaCl salinity. Scientia Horticulturae, 93: 65-74.
32. Navarro, J.M., V. Martinez and V. Carvajal, 2000. Ammonium, bicarbonate and calcium effects on tomato plants grown under saline conditions. Plant Sci., 157: 89-96.
33. Cramer, G.R., A. Lauchli and E. Epstein, 1986. Effects of NaCl on ions activities in complex nutrient solutions and root growth in cotton. Plant Physiol., 81: 792-797.

34. Busch, D.S., 1995. Calcium regulation in plant cell and his role in signaling. Annu. Rev. Plant physiol., 46: 95-102.
35. Silva, C., F.J. Aranda, A. Ortiz, M. Carvajal, V. Martinez and J.A. Teruel, 2007. Root plasma membrane lipid changes in relation to water transport in pepper are response to NaCl and $CaCl_2$ treatment. J. Plant Biol., 50: 650-657.
36. Rengel, Z., 1992. The role of calcium in salt toxicity. Plant Cell Environ., 15: 625-632.
37. Perez-Alfocea, F., M.T. Estan, M. Caro and G. Guerrier, 1993. Osmotic adjustment in *Lycopersicon esculentum* and *L. penneli* under NaCl and polyethylene glycol 6000 iso-osmotic stress. Plant Physiol., 87: 493-498.
38. Pandey, R. and R.M. Agarwal, 1998. Water stress-induced changes in proline contents and nitrate reductase activity in rice under light and dark conditions. Physiol. Mol. Biol. Plants, 4: 53-57.
39. Slama, I., T. Ghnaya, K. Hessini, D. Messedi, A. Savoure and C. Abdelly, 2007. Comparative study of mannitol and PEG osmotic stress effects on growth, proline and soluble sugars accumulation in *Sesuvium portulacastrum*. Environmental and Experimental Botany, 61: 10-17.
40. Ahmed, F.F., M.A. El-Sayed and M.A. Mohamed, 1991. Effect of soil application of some sulphur containing fertilizers on the yield and quality of Red Roomy grapevines. Minia J. Agric. Res. and Develop., 13: 633-648.
41. Daft, M.J. and B.C. Hogarth, 1983. Competitive interaction among four species of Glomus on Maize and Onion. Trans. Brit. Myol. Soc., 80: 339-345.
42. Tannant, D., 1975. A test of a modified line interact method of estimating root length. J. Ecol., 63: 995-1001.
43. Bates, L.S., R.P. Waldern and L.D. Teare, 1973. Rapid determination of free proline for water-stress studies. Plant and soil, 939: 205-207.
44. Jackson, M.L., 1958. Soil chemical analysis. Constable and Co. Ltd. London, pp: 498.
45. Brown, J.D. and O. Lilleland, 1946. Rapid determination of Potassium and sodium in plant material and soil extract by flame photometery. Proc. Amer. Soc. Hort. Sci., 73: 813.
46. Snedecor, G.W. and W.G. Cochran, 1980. Statistical methods. 7th ed. Iowa State Univ. Press, Iowa, U.S.A.
47. Ismail, M.A.A., 1996. Studies on tolerance of some grapevine cultivars to stress. Ph.D. Thesis, Fac. Agric., Cairo Univ., Egypt.
48. Gaser, A.S., 1999. Effect of saline irrigation water on three grape cultivars. Annals of Agric. Sci. Moshtohor, 37: 2715-2734.
49. Gendiah, H.M., 1991 Stimulating root growth of grape hardwood cuttings by using endomycorrhizal fungi. Annals of Agric. Sci. Moshtohor, 29: 1713-1723.
50. Awad, S.M., 1999. Response of Flame grape transplants to mycorrhizal inoculation and phosphorus fertilization. Egypt. J. Hort., 26: 421-433.
51. Gaser, A.S., 1992. Salt tolerance of some grapevine rootstocks. Ph.D. Thesis, Fac. Agric., Cairo Univ., Egypt.
52. Stewart, G.R. and J.A. Lee, 1974. The role of proline accumulation in halophytes. Planta, 120: 279-289.
53. Eissa, A.M., M.N. Haggag, M.B. El-Sabrout and M.E. Abd El-Rahman, 2003. Effect of some sodium salts on the growth, mineral composition and organic content of some grape rootstocks: II- The mineral composition. J. Agric. Sci. Mansoura Univ., 28: 6841-6864.
54. Sanchez-Sanchez, A., J. Sanchez-Andreu, M. Jurez, J. Jord and D. Bermdez, 2006. Improvement of iron uptake in table grape by addition of humic substances. J. of Plant Nutrition, 29: 259-272.
55. Mackowiak, C. L. Grossl, P.R. and B.G. Bugbee, 2001. Beneficial effects of humic acid on micronutrient availability to wheat. Soil Sci. Soc. Am. J., 65: 1744-1750.
56. Mukerji, K.G. and B.P. Chamol, 2003. Compendium of mycorrhizal research, A. P. H. Publisher, New Delhi, pp: 310.