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SELECTION OF PROMISING WALNUT GENOTYPES (*Juglans regia* L.) FROM INNER ANATOLIA

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Abstract. Turkey is one of the most important walnut producers in the world. The aim of this study to select superior walnut genotypes among the walnut seedling populations naturally grown in Gumushacikoy district of Amasya province located in Inner Anatolia between 2010–2011 years. In the study, a large number walnut genotypes in Inner Anatolia were screened according to selection criteria and after evaluation twenty promising walnut genotypes were selected as cultivar candidate among genotypes. The average fruit weights, kernel weights and kernel ratios were ranged from 8.93 to 13.92 g, 4.62 to 7.36 g and 47.80 to 58.98% among twenty promising walnut genotypes, respectively. Measurements of fruit dimensions showed that the average fruit length, width and heights were found between 42.80–29.97 mm; 25.73–34.77 mm and 28.86–33.85 mm, respectively. Considering 20 promising walnut selections, 11, 5 and 4 genotypes had been found protandry, protogyny and homogamy. The chemical analyses showed that protein, crude oil and ash contents of selected twenty walnut genotypes were between 13.75–19.69%; 44.08– 70.81% and 1.53–2.15%, respectively.

Key words: Biodiversity, fruit quality, genetic resources, selection, walnut

INTRODUCTION

Biodiversity provides the raw materials, combinations of genes that produce the plant varieties and animal breeds upon which agriculture depends. The genetic resources of plants are a global asset of inestimable value to humankind whether they are used in traditional farming systems, conventional or modern breeding or genetic engineering. As genetic diversity erodes, our capacity to maintain and enhance crops and livestock productivity decreases along with the ability to respond to changing conditions. Genetic

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resources hold the key to increasing food security and improving the human condition as well [Ercisli 2004].

Crop genetic diversity is still concentrated mainly in regions known as “centres of diversity”, and located in the developing world. Farmers in these areas, who still practice traditional agriculture, cultivate local varieties known as “land races” that have been selected over many generations. Closely related species that survive in the wild are known as “wild relatives” of crops. Together, land races and their wild relatives are the richest repositories of crop genetic diversity [Ercisli 2004].

Turkey is one of the most important countries in the world in terms of walnut production. The country produces annually 183.000 tons walnut and ranking 4th place after China (1.655.000 tons), Iran (485.000 tons) and USA (418.000 tons) [FAO 2012].

Anatolia is also germplasm center of walnut and walnut trees exceptionally are abundant almost all regions in Turkey. Walnut trees are cultivated in Turkey mainly for its nutritious nuts which used as a food, in the chocolate industry, for baked foods, and in the pharmaceutical and cosmetic industry. The trees are also valuable as timber [Asma 2012, Ercisli et al. 2012].

Continuous seed propagation for thousands of years in Turkey has given rise to a great number of seedling walnut trees, which represent valuable walnut gene resources. The number of native trees is estimated to be over 5 million and they possess large genetic variability in yield, nut and kernel characteristics, late bud breaking, late flowering, winter hardiness, tolerance to disease etc [Sen and Tekintas 1992].

This high genetic variation of native walnut populations throughout country presents good opportunities for walnut breeding to obtain new cultivars directly or to use them in cross breeding activity [Asma 2012].

During the last decades the gene pool of walnut in Turkey has been studied and some promising genotypes were selected and later they registered as Sebin, Bilecik, Kaman 1, Sen 1 etc. [Akca 2009, Akca et al. 2012]. However, there were wide areas covered by walnut trees in different parts of the country, which have not been searched so far.

These previous studies revealed that Turkish standard walnut cultivars have early leafing and low bud fruitfulness characteristics. Therefore, the obtain late leafing, lateral bud fruitfulness, nut quality and resistance against blight is an important breeding goals and these kind of genotypes could be present in natural walnut populations [Akca 2001, Akca 2009].

The aim of this study was to select promising walnuts from Inner Anatolia region in Turkey. In this study we considered main selection criteria including lateral fruitfulness, late leaf break, resistance to pathogens (*Xanthomonas juglandis* and *Gnomonia juglandis*), regular yield and high fruit quality. These breeding criteria were previously highlighted by different researchers [Germain et al. 1999, Akca 2001, Mitrovic et al. 2007, Beyhan and Demir 2006].

MATERIALS AND METHODS

Selection was done in the middle Black Sea region of Turkey (Amasya province, Gumushacikoy district, 40°52’N, 35°13’E). In the Gumushacikoy district, average atti-

tude is 810 m. At the beginning of the study, pre-selection was done early leafing genotypes were eliminated in the study. The trees with both late leafing and lateral bud fruitfulness were selected in both 2010 to 2011. The most important characteristics on selection study 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 [Balci et al. 2001]. The nut traits were measured using 20 nuts chosen randomly [Beyhan and Demir 2006].

RESULTS AND DISCUSSION

For the Persian walnut populations grown from seed, were evaluated during 2010 to 2011. In 2010 year among numerous walnut genotypes were screened and first year (2010) a total 40 walnut trees with late leafing and lateral bud fruitfulness were selected and in 2011 year important fruit and tree characteristics of these 40 walnut genotypes were re-examined and finally according to weighted ranking method, the most promising 20 walnut genotypes were selected.

Table 1 and 2 shows some phenological and pomological characteristics of selected walnut genotypes.

Late leafing characteristics of walnut cultivars are very important if they cultivated in areas where late frosts are frequent.

In the selections leafing times of selected types are similar to each other. Leafing times changed between 2 May and 12 May. Receptive period in female flowers and pollen shedding ranged varied between the first decade of May and the third decade of May (tab. 1).

According to phonological observation, 5 genotypes (05.GHK.01, 05.GHK.20, 05.GHK.30, 05.GHK.31 and 05.GHK.32) had a late leafing and lateral bud fruitfulness. Leafing time of selected genotypes 9 to 15 days later than international Serr walnut cultivar grown in this region and considered as control. Leafing time of 05.GHK.20, 05.GHK.31, 05.GHK.01, 05.GHK.18 and 05.GHK.19 genotypes was 2 to 7 days later than Chandler cv. grown in this region. 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] reported that lateral bud fruitfulness was fairly correlated with early leafing. Late leafing is also tolerant to bacterial blight in areas with spring rains and dry summer occurs [Forde 1975].

Currently the breeding aim of new walnut cultivars concentrated on earlier fruiting, higher yield, lateral bearing, good adaptability to different ecological conditions and good fruit quality [Akca 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 [Akca 2009, Asma 2012].

The lateral fruitfulness is the important factor that determined the potential yield in *J. regia* L. The main environmental adaptation problems of Turkish national walnut cultivars are early bud break and sensitivity to walnut blight and anthracnose. Among

selected walnut genotypes in this study, the percentages of lateral bud fruitfulness were determined between 0 (05.GHK.34) and 75% (05.GHK.03) (tab. 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 percentage of lateral bud fruitfulness of Turkish walnut cultivars, namely Sebin, Bilecik, Kaman 1, Sen 1, Yalova 1, Yalova 3, Yalova 4, Bursa 95 is 20 to 40% [Akca 2009].

The percentage of lateral fruitfulness ranged between 40 and 63% in the selected walnut genotypes in Çoruh valley of Northeastern Turkey [Aslantas 2006].

In mid of black sea region of Turkey, it was between 10–70% Akca and Ozongun 2004]. Lateral bud fruitfulness was found to be similar to previous studies by Akca and Sen [2004] and Sutyemez and Caglar [2001].

In respect of flowering characteristics, 11 genotypes were protandry, 5 genotypes were protogyny and 4 genotypes were homogamy in our promising 20 genotypes (tab. 1). Akca and Ozongun [2004] selected 17 walnut genotypes and they determined 11 genotypes protogyny and 6 selections as protandry. Protandry is a genetically dominant character in *J. regia* [Akca 1995].

In the selected genotypes, nut weight ranged from 8.93 (05.GHK.18) to 13.82 g (05.GHK.32), kernel weight ranged from 4.62 (05.GHK.18) to 7.36 g (05.GHK.26) and kernel ratio varied from 47.80 (05.GHK.03) to 58.98% (05.GHK.12) (tab. 2). Kernel ratio of selected genotypes are very high (> 55%) in selection 05.GHK.20, 05.GHK.26, 05.GHK.21, 05.GHK.12, 05.GHK.22, 05.GHK.15, 05.GHK.27, 05.GHK.04 and 05.GHK.34. In selections 05.GHK.30, 05.GHK.32, 05.GHK.01, 05.GHK.05, 05.GHK.18, 05.GHK.37 and 05.GHK.19 had kernel ratio between 50 to 55%. We did not find very low (< 40%) kernel ratio but 4 genotypes (05.GHK.31, 05.GHK.11, 05.GHK.03 and 05.GHK.29) had low (40–44%) kernel ratio (tab. 2).

Sebin Turkish walnut cultivar has nuts averaging 9.40 g with 63% kernel ratio. 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 [Akca and Koroglu 2005, Akcay and Tosun 2005, Unver 2005, Aslantas 2006].

In this research shell thickness of the selected genotypes determined varied between 0.80 and 1.77 mm (tab. 2). In the previous selection researches, shell thickness varied from 1.32 to 2.45 [Akça and Sen 1994] and 0.91 to 1.76 [Akça and Sen 1999]. Shell thickness is essential for saving kernels from the external effects.

In addition, average nut length ranged from 29.97 (05.GHK.18) to 42.80 mm (05.GHK.29), nut width varied from 28.86 (05.GHK.11) to 33.85 mm (05.GHK.04), nut cheek varied from 25.73 (05.GHK.11) to 34.77 mm (05.GHK.26) in the selected genotypes (tab. 2). The pomological characteristics of selected genotypes were similar to selected walnut genotypes [Akca and Sen 1994, Akca et al. 2005, Aslantas 2006].

The percentage of clean yellow kernel should be at least 50% in promising selection according to previous findings. In our study, five selected genotypes had extra light, seven selected genotypes had light colored kernels. Only 2 genotypes had dark colored kernels (tab. 2).

Table 1. Leafing time, flowering and fruiting characteristics of selected walnut (*Juglans regia*) genotypes from Amasya province in Turkey

Genotypes	Coordinates		Altitude	Leafing time	Receptive period in female flower	Pollen shedding	Dichogamy	Lateral fruitfulness (%)
	latitude	longitude						
05.GHK.20	035 11 56D	40 53 12K	853	8 May	14–17 May	9–12 May	protandry	60
05.GHK.30	035 12 59D	40 53 29K	871	7 May	13–16 May	9–12 May	protandry	55
05.GHK.32	035 13 53D	40 53 35K	880	7 May	12–15 May	8–11 May	protandry	40
05.GHK.31	035 13 02D	40 53 36K	886	12 May	17–20 May	17–20 May	homogamy	50
05.GHK.01	035 11 32D	40 52 42K	861	7 May	13–16 May	13–16 May	homogamy	40
05.GHK.26	035 12 58D	40 53 26K	868	6 May	12–15 May	15–18 May	protogyny	40
05.GHK.11	035 11 21D	40 52 46K	876	3 May	12–15 Ma	14–17 May	protogyny	66
05.GHK.21	035 11 56D	40 5313K	847	5 May	13–16 May	11–14 May	protandry	50
05.GHK.12	035 11 23D	40 52 49K	867	2 May	14–17 May	10–13 May	protandry	55
05.GHK.03	035 11 32D	40 52 43K	861	2 May	11–14 May	7–10 May	protandry	75
05.GHK.05	035 11 30D	40 52 45K	862	4 May	11–14 May	14–17 May	protogyny	50
05.GHK.22	035 11 59D	40 53 17K	849	4 May	15–18 May	12–15 May	protandry	30
05.GHK.15	035 12 05D	40 52 55K	845	4 May	12–15 May	8–11 May	protandry	10
05.GHK.18	035 11 57D	40 52 55K	856	8 May	15–18 May	15–18 May	homogamy	10
05.GHK.27	035 12 58D	40 53 26K	868	5 May	12–15 May	15–18 May	protogyny	30
05.GHK.29	035 12 58D	40 53 28K	869	3 May	12–15 May	11–14 May	protandry	40
05.GHK.37	035 10 52D	40 50 13K	840	2 May	11–14 May	6–9 May	protandry	50
05.GHK.04	035 11 29D	40 52 44K	862	2 May	12–15 May	16–19 May	protandry	40
05.GHK.34	035 13 58D	40 53 14K	851	5 May	13–16 May	13–16 May	homogamy	0
05.GHK.19	035 11 50D	40 53 06K	860	6 May	14–17 May	10–13 May	protandry	30

Table 2. Nut traits of selected promising walnut genotypes evaluated according to their nut characteristics

Genotype	Width (mm)	Length (mm)	Nut cheek (mm)	Nut weight (g)	Kernel weight (g)	Kernel ratio (%)	Shell thickness (mm)	Kernel color	Empty kernel percent (%)
05.GHK.20	31.07	32.80	31.66	10.43	6.07	58.21	1.23	light	5
05.GHK.30	32.04	37.28	32.14	11.68	6.01	51.46	1.60	light	0
05.GHK.32	31.44	37.14	31.87	13.82	7.02	50.82	1.49	extra light	0
05.GHK.31	31.98	36.31	33.74	12.09	5.89	48.71	1.41	light	0
05.GHK.01	32.95	33.34	33.60	10.49	5.65	53.88	1.07	light	5
05.GHK.26	34.77	34.54	32.22	12.60	7.36	58.37	1.49	light	0
05.GHK.11	25.73	35.05	28.86	10.50	5.23	49.84	1.02	extra light	0
05.GHK.21	29.61	31.75	30.62	9.50	5.28	55.58	1.04	extra light	0
05.GHK.12	29.26	32.21	29.82	9.13	5.39	58.98	1.13	medium	0
05.GHK.03	28.78	31.65	30.07	10.30	4.92	47.80	1.56	light	0
05.GHK.05	30.18	34.62	30.50	10.44	5.27	50.53	1.77	light	0
05.GHK.22	27.89	33.31	30.62	11.14	6.52	58.47	1.31	medium	0
05.GHK.15	31.14	36.04	33.03	12.37	6.88	55.64	1.44	medium	0
05.GHK.18	28.79	29.97	30.95	8.93	4.62	51.74	1.62	medium	0
05.GHK.27	31.25	39.44	31.49	9.94	5.55	55.87	1.64	medium	0
05.GHK.29	31.80	42.80	32.53	12.69	6.18	48.72	1.27	extra light	0
05.GHK.37	30.76	36.73	33.04	12.79	6.42	50.15	1.60	dark	5
05.GHK.04	31.26	34.03	33.85	9.61	5.41	56.26	0.80	dark	0
05.GHK.34	29.40	34.84	32.15	10.70	6.12	57.23	1.59	extra light	0
05.GHK.19	30.83	39.55	30.50	11.85	6.05	51.04	1.11	medium	

Table 3. Protein, oil, ash and moisture content of selected walnut genotypes from Amasya, Turkey

Genotypes	Oil ratio (%)	Protein ratio (%)	Ash ratio (%)	Moisture ratio (%)
05.GHK.20	60.25	18.95	1.86	3.06
05.GHK.30	70.81	14.81	1.98	1.98
05.GHK.32	67.49	15.69	2.11	3.13
05.GHK.31	65.12	17.75	2.15	3.26
05.GHK.01	60.88	13.75	1.58	3.23
05.GHK.26	48.72	14.13	1.59	3.19
05.GHK.11	66.36	15.31	1.53	3.10
05.GHK.21	68.62	19.69	2.05	3.18
05.GHK.12	66.89	15.69	1.98	3.03
05.GHK.03	48.21	15.31	1.93	3.46
05.GHK.05	67.07	15.06	1.60	3.04
05.GHK.22	55.02	19.38	1.97	2.80
05.GHK.15	59.95	13.88	1.81	3.61
05.GHK.18	55.23	15.23	1.56	3.03
05.GHK.27	56.23	14.62	1.89	2.80
05.GHK.29	70.06	15.25	1.75	2.56
05.GHK.37	62.54	17.38	1.65	3.25
05.GHK.04	60.95	17.88	1.85	3.42
05.GHK.34	44.08	16.19	1.69	2.79
05.GHK.19	63.87	15.00	1.91	3.54

05.GHK.20, 05.GHK.01 and 05.GHK.37 genotypes have 5% empty kernel percentage (tab. 2). Selected genotypes had good field resistance against bacterial blight and anthracnose. 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, and our selected 20 genotypes seems good resistance and it should be searched more detailed in future.

In this study, chemical properties of walnuts were also determined. The analysis results showed that; average protein ratio is 16.05%, average oil content is 60.92% and average ash content is 1.82% and average moisture content is about 3.10% (tab. 3).

Simsek [2010] determined average protein content between 13.70–20.18%, average oil content 58.88–65.64%, average ash content between 1.88–2.89% and average moisture content 1.63–4.73%. Kahraman [2006] reported oil content in walnut genotypes between 51.70–72.80% and protein content between 15.61–27.50%, respectively. In selected genotypes, *Cydia pomonella* damage was seen only on two genotypes (05.GHK.20 and 05.GHK.12) (tab. 1). Selected genotypes had regularly yielded every year. The features of all selected selections are dominant protandric blossom, medium large to large fruit and good kernel quality.

CONCLUSIONS

This study is significant because it is the first selection work in Amasya province in Turkey. We found considerable differences most of the phonological and pomological characteristics. To make an objective comparison of fruit quality, precocity, and yield of these selected genotypes, they all need to be grown using the same rootstock, soil, climate, and cultural practices. Adaptation studies will also be required for the selected walnut genotypes. Therefore, walnut genotypes selected in the first stage of selection should be studied in the second stage of selection.

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SELEKCJA OBIECUJĄCYCH GENOTYPÓW ORZECHA WŁOSKIEGO (*Juglans regia* L.) ZE ŚRODKOWEJ ANATOLII

Streszczenie. Turcja jest jednym z najważniejszych producentów orzecha włoskiego. Celem niniejszego opracowania jest wybór najlepszych genotypów orzecha spośród populacji sadzonek orzecha hodowanych w latach 2010–2011 w naturalnych warunkach w rejonie Gumushacikoy w prowincji Amasya położonej w środkowej Anatolii. Przebadano dużą liczbę genotypów orzecha w środkowej Anatolii według kryteriów selekcji. Po ocenie wybrano dwadzieścia obiecujących genotypów orzecha jako propozycje odmian. Średnia waga owocu, waga jądra oraz proporcja jądra orzecha dwudziestu obiecujących genotypów orzecha wahały się odpowiednio w granicach 8,93–13,92 g, 4,62–7,36 g oraz 47,80–58,98%. Pomiary rozmiarów orzecha wykazały, że przeciętna długość, szerokość oraz wysokość wynosiły odpowiednio 42,80–29,97 mm; 25,73–34,77 mm oraz 28,86––33,85 mm. Biorąc pod uwagę 20 obiecujących genotypów, 11, 5 oraz 4 genotyp zaliczono do protandrii, protoginii oraz homogamii. Analizy chemiczne wykazały, że zawartość białka, oleju oraz popiołu w wybranych dwudziestu genotypach orzecha włoskiego wynosiła odpowiednio między 13,75–19,69%, 44,08–70,81% oraz 1,53–2,15%.

Słowa kluczowe: bioróżnorodność, jakość owoców, zasoby genetyczne, selekcja, orzech włoski

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