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Relative Comparison Salinity Stress Tolerance for "Manfaluty" and "Wonderful" Pomegranate Cultivar Transplants

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THE goal was to evaluate the response of pomegranate cultivar transplants "Manfaluty" and "Wonderful" for salinity stress. A pot investigation was conducted during (2016 and 2017) seasons in a glasshouse, Faculty of Agriculture, Ain Shams Univ., Shoubra El- Kheima, Egypt. Pots were arranged in a randomized complete design with two factors, the first one was pomegranate cultivars which included two cultivars namely (Manfaluty and Wonderful) and the second factor was NaCl levels whereas, transplants were irrigated with five levels of water salinity (0, 20, 40, 60, and 80 mM NaCl). It could be summarized results in some main points:

- Both pomegranate cultivars were moderately resistant to salinity up to 40 Mm NaCl with slight growth reduction.

-More increase in salinity level up to 60 and 80 mM NaCl reduction growth around 50-70% compared with untreated transplants. Generally, "Manfaluty" had a slightly higher reduction in growth than "Wonderful".

-Increasing salinity levels caused a significant reduction in leaf K content otherwise Na was accumulated in the leaves of both 'pomegranate cultivars.

-Proline leaves content, increased gradually by the increase in salinity levels up to (60 mM NaCl), and the highest significant values of proline content were obtained when combing (60mM NaCl) with "Wonderful".

So it could be concluded that, increasing salinity level more than 40 mM NaCl will inhibit pomegranate growth and make an imbalance of nutrient status in pomegranate transplants with slight differences between the response of two cultivars.

Keywords: Growth reduction, Ion accumulation, Manfaluty pomegranate, Nacl, Proline, Salt stress, Transplants, Wonderful pomegranate .

Introduction

Water and food are the major requirements for all creature's life. The obtainability of them became difficult as result to the increment rate of the residents. Water cost required per unit of food is excess additionally the quantity and quality of water are reducing day after day (Tuteja, 2007). Irrigation methods have become a necessary factor for agriculture in arid and semi-arid zones. At present, around one-third of the irrigated land is suffering from increment salinity in the soil solution (Prasad et al., 2003). Therefore, salinity is an ever-present challenge to agriculture, especially in arid and semi-arid regions such as those located in the Mediterranean area where secondary salinization has increased through irrigation (Flowers and Flowers, 2005). Pomegranate trees have been commonly cultivated in poor soil in arid and semi-arid regions, areas greatly affected by high salinity stress (Naeini et al., 2006).

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Famous pomegranate cultivars were found in many continents all over the world, including Europe, Asia, and North Africa (Holland et al., 2009). in Egypt, new reclamation land mainly cultivated by "Wonderful" cv while the local pomegranates cultivars were grown at the Assuit governorate. The common Egyptian pomegranate cultivars called 'Arabi', 'Manfaloty', 'Nab ElGamal', and 'Wardy' (Abo-Taleb et al. 1998; Saeed 2005). 'Manfaloty' (or 'Manfaloot') trees have large & juicy dark-red arils and ripe from the end of August or the beginning of September (Van der Wiel 2000 "Wonderful" cultivar is considered the most important cultivar in the USA (LaRue 1980). "Wonderful" cultivar has large fruit with red arils, sweet-sour taste, and semi hard seeds (Stover and Mercure 2007). Few literatures reported that pomegranate trees were relatively tolerant to salinity stress with a difference between cultivars (Bhantana and Lazarovitch, 2010 and El-Khawaga et al., 2013) In general, fruit trees were very sensitive to soil salinity whereas, (EC) = 4 mS cm^{-1} of soil extract is considered as critical level in fruit orchards.

An electric conductivity (EC) of 4 mS cm^{-1} of soil extract is considered as critical in fruit orchards. From many research papers it was notable that fruit trees were irrigated with water should not exceed 2 mS cm^{-1}. However, pomegranate is considered to be moderately sensitive to salinity (EC = 3 mS cm^{-1}). (Elias et al., 2011)

Consequently, pomegranate growers interest to increase his planting area by introducing new cultivars such as "Wonderful" to replace the old local ones. Therefore, the present investigation aimed to evaluate and compare the salinity tolerance between the most common traditional Egyptian pomegranate cultivar namely, "Manfaluty" and the newly introduced cultivar "Wonderful" to determine the most promising cultivar for salinity.

Materials and Methods

A pot investigation was conducted (2016 and 2017) seasons in a glasshouse, Faculty of Agriculture, Ain Shams Univ., Shoubra EL- Kheima, Egypt. Pots were arranged in a randomized complete design with two factors, the first one was pomegranate cultivars which included two cultivars namely (Manfaluty and Wonderful) and the second factor was NaCl levels whereas, transplants were irrigated with five levels of water salinity (0, 20, 40, 60, and 80 mM NaCl). Each treatment had 5 replicates and each replicate included one transplant. In the second week of February from each season, 25 one-year-old transplants from each cultivar were planted in plastic containers (35 cm in diameter and 30 cm in length), filled with sand which was previously treated with 10% commercial hydrochloric acid for 24 hours, then thoroughly washed with a tap to free it from all solutes and any trace of acid. At planting, for each transplant 2-3 stems were selected and shortened into 50 cm. Transplants were fertilized at 10-day intervals with a commercial fertilizer (19-19-19 NPK) + micro nutrients. The different salinity levels (20, 40, 60, and 80 mM NaCl) were started in late May by adding NaCl to irrigated water used except for control. All treatments were irrigated every other day by a rate of 1 liter/plant.

Measurements

Soil samples: At the end of each growing season (September) soil samples were taken from root system zoon then air-dried and kept in plastic bags. Electrical conductivity was determined in the extract of saturated soil paste according to the method mentioned by Jackson (1973). The pH values were measured in (1:2.5) soil suspension using pH meter according to the method mentioned by Black et al (1965).

Growth measurements: At the end of each season (September) transplants were measured for stem diameter at 5 Cm above the ground surface, stem length, and the total number of leaves. Four leaves from 5-7th leaves from plant top were taken to measure total chlorophyll content by using a Soil Plant Analysis Division (SPAD) – 502 MINOLTA). Plants were taken out and cut into three parts (roots, stem, and leaves). The different fresh samples were washed with distilled water, oven-dried at 60-70°C until constant weight, and then the dry weight of each part was recorded. Thereafter, the dry weight of the total plant was calculated.

Chemical analysis: In mid-June, samples were collected from the 5-7th nodes from the plant top. five leaves from each replicate in each season. The leaf samples were and dried at 70°C. Dry leaves were grounded and digested according to (Jackson, 1973). Leaf mineral content of N, P, K, Na, Fe, Zn, and Mn was determined according to (Cottenie et al., 1982).

Total carbohydrates content: in each season, total carbohydrates content was determined in

stem samples by the phenol sulfuric method according to Dubois et al. (1956) then C/N ratio was calculated as follows: C/N ratio = Total carbohydrates of stem/ total nitrogen of stem.

Proline content: free proline amount (ppm) was measured according to Bates et al. (1973).

Statistical analysis

The obtained data were analyzed of variance by ANOVA techniques was performed using CoStat program Computer Software. Significant differences of the mean values ($P<0.05$ for F-test) were determined by Duncan multiple range tests (Duncan, 1955).

Results and Discussion

Effect on some chemical characteristics of soil samples at the end of experiment

Results in Table 1 show the effect of pomegranate (*Punica granatum* L.) cultivars, salinity levels and their interaction on some chemical characteristics of soil samples at the end of the experiment during 2016 and 2017. Data revealed that in the first season only soil pH and EC were affected significantly by pomegranate cultivars whereas, Wonderful cultivar gave the highest significant value of soil pH and the least value of soil EC. On the other hand, control and low level of salinity L_2 (20 mM NaCl) gave the least significant values of pH, other salinity levels gave more or less pH values with the same statistical standpoint. Regarding the interaction, it seems that the least significant values of pH were recorded by control under two pomegranate cultivars other combinations gave higher values than control treatment but without any significant difference between them. Soil EC was gradually increased significantly by increasing salinity level up to L_5 (80 mM NaCl). Meanwhile, salts accumulated in the root zone of pomegranate transplants irrigated with high saline levels compared with those with control and low levels of saline water. Values of interaction showed that in the two seasons untreated transplants from two cultivars gave the least significant values of EC. In the two seasons, EC values were increased by increasing salinity levels irrespective of the cultivar. Nevertheless, when combined the high level of salinity L_5 (80 mM NaCl) with any cultivar gave higher significant EC values than other combinations. El-Khawaga et al. (2013) noticed that saline groundwater irrigation at EC 1.8 $dS \cdot m^{-1}$ and 6.0 $dS \cdot m^{-1}$ increased salt accumulation in the root zone at a soil depth of 60-90 cm from 3.7 $dS \cdot m^{-1}$ to 4.8 $dS \cdot m^{-1}$ and 7.7 $dS \cdot m^{-1}$ respectively, when pomegranate trees were grown in sandy clay loam soil.

TABLE 1. Effect of pomegranate cultivars and salinity levels on some chemical characteristics of soil samples at the end of the experiment during 2016 and 2017seasons.

Salinity levels	Cultivars					
	M*	W**	Mean	M*	W**	Mean
	Soil pH			Soli EC (dS/m)_		
	2016 season					
L_1:0 (control)	8.50b-d	8.43cd	8.46B\	0.60f	0.61f	0.61E\
L_2:20 mM NaCl	8.20d	8.87a-c	8.53B\	2.32de	2.22e	2.27D\
L_3:40 mM NaCl	9.00a	9.13a	9.06A\	2.64c	2.53cd	2.59C\
L_4:60 mM NaCl	8.90ab	9.23a	9.06A\	3.77b	3.55b	3.66B\
L_5:80mM NaCl	8.90ab	8.94ab	8.92A\	4.89a	4.67a	4.78A\
Mean	8.70B	8.92A		2.84A	2.72B	
	2017 season					
L_1:0 (control)	8.70ab	8.57bc	8.63B\	0.59e	0.64e	0.62E\
L_2:20 mM NaCl	8.37c	8.97ab	8.66B\	2.25cd	2.10d	2.18D\
L_3:40 mM NaCl	9.27a	9.30a	9.28A\	2.55c	2.42cd	2.49C\
L_4:60 mM NaCl	9.00ab	9.27a	9.13A\	3.69b	3.45b	3.57B\
L_5:80mM NaCl	9.33a	9.34a	9.33A\	4.74a	4.59a	4.67A\
Mean	8.93A	9.08A		2.76A	2.64A	

M*: Manfaluty W**: Wonderful

In each season, means of each of cultivars and salinity levels or their interactions having the same letters are not significantly different at 5% level.

Effect on some vegetative growth parameters

Results in Table 2 show the effect of pomegranate (*Punica granatum* L.) cultivars, salinity levels and their interaction on some vegetative growth parameters during 2016 and 2017. Data revealed that in the two growing seasons all vegetative growth parameters of the two pomegranate cultivars (Manfaluty and Wonderful) responded similarly without any significant difference to different saline solution applied. Regarding salinity levels, in most cases L_1 (control) gave the highest significant values of most growth parameters followed closely by L_2 (20 mM NaCl) in the two seasons (2016 and 2017). On the other hand, in the two growing seasons increasing salinity levels up to L_5 (80 mM NaCl) resulted in adverse effects in all growth parameters with some foliar salt damage like leaf burn and necrosis. The interaction revealed that L_1 (control) and L_2 (20 mM NaCl) treatments increased all vegetative growth parameters of two pomegranate cultivars (Manfaluty and Wonderful) in the two seasons followed closely by L_3 (40 mM NaCl) treatment with both pomegranate cultivars. On the other hand, L_4 (60 mM NaCl) and L_5 (80 mM NaCl) treatments had their worst prominent effects on all vegetative growth parameters in both cultivars of pomegranate (Manfaluty and Wonderful) in the two seasons. So it could be concluded that, there were insignificant effect on most vegetative growth parameters of Wonderful cultivar especially in the first season with increasing salinity level up to L_3 (40 mM NaCl), but a decline in vegetative growth occurred at salinity levels higher than L_3 (40 mM NaCl).

In this respect, Sivritepe et al., 2010 observed that leaf chlorophyll content of all grafted grapevines was reduced by salinity. Salt stress was well-known to decrease the life-span of leaves. This reasoned accelerated senescence as a consequence, chlorophyll degradation (Yeo and Flowers, 1984).

Results in Fig.1 show the effect of salinity levels on stem length reduction % of Manfaluty and Wonderful cultivars depending upon the average of the interaction in the two seasons compared with the control. It could be safely concluded that the least reduction in stem length were 3% and 7% for Wonderful and Manfaluty, respectively after exposure to L_2 (20 mM NaCl) whereas, stem length was decreased by 14% and 18% when transplants were supplied with L_3 (40 mM NaCl). Increasing salt stress up to L_4 (60 mM NaCl) reverse the response of two cultivars whereas, stem length was decreased by the rate of 47% and 52% for Manfaluty and Wonderful, respectively More increase in salt stress L_5 (80 mM NaCl) gave the greatest reduction in stem length by the rate of 61% and 70% for Manfaluty and Wonderful, respectively. The foregoing data showed that when treated with L_5 (80 mM NaCl) stem length reduction % decreased by a 60-70% when compared with untreated plants (control).

These results are in line with, Naeini et al. (2006) who observed that 'Malas Torsh' and 'Alak Torsh' pomegranate cultivars had reduced stem length, internode length & number, and leaf surface after exposure to different salinity levels (40, 60, and 80 Mm NaCl). Net productivity and crop yield of pomegranate would be reducing as growth reduction occurred due to salinity. previous work that proved that increasing salinity level would inhibit pomegranate vegetative growth parameters such as shoot length, leaf area and, shoot biomass. (El-Khawaga et al., 2013) worked on seven-year-old 'Manfalouty', 'Wonderful', and 'Nab-Elgamal' pomegranate trees grown in upper Egypt, and they found that higher reduction in growth, flowering, and yield when trees irrigated with saline groundwater at an EC of 6.0 $dS{\cdot}m^{-1}$ than at an EC of 1.8 dS·m–1 (El-Khawaga et al., 2013). While Hasanpour et al. (2015) indicated that high salinity treatment decreased the chlorophyll index and chlorophyll fluorescence of pomegranate trees.

Effect on dry weight of different organs and total plant

Results in Table 3 indicated that, in most cases different organs and total plant dry weight were significantly affected by cultivars, salinity levels, and their interaction in both seasons. The cultivars showed some variation in response to different salinity levels special in the first season whereas, Wonderful superior on Manfaluty pomegranate cultivar in Leaves, stem and total plant dry weights. In both seasons, L_1 (control) gave the highest significant values of different organs and total plant dry weight. It is noticed that different organ and total plant dry weights were decreased gradually by increasing the salinity level up to L_5 (80 mM NaCl). Combing cultivars and salinity levels in both seasons had a significant effect on all dry weight characters. It is observed that, dry weight characters of the two cultivars negatively affected by high salinity levels L_4 and L_5 whereas, moderate levels L_2 and L_3 gave intermediate values between control and high salinity levels L_4 and L_5 treatments.

Results in Fig.2 show the effect of salinity levels on total plant dry weight reduction % of Manfaluty and Wonderful cultivars depending upon the average of the interaction in the two seasons compared with the control. It could be safely concluded that, the least reduction % in total plant dry weight was 15% for Wonderful and 23% for Manfaluty cultivar after exposure to L2 (20 mM NaCl). The greatest reduction % was 67% for Wonderful and 69% Manfaluty cultivar after exposure to L5 (80 mM NaCl). The foregoing data showed that, when treated with L5 (80 mM NaCl) total plant dry weight reduction % decreased by approximately 70% when compared with untreated plants (control).

So it could be concluded that increasing salinity level more than 40 mM NaCl will inhibit pomegranate growth in term of stem length, number of leaves, dry weight of each organ and total plant. Furthermore, in most cases "Manfaluty" pomegranate cultivar had a slightly higher reduction in growth than "Wonderful" pomegranate cultivar when they were irrigated with saline water spiked with 40, 60 or 80 Mm NaCl.

In this respect, Sivritepe et al. (2010) found that salt stress consequential in a reduction in the dry biomass of shoots leaves, and roots of all grapevines scion-rootstock combinations. This results could be explained by Munns (1993), who pointed out that the reduction in plant biomass due to salt stress maybe related to low external water potential, ion imbalance and, toxicity. Grapevines were decreased transpiration and biomass production due to the effect of salt stress on osmotic potential of soil solution. The chemical potential of the saline media primarily created a water potential imbalance between the apoplast and symplast, which lead to a decrease in pressure potential, may be causing a growth reduction (Bohnert et al., 1995).

Effect on some macronutrients content

Results in Table 4 show the effect of pomegranate (*Punica granatum* L.) cultivars, salinity levels and their interaction on some macronutrients content in leaves during 2016 and 2017 seasons.

Effect on nitrogen content: The cultivars differed in their response to salinity from season to another whereas; Wonderful gave lower values of nitrogen content than Manfaluty in the first season only while in the second season the two cultivars gave insignificant difference between them. Data indicated that, salinity levels affected significantly on leaves N content during the two seasons. The least values of N content were observed by the highest levels of salinity during the two seasons, other salinity levels gave more or less similar values without any significant difference between them except L_4 (60 mM NaCl) in the first season. The interaction pointed out that, with increasing salinity level, leaves N content of the two cultivars affected insignificantly up to L_4 (60 mM NaCl) but more increase in salinity level L_5 (80 mM NaCl) reduced N content and gave the least significant values of leaves N content under the two cultivars.

Effect on phosphorus content: Results showed that in the two growing seasons phosphorus content was affected significantly by salinity levels only. Control gave the least significant values of P content followed by L_3 (40 mM NaCl) and L_5 (80mM NaCl). On the other hand, the second and the fourth levels of salinity (20 and 60 mM NaCl) gave the highest significant values of P content during the two growing seasons.

Effect on potassium and sodium content: In general, cultivars caused no significant differences in the accumulation of K and Na ions in the leaves after exposure to different salinity levels. Increasing salinity levels caused a significant reduction in leaf K content otherwise Na was accumulated in the leaves of both 'pomegranate cultivars.

In this respect, high salinity levels increased sodium content and decreased potassium and calcium content in the cytosol. So, plants suffer from high Na connect due to disruption of ionic balance, damaging of enzyme function, osmotic impairment, membrane damage, growth reducing by inhibiting cell division and expansion. Also, high Na content leads to a reduction in photosynthesis (Mahajan and Tuteja, 2005). Moreover, reduction in leaf K content may be a strategy for trees to decrease salt stress as K plays an essential role in adjusting the osmotic potential of plant cells and also activating enzymes controlled on respiration and photosynthesis (Taiz and Zeiger, 2015)

TABLE 2. Effect of pomegranate cultivars and salinity levels on some vegetative growth parameters during 2016 and 2017seasons.

Salinity levels	Cultivars											
	M*	W**	Mean	M*	W**	Mean	M*	W **	Mean	M*	W**	Mean
	Stem diameter (Cm)			Stem length (Cm)			Leaves number			Leaf chlorophyll (SPAD)		
2016 season												
L_1:0 (control)	0.62ab	0.68a	0.64A\	132.0ab	142.7a	137.0A\	251.7ab	275.7a	263.7A\	66.0a	62.9a	64.4A\
L_2:20 mM NaCl	0.54b	0.59ab	0.56B\	122.3b	142.3a	132.3A\	220.7b	248.0ab	234.3B\	62.8a	59.5a	61.2AB\
L_3:40 mM NaCl	0.51b	0.61ab	0.56B\	115.0b	122.7b	118.8B\	233.3b	242.7ab	238.0B\	60.4a	61.1a	60.8B\
L_4:60 mM NaCl	0.35c	0.33c	0.34C\	79.7c	76.0c	77.8C\	172.7c	174c	173.3C\	41.3bc	44.0b	42.7C\
L_5:80mM NaCl	0.23cd	0.20d	0.21D\	55.0d	46.7d	50.8D\	96.3d	89.7d	93.0D\	37.3c	35.7c	36.5D\
Mean	0.45A	0.48A		100.8A	106.0A		194.9A	206.0A		53.6A	52.6A	
2017 season												
L_1:0 (control)	0.58a	0.68a	0.62A\	151.7a	147.7a	149.7A\	265.0a	273.3a	269.0A\	68.3a	69.3a	68.8A\
L_2:20 mM NaCl	0.61a	0.60a	0.60A\	141.3ab	140.0ab	140.7A\	230.7bc	250.0ab	240.3B\	65.7ab	64.0a-c	64.8B\
L_3:40 mM NaCl	0.56a	0.62a	0.56A\	117.7c	125.0bc	121.3B\	220.0c	218.3c	219.1C\	60.5bc	58.8c	59.7C\
L_4:60 mM NaCl	0.30b	0.27b	0.28B\	72.0d	62.0d	67.0C\	103.0d	103.0d	103.0D\	44.3d	43.0d	43.6D\
L_5:80mM NaCl	0.32b	0.21b	0.26B\	55.3de	41.3e	48.3D\	90.3d	85.7d	88.0E\	31.0e	31.0e	31.0E\
Mean	0.47A	0.48A		107.6A	103.2A		181.8A	186.0A		54.0A	53.2A	

M*: Manfaluty W**: Wonderful

In each season, means of each of cultivars and salinity levels or their interactions having the same letters are not significantly different at 5% level.

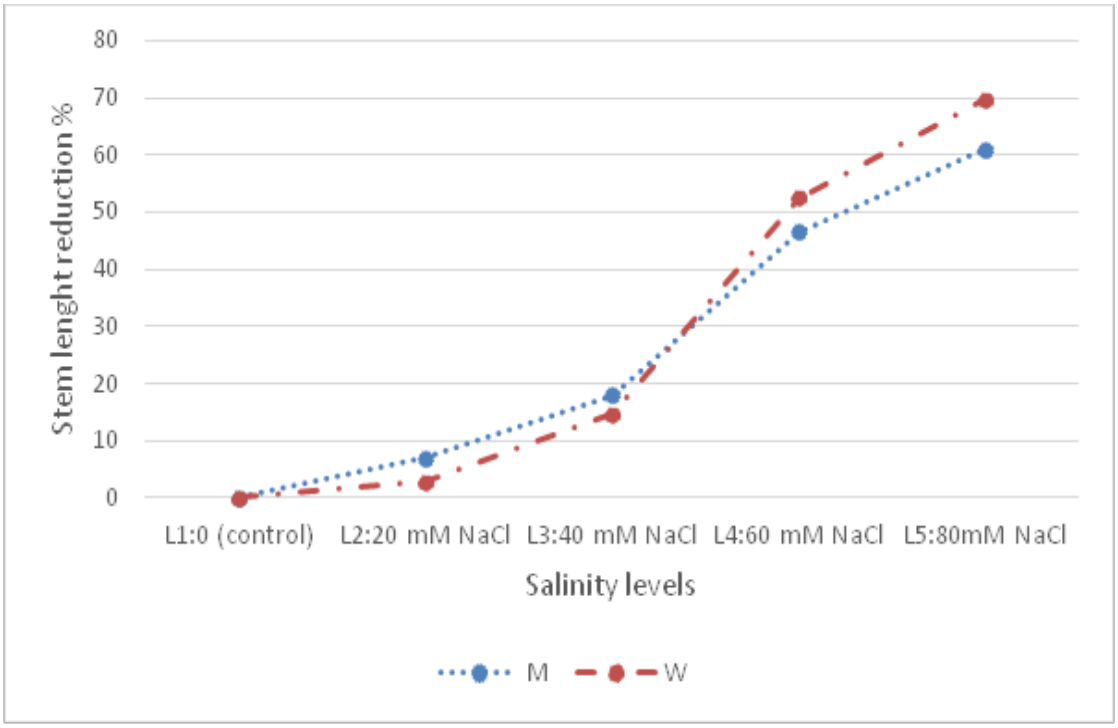

Fig. 1. Effect of salinity levels on stem length reduction % of Manfaluty and Wonderful pomegranate cultivars depending upon the average of the interaction in the two seasons compared with the control.

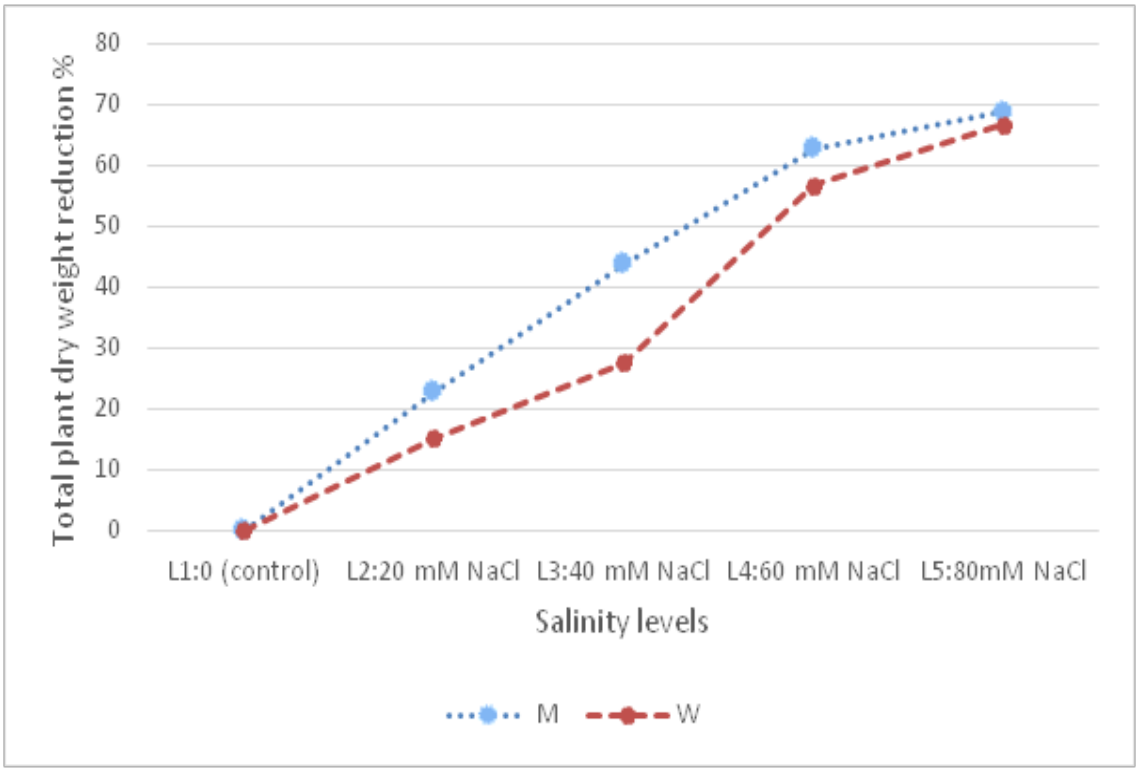

Fig. 2. Effect of salinity levels on total plant dry weight reduction % of Manfaluty and Wonderful pomegranate cultivars depending upon the average of the interaction in the two seasons compared with the control.

TABLE 3. Effect of pomegranate cultivars and salinity levels on dry weight of different organs and total plant during 2016 and 2017seasons.

Salinity levels	Cultivars											
	M*	W**	Mean	M*	W**	Mean	M*	W **	Mean	M*	W**	Mean
	Leaves dry weight (g)			Stem dry weight (g)			Root dry weight (g)			Total plant dry weight (g)		
2016 season												
L_1:0 (control)	9.90a	9.11b	9.50A\	42.92a	41.29ab	42.10A\	16.81a	16.16a	16.48A\	69.63a	66.56a	68.09
L_2:20 mM NaCl	6.12d	7.28c	6.70B\	34.30b	34.64ab	34.46B\	10.30b	10.73b	10.51B\	50.72b	52.66b	51.68B
L_3:40 mM NaCl	6.01d	7.43c	6.72B\	17.70c	33.00b	25.34C\	7.14c	8.33bc	7.73C\	30.85c	48.76b	39.80C
L_4:60 mM NaCl	5.00e	5.21e	5.10C\	14.61c	16.67c	15.64D\	6.89c	7.95bc	7.42C\	26.50cd	29.83c	28.16
L_5:80mM NaCl	4.73e	4.72e	4.72C\	12.67c	11.00c	11.83D\	5.83c	6.33c	6.08C\	23.23cd	22.06d	22.64E
Mean	6.35B	6.75A		24.43	27.31A		9.39A	9.90A		40.18B	43.97	
2017 season												
L_1:0 (control)	12.00a	10.67b	11.33	46.67a	38.33bc	42.50	18.65a	17.00a	17.82A\	77.31a	66.00b	71.65
L_2:20 mM NaCl	8.60cd	9.67bc	9.13B\	43.67ab	39.00bc	41.30	10.47bc	11.00b	10.73B\	62.73b	59.67b	61.20B
L_3:40 mM NaCl	7.33de	7.67d	7.50C\	36.33cd	31.00d	33.66	8.00de	8.57cd	8.28C\	51.67c	47.23c	49.45C
L_4:60 mM NaCl	7.67d	6.16ef	6.90C\	13.33e	13.67e	13.50	7.08d-f	7.62d-f	7.34C\	28.08d	27.45d	27.76
L_5:80mM NaCl	5.27f	5.27f	5.20D\	11.00e	11.00e	11.00	6.33ef	5.75f	6.04D\	22.60d	22.02d	22.30E
Mean	8.17A	7.88A		30.20A	26.60		10.10A	9.98A		48.47A	44.47B	

M*: Manfaluty W**: Wonderful

In each season, means of each of cultivars and salinity levels or their interactions having the same letters are not significantly different at 5% level.

TABLE 4. Effect of pomegranate cultivars and salinity levels on some leaves macronutrients content during 2016 and 2017seasons.

Salinity levels	Cultivars											
	M*	W**	Mean	M*	W**	Mean	M*	W**	Mean	M*	W**	Mean
	N %			P %			K %			Na %		
2016 season												
L_1:0 (control)	1.80a	1.91a	1.85A	0.114a	0.118a	0.116D|	0.759a-c	0.744a-d	0.752A|	0.064a	0.072a	0.068E|
L_2:20 mM NaCl	1.98a	1.93a	1.95A	0.147a	0.182a	0.165AB	0.764a-c	0.800a	0.782A|	0.090a	0.093a	0.092D|
L_3:40 mM NaCl	1.82a	1.71a	1.76A	0.163a	0.110a	0.137C|	0.738a-d	0.770ab	0.754A|	0.107a	0.120a	0.114C|
L_4:60 mM NaCl	1.80a	1.25b	1.52B	0.167a	0.182a	0.175A|	0.676de	0.692c-e	0.684B|	0.108a	0.139a	0.124B|
L_5:80mM NaCl	1.27b	1.18b	1.22C	0.140a	0.158a	0.149BC|	0.650e	0.697b-e	0.674B|	0.147a	0.146a	0.146A|
Mean	1.73A	1.59B		0.146A	0.150A		0.752A	0.741A		0.103B	0.114A	
2017 season												
L_1:0 (control)	1.95a	1.92a	1.93A|	0.119a	0.126a	0.122C|	0.733ab	0.728ab	0.731AB	0.071a	0.061a	0.066C|
L_2:20 mM NaCl	1.93a	1.91a	1.91A|	0.150a	0.175a	0.163A|	0.754ab	0.785a	0.770A|	0.096a	0.071a	0.084C|
L_3:40 mM NaCl	1.82a	1.80a	1.80A|	0.149a	0.120a	0.135BC|	0.712ab	0.785a	0.749AB	0.121a	0.091a	0.106B|
L_4:60 mM NaCl	1.71a	1.78a	1.74A|	0.162a	0.178a	0.170A|	0.712ab	0.728ab	0.720AB	0.139a	0.114a	0127A|
L_5:80mM NaCl	1.32b	0.967b	1.20B|	0.145a	0.149a	0.147B|	0.666b	0.718ab	0.692B|	0.146a	0.139a	0.143A|
Mean	1.74A	1.70A		0.145A	0.150A		0.715A	0.749A		0.115A	0.095A	

M*: Manfaluty W**: Wonderful

In each season, means of each of cultivars and salinity levels or their interactions having the same letters are not significantly different at 5% level.

Also, this results are similar to previous studies done on pomegranate tress by Okhovatian-Ardakani et al. (2010), Khayyat et al. (2016) and (Karimi and Hassanpour 2017) they all observed an increase in Na in leaf tissue with increasing NaCl concentration in irrigation water. This result proved that pomegranate trees had high ability to minimize Na transportation into the shoots to decrease foliar salt damage (Karimi and Hassanpour, 2014).

Effect on some micronutrients content

Results in Table 5 show the effect of pomegranate (*Punica* granatum L.) cultivars, salinity levels and their interaction on some micronutrients content in leaves during 2016 and 2017 seasons.

Data revealed that, Manfaluty cultivar gave significant lower values of iron and zinc than Wonderful cultivar in the first season whereas, in the second season two cultivars showed no significant differences in Fe, Zn and Mn leaves content after supplied with different salinity levels. Data indicated that, salinity levels affected significantly on Zn content in the second season and Mn content in the two seasons, whereas the high salinity levels (L_5:80mM NaCl) gave the least significant values of Zn and Mn content. Regarding the interaction in general, NaCl salinity levels did not affect the leaves Fe, Zn and Mn content in two pomegranates cultivars except some exceptions like, Zn content in leaves of two pomegranate cultivars treated by high level of NaCl (L_5:80mM NaCl) which gave the least significant values in the second seasons.

In this respect, High ions concentration of leaves could be benefit for plants if the ions were compartmentalized. As the vacuole can make up approximately 90% of the mature cell volume, ions could act as "cheap osmolytes" in the vacuole (Cramer et al., 2007). Sivritepe et al., (2010) proved that NaCl salinity lead to significant N, P, Mg, Fe, Mn and Zn accumulation in the leaves of all grafted grapevines.

Effect on stem total carbohydrate, total nitrogen and C/N ratio

Results in Table 6 show the effect of two cultivars, salinity levels and their interaction on total carbohydrate, total nitrogen and C/N ratio in stems of pomegranate trees in 2016 and 2017 seasons. Results indicated that values of total carbohydrates, total N and C/N ratio were significantly affected by cultivars, salinity levels and their interaction.

The significant highest values of total carbohydrate, and C/N ratio were obtained by Wonderful cultivar during two seasons. Regarding salinity levels, it is observed that the highest significant values of three characters were recorded by control followed closely by L_2 (20 mM NaCl). On the other hand, increasing salinity levels up to L_5 (80 mM NaCl) gradually decreased total carbohydrate, total nitrogen, and C/N ratio. Concerning the interaction, it is observed that, total carbohydrate, total nitrogen, and C/N ratio of the two cultivars passively affected by high salinity levels L_4 and L_5 whereas, moderate level L_3 gave intermediate values between (control & L_2) and (L_4 & L_5) treatments**.**

(Patakas et al., 2002) pointed out that, production of sufficient organic osmotic was metabolically costly and probably limited plant growth by using significant quantities of carbon that could be used for plant growth.

Effect on proline content

Results in Table 7 show the effect of pomegranate (*Punica granatum* L.) cultivars, salinity levels and their interaction on proline content in leaves during 2016 and 2017 seasons.

Data revealed that in most cases, the cultivars showed no significant differences in proline leaves content after supplied with different salinity levels. Proline leaves content, as an important factor affecting the resistance to stress, increased gradually by the increase in salinity levels up to L_4 (60 mM NaCl). On the other, the high level of salt L_5 (80 mM NaCl) significantly decreased proline content. The interaction pointed out that, the least significant values of proline content were obtained when combing L_5 (80mM NaCl) with two pomegranate cultivars followed by control treatment also under two pomegranate cultivars whereas, the highest significant values of proline content were obtained when combing L_4 (60mM NaCl) with Wonderful cultivar during the two growing seasons.

In this respect, Misra and Gupta (2005) noticed that stress-tolerant plants had higher proline concentrations than stress-sensitive plants.

TABLE 5. Effect of pomegranate cultivars and salinity levels on some leaves micronutrient content during 2016 and 2017seasons.

Salinity levels	Cultivars								
	M*	W**	Mean	M *	W**	Mean	M*	W**	Mean
	Fe (ppm)			Zn (ppm)			Mn (ppm)		
2016 season									
L_1:0 (control)	136.0ab	144.7ab	140.3A\	11.33a	11.67a	11.50A\	62.67a-c	56.67a-c	59.66A\
L_2:20 mM NaCl	133.3ab	150.7ab	142.0A\	10.33a	12.33a	11.33A\	65.50a	53.33a-c	59.41A
L_3:40 mM NaCl	139.0ab	162.3a	150.7A\	11.00a	13.00a	12.00A\	63.67ab	50.33a-c	57.00A\
L_4:60 mM NaCl	133.0ab	154.0ab	143.5A\	10.67a	12.33a	11.50A\	52.00a-c	51.33a-c	51.66AB\
L_5:80mM NaCl	110.7b	155.7ab	133.2A\	11.00a	12.83a	11.92A\	48.33bc	48.00c	48.16B\
Mean	130.4B	153.4A		10.86B	12.43A		58.43A	51.93B	
2017 season									
L_1:0 (control)	142.7a	179.8a	161.0A\	11.33ab	12.67a	12.00A\	41.47ab	47.20ab	44.33AB\
L_2:20 mM NaCl	191.1a	171.2a	181.0A\	10.93ab	11.33ab	11.13A\	50.80a	48.13a	49.46A\
L_3:40 mM NaCl	204.0a	172.9a	188.0A\	10.80ab	10.67ab	10.73A\	42.13ab	46.13ab	44.13AB\
L_4:60 mM NaCl	161.8a	163.8a	162.0A\	10.20ab	10.67ab	10.43AB\	39.67ab	38.60ab	39.13B\
L_5:80mM NaCl	173.3a	152.7a	163.0A\	8.53b	8.67b	8.60B\	34.00b40b	40.13ab	37.26B\
Mean 174.0A		168.0A		10.36A	10.80A		41.69A	44.04A	

M*: Manfaluty W**: Wonderful

In each season, means of each of cultivars and salinity levels or their interactions having the same letters are not significantly different at 5% level.

TABLE 6. **Effect of pomegranate cultivars and salinity levels on stem total carbohydrate, total nitrogen and C/N ratio during 2016 and 2017seasons**

Salinity levels	Cultivars								
	M*	W**	Mean	M*	W**	Mean	M*	W**	Mean
	Total Carbohydrates			Total nitrogen %			C/N ratio		
					2016 season				
L_1:0 (control)	46.67a	51.67a	49.16A\	1.05a	0.910a-c	0.980A\	45.89a-c	57.26a	51.57A\
L_2:20 mM NaCl	36.67b	46.00a	41.33B\	0.844a-c	0.899a-c	0.872AB\	43.23bc	51.49ab	47.36A\
L_3:40 mM NaCl	32.67b-d	35.00bc	33.83C\	0.899a-c	0.987ab	0.943AB\	36.33cd	35.46cd	35.89B\
L_4:60 mM NaCl	29.57cd	30.33cd	29.95D\	0.833a-c	0.847a-c	0.840BC\	36.17cd	36.74cd	36.45B\
L_5:80mM NaCl	20.00e	27.33d	23.66E\	0.746bc	0.724c	0.735C\	27.14d	37.85cd	32.49B\
Mean	33.11B	38.06A		0.874A	0.873A		37.75B	43.75A	
					2017 season				
L_1:0 (control)	49.00a	51.00a	50.00A\	1.10a	0.943ab	1.02A\	45.71a-c	54.08a	49.89A\
L_2:20 mM NaCl	52.00a	50.33a	51.16A\	0.943ab	1.03ab	0.987A\	55.44a	49.01ab	52.22A\
L_3:40 mM NaCl	32.00c	37.33b	34.66B\	0.965ab	0.965ab	0.965A\	33.22d	39.02b-d	36.11B\
L_4:60 mM NaCl	22.24d	33.67bc	27.95C\	0.680c	0.899b	0.790B\	32.85d	37.47cd	35.75B\
L_5:80mM NaCl	20.47d	20.33d	20.40D\	0.614c	0.636c	0.625C\	33.76d	32.29d	33.02B\
Mean	35.14B	38.53A		0.860A	0.895A		40.19A	42.37A	

M*: Manfaluty W**: Wonderful

In each season, means of each of cultivars and salinity levels or their interactions having the same letters are not significantly different at 5% level.

TABLE 7. Effect of pomegranate cultivars and salinity levels on Proline leaves content during 2016 and 2017seasons.

Salinity levels	Cultivars		
	M*	W **	Mean
	Proline (ppm)		
	2016 season		
L_1:0 (control)	100.3f	107.7ef	104.0D\
L_2:20 mM NaCl	123.3cd	119.0de	121.2C\
L_3:40 mM NaCl	134.3c	123.7cd	129.0B\
L_4:60 mM NaCl	150.0b	163.3a	156.9A\
L_5:80 mM NaCl	85.0g	82.7g	83.8E\
Mean	118.6A	119.3A	
	2017 season		
L_1:0 (control)	111.7de	102.3e	107.0C\
L_2:20 mM NaCl	120.0d	112.4de	116.2B\
L_3:40 mM NaCl	135.3c	106.7e	121.0B\
L_4:60 mM NaCl	146.0b	160.5a	153.3A\
L_5:80 mM NaCl	89.0f	91.2f	90.1D\
Mean	120.4A	114.6B	

M*: Manfaluty W**: Wonderful

In each season, means of each of cultivars and salinity levels or their interactions having the same letters are not significantly different at 5% level.

Conclusion

In the context of this investigation, the pomegranate was moderately resistant to salinity up to 40 Mm NaCl with slight growth reduction. More increase in salinity level up to 60 and 80 mM NaCl reduction growth around 50-70% compared with control (untreated transplants). Furthermore, in most cases, "Manfaluty" pomegranate cultivar had a slightly higher reduction in growth than "Wonderful" pomegranate cultivar when they were irrigated with saline water spiked with 40, 60, or 80 Mm NaCl. Increasing NaCl caused a significant reduction in leaf K content otherwise Na was accumulated in the leaves of both 'pomegranate cultivars. the highest significant values of proline content were observed when combing L_4 (60mM NaCl) with a Wonderful cultivar during the two growing seasons. So it could be concluded that, increasing salinity level more than 40 mM NaCl will inhibit pomegranate growth and make an imbalance of nutrient status in pomegranate transplants with slight differences between two cultivars.

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Conflicts of Interest

No conflicts of interest during this research

References

Abo-Taleb, S.A., Moaman, V.F. and El-Deen, S.S. (1998) Growth of pomegranate transplants as affected by different water regimes. *Ann. Agr. Sci. Moshtohor.,* **36**,1073–1091

Bates L.S, Walderd R.P, Teare I.D. (1973) Rapid determination of free proline for water stress studies. *Plant Soil.,* **39**,205–208.

Bhantana, P. and Lazarovitch, N. (2010) Evapotranspiration, crop coefficient and growth of two young pomegranates (Punica granatum L.) varieties under salt stress. *Agricultural Water Management,* **97**,715-722

Black, C.A., Evans, D.D., Ensminge, L.E., White, J.L., Clark ,F. E. and Dinauer, R.C. (1965) *Methods of Soil Analysis. II*: Chemical and Microbiological Properties. Amer. Soc. Agron. Inc. Bull., Madison, Wisconsin, USA.

Bohnert, H.J., Nelson, D.E. and Jensen, R.G. (1995) Adaptations to environmental stresses. *Plant Cell,* **7**,1099-1111.

Cottenie,A., Verloo, M., Kiekens, L., Velgh, G. and Camerlynk, R. (1982) Chemical analysis of plants and soils state *Univ.Ghent, Belgium*, **63**,44-45.

Cramer, G.R., Ergül, A., Grimplet, J., Tillett, R.L., Tattersall, E.A.R., Bohlman, M.C., Vincent, D., Sonderegger, J., Evans, J., Osborne, C., Quilici, D., Schlauch, K.A., Schooley, D.A. and Cushman, J.C. (2007). Water and salinity stress in grapevines: Early and late changes in transcript and metabolite profiles. *Funct. Integr. Genomics,* **7**,111-134

Dubois, M., Gilles K.A., Hamilton, J.K., Rebers, P.A. and Smith, F. (1956) Colorimetric method for determination of sugars and related substances. *Annal. Chem*., **26**, 350-356.

Duncan, D.B. (1955) Multiple range and multiple F tests. *Biometrics*, **11**, 1- 42

Elias, A, Mirzaei, M., Moradi, M. and Zare, K. (2011) The effects of spermidine and putrescine polyamines on growth of pomegranate (Punica granatum L. cv 'Rabbab') in salinity circumstance. *International Journal of Plant Physiology and Biochemistry*, **3**(3), pp. 43-49

El-Khawaga, A.S., Zaeneldeen, E.M.A. and Yossef, M.A. (2013) Response of three pomegranate cultivars (Punica granatum L.) to salinity stress. *Middle East Journal of Agriculture Research,* **1**(1),64-75.

Flowers, T.J. and Flowers, S.A. (2005) Why does salinity pose such a difficult problem for plant breeders? *Agricultural Water Management*, **78**, 15–24

Hasanpour, Z., Karimi, H.R. and Mirdehghan, S.H. (2015) Effects of salinity and water stress on echo-physiological parameters and micronutrients concentration of pomegranate (*Punica granatum* L.). *Journal of Plant Nutrition,* **38**,795-807.

Holland D., Hatib, K. and Bar-Ya'akov, I. (2009) Pomegranate: Botany, Horticulture, Breeding. Horticultural *Reviews Edited by Jules Janick* , **35**, 127-192

Jackson, M.L. (1973) Soil chemical analysis . Prentice-Hall of India Private Limited, New Delhi.

Karimi, H.R. and Hassanpour, H. (2017) Effects of salinity, rootstock, and position of sampling on macro nutrient concentration of pomegranate cv. Gabri. *Journal of Plant Nutrition*, **40**(16),2269-2278.

Karimi, H.R. and Hassanpour, Z. (2014) Effects of salinity and water stress on growth and macro nutrients concentration of pomegranate (Punica granatum L.). *Journal of Plant Nutrition,* **37**(12),1937-1951.

Khayyat, M., Tehranifar, A., Davarynejad, G.H. and Sayyari-Zahan, M.H. (2016) Effects of NaCl salinity on some leaf nutrient concentrations, non-photochemical quenching and the efficiency of the PSII photochemistry of two Iranian pomegranate varieties under greenhouse and field conditions: preliminary results. *Journal of Plant Nutrient*, **39**(12),1752-1765.

LaRue, J.H. (1980) Growing pomegranates in California. UC Fruit & Nut Research Information Center. http://fruitsandnuts.ucdavis.edu/crops/pomegranate_factsheet. shtml

Mahajan, S., Tuteja, N. (2005) Cold, salinity and drought stresses: An overview. *Archives of Biochemistry and Biophysics,* **444**, 139-158.

Misra N and Gupta, A.K. (2005) Effect of salt stress on proline metabolism in two high yielding genotypes of green gram. *Plant Sci.,* **169**, 331-339.

Munns, R. (1993) Physiological processes limiting plant growth in saline soils: Some dogmas and hypotheses. *Plant Cell Environ*., **16**,15-24.

Naeini, M.R., Khoshgoftarmanesh, A.H. and Fallahi, E. (2006) Partitioning of chlorine, sodium, and potassium and shoot growth of three pomegranate cultivars under different levels of salinity. *Journal of Plant Nutrition*, **29**,1835-1843.

Okhovatian-Ardakani, A.R., Mehrabanian, M., Dehghani, E. and Akbarzadeh, A. (2010) Salt tolerance evaluation and relative comparison in cuttings of different pomegranate cultivars. *Plant Soil Environment*, **56**(4),176-185.

Patakas, A., Nikolaou, N., Zioziou, E., Radoglou, K. and Noitsakis, B. (2002) The role of organic solute and ion accumulation in osmotic adjustment in drought-stressed grapevines. *Plant Sci,* **163**,361-367

Prasad, R.N., Banker, G.J. and Vashistha, B.B. (2003) Effect of drip irrigation on growth, yield and quality of pomegranate in arid region. *Indian Journal of Horticulture*, **60**, 140-142.

Saeed, W.T. (2005) Pomegranate cultivars as affected by Paclobutrazol, salt stress and change in fingerprints. *Bull. Faculty Agr., Cairo Univ,* **56**,581–615

Sivritepe, N., Sivritepe, H.Ö, Çelik, H. and Katkat, A.V. (2010) Salinity Responses of Grafted Grapevines: Effects of Scion and Rootstock Genotypes. Not. *Bot. Hort. Agrobot. Cluj,* **38** (3), 193-201

Stover, E.W. and Mercure, E.W. (2007) The pomegranate: a new look at the fruit of paradise. *HortScience,* **42**,1088–1092

Taiz, L. and Zeiger, E. (2015) Plant physiology and development, 6th ed., Sinauer Associates, Inc., Publishers, Sunderland, M.A.

Tuteja, N. (2007) Mechanism of high salinity tolerance in plants. *Methods in Enzymology*, **428**, 419-438.

Van der Wiel, A. (2000) First Iranian pomegranates ready for picking. FreshPlaza: Global Fresh Produce and Banana News. www.freshplaza.com/news_detail.asp?id =5731

Yeo, A.R. and Flowers, T. (1984) Mechanisms of salinity resistance in rice and their role as physiological criteria in plant breeding, pp. 151-171. In: Staples, R.C. (Ed.), Salinity Tolerance in Plants: Strategies for Crop Improvement, John Wiley & Sons, New York.

مقارنة نسبية للتحمل للاجهاد الملحى لشتلات صنفى الرمان "المنفلوطى" و "وندرفول"

نهى منصور
قسم البساتين - جامعة عين شمس - كلية الزراعة - شبرا الخيمة - القاهرة - مصر.

تهدف هذه الدراسة لتقيم تحمل شتلات الرمان صنفي "المنفلوطى" و "وندرفول" للاجهاد الملحي. أجريت تجربة أصص بالصوبة الزجاجية بكلية الزراعة – جامعة عين شمس-شبرا الخيمة-مصر خلال موسمي ٢٠١٦،٢٠١٧ ووزعت الاصص في تجربة عاملية في تصميم عشوائى كامل حيث مثل العامل الاول بأصناف الرمان المستخدمة "المنفلوطى" و "وندرفول" والعامل الثاني بمستويات كلوريد الصوديوم (0, 20, 40, 60, and 80 mM NaCl) .

* وقد أمكن تلخيص أهم النتائج في النقاط التالية:

-بشكل عام أظهر كلا الصنفين تحمل متوسط للملوحة حتي (40 mM NaCl) مع انخفاض بسيط في النمو.

-مستويات الملوحة الاعلي (60, and 80 mM NaCl) أدت الي نقص النمو ٥٠-٧٠% مقارنة بالشتلات غير المعاملة، وبشكل عام حدث في النمو في صنف المنفلوطي بدرجة أكبر من الوندرفول ولكن التفاوت بينهما كان طفيف.

-زيادة مستويات الصوديوم كلوريدأدت الى نقص معنوي في محتوي الاوراق من البوتاسيوم وزيادة تراكم الصوديوم بها لاوراق كلا الصنفين.

- زاد محتوي الاوراق من البرولين تدريجى مع زيادة مستويات الصوديوم كلوريد حتي (60 mM NaCl) واعلي محتوي من البرولين تم تسجيله مع تركيز(60 mM NaCl) تحت صنف الوندرفول.

وعلى ذلك يمكن استنتاج أن ارتفاع مستويات الصوديوم كلوريد أعلي من (40 mM NaCl) يؤدي الي تثبيط النمو وحدوث خلل في الحالة الغذائية لشتلات كلا الصنفي. وأن الاختلاف في درجة التحمل للاجهاد الملحى كانت طفيفة ما بين كلا الصنفين.