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Fruit Characteristics of Promising Almond (*Prunus amygdalus* L.) Genotypes Selected from Yeşilli (Mardin) District

Mardin Yeşilli'de Seçilen Ümitvar Badem (*Prunus amygdalus* L.) Genotiplerinin Meyve Özellikleri

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Abstract: In this study, which was conducted between 2021 and 2022 in Yeşilli district of Mardin, 56 almond genotypes were identified from the naturally grown almond population in the region and some fruit characteristics and flowering observations of these genotypes were evaluated over two years. Based on the analyses and weighted rating results, 12 genotypes were selected as promising. The full flowering dates of these genotypes were recorded between March 5–31 in 2021 and February 17–March 2 in 2022. For the selected genotypes, average nut weight ranged from 2.09 to 5.10 g, nut width from 15.77 to 23.72 mm, nut length from 23.93 to 36.37 mm, nut thickness from 12.69 to 16.05 mm, kernel weight from 0.74 to 1.12 g, kernel percentage from 15.76% to 36.82%, and double kernel percentage from 0% to 35%. In addition, the overall weighted scores for flowering and quality traits were determined to be between 586–654 and 580–649 respectively. As a result, it was found that the natural almond genotypes in the Yeşilli region have significant genetic variation and are valuable resources for almond breeding programs.

Keywords: Almond, Selecting,Weighted ranked method, Fruit properties, Flowering time

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Öz: Bu çalışma, 2021–2022 yılları arasında Mardin'in Yeşilli Mahallesi'nde doğal olarak yetişen badem (*Prunus dulcis*) populasyonunun değerlendirilmesi amacıyla yürütülmüştür. Çalışma kapsamında toplam 56 badem genotipi belirlenmiş, bu genotiplerin pomolojik özellikleri ve çiçeklenme durumları iki yıl boyunca gözlemlenmiştir. Yapılan analizler ve ağırlıklı puanlama sonuçlarına göre 12 genotip ümitvar olarak seçilmiştir. Seçilen genotiplerde tam çiçeklenme tarihleri 2021 yılında 5–31 Mart, 2022 yılında ise 17 Şubat–2 Mart tarihleri arasında gerçekleşmiştir. Bu genotiplerde kabuklu meyve ağırlığı 2.09–5.10 g, meyve genişliği 15.77–23.72 mm, meyve uzunluğu 23.93–36.37 mm ve meyve kalınlığı 12.69–16.05 mm arasında değişmiştir. İç badem ağırlığı 0.74–1.12 g, iç verimi %15.76–36.82 ve çift badem oranı ise %0–35 arasında tespit edilmiştir. Çiçeklenme ve kalite özelliklerine ilişkin genel ağırlıklı puanlar sırasıyla 586–654 ve 580–649 arasında belirlenmiştir. Elde edilen bulgular, Yeşilli bölgesinde doğal olarak yetişen badem genotiplerinin önemli düzeyde genetik varyasyona sahip olduğunu ve badem ıslah programları açısından değerli genetik kaynaklar sunduğunu ortaya koymaktadır.

Anahtar Kelimeler: Badem, Seleksiyon, Tartılı derecelendirme metodu, Meyve özellikleri, Çiçeklenme zamanı

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INTRODUCTION

Almond belongs to the subgenus *P. amygdalus* within the genus Prunus of the Rosaceae family (*Rosaceae*), which belongs to the order Rosales. There are about 40 known almond species belonging to the subgenus *P. amygdalus* (Kester et al., 1991; Socias I company, 1999). *P. amygdalus* Batsch. (synonym P. dulcis Miller) is mainly valued for its fruit. Almond spread naturally in the high mountain regions of Central Asia (Pakistan, Iran and India) and later colonised the Mediterranean region (Rugini and Monastra, 2003; Özçağıran et al., 2005). Although many regions of our country have suitable climatic conditions for almond cultivation, the majority of production is concentrated in the Marmara, Mediterranean and Aegean regions (Küden, 1998; Şimşek and Gülsoy, 2017).

Selection is one of the oldest breeding methods. In selection, the researcher does not create genetic variation, but utilizes the existing genetic diversity within the population. All breeding methods include a selection phase (Gülsoy and Balta, 2014).

Commercial almond varieties such as Texas, Ne Plus Ultra, Monterey, Solano, Peerless, Avalon and Valenta have emerged as random seedlings from selection. These varieties account for a large portion of almond production in the United States. Similarly, many widely cultivated almond varieties worldwide have also been obtained as chance seedlings from local gene pools. (Kester et al., 1991; Okie, 2000; Gradziel et al., 2017).

Our country, one of the homelands of the almond, has developed a rich genetic variation and different ecotypes with unique characteristics adapted to local ecological conditions through many years of seed-based cultivation. Within this rich almond population, many researchers have conducted selection studies to identify almond genotypes with superior traits (Aslantaş, 1993; Balta, 2002; Yıldırım, 2007; Şimşek and Osmanoğlu, 2010; Şimşek, 2011; Sümbül, 2012; Çelapkulu 2015; Yılmaz, 2017; Acar et al., 2018; Büyükfırat et al., 2022) In these selection studies, numerous almond genotypes with late flowering and superior fruit characteristic were selected for almond breeding purposes.

In many countries, almond production is mainly based on selected seedling populations composed of different genotypes. These genotypes, which have adapted to the conditions of their local environment, are shaped by natural selection processes. The long-standing tradition of propagating almonds by seed in various regions of Anatolia has contributed to the development of extensive seedling populations of almonds. Unfortunately, these populations, which represent valuable local genetic resources, are steadily declining and are threatened with extinction in certain areas. However, such seedling populations, characterized by their high genetic diversity, can harbor valuable individuals or adventitious seedlings with remarkable resistance to a range of biotic and abiotic stress factors. (Mısırlı and Gülcan, 2000; Gülsoy and Balta, 2014; Celapkulu and Balta, 2024).

One of the basic strategies in almond breeding is the selection and evaluation of promising genotypes from local seedling populations (Gülsoy, 2012; Khadivi et al., 2019). The identification valuable individuals in different regions supports breeding progress and contributes to the conservation of genetic diversity (Balta, 2002; Yıldırım, 2007; Gülsoy, 2012). Morphological traits serve as an essential reference for plant breeders in this process (Sepahvand et al., 2015). This study aimed to investigate the characteristics of natural almond genetic resources in the Yeşilli district of Mardin and to identify genotypes with superior fruit traits for potential use in future breeding programs.

MATERIAL AND METHOD

Material

The material of the study consisted of almond genotypes grown from seeds in Yeşilli district and its affiliated villages of Mardin. Based on the preliminary information provided by the growers and the selection criteria, fruit samples of 56 marked almond genotypes were collected over a period of two years (2021-2022) and pomological analyses and phenological observations were carried out. No irrigation, fertilization, or pruning practices were applied in the areas where the selected genotypes were obtained.

The trees developed entirely under natural conditions. The map below shows the location of Yeşilli district within Türkiye and its location within Mardin province (Figure 1).

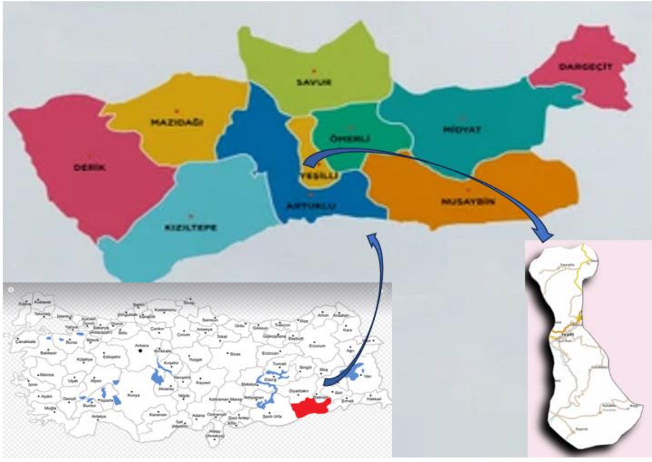

Figure 1. Study area map showing the location of Yeşilli district in Mardin Province.
Şekil 1. Mardin ili Yeşilli ilçesinin konumunu gösteren çalışma alanı haritası.

Climatic and Soil Characteristics of the Study Area

The study area is located in Yeşilli district of Mardin province in Southeastern Türkiye. The soil is generally clay-loam in texture, with slightly alkaline properties (pH 7.5–8.0), low salinity (<0.5 dS m^{-1}), and moderate levels of organic matter (1.0–1.5%) (TAGEM, 2023). The region receives limited annual rainfall, mostly concentrated between November and March, with an average of 400–600 mm per year. Summers are hot and dry, while winters are mild and short. The average relative humidity drops to 30–35% in summer months, and daily temperatures can reach up to 40–42°C in July and August (TSMS, 2025). The average, minimum, and maximum temperature values, precipitation amounts, and average relative humidity for the years 2021 and 2022 in the study area are presented in Table 1.

Table 1. Climatic parameters of Yeşilli district for February to August in 2021 and 2022.
Çizelge 1. 2021 ve 2022 yıllarında Şubat–Ağustos ayları için Yeşilli ilçesine ait iklimsel parametreler

Climate Parameters	Years	Feb	Mar	Apr	May	Jun	Jul	Aug
Mean Temperature (°C)	2021	4.2	8.0	13.6	19.5	25.6	29.8	29.7
	2022	5.1	9.0	14.2	20.0	26.1	30.4	30.1
Max Temperature (°C)	2021	10	151	21	28	35	40	39
	2022	12	17	23	30	36	41	40
Min Temperature (°C)	2021	0	3	8	12	17	21	21
	2022	1	4	9	13	18	22	22
Total Precipitation (mm)	2021	102.3	98.9	80.1	46.7	6.4	3.0	2.3
	2022	98.9	80.1	46.7	6.4	3.0	2.3	4.0
Average Relative Humidity (%)	2021	74	68	60	54	45	38	39
	2022	72	65	58	52	42	35	38

Method

Table 2. Weighted evaluation of flowering and fruit quality criteria based on relative scores, classes, and scores of genotypes.

Çizelge 2 Genotiplerin göreceli puan, sınıf ve skorlarına dayalı çiçeklenme ve meyve kalitesi kriterlerinin ağırlıklı değerlendirmesi.

Characteristics	Relative scores (%)			
	Flowering	Quality	Classes	Score
Flowering period	30	10	Very early	1
			Early	3
			Mid-late	5
			Late	7
			Very late	9
Tree shape	3	3	Very upright	1
			Upright	2
			Upright-spreading	3
			Spreading	4
			Very spreading	5
Yield condition	5	20	Low	3
			Medium	5
			High	7
Fruit size	8	10	Small	3
			Medium-large	5
			Large	7
			Very large	9
Shell suture openness	3	6	Very open	0
			Open	5
			Closed	9
Shell hardness	20	12	Very hard	1
			Hard	3
			Medium	5
			Soft	7
			Thin-shelled	9
Kernel color	3	7	Very dark	1
			Dark	3
			Medium	5
			Light	7
			Very light	9
Kernel roughness	2	4	Wrinkled	1
			Slightly wrinkled	5
			Smooth	7
Kernel hairiness	7	10	Very hairy	3
			Hairy	5
			Medium hairy	7
			Slightly hairy	9
Kernel taste	11	15	Bitter	3
			Medium	5
			Sweet	7
Double kernel rate	7	2	Low	7
			Medium	5
			High	1
Sound kernel ratio	1	1	Calculated as a percentage value	
Total	100	100		

Fruit measurements were performed on a total of 30 fruits, with 3 replicates from each almond type and 10 fruits in each replicate. In the study, the nut traits (nut weight, width, length, nut thickness, nut color, nut size, nut shape, nut firmness, nut suture opening) and kernel traits (kernel weight, kernel fruit thickness, kernel fruit width, kernel fruit length, kernel ratio, double kernel ratio, kernel color, hairiness, smoothness, taste, kernel size) were evaluated. Before the measurements, the harvested fruits were hulled to remove the green outer shells and dried at room temperature in a shaded area for two weeks.

The size of the nut and kernel fruits was determined using a digital caliper (WPI Inc., Model 501601), and the weight of the nut and kernel fruits was determined using a scale with a sensitivity of 0.01 g. (A&D, Model EJ-3002). In addition, the dates of first flowering (5-10% flower opening), full flowering (70% flower opening) and end of flowering (shedding of 95% of petals) were recorded as phenological observations in the genotypes (Yıldırım, 2007).

In the study, the weighted rating method was used to identify the superior genotypes. The weighted rating scores of the genotypes were calculated by multiplying the value score for each criterion by the corresponding relative score and summing the resulting scores separately (Yıldırım, 2007; Gülsoy and Balta, 2014). The genotypes subjected to a weighted evaluation were ranked based on their scores. Twelve genotypes that ranked in the top twenty for both flowering and quality, overlapping in both groups, were selected as promising. The criteria used in the weighted rating method, the relative scores assigned based on flowering and fruit quality traits, and the classes and scores formed by the genotypes are shown in Table 2.

RESULTS AND DISCUSSION

In order to identify the promising genotypes among the investigated ones, the weighted rating scores were calculated separately for both flowering and quality traits (Table 3). In the weighted evaluation based on flowering traits, genotype YŞL-15 scored the highest with 654 points, while genotypes YŞL-17 and YŞL-21 recorded the lowest with 586 points. Similarly, in the weighted evaluation based on quality traits, genotype YŞL-15 once again obtained the highest score with 648 points, whereas genotype YŞL-14 had the lowest score with 580 points (Table 3).

Table 3. Weighted rating scores of promising selected genotypes.
Çizelge 3. Ümitvar genotiplerin ağırlıklı puanlama değerleri.

Genotype No	Based on Flowering	Based on Quality	Genotype No	Based on Flowering	Based on Quality
YŞL-1	631	619	YŞL-22	649	621
YŞL-14	632	580	YŞL-23	643	629
YŞL-15	654	648	YŞL-25	608	584
YŞL-17	586	598	YŞL-27	645	595
YŞL-18	593	591	YŞL-33	607	609
YŞL-21	586	598	YŞL-42	622	608

In almond breeding programs, late flowering is considered an important trait in addition to fruit characteristics. Differences in flowering time and duration were observed among the genotypes examined in the study. The first flowering and full flowering dates of the genotypes were recorded between February 23 – March 5 and March 1 – 11 in 2021, respectively; and between February 12 – 24 and February 17 – March 1 in 2022, respectively. Promising genotypes were harvested between August 12 – 20 in 2021, and between August 9 – 16 in 2022 (Table 4).

Table 4. Phenological observations of promising selected genotypes.
Çizelge 4. Seçilen ümitvar genotiplere ait fenolojik gözlemler.

Genotype No	First Flowering		Full Flowering		End of Flowering		Harvest Date	
	2021	2022	2021	2022	2021	2022	2021	2022
YŞL-1	Mar. 2	Feb. 21	Mar. 7	Feb. 26	Mar. 11	Mar. 2	Aug. 17	Aug. 12
YŞL-14	Mar. 1	Feb. 23	Mar. 7	Mar. 1	Mar. 11	Mar. 6	Aug. 17	Aug. 12
YŞL-15	Mar. 2	Feb. 20	Mar. 8	Feb. 26	Mar. 12	Mar. 3	Aug. 18	Aug. 15
YŞL-17	Feb. 28	Feb. 17	Mar. 5	Feb. 22	Mar. 9	Feb. 26	Aug. 20	Aug. 16
YŞL-18	Mar. 2	Feb. 21	Mar. 8	Feb. 25	Mar. 12	Mar. 2	Aug. 17	Aug. 15
YŞL-21	Feb. 28	Feb. 18	Mar. 6	Feb. 23	Mar. 10	Feb. 28	Aug. 20	Aug. 16
YŞL-22	Mar. 5	Feb. 24	Mar. 11	Mar. 1	Mar. 15	Mar. 6	Aug. 20	Aug. 16
YŞL-23	Feb. 23	Feb. 12	Mar. 1	Feb. 17	Mar. 5	Feb. 22	Aug. 12	Aug. 9
YŞL-25	Mar. 1	Feb. 20	Mar. 7	Feb. 26	Mar. 11	Mar. 2	Aug. 17	Aug. 13
YŞL-27	Mar. 5	Feb. 24	Mar. 11	Mar. 1	Mar. 15	Mar. 7	Aug. 21	Aug. 17
YŞL-33	Mar. 7	Feb. 25	Mar. 12	Mar. 2	Mar. 16	Mar. 6	Aug. 22	Aug. 18
YŞL-42	Feb. 25	Feb. 14	Mar. 31	Feb. 19	Mar. 5	Feb. 25	Aug. 14	Aug. 10

In previous studies, Kazankaya et al. (2017) reported that full flowering in promising almond genotypes from Midyat and Şavur (Mardin) occurred between March 22 and 25 in 2013, and between March 13 and 16 in 2014. Polat and Kazankaya (2020) reported that, in almond genotypes from Şanlıurfa region, first flowering occurred between March 5 and 23 and full flowering between March 10 and 26 in 2017; whereas in 2018, first flowering was observed between February 17 and March 15, and full flowering between February 22 and March 21. Büyükfırat et al. (2022) reported that in almond genotypes from Yeşilyurt (Malatya), first and full bloom occurred during March 20–April 1 and March 25–April 6, respectively, in 2017; and during March 16–April 1 and March 21–April 6, respectively, in 2018.

In studies on the adaptation and selection of almonds, differences in flowering time observed among genotypes and cultivars have been attributed to factors such as genetic structure, altitude, soil characteristics, ecological conditions, and the cultivation practices applied. (Dokuzoğuz and Gülcan, 1973; Aslantaş, 1993; Socias I Company, 1999; Balta, 2002; Yıldırım, 2007; Dicenta et al., 2010; Acar et al., 2018; Gülsoy and Şimşek, 2020; Freitas et al., 2023).

The nut weight of 12 selected genotypes from Yeşilli ranged from 2.09 g (YŞL-27) to 5.10 g (YŞL-22) (Table 5). In previous almond selection studies, nut weight was reported as 1.75–4.70 g in selection Derik (Mardin) district (Şimşek and Osmanoğlu, 2010), 2.44–7.57 g in selection Yenipazar, Bozdoğan, and Karacasu (Aydın) districts (Gülsoy and Balta, 2014), 3.52–6.70 g in selection Midyat and Savur (Mardin) districts (Kazankaya et al., 2017), and 3.50–12.07 g in selection Yeşilyurt (Malatya) district (Büyükfırat et al., 2022). The nut weight of the genotypes selected from Yeşilli was comparable to those reported in previous almond selection studies conducted in various districts.

Shell thickness is an important trait in almond cultivation, particularly in terms of ease of processing, transport durability, and protection against pests, including insects and bird damage(Luck et al., 2013; Bayazıt et al., 2025). In this study, the promising genotypes had shell thickness ranging from 2.07 mm (YŞL-27) to 4.17 mm (YŞL-42); nut thickness from 12.69 mm (YŞL-27) to 16.05 mm (YŞL-1); nut width from 15.77 mm (YŞL-27) to 23.72 mm (YŞL-14); and nut length from 23.93 mm (YŞL-27) to 36.37 mm (YŞL-1) (Table 5). In previous studies, Şimşek and Osmanoğlu (2010) reported nut width, length and thickness of 17.11 to 27.90 mm, 26.13 to 35.71 mm and 11.84 to 16.77 mm, respectively, in selected genotypes from Derik district (Mardin). Similarly, Akçalı (2015) reported nut length, height and width values of 19.90 to 40.74 mm, 10.29 to 17.37 mm and 11.79 to 27.62 mm, respectively, in almond genotypes grown on the slopes of Mount Erciyes. Büyükfırat et al. (2022) found that the width, length and thickness of nuts in genotypes from Yeşilyurt district (Malatya) ranged from 19.15 to 30.64 mm, 29.79 to 45.38 mm and 12.30

to 18.91 mm, respectively. Compared to previous studies, the nut width, length and thickness determined in the promising genotypes from Yeşilli generally agreed with the ranges reported by Şimşek and Osmanoğlu (2010), Akçalı (2015) and Büyükfırat et al. (2022), with slight variations depending on genotypic traits and location.

When evaluating the genotypes for fruit shape, 1 was long oval, 4 long narrow, 4 heart-shaped, 2 elliptical and 1 round; for nut size, 9 were small and 3 medium; for shell color, 5 were light, 6 medium-light and 1 dark; shell hardness was determined as hard in 11 genotypes and very hard in 1 genotype; and the shell suture opening was closed in all genotypes.

Table 5. Nut fruit characteristics of promising selected almond genotypes.
Çizelge 5. Seçilen ümitvar badem genotiplerinin meyve özellikleri.

Genotype	NFW (g)	NFT (mm)	NFWi (mm)	NFL (mm)	ST (mm)	SC	NFS	FS	SH	SSO
YŞL-1	4.57±0.39	16.05±0.72	23.16±1.49	36.37±1.49	3.75±0.32	D	ML	E	VH	C
YŞL-14	5.08±0.55	15.24±0.96	23.72±3.12	31.12±1.98	4.11±0.38	ML	ML	LO	VH	C
YŞL-15	3.55±0.65	14.03±0.94	20.07±1.54	28.44±7.08	2.93±0.40	ML	S	E	VH	C
YŞL-17	3.54±0.33	14.21±0.57	18.29±0.85	31.04±2.45	2.98±0.28	ML	S	LN	VH	C
YŞL-18	4.84±0.45	13.70±0.72	22.64±0.71	34.11±1.25	3.62±0.57	L	ML	H	VH	C
YŞL-21	3.07±0.32	13.49±0.41	17.91±1.64	33.00±2.39	2.69±0.38	ML	S	LN	VH	C
YŞL-22	5.10±0.42	15.15±1.37	22.49±0.75	31.74±1.30	4.14±0.27	L	ML	H	VH	C
YŞL-23	4.10±0.74	13.53±0.54	19.79±0.98	29.81±5.83	3.29±0.28	ML	S	R	VH	C
YŞL-25	3.41±0.42	15.50±0.88	18.35±1.19	27.85±2.26	3.73±0.69	ML	S	H	VH	C
YŞL-27	2.09±0.42	12.69±0.92	15.77±0.83	23.93±2.01	2.07±0.29	L	S	LN	VH	C
YŞL-33	3.14±0.27	13.43±0.66	17.73±1.08	30.16±8.58	3.24±0.26	L	S	LN	VH	C
YŞL-42	4.46±0.37	15.98±1.13	21.30±0.93	26.85±1.09	4.17±0.22	L	S	H	H	C

NFW: Nut Fruit Weight. NFT: Nut Fruit Thickness. NFWi: Nut Fruit Width. NFL: Nut Fruit Length. ST: Shell Thickness. SC: Shell Color (L: Light. M: Medium Light. D: Dark.). NFS: Nut Fruit Size (S: Small. ML: Medium Large). FS: Fruit Shape (LO: Long Oval. LN: Long Narrow. H: Heart. R: Round, E: Elliptical). SH: Shell Hardness (H: Hard. VH: Very Hard). SSO: Shell Suture Opening (C: Closed)

Kernel weight and kernel ratio are among the important criteria emphasized in almond selection studies (Table 6). In this study, the highest kernel weight was found in genotype YŞL-1 (1.12 g), followed by YŞL-14 (1.00 g) and YŞL-15 (1.00 g). The lowest kernel weight was found in YŞL-42 (0.74 g) (Table 6). The kernel percentage of the promising genotypes ranged from 15.76% (YŞL-22) to 36.82% (YŞL-27). In previous studies, the following values for kernel weight and kernel ratio were reported: 0.99–1.27 g and 22.10%–36.10% in the selection from Isparta region (Yıldırım, 2007); 0.67–1.56 g and 15.57%–47.45% in the selection from Yenipazar, Bozdoğan and Karacasu districts of Aydın province (Gülsoy and Balta, 2014); 0.80–1.26 g and 17.51%–22.63% in the selection from Midyat and Savur districts of Mardin province (Kazankaya et al., 2017); and 0.76–1.56 g and 12.96%–26.69% in the selection from Yeşilyurt district (Malatya) (Büyükfırat et al., 2022). In this study, kernel weight and kernel ratio values were found to be lower than those reported in some studies and higher than in others. These differences are thought to be influenced by factors such as ecological conditions, soil structure, tree nutrition, cultivation practices, and irrigation.

In almonds, the rate of double kernel formation is reported to be influenced not only by cultivar and genotypic characteristics but also by environmental factors (Cordeiro et al., 2001). However, double and twin kernels are considered undesirable in terms of commercial value (Yılmaz, 2017). In this study, the double kernel rate among the promising genotypes ranged from 0% to 35%. In previous almond selection studies, the reported double kernel rates ranged from 0% to 19.3% in the selection from Isparta region (Yıldırım, 2007); 0% to 10% in the selection from Tillo and Kurtalan districts of Siirt (Çelapkulu, 2015); 0% to 23% in the selection from Midyat and Savur (Mardin) (Kazankaya et al., 2017); and 0% to 20% in the selection from Yeşilyurt district (Malatya) (Büyükfırat et al., 2022). The double kernel rates obtained in this study are similar to those reported for selected or evaluated genotypes in previous studies.

Table 6. Kernel fruit characteristics of promising selected almond genotypes.
Çizelge 6. Seçilen umut verici badem genotiplerinin tohum özellikleri.

Genotype	KW (g)	KFT (mm)	KFW (mm)	KFL (mm)	KR (%)	DKR (%)	KC	KFH	KFSS	TS	KFS
YŞL-1	1.12±0.11	6.94±0.47	13.64±0.66	22.29±1.22	24.24±2.11	0	D	H	S	T	ML
YŞL-14	1.00±0.13	6.30±1.12	13.72±0.63	23.10±1.68	19.76±1.44	0	L	SH	S	T	ML
YŞL-15	1.00±0.14	6.45±0.73	13.51±1.02	22.20±1.46	28.29±1.24	0	M	SH	S	T	ML
YŞL-17	0.99±0.05	7.44±0.35	11.26±0.68	24.60±0.88	28.15±2.16	25	M	SH	S	T	ML
YŞL-18	0.91±0.10	6.26±1.21	12.45±0.74	23.38±0.81	18.69±3.04	5	D	SH	SW	T	S
YŞL-21	0.88±0.09	6.97±0.43	11.27±0.60	23.46±0.90	28.51±2.62	0	M	SH	S	T	S
YŞL-22	0.80±0.10	5.61±0.69	12.73±0.76	20.14±1.04	15.76±4.23	5	M	SH	S	T	S
YŞL-23	0.80±0.10	5.61±0.77	12.42±0.73	22.48±1.06	19.59±3.88	0	M	SH	S	T	S
YŞL-25	0.79±0.29	7.27±0.50	11.60±0.53	17.85±0.64	23.10±6.08	35	M	SH	S	T	S
YŞL-27	0.77±0.16	8.38±1.12	9.90±0.64	17.03±1.24	36.82±3.16	20	M	SH	S	T	S
YŞL-33	0.75±0.12	6.10±1.20	11.27±2.45	21.76±1.39	24.07±4.43	0	M	SH	S	T	S
YŞL-42	0.74±0.18	6.22±1.13	12.16±1.12	19.26±2.40	16.62±8.67	10	M	SH	S	T	S

KW: Kernel Weight, KFT: Kernel Fruit Thickness, KFW: Kernel Fruit Width, KFL: Kernel Fruit Length, KR: Kernel Ratio, DKR: Double Kernel Ratio, KC: Kernel Color (D: Dark, L:Light, M: Medium), KFH: Kernel Fruit Hairiness (H: Hairy, SH: Slightly Hairy), KFSS: Kernel Fruit Smoothness Status (S: Smooth, SW: Slightly Wrinkled), TS :Taste Status (S: Sweet), KFS: Kernel Fruit Size (ML: Medium Large, S:Small)

Fruit shape, size, and shell color are among the key pomological traits evaluated in almond selection studies. These characteristics not only influence visual appeal and consumer preference but also play a significant role in processing suitability and marketability. Therefore, their assessment is essential for the development of new cultivars with improved commercial potential (Gradziel and Gradziel, 2009; Al-Khayri et al., 2018).The kernel color was classified as dark in 2 genotypes, light in 1, and medium in 9 genotypes. Kernel size was medium in 4 genotypes and small in 8 genotypes (Table 6). A sweet kernel taste, a smooth surface, and slight pubescence are among the desirable characteristics in almonds (Gradziel and Gradziel, 2009). In this study, all of the promising genotypes were found to have a sweet taste. Regarding the smoothness of the surface, 1 genotype was slightly wrinkled, while the other 11 were smooth. In terms of hairiness, 1 genotype was hairy and 11 were slightly hairy.

CONCLUSION

Almond has been propagated by seed in Turkey for many years, which has led to a wide genetic variation over time. The rich population structure observed in cultivation areas enables the standardization of varieties through selection breeding. In this context, similar breeding studies to be conducted in different regions of the country are of great importance for the development of new and standardized almond cultivars. Late spring frosts are among the most critical limiting factors in almond cultivation. Therefore, growing late-flowering cultivars is an effective strategy to minimize frost damage. In this study, 12 genotypes from the naturally growing almond population in the Yeşilli district of Mardin were identified as promising. However, to accurately determine the superior characteristics of these genotypes, adaptation and comparative trials should be carried out under orchard conditions, using suitable rootstocks and the same climate and soil conditions, alongside standard cultivars. This approach will help identify the most suitable cultivar candidates for the region, which can then be officially registered as new varieties.

CONFLICT OF INTEREST

The authors have no competing interests to declare that are relevant to the content of this article.

DECLARATION OF AUTHOR CONTRIBUTION

The authors' contributions to the article are equal.

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