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Evaluation of Three Wild Species of Almond on the Basis of Their Morphological Characters

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Abstract: The present study aims to evaluate the seedling behaviour of *Amygdalous scoparia, A. webbii* and *A. orientalis* at the inter-specific level. The analysis of variance showed a significant difference between species. However, *A. scoparia* had highest stem height and leaf length. At the end of the experiment, the thickest stems were developed by *A. scoparia*, whereas the thinnest stems by *A. orientalis*. *A. webbii* produced more number and longer roots per seedling than the other two species. The correlation between various morphological traits showed that a few shoot characters were significantly correlated with root traits. However, leaf length, leaf width, leaf area, root number and root diameter for *P. webbii* and leaf number, leaf length, leaf width, petiole length and root number characters for *P. scoparia* and stem height, leaf number, leaf length, petiole length, internode length and root number for *P. orientalis* were found to be important morphological traits to evaluate seedling charactristics of wild almond genotypes before their nursery test.

Key words: Morphological attributes, *Prunus webbii*, *P. scoparia*, *P. orientalis*

Introduction

The cultivated almond (*Prunus amygdalus* Batsch) belongs to Rosaceae family, subfamily Prunoideae and typified by a drupe fruit structure (Kester and Gradiziel, 1996). Wild populations of almond species representing a wide range of morphological and geographical forms have evolved throughout southwest and central Asia from Turkey and Syria into the Caucasus Mountains, through Iran and into the deserts of Tian-Shan and Hindu Kush Mountains of Tadjikystan, Uzbckistan and Afghanistan (Browicz, 1969; Browicz and Zohary, 1996; Denisov, 1998; Kester *et al*., 1990). Over 30 species have been described by botanists may represent subspecies or ecotypes within a broad collection of genotypes which are adapted to a range of ecological niches in the deserts, steppes and mountains of central Asia (Kester and Gradiziel, 1996).

P. orienatlis, *P. webbii* and *P. scoparia* are the three wild species of almond naturally distributed in many parts of Iran (Sabeti, 1994). Because of their adaptability to severe environmental conditions, they can be used in semi-desert areas to control soil erosion.

Kester and Gradziel (1996) reported that immense possibilities exist for rootstock improvement through the use of other almond species either by direct selection within the species or by their hybridization with cultivars almond. The wide genetic diversity present among related almond species provides an enlarged pool of available germplasm that has not been sufficiently exploited (Grasselly, 1977). These group of related species provide a potential source of variability including

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hardiness and late bloom (e.g., *P. webbii*, *P. bucharica*), self-fertility (*P. webbii* and *P. mira*), modified growth habit and tree size (*P. webbii* and *P. argentea*) but they might be expected to result in combinations of genes with unexpected phenotypic expressions (Kester *et al*., 1990). Vlasic (1977) concluded that the sources of drought tolerance may come from other almond species which are highly xerophytic including *P. webbii*. *P. webbii* can be used as a rootstock for almond, nectarine and peach (Alberghina, 1978; Dimitrovski and Ristevski, 1973). According to Dimitrovski and Ristevski (1973) *P. webbii* is dwarf rootstock for cultivated almond. They reported that, seedlings of *P. webbii* made 30-50% less growth than those of *P. amygdalus* and almond cvs grafted on *P. webbii* showed a similar reduction in vigor. Chilling as expressed by vegetative bud break in relation to flowering may also be a useful indicator of rest requirement (Kester and Gradiziel, 1996). *P. orientalis* plants leaf out later than the opening of flowers and this trait may be associated with increased tolerance to blossom freezing (Buyukilmaz and Kester, 1976).

For rootstock production, reliable seed materials with fast seedling growth are required in the nursery. Since Iran is extremely rich in wild almond tress, finding such seed materials should not be difficult. These species can be used as a rootstock for almond after testing their effects on the scion productivity, nut quality and their tolerance to soil-borne diseases.

There is no study in the literature demonstrating variation of seedling characteristics of wild almond species. Therefore, this study aims to evaluate seedling behavior of *P. orientalis*, *P. webbii* and *P. scoparia* at the inter-specific level.

Materials and Methods

Seeds of *P. orientalis*, *P. webbii* and *P. scoparia* were obtained from the Research Centre of Natural Resources and Animal Science at Shiraz. Table 1 enlist the seed traits of wild almonds tested. Sound seeds of all species were mechanical scarified and then soaked in water for 48 h. The nuts were mixed with peat-moss (3:1, peat-mass:seed (V/V)) and stratified at 4±1°C for 30 days.

After stratification, nuts were sown directly in 5 kg black plastic bags filled with a 1:1:1 (V/V) mixture of fine sand, leaf mould and soil. The bags were then transferred to the glasshouse, with an average temperature of 29.8±5°C under natural photoperiod for the whole period of the experiment. The experiment was arranged in a completely randomized design with ten replications and five plants per replication. Four months after sowing, seedlings were removed from the containers and the root system was carefully washed for the removal of media and following observations were recorded. Table 2 enlist the traits surveyed in this study.

Table 1: Quantitative nut traits of wild almonds tested

Traits	*P. webbii*	*P. scoparia*	*P. orientalis*
Nut			
Weight (g)	0.65±0.1	0.45±0.1	0.6±0.1
Length (mm)	17.0±2.0	12.5±2.50	16.5±2.5
Width (mm)	10.8±1.2	8.9±1.90	9.8±1.1
Volume (cc)	0.7±0.1	0.5±0.12	0.6±0.1
Shell			
Thickness (mm)	1.88±0.22	1.28±0.2	1.50±0.4
Kernel			
Weight (g)	0.19±0.08	0.16±0.05	0.20±0.07
Length (mm)	15.0±2	10.00±1.0	13.1±1.9
Width (mm)	5.5±1.5	5.3±0.9	6.1±1.1
Volume (cc)	0.3±0.06	0.2±0.03	0.4±0.05

Table 2: The list of traits and their measures

Character measures	Traits
	Shoot characters
From soil level to the terminal meristem	Stem height (cm)
At the most diameter of stem	Stem diameter (mm)
The distance between the two node in middle of stem	Internode length (mm)
	Shoot fresh weight (g)
Determined after 72 h of drying at 70°C	Shoot dry weight (g)
	Leaf characters (four leaves were collected from the mid-shoot portion and used for measurement)
	Leaf number
From the base of petiole to the tip of blade	Leaf length (mm)
At the widest part of blade	Leaf width (mm)
Using the leaf area meter	Leaf area (mm^2)
From the base of petiole to starting point of blade	Petiole length (mm)
	Root characters
	Root length (mm)
Using the Delta- T SCAN image analysis system	Average root diameter (mm)
	Root number
	Root fresh weight (g)
Determined after 72 h of drying at 70°C	Root dry weight (g)

Correlations were performed between morphological traits of the seedling characteristics of each species.

The data was statically analyzed and the mean were compared using Duncan's Multiple Range Test (DMRT). Data recorded as percentage were analyzed after appropriate statistical transformation. Correlation coefficients among morphological traits were calculated using the SAS package program.

Results and Discussion

The analysis of variance showed a significant difference among species for most of the traits measured. Differences for most traits showed high genetic variability among these species. Therefore, this genetic variability can be used either in rootstock selection or rootstock breeding programs. Table 3 and 4 shown comparison of means of shoot and root traits measured of all species, respectively.

The stem height was not significantly different between *P. scoparia* and *P. orienatlis*, whereas the differences were significant between these two species and *P. webbii* (Table 3). However, at the end of the study, *P. scoparia* had the tallest (20.58 cm) and *P. webbii* the shortest stem (14.88 cm) (Table 3). These results are in agreement with Dimitrovski and Ristevski (1973) who found that *P. webbii* was dwarfing rootstock for cultivated almond.

Another character to be taken into consideration was the tree growth capacity, as determined by stem diameter. Stem diameter, which is essential to allow early budding and transplanting in to orchard. Differences in stem diameter were observed among the species (Table 3). The thickest stems were developed by *P. scoparia* (1.83 mm), whereas the thinnest stems were measured in *P. webbii* and *P. orieantalis* (1.40 and 1.30 mm, respectively) (Table 3). Emergence time of the species grown in the greenhouse may affect seedling growth. In this experiment, we observed emergence in *P. scoparia* was earliest than the other species. Such a difference might explain the season for better stem height and diameter of *P. scoparia* than the other species. The reasons for the differences in stem diameter might

Table 3: Comparison of means of shoot traits measured in wild almonds species

Traits	*P. webbii*	*P. scoparia*	*P. orientalis*
Stem height (cm)	14.88b	20.58a	19.10a *
Stem diameter (mm)	1.40b	1.83a	1.30b
Leaf number	25.13c	29.15b	33.88a
Leaf length (mm)	34.10a	32.83a	27.63b
leaf width (mm)	14.25a	5.90b	7.88ab
Leaf area (mm^2)	309.80a	147.30b	125.00b
Petiole length (mm)	1.30b	2.50a	2.75a
Internode length (mm)	9.83a	9.90a	11.38a
Shoot fresh weight (g)	0.49a	0.65a	0.55a
Shoot dry weight (g)	0.13a	0.11a	0.13a

* In each row or column, means with the similar letter(s) are not significantly different at 1% level of probability using DMRT

Table 4: Comparison of means of root traits measured of wild almonds

Traits	*P. webbii*	*P. scoparia*	*P. orientalis*
Root length (mm)	407.20a	235.00b	231.30b*
Average Root diameter (mm)	0.87a	1.05a	1.06a
Root number	37.42a	15.07b	16.00b
Root fresh weight (g)	0.28a	0.19b	0.17b
Root dry weight (g)	0.04a	0.02b	0.02b

* In each row or column, means with the similar letter(s) are not significantly different at 1% level of probability using DMRT

be controlling other genetic factors responsible for seedling growth. There is no report in the literature on stem diameter of these species. The leaf number and petiole length of *P. orientalis* were more and large (33.88 and 2.75mm, respectively) followed by *P. scoparia* and *P. webbii* (Table 3). Although, *P. webbii* produced seedlings with less leaves, but the leaf length, width and area (34.10, 14.25 mm and 309.80 mm^2, respectively) were larger than the other species (Table 3). Leaf characters of *P. scoparia* and *P. oreintalis* were similar to there reported by Sabeti (1994) and Zeinalabedini *et al*. (2002).

In this study differences among fresh and dry weight of shoot of the species were not significant (Table 3). However, shoot fresh weight and dry weight were greatest in *P. scoparia* (Table 3).

The characters of root system have also been determined. The results showed that *P. webbii* seedlings had more, larger and greater fresh and dry weights of root system (37.42, 407.20 mm, 0.28 and 0.04 g, respectively) than the other two species (Table 4). There is no report in the literature on root system of species and our study shows that there is a variation between the three species with regard to these important traits.

The correlations between pair of traits are shown separately for each species (Table 5-7). Several shoot characters were significantly correlated with root characters. In *P. webbii*, stem diameter was significantly correlated with leaf number, leaf length and root number. This might be due to the role of the leaf in carbohydrate synthesis and root in the absorption of water and mineral salts. Root diameter was significantly correlated with leaf length, leaf width and leaf area and negatively with shoot fresh and dry weights (Table 5).

In *P. scoparia*, root length was significantly correlated with leaf width and internode length. Root number was significantly correlated with leaf length, petiole length, internode length and root length (Table 6).

In *P. orientalis*, stem diameter was significantly correlated with leaf number and negatively with leaf area, internode length, shoot fresh weight, shoot dry weight, root number and root dry weight (Table 7).

These correlations suggest that many of the associations between morphological traits of shoot and root vary between these three species. However, leaf length, leaf width, leaf area, root number and root diameter for *P. webbii* and leaf length and width, petiole length and root number characters for

P. scoparia and stem diameter, leaf number, leaf length, petiole length, internode length and root number for *P. orientalis* were found to be important morphological traits to evaluate seedling characteristics of almond genotype before nursery test.

Table 5: Correlation between measured traits of *P.webbii*

Traits	Stem height	Stem diameter	Leaf No.	Leaf length	Leaf width	Leaf area	Petiole length	Internode length
Stem height	1	0.332	0.890**	-0.495	0.095	-0.022	-0.493	0.969**
Stem diameter		1	0.708*	0.814**	0.292	-0.167	0.418	-0.517
Leaf number			1	-0.363	0.223	0.049	-0.040	0.973**
Leaf length				1	0.812**	0.878**	0.299	-0.402
Leaf width					1	0.980**	0.111	0.205
Leaf area						1	0.034	0.056
Petiole length							1	-0.273
Internode length								1
Shoot fresh weight								
Shoot dry weight								
Root length								
Root diameter								
Root number								
Root fresh weight								
Root dry weight								

Traits	Shoot fresh weight	Shoot dry weight	Root length	Root diameter	Root No.	Root fresh weight	Root dry weight
Stem height	0.008	0.05	-0.537	-0.184	0.977**	0.493	0.321
Stem diameter	0.764*	0.723*	0.099	-0.423	0.802**	0.271	0.312
Leaf number	-0.39	-0.098	-0.62	0.165	-0.948**	0.041	0.127
Leaf length	-0.562	-0.885**	-0.454	0.781*	0.349	-0.299	0.282
Leaf width	-0.702*	-0.989**	-0.888**	0.832**	-0.262	-0.111	-0.543
Leaf area	-0.607	-0.985**	-0.809**	0.770*	-0.126	-0.034	0.252
Petiole length	-0.708*	-0.192	0.081	0.643	0.347	-0.987**	0.614
Internode length	-0.225	-0.067	-0.629	0.025	-0.994**	0.273	-0.128
Shoot fresh weight	1	0.730*	0.645	-0.955**	0.201	0.708*	0.414
Shoot dry weight		1	0.813**	-0.866**	0.122	0.192	0.618
Root length			1	-0.647	0.675	-0.081	0.427
Root diameter				1	-0.026	-0.643	0.558
Root number					1	0.122	0.313
Root fresh weight						1	0.793**
Root dry weight							1

* Significant at the 5% probability level, ** Significant at the 1% probability level

Table 6: Correlation between measured traits of *P. scoparia*

Traits	Stem height	Stem diameter	Leaf No.	Leaf length	Leaf width	Leaf area	Petiole length	Internode length
Stem height	1	0.286	0.747*	0.477	-0.417	-0.806*	-0.429	0.009
Stem diameter		1	0.849**	0.943**	0.142	-0.789*	0.301	-0.960**
Leaf number			1	0.923**	-0.198	-0.985**	0.221	0.671
Leaf length				1	0.132	-0.849**	0.366	0.855**
Leaf width					1	0.354	0.942**	0.154
Leaf area						1	0.167	-0.586
Petiole length							1	0.468
Internode length								1
Shoot fresh weight								
Shoot dry weight								
Root length								
Root diameter								
Root number								
Root fresh weight								
Root dry weight								

Table 6: Continued

Traits	Shoot fresh weight	Shoot dry weight	Root length	Root diameter	Root No.	Root fresh weight	Root dry weight
Stem height	0.658	0.624	-0.625	0.221	0.193	-0.724*	0.321
Stem diameter	0.177	0.09	0.352	0.59	0.741	0.231	0.414
Leaf number	0.49	0.567	-0.08	0.263	0.425	-0.255	0.142
Leaf length	0.494	0.416	0.306	0.292	0.739*	-0.089	-0.212
Leaf width	0.401	0.426	0.824**	-0.449	0.653	-0.103	0.503
Leaf area	-0.447	-0.371	0.236	-0.289	-0.276	0.264	0.173
Petiole length	0.303	0.301	0.946**	-0.15	0.861**	0.109	-0.235
Internode length	0.022	-0.056	0.568	0.653	0.848**	0.431	0.325
Shoot fresh weight	1	0.995**	-0.005	-0.678	0.254	-0.869**	0.467
Shoot dry weight		1	-0.015	-0.741*	0.206	-0.893**	0.185
Root length			1	0.134	0.867**	0.425	0.724*
Root diameter				1	0.427	0.831**	0.327
Root number					1	0.253	0.418
Root fresh weight						1	0.818**
Root dry weight							1

* Significant at the 5% probability level, ** Significant at the 1% probability level

Table 7: Correlation between measured traits of *P. orientalis*

Traits	Stem height	Stem diameter	Leaf No.	Leaf length	Leaf width	Leaf area	Petiole length	Internode length
Stem height	1	-0.349	0.481	0.542	-0.611	0.082	0.904**	0.357
Stem diameter		1	0.979**	0.532	-0.426	-0.923**	-0.707	-0.865**
Leaf number			1	0.679	0.243	0.905**	0.808**	0.790*
Leaf length				1	-0.383	0.61	0.706	0.107
Leaf width					1	0.487	-0.301	0.52
Leaf area						1	0.497	0.642
Petiole length							1	0.612
Internode length								1
Shoot fresh weight								
Shoot dry weight								
Root length								
Root diameter								
Root number								
Root fresh weight								
Root dry weight								

Traits	Shoot fresh weight	Shoot dry weight	Root length	Root diameter	Root No.	Root fresh weight	Root dry weight
Stem height	0.221	0.405	0.47	-0.406	0.615	0.954**	0.221
Stem diameter	-0.816**	-0.857**	0.094	-0.706	-0.866**	-0.239	-0.816**
Leaf number	0.866**	0.924**	0.098	0.571	0.848**	0.409	0.866**
Leaf length	0.842**	0.879**	0.787*	0.016	0.307	0.692	0.842**
Leaf width	0.174	0.073	-0.811**	0.916**	0.246	-0.764*	0.174
Leaf area	0.935**	0.906**	0.014	0.794*	0.608	0.062	0.935**
Petiole length	0.577	0.727*	0.379	0.118	0.816**	0.845**	0.577
Internode length	0.417	0.499	-0.467	0.632	0.954**	0.122	0.417
Shoot fresh weight	1	0.980**	0.366	0.551	0.471	0.292	0.123
Shoot dry weight		1	0.4	0.463	0.594	0.45	0.980**
Root length			1	-0.546	-0.213	0.711	0.366
Root diameter				1	0.425	-0.513	0.551
Root number					1	0.414	0.471
Root fresh weight						1	0.292
Root dry weight							1

* Significant at the 5% probability level, ** Significant at the 1% probability level

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