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Evaluation of the Behavior of Native Iranian Pistachio Species as Rootstocks

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Abstract
The aim of this research was evaluate the seedling behavior of among *Pistacia* species can be used as rootstock in pistachio. Differences in stem diameter were observed among the species. The thickest stems were developed by *P. atlantica* (5.67 mm), *P. vera* cv. 'Qazvini' (25.47mm) and 'Badami-e-Riz-e-Zarand' (5.13 mm) whereas the thinnest stems were measured in *P. atlantica* subsp. *kurdica* (3.48 mm), *P. atlantica* subsp. *mutica* (3.52 mm) and *P. atlantica* subsp. *cabulica* (3.84 mm). *P. atlantica* produced more leaf number per seedling than the other species and *cabulica* had the most SPAD index. The correlation between various morphological traits showed that a few growth characters were significantly correlated with echophysiological. However, leaf dry weight was in significant correlation with RWC for *P. vera* cv. 'Badami-e-Riz-e-Zarand' and 'Sarakhs', fresh weight of leaf for *P. khinjuk* and *P. atlantica* subsp. *kurdica*, shoot dry weight was in correlation with stomata resistance for *P. atlantica* subsp. *mutica* and *cabulica* and leaf fresh weight and dry weight negatively correlated with SPAD for *P. atalntica*.

Keywords: Correlation, *P. atlantica*, *P. khinjuk*, Morphological traits, Stomata resistance

Introduction

The genus *Pistacia* L. in the Anacardiaceae family contains 13 or more species, among which *Pistacia vera* L. produces commercially valuable edible nuts (Kafkas et al. 2002). The other species grow in the wild and their seedlings are used mainly as rootstocks for pistachios. Selection of high vigor genotypes which grafted early and resistant to unfavorable environmental and diseases, are important for precocity and increasing yield of cultivated pistachio. *Pistacia* species have a high genetic diversity due to their dioecious character, pollination mechanism and high heterozygosity. Because of these factors high selectivity in rootstocks breeding is required. It has been reported that there are six species and subspecies of *Pistacia* in Iran (Karimi et al. 2009) which provide an enlarged pool of available germplasm and suitable characteristics such as resistance to drought, salinity and diseases. *P. vera* var. Sarakhs naturally is distributed in northeast of Iran and is used as resistance rootstock to drought stress. The *P. atlantica* have three subspecies, *mutica*, *kurdica* (Zoh.) Rech. and *cabulica* in Iran (Rechinger 1969) that has been identified as resistance rootstocks to nematode. *P. khinjuk* also has been used as a resistance rootstock to drought stress in Iran and Turkey (Karimi et al. 2012) For pistachio rootstock production, in additional to resistance to soil borne diseases, fast seedling growth is required in the nursery; therefore knowledge of the behavior *Pistacia* species would be very useful in selection and breeding of pistachio rootstocks.

There is no study in the literature demonstrating variation of seedling characteristics of *Pistacia* species. Therefore, this study aims to evaluate seedling behavior of *P. vera*, *P. khinjuk*, and subspecies of *P. atlantica* (*P. atlantica* subsp. *atlantica*, *P. atlantica* subsp. *mutica*, *P. atlantica* subsp. *kurdica* and *P. atlantica* subsp. *cabulica*) as rootstock, including the study of growth characteristics and echophysiological.

Materials and Methods

Seeds of *P. vera* var. Sarakhs, *P. khinjuk*, *P. atlantica* subsp. *kurdica*, *P. atlantica* subsp. *mutica* and *P. atlantica* subsp. *cabulica* gathered from Khorasan, Ilam, Fars and Kerman provinces of Iran and atlantica (*P. atlantica* subsp. *atlantica*) provided from IRTA of Spanish. The seeds of *P. vera* cv. 'Badami-e-Riz-e-Zarand' and 'Qazvini' also were provided from IPRI (Iranian Pistachio Research Institute). The wild pistachio seeds were scarified and stratificated according to the method described by Baninasab and Rahemi (2008). The seeds were planted in plastic bags, contained two kg soil. A sandy clay soil with a pH of 7.5 and electrical conductivity (EC_e) of 0.85 dS. m^{-1} was used for this experiment. One-year after sowing growth indices (leaf fresh and dry weight, shoot and root fresh and dry weight and leaf area) and echo-physiological parameters (stomata resistance, relative water content of leaves and leaf chlorophyll index) were measured.

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Leaf area of 3-5 youngest, fully expanded leaves from the terminal shoots were measured with a portable leaf area meter (LI-COR 3000, Lincoln, Neb.). The relative water content was calculated on an exponential basis, using the equation.

RWC= FW-DW/ TW-DW×100

Where FW and DW represent the fresh and dry weight of leaf discs respectively and TW represents the weight of leaf discs after soaking in distillate water for six hour. At the end of the experiment, seedlings were cut at the soil level and roots were washed free from soil and separately were dried for 72 h at 70º C.

The experiment was carried out in completely randomized experimental design (CRD) with three replications, and 5 pots per replication. The data were statistically analyzed using SAS package and the means were compared using Duncan's Multiple Range Test (DMRT) at *P=0.05* level. Correlation analysis was also performed between measured traits at *P= 0.05* and *P=0.01* level using SAS software (SAS 1989).

Results

The analysis of variance showed a significant difference among species for most of the traits measured. Table 1 shown comparison of means of traits of all genotypes, respectively. The stem height, stem diameter, leaf length, leaf area, leaf fresh weight, leaf dry weight, shoot and root dry weight were not significantly different between 'Badami-e-Riz-e-Zarand' and 'Qazvini' with atlantica, whereas the differences were significant between these genotypes and other, however 'Badami-e-Riz-e-Zarand' had the tallest (26.77 cm) and kurdica the shortest stem (11.92cm) (Table 1). Another character to be taken into consideration was stem diameter. Stem diameter, which is essential to allow early budding. Differences in stem diameter were observed among the species (Table 1). The thickest stems were developed by atlantica (5.67 mm), 'Qazvini' (25.47mm) and 'Badami-e-Riz-e-Zarand' (5.13 mm) whereas the thinnest stems were measured in kurdica (3.48 mm), mutica (3.52 mm) and cabulica (3.84 mm). Stem diameter was not significantly different between Sarakhs and khinjuk genotypes. The number of leaf in each plant and leaflets in each leaf of atlantica were more and wider (5.20 cm), whereas kurdica produced seedlings with less leaves and narrower (2.55 cm). In this study differences among fresh and dry weight of tissues of the genotypes were significant so that the highest shoot fresh and dry weight, leaf fresh and dry weight and root fresh and dry weight were observed in atlantica, 'Badami-e-Riz-e-Zarand' and 'Qazvini' and the lowest these parameters were found in kurdida. There was not observed significant difference between mutica and cabulica in upper traits, however, leaf fresh weight and dry weight in khinjuk had more than Sarakhs (Table 1).

The leaf area, SPAD index and RWC have also been determined. The results showed that 'Badami-e-Riz-e-Zarand', 'Qazvini' and atlantica had more extensive leaf than other genotypes (Table 1). Cabulica and khinjuk had the most and lowest SPAD index irrespectively. The highest RWC of leaf was observed with khinjuk and the lowest in atlantica and kurdica.

The correlations between pair of traits are shown separately for each genotype. In 'Badami-e-Riz-e-Zarand', stem length (r = +0.99) correlated with leaf area meter. Also leaf dry weight was in significant correlation with RWC. In 'Qazvini', stem diameter (r= -0.99) negatively correlated with RWC and number of leaf positively and negatively correlated with RWC (r= +0.99) and stomata resistance (r = -0.99) respectively (Table 2).

In Sarakhs, leaf area was correlated with stem length (r= -0.99) and leaf number (r= +0.99). Also RWC was in significant correlation with leaf fresh weight (r= +0.99) and dry weight (r= +0.99) (Table 3).

In khinjuk fresh weight of leaf, shoot and root correlated with stomata resistance and shoot fresh weight, root fresh weight and leaf and shoot dry weight was in significant correlation with RWC (Table 3). Also leaf dry weight correlated with leaf area and leaf length negatively correlated with root dry weight (r= -0.99). In atalntica, leaf fresh weight and dry weight negatively correlated with SPAD index. Results of correlation showed that leaflet number was in significant correlation with shoot fresh weight, shoot dry weight, stem diameter and RWC. Also root dry weight was correlated with leaf fresh weight and dry weight (Table 4). In kurdica leaf fresh weight (r= 0.99) correlated with stomata resistance and RWC with stem length. Also it was observed that shoot fresh weight correlated with root fresh weight and leaf number. Shoot dry weight had a positively correlation with root fresh weight. There are a correlation between leaf fresh weight and leaf dry weight with RWC (Table 4). In mutica, shoot dry weight was in correlation with stomata resistance and shoot fresh weight with root fresh weight and dry weight (Table 5). In similar to atlantica, leaf fresh weight and dry weight correlated with RWC. In cabulica correlations was observed between shoot dry weight and stomata resistance, number of leaflet and stomata resistance and also root fresh weight and dry weight with RWC (Table 5).

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Table 1. Means comparison of traits in studied genotypes.

Genotype	Traits							
	Leaf area (cm)	SPAD index	Leaf fresh weight (g)	Shoot fresh weight (g)	Leaf dry Weight (g)	Shoot dry Weight (g)	Root fresh weight (g)	Root dry Weight (g)
Badami-e- Riz-e- Zarand	13.88 a	49.2 ab	4.07 a	3.23 a	1.71 a	1.56 a	5.53 ab	1.75 a
Qazvini	12.96 a	48.16 ab	4.14 a	2.87 a	1.67 a	1.33 a	5.09 b	1.77 a
Sarakhs	5.96 b	48.85 ab	0.97 c	0.67 b	0.41 c	0.32 b	1.65 cd	0.52 bc
Khinjuk	11.81 a	41.71 b	2.87 b	0.99 b	1.19 a	0.43 b	2.31 c	0.76 b
Kurdica	3.99 b	47.24 ab	0.47 c	0.52 b	0.21 c	0.25 b	0.85 d	0.29 c
Atlantica	12.06 a	48.52 ab	4.38 a	3.41 a	2.00 a	1.61 a	6.29 a	2.00 a
Mutica	4.57 b	49.38 ab	0.93 c	0.87 b	0.40 c	0.40 b	1.50 cd	0.46 bc
Cabulica	4.69 b	51.99 a	1.17 c	1.04 b	0.50 c	0.45 b	1.59 cd	0.43 bc

Genotype	Traits						
	Stem Length (cm)	Stem diameter (mm)	Number of leaf	Number of leaflets	Leaf length (cm)	Leaf width (cm)	RWC (%)
Badami-e- Riz-e- Zarand	26.77 a	5.13 a	10.13 bc	1.13 e	7.73 a	4.08 b	71.30 abc
Qazvini	25.47 a	5.45 a	10.22 bc	1.00 e	7.95 a	4.06 b	72.17 ab
Sarakhs	14.34 b	3.82 cd	11.31 b	2.33 d	4.53 cd	2.33 e	67.42 bc
Khinjuk	14.67 b	4.44 bc	9.60 bc	1.00 e	5.46 b	3.33 c	79.52 a
Kurdica	11.92 b	3.48 d	8.06 c	3.26 c	4.30 d	2.55 ed	62.78 c
Atlantica	26.5 a	5.67 a	15.33 a	6.73 a	7.62 a	5.20 a	62.08 c
Mutica	14.63 b	3.52 d	8.33 c	4.06 bc	4.90 bcd	2.65 ed	64.08 bc
Cabulica	16.76 b	3.84 cd	10. 80 bc	4. 27 b	5.00 bc	3.08 cd	68.37 bc

Means with similar letters in each column are not significantly different (Duncan test, P=0.05).

Table 2. Bivariate correlations measured traits in 'Badami-e-Riz-e-Zarand' (lower diagonal) and 'Qazvini' (upper diagonal) cultivars.

No	Traits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Leaf area	-	0.72	0.54	0.61	0.17	0.39	0.51	-0.45	-0.22	0.87	-0.87	0.87	-0.57	0.96	0.99	-0.31
2	SPAD index	0.87	-	-0.72	-0.54	0.62	0.18	0.40	.015	-0.45	-0.22	-0.87	-0.87	-0.57	0.97	-0.99	-0.32
3	Stomata resistance	0.27	-0.70	-	-0.99*	0.72	0.55	0.44	0.86	0.94	-0.51	-0.96	0.29	-0.16	-0.52	-0.64	-0.42
4	RWC	0.66	-0.94	0.89	-	-0.66	-0.47	-0.35	-0.81	0.50	0.93	-0.7	0.88	0.99*	-0.73	-0.62	0.97
5	Leaf fresh weight	-0.96	0.97	-0.53	-0.84	-	0.97	0.93	0.97	-0.42	-0.90	0.16	-0.92	-0.99*	0.79	0.69	-0.94
6	Shoot fresh weight	-0.83	0.45	0.30	-0.14	0.64	-	0.99	0.89	0.95	0.92	0.63	0.32	0.70	-0.06	0.07	0.87
7	Leaf dry weight	-0.68	0.95	-0.89	0.99**	0.85	0.16	-	0.83	0.99	0.72	0.86	-0.03	0.41	0.28	0.42	0.65
8	Shoot dry weight	-0.89	0.56	0.18	-0.26	0.73	0.99	0.28	-	0.87	0.68	0.44	0.52	0.84	-0.28	-0.15	0.96
9	Root fresh weight	-0.93	0.65	0.07	-0.37	0.80	0.97	0.38	0.99	-	0.76	0.82	0.03	0.47	0.22	0.36	0.70
10	Root dry weight	-0.80	0.99	-0.77	-0.97	0.94	0.36	.097	0.48	0.57	-	0.27	0.66	0.92	-0.45	-0.32	0.99*
11	Stem Length	0.99*	-0.92	0.37	0.74	-0.96	-0.77	-0.75	-0.84	-0.89	-0.87	-	-0.53	-0.10	0.73	0.83	0.17
12	Stem diameter	-0.20	-0.30	0.88	0.59	-0.08	0.70	-0.58	0.01	0.52	-0.39	-0.09	-	0.89	-0.96	-0.96	-0.95
13	Number of leaf	-0.94	0.98	-0.58	-0.88	0.99*	0.59	0.88	0.69	0.76	0.96	-0.97	-0.14	-	-0.75	-0.65	0.95
14	Number of leaflets	0.76	0.03	-0.41	0.03	-0.55	-0.99	-0.05	-0.97	-0.93	-0.25	0.69	-0.78	0.50	-	0.98	-0.54
15	Leaf length	0.45	0.03	-0.73	-0.36	-0.18	-0.87	0.34	-0.80	-0.73	0.14	0.35	-0.96	-0.12	0.92	-	-0.41
16	Leaf width	-0.99	0.86	-0.25	-0.65	0.95	0.84	0.66	0.90	0.94	0.80	0.99	0.22	0.93	-0.77	-0.47	-

Table 3. Bivariate correlations measured traits in Sarakhs (lower diagonal) and Khinjuk (upper diagonal) genotypes.

No	Traits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Leaf area	-	0.92	0.80	0.50	0.28	0.98	0.93	0.89	0.99*	0.90	0.97	0.92	0.93	0.99*	0.63	0.96
2	SPAD index	0.8	-	0.45	0.14	0.62	0.84	0.72	0.66	0.94	0.67	0.81	0.71	0.72	0.94	0.87	0.99
3	Stomata resistance	0.98	0.67	-	-0.81	0.98	-0.01	-0.27	-0.35	0.12	-0.35	-0.14	-0.30	-0.27	0.15	0.823	0.33
4	RWC	0.81	0.29	0.90	-	-0.68	0.66	0.78	0.83	0.47	0.83	0.65	0.80	0.78	0.45	-0.35	0.27
5	Leaf fresh weight	0.79	0.27	0.89	0.99**	-	0.09	-0.08	0.16	0.33	-0.15	0.05	0.10	-0.08	0.34	0.92	0.51
6	Shoot fresh weight	0.88	0.42	0.95	0.99	0.98	-	0.98	0.96	0.97	0.96	0.99*	0.97	0.98	0.96	0.46	0.90
7	Leaf dry weight	0.76	0.22	0.80	0.99*	0.99*	0.97	-	0.99*	0.91	0.99*	0.99	0.99**	0.99**	0.90	0.29	0.81
8	Shoot dry weight	0.97	0.65	0.99**	0.91	0.90	0.96	0.88	-	0.88	0.99**	0.97	0.99*	0.99*	0.86	0.21	0.81
9	Root fresh weight	0.75	0.21	0.86	0.99*	0.99*	0.97	0.99**	0.88	-	0.88	0.96	0.90	0.91	0.99**	0.65	0.97
10	Root dry weight	0.87	0.29	0.90	0.99**	0.99**	0.99	0.99*	0.91	0.99*	-	0.97	0.99*	0.99*	0.87	0.22	0.76
11	Stem Length	0.90	0.46	0.96	0.98	0.97	0.99*	0.96	0.97	0.96	0.98	-	0.98	0.98	0.95	0.42	0.88
12	Stem diameter	0.51	0.92	0.34	-0.08	-0.10	0.05	-0.15	0.32	-0.16	-0.08	0.09	-	0.99**	0.89	0.27	0.79
13	Number of leaf	0.27	-0.35	0.15	-0.27	-0.30	-0.14	-0.35	0.12	0.83	0.78	0.66	-0.68	-	0.90	0.29	0.81
14	Number of leaflets	0.33	0.83	0.15	-0.27	-0.30	-0.14	-0.35	0.12	-0.35	-0.27	-0.09	0.98	-0.81	-	0.67	0.98
15	Leaf length	0.99	0.87	0.94	0.72	0.71	0.81	0.67	0.94	0.66	0.72	0.84	0.62	0.14	0.45	-	0.82
16	Leaf width	0.96	0.62	0.99*	0.93	0.92	0.97	0.90	0.99*	0.89	0.93	0.98	0.28	0.50	0.08	0.92	-

Table 4. Bivariate correlations measured traits in Kurdica (lower diagonal) and Atlantica(upper diagonal) genotypes

No	Traits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Leaf area	-	0.75	-0.15	-0.51	-0.24	-0.57	0.29	0.75	0.09	0.30	-0.10	0.26	-0.24	0.72	-0.29	0.86
2	SPAD index	-0.91	-	-0.79	-0.96	-0.84	-0.98	-0.44	0.09	-0.75	-0.42	-0.76	-0.47	-0.84	0.06	0.44	0.28
3	Stomata resistance	-0.81	0.52	-	0.92	0.99*	0.89	0.89	0.53	0.99*	0.89	0.99*	0.91	0.99*	0.55	-.89	0.35
4	RWC	0.65	-0.29	-0.97	-	0.95	0.99*	0.66	0.17	0.90	0.65	0.90	0.69	0.95	0.19	-0.66	-0.01
5	Leaf fresh weight	-0.81	0.51	0.99**	-0.97	-	0.92	0.85	0.44	0.98	0.84	0.98	0.86	0.99**	0.47	-0.85	0.26
6	Shoot fresh weight	0.31	-0.08	0.80	-0.92	0.81	-	0.61	0.10	0.86	0.59	0.87	0.63	0.93	0.12	-0.61	-0.08
7	Leaf dry weight	-0.90	0.66	0.98	-0.91	0.98	0.69	-	0.85	0.92	0.99**	0.91	0.99*	0.85	0.86	-0.99**	0.73
8	Shoot dry weight	-0.29	-0.10	0.79	-0.92	0.80	0.99*	0.67	-	0.58	0.85	0.57	0.83	0. 45	0.99*	-0.84	0.98
9	Root fresh weight	-0.28	-0.11	0.78	-0.91	0.79	0.99*	0.66	0.99*	-	0.91	0.99**	0.93	0.98	0.60	-0.92	0.41
10	Root dry weight	0.30	-0.65	0.30	-0.52	0.30	0.80	0.13	0.81	0.62	-	0.91	0.99*	0.84	0.87	-0.99*	0.74
11	Stem Length	-0.62	0.25	0.97	0.99*	0.96	0.94	0.89	0.93	0.93	0.56	-	0.93	0.99	0.59	-0.91	0.40
12	Stem diameter	0.59	-0.86	-0.10	-0.22	-0.007	0.57	-0.18	0.59	0.60	0.94	0.27	-	0.87	0.84	-0.99*	0.71
13	Number of leaf	-0.39	0.007	0.85	-0.95	0.86	0.99*	0.75	0.99	0.99	0.74	0.96	0.50	-	0.47	-0.85	-0.27
14	Number of leaflets	0.82	-0.98	-0.24	0.10	-0.33	0.27	-0.50	0.29	0.31	0.79	0.05	0.94	0.18	-	-0.89	0.97
15	Leaf length	0.82	-0.98	-0.34	0.10	-0.33	0.27	-0.50	0.29	0.31	0.79	-0.05	0.94	0.18	0.99**	-	-0.73
16	Leaf width	0.98	0.97	-0.70	0.50	-0.69	-0.14	-0.81	-0.12	-0.10	0.47	0.46	0.72	-0.23	0.91	0.91	-

Table 5. Bivariate correlations measured traits in Mutica (lower diagonal) and Cabulica(upper diagonal) genotypes.

No	Traits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Leaf area	-	-0.86	0.18	0.80	0.94	0.91	0.85	0.99*	0.98	0.99*	0.98	0.99	0.73	0.98	-0.16	0.53
2	SPAD index	0.63	-	0.33	-0.99	-0.98	-0.99	-0.99**	-0.88	0.94	-0.87	-0.93	-0.91	-0.28	-0.93	0.64	-0.88
3	Stomata resistance	0.88	0.92	-	-0.45	-0.14	-0.22	-0.35	-0.01	0.13	0.16	0.02	0.07	0.80	0.03	0.93	-0.73
4	RWC	0.42	0.96	0.79	-	0.94	0.97	0.99	0.82	0.89	0.80	0.88	0.85	0.16	0.87	-0.73	0.93
5	Leaf fresh weight	0.32	0.93	0.72	0.99*	-	0.99*	0.97	0.96	0.99	0.95	0.98	-0.97	0.47	0.97	-0.47	0.77
6	Shoot fresh weight	-0.99	-0.52	-0.81	-0.29	-0.19	-	0.99	0.93	0.97	0.92	0.96	0.95	0.39	0.96	-0.54	0.83
7	Leaf dry weight	0.39	0.96	0.78	0.99**	-0.99*	-0.27	-	0.88	0.94	0.87	0.93	0.90	0.27	0.92	-0.65	0.89
8	Shoot dry weight	-0.82	-0.27	-0.59	0.02	0.13	0.95	0.05	-	0.88	0.99*	0.99*	0.99*	0.69	0.99*	-0.22	0.58
9	Root fresh weight	-0.72	0.08	-0.31	0.33	0.43	0.80	0.35	0.95	-	0.98	0.99*	0.99*	0.58	0.99*	-0.36	0.62
10	Root dry weight	0.37	-0.49	-0.07	-0.69	-0.77	-0.50	-0.71	-0.75	-0.91	-	0.99	0.99*	0.71	0.99	-0.18	0.55
11	Stem Length	-0.99*	-0.70	-0.92	-0.50	-0.41	0.97	-0.47	0.85	0.65	-0.28	-	0.99*	0.60	0.99**	-0.32	0.66
12	Stem diameter	0.49	-0.35	0.035	-0.57	-0.66	-0.60	-0.60	-0.83	-0.96	0.99	-0.42	-	0.64	0.99*	-0.27	0.62
13	Number of leaf	0.99*	0.70	0.92	0.50	0.41	-0.97	0.48	-0.85	-0.65	0.27	-0.99**	0.41	-	0.61	0.55	-0.19
14	Number of leaflets	-0.95	-0.48	-0.78	-0.24	-0.14	0.99*	-0.22	0.96	0.83	-0.53	0.96	-0.65	-0.96	-	-0.32	0.66
15	Leaf length	-0.88	-0.19	-0.55	0.056	0.16	0.93	0.089	0.99	0.92	-0.76	0.83	-0.84	-0.83	0.95	-	-0.92
16	Leaf width	-0.86	-0.13	-0.50	0.11	0.22	0.91	0.14	0.99*	0.97	-0.80	0.79	-0.78	0.79	0.93	0.99	-

Discussion

The significant differences were detected among species for all the measured characteristics by analysis of variances. Differences for most traits showed high genetic variation among these species. Therefore these variations can be used either in rootstock selection or rootstock program breeding. These results are in agreement with Karimi et al. (2009). They studied morphological diversity of *Pistacia* species in Iran and reported that there is a high variation in *Pistacia* species for selection of resistance rootstock to unfavorable environment and soil condition and diseases.

In this experiment, we observed that vigorous genotypes, atantica, 'Badami-e-Riz-e-Zarand' and 'Qazvini had the most diameters which can be grafted early. In similar study Atli etal. (2001), compared seedling characteristics of *P. vera* cv. 'Karmazi', *P. khinjuk*, *P. terebintus*, *P. atlantica*, UCB_1 and PGII and reported that the highest stem length and most diameter stem were observed with *P. vera* cv. 'Kirmizi' and UCB_1 respectively. The lowest growth was observed in kurdica which can be considered as dwarfing rootstock for cultivated pistachio.

There is no report in the literature on SPAD index and RWC of these genotypes. In present research was identified that khinjuk was the lowest SPAD index. In similar study Ranjbar fordoel et al. (2002) reported that despite the high chlorophyll a content in *P. mutica*, this species showed a greater reduction of this parameter at increasing osmotic drought stress compared to *P. khinjuk*.*P. khinjuk* exhibited a higher RWC than kurdica, which reflects the ecological adaptation to the land where they are native. The former genotypes are native in aird area while the latter is native in semi-aird area. It has been reported that kurdica is distributed in area with shorter growing season than khinjuk. It is mainly extended between 900-2800 m and annual precipitation 500-600 mm with maen annual temperature 15 ºC (Rechinger, 1969).

In 'Badami-e-Riz-e-Zarand', Sarakhs, khinjuk, kurdica and mutica was significantly correlated leaf dry weight and RWC. It was deduced that photosynthesis may do better in high RWC of leaf. In khinjuk and kurdica, leaf fresh weight was correlated with stomata resistance. This might be due high Co_2 assimilation in these genotypes. In mutica and cabulica correlations was observed between shoot dry weight and stomata resistance which reflects the ecological adaptation to the land where they are native. Behboodi (2003) studied the ecological distribution of *P. atlantica* subspecies in Iran and reported that cabulica is extended in areas with annual precipitation lower than 100 mm, southeast of Iran, and mean annual temperatures 15-25 º C, hence this genotypes is able to tolerant dry and warm condition. According this study, genotypes of 'Badami-e-Riz-e-Zarand', 'Qazvini' and atlantica is more vigorous than other and can be grafted early whereas kurdica can be considered as dwarf rootstock. Also leaf

dry weight was found to be important trait to evaluate seedling of pistachio genotypes in regarding to RWC and stomata resistance in nursery.

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