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Effect of Salicylic Acid and Irrigation Water Quality on Pistachio in Pumice Substrate

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Abstract

Pistachio is one of the most important commercial trees grown in Iran arid and semi-arid regions. Salt stress has been reported to cause an inhibition of growth and development, reduction in many plant characteristics. Adverse effects of salinity on growth, and characteristics of pistachio have demonstrated. Salicylic acid (SA) is known to have an affect on normal conditions and stresses in plants. This study evaluated the vegetative characteristics (fresh and dry weight of shoot and root) and physiological characteristics (chlorophyll) as responses to salinity and salicylic acid in pistachio under a pumice substrate. A factorial experiment was conducted on the basis of a completely randomized design with three replications at the research greenhouse of Islamic Azad University of Damghan. The study was designed to evaluate two factors , included 9 treatments at three replication .The first factor was three levels of irrigation water salinity including : Ecw0 = 2.7 $dS.m^{-1}$, Ecw1 = 4 $dS.m^{-1}$, Ecw2 = 8 $dS.m^{-1}$ .The second factor was salicylic acid with three concentrations as following: 0 $mg.l^{-1}$ (control) , 80 $mg.l^{-1}$ and 160 $mg.l^{-1}$. The studied parameters were fresh and dry weight of the shoots & roots and chlorophyll a. Analysis of variance indicated significant differences due to salinity and salicylic acid on fresh and dry weight of shoot and root of pistachio at the all levels in comparison with the control. The interaction between the salicylic acid concentrations and type of irrigation water gave significant differences in all of the study parameters (except for chlorophyll a). The most significant results were obtained with salicylic acid treatment at 160 $mg.l^{-1}$. Results indicated that salinity treatments decreases studied parameters including: Shoot (FW), Shoot (DW), Root (FW), Root (DW) and Chlorophyll a. Results showed that lower salinity brings improved plant growth. Results showed that salicylic acid improved the chlorophyll a content of pistachio.

Keywords: Irrigation water, Salicylic acid, Pistachio, Salinity.

Introduction

Pistachio is one of the most important commercial trees grown in Iran, Turkey, and recently in the USA. Iran exports 150,000 to 200,000 tons of pistachios annually. This is while the global demand for Iranian pistachios can even reach a few million tons. Pistachio is considered as a suitable plant for arid and semi-arid regions. Pistachio plants are known to be tolerant to salts (Sepaskhah and Maftoun, 1981; Behboudian *et al.*, 1986a; Picchioni and Miyamota, 1990; Najmabadi (1969) also stated that pistachio can grow on lands that are too saline for other crops; however Parsa and Karimian (1975) 2002).

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have shown that salt adversely affects the aerial and root growth of *P. vera.* Adverse effects of salinity on growth, photosynthetic rates, and morphological changes in the leaves of pistachio have been reported (Behboudian *et al.*, 1986a; Picchioni and Miyamota, 1990; Munns *et al.*, 2002; Ranjbar *et al.*, 2002). The advantages of seedling production in pots over field production are primarily due to easy marketing, long planting and marketing period, easy transportation and rapid product rotation. Choosing the most suitable growing media for the achievement of successful plant production is very important in potted growth (Ingram *et a*l., 2003). The impact of pumice on crop growth and substrate physical properties has been studied throughout the world, as pumice from each volcanic region has unique properties (Gizas and Savvas, 2007; Gunnlaugsson and Adalsteinsson, 1995; Lenzi *et al.*, 2001). Also soil salinity is a widespread problem especially in arid and semiarid regions. Some studies indicate that 20-50% of all irrigated croplands are affected by high salt concentration, resulting in considerable economic losses (Flowers, 1999). Salt stress has been reported to cause an inhibition of growth and development, reduction in photosynthesis, respiration and protein synthesis in sensitive species (Boyer, 1982; Pal *et al.*, 2004, Ashraf *et al.*, 2008; Kamal Uddin *et al.*, 2009, Flowers, 1999; Ghassemi *et al.*, 1995). Salts in the soil water may inhibit plant growth for two reasons: The salts reduce the ability of the plant to take up water. When salts in the soil solution inhibit water uptake by the roots, the effect is the same as *drought stress*. Alzubaidi (1989) showed that the irrigation water carried a lot of salts to the soil, increasing soil salinity, adds another problem for the plant to tolerate salinity**.**

Some research has indicated that there is relationship between the salicylic acid and the tolerance to salt stress in plants (Dat *et al.*, 1998; lopez-Delgado, 1998). Salicylic acid induces many physiological processes in plants, some being promoted and others inhibited (Raskin, 1992). Different levels of acetylsalicylic acid appeared to function as antitranspirants in leaves of *Phaseolus vulgaris*, and inhibited the opening of stomata in epidermal strips of *Commelina communis* (Larqué-Saavedra, 1979). Khodary (2004) studied different levels of salicylic acid in maize plants under stressed conditions and found that salicylic acid could stimulate salt tolerance by accelerating photosynthesis performance and carbohydrate metabolism, Salicylic acid increased the protein content inside the plant cells improving plant's ability to tolerant salt stress (Kumer *et al.*,1999). Similarly, another study mentioned that salicylic acid increased the activity of nitrate reductase in the presence of NO_3^- and also favored protection of the enzyme against the protease, trypsin (Rane *et al*., 1995). The aim of present study was to evaluate the vegetative characteristics (fresh and dry weight of shoot and root) and physiological characteristics (chlorophyll) as responses to salinity and salicylic acid in pistachio under the substrate pumice.

Materials and Methods

The study was conducted at the research greenhouse of Islamic Azad University of Damghan, in 2012. First seeds of pistachio were sterilized with 0.1% sodium hypochlorite for 4 hours and rinsed repeatedly with distilled water. After sterilization, the seeds were planted in pots containing 4 kg of amended soil (50% soil +50% pumice). Seeds were irrigated after the planting with distilled water. After 35 days irrigation water containing salicylic acid was added to the pots. Saline solutions were prepared by adding sodium chloride (NaCl). Some physical and chemical characters of studied soil and irrigation water are given in Tables 1 and 2.

Table 1. Some physical and chemical soil characters for studied soil.

physical characters			Chemical characters				
Texture							
Sand (%)	Silt (%)	Clay (%)	Ec(ds/m)	pH	Ca^{++} + Mg^{++}	Na^{+}	$CaCO_3$
74	12	14	5.8	8.1	8.1	6.5	27.5

Table 2. Some chemical characters of irrigation water.

Ec (ds/m)	pH	Ca^{++}	Cl^{-}	Na^{+}	Mg^{++}	CO_3^{-}	HCO_3^{-}	So_4^{--}	SAR
2.7	7.30	2.70	14.5	22	2.5	0	5.0	6	13.8

Plots were maintained under controlled conditions at temperature of 25°C and a relative humidity of 40% in a greenhouse. At the end of research, seedlings were harvested from pots and the plants were divided into root and shoot. The parameters studied were the fresh and dry weights of the shoots and roots and the amount of chlorophyll a. Chlorophyll content is obtained by rinsing in 85% acetone solution according to Mackinney [Mackinney, 1941] and measuring its absorbance using Campspec M501 Single Beam UV/Vis Spectrophotometer at λ= 663 nm and λ= 645 nm.

The analysis of variance (ANOVA) was done using the method of Duncan [Whitely and Ball, 2002]. The treatment and experimental design: A factorial experiment on the greenhouse specimens was conducted on the basis of Randomized Complete Design (RCD) with three replications. The study was designed in terms of two factors, included 9 treatments with three replication of each. The first factor was three levels of irrigation water (W) as follows: well water: with Ec = 0 $dS.m^{-1}$ (W0), Ec = 4 $dS.m^{-1}$(W1), Ec = 8 $dS.m^{-1}$(W2). The second factor was salicylic acid (A) with three concentrations as follows: 0 $mg.l^{-1}$ (control) (A0), 80 $mg.l^{-1}$, (A1) and 160 $mg.l^{-1}$ (A2).

Results

Analysis of variance indicated significant differences due to salinity and salicylic acid on fresh and dry weights of shoot and root of pistachio at all levels by compared with control (Table 3). The interaction between the salicylic acid concentrations and kind of irrigation water gave significant differences in all of the study parameters (except for chlorophyll a). Comparison of the Duncan test on effect of salicylic acid and irrigation water treatments on the dry weight of the shoots and roots and chlorophyll a of pistachio is shown in Figs. 1 to 10 and Tables 4 to 7). The most studied parameters were obtained with salicylic acid treatment at 160 $mg.l^{-1}$. Results indicated that salinity treatments decreased the parameters studied, namely the weights of Shoots (FW and DW), Roots (FW and DW) and Chlorophyll a. The results showed that lower salinity brings longer plant growth and that salicylic acid improved the chlorophyll a content in pistachio.

Table 3. Analysis of variance for shoot and root fresh and dry weight and chlorophyll a content

ANOVA Table						
		MS				
Sources of Variation	df	Plant properties				
		Shoot(FW)	Shoot(DW)	Root(FW)	Root(DW)	Chol a
Water salinity	2	0.593 **	0.910**	0.154**	0.145 **	0.0008**
Salicylic acid	2	0.751**	0.778**	0.653**	0.562**	0.0034**
Water salinity * Salicylic acid	4	0.022*	0.010^{ns}	0.021**	0.024**	0.00001^{ns}
CV		1.96	1.78	1.86	2.52	5.39

FW: Fresh weight, DW: Dry weight, *: significant at %5, **: significant at %1 , ns: not significant

Table 4. Effect of salicylic acid and kind of irrigation water & the interaction shoot (DW)

Treatment	Salicylic acid		
	A0	A1	A2
	Water salinity		
W0	1.36 c	1.66 b	2.03 a
W1	1.15c	1.33c	1.66b
W2	0.73d	1.12c	1.30c

Table 5. Effect of salicylic acid and kind of irrigation water & the interaction on shoot (FW)

Treatment	Salicylic acid		
	A0	A1	A2
	Water salinity		
W0	1.66b	2.16a	2.30a
W1	1.53b	1.76b	2.13a
W2	1.30c	1.50b	1.76b

Table 6. Effect of salicylic acid and kind of irrigation water & the interaction on root (FW)

Treatment	Salicylic acid		
	A0	A1	A2
Water salinity			
W0	2.50C	2.64b	2.88a
W1	2.67b	2.88a	3.08a
W2	2.25d	2.69b	3.05a

Table 7. Effect of salicylic acid and kind of irrigation water & the interaction on root (DW)

Treatment	Salicylic acid		
	A0	A1	A2
Water salinity			
W0	2.15c	2.25c	2.61a
W1	2.37b	2.58a	2.75a
W2	2.03c	2.46b	2.70a

Discussion

The results showed significant differences in averages of fresh and dry weights of the shoots and roots, where plants were irrigated with the salicylic acid compared with untreated plants (Table 3). This could be because salicylic acid improved the chlorophyll content (Ghia *et al*., 2002), but it also could be explained by salicylic acid improving the vegetative and root characteristics of the plants. Salinity reduced the majority of the parameters studied and salicylic acid increased all parameters. Saline water decreased the fresh and dry weights of the shoots and roots compared with well water. Salt stress has been reported to cause an inhibition of growth and development, reduction in photosynthesis, respiration and protein synthesis in sensitive species (Boyer, 1982; Pal *et al*., 2004). Other studies show that the use of a silica compounds and salicylic acid enhanced growth and resistance of plants to salt stress (Snyder *et al.*, 1986). These researchers showed that increases the antioxidant protective system, thus enhancing salinity tolerance in plants (Wang *et al*., 2006). Salinity normally decreases vegetative growth of plants such as pistachios. It has been claimed that the growth of pistachio trees under stress surpasses that of all other fruit trees species (Spigel-Roy *et al.*, 1997). Exposure to salt may affect plant metabolism by an osmotic effect, causing a water deficit, or by a specific ion effect (depending on the types of salt and species), causing excessive ion accumulation. The reduction in plant tissues, as well as visible-injury observations suggests that the salinity not only decreases plant growth but also increases chlorosis, defoliation and other toxicity symptoms (Tvallali *et al.*, 2008). The interaction between the salicylic acid concentrations and level of irrigation water gave a significant difference on all of the studied parameters except for chlorophyll a (Table 1 and Figs. 1 to 10). Researchers found that salicylic acidincreased drought tolerance in beans and tomatoes (Astychr *et al*., 1997). The ability of salicylic acid to aid plant tolerance may be explained as the salicylic acid promotes the formation of reactive oxygen species(ROS) in the photosynthetic tissues of plants during salt and osmotic stress (Borsani *et al.*, 2001), or may be due to providing protection against salinity in plants (Tari *et al*., 2002; Szepesi *et al.*, 2005). Similarly, another study has suggested that salicylic acid increases the activity of nitrate reductase in the presence of NO_3 and also favors protection against the protease, trypsin (Rane *et al*., 1995). Salicylic acid is produced naturally in plants, and plant physiological processes such as stomatal closure, ion uptake, protein synthesis, chlorophyll synthesis, inhibition of ethylene biosynthesis are involved (Shkyrvva *et al*., 2003). The use of salicylic acid in salinity stress studies is reported to have increased proline, chlorophyll and carotenoids (Xu *et al*., (2008).

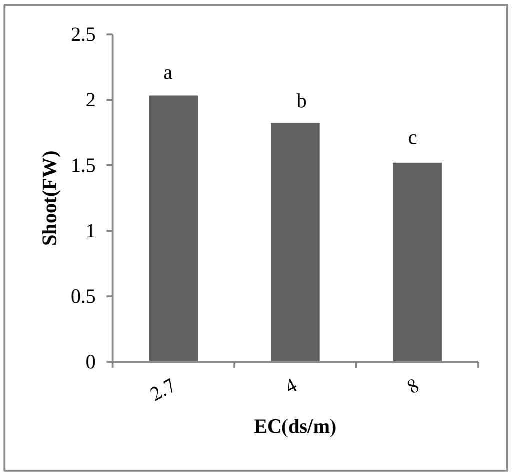

Fig. 1. Different levels of irrigation water salinity on shoot (FW)

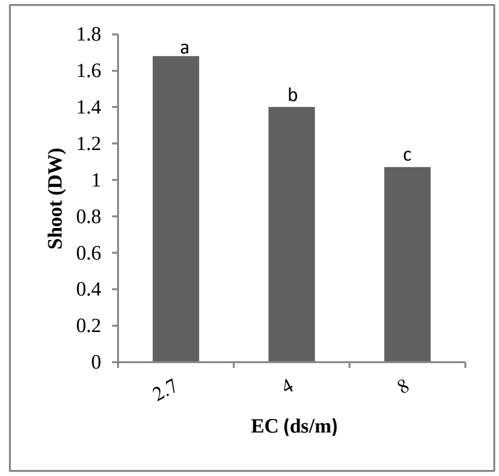

Fig. 2. Different levels of irrigation water salinity on shoot (DW)

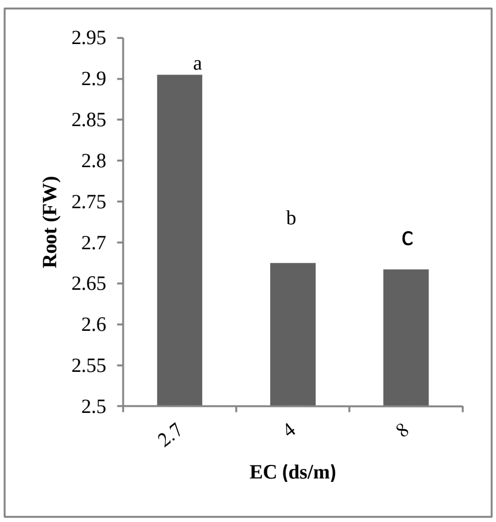

Fig. 3. Different levels of irrigation water salinity on root (FW)

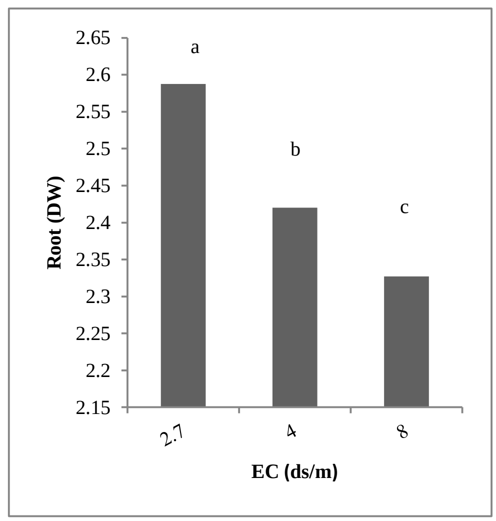

Fig. 4. Different levels of irrigation water salinity on root (DW)

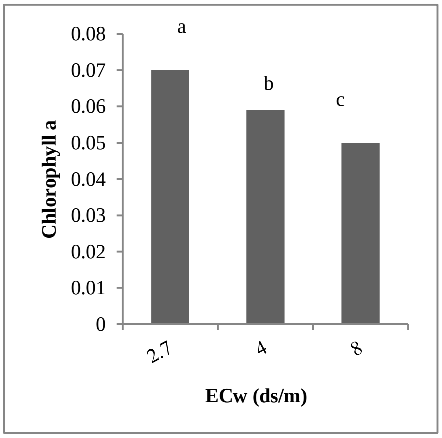

Fig. 5. Different levels of irrigation water salinity on Chlorophyll a

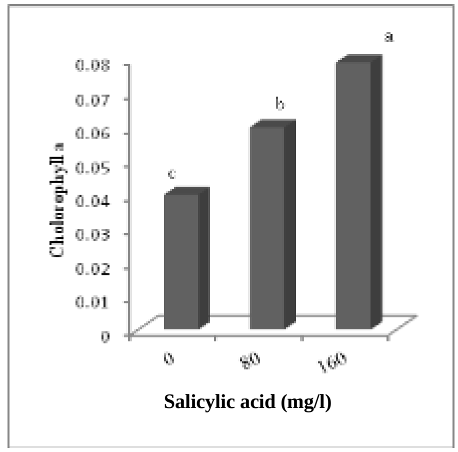

Fig.6. Effect of salicylic acid on chlorophyll a

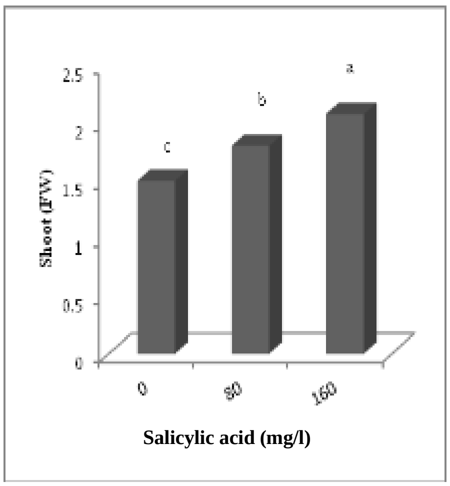

Fig .7. Effect of salicylic acid on shoot (FW)

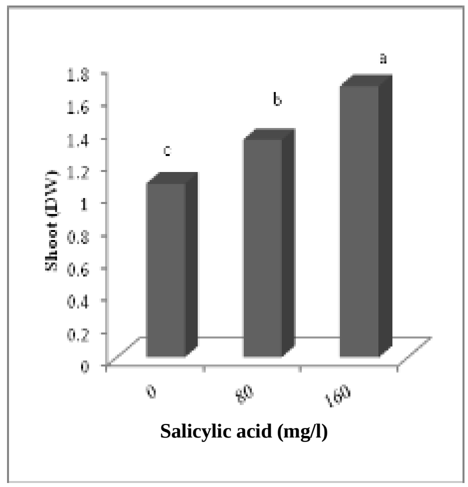

Fig .8. Effect of salicylic acid on shoot (DW)

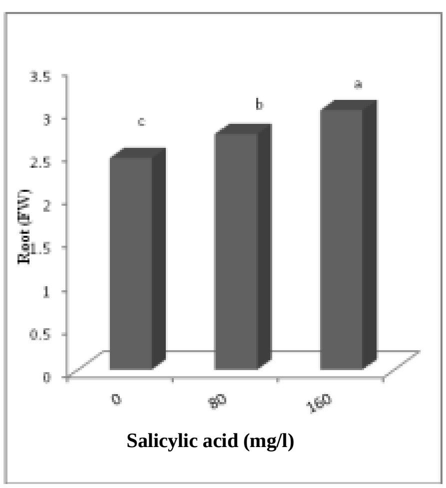

Fig.9. Effect of salicylic acid on root (FW)

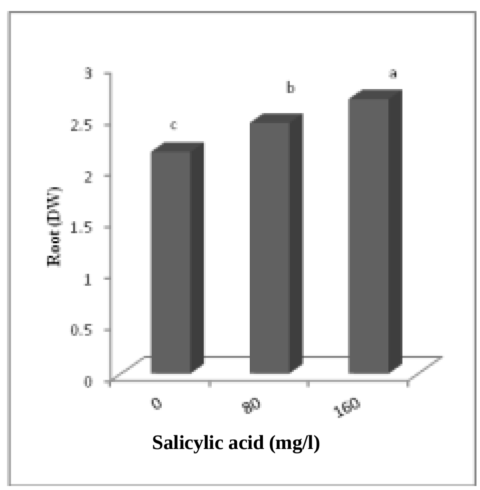

Fig.10. Effect of salicylic acid on root (DW)

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