Comparative Responses of Three Pomegranates (Punica Granatum L.) Varieties to Salinity

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Abstract: *During 2011 and 2012 seasons, three pomegranate cultivars Manfalouty, Wonderfull and Nab–Elgamal. were subjected to saline ground water at concentration (1.8 and 6.0 dSm-1). The trees about seven years old grown at 2.5 x 3.5 m apart in sandy clay loam soil under Sohag environmental conditions. Results revealed that irrigation with saline water (6 dSm-1), increased salt accumulation in leaves. On the other hand the higher significant reduction was observed in growth; flowering and yield with highly fruit cracking in relative to 1.8 dSm-1. Total Sugar and acidity percentages did not alter significantly with varying Saline irrigation. The studied varieties were affected differently by salt-stress, Manfalouty, Wonderfull, and Nab-Elgamal in descending order in response to salinity.*

Keywords: *Salinity, Pomegranate, Saline ground water, Salt-stress, Vegetative growth characteristics.*

Introduction

Pomegranates (*Punica granatum*) are one of the important fruit crops for new reclaimed soils in Egypt. Saline irrigation water is currently one of the most severe a biotic factors limiting area cultivation. Where the salinization is has been developed through irrigation. That, decreasing crop yields, and land degradation as a result of excess salts being present in water during irrigation (Ayers and Westcot, 1985). The deleterious effects of salinity on plant growth are associated with, low osmotic potential of soil solution (Khan, 2001) nutritional imbalance, specific ion effect (toxic accumulation) (Benlloch *et al*., 1991; Bongi and Loreto, 1989) moreover, the combination of these factors. During the onset and development of salt stress within a plant, all the various plant growth processes such as photosynthesis, protein synthesis and energy and lipid metabolisms are affected (Parvaiz and Satyawati, 2008). The earliest response is a reduction in the rate of leaf surface that due to the interference osmotic balance in the root system zone that, as well in root as in leaves. (Khan, 2001). However, the cumulative effect of salt stress on plants depends on the concentration and time of exposure of salt, plant genotypes and environmental factors (Maas and Hoffman, 1977). Nevertheless, few studies have been conducted on the differences between cultivars in response to varying water salinity levels and growth responses of pomegranate under field conditions. On the other hand, the amount and the quality of available irrigation water of the arid and semi-arid regions of the world such as Egypt, are limiting for the extension agriculture (Beaumont, 1993). In spit of the pomegranate trees are moderately salt tolerant under field condition (FAO, 1985). However, (Abu-Taleb *et al*., 1998; Saeed, 2005). They noted that Manfalouty pomegranate was more sensitive to saline water stress than Nab-Elgamal, The differences results have been reported by EL-Agamy *et al*. (2010) who observed that Manfalouty pomegranate was most tolerance salinity to Nab-ELgamal under in vitro conditions. At the same time, Okhovatian *et al.*

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(2010) showed that pomegranate cultivar Voshike-e-Saravan was the most salinity resistant among 10 studied Iranian cultivars.

Incorporation of saline water in irrigation reduces the length stem, length and number of the internodes, leaf area and root development in Rabbab pomegranate Amri *et al.* (2011). In contrary, Parashuram and Lazarovitch (2010) observed that there were no differences between two varieties of pomegranate, P. *granatum* L. vars. Wonderful and SP-2 in response to varying saline water stress. Some results showed that a significant reduction and anatomical structures of roots and leaves in cuttings of different pomegranate cultivars as a resulting of increasing levels of salinity from 800 to 4000 dSm^{-1} Zarinkamar and Asfa (2005).

The main problem related to irrigation water quality is the water salinity that may affect both crop yields and soil physical conditions even if all other conditions and cultural practices are favorable. In addition, different crops require different irrigation water qualities (Ayers and Westcot, 1985). The ability of plant to alleviate the adverse effects of salinity is associated with decreasing in leaf osmotic potential. Gucci *et al.* (1997). The differences between cultivars have been linked to Na+ and/or Cl- ion exclusion mechanisms or to the retention of salt ions in roots (Tattini *et al*., 1994) and/or preventing the accumulation of Na+ and/or Cl- in shoots and leaves (Gucci and Tattini, 1997). Therefore, selection of suitable cultivar is important for increasing yield efficiency of this strategy nut crop.

The aim of this work was to investigate and compare the effect of two natural water salinity levels (1.8. and 6.0 dSm^{-1}) on growth indices, physiological parameters, and ions accumulation of three Pomegranate cultivars. With regard to this area (west Bait Dawood project) 40 Km south Sohag Governorate, more over 10,000 fed. (1 feddan = 0.42 hectares).Where's the soil is sandy characterized, at the same time the ground water has only available source of irrigation which was often differ of salinity, it ranged about (1000 to 8200 ppm). On the other hand, the area of fruit trees plantation has been increased gradually without any adequate that may be affected many factors such as, cultivars types, furthermore the different ion between cultivars of tolerance to salinity levels. The main problem under such conditions by applying high salinity levels of irrigation water that, led to the abandonment of many agricultural farms.

Materials and Methods

The present study was conducted during two successive seasons of 2011 and 2012 on three pomegranate cvs. Manfalouty, Nab-Elgamal and Wonderful to determine the effect two levels of salinity groundwater (1.8 and 6.0 dSm^{-1}) on vegetative growth, flowering, fruit set and productivity as well as physical and chemical fruit characteristics. Cultivars were planted at spacing (2.5 x 3.5 m) representing a density of 450 plants/fed. The trees were about 7-years old grown on a loamy sandy soil (newly reclaimed lands) under drip irrigation system (four drip emitters per tree 4 Lh-1) at a private orchard on west Bait Dawood project, Sohag Governorate, Upper Egypt. Soil sample with depth from 0-90 cm were collected and analyzed for some physical and chemical properties. As well as chemical properties of water irrigation was analyzed Table (2). The electrical conductivity of the soil (ECe) was measured before and after the experimental work, according to described by Page *et al.* (1982).

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Table (1): Physical and chemical properties of the experimental soil.

Soil depth (cm)	ECe dSm^{-1}	pH	$CaCO_3$ %	Texture			Text - class	meq /L						
				S.	Si.	C.		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCo_3^{-}	Cl^{-}	SO_4^{-}
0 – 30	2.56	7.82	12.11	62.43	11.12	26.45	SCL	12.32	7.11	5.24	0.45	4.34	8.53	12.26
30 – 60	3.12	7.73	15.37	67.72	15.22	17.02	SL	15.42	8.75	6.17	0.38	4.78	11.17	14.82
60 – 90	3.72	7.92	16.78	73.60	13.14	13.26	SL	18.58	10.4	7.55	0.49	4.94	14.53	17.48

The same cultural practices such as, fertilization, pruning, pest control were conducted according the recommendations of Egyptian Ministry of Agriculture. The average of water applied and leaching requirements were shown in Table (3) the area has been divided into two sites. On each side, 30 trees of each cultivar uniform in growth and healthy were irrigated by the lowest levels of salinity (1.8 dSm^{-1}) whereas, the highest saline water (6.0 dSm^{-1}) for other side.

Table (2) chemical properties of saline irrigation water.

	EC_w dSm^{-1}	p^H	SAR (meq/L)	Cations (meq/L)				Anions (meq/L)			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{--}	Cl^{-}	SO_4^{---}
S_1	1.8	8.1	6.4	4.0	3.76	12.6	0.13	0.0	3.9	10.3	6.0
S_2	6.0	7.9	10.9	15.4	9.8	39.0	0.36	0.0	2.9	39.9	21.7

The amount of the used actual water was calculated according to Doorenbos and Pruit (1997) as follows:- ETc = ETo x Kc x Kr Where: Etc=crop evapotranspiration (Actual water needs) mm/day. ETo (Reference evapotranspiration) and Kc (crop coefficients) were obtained from climate program. Kr was calculated through the relationship GC/85 where GC (ground cover) equal the percentage of tree cover to planting spacing it is already less than 1.0.

Water requirements (WR) of the pomegranate orchard were calculated on daily basis through the relationship of the simplified water budget WR = ETc–Er, where:- Er (effective rainfall) was obtained from climate program too. Where: Leaching Requirement LR (%) = ECiw / (5ECth-ECiw) LR = Leaching Requirement. ECiw is the EC of the irrigation water, ECth the salinity soil. (At depth 60-90cm) For calculating irrigation requirement through the relationship Where:

IR = (Etc+ LR) x Sl x Sm /Ea (Liter \ tree\ day)

Sl = The distance between the rows.
Sm = the distance between the trees.
Ea = the efficiency of the irrigation system.

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Table (3) water, leaching and irrigation requirements of pomegranate trees under saline water

Month	ETo mm/day	Kc	Kr	Et crop mm/day	Rain mm/day	WR mm/day	LR S1 mm/day	LR S2 mm/day	I W of S1 L/ tree/day	I W ofS2 L/ tree /day
January	3.41	-	-	-	0.0	-	-	-	-	-
February	4.26	0,4	0,42	0,72	0,03	0,69	0,077	0,3384	8,204412	10,89529
March	5.47	0,5	0,42	1,15	0.0	1,15	0,12305	0,5405	13,10493	17,40221
April	7.39	0,6	0,42	1,86	0.0	1,86	0,19902	0,8742	21,19579	28,14618
May	8.87	0,7	0,42	2,61	0.0	2,61	0,27927	1,2267	29,74249	39,49544
June	9.47	0,8	0,42	3,18	0.0	3,18	0,34026	1,4946	36,23797	48,12088
July	9.11	0,8	0,42	3,07	0.0	3,07	0,32849	1,4429	34,98446	46,45632
August	8.41	0,8	0,42	2,83	0.0	2,83	0,30281	1,3301	32,24951	42,82456
September	7.41	0,8	0,42	2,49	0.0	2,49	0,26643	1,1703	28,37501	37,67956
October	3.21	0,8	0,42	1,08	0.0	1,08	0,11556	0,5076	12,30724	16,34294
November	2.28	-	-	-	0.0	-	-	-	-	-

Therefore, Irrigation treatments were applied from 1st February and continued until mid October.

Vegetative growth characteristics:

A-Average shoot length (cm): In Oct. of each season, under different water salinity the average length of shoots were recorded by measuring the length of labeled shoots per tree and then the average shoot length was calculated in (cm)

B-Leaf area (cm2): Fifty mature leaves randomly chosen from the third and fourth basal nodes of shoot from the trees under each plot of soil salinity and measuring by leaf area meter Model Ci 203 apparatus (USA made).

Leaf analysis:

Fifty fully expanded mature leaves were sampled from each tree in October and weighed immediately and then dried at 70o C for 24 hr. To analysis sodium and chloride, Sodium was determined using a parking flame photometer after dry ashing samples overnight at 500. Chloride was extracted from a shed samples with hot water and titrated with stander silver nitrate solution and then determined according to Page *et al*. (1982).

Flowering parameters:

A-Number of Total flowers /tree: all complete flowers (vas-shape) long pistillate and incomplete flowers (bell shaped), short pistillate were weekly counted along the flowering seasons from mid March till mid July.

B-Fruit Set (%): was calculated as follow: = number of set fruits / total number of flowers X 100

C-Fruit drop (%): Was calculated by the following equation:

$$\frac{\text{Total number of fruit set - Total number of fruits at harvest}}{\text{Total number of fruit set}} \times 100$$

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D - U Fruit retention (%): Was calculated as follow

$$\frac{\text{Total number of fruit set} - \text{Total number of fruits at harvest}}{\text{Total number of fruit set}} \times 100$$

E - Number of fruit/tree: Fruits were picked at first August in both seasons and number of fruits per tree was calculated.

F -Average fruit weight (g): At harvest time, fruits per tree for each treatment were weighted and then average fruit weight (g) was estimated.

G -Fruit cracking %: Was calculated for each cultivar under different levels of salinity, as follow:

$$\frac{\text{Number of fruits cracking}}{\text{Total number of fruits}} \times 100$$

H-Chemical characters of fruits:
All fruit samples were similar in their date of fruit setting to evaluate total acidity % which was estimated in juice as citric acid, by titrating of 0. 1 sodium hydroxide against 5 ml juice using phenolphalein as an indicator. Total sugar % was determined in juice according to the method of Lane & Eynon as described in the A.O.A.C. (1995).

Statistical Analysis:
The study design in split plot and the treatments (twenty trees from each cultivar in each location) were selected and arrangement in complete randomized block design. The two levels of salinity were used as the main plot (factor A). The three pomegranate cultivars were used as the sub plot (factor B).

Results and Discussion
Salinity is one of the most brutal environmental factors limiting the productivity of crop plants because most of the crop plants are sensitive to salinity, which constrained by salt accumulation in the root zone. Therefore, under these conditions the amount of water must be increased to allow leaching of salts below the root zone in order to avoid salinity buildup. On the other hand, growth and development retarded when water supply was restricted.

Vegetative growth characters:
Data in table (5) clearly showed a significant difference between the two saline irrigation treatment in terms of average shoot length growth (cm) and Leaf area (cm^2) in both seasons. The saline irrigation treatment at 6.0 dSm^{-1} that shortened the average of shoot length from 30.88 to 23.95 and 31.11 to 22.81cm and leaf area 6.03 to5.69 and 6.08 to 5.66 cm^2 (as an average of the three cultivars) than using saline water at 1.8 dSm^{-1}during both seasons respectively. The growth parameters deficiency decreased in all the cultivars under studied as a results with increasing water salinity. On the other hand, the compared with cultivars on a reduction in vegetative growth as a result of the higher salinity stress. The same tendency was observed for all tested varieties without any significant compared them. However, Manfalouty pomegranate had a slightly (insignificant) higher vegetative growth among other cultivars Nab-Elgamal and Wonderful in descending order, in both seasons.

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For the interaction between two levels of saline irrigation 1.8 and 6.0 dSm^{-1} and three pomegranate cultivars the best results in terms shoot length and Leaf area performance were noticed with Manfalouty cultivar under 1.8 dSm^{-1}, meanwhile Wonderful cultivar under level saline water 6.0 dSm^{-1} recorded the least value in this respect. These differences may be attributed to the natural characteristics of some pomegranate cultivars to their rate of adaptation to the environmental conditions rather than other related to salinity under this study. Furthermore, this adaptation seems to play an important role in the controlling of abscisic acid and proline accumulation (Winicov and Button, 1991).

Table (5): Effect of irrigation with two levels of saline groundwater on average shoot length (cm) and Leaf area (cm^2) of three varieties of Pomegranate.

Water Salinity (Ec_e dSm^{-1})		Average shoot length (cm)							
		2010/2011				2011/2012			
		Manfalouty	Nab Elgamal	wonderful	Mean (A)	Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	30.90	30.88	30.87	30.88	31.19	31.01	31.12	31.11
S_2	6.0	24.68	23.62	23.55	23.95	23.87	22.34	22.23	22.81
Mean (B)		27.49	27.25	27.21		27.53	26.68	26.68	
LSD 0.05%		A	B	AB		A	B	AB	
		2.2	1.2	2.7		2.4	1.6	2.8	

Water Salinity (Ec_e dSm^{-1})		Leaf area (cm^2)							
		2010/2011				2011/2012			
		Manfalouty	Nab-Elgamal	wonderful	Mean(A)	Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	6.04	6.02	6.02	6.03	6.12	6.06	6.07	6.08
S_2	6.0	5.72	5.68	5.67	5.69	5.70	5.66	5.64	5.66
Mean (B)		5.88	5.85	5.85		5.91	5.86	5.86	
LSD 0.05%		A	B	AB		A	B	AB	
		0.32	1.1	0.66		0.3	0.4	0.62	

The same trend was observed by EL-Agamy *et al.* (2010), observed that Manfalouty pomegranate was most tolerance salinity to Nab-ELgamal under vitro conditions. On the other hand, Abu-Taleb *et al.* (1998) and Saeed (2005). They noted that under saline stress Manfalouty pomegranate was very sensitive than Nab-Elgamal. Overall, the ability of salt concentrations tolerance differed greatly from species to species between pomegranates cultivars. Okhovatian *et al.* (2010) and Amri *et al.* (2011).

Leaf analysis

As could be seen in Table (6) the levels of sodium and chloride ions were found to be higher and significant in leaves at saline-irrigated 6.0 dSm^{-1} than 1.8 dSm^{-1} irrigated trees. These results due to the high saline-irrigation (6.0 dSm^{-1}) contain excessive amounts of salts that increasing absorption of this cations in all tested varieties. At the same time the salt tolerant plants transport fewer amounts of toxic ions like Na^+ and Cl^- to the upper parts (leaf and shoot) because they store maximum ratios of these ions in their roots, it is an adaptation to withstand saline conditions while salt sensitive plants do not have such an adaptation. In general this difference in Na^+ and Cl^- of pomegranate genotypes may be due to their genetic variability and root permeability for these ions.

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The highest level and significant of sodium and chloride were found in leaves of, Wonderful, Nab-Elgamal trees respectively. This response could be explained by the ability of Manfalouty cultivar to alleviate the adverse effects of salinity by decreasing the leaf osmotic potential. Gucci *et al.*, (1997) or preventing the accumulation of Na+ and/or Cl- in leaves (Gucci and Tattini, 1997). Variety interaction was statistically significant related to sodium and chloride ions accumulation, in this respect Manfalouty trees were the most tolerance of water salinity than other studied varieties Nab-Elgamal and Wonderful respectively, concerning the accumulation and transport of sodium chloride in leaves.

Table (6): Effect of irrigation with two levels of saline groundwater on Na and Cl content % on leaves of three varieties of Pomegranate.

Water Salinity (Ec_e dSm^{-1})		Na content %							
		2010/2011				2011/2012			
		Manfalouty	Nab-Elgamal	wonderful	Mean (A)	Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	0.21	0. 22	0.23	0.22	0.20	0.23	0.24	0.22
S_2	6.0	0.35	0.37	0.38	0.37	0.38	0.40	0.42	0.40
Mean (B)		0.28	0.30	0.31		0.29	0.32	0.33	
		A	B	AB		A	B	AB	
LSD 0.05%		0.11	0.02	0.2		0.14	0.03	0.21	
Water Salinity (Ec_e dSm^{-1})		Cl content %							
		2010/2011				2011/2012			
		Manfalouty	Nab-Elgamal	wonderful	Mean(A)	Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	0.04	0.04	0.04	0.04	0.035	0.050	0.060	0.048
S_2	6.0	0.10	0.11	0.12	0.11	0.120	0.140	0.160	0.14
Mean (B)		0.070	0.075	0.080		0.078	0.095	0.110	
LSD 0.05%		A	B	AB		A	B	AB	
		0.02	0.03	0.05		0.03	0.01	0.03	

Flowering parameters

It is evident from the data in Table (7) that Total flower/tree and perfect flower percentage were significantly affected by the two salinity Irrigation levels. Hence, the total reduction of total flower/tree ranged between 26.05 and 24.12 % with water salinity irrigation at 6.0 than 1. 8 dSm^{-1} in the first and second seasons. Perfect flower was also affected by salinity stress which decreased about 14.09 &16.61 %, respectively. These results may be attributed to using saline irrigated water for along time that can greatly increased the salt accumulation in of soil profile, decreased the absorption of water and nutrient uptake resulting decreasing in all the major processes and plant hormone in addition increasing the energy that plants using to extract moisture (Parvaiz and Satyawati 2008). These results presented a significant difference in total flower /tree between pomegranate cultivars in salt tolerance trait. Nab-Elgamal and Wonderful cultivars were very sensitive to salinity, than Manfalouty cultivar. The same trend was observed during both seasons. These results attributed to the high adaptation and genetic nature of Nab-Elgamal cultivar to salinity stress than other cultivars. These findings are in agreement with those obtained by EL-Agamy *et al.* (2010). The differences results were observed with, Abu-Taleb *et al*. (1998) and Saeed (2005).

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The interaction between water salinity and cultivars was significant. However, Manfalouty cultivar recorded the best results of Total flower/tree (248.09 & 213.85), meanwhile Wonderful cultivar was the lowest (230.92 & 184.28) in this respect. No significant differences were noticed between three cultivars related to perfect flower percentage.

Table (7): Effect of irrigation with two levels of saline groundwater on total flower/tree and perfect flower % of three varieties of Pomegranate.

Water Salinity (Ec_e dSm^{-1})		Total flower /tree							
		2010/2011				2011/2012			
		Manfalouty	Nab-Elgamal	wonderful	Mean (A)	Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	282.07	264.16	271.10	273.44	240.13	209.98	218.28	222.79
S_2	6.0	214.1	201.82	190.74	202.22	187.56	169.34	150.28	169.06
Mean (B)		248.09	232.99	230.92		213.85	189.66	184.28	
LSD 0.05%		A	B	AB		A	B	AB	
		12.6	6.9	14.8		14.9	7.5	16.9	
Water Salinity (Ec_e dSm^{-1})		Perfect flower %							
		2010/2011				2011/2012			
		Manfalouty	Nab-Elgamal	wonderful	Mean(A)	Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	29.86	30.24	30.00	30.03	30.53	31.83	32.98	31.78
S_2	6.0	26.75	25.85	24.81	25.80	27.72	26.21	25.56	26.50
Mean (B)		28.31	28.05	27.41		29.13	29.02	29.27	
LSD 0.05%		A	B	AB		A	B	AB	
		3.6	NS	4.2		3.4	NS	4.2	

In spit of Manfalouty cultivar gave the best results in this respect (28.31 & 29.13) whereas the less value obtained with Wonderful cultivar (27.41 & 29.27) in both seasons. This behavior may be explained by varying degree of adaptability of cultivars to salinity stress. Moreover, differences in salt tolerance exist not only between species but also between genotypes of a certain species (Marschner et al., 1981). Similar findings were found by EL-Agamy *et al*. (2010) but was contrast with these obtained by Abu-Taleb *et al*. (1998) and Saeed (2005). On the other hand, Parashuram and Lazarovitch (2010) noted that there were no differences between two varieties of pomegranate, Wonderful and SP-2 in response to varying saline water stress.

Results presented in Table (8) reveal a significant effect on fruit set and fruit drop percentages in response to two saline irrigation levels. The highest reduction of statistical effect in comparison with the two levels of saline irrigation was noticed in water salinity 6.0 dSm^{-1}. That, retardation of fruit set to (16.97 & 18.05 %) with a greater values in fruit drops (20.88 & 20.80 %) in the first and second seasons when water salinity irrigated raised from1.8 to 6.0 dSm^{-1}. This reduction might be attributed to the inhibition accumulation of carbohydrates and plant hormone under saline water than those grown under normal conditions (Nounjan *et al.,* 2012). Furthermore, under salinity conditions, Carbohydrates have less hydrolyzed and less mobilized towards the meristematic growing points Hopkins (1999). These results are in conformity with those obtained by Okhovatian *et al*. (2010) and Amri *et al*. (2011).

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Fruit set and fruit drop percentages were significantly varied among the three pomegranate cvs grown under saline water. The highest Fruit set percentage was observed in Manfalouty cultivar (29.47 & 29.32) followed by Nab-Elgamal (28.07& 27.97 %), meanwhile Wonderful cultivar recorded the lowest salinity resistance (27.32&27.38%) during the first and second year respectively. On the other hand, effectively maximized decreasing in fruit drop was observed by Manfalouty cultivar (14.20 & 15.15 %). The lack of significant response of fruit drop was observed by Nab-Elgamal and Wonderful cultivars, in descending order. Generaly, it can be observed that Manfalouty tree is considered as a highly tolerant and significant to salinity compared to other cultivars (Nab-Elgamal and Wonderful) in descending order in respect to fruit set and fruit drop. These variations could be mainly due to their genetically differences between cultivars in terms of fruit set, fruit drop and yield, rather than to water quality, and also the reaction between genital and environment conditions. Similar finding were found by several investigators, Melgar *et al.* (2008) on olive, EL-Agamy *et al*. (2009a) on grape. On other hand, Parashuram and Lazarovitch (2010) noted that there were no differences between two varieties of pomegranate, Wonderful and SP^{-2}. in response to varying saline water stress.

Table (8): Effect of irrigation with two levels of saline groundwater on Fruit set % and Fruit drop % of three varieties of Pomegranate.

Water Salinity (Ec_e dSm^{-1})		Fruit set %							
		2010/2011				2011/2012			
		Manfalouty	Nab-Elgamal	wonderful	Mean (A)	Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	30.18	29.73	29.54	29.81	31.98	30.74	30.35	31.02
S_2	6.0	28.75	26.41	25.10	24.75	26.66	25.20	24 .42	25.42
Mean (B)		29.47	28.07	27.32		29.32	27.97	27.38	
LSD 0.05%		A	B	AB		A	B	AB	
		2.1	1.1	2.3		2.0	1.2	2.3	

Water Salinity (Ec_e dSm^{-1})		Fruit drop %							
		2010/2011				2011/2012			
		Manfalouty	Nab-Elgamal	wonderful	Mean(A)	Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	13.26	14.23	14.21	13.90	13.91	15.28	15.11	14.77
S_2	6.0	15.13	18.29	19.28	17.57	16.38	19.32	20.26	18.65
Mean (B)		14.20	16.26	16.75		15.15	17.30	17.69	
LSD 0.05%		A	B	AB		A	B	AB	
		2.88	1.7	3.3		3.1	1.9	3.2	

Regarding the combination between the cultivars and saline irrigation treatments, there was a great variability among three cultivars pomegranates in fruit set and fruit drop. The significant response in the tested pomegranate cultivars was observed in Manfalouty pomegranate (30.18 & 31.98 %) in fruit set and (13.26 & 13.91 %) in fruit drop, during the first and second seasons respectively. Nab-Elgamal cultivar recorded the intermeditiate values in this respect, while Wonderful was considered a low tolerance to salinity without any significant.

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Such finding attributed to responses of plants to saline environments and the mechanisms by which growth and development and physiology of plants are affected by salinity. The results of the present study are in agreement with those obtained by Sotiropoules *et al.* (2007) on apple, EL-Agamy *et al.* (2009a) on grape and EL-Khawaga (2013) on date palm. Data in Table (9) showed that Fruit retention % and number of fruit /tree were significantly affected by two levels of water salinity. Such salinity stress responsible for a remarkable decrease in Fruit retention. percentage from (86.10 to 82.43) in the first seasons and (85.23 to 81.35) in the second seasons respectively This could explain the significantly higher number of fruit /tree, while 1.8 dSm^{-1} levels recorded (21.00 and 18.71) fruit /tree, than other saline water 6 dSm^{-1} registered 11.61 and 9.53 fruit /tree. This may be related to less activity of the trees in their photosynthesis performance and fruit production due to high salinity, which reduce plant through osmotic effects, toxicity of ions, nutrient uptake imbalance, or a combination of these factors. Gucci and Tattini, (1997). These results regarding saline treatments are in harmony with those obtained by Okhovatian *et al.* (2010) and Amri *et al*. (2011).

Table (9): Effect of irrigation with two levels of saline groundwater on Fruit retention % and No, of fruit /tree of three varieties of Pomegranate

Water Salinity (Ec_e dSm^{-1})		Fruit retention %							
		2010/2011				2011/2012			
		Manfalouty	Nab-Elgamal	wonderful	Mean (A)	Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	86.74	85.77	85.79	86.10	86.09	84.72	84.89	85.23
S_2	6.0	84.87	81.71	80.72	82.43	83.62	80.68	79.74	81.35
Mean (B)		85.81	83.74	83.26		84.86	82.70	82.32	
LSD 0.05%		A	B	AB		A	B	AB	
		3.1	1.8	3.6		2.7	1.84	3.7	
Water Salinity (Ec_e dSm^{-1})		No, of fruit /tree							
		2010/2011				2011/2012			
		Manfalouty	Nab-Elgamal	wonderful	Mean(A)	Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	22.05	20.37	20.59	21.00	20.18	17.41	18.55	18.71
S_2	6.0	13.97	11.26	9.59	11.61	11.59	9.52	7.48	9.53
Mean (B)		18.01	15.82	15.09		15.89	13.47	13.02	
LSD 0.05%		A	B	AB		A	B	AB	
		5.1	2.4	6.1		4.3	2.0	5.3	

The obtained results revealed that percentage of fruit retention and numbers of fruit /tree were significantly varied among the three pomegranate cvs in response to salinity tolerance. Manfalouty cultivar recorded the highest fruit retention (85.81 & 84.86%) and number of fruit /tree (18.01 &15.89) followed by and significant Nab-Elgamal cultivar (83.74 & 82.70 %) in fruit retention and (15.82 &13.47) fruit /tree. Meanwhile Wonderful cultvar was the lowest values in both aseptic (83.26 & 82.32%) fruit retention and (15.09 &13.02) fruit /tree during the first and second experimental seasons.
Differences in fruit retention and number of fruit /tree could be attributed to their genetically differences and adaptation between cultivars rather than to water quality.

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These indicated that Nab-Elgamal cultivar was having a highly adaptation under such salinity conditions. Other plants showed the same responses to salinity by several investigators. Melgar *et al*. (2008) on olive, EL-Agamy *et al*. (2009a) on grape. On other hand, Parashuram and Lazarovitch (2010) noted that there were no differences between two varieties of pomegranate, Wonderful and SP^{-2}. in response to varying saline water stress.

In regard the interaction among the three pomegranate cvs in response to salinity tolerance in respect to fruit retention and number of fruit /tree. Analysis of variance clearly showed a significant effect in fruit retention percentage and number of fruit /tree between pomegranate cultivars and salinity stress treatments. The best tolerance of water salinity was found in Manfalouty cultivar (86.74 & 86.09%) accompanied with great number of fruit /tree (22.05 & 20.18).Meanwhile the reduction in fruit retention and numbers of fruit /tree were more pronounced in Wonderful cultivar which recorded (83.26 & 82.32%) in fruit retention and (15.09&13.02) fruit /tree, in the first and second seasons respectively. Varition in fruit retention and number of fruit /tree under saline conditions depending on the adaptation of cultivars to salinity stress and also the reaction between genetic and environment conditions.

The results of the present study are in good agreement with previous reports concerning the effect of salinity on other plants by Sotiropoules *et al*. (2007) on apple, EL-Agamy *et al*. (2009a) on grape and EL-Khawaga (2013) on date palm. Other study was in contrast with this results observed by Parashuram and Lazarovitch (2010) they noted that there were no differences between two varieties of pomegranate, Wonderful and SP^{-2}. in response to varying saline water stress.

Table (10): Effect of irrigation with two levels of saline groundwater on average Fruit weigh (g) and Fruit cracking % of three varieties of Pomegranate.

Water Salinity (Ec_e dSm^{-1})		Fruit weigh (g) 2010/2011 Manfalouty	Nab-Elgamal	wonderful	Mean (A)	2011/2012 Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	195.80	193.50	197.63	195.64	204.30	202.88	208.47	205.22
S_2	6.0	170.12	165.14	162.18	165.81	158.66	149.89	145.63	151.39
Mean (B)		182.96	179.32	179.91		181.48	176.39	177.10	
LSD 0.05%		A	B	AB		A	B	AB	
		3.1	2.1	4.2		4.1	2.2	4.4	

Water Salinity (Ec_e dSm^{-1})		Fruit Cracking % 2010/2011 Manfalouty	Nab-Elgamal	wonderful	Mean(A)	2011/2012 Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	8.77	8.96	8.69	8.81	7.65	7.77	7. 54	7.65
S_2	6.0	11.61	11.70	11.68	11.66	12.02	12.76	12.44	12.41
Mean (B)		10.19	10.33	10.19		9.84	10.27	9.99	
LSD 0.05%		A	B	AB		A	B	AB	
		1.4	1.0	1.5		1.3	1.1	1.4	

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As the salinity levels of irrigation water increased the Fruit weigh (g)/trees were significantly decreased (Table 10). The reduction of Fruit weigh ranged (15.25 & 26.23 %) under high levels of salinity stress (6 dSm^{-1}), which recorded (165.81 & 151, 39) (g) /fruit.

Whereas (1.8 dSm^{-1}) registered (195.64 & 205, 24) weighs/ fruit (g) in the first and second seasons respectively. That means yield/ tree were greatly decreased under high levels of salinity stress (6 dSm^{-1}) compared with (1.8 dSm^{-1}). This lowering in fruit production and quality parameters may be due to Excessive amount of salt in cultivated soils retards the water uptake and plant hormones activities. Consequently due to the general inhibition of growth and limits of economic yield. Okhovatian *et al.* (2010) and Amri *et al*. (2011). Form this Table it can noticed that pomegranate cultivars differences in salt tolerance. The highest values and significant in Fruit weigh was observed with Manfalouty cultivar (182.96 & 181.48 Fruit weigh's) followed by Wonderful and Nab-Elgamal cultivar.

The stress salinity effect depends on genetic nature of variety and/or the reaction between genetic and environment conditions. Other plants showed the same responses to salinity by several investigators. Melgar *et al*. (2008) on olive, EL-Agamy *et al.* (2009a) on grape. On other side, Parashuram and Lazarovitch (2010) noted that there were no differences between two varieties of pomegranate, Wonderful and SP^{-2}. in response to varying saline water stress.

With regard to the combination between two levels of saline water and three pomegranate cvs. Data reveals that significant effect was observed on Fruit weigh. The bigger fruit weights were found in Wonderful cultivar (197.63 & 205.22 Fruit weigh (g)/ tree) under the lowest salinity. Meanwhile this cultivar recorded the least salt tolerance cultivars which recorded the lowest Fruit weigh (g)/ tree (162.18 & 145.63) in the first and second seasons respectively.

Such results attributed to the response of plant to saline condition and the mechanism by which growth and development and physiology of plant was affected by salinity. Furthermore, the ability of salt tolerance depending on the adaptation of cultivars to salinity stress and the reaction between gentic and environment conditions. Similar finding were found by several investigators, Sotiropoules *et al*. (2007) on apple, EL-Agamy *et al*. (2009a) and EL-Khawaga (2013) on date palm. On the other hand, Parashuram and Lazarovitch (2010) revealed that there were no differences between two varieties of pomegranate, Wonderful and SP^{-2}. in response to varying saline water stress. SO, we suggesting that when selecting pomegranate cultivars for cultivation, most attention should be directed to the genetic differences between cultivars in terms of vegetative growth, productivity, fruit quality and the ability of salt tolerance.

Table (10) obviously reveals that significant differences were observed on the percentages of fruit cracking between two levels of water salinity. The improvement of water quality with irrigation had a positive effect on fruit cracking, which was decreased it from (11.66 to 8.81) in the first seasons and (12.41 to 7.65) in the second only. This may be related to with saline water the less activity of the trees in their photosynthesis and fruit production, that lead to a great reduction in nutrient uptake especially micro nutrients and potassium furthermore decreasing amount of water absorbed by the plant (Parvaiz and Satyawati, 2008).

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On the other hand, the high salt concentration in the irrigation water can also have a devastating effect on Calcium ions being, such results increased wall weakening in fruits (Poovaiah, 1988).

These results are in accordance with those reported by. (Bielorai *et al*., 1988) and (Ibrahim, 1988) who noted that fruit cracking was increased gradually with the increase in the number of saline irrigation.No, significant differences were observed on fruit cracking among three pomegranate cultivars, under different salinity stress levels in both studied seasons. In most cases fruit cracking due to some agro-environment practices such as irregular irrigation or fluctuation of soil moisture and relative humidity, EL-Kassas (1984), plant nutrients and transpiration rates (Aksoy and Akyüz, 1993) in addition, harvesting date and partly cultivar dependent. El Sese (1988).

In regard to the interaction between two levels of saline water and three pomegranates cvs. The significant effect was observed on fruit cracking among three cultivars. The best results relative fruit cracking percentage was found in Wonderful cultivar (8.69 & 7.54) under salinity stress (1.8 dSm^{-1}) Meanwhile, under salinity stress (6 dSm^{-1}) Nab-Elgamal cultivar was a higher and significant in fruit cracking (11.70 & 12.76) in the first and second seasons respectively. The previous effects of two levels of saline water on fruit cracking with three cultivars of pomegranate might be attributed to the hardening of the fruit skin during long dry period and then sudden expansion in the volume of inner part of the fruit after heavy irrigation.(EL-Kassas, 1984). Also the great variations on the temperature, winds, relative humidity, light moreover, genotypic differences have been related to direct fruit cracking due to the moisture loosing from peel.(Bacha and Ibrahim, 1979).

Similar results were obtained by numerous investigators on different fruit species. Sotiropoules *et al*. (2007) on apple,. On the other hand, Parashuram and Lazarovitch (2010) revealed that there were no differences between two varieties of pomegranate, Wonderful and SP^{-2}. In response to varying saline water stress.

Chemical characters of fruits

Data in Table (11) obviously reveal that total Sugar and acidity percentages did not alter significantly with varying saline irrigation treatments. This may be attributed to salinity decreasing amount of water absorbed by the plant that reducing vegetative growth cases increasing total soluble materials.(Bielorai *et al*., 1988).

Table (11): Effect of irrigation with two levels of saline groundwater on Total Sugar % and Acidity % of three varieties of Pomegranate

Water Salinity (Ec_e dSm^{-1})		Total Sugar %							
		2010/2011				2011/2012			
		Manfalouty	Nab-Elgamal	wonderful	Mean (A)	Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	13.48	13.46	13.45	13.46	13.56	13.45	13.44	13.48
S_2	6.0	13.50	13.47	13.46	13.48	13.56	13.47	13.45	13.49
Mean (B)		13.49	13.47	13.46		13.56	13.46	13.45	
LSD 0.05%		A	B	AB		A	B	AB	
		N.S	0.1	0.21		N.S	0.11	0.22	
Water Salinity (Ec_e dSm^{-1})		Acidity %							
		2010/2011				2011/2012			
		Manfalouty	Nab-Elgamal	wonderful	Mean(A)	Manfalouty	Nab-Elgamal	wonderful	Mean (A)
S_1	1.8	1.146	1.137	1.146	1.143	1.154	1.138	1.152	1.145
S_2	6.0	1.148	1.135	1.147	1.143	1.156	1.139	1.151	1.145
Mean (B)		1.147	1.136	1.1465		1.155	1.1385	1.152	
LSD 0.05%		A	B	AB		A	B	AB	
		0.02	0.01	0.04		NS	0.01	0.012	

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On the other hand, varying total Sugar percentage was observed among three cultivars, the best results was found in Manfalouty cultivar (13.49 &13.56) meanwhile, Wonderful cultivar was significantly and lower in total Sugar percentage of fruits (13.46 & 13.45) in the first and second seasons. Similar trend was observed of acidity percentages in both seasons. Such finding might be attributed to the great variations towards nutrient uptake especially nitrogen and potassium. Overall, Manfalouty cultivar was considered to be well-adapted to exclude the major part of incoming salts at the root level and avoiding Na and / or Cl accumulation in actively growing tissue than other under this study.

The studied interaction showed a significant effect on total Sugar and acidity percentages during both seasons. The great values were observed with Manfalouty cultivar under salinity stress (6 dSm^{-1}) were (13.50 & 13.56) in total Sugar, whereas Nab-Elgamal fruits contains a low of acidity percentages than other (1.136 & 1.1385) in both seasons. Such results could be attributed to differences between cultivars to salt tolerance in addition salinity stress might be related in decreasing the water absorption.(Bielorai *et al*., 1988) and (Ibrahim, 1988).

These results are confirmed with those reported by many workers on different fruit species. Sotiropoules *et al*. (2007) on apple, EL-Agamy *et al.* (2009a) and EL-Khawaga (2013) on date palm, On the other hand, Parashuram and Lazarovitch (2010) revealed that there were no differences between two varieties of pomegranate, Wonderful and SP-2. in response to varying saline water stress.

Table (12): The changing in Physical and chemical properties with saline groundwater 1.8 EC at the end of the experimental.

Soil depth (cm)	ECe dSm^{-1}	pH	$CaCO_3$ %	Texture			Text . class	meq /L						
				S	Si	C		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
0 – 30	3.30	7.82	12.11	62.43	11.12	26.45	SCL	15.10	10.08	7.18	0.55	6.34	11.53	15.04
30 – 60	4.10	7.73	15.37	67.72	15.22	17.06	SL	18.42	12.75	8.67	0.42	8.62	14.13	17.51
60 – 90	4.80	7.92	16.78	73.60	13.14	13.26	SL	21.99	13.88	11.35	0.50	9.16	17.69	20.87

Table (13): The changing in Physical and chemical properties with saline groundwater 6.0 EC at the end of the experimental.

Soil depth (cm)	ECe dSm^{-1}	pH	$CaCO_3$ %	Texture			Text . class	meq /L						
				S	Si	C		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
0 – 30	5.60	7.79	12.16	62.42	12.13	25.45	SCL	27.76	15.75	11.12	0.68	8.61	20.11	26.59
30 – 60	6.30	7.83	15.47	67.21	15.71	17.08	SL	30.68	18.72	13.68	0.89	9.01	25.15	29.82
60 – 90	7.7	7.92	16.78	73.60	14.14	12.20	SL	35.44	23.61	16.74	0.97	10.01	30.82	36.21

Data in Tables (12&13) showed that increasing salinity levels of irrigation water resulted increased the total soluble salt in the soils under investigation. Total soluble salts were increased under two saline ground water. The increase of soil ECe was more pronounced under 6 dSm^{-1}.The highest values were recorded in the depth layer 60-90 cm 7.7 and 4.8 $dS.m^{-1}$ under the highest and lowest saline ground water respectively compared to control 3.72 dSm^{-1} these results might be attributed to the cumulative effect of salt stress on plants depends on the concentration and time of exposure of salt, plant genotypes and environmental factors (Maas and Hoffman, 1977).

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