Salt tolerance evaluation and relative comparison in cuttings of different pomegranate cultivars

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ABSTRACT

A pot experiment was conducted during a two-year period in order to evaluate and compare the salinity tolerance of 10 Iranian commercial cultivars of pomegranate. Pots were arranged in a split plot design with two factors included water salinity as main plot in 3 levels of 4, 7 and 10 dS/m and 10 pomegranate cultivars as sub-plot and 3 replications. The properties concerned during the experiment were vegetative growth, percentage of alive cuttings after 2 month and the necrosis and chlorosis of leaves. In the end of the experiment the vegetative yield and root dry weight were also measured. In addition, irrigation water, drainage water, soil in plots, root, stem and leaves were analyzed for elements such as Na^+ and Cl^-. The obtained results indicated that the best vegetative growth conditions were related to Voshike -e- Saravan and Tab -o- Larz cultivars at 4 and 7 dS/m salinity levels, respectively. Moreover, the most significant percentage of alive cuttings was related to Voshike -e- Saravan cultivar at each of the three studied salinity levels. Similarly, this cultivar had the minimum values of leaves necrosis and chlorosis at all three levels of salinity. Furthermore, the highest level of fresh yield was related to Zagh cultivar at 4 dS/m salinity level. The highest values of total Na^+ and Cl^- were observed in shoots and leaves of Zagh and Voshike -e- Saravan cultivars at 10 dS/m salinity level as well. In general, Voshike -e- Saravan is the most salinity-resistant cultivar among 10 studied cultivars. Besides, Malas -e- yazdi and Tab -o- larz can be planted as salinity resistant cultivars in the second hand. Other cultivar cuttings were not resistant in salinity and finally died (even after the second year) and three cultivars of Gabri, Malas -e- Esfahani and Khafri -e- Jahrom were the most sensitive cultivars with the lowest salinity resistance.

Keywords: pomegranate; iranian cultivars; saline irrigation water; salinity tolerance

The use of saline water for irrigation requires an adequate understanding of how salts affect soil characteristics and plant performance (Chartzoulakis et al. 2002). According to the incapacity to grow on high salt medium, plants have been classified as glycophytes or halophytes. Most plants are glycophytes and cannot tolerate salt stress (Parvaiz and Satyawati 2008). Consequently, salinity is an ever-present threat to agriculture, especially in areas where secondary salinisation has developed through irrigation (Flowers and Flowers 2005). The deleterious effects of salinity on plant growth are associated with: (1) low osmotic potential of soil solution (water stress); (2) nutritional imbalance; (3) specific ion effect (salt stress) or (4) a combination of these factors. During the onset and development of salt stress within a plant, all the major processes such as photosynthesis, protein synthesis and energy and lipid metabolisms are affected. The earliest response is a reduction in the rate of leaf surface expansion followed by cessation of expansion as the stress intensifies but growth resumes when the stress is relieved (Parvaiz and Satyawati 2008). Hence, an effective way to use saline lands should be found by the cultivation of tolerant cultivars or other agrotechniques (Tabatabaei 2006). Attempts to improve the salt tolerance of crops have met with very limited success, due to the complexity of the trait, both genetically and physiologically influenced (Flowers and Flowers 2005). However, conventional selection and breeding techniques have been used to improve salinity tolerance in crop plants. The agronomical parameters used for salt tolerance are yield, survival, plant height, leaf area, leaf injury, relative growth rate and relative growth reduction (Parvaiz and Satyawati 2008).

Pomegranate (*Punica granatum* L.) is an economically important commercial fruit plant species belonging to family Punicaceae (Aseri et al. 2008). This plant is native from Iran to the Himalayas in northern India and has been cultivated and naturalized over the Mediterranean region and the Caucasus region of Asia since ancient times (Glozer and Ferguson 2008). Many cultivar names are unique to the country where they are grown and genetic origins of these cultivars are often undetermined, therefore, there may be more than one cultivar name for a given pomegranate. In Iran there are several cultivars commercially produced by the farmers. Generally, these cultivars are marked as Alak -e- Shirin, Alak -e- Torsh, Bihasteh, Syah, Agha Mohammad Ali Shirin, Malas -e- Shirin, Malas -e- Torsh, Malas -e- Yazdi, Malas -e- Esfahani, Pust siah, Pust Sefeed -e- Shirin, Pust Sefeed -e- Torsh, Gabri, Tabestani, Zagh, Shahvar, Torsh -e- Zabol, Khafri -e- Jahrom, Voshike -e- Saravan and Tab -o- Larz (Naeini et al. 2004, 2006, Glozer and Ferguson 2008).

Pomegranate has been widely cultivated in arid and semi-arid regions of Iran, areas frequently affected by high salinity (Naeini et al. 2006). However, majority of the pomegranate-producing regions in Iran have salinity problems (Naeini et al. 2004). Not many studies related to various aspect of adverse effects of irrigation water and soil salinity on pomegranate production have been conducted so far (Patil and Waghmare 1982, Doring and Ludders 1986, 1987, Jain and Dass 1988). For example, Naeini et al. (2004, 2006) reported that in Malas -e- Torsh and Alak -e- Torsh cultivars, increasing salinity was proportional to NaCl concentration and reduced the length of stem, the length and number of the internodes, and leaf surface. They also observed that there was an increase in the growth rate of the Malas -e- Shirin cultivar with increasing salinity up to 40mM, but a decline in growth rate occurred at salinity levels higher than 40mM. Also, with increasing salinity level, the tissue concentration of Na and Cl increased while the K/Na ratio decreased. Consequently, they concluded that Malas -e- Shirin grew better under saline conditions compared with the Malas -e- Torsh and Alak -e- Torsh cultivars. In another investigation Zarinkamar and Asfa (2005) studied the effect of irrigation with saline water on anatomical structure and alkaloid production in pomegranate cultivar of Malas -e- Torsh in Saveh region of Iran. The 71 pomegranate trees were irrigated with waters having salinity levels of 800, 1200, 1600, 2000, 3200 and 4000 μmohs per cm in this study. They observed a significant rising in total root's alkaloids from increasing of salinity level from 800 to 4000 μmohs/cm. They concluded that salinity will change the anatomical structures of root and leaves of this Iranian cultivar of pomegranate.

Yazd region which is located in the central Iran is considered as one of the areas having high potential to produce pomegranate because of its special climate. However, salinity is a major problem in a wide pomegranate-growing area of central Iran (Naeini et al. 2006). Despite the economic importance of pomegranate and its by-products, the study on the response of its different growth indices to the increasing soil salinity. Also, the most resistant native cultivars of pomegranate to soil salinity are unknown for lost of gardeners in the region yet. The present study was therefore, carried out with the objective to identify and introduce the most-tolerant Iranian cultivars of pomegranate cutting that were selected from Yazd pomegranate collection to different salinity levels of irrigation water.

MATERIAL AND METHODS

In this study a pot experiment was conducted during a two-year period. Pots were arranged in a split plot design with two factors, water salinity as a main plot in 3 levels of 4 (W_1), 7 (W_2) and 10 (W_3) dS/m and 10 pomegranate cultivars as a sub-plot that included as 1-Gabri, 2-Malas -e- Esfahani, 3-Zagh, 4-Shahvar, 5-Malas -e- Yazdi, 6-Torsh -e- Zabol, 7-Khafri -e- Jahrom, 8-Voshike -e- Saravan, 9-Tab -o- Larz and 10-Pust siah (from K_1 to K_{10} respectively) and 3 replications. All of these 10 pomegranate cultivars were commercial and selected from Yazd pomegranate collection and planted in 90 pots at the Yazd Agricultural Research Center. However, the mentioned pomegranate cultivars were selected on the basis of salinity level of their origin irrigation water, marketing properties and in view of profit. Hence for achieving to this issue, the most tolerant cultivars to the present salinity in the region were selected from the existing scheme of collection characteristics of pomegranate hereditary resources of Yazd center. Between the 10 mentioned cultivars, -Malas -e- Yazdi and Tab -o- Larz are also known as the medicinal and

Table 1. Some chemical characteristics of saline waters used in this study

Samples	EC (dS/m)	pH	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	SAR
			(meq/l)							
W_1	4	7.7	0.0	2.4	29.3	10.5	12.0	12.8	18.7	5.3
W_2	7	8.0	0.0	2.5	56.5	12.5	14.0	20.0	38.7	9.4
W_3	10	8.0	0.0	3.7	82.5	13.6	14.8	27.6	57.5	12.5

premature cultivars of pomegranate in the region (Yazd province), respectively. In addition, the salinity treatments were selected on the basis of origin salinity of chosen cultivars (between ranges of 2–7 dS/m) and according to the salinity distribution of Yazd province water resources. Therefore the three mentioned salinity levels were obtained from mixing saline waters related to Hoseinabad Rastagh region with saline water of a representative well in the research center. The rates of some important parameters of these mixed saline waters are presented in Table 1.

In the early January, the pomegranate cuttings were prepared from the Yazd pomegranate collection. The most suitable pomegranate cuttings were selected and all of them was almost uniform. Also, the length and diameter of cuttings were in the ranges of 30–35 cm and 2–2.5 cm, respectively (Koshkhooi 2006). The cuttings were planted into the large plastic pots having 65 liter volume, 60 cm height, 42 cm upper opening mouth diameter and 32 cm bottom diameter. In the bottom of each pot, a system for outflow of drainage water was devised. In addition, in the floor of each pot a layer of thin plastic netting was installed. Then over the nettings a layer of fine sand particles having approximately 5 cm thickness was settled as a filter. The pots were filled with a saline soil having Sandy loam texture taken from Hoseinabad Rastagh region in Yazd province of Iran. Some physical and chemical properties of the soil used in this study before planting the pomegranate cuttings are presented in Table 2. Adding 5 cm from upper empty space of edge of each pot, the actual height of soil inside the pots was about 50 cm. For making of equilibrium condition in all of the pots, their soils were irrigated in several periods by saline water having electrical conductivity of 4 dS/m. Moreover the pots were installed on the metal frameworks and hence, for preventing from intense sunlight radiation in summers and adverse effect of heat on root development, breaking the casing of pots and other unpredicted environmental stresses, all of the pots were covered using a relatively thick glass wool layer. The numbers of four cuttings related to one cultivar were planted in each pot. Irrigating by water having electrical conductivity of 4 dS/m continued until the primary germination of cuttings and followed by three saline water treatments mentioned in Table 1. The rate of water demand for cuttings in each water treatment was measured using the equation 1 (Alizadeh 1989).

$$d = \frac{(FC - \Psi) \times \rho b \times D \times Ra}{100\ (1 - LR)} \qquad (1)$$

Where: d denotes the depth of irrigation water, FC is the water content at field capacity level (15.3%), Ψ is the present water content at the irrigation time (9%), ρb is the soil bulk density (1.55 g/cm^3), D is the soil depth (50 cm), Ra is the water use efficiency (100% = 1) and LR denotes the leaching coefficient which is variable for each salinity limit with respecting to FAO table.

Table 2. Some physical and chemical properties of the soil before planting the cuttings

Textural class (sandy loam)		Total N	O.C	T.N.V	pH	EC (dS/m)	K_a	P_a
		(%)					(mg/kg)	
		0.06	0.067	29.9	7.6	33.2	175	7.2
		Cations and Anions						
Clay (%)	15.0	Na^+	Mg^+	Ca^{2+}	SO_4^{2-}	Cl^-	HCO_3^-	CO_3^{2-}
Silt (%)	26.1	($cmol_c$/kg)						
Sand (%)	58.9	300	57	67.5	79.5	342.5	2.4	–

Table 3. Mean of electrical conductivity (EC) and sodium adsorption ratio (SAR) related to soil samples taken from four depths of pots in different salinity treatments at the end of experiment

Salinity treatments	Soil depth (cm)	EC (dS/m)	SAR
W_1	0–12.5	14.27	14.51
	12.5–25	10.79	12.05
	25–37.5	10.11	9.59
	37.5–50	8.93	10
W_2	0–12.5	46.04	31.76
	12.5–25	15.36	18.30
	25–37.5	14.24	17.80
	37.5–50	13.63	14.60
W_3	0–12.5	47.07	55.60
	12.5–25	21.71	28.60
	25–37.5	18.9	28.10
	37.5–50	18.2	18.80

So that, the leaching coefficient for salinity levels of 4, 7 and 10 dS/m is 0.15, 0.30 and 0.45, respectively (Smaeili 2001). Therefore in each irrigation intervals with regarding to leaching water for salinity levels of 4, 7 and 10 dS/m, the rates of used water by cuttings were 6, 7.3 and 9.6 liter, respectively. According to climatic conditions of the region and present circumstances, the irrigation interval was applied in a week cycle which sometimes reduced to 5–6 day at hot months and seasons.

Apparent conditions of all treatments including vegetative growing indices (length and number of main stem and trunk diameter), primary percentage of germinated cuttings in the first experimental year (alive cutting percentage after 2 month), percentage of survived germinated cuttings from first year (cutting established percentage) at the end of experiment (second experimental year), the necrosis and chlorosis of leaves and their falling rates in treatments, were recorded during the experiment. At the end of each month, the vegetative growth parameters and other studied indices of treatments were investigated and scores between ranges from 1 to 4 were allocated to them according to their conditions. So that monthly numbers of 4 and 1 were related to maximum and minimum rates of vegetative growth, necrosis and chlorosis respectively. Percentage of survived germinated cuttings at the end of second experimental year (end of experiment) on the basis of four planted cuttings in each pot was presupposed 100%. Hence, the contents of 25, 50, 75 and 100% were related to 1, 2, 3 and 4 established cuttings at the end of experiment, respectively. In the end of the experiment, in early October of second experimental year, all of alive cuttings were cut at 10 cm above soil surface at the same time and then vegetative yield and root dry weight of each treatment were measured. Ultimately, soil samples were prepared from 4 different depths of each pot (4 depths of 12.5 cm) in the form of a combined method for each replication and water treatment (totally 36 soil samples). The level of EC and SAR for these samples was measured and it is presented in Table 3. The drainage water samples of last irrigation period at end of experiment were also analyzed (Table 4). The statistical analysis of the obtained data was done by MSTAT-C software using general model procedures. Comparison of mean values for various parameters was also made using the Duncan Multiple Range Test at 5% probability level.

RESULTS

The comparison of means for vegetative growth of cuttings in three salinity treatments showed that the best vegetative growth was related to W_1 (4 dS/m) treatment. Hence, the salinity level of irrigation water had an adverse effect on pomegranate growth. The percentage of death cuttings at the end of second experimental year in pots irrigated by 10 dS/m water were significantly ($P < 0.05$) increased (Table 5). Similarly, the comparison of means in interaction between salinity and cultivar explains that the best vegetative growth condition was obtained at Voshike -e- Saravan at 4 dS/m salinity level. Besides Voshike -e- Saravan, Tab -o- Larz at 7 dS/m salinity level took the second order among 10 pomegranate cultivars with respect to its vegetative growth. Generally, Voshike -e- Saravan had the best vegetative growth results in all three salinity levels compared with other cultivars. Moreover, three cultivars of Gabri,

Table 4. Some chemical characteristics of drainage water samples at the end of experiment

Samples	SAR	pH	EC (dS/m)
W_1	13.6	8.2	11.9
W_2	27.7	8.2	13.2
W_3	32.3	8.1	45.0

Table 5. Effect of different salinity levels on mean of different studied parameters at the end of experiment

Salinity treatments	Vegetative growth	Alive cutting percentage	Leaves necrosis	Leaves chlorosis	Fresh yield (kg)
W_1	1.40[a]	0.17[a]	2.67[b]	2.57[b]	0.34[a]
W_2	0.73[ab]	0.11[a]	3.43[ab]	3.27[ab]	0.11[b]
W_3	0.43[b]	0.07[a]	3.53[a]	3.50[a]	0.09[b]

Means in each column with similar letters are not significantly different at the 5% probability level using the Duncan Multiple Range Test

Malas -e- Esfahani and Khafri -e- Jahrom had the minimum values of vegetative growth in all three studied salinity levels (Figure 1).

The comparison of means of percentage of alive cuttings in different salinity levels shows that none of the three salinity treatments could affect this characteristic (Table 5). In addition, dying of cuttings during the growth season revealed that the adverse effect of salinity is rather gradual and, in all the cultivars except Malas -e- Yazdi, the death of cuttings was increased with increasing salinity level. Therefore, with regard to low percentages of alive cuttings in the case of Malas -e- Yazdi even at 10 dS/m salinity level, it can be concluded that this cultivar can tolerate soil salinity after passing the first root development stage and germination. Also, the comparison of means in interaction between salinity and cultivar clarifies that the most significant ($P < 0.05$) percentage of alive cuttings was recorded at Voshike -e- Saravan at 4 and 7 dS/m salinity levels. Tab -o- Larz at 7 dS/m salinity level took the second order again. Furthermore, three cultivars of Gabri, Malas -e- Esfahani and Khafri -e- Jahrom had the minimum percentage of alive cuttings in all three studied salinity levels (Figure 2).

The results of comparison of mean for both leaves necrosis and chlorosis showed that increasing salinity enhanced their values and thus, the most levels of these characteristics were observed in the 10 dS/m treatment. Hence, W_3 (10 dS/m) treatment significantly ($P < 0.05$) affected leaves necrosis and chlorosis (Table 5). Also, the comparison of means in interaction between salinity and cultivar for leaves necrosis and chlorosis shows that Voshike -e- Saravan had the minimum values at all three levels of salinity (Figures 3 and 4); this cultivar can resist to soil salinity effortlessly genetically and due to having special mechanisms. Besides Voshike -e- Saravan, Zagh at 4 dS/m salinity level

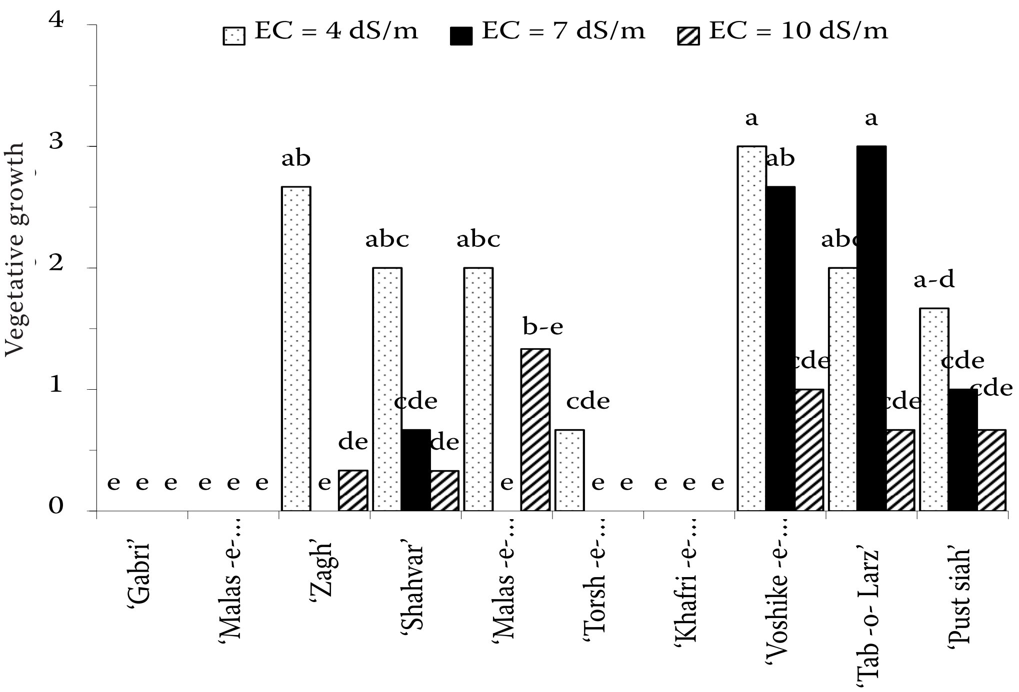

Figure 1. Effect of different levels of salinity on vegetative growth of 10 pomegranate cultivars

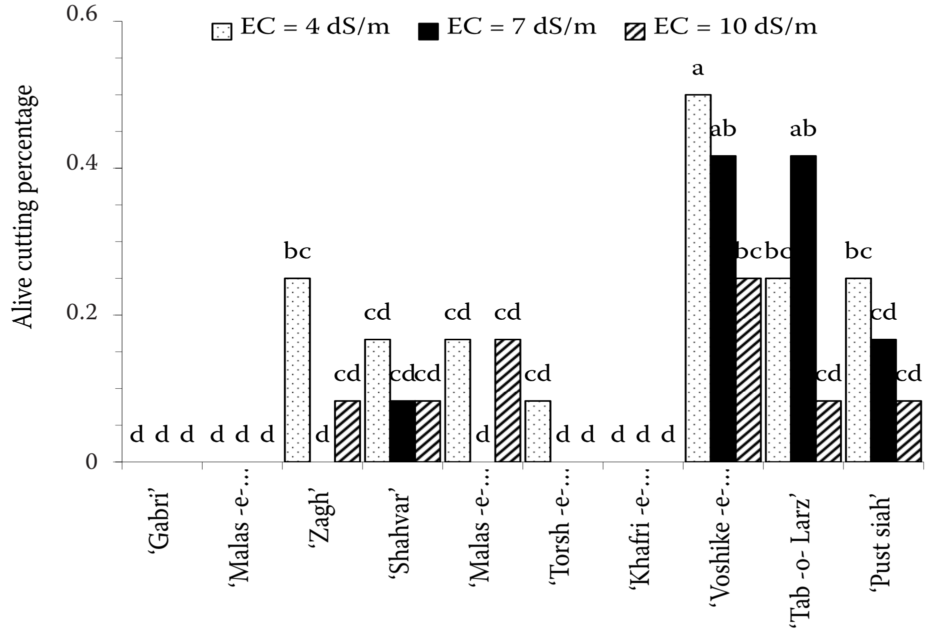

Figure 2. Effect of different levels of salinity on percentage of alive cuttings of 10 pomegranate cultivars

had the minimum values of leaves necrosis and chlorosis. Similarly, the Tab -o- Larz cultivar at 4 and 7 dS/m salinity levels showed low values of leaves necrosis and chlorosis (Figures 3 and 4).

The comparison of means for effect of salinity on fresh yield (above ground parts of plants) of pomegranates shows the descending yield with increasing salinity; W_2 (7 dS/m) and W_3 (10 dS/m) treatments significantly ($P < 0.05$) affected this characteristic (Table 5). This is a natural result and we can easily observe this procedure even at tolerant cultivars. Moreover, the comparison of means in interaction between salinity and cultivar for fresh yield shows that at W_1 (4 dS/m) treatment the highest level of fresh yield is related to Zagh. However, in general the most yield is related to Tab -o- Larz (Figure 5). On the other hand, the effect of salinity on non-halophytes is a reduction in growth and yield (Chartzoulakis et al. 2002). Low salinity (4 dS/m) seems to stimulate growth in some cultivars such as Zagh, while at moderate and high levels (7 and 10 dS/m) the reduction in fresh yield is so common. In addition, three cultivars of Gabri, Malas -e- Esfahani and Khafri -e- Jahrom had the minimum values of fresh yield in all three studied salinity levels (Figure 5).

The results of soil analysis in different salinity treatments at the end of experiment in different

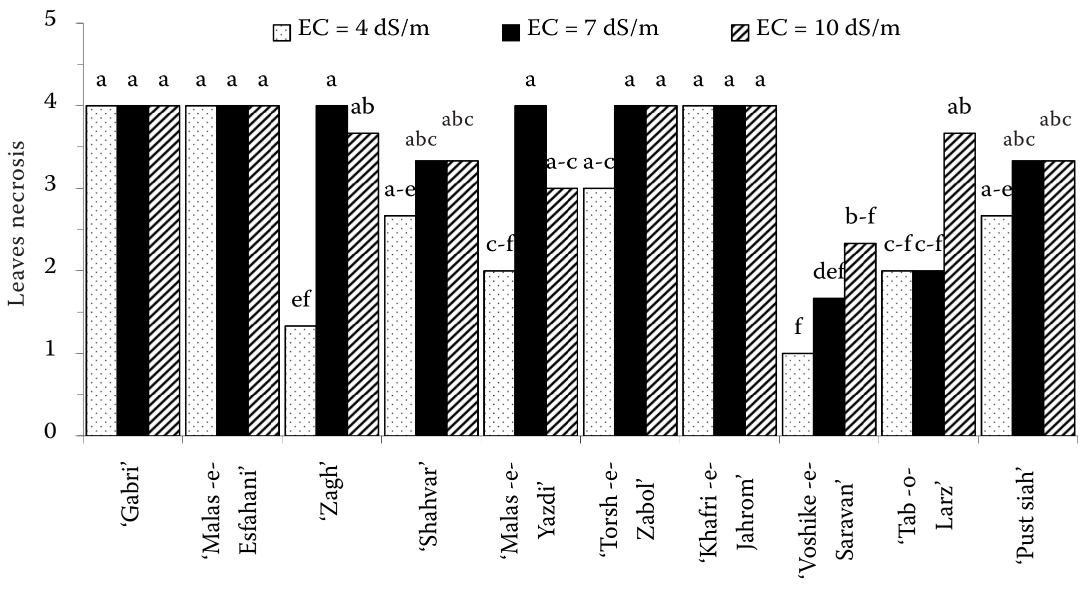

Figure 3. Effect of different levels of salinity on leaf necrosis of 10 pomegranate cultivars

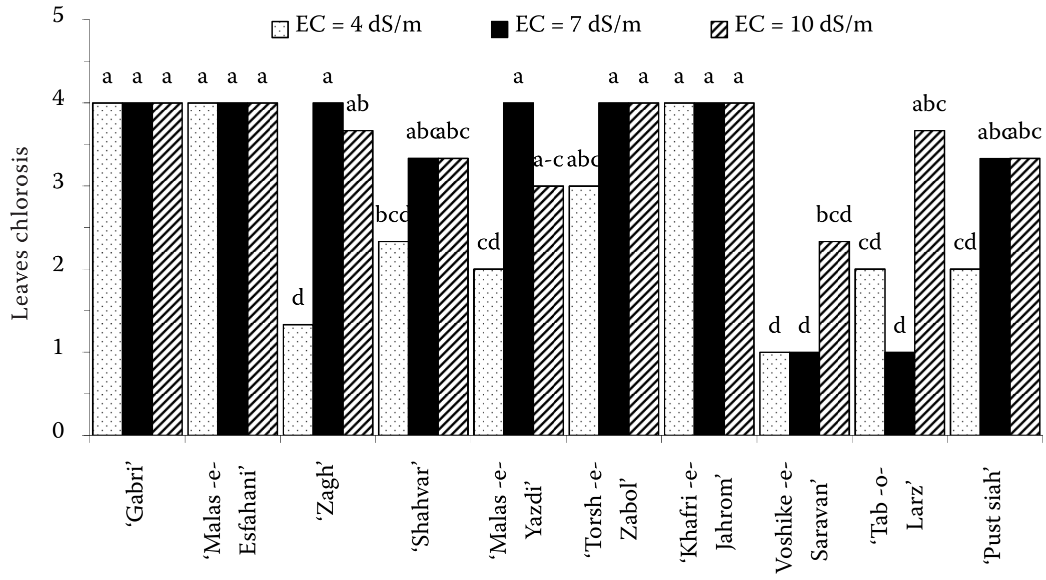

Figure 4. Effect of different levels of salinity on leaf chlorosis of 10 pomegranate cultivars

depth of pots shows that soil salinity level at overlying parts of the pots in all of the treatments is significantly higher than in layers underneath. A similar result was derived for SAR levels measured in different depth of pots (Table 3). This was probably caused by evaporation from soil surface at the hot months of summers in the study area; movement of dissolved salts along with capillary water toward soil surface and therefore their accumulation in hot months was the reason of these observations. Also the results of measuring of dry root yield showed that just about 5% of root mass were concentrated at upper first layer (0–12.5) and the remaining (about 95%) were developed at other layers specially at the second (12.5–25) and third layers (25–37.5).

The results of measuring of amounts (concentrations) of Na^+ and Cl^- in shoots and leaves of different cultivars and salinity levels are presented in Table 6. The highest values of total Na^+ and Cl^- in alive cuttings at the end of the experiment belonged to Zagh and Voshike -e- Saravan cultivars at 10 dS/m salinity level (K_8W_3 and K_3W_3). Also, on the basis of the obtained results, an increase of Na^+ and Cl^- in shoots and leaves of all cultivars had a direct relationship with increasing salinity level (Table 6).

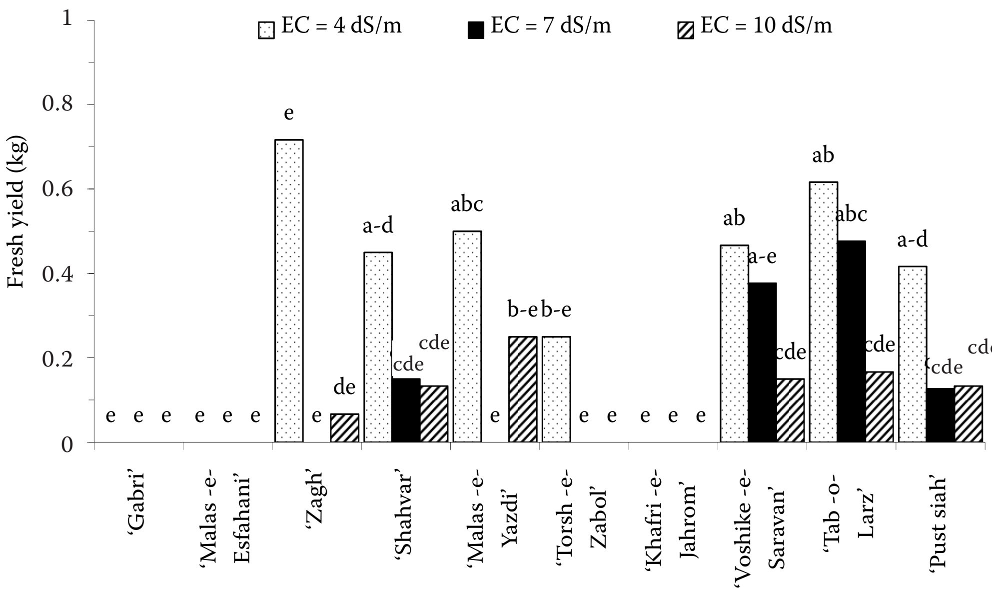

Figure 5. Effect of different levels of salinity on fresh yield of 10 pomegranate cultivars

Table 6. Concentrations of Na^+ and Cl^- (ppm) in the shoots and leaves of different cultivars and salinity levels

Treatments	Na^+	Cl^-	Total
K_3W_1	0.26	0.62	0.88
K_3W_3	1.90	1.32	3.22
K_4W_1	0.20	0.97	1.17
K_4W_2	0.75	1.32	2.07
K_4W_3	1.67	0.98	2.65
K_5W_1	0.32	0.80	1.12
K_5W_3	1.35	1.94	3.24
K_6W_1	0.14	0.88	1.02
K_8W_1	0.20	0.88	1.08
K_8W_2	0.75	1.50	2.25
K_8W_3	1.50	2.38	3.88
K_9W_1	0.09	0.53	0.62
K_9W_2	0.46	1.41	1.87
K_9W_3	0.86	1.14	2.00
$K_{10}W_1$	0.37	0.70	1.07
$K_{10}W_2$	1.32	0.88	2.20
$K_{10}W_3$	1.15	1.41	2.56

DISCUSSION

The results showed that the Voshike -e- Saravan had the most significant vegetative growth in seedling stage among the 10 studied cultivars. In addition, early in the second year one of its wilted cuttings at 7 dS/m treatment was generated again and showed an excellent vegetative growth. These reasons are sufficient to introduce Voshike -e- Saravan as a cultivar tolerant to salinity. Besides, Voshike -e- Saravan had the highest percentage of alive cuttings, but its fresh yield was lower than Tab -o- Larz. However, the reason of salinity tolerance of Voshike -e- Saravan probably comes back to its adoptability during long periods of years. Also, it seems that this cultivar is genetically resistant to salinity, which requires further study. However, knowledge of heritability and the genetic mode of salinity tolerance is lacking because few studies have yet been conducted in these areas. Indeed, genetic information is lagging behind the physiological information. Thus, there is a need to determine the underlying biochemical mechanisms of salinity tolerance so as to provide plant breeders with appropriate indicators. Although there is a number of promising selection criteria, the complex physiology of salt tolerance and the variation between species make it difficult to identify single criteria (Ashraf and Harris 2004). Furthermore, the unique external figure of Voshike -e- Saravan such as its massive and dumpy stems and thick and fleshy leaves distinguishes this cultivar from the other cultivars. These characteristics are related to plants grown in arid and desert areas. Yet, the only advantage of Voshike -e- Saravan related to its marketing property is its large volume of fruits; the grain (seed) size of its fruits is very tiny having relatively white color and this cultivar has not good taste. With regard to high levels of yields of Voshike -e- Saravan, this cultivar can be introduced as a suitable stalk for hybridization.

The results of this study also indicated that the Malas -e- yazdi and Tab -o- larz cultivars can be used as salinity resistant cultivars in the second hand. Due to low alive cutting percentages of Malas -e- Yazdi and Tab -o- Larz, the number of seedlings for cultivation in orchards should be more (at least 4 fold) than in the case of Voshike -e- Saravan. Cuttings of other cultivars were not resistant to salinity and finally died (even after second year). Three cultivars, namely Gabri, Malas -e- Esfahani and Khafri -e- Jahrom are the most sensitive cultivars with the lowest salinity-resistance; these three cultivars of pomegranate showed the lowest values of shoot and leaf growth biomass. Similar findings about decrease in roots, shoots and leaves growth biomass of many agricultural crops with increasing NaCl level was reported before (Anthraper and Dubois 2003, Aragües et al. 2004, Sairam and Tyagi 2004, Hajer et al. 2006). Reduced growth rates as a result of salt stress were initially related to loss of turgor and its accompanying relaxation of cell wall tension. However, the relationship appears to be more complex. Reduction of growth rate occur even without loss of turgor and it appears likely that growth is actively controlled, independently of the sensing of turgor pressure, via changes in cell wall extensibility. Such changes appear to be related to changes in protein composition of cell walls. Thus, adverse effects of salinity on growth and metabolism may be due to osmotic inhibition of water availability, toxic effects of high salts ions and disturbance of the uptake and translocation of nutritional ions (Ates and Tekeli 2007).

In general, the increase of Na^+ and Cl^- in shoots and leaves of all studied cultivars had a direct relationship with increasing salinity level. The high concentrations of Na^+ and Cl^- observed in pomegranate cultivars might disturb the equilibrium between anions and cations (Naeini et al. 2004, 2006). Therefore, the higher growth rate and salt tolerance of Voshike -e- Saravan compared with other studied cultivars is probably not related to the amount of absorption or translocation of Na^+ and Cl^-, but to the critical toxicity levels of these ions in plant tissues. However, it can be concluded that the level of Na^+ and Cl^- uptake by plants and their accumulation into the leaves was not affected by cultivar. Indeed, cultivar by itself can show different resistance against adverse affect of these salts via their accumulation in its tissues and other reactions. This finding is in line with the works done by Tattini et al. (1994), Naeini et al. (2006), Neocleous and Vasilakakis (2007), and Khoshgoftarmanesh and Naeini (2008). All of these researchers reported that increasing salinity level will ultimately increase Na^+ and Cl^- concentration in the plant tissues. However, high Cl^- and Na^+ concentration in leaf tissue may damage plants, which is apparent in loss of chlorophyll. As the high levels of Na^+ or Na^+:K^+ ratio can disrupt various enzymatic processes in the cytoplasm, K^+ activates more than 50 enzymes and is an essential element in protein synthesis as it binds tRNA to the ribosomes. The disruption in protein synthesis appears to be an important cause of damage by Na^+ (Parvaiz and Satyawati 2008). The loss of chlorophyll, which is an important protein in plant tissues, as a result of toxicity symptoms leads to leaf chlorosis and necrosis (Lycoskoufis et al. 2005, Khoshgoftarmanesh and Naeini 2008). Accordingly, intensity of leaf injury by salt was observed among sensitive cultivars such as Gabri, Malas -e- Esfahani and Khafri -e- Jahrom showing more severe leaf necrosis and chlorosis than tolerant cultivars. Hence, growth and yield reductions of these three cultivars occurred as a result of shortening of the lifetime of individual leaves, thus reducing net productivity and crop yield (Tester and Davenport 2003).

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