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Full Length Research Paper

Phenological and pomological properties of promising walnut (*Juglans regia* L.) genotypes from selected native population in Amasya Province

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Walnut production in Turkey fluctuates quantitatively and qualitatively. The main problem is almost always early leafing. The environmental adaptations of Turkish national walnut cultivars are often poor due to early bud break and sensitivity to walnut blight and anthracnose. Therefore it is necessary to carry out a breeding programme for developing new cultivars in Turkey. This study was conducted out to determine genetic variability and select superior walnut types within seedling population of Amasya Province. During the study, 5000 walnut seedling trees were evaluated for late flowering, lateral bud fruitfulness, blight and antracnosis tolerance and high quality fruits. In term of high yield capacity in lateral branch and late leafing, 20 walnut types were selected. The vegetation cycle begins mainly in the second and third decade of April. In the selected genotypes, nut weight ranged from 7.46 to 15.21 g, kernel weight ranged from 3.73 to 7.44 g and kernel percent varied from 46.15 to 63.16%. The kernel of selected types was light colored. Among selected walnut types, the percentages of lateral bud fruitfulness were determined between 30 and 70%. Selected walnut genotypes will be used for further breeding purposes in terms of yield capacities, nut characteristics, and cold hardiness.

Key words: Lateral bud fruitfulness, late leafing, nut quality, bacterial blight, anthracnose.

INTRODUCTION

The Turkish walnut populations have important genetic variability consisting of more than 8.5 million natural hybrids on their own roots. These walnut trees are important source of genetic diversity for *Juglans regia* L. This genetic variation of native walnut populations presents many opportunities for walnut breeding. The first breeding program was started in 1970 in Turkey. At the first stage of the walnut breeding in Turkey during 1970 to 2006 years, the selections of types have been done according to nut quality. They were characterized by economically valuable fruit traits, but had limited potential productivity for the lateral bud fruitfulness (Akça, 2005).

During the last 35 years the gene pool of walnut in Turkey has been studied, with best varieties selected. These 8 main varieties were registered on national variety list, named as Şebin, Bilecik, Kaman 1, Şen 1, Yalova 1, Yalova 3, Yalova 4, Bursa 95. Twenty promising walnut types that have high fruit quality were selected in Marmara Region for production (Ölez, 1971; Celebioglu et al., 1988). Other selection studies have been implemented in native walnut populations of all Turkey areas. Many selections works were conducted to select superior walnut types and their adaptation abilities in various parts of the country. More than 200 promising types were selected among these trees in Ankara, Bitlis, Hakkari, Van, Malatya, Kırşehir, Konya, Sivas and other Provinces (Şen, 1980; Akça and Şen, 1994; Askın and Gun, 1995; Küden et al., 1995; Akça and Ayhan, 1996; Akça and Osmanoglu, 1996; Kaska et al. 1996; Yarılgaç, 1997; Secilmis, 1997; Gun, 1998; Kumral, 1998; Oğuz, 1998; Yavic, 2000; Akça et al., 2001; Yılmaz, 2001; Guven and Guleryuz, 2001; Yıldırım et al., 2005; Unver, 2005; Akça and Koroglu, 2005; Yarılgac et al., 2005; Muradoglu, 2007).

The foreign walnut cultivars were introduced from USA and France. These cultivars have been planted in the main nut growing areas in Turkey for further

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observations. The Turkish walnut cultivars have early leafing and low bud fruitfulness. Therefore, the main criteria should be late leafing, lateral bud fruitfulness, nut quality and resistance against blight in future works in Turkey. The aim of this study was to select new types combining lateral fruitfulness, late leaf break, resistance to pathogens (*Xanthomonas juglandis* and *Gnomonia juglandis*), regular yield, and high fruit quality. These breeding criteria were particularly highlighted by Akça (2001), Beyhan (1993), Germain et al., (1997, 1999), Mitrovic et al. (2003), Ünver (2005), Akça and Köroğlu (2005), Beyhan and Demir (2006). The best selections will be used as parents in variety breeding programs in the future. The basic aims of walnut selection in this work were resistance to late spring frosts, and fruit quality.

MATERIALS AND METHODS

Selection was done in the middle Black Sea region of Turkey (in Amasya). In the area of research, average annual temperature is 13.6°C, with 400 to 433 m attitude and 454 mm annual precipitation. The country is 120 km from the coast of Black Sea (Anonymous, 2009).

About 5000 walnut trees were investigated. Pre-selection was done according to leafing time and the types with early leafing were eliminated. The trees with both late leafing and lateral bud fruitfulness also were selected in 2005 to 2007. The most important identifying characteristics were the date of leaf bud break, blooming date of male and female flowers, pollination time, time of pistil receptivity, dichogamy, lateral bud fruitfulness, and pomological characteristics, including the average nut weight, kernel weight, kernel percentage, kernel colour, average nut length and diameter and shell thickness (Anonymous, 1994; Balcı et al., 2001). The nut traits were measured using 20 nuts chosen randomly (McGranahan and Ramos, 1992).

RESULTS AND DISCUSSION

For the Persian walnut populations grown from seed, over 5000 were evaluated during 2005 to 2007 and 250 walnut trees with late leafing and lateral bud fruitfulness were collected. Important fruit and tree characteristics in these walnut types were examined. The result of evaluations of the 20 walnut types selected is promising. Tables 1and 2 show some phenological and pomological characteristics of selected types. The age of the selected types ranged from 30 to 50 years old. In the selected types, trunk height varied from 0.8 to 1.9 m. Aslantas (2006) determined the trunk diameter of the evaluated 528 trees. In these trees, trunk diameter ranged from 0.7 to 4.3 m. Akça and Ozongun (2004) also found trunk circumferences of the selected types in the middle Black Sea region as 0.80 to 2.80 m.

Late leafing walnut cultivars cultivated in the late frosts are frequent. The second and third decade of April was the average leafing onset time of our new selections. In the selections AMS/02, AMS/07, AMS/08 and AMS/09, leafing times begins in early April. But in the selections AMS/12, AMS/13, AMS/14, and AMS/19, leafing times begins in late April. Receptive period in female flowers and pollen shedding ranged varied between the third decade of April and the first decade of May. The harvest time was found in selected types in the first and second decade of October (Table 1).

Observation from this collection has shown that: 4 seedlings had a late leafing and lateral bud fruitfulness (AMS/04, AMS/05, AMS/13, AMS/19), while 5 seedlings had an early bud break and lateral bud fruitfulness (AMS/01, AMS/02, AMS/07, AMS/08, AMS/18). Leafing time of selected types was 10 to 15 days later than Şebin cv. commonly grown in this region. AMS/04, AMS/05, AMS/13 and AMS/19 selections had late leafing and lateral bud fruitfulness according to Şebin cv.Walnut cultivars with late leafing have lower lateral bud fruitfulness than early leafing cultivars.

There is a negative correlation between late leafing and lateral bud fruitfulness. Germain (1989) said that lateral bud fruitfulness was fairly correlated with early leafing. AMS/13 and AMS/19 selections for this character are particularly important in Turkey where many areas have late spring frost. Late leafing is also tolerant to bacterial blight in areas with spring rains and dry summer (Forde, 1975). Breeding of new walnut varieties is characterized by earlier fruiting, higher yield, lateral bearing, good adaptability to different ecological conditions and good fruit quality (Germain, 1988; Akça, 2009). Walnut productivity is highly dependent on the number of pistillate flowers on annual shoots, the number of pistillate flowers per fruit bud, the percent of fruit set, the number of nuts per cluster, nut size and kernel percentage (Serr, 1962; Forde, 1979; Akça, 2009).

The lateral fruitfulness treatment is the important factor that determined the potential yield in *J. regia* L. The environmental adaptation of Turkish national walnut cultivars has early bud break and sensitivity to walnut blight and anthracnose. Among selected walnut types in this study, the percentages of lateral bud fruitfulness were determined between 30 (AMS/09) and 70% (AMS/19) (Table 1). Chandler, Fernor, Fernette, Vina and Tulare have late leafing and lateral bud fruitfulness. The ratio of lateral bud fruitfulness of these cultivars ranged from 80 to 90%. Although there is no harmony in some literatures, in general, it is regarded that the percentage of lateral bud fruitfulness should be at 50 to 70% in new promising types that is late leafing. The ratio of lateral bud fruitfulness of 'Sebin' is 40%. The percentage of lateral bud fruitfulness of Turkish walnut cultivars, Şebin, Bilecik, Kaman 1, Şen 1, Yalova 1, Yalova 3, Yalova 4, Bursa 95 is 20 to 40% (Akça, 2009). The percentage of lateral fruitfulness ranged between 40 and 63% in the selected types in Çoruh valley (Aslantaş, 2006), 70 and 10% in Middle of Karadeniz region (Akça and Ozongun, 2004). Lateral bud fruitfulness was found to be similar to previous studies by Akça and Şen, 1994; Sütyemez and Çağlar, 2001.

Table 1. Leafing time, flowering and fruiting characteristics of selected walnut (*Juglans regia*) trees.

Selection	Geographical Coordinate		Leafing time	Receptive period in female flower	Pollen shedding	Growth habit	Flower: number of male catkin	Fruitfulness on lateral branches (%)	Harvest Date
	Longitude	Latitude							
05.AMS.01	40° 41.271' N	035° 51.316' E	14 - 18 April	28 - 30 April	01 - 04 May	Upright	Few	50	October 1 - 7
05.AMS.02	40° 40.951' N	035° 53.260' E	11 - 14 April	23 - 24 April	05 - 06 May	Spreading	Medium	60	October 1 - 7
05.AMS.03	40° 41.148' N	035° 54.040' E	25 - 28 April	06 - 07 May	01 - 05 May	Upright	Few	40	October 1 - 7
05.AMS.04	40° 40.574' N	035° 52.435' E	22 - 25 April	29 April - 01 May	01 - 05 May	Spreading	Many	50	October 7 - 14
05.AMS.05	40° 40.524' N	035° 52.421' E	22 - 24 April	03 - 04 May	04 - 07 May	Spreading	Medium	60	October 7 - 14
05.AMS.06	40° 40.451' N	035° 52.186' E	20 - 24 April	03 - 04 May	04 - 07 May	Spreading	Medium	40	October 7 - 14
05.AMS.07	40° 43.677' N	035° 46.798' E	10 - 14 April	22 - 23 April	22 - 25 May	Spreading	Medium	60	October 7 - 14
05.AMS.08	40° 40.271' N	035° 51.316' E	11 - 14 April	19 - 22 April	22 - 25 April	Upright	Few	50	October 1 - 7
05.AMS.09	40° 40.550' N	035° 52.320' E	11 - 14 April	19 - 22 April	22 - 24 April	Upright	Few	30	October 7 - 14
05.AMS.10	40° 43.122' N	035° 47.700' E	19 - 22 April	29 - 01 May	24 - 25 April	Upright	Few	40	October 7 - 14
05.AMS.11	40° 40.468' N	035° 52.320' E	18 - 23 April	29 - 30 April	03 - 05 May	Semi-Upright	Medium	50	October 1 - 7
05.AMS.12	40° 40.544' N	035° 52.386' E	26 - 29 April	05 - 07 May	07 - 09 May	Spreading	Few	40	October 7 - 14
05.AMS.13	40° 40.565' N	035° 52.381' E	24 - 27 April	05 - 08 May	07 - 09 May	Spreading	Many	60	October 7 - 14
05.AMS.14	40° 46.944' N	035° 46.380' E	23 - 24 April	01 - 04 May	04 - 08 May	Spreading	Medium	50	October 1 - 7
05.AMS.15	40° 41.103' N	035° 53.140' E	16 - 19 April	23 - 26 April	23 - 26 April	Spreading	Few	50	October 7 - 14
05.AMS.16	40° 41.100' N	035° 53.112' E	16 - 20 April	24 - 27 April	24 - 27 April	Spreading	Medium	40	October 7 - 14
05.AMS.17	40° 41.005' N	035° 51.550' E	15 - 18 April	25 - 28 April	21 - 24 April	Upright	Few	60	October 7 - 14
05.AMS.18	40° 41.047' N	035° 52.481' E	12 - 15 April	22 - 25 April	26 - 29 April	Semi-Uprigth	Many	50	October 7 - 14
05.AMS.19	40° 41.954' N	035° 52.534' E	23 - 27 April	29 April - 01 May	03 - 06 May	Spreading	Few	70	October 7 - 14
05.AMS.20	40° 40.480' N	035° 52.261' E	19 - 21 April	26 - 29 April	29 April - 01 May	Semi-Uprigth	Many	60	October 7 - 14

Table 2. Nut traits of selected types evaluated according to their nut characteristics.

Selection	Suture (cm)	Length (cm)	Cheek (cm)	Shell thickness (mm)	Weight (g)	Kernel weight	Kernel ratio (%)	Kernel intensity of ground color	Empty kernel percent (%)	Structure of surface of shell
05.AMS.01	30.35	33.80	31.58	1.05	8.53	4.48	52.52	Dark	0	Moderately grooved
05.AMS.02	35.87	44.34	37.29	1.16	12.83	6.78	52.89	Medium	5	Moderately grooved
05.AMS.03	29.49	29.43	31.77	1.35	9.40	5.22	55.59	Dark	0	Strongly grooved
05.AMS.04	29.28	32.83	32.04	1.11	9.71	5.03	51.83	Light	0	Slightly grooved
05.AMS.05	29.65	37.96	29.20	1.60	10.05	4.81	47.84	Light	5	Moderately grooved
05.AMS.06	26.04	32.75	26.89	1.10	8.19	5.03	61.42	Medium	0	Slightly grooved
05.AMS.07	26.71	24.36	28.92	1.09	7.46	4.50	60.29	Light	0	Slightly grooved
05.AMS.08	26.30	37.40	25.80	1.47	7.95	3.74	47.02	Light	0	Slightly grooved
05.AMS.09	28.97	34.91	32.46	1.15	12.00	7.05	58.77	Light	0	Slightly grooved
05.AMS.10	28.70	34.64	29.21	1.58	10.68	4.95	46.40	Medium	0	Moderately grooved
05.AMS.11	30.29	35.80	32.44	1.18	10.69	6.21	58.12	Light	0	Slightly grooved
05.AMS.12	33.03	41.20	34.06	1.67	15.21	7.70	50.64	Light	0	Slightly grooved
05.AMS.13	33.58	35.38	32.50	1.69	10.75	5.59	51.98	Light	0	Strongly grooved
05.AMS.14	28.96	36.17	31.32	1.22	9.71	5.21	53.60	Medium	0	Slightly grooved
05.AMS.15	28.33	34.43	30.57	1.51	10.55	5.80	54.96	Light	0	Slightly grooved
05.AMS.16	29.69	34.42	31.62	1.37	10.28	4.74	46.15	Light	0	Slightly grooved
05.AMS.17	30.39	33.72	32.86	1.54	9.99	4.83	48.38	Medium	0	Slightly grooved
05.AMS.18	32.64	35.27	31.92	1.59	10.70	5.53	51.68	Light	0	Strongly grooved
05.AMS.19	31.61	36.92	32.49	0.99	11.79	7.44	63.16	Medium	5	Slightly grooved
05.AMS.20	34.42	34.42	34.03	1.41	10.69	5.96	55.75	Dark	0	Slightly grooved

In respect of flowering characteristics, 3 types were protan-drous, 15 types were protogynous and 2 types were homogamous in our selected types. Akça and Ozongun (2004) determined with respect to dichogamy, 11 types as protogynous and 6 selections as protandrous. Protandry is a genetically dominant character in *J. regia* (Akça, 1995).

The kernel weight should be 6 to 8 g, kernelratio should be 50 to 55%, and shell thickness should be 0.7 to 1.5 mm in promising new walnut varieties according to Akça (2009), Nenjuhin, (1971); Zhadan and Strokov, (1977). In the selected types, nut weight ranged from 7.46(AMS/07) to 15.21 g (AMS/12), kernel weight ranged from 3.73 (AMS/08) to 7.44 g (AMS/19) and kernel ratio varied from 46.15 (AMS/16) to 63.16% (AMS/19). In selected types, kernel ratios of three types were bigger than 60% (Table 2).

AMS/12 selection with lateral fructification gave sizeable nuts (15.21 g) and high kernel percentage of (50.64%). Very big nuts (>14.5 g) is found in selection AMS/12. Kernel ratio of selected types are very high (> 55%) in selection AMS/03, AMS/06, AMS/07, AMS/09, AMS/11, AMS/19 and AMS/20 and in selections AMS/01, AMS/02, AMS/04, AMS/12, AMS/13, AMS/14, AMS/15, AMS/16, AMS/18 kernel ratio was 50 to 55%. We did not find very low (< 40%) and low(40-44%) kernel ratio in selected types. l ratio

Kernevalues of selected types were generally higher than other selections study in Turkey.Şebin Turkish walnut cultivar has nuts averaging 9.40 g with 63% kernel. In other selection studies in Turkey, nut weight varied from 7.82 to 18.74 g, kernel weight from 4.04 to 9.00 g, kernel ratio from 42.88 to 67.14% and shell thickness from 0.58 to 2.03 mm (Akça and Koroglu, (2005), Akçay and Tosun 2005, Yıldırım and al. 2005; Unver, 2005; Aslantas, 2006). In this research shell thickness of the selected genotypes determined varied between 0.99 and 1.60 mm. In the previous selection researches, shell thickness varied from 1.32 to 2.45 (Akça and Şen, 1994) and 0.91 to 1.76 (Akça and Şen, 1999). Shell thickness is essential for saving kernels from the external effects. More also, average nut length ranged from 24.36 (AMS/07) to 44.34 mm (AMS/02), nut width varied from 26.047 (AMS/06) to 35.87 mm (AMS/02), nut cheek varied from 25.80 (AMS/08) to 37.29 mm (AMS/02) in the selected types (Table 2). The pomological characteristics of selected types were similar to selected types of Ölez (1971), Şen (1980); Akça and Şen, (1994); Özongun and Akça, (2005); Aslantaş, (2006).

The percentage of clean yellow kernel should be at least 50% in promising selection. Eleven selected types had extra light colored kernels. Only 3 types had dark colored kernels. There was 5% determined as empty kernel in selected 3 genotypes (AMS/02, AMS/05, AMS/19) and defective kernel percent determined to be 5% in selected 2 genotypes (AMS/02, AMS/19). Selected types had good field resistance against bacterial blight and anthracnose despite there being many affected trees. Serr (1964), suggested that the wild walnut types of north-eastern Turkey, which are growing under heavy rainfall including summer rains, should be evaluated for potential blight resistance. In spite of the fact that the area of research has suitable conditions for blight and anthracnose disease, our selected types had resistance. In selected types, *Cydia pomonella* damage was seen in only one genotype (AMS/12). The harvest date of selected types was at beginning of October. Short growing seasons is important walnut breeding criteria. There are not short growing season types among selected types according to 'Sebin'. Selected types had regularly yielded every year.

The features of all selected selections are dominant protandric blossom, medium large to large fruit, high yield (over 50%) and good kernel quality. In the city center, the annual average temperature is 13.6°C, annual average relative humidity of 61%, the highest temperature in 2000 was 45°C, while the lowest temperature was -20.4°C in 1985 as have been identified. The average annual number of frost days was 50 days. Selections are resistant to winter frosts. Most selections have resistance to *X. juglandis* and *G. juglandis*. Morphological and pomological characteristics of selected types are similar to other promising selection of Turkish. However, selected types with late leafing and lateral bud fruitfulness fulness are suggested for good performance, which may be limiting factors for example late frost damage. Selected types were collected and propagated by grafting.

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