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Phenological and Pomological Characteristics of Five Promised Walnut Genotypes in Karaj, Iran

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Abstract

Late spring frost is one of the most important factors causing loss of production of the Persian walnut (*Juglans regia* L.). Therefore, the selection of spring frost tolerant genotypes has been among the most important priorities in the breeding programs during the recent years in Horticultural Science Research Institute, Karaj-Iran. After the spring frost in 2010, five superior genotypes (B10, H1/1, H1/7, H2/1, and H2/12) were selected among 250 walnut genotypes of Kamalshar walnut collection in Karaj. At the second stage, vegetative and reproductive characteristics (Leafing and flowering date, yield, nut and kernel) of the selected genotypes were evaluated and compared with Chandler, Hartley, Pedro, Ronde de Montignac and Franquette in 2010 and 2011. Among the genotypes, H2/12 with 534 and 312g/m^2 of scaffold cross area of nut and kernel yield showed the maximum production. The H2/1 with 3.37 nut/ cm^2 of trunk cross sectional area and H2/12 with 48.1 nut/m^2 of scaffold cross area showed the highest crop density. Based on this evaluation, the five promised walnut genotypes showed very good performance in comparison with the commercial walnut cultivars.

Keywords: *Juglans regia* L., Selection, Spring frost, Superior genotype, Walnut.

Introduction

Persian walnut (*Juglans regia* L.) is a temperate nut crop, and Iran is one of its centers of origin and diversity (Arzani *et al*., 2008). According to the Food and Agriculture Organization, Iran ranks fourth (after China, the United States and Turkey) in global walnut production (FAO, 2012). Most walnut trees in Iran originated from a seed, so there is considerable variability in their nut and kernel characteristics (Hassani, 2011). The high genetic variation in walnut trees is due to their seed based propagation, high heterozygosis and dichogamy (Aslantas, 2006). Some genotypes with high variation are important in breeding programs (Aslantas, 2006; Zeneli *et al*., 2005), for they may show characters such as high quality nuts, late leafing, spring late frost resistant and disease resistance (Germain, 1997). Spring late frost is one of the most important factors that cause loss of production in walnut in Iran. Therefore, selection of spring frost tolerant walnut genotypes have been among very important aims in the breeding programs during the (Hassani, 2010). Trees that leaf out late

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enough to escape these frosts should be selected (Shreve, 1999).High variability in phonological and nut traits has been reported in walnut trees from different regions. Haghjooyan *et al.* (2005) evaluated morphological traits of 138 seedling walnut genotypes grown in different regions of Iran. Arzani *et al.* (2008) identified promising walnut genotypes in the Taft region of Yazd Province. The walnut breeding program that was started at Seed and Plant Improvement Institute, Karaj, Iran in 1983, released new cultivars, Jamal and Damavand (Hassani *et al*., 2011). Identification of promising walnut genotypes based on late leafing, high production and good nut and kernel characteristics has been reported in other countries such as India (Sharma and Sharma, 1998; Sharma and Sharma, 2001), Turkey (Yarilgac *et al*., 2001; Kazankaya *et al*., 2001; Sutyemez and Kaska, 2005; Ozkan and Koyunca, 2005; Aslantas, 2006), Kyrgyzstan (Hemery, 1998) and Slovenia (Solar and Stampar, 2005; Zeneli *et al*., 2005; Colaric *et al*., 2006). The aim of this study was to evaluate the characteristics of leafing date, lateral bearing, and nut and kernel quality of the five superior walnut selected genotypes and compare them with important commercial cultivars.

Materials and Methods

This research was carried out during the 2010-2011on 15 years old walnut trees in of Kamalshahr Station of Horticulture Department, Seed and Plant Improvement Institute, Karaj-Iran. Among the 250 native genotypes planted and evaluated in Kamalshar Station, five superior walnut genotypes were selected based on resistance to spring frost accrued in 2010. The annual average temperature and rainfall were 13.7 ºC and 245.5 mm, respectively. The vegetative and reproductive characteristics of the five selected genotypes (B10, H1/1, H1/7, H2/1, and H2/12) were evaluated and compared with Chandler, Hartley, Pedro, Ronde de Montignac and Franquette in 2010 and 2011. The most important characteristics that were examined included leafing date, pistillate flowering and pollen shedding period, nut weight and size, kernel weight, kernel percentage and kernel color.

Phenological traits

According to IPGRI descriptor (1994), characters such as leafing date, beginning and end of pollen shedding, beginning and end of pistil receptivity were recorded. On this basis, leafing date is when 50% of terminal buds are open and leaves are visible from inside the buds. The dates on which the first and last pollen shedding occurred is considered the beginning and end of pollen shedding. In addition, the start and end of flower receptivity was when the first and last female flowers became receptive (IPGRI, 1994). Nuts were harvested when the membrane between the kernel halves turned completely brown, which is when the kernels have the lightest color and highest quality (Ramos, 1998).

Pomological characteristics

Nut characteristics such as, nut size (length, width, and thickness), nut form (Arzani *et al*., 2008), shell thickness, nut and kernel weight, kernel ratio, kernel color, shell seal and texture, kernel removal and kernel oil percent were evaluated.

Results

Late-leafing in Iranian walnuts, such as the Turkish cultivars (Akca and Ozongun, 2004), is not common (Khadivi-Khub *et al*., 2015). As a result of the preselections, the five selected walnut trees in our study were selected based on possession of late leafing. The superior genotypes B10, H1/1, H1/7, H2/1 and H2/12 that were selected based on these characters showed very good performance during 2010 and 2011. Table 1 shows phenological characteristic of selected genotypes and cultivars. Receptive period in female flowers and pollen shedding period varied from first decade of April

to first decade of May. The harvest time of selected genotypes was in the first and second decade of August.

Leafing time in the selected genotypes B10, H1/1, H1/7, H2/1 and H2/12 started in the first decade of April in 2010. Walnut cultivars showed to be leafing in the second decade of April (Fig.1). Pistillate flowers receptive and pollen shedding period varied between the second and the third decade of April in 2010 (Fig.1).

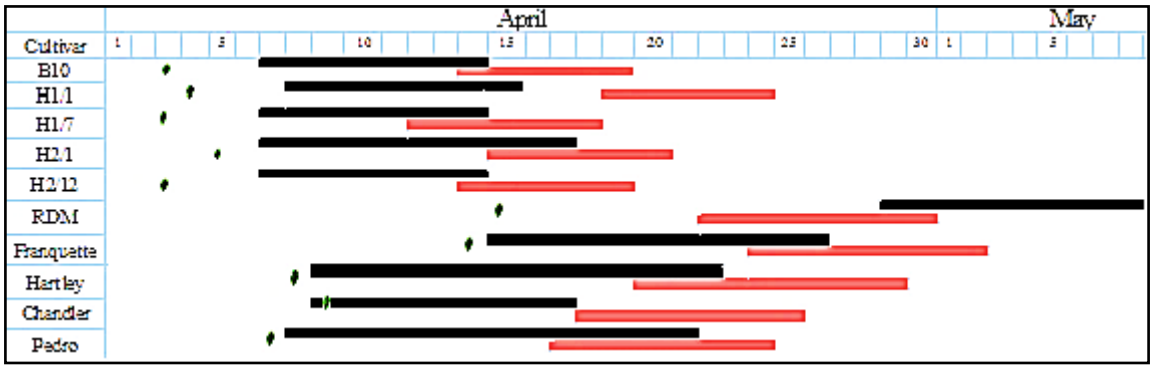

Fig.1. Leafing time, flowering time characteristics of selected walnut trees in 2010.

: Leafing time : Pollensheddingperiod : Pistillate Receptivity

Pollen shedding took place between April 6th (H1/7) and April 28th (Ronde de Montignac) in 2010 (Fig. 1) and April 6th (H2/1) and April 27th (Ronde de Montignac) in 2011 (Fig. 2).

Genotype H2/12 had the shortest (6 days) and cultivar Ronde de Montignac the longest (10 days) pollen shedding period in the tow years. Receptivity of pistillate flowers were from April 12th (H1/7) to April 25th (Franquette) in 2010 (Fig. 1) and from (H1/7) April 14th to April 29th (Franquette) in 2011 (Fig. 2). Genotypes H1/1, H2/1 and H2/12 had the shortest (4 days) and the cultivar Hartley the longest (8 days) pistillate receptive periods.

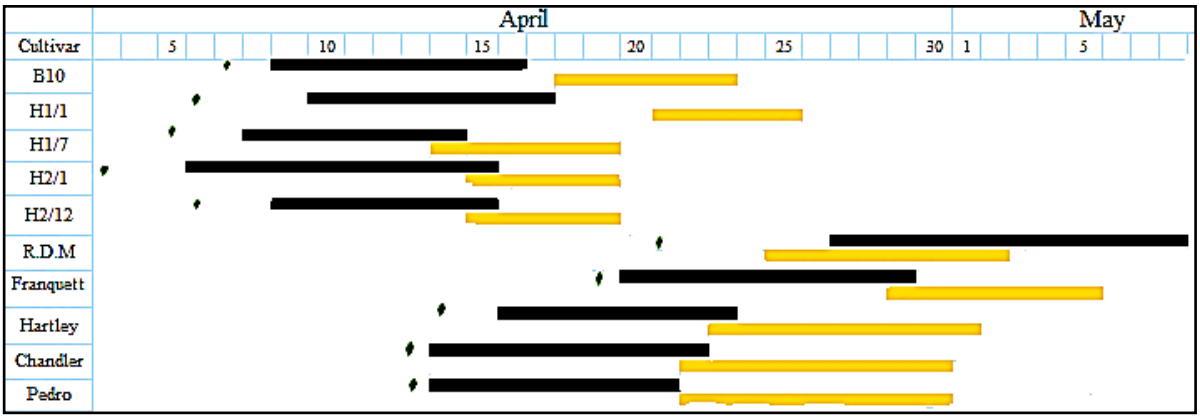

Fig.2. Leafing time, flowering time characteristics of selected walnut trees in 2011.

: Leafing time. : Pollen shedding period :Pistillate Receptivity

Nut and kernel traits

The genotypes and cultivars showed high variability for nut and kernel characteristics, which is shown in Table1. In the selected genotypes, nut weight ranged from 10.1g (H1/1) to 12/8g (B10), kernel weight ranged

from 5.07g (H2/1) to 6.52 g (H2/12) and kernel ratio varied from 42.5% (H2/1) to 58.4% (H2-12). The five promised walnut genotypes showed very good performance in comparison with commercial walnut cultivars (Table 1).

Table 1. Nut traits of selected Genotypes/Cultivars evaluated according to their nut characteristics.

Genotypes/Cultivars	Nut weight	Kernel weight	Kernel ratio	Shell thickness	Oil ratio
B10	12.8±0.525	5.70±0.210	44.8±0.97	2.02±0.638	67.7±0.515
H1/1	10.1±0.300	5.16±0.242	50.9±1.89	1.45±0.459	71.7±0.214
H1/7	11.0±0.286	5.18±0.145	47.3±1.24	1.61±0.508	66.6±0.136
H2/1	11.9±0.360	5.07±0.249	42.5±1.01	1.72±0.543	68.8±0.107
H2/12	11.2±0.413	6.52±0.264	58.4±1.62	1.30±0.411	71.6±0.279
Hartley	8.2±0.383	3.43±0.197	41.6±1.50	1.55±0.490	67.4±0.601
Pedro	8.6±0.480	3.60±0.267	41.5±1.49	1.40±0.443	64.9±0.829
Chandler	7.7±0.324	3.32±0.203	42.8±1.57	1.28±0.404	69.1±0.351
Ronde de Montignac	7.0±0.349	3.17±0.200	45.6±1.73	1.20±0.379	68.4±0.364
Franquette	8.2±0.328	3.51±0.223	42.5±1.55	1.50±0.475	67.6±0.309

The harvest dates of selected genotypes/cultivars varied from the end of August to the end of September. Start and end of nut maturity, days from pistillate flowering to end of maturity of five promising genotypes and control cultivars are shown in Table 2. The highest production (534 g/m^{2}SCA nut yield, and 312g/m^{2}SCA kernel yield) was recorded for 'H2/12.' The highest nut production efficiency (3.37 No. nut/TCSA cm^2) was in H2/1 and the number of nut to Scaffold cross area was in H2/12 (48.1 nuts/SCA m^2) (Table 3). (TCSA: Trunk Cross Sectional Area, SCA: Scaffold Cross Area)

Table 2. Start and end of maturity, days to maturity, and yield efficiency of walnut genotypes/cultivars.

Genotypes/Cultivars	Start maturity date	End maturity date	Time from start to end of Maturity (day)	Day from pistillate flowering to maturity (day)	Fruit Yield (g/m^{2}SCA)	Kernel Yield (g/m^{2}SCA)	Number of fruits to TCSA (No Nut/cm^2)	Number of fruits to SCA (No Nut/m^2)
B10	27-Jul	24-Aug	28	120	224	100	1.419	17.5
H1/1	4-Aug	27-Aug	23	124	354	180	1.661	34.8
H1/7	1-Aug	28-Aug	27	121	401	189	1.868	36.5
H2/1	4-Aug	27-Aug	23	123	497	213	3.373	41.9
H2/12	1-Aug	27-Aud	26	121	534	312	2.699	48.1
Hartley	10-Aug	10-Sep	31	126	117	49	1.069	13.4
Pedro	27-Jul	29-Aug	23	117	93	39	1.053	11.0
Chandler	13-Aug	16-Sep	33	135	104	45	1.038	13.7
Rond de Montignac	4-Aug	26-Aug	22	115	42	19	0.780	7.1
Franquette	8-Aug	7-Sep	30	126	84	36	0.918	9.3

The correlations between pair characters are reported in Table 3. Nut weight showed a positive correlation with shell thickness that means heavier nuts have thicker, heavier shells. The form index was correlated with nut length, nut width, and nut thickness.

Table 3. Correlations coefficients among several nut and kernel characteristics in the promising genotypes.

	NT	NWi	NL	FI	NW	KW	KR	MT	ST	OR
NT	1									
NWi	0.868**	1								
NL	0.108	0.520	1							
FI	-0.650*	-0.264	0.680*	1						
NW	0.670*	0.844**	0.674*	0.022	1					
KW	0.750*	0.563**	0.446	-0.222	0.898**	1				
KR	0.556	0.552	-0.100	-0.510	0.368	0.739*	1			
MT	-0.266	-0.116	0.479	0.588	0.306	0.046	0.361	1		
ST	0.323	0.516	0.711*	0.322	0.743*	0.417	-0.253	0.339	1	
OL	0.234	0.188	-0.307	0.441	0.205	0.489	0.735*	0.360	0.250	1

NT: Nut thickness; **NWi**: Nut width; **NL**: Nut length; **FI**; Form index; **NW**: Nut weight; **KW**; Kernel weight; **KR**: Kernel ratio;**MT**:membrane thickness;**ST**: Shell thickness; **OL**: Oil ratio * and **: Significant at the 0.05 and 0.01 probability levels, respectively

Discussion

In order to select the superior genotypes, it is essential to evaluate their performance or characteristics compared with already available commercial cultivars. In this case, five walnut superior genotypes (B10, H1/1, H1/7, H2/1, and H2/12) were evaluated with some commercial cultivars in a breeding program. Among the walnut key characteristics, late leafing is considered the important character to escape the spring frost injury as shown by others (Forde, 1979 and Barone *et al*., 1990). Per sure later bud break and so later flowering create more opportunity to survive the late spring frosts. In climates with wet springs, late leafing individuals escape the early favorable environmental conditions to blight infection.

The present study was carried out to select superior walnut genotypes in term of relatively late leafing and high kernel quality. Flowering characteristics such as pistillate flowers receptive period and pollen shedding period are also important traits used in characterization and studies in walnut (Sharma, 2004). Walnut is a hetero-dichogamous species demonstrating protandry, protogyny and homogamy in different genotypes (Sharma, 2004).The evaluated genotypes all were protandrous, similar to commercial cultivars like 'Hartley', 'Chandler', 'Franquette' and 'Pedro'. These varieties need pollinizer with sufficient overlapping period of blooming for effective pollination.

Since leafing and harvest dates were characteristics with very high and high heritability, respectively (Hansche *et al*., 1972), they could be used more effectively in selection of promising genotypes. The genotypes B10, H1/1, H1/7, H2/1 and H2/12 showed to be relatively late-leafing and having the shorter growing period to maturity compared to control cultivars (Hartley, Chandler, Franquette). Early maturity is a good characteristic, which allow the cultivars to escape early au-

tumn frost injury and plays an important role to catch market demand. (Aslantas, 2006).

Desirable nut and kernel weights should be10–18 g and 5–10 g, respectively, or kernel weight should be at least 40% of the entire nut weight, with a light color kernel (McGranahan and Leslie, 1990). The five genotypes were superior cosidering these desirable traits. Different studies showed very high variation in walnut population. In two studies in Turkey, nut weight varied from 7.82g to 18.74g, kernel weight from 4.04g to 9.00 g, kernel ratio from 42.88% to 67.14% and shell thickness from 0.58mm to 2.03 mm (Akça and Koroglu 2005; Aslantas 2006). In this study, fat ratio differed from 64.9% (Pedro) to 71.7% (H1/12). In overall, the five promised walnut genotypes showed very good performance in comparison with commercial control walnut cultivars.

The study of the correlations among characters could be beneficial especially in breeding programs. In this study nut weight was positively correlated with nut width and nut length. Kernel weight showed positive correlation with nut weight and nut width, that were in agreement with findings of others (Sharma and Sharma, 2001; Eskandari *et al*., 2005; Ebrahimi *et al*., 2011; Khadivi-Khub *et al.*, 2015). Shell thickness showed a negative correlation with kernel ratio, which was similar to results of Sharma and Sharma (2001) and Arzani *et al*. (2008).

Negative correlation was found between kernel ratio and shell thickness in other studies (Sharma and Sharma, 2001; Khadivi-Khub *et al*., 2015).

Conclusions

In the areas with frequent late spring frost, such as many regions of Iran, late leafing in addition to lateral bearing or high production are the most important and key characters in selection and release of new walnut cultivars. The present study was conducted evaluating promising genotypes through the use of criteria with high heritability, such as leafing date and nut and kernel characteristics. Genotypes B10, H1/1, H1/7, H2/1, H2/12 in spite of being earlier in leafing respect to commercial cultivars like chandler, were significantly superior in terms of higher nut and kernel production and earliness in ripening. The selected promising genotypes were considered for further evaluation in breeding program for multilocation experiment in different walnut growing regions in Iran.

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