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Morphopomological study of some new Japanese plum (*Prunus Salicina* Lindl) cultivars grown in Iran

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Abstract

Japanese plum (*Prunus Salicina* Lindl) is one of the most important plums in the world for fresh marketing. Successful plum production requires cultivars well adapted to the specific growing conditions in the area of production. Due to the interaction between environment and genotype in different species, preliminarily evaluation of agronomical and pomological performance for newly released cultivars in the areas where they will be cultivated is necessary. During the period 2012–2013, the suitability of 18 Japanese plum cultivar and genotype for cultivation, evaluated in Horticultureal Research Station (Karaj-Iran). 31 morphopomological traits such as bloom start and end date, ripening time, vegetative growth, trunk section area, internode length, vegetative bud size, leaf, fruit and stone size, flesh diameter, fruit and stone weight, TSS, TA, fruit texture, stone clinging, pH, dry matter and yield in two year were studied. The experiment was conducted in a Complete Randomized Design (CRD). Analysis of variance indicated that the cultivars were significantly different (P≤1%) for all traits. Cluster analysis classified cultivars into 5 main groups and 1 independent cultivar. The earliest cultivars '*Black Star*' and '*Morittini*', mid season '*Shiro*', '*Simka*', '*No.16*', '*Friar*', and the late one '*Angeleno*', were most suitable and recommended for cultivation in Iran.

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Introduction

Plum is the most important fruits in the world and more than 6000 cultivars are from 19 to 40 species (Blazek, 2007; Riger, 2006) distributed across Asia, Europe and America. Plums have a greater range of flavor, aroma, texture, color, size and other characteristics which make their fruits desirable, than other horticultural crops (Westwood, 1993; Baden and Byren, 2012). Plums are the center of the *Prunus* genetic stage because they have the largest diversity of any subgenus and are a link between the major subgenera (Miggini and Lipman, 2006). Most plums in commercial production today are classified as European (hexaploid; 2*n* = 48) or Japanese and myrobalan (diploid; 2*n* = 16) types (Okie and Weinberger, 1996). The term Japanese plum was applied originally to *Prunus salicina* Lindl**.** and European plums are *P. domestica* L. that they are the main plum production species in the world but in our country the majority of prune harvested in spring is *P. cerasifera* Hedr (Ozbek, 1978).

Plums are temperate zone fruits, but they are widely grown throughout the world, from the cold climate of Siberia to the sub-tropical conditions of the Mediterranean region (Son, 2010). Iran, with a yearly production of 295000 tons, is the Fifth of the major plum producers in the world (FAOSTAT, 2012). In the past decades, increasing demands for fresh consumption have contributed to the establishment and development of new orchard that are harvested earlier and supply better quality fruits to markets (Blazek and Pistekova, 2009). Plum breeding programs throughout the world are focusing on improving fruit quantity and quality, prolonging the harvest season and developing resistance/ tolerance to biotic and abiotic stress (Hartmann and Petruschke, 2002; Blazek, 2007).

Morphological traits are the primary markers utilized in germplasm management and cultivar evaluation (Karimi *et al*., 2008). These traits are in common use for elucidation of wide genetic diversity in different field and horticultural crops (Blazek, 2007). Leaf, flower and related fruit traits, have been used as main morphological traits in inter-specific hybrids and cultivar characterization of plum trees (Naotoshi *et al*., 1998; Jakubowski, 2002; Ertekin *et al*., 2006). Phenological traits are very important in cultivation programs and escape from abiotic stress such as spring frost in Iran. Maliga (1980) reported that estimation by observation is the simplest method for determining the blooming windows. In Turkey, an experiment was conducted to determine the phenological and pomological characteristics of 14 Japanese plum (*Prunus salicina*) cultivars (Son, 2010) and reported that fruit ripening was earlier in '*Black Beauty*' and '*Obilnaja*' cultivars than in the other cultivars. '*Black Diamond*', '*Queen Rosa*', '*October Sun*' and '*Autumn Giant*' produced bigger and heavier fruits (Son, 2010). Gunes (2003) studied the pomological and phenological characteristics of nine local plum varieties in Turkey. From the nine varieties, '*Hatun Gobegi*' was recommended as suitable for fresh consumption and canning, while '*Hurma Erigi*' and '*Yesil Erik*' were recommended for drying. Askin and Koyuncu (1992) collected different local varieties in Turkey, and determined some of their characteristics. Ertekin *et al.* (2006) found that the phenological and pomological characteristics of plum cultivar '*Firenze 90*' were superior to those of '*Stanley*' in Antalya, Turkey. Azami and Jalili (2011) Studied genetic diversity of some Iranian plum genotype based on morphological criteria and reported that cluster analysis at 9 distances, divided genotypes to four main groups. These groups mainly had differences in stone and fruit shape, self fertility range and stone clinging. Ganjimogadam *et al*., (2010) studied the pomological and phonological characteristics of 22 plum cultivars in Mashad, Iran. The cultivars were separated into tree group on flowering date and some cultivar such as '*President*', '*Simka*', '*Zuccella*' recommended for cultivation in northeastern of Iran.

The objective of this research was to evaluate morphological, pomological and phenological traits of some new imported cultivars and local plum genotypes in Iran.

Materials and methods

Plant material

The experiment was conducted at Kamalshahr horticultural Research Station of Seed and Plant Improvement Institute, Karaj - Iran, during the 2012-2013. 18 Japanese plum cultivars ('*Alu Zard*', '*Mariana In.*', '*SngorAbadi*', '*Early Golden*', '*K-P.2*', '*Shiro*', '*Obelnaja*', '*Bermosa*', '*Morittini*', '*Angelono*', '*Black Star*', '*Simka*', '*K.P.1*', '*No.16*', '*No.17*', '*G7/2*', '*Friar*' and '*Burbank*'), were evaluated using a randomized complete design (RCD).

Traits

31 Morphological, pomological and phenological traits (Tab. 1) such as bloom start and end date, ripening time, vegetative growth, trunk section area, internode length, vegetative bud size, leaf, fruit and stone size, flesh diameter, fruit and stone weight, TSS, TA, fruit texture, stone clinging, pH, dry matter and yield were studied in two years. Onset of flowering was recorded when at least 5% of flower buds had bloomed, and the end of flowering was determined when 90% of flower buds had bloomed and corollas had begun to fall off; harvesting date was determined as the day the fruits were sufficiently colored and soft for eating (Tzoner and Yamaguchi, 1999; Funt, 1998). Twenty samples from each tree were evaluated to determine each characteristic.

Results and discussion

In order to enrich the Japanese plum assortment and offer new cultivars, we conducted a comparative cultivar study of some introduced and native Japanese cultivars and genotypes. In order to organize profitable plum production , wich does not create strenuous work during picking, it is necessary to supply the market with rhythmically. That requires planting and uses of cultivars providing a long picking period.

Table 1. Summary of variance analysis for traits of some Japanese plum cultivars.

Source of variation	df	Bloom Start	LeafL	LeafWed	FruL	FruWed	FleshDia	FD_SD	FrutWigt	sW_FW	TSS	TA2	TextHard	HarvesTim	pHJuice	yeild	TrunSeA
genotype	17	33.86**	9.44**	3.44**	447.92**	452.2**	64.48**	8.3**	1493.15**	29.72**	91.35**	186.75**	13.31**	8676.18**	0.76**	196.87**	163392.28**
Error		0	0.15	0.08	1.04	1.29	0.6	0.26	3.78	0.4	2.31	3.41	0.09	7.57	0.02	1.56	2052.21
		2.11	6	8.82	6.04	3.39	6.98	6.65	7.01	8.78	8.38	14.17	9.8	6.31	4.35	6.81	15.02

* Significant in p≤0.05, ** Significant in p≤0.01.

Analysis of variance results showed that there were significant differences at the probability level of one percent (p≤0.01), between cultivars in respect to the all studied traits (Tab. 1). The mean and CV percent of different traits are presented in Table 2. Some criteria with high coefficient variance had a wide range of quantitative data as well as wide array of selection opportunists. A number of these traits were included trunk section area, vegetative growth, shoot diameter, titrable acidity, texture, and, Brix (TSS) (Azami and Jalili., 2011; Usenik *et al.*, 2008).An earlier investigation on the wild Iranian prune cultivars showed that leaf related criteria had significant morphological diversity. In contrast, stone had the lowest diversity and can use to genotype identification. In this study stone characteristics have minimum C.V. (Tab. 2).

The mean bloom start was earlier for '*Shiro*' and the latest one were '*K-P-1*' genotype, '*moritini*' and '*G-7-2*' genotypes (Fig. 1). This late blooming genotypes can use for breeding program and recommended to cultivate in area with spring frost. These results correspond with other research (for common cultivars) (Caliskan *et al.*, 2006; Gangomogadam *et al.*, 2010; Balik, 2004).

Harvest time of the plum cultivars ranged from the middle of June to the 3rd week of September (data not shown). 'Early Golden' and 'Black Star' ripened earliest, on 16 to 22 June, and then '*Morittini*' and '*Oblinaja*' ripened before any of the other cultivars. These findings are in accord with those of other studies done in different ecological regions of Iran and Turkey (Gangomogadam *et al.*, 2010; Balik, 2004; Caliskan, 2006). '*Angeleno*' and '*No. 17*', were

the latest ripening cultivars and matured in the first to 3rd week of September (data not shown).(Gangomogadam *et al.*, 2010; Ozakman *et al.*, 1995). Increasing the duration of harvest time is important to be able to send an adequate supply of fresh fruit to market, due to its high demand and high price. To reduce risks and prevent spring frost damages, expand harvest time and increase the supply of fresh fruit to market, early, medium and late plum cultivars can be grown considering climatic conditions in target areas (Kemp *et al.,* 1986).

Table 2. Morphological traits recorded for 18 plum cultivars.

			Minimum	Maximum	Mean	cv %
1	bloomStart	Days*	10.00	25.00	17.5	17.84
2	fullBloom	Days	10.00	31.00	20.5	14.69
3	bloomEnd	Days	14.00	35.00	24.5	12.30
4	b. period	Day	9.00	22.00	15.5	16.35
5	yeild	Kg/tree	9.00	36.15	22.58	29.19
6	TrunSeA	Cm^2	80.26	681.23	380.75	47.87
7	Vegetative Growth.1	Cm	4.80	88.61	46.71	63.74
8	ShD**	mm	1.24	8.75	5.00	48.72
9	Internodes L.	Cm	10.48	18.67	14.58	34.77
10	Suport	mm	0.34	2.40	1.37	28.85
11	VegBSiz	mm	5.91	8.93	7.42	27.65
12	LeafL	Cm	2.81	10.30	6.56	23.67
13	LeafWed	Cm	1.75	5.42	3.59	27.11
14	L/W ratio	-	0.86	3.33	2.10	20.34
15	PetL	Cm	0.45	3.03	1.74	34.03
16	FruL	mm	20.40	50.14	35.27	28.29
17	FruWed	mm	20.50	52.96	36.73	28.67
18	FruDia	mm	20.48	55.80	38.14	28.30
19	Frust	mm	3.94	32.73	18.34	30.40
20	StonL	mm	15.24	28.20	21.72	13.61
21	StonW	mm	16.46	22.49	19.48	14.75
22	StonDia	mm	14.46	19.86	17.16	13.65
23	FleshDia	mm	3.26	20.86	12.06	32.81
24	FrutWigt	gr	15.20	76.70	50.95	41.61
25	StonWigt	gr	2.24	4.50	3.37	28.88
26	TSS	%	18.31	24.37	21.34	14.90
27	TA	Mg/100g	4.4	20.55	12.25	36.55
28	TextHard	Kg/cm^2	2.00	6.73	4.37	41.42
29	StonStic	rank (1-4)	1.00	4.00	2.50	39.18
30	HarvesTim	Days	86.17	188.67	142.42	18.92
31	pHJuice	-	3.12	5.08	4.1	13.31

* Days from Solar new year in Iran

** Abbreviations Sh. L. shoot length, : VegBSiz: Vegetative bud size, PetL. : petiole length, FruL: fruit length, Wed: width, Dia: diameter, Wigt: weight, Frust: fruit stalk, Hard: hardiness, Stic: sticky,

One of the important characteristics of the plum fruits is their size. Large-fruited cultivars are preferred, both for fresh consumption and for processing. The fruit weight is a highly variable value and in some years, it varies depending on the climatic condition during the year. The average fruit weight is also highly influenced by the fruit load of the trees and the obtained yield per tree. In the present study, for fruit weight, '*K-p-1*', '*Simka*' and '*Friar*' were superior than the others under Karaj conditions. These data agree with the results of Gangomogadam et al., (2010). Fruit weight ranged from 15.2 g ('*Early Gplden*') to 76.6 g ('*KP1*'). The smallest fruits were obtained from '*Early Golden*', '*G-7/2'* and *'KP2*' (Fig. 3). These findings are in accordance with the results of adaptation studies carried out in different areas

(Gangomogadam *et al*., 2010; Balık, 2004; Caliskan *et al*., 2006). Flesh diameter was the greatest in 'K-p-1'genotype and it was followed by '*Frair*' and 'No.17'. The lowest ratio was obtained from '*Early Golden*' (Fig. 4). Different soil and climatic conditions and management practices could be effect on many differences of flesh diameter.

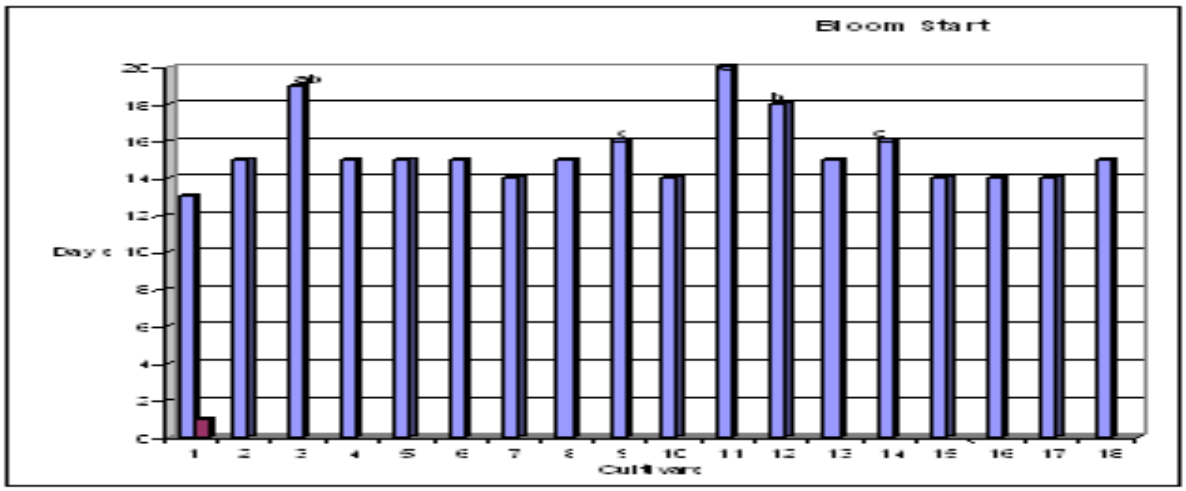

Fig. 1. Mean comparison of bloom start on evaluated accession in this study: 1-Shiro 2- Obelnaja 3- Morittinii 4- Black Star 5- Bermosa 6- Angeleno 7- Simka 8- No16 9- No17 10- Burbank 11- Kp1 12- G7/2 13- Frair 14- Aluzard 15- Kp2 16- Early Golden 17- Songorabadi18- Mariana Inra.

The average stone weight is a relatively more constant characteristic and it varies slightly in the different years. The stone weight of the studied cultivars varies from 0.6 g for '*Early Golden*' to 2.45 g for 'K-p-1'genotype. The relative portion of the stone to the fruit is a generalizing trait for the fruit size. In the study the trait varies from 1.98% for 'Black Star' to 4.2% for '*G7/2*' (data not shown).

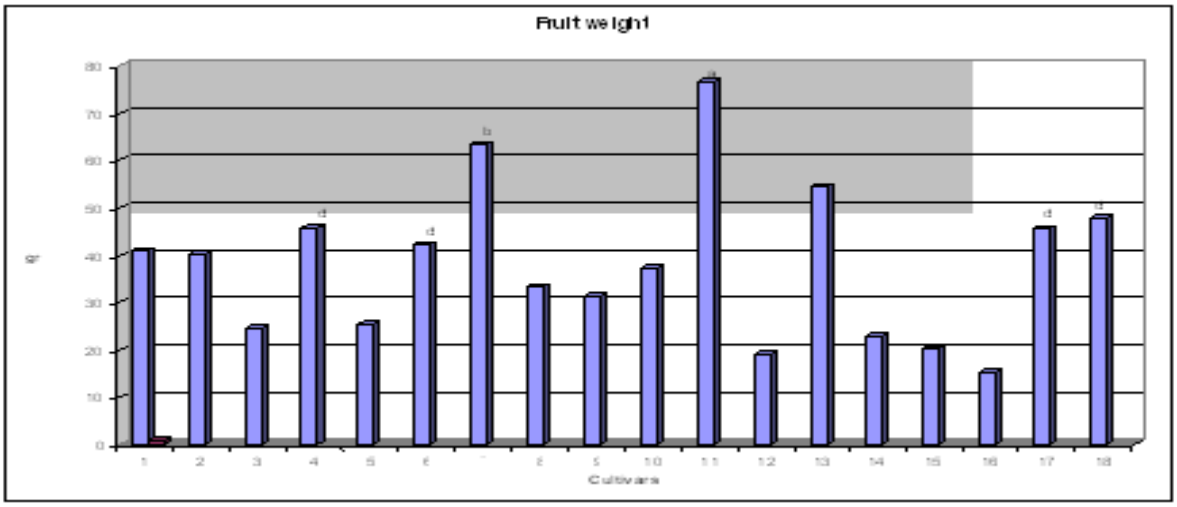

Fig. 2. Mean comparison of fruit weight on evaluated accession in this study: 1-Shiro 2- Obelnaja 3- Morittinii 4- Black Star 5- Bermosa 6- Angeleno 7- Simka 8- No16 9- No17 10- Burbank 11- Kp1 12- G7/2 13- Frair 14- Aluzard 15- Kp2 16- Early Golden 17- Songorabadi18- Mariana Inra.

Adherence of stone to flesh ranged from strong ('*Shiro*'), medium ('*KP2*'), and weak ('*No.16*'), to free ('*Angelono*') these result corresponding with Ganjimogadam *et al*., (2010).

An important character of the plum cultivar and other fruits for cultivation is their yield. Among the studied cultivars, '*No16*' cultivar with 36.2 kg/tree (means of two years) was the heaviest bearing cultivar and '*Early Golden*' with 10.2 kg/tree (means of two years) was the least one. Ganjimogadam *et al.*, (2010) reported that 'No16' cultivar produced higher fruit yields (30-35 kg/tree) than other cultivars (Gangomogadam *et al.*, (2010).

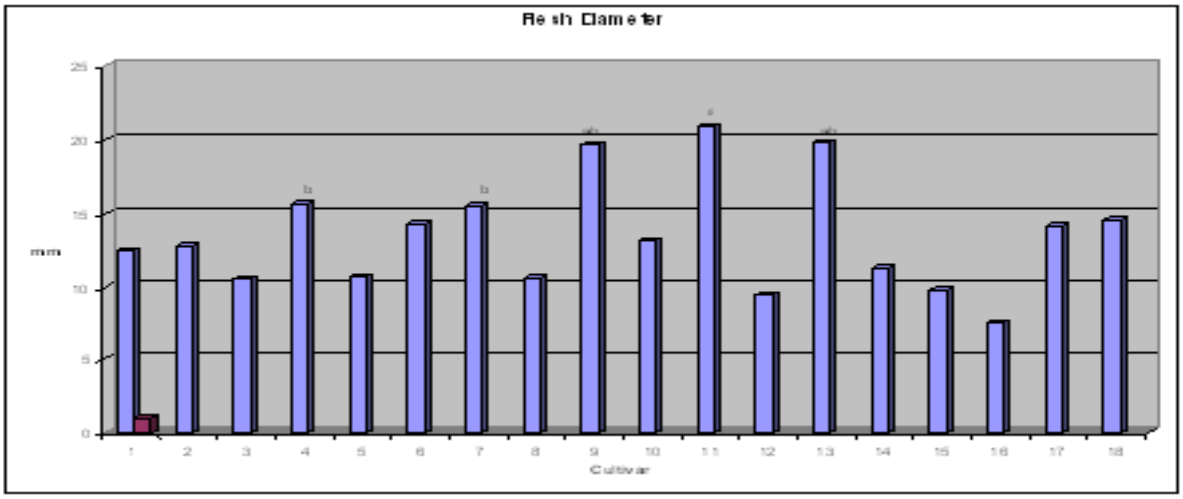

Fig. 3. Mean comparison of flesh diameter on evaluated accession in this study: 1-Shiro 2- Obelnaja 3- Morittinii 4- Black Star 5- Bermosa 6- Angeleno 7- Simka 8- No16 9- No17 10- Burbank 11- Kp1 12- G7/2 13- Frair 14- Aluzard 15- Kp2 16- Early Golden 17- Songorabadi18- Mariana Inra.

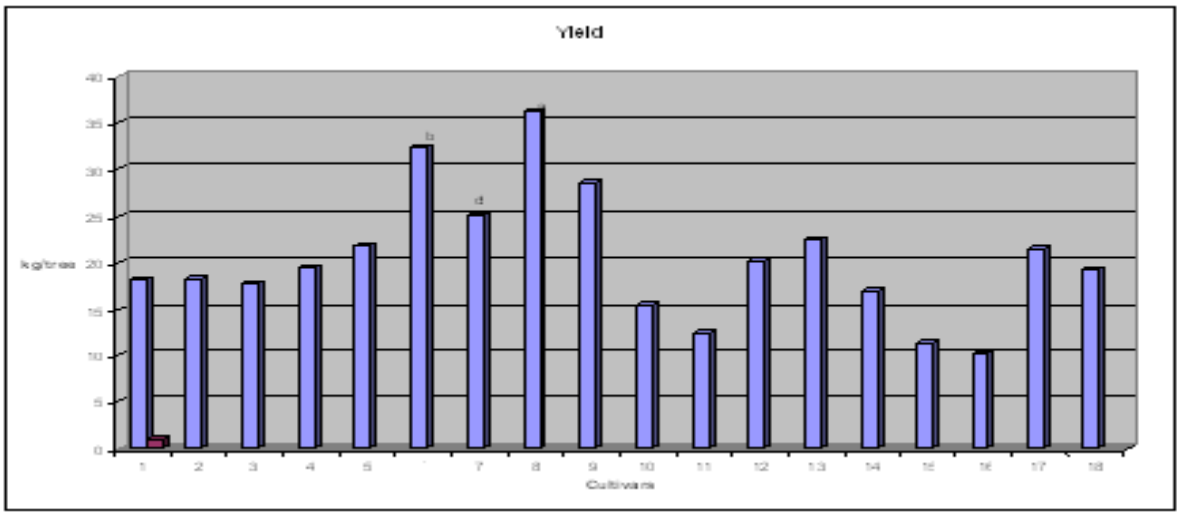

Fig. 4. Mean comparison of yield on evaluated accession in this study: 1-Shiro 2- Obelnaja 3- Morittinii 4- Black Star 5- Bermosa 6- Angeleno 7- Simka 8- No16 9- No17 10- Burbank 11- Kp1 12- G7/2 13- Frair 14- Aluzard 15- Kp2 16- Early Golden 17- Songorabadi18- Mariana Inra.

Sugar and TA are an important part of in the content of plum fruit and related to fruit quality. Their quantity in the different cultivars depends on the climatic conditions during the year, applied cultural practices, state of health of the trees (Minova and Stoyanova, 2012). The cultivar '*KP2*' (21.8%) have the highest content of TSS (Total Soluble Solid) and '*Early Golden*' (12.1%) have a lowest one. TA varies from 4.4 for '*Friar*' to 20.55 for '*Oblenaja*' cultivars.

In the present study cluster analysis was carried out based on all traits At 4.8 distances, genotypes were

categorized into 6 main groups and on independed cultivar with differences in traits (Fig. 5). First group was distinguished with distinct fruit shape and flowering phonology. In the second group was distinguished with vegetative traits of trunk, shoot and leaf. The third group has spindle shaped fruits and stretched stones. The fourth group was characterized with late ripening and large size of fruits. The fifth group has early ripening fruits. Other independent genotype was in distinct large size and shape and this genotype is promising for introducing new cultivar.

In conclusion, on the basis of fruit quality '*KP1*', '*Simka*', '*Songorabadi*' and '*Black Star*'; for the earliness '*Black Star*' and '*Obilnaja*' and for late ripening '*Angeleno*' were found to be the most suitable cultivars and recommended for cultivation in the Karaj climate and the likely region of Iran.

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