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Selection of Superior Properties of Walnut Genotypes in Ereğli-Halkapınar (Konya) and Ayrancı (Karaman) Walnut Population

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HIGHLIGHTS

- In this selection study, 8 genotypes in total, including 5 genotypes in shelled walnuts and 4 genotypes in kernels were found to be promising.
- In selected genotypes showed homogamy, 1 showed protogeny and 1 showed protandry flowering properties.

Abstract

This selection study was conducted to determine the walnut genotypes with superior characteristics grown from seeds in Ereğli and Halkapınar districts of Konya province and Ayrancı district of Karaman province between 2019-2022. In 2021 on the fruits taken, 8 genotypes in total, including 5 genotypes in shelled walnuts and 4 genotypes in kernels (1 genotype received high scores in both shelled and kernel walnuts) were found to be promising. In 8 genotypes selected, the shelled weight is 10.66-26.31 g, the kernel weight is 5.32-9.82 g, the kernel percentage is 37.33-57.91%, the shell thickness is between 1.06-1.90 mm, the shell color is "light" in 1 genotype, "moderate" in 4 genotypes, "dark" in 3 genotypes, kernel color is in 1 genotype "extra light", "light" in 7 genotypes, remove of kernel from the shell was "easy" in all genotypes. Shell adhesion was "good" in all genotypes, cracking of the shell was detected "easy" in 7 genotypes, "moderate" in 1 genotype, shell texture was "smooth" in 3 genotypes, "moderate" in 4 genotypes, and "rough" in 1 genotype. Remove of kernel from the shell was determined "easy" in all genotypes. Kernel fill and healthy kernel percentage was determined as 100% in all genotypes. At the end of the research, 6 of the selected genotypes showed homogamy, 1 showed protogeny and 1 showed protandry flowering properties.

Keywords: Walnut; Selection; Ereğli; Halkapınar; Ayrancı

1. Introduction

Walnut belongs to the genus Juglans of the family Juglandacea of the order Juglandales. 21 genera are known, including the genus Juglans. Among these species, Juglans regia (Anatolian walnut), which gains importance for its fruit, grows naturally in Anatolia, Iran, Himalaya, and Southeast Europe (Şen, 1986). Juglans regia has a wide variety of genotypes, and when walnut is mentioned, it is the first species that comes to mind with its superior fruit quality.

Anatolia, whose fruit growing culture dates back to ancient times, is among the homelands of walnuts as well as many fruit species. Walnut is a species that is cultivated in many regions of Türkiye, except for extreme

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climatic conditions. In Türkiye, a significant part of walnut production is still made with plants grown from seeds. According to the data of 2020, walnut growing is conducted in an area of 1.417.899 decare in Türkiye. Türkiye production area is 10.9% of the world walnut production area and we are in the 3rd place in the ranking (Anonymous, 2022a).

While the export of shelled walnuts in the world was approximately 384 thousand tons in 2020, the USA ranks first with an export amount of 138 thousand tons. While the import of shelled walnuts in the world was 344 thousand tons in 2020, Türkiye ranked first with 63 thousand tons. While the world's kernel exports amounted to approximately 335 thousand tons, the USA ranked first with an export amount of 130 thousand tons. While the world's kernel import was 266 thousand tons in 2020, Germany ranked first with 45 thousand tons (TEPGE, 2022).

The most important reason, Türkiye is not at the point we want in walnut exports, and therefore Türkiye meets our production deficit through imports is that we still continue production with walnut trees grown from seed. Today, although the plants established with standard varieties is increasing, productivity is still not at the desired levels. One of the ways for our country to reach the desired yield and quality values in walnut cultivation is to determine the types with superior characteristics suitable for the climatic conditions of the regions, to register the variety and to continue production with these varieties.

Türkiye is a large source for selection studies due to its location among the homelands of walnuts. The first research in our country which started with the "Selection of Walnuts from the Marmara Region", was initiated by Olez (1971). Later, the research that Şen (1980) continued with his associate professorship thesis titled "Research on the Breeding of Walnuts in Northeast Anatolia and the Eastern Black Sea Region by Selection" and selection studies on the basis of provinces and districts in different regions until today. As a result of these selection studies, many promising genotypes were determined and some of them were registered as cultivars.

The fruit growing culture in Ereğli and Halkapınar districts of Konya province and Ayrancı districts of Karaman province, where the research was conducted, dates back to ancient times. Sweet Cherry, apple and walnut cultivation in the region is conducted both on the Ereğli plain and on the north-facing foothills of the Taurus Mountains. Most of the walnut trees in the study area are walnut genotypes grown from seed. This research was conducted for the selection of superior walnut types grown from seeds in the afore mentioned regions.

According to Turkish Statistical Institute data there are 100 hectares of walnut orchards in Ereğli district, The total number of fruit bearing walnut trees is 3,500 and the total number of fruitless trees is 7,630. The yield per tree is 35 kg and the production is 122.5 tons. There are 195 hectares of covered walnut orchards in Halkapınar district. The total number of fruit bearing walnut trees is 10.500 and the number of fruitless walnut trees is 20.700. Yield per tree is 28 kg and total production is 294 tons. There are 59.2 hectares of walnut orchards in Ayrancı district. The number of fruit bearing trees is 5.300 and the total production amount is 117 tons. In most of the old orchards, the trees are genotypes grown from seeds, and standard fruit production is not possible, and the yield is extremely low (Anonymous, 2022b).

This study conducted in 2 provinces, 3 districts and 19 neighborhoods 2019-2022.

2. Materials and Methods

This research was conducted in Ereğli and Halkapınar districts of Konya province and Ayrancı district of Karaman province between 2019 and 2022.

At the beginning of the research, 19 neighborhoods in 3 districts were visited in 2019, and a total of 67 trees with high yield and fruit quality were determined in the first stage by interviewing the District Directorates of Agriculture and Forestry, the headmen of the neighborhoods and the leading farmers. 50 fruit samples were taken from each tree in September-October period. The samples taken were separated from their hulls and dried in a cool place, then they were measured and weighed according to the modified ranked method and Interntional Union for the Protection of New Varieties of Plants (Anonymous, 2017). For nut fruit

characteristics in weighted ranked scores and their relative scores are, 1-fruit weight (g) has 25% (very high:10, high:8, moderate:6, low:4, very low:2), 2- kernel percentage (%), has 20% (very hig:10, high:8, moderate:6, low:4, very low:2) 3-shell color has 15% (light:10, moderate:6, dark:2), 4-fruit size (mm) has 10% (large:10, moderate:8, small:4, very small:2), 5-shell thickness (mm) has 5% (very thin:10, moderate:8, thin:4, thick:2), 6-shell adhesion has 5% (good:10, moderate:6, poor:2), 7-shell texture has 5% (smooth:10, moderate:6, rough:2), 8-cracking of shell has 5% (easy:10, moderate:6, difficult:2), 9-kernel fill has 5% (100%:10, 80-90%:6, 70%≥:2), 10- healthy kernel percentage 5%, (100%:10, 80-90%:6, 70%≥:2).

For kernel characteristics in weighted ranked scores and their relative scores are, 1- kernel weight (g) has 25% (very high:10, high:8, moderate:6, low:4, very low:2), 2-kernel percentage (%) has 25% (very high:10, high:8, moderate:6, low:4, very low:2),3- kernel color has 20% (extra light:10, light:6, dark:2), 4- remove of kernel from the shell has 15% (easy:10, moderate:6, difficult:2), 5- cracking of shell (easy:10, moderate:6, difficult:2), 6-kernel fill (%) has 5% (100%:10, 80-90%:6, 70%≥:2), 7-healty kernel percentage (%) has 5% (100%:10, 80-90%:6, 70%≥:2).

The total scores of the genotypes were calculated by multiplying the scores of the genotypes in terms of each feature with the importance level of that feature. These scores, which were calculated separately for each genotype in terms of shelled walnuts and kernels were evaluated by ranking from the highest to the lowest.

As a result of the scoring and grading, 24 genotypes were found to be superior. As a result of the evaluations made in the summer of 2020, 24 new genotypes with superior characteristics were included in the research and the number of genotypes was increased to 48. Samples from 48 genotypes were evaluated in 2020 and 33 genotypes received high scores. Samples from 33 genotypes were taken during the harvest period in 2021, and 5 genotypes were determined in shelled walnuts with the highest scores and 4 genotypes in kernel (one genotype scored high in both shelled and kernels).

Fruit weight, kernel weight, kernel percentage, shell thickness, fruit size, shell color, kernel color, shell texture, cracking of shell, shell adhesion, remove of kernel from the shell, kernel fill, healthy kernel percentage of genotypes, leafing and flowering dates and flowering characteristics were investigated. Evaluations were made using the modified ranked method. In the selection of genotypes, modified ranked method scores were taken as basis. 8 genotypes selected in 2021 according to the modified ranked method score were found to be promising.

The genotypes included in the evaluation were numbered starting from the license plate numbers of the provinces (42 and 70), the first two letters of the districts (Ereğli ER, Halkapınar HA and Ayrancı AY). For example: 42-ER-01.

3. Results and Discussion

The first fruit samples were taken from 67 genotypes in September and October 2019. Pomological measurements and weighing of dried fruits were made according to modified ranked method and UPOV (Anonymous, 2017) the scores of the selection genotypes for each feature were multiplied by the importance of that feature and written as the total score of the genotypes. These scores, which were calculated separately for shelled walnuts and kernels for each selection genotype, were evaluated by sorting from the highest to the lowest (Şen, 1980).

In 67 genotypes determined in 2019, the fruit weight 6.76-17.98 g, kernel weight 2.31-9.54 g, kernel percentage 29.60-66.31%, fruit size 25.59-43.14 mm, kernel color "extra light" in 40 genotypes, "light" in 22 genotypes, “dark” in 5 genotypes, shell color “light” in 15 genotypes, “moderate” in 26 genotypes, “dark” in 26 genotypes, shell thickness 0.92-2.02 mm, shell adhesion “good” in 34 genotypes, “moderate” in 29 genotypes, “poor” in 4 genotypes, remove of the shell from kernel “easy” in 47 genotypes, “moderate” in 16 genotypes, “difficult” in 4 genotypes, shell texture “smooth” in 24 genotypes, “moderate” in 27 genotypes, “rough” in 16 genotypes, cracking of shell “easy” in 53 genotypes, “moderate” in 6 genotypes, “difficult” in 8 genotypes, kernel fill and healthy kernel percentage 100% in all genotypes.

According to the modified ranked method, 24 genotypes with a score of 715 and above in shelled walnut and 17 genotypes with a score of 850 and above in kernel were selected from among 67 walnut genotypes sampled. 17 genotypes with high scores in kernel also scored high in shelled walnuts, and the total number of superior genotypes was 24.

Fruit weight was between 8.81-17.14 g in selected 24 genotypes, the lowest fruit weight was measured in 42-ER-24 genotype, and the highest fruit weight was measured in 70-AY-02 genotype, kernel weight 4.84 g (42-ER-07) to 8.85 g (42-ER-01), kernel percentage 37.16% (70-AY-02) to 66.31% (42-HA-01), fruit size 30.07 mm (42- ER-08) with 40.44 mm (42-HA-09), kernel color is "extra light" in 10 genotypes, "light" in 10 genotypes, "dark" in 4 genotypes, shell color "light" in 4 genotypes, "moderate" in 7 genotypes , "dark" in 13 genotypes, shell thickness 1.04 mm (42-HA-09) to 1.81 mm (70-AY-02), shell adhesion "good" in 13 genotypes, "moderate" in 11 genotypes, remove of kernel from the shell "easy" in 20 genotypes , "medium" in 2 genotypes, "difficult" in 2 genotypes, shell texture is "smooth" in 17 genotypes, "rough" in 7 genotypes, cracking of shell is "easy" in 10 genotypes, "moderate" in 6 genotypes, "difficult" in 8 genotypes, kernel fill and healthy kernel percentage rate was found to be 100% in all. It was determined that genotype 70-AY-02 (17.14 g), which had the highest fruit weight, had the highest shell thickness (1.81 mm) and the lowest kernel percentage (37.16%).

In the spring of 2020, phenological observations were made in 24 genotypes that were superior according to the modified ranked method result of 2019. While the leaf starting date was between 14-30 April in genotypes, male flowers were active between 25 April-20 May and female flowers were active between 25 April-20 May. The earliest leafing was observed in 42-HA-12 genotype, and the latest leafing was observed in 42-HA-01 and 42-HA-02 genotypes. The earliest male flower was seen on April 25 in 42-HA-02, 42-HA-11 and 42-HA-12 genotypes, and the earliest female flower was seen on April 15 in 42-HA-11 genotype. 15 genotypes homogamy, 7 genotypes protandry and 2 genotypes showed protogeny flowering properties.

It was decided to include 24 new genotypes that could not be detected in 2019, in line with the observations made during the 2020 harvest period and the information received from the regional farmers. 24 new genotypes were added to 24 genotypes from 2019, and fruits were taken from a total of 48 trees in September-October, dried in a cool place and measured.

Fruit weight was between 8.39 g (42-HA-13)-23.30 g (42-HA-07), kernel weight 3.67 g (42-HA-01)-9.59 g (42-HA-07), kernel percentage 30.07% (42-HA-15)-61.74% (42-HA-11), kernel color is " light" in 42 genotypes, "light" in 6 genotypes, shell color is "light" in 38 genotypes, "medium" in 9 genotypes, "dark" in 1 genotype, shell thickness 0.95 mm (42-HA-13)-2.24 mm (42-HA-05) determined in 48 genotypes.

According to the scoring a total of 33 genotypes were found to be superior, 25 genotypes with a score of 700 and above in shelled walnuts, 25 genotypes with a score of 800 and above in kernel (17 genotypes scored high in both shelled and kernels).

Fruit weight was between 9.17 g (42-HA-11)-23.30 g (42-HA-07), kernel weight 4.81 g (70-AY-02)-9.59 g (42-HA-07), kernel percentage 37.35% (42-HA-18)-61.74% (42-HA-11), kernel color is " light" in 28 genotypes, "light" in 5 genotypes, shell color is "light" in 28 genotypes, "moderate" in 5 genotypes, shell thickness 0.96 mm (70-AY-01)- 2.24 mm (42-HA-05) determined in 33 selected genotypes.

Phenological observations of 33 genotypes selected in the previous year were made in 2021. As a result of the observations, it was determined leaf starting date took place between 16-28 April, male flowering between 22 April-8 May and female flowering between 25 April-7 May. Due to the low temperatures in winter and late spring frosts (the lowest temperature in Ereğli district is -22.2°C in January, -5.1°C in March, -1.1°C in April, -15.8°C in January in Halkapınar district, -12.6°C in March and in April -1.8°C). No female flowers were observed in 2 genotypes (42-HA-11 and 42-HA-18) in Halkapınar district, and no male flowers in 1 genotype (42-ER-17) in Ereğli district. While 20 genotypes showed homogamy, 6 genotypes protandry and 4 genotypes showed protogeny flowering, 3 genotypes could not detect flowering properties.

Due to the average temperature of 10°C in Ereğli and Halkapınar districts in April 2021, 42-ER-17, 42-ER-18, 42-HA-12, 42-HA-16, 42-HA-19, 42-HA-20, and 42-HA-23 genotypes fruit dropping occurred during the

small fruit formation period after flowering (MGM, 2022). In the 42-HA-11 and 42-HA-18 genotypes, the female flowers were never seen. Thus, fruit samples from a total of 9 genotypes could not be taken. Samples could be taken from 24 genotypes during the harvest period.

As a result of pomological measurements and subsequent scoring in fruit samples taken from 24 genotypes in September-October 2021, 5 genotypes scored 715 and above in shelled walnuts, 4 genotypes with a score of 900 and above in kernel (1 genotype scored high in both shelled walnuts and kernel). A total of 8 genotypes were found to be superior at the figures (1-8).

In the genotypes superior in shelled walnuts, shell fruit weight is 12.99 g (70-AY-01) to 26.31 g (42-HA-07), kernel weight is 6.23 g (70-AY-06) to 9.82 g (42-HA-07), kernel percentage is 37.33% (42-HA-07) to 57.91% (42-ER-01), fruit size 34.71 mm (70-AY-06) to 50.95 mm (42-HA-07), kernel color "light" in all genotypes, shell color "light" in 1 genotype, "moderate" in 2 genotypes, "dark" in 2 genotypes, shell thickness 1.15 mm (70 AY 01) to 1.90 mm (70-AY-05), shell adhesion "good" in all genotypes, remove of kernel from the shell was "easy" in all genotypes, shell texture is "smooth" in 2 genotypes, "moderate" in 2 genotypes, "rough" in 1 genotype, cracking of shell status "easy" in 4 genotypes, "moderate" in 1 genotype, kernel fill and healthy kernel percentage is 100% found in all genotypes (Table 1).

In the genotypes superior in kernel, the shell fruit weight is 10.66 g (42-HA-04) to 26.31 g (42-HA-07), kernel weight is 5.32 g (42-HA-04) to 9.82 g (42-HA-07), kernel percentage is 37.33% (42-HA-07) to 53.08% (42-HA-03), fruit size 31.50 mm (42-HA-04) to 50.95 mm (42-HA-07), kernel color "extra light" in 1 genotype ", "light" in 3 genotypes, shell color "moderate" in 2 genotypes, "dark" in 2 genotypes, shell thickness 1.06 mm (42-HA-06) and 1.64 mm (42-HA-07), shell adhesion in all genotypes " good", remove of kernel from the shell is "easy" in all genotypes, shell texture is "smooth" in 1 genotype, "moderate" in 2 genotypes, "rough" in 1 genotype, cracking of shell status is "easy" in 3 genotypes, "moderate" in 1 genotype, kernel fill and healthy kernel percentage is found to be 100% in all genotypes (Table 2).

Table 1. The average values of selected superior genotypes in shelled walnuts

Genotype	Fruit weight (g)	Kernel weight (g)	Kernel percentage (%)	Fruit size (mm)	Kernel color	Shell color	Shell thickness (mm)	Shell adhesion	Remove of kernel from the shell	Shell texture	Cracking of shell
42-HA-07	26.31	9.82	37.33	50.95	Light	Dark	1.64	Good	Easy	Rough	Moderate
42-ER-01	16.83	9.75	57.91	43.17	Light	Dark	1.33	Good	Easy	Moderate	Easy
70-AY-06	13.82	6.23	51.37	34.71	Light	Moderate	1.52	Good	Easy	Smooth	Easy
70-AY-05	15.74	7.24	45.96	36.81	Light	Light	1.90	Good	Easy	Smooth	Easy
70-AY-01	12.99	7.06	54.54	35.39	Light	Moderate	1.15	Good	Easy	Moderate	Easy

Table 2. The average values of selected superior genotypes in kerne

Genotype	Fruit weight (g)	Kernel weight (g)	Kernel percentage (%)	Fruit size (mm)	Kernel color	Shell color	Shell thickness (mm)	Shell adhesion	Remove of kernel from the shell	Shell texture	Cracking of shell
42-HA-03	12.41	6.60	53.08	35.76	Light	Dark	1.32	Good	Easy	Moderate	Easy
42-HA-04	10.66	5.32	49.77	31.50	Extra Light	Moderate	1.44	Good	Easy	Moderate	Easy
42-HA-06	12.34	6.23	50.54	35.41	Light	Moderate	1.06	Good	Easy	Smooth	Easy
42-HA-07	26.31	9.82	37.33	50.95	Light	Dark	1.64	Good	Easy	Rough	Moderate

Table 3. Phenological observation of superior genotypes

Genotype	Leaf starting date	Male blooming date	Female blooming date	Type of blossom
42-HA-07	20 April	3 May-7 May	25 April - 30 April	Protogeny
42-ER-01	20 April	25 April - 30 April	1 May - 5 May	Protandry
70-AY-06	20 April	25 April - 30 April	25 April - 30 April	Homogamy
70-AY-05	20 April	29 April - 4 May	1 May - 5 May	Homogamy
70-AY-01	22 April	30 April - 4 May	26 April - 30 April	Homogamy
42-HA-03	22 April	30 April - 5 May	30 April - 5 May	Homogamy
42-HA-04	20 April	27 April - 3 May	27 April - 3 May	Homogamy
42-HA-06	20 April	25 April - 30 April	25 April - 30 April	Homogamy

At the end of the study, the phenological observations of a total of 8 genotypes in 2021 are presented below, 6 genotypes showed homogamy flowering, 1 genotype showed protandry and 1 genotype showed protogeny flowering status (Table 3).

4. Conclusions

This selection study was conducted to determine the walnut genotypes with superior characteristics grown from seeds in Ereğli and Halkapınar districts of Konya province and Ayrancı district of Karaman province between 2019-2022. At the end of the study, 8 genotypes in total, including 5 genotypes in shelled walnuts and 4 types in kernel (1 type received high scores in both shelled and kernel) were found to be promising.

In our research, the fruit weight was 10.66-26.31 g, the kernel weight was 5.32-9.82 g, the percentage of kernel was 37.33-57.91%, and the fruit size was 31.50-50.95 mm in 8 promising genotypes. Promising genotypes were found above the values obtained by Aslantaş (2006), Oğuz and Aşkın (2007), Serdar et al (2001), Sütyemez and Eti (2001), Kazankaya et al (2017), Akça (1993), Beyhan (1993), Cicek (2020), Oruc (2020), Güller (2020) and Mestav (2022) in terms of these characteristics.

In walnut selection, apart from fruit characteristics, another feature that is overemphasized is the thickness of the shell. The shell thicknesses of the selected genotypes were found to be between 1.06-1.90 mm. Promising genotypes were found above the values obtained by Yarılgaç et al (2005), Kahraman (2006), Yıldırım et al (2005), Abdis (2010), Kırısık (2017), Demir (2018), Ates (2018) and Demirhan (2021).

In the selected genotypes, adhesion to the shell was "good" in 7 genotypes (87.5%), "moderate" in 1 genotype (12.5%), and remove of the kernel from the shell was "easy" in all genotypes. Promising genotypes were found above the values obtained by Maden (2011), Aslansoy (2012), Orbay (2016), Goksuncukgil (2017), Cicek (2020) in terms of these characteristics.

In our study, at the end of 2021, the superior genotypes showed 6 homogamy (75%), 1 protandry (12.5%), and 1 protogeny flowering status. If there is no self-incompatibility in homogamy type flowering, it can be advantageous in breeding studies and breeding. Incompatibility and pollen viability should be evaluated separately, and it should be determined whether it requires a pollinator variety. Other researchers, Akça (2001), Unver and Celik (2005), Reis (2010), found fewer genotypes showing homogamous flowering status in their studies.

When the walnut genotypes examined in this study, which was conducted in Konya province Ereğli and Halkapınar districts and Karaman province Ayrancı district, are compared with the fruit characteristics of the genotypes obtained as a result of studies conducted both in our country and abroad, it is seen that they have important values. This situation shows that our region, like many regions of our country, has a rich genetic resource in terms of walnuts.

It is aimed that this study will contribute to the determination of genotypes with good fruit characteristics among the walnut genotypes grown from seed in our country and to prevent the extinction of our gene resources. This study will shed light on future studies on the protection, reproduction and standardization of genotypes determined as promising.

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Figure 1. 42 HA 07 genotype

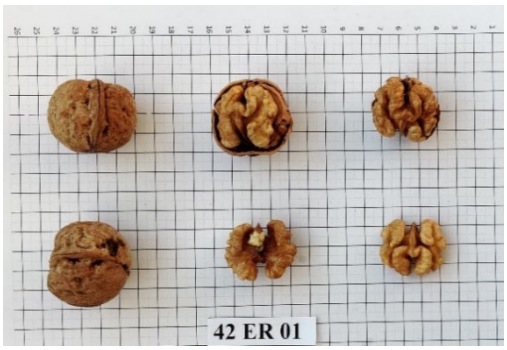

Figure 2. 42 ER 01 genotype

Figure 3. 70 AY 06 genotype

Figure 4. 70 AY 05 genotype

Figure 5. 70 AY 01 genotype

Figure 6. 42 HA 03 genotype

Figure 7. 42 HA 04 genotype

Figure 8. 42 HA 06 genotype

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