

Performance of Walnut Varieties Produced in Kale/Denizli District

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ABSTRACT: Walnut (*Juglans regia L.*), which is an important nut fruit species in Türkiye, is grown in different ecological conditions. Economically, production is possible by carrying out adaptation studies of varieties. This study was conducted between 2021-2022. It was aimed to determine the performance of Bursa-95, Chandler, Pedro, Şebin, Topak, Yalova-1 and Yavuz walnut varieties in Kale (Denizli) ecology. Accordingly, the average nut weight varied between 10.64 g (Pedro and 16.50 g (Yalova-1) and kernel weight ranged from 4.98 to 8.14 g (Yalova-1). While Yalova-1 variety ranked first in terms of nut width and Topak variety was first in terms of nut length and height, Pedro variety ranked last for both characteristics. In the ecology in question, the Chandler variety, which has a saturated, light yellow color, was in first place, while Bursa-95 was in last place.

Keywords: Adaptation, *Juglans regia L.*, quality.

Kale / Denizli İlçesinde Yetiştirilen Ceviz Çeşitlerinin Performansları

ÖZ: Ülkemizde sert kabuklu meyve türlerinde önemli bir yere sahip olan cevizin (*Juglans regia L.*), farklı ekolojik koşullarda yetiştiriciliği yapılmaktadır. Ekonomik anlamda üretim, çeşitlerin adaptasyon çalışmalarının yapılmasıyla mümkün olabilmektedir. 2021-2022 yılları arasında yürütülen bu çalışmada, Bursa-95, Chandler, Pedro, Şebin, Topak, Yalova-1 ve Yavuz ceviz çeşitlerinin Kale (Denizli) ekolojik koşullarında performanslarının belirlenmesi amaçlanmıştır. Buna göre, ortalama meyve ağırlığının çeşitlere göre değişimi 16.50 g (Yalova-1) – 10.64 g (Pedro) ve iç ağırlığının değişimi ise 8,14 g (Yalova-1) – 4,98 g (Pedro) aralığında olmuştur. Yalova-1 meyve eni, Topak ise meyve boyu ve yüksekliği bakımından ilk sırada bulunurken, her iki özellik açısından Pedro çeşidi ise son sırada yer almıştır. Söz konusu ekolojide, meyveleri doymun ve açık sarı renge sahip olan Chandler ilk sırada olurken Bursa-95 son sırada yer almıştır.

Anahtar kelimeler: Adaptasyon, *Juglans regia L.*, kalite.

INTRODUCTION

Anatolia, which has a very old fruit growing culture, is among the origins of walnuts (*Juglans regia L.*) as well as many fruit species. Therefore, Türkiye is one of the oldest walnut growing countries in the world (Bayazit *et al.*, 2016; Güvenç and Kazankaya, 2019). Due to consumer demand, the number of trees and production areas are increasing.

Walnut trees can be grown in almost all Türkiye's provinces. According to 2022 data in Türkiye, about half of the 27.500 thousand trees bear fruit. Total walnut production is 335 thousand tons with Kahramanmaraş (19.059 tons), Bursa (16.111 tons), Mersin (15.245 tons) and Denizli (14.910 tons) provinces in the first ranks in this regard (Anonim, 2023).

Due to the different climatic conditions in Türkiye, significant progress has been carried out in walnut cultivation. However, since fruit growing is a difficult and expensive investment, it is important to determine the performance of varieties in new growing areas. Walnut, which has the ability to adapt to ecological conditions, needs 400 to 1800 hours chilling requirement and can grow at 0-1700 m altitude. In this species, temperature is one of the most important factors affecting the fruit quality (Akça and Yılmaz 2016).

As is known, cultural practices affect yield and quality, but the main effect is caused by ecological conditions (Miletić *et al.*, 2009). As a matter of fact, the most important factor for sustainability and successful production in fruit growing is its adaptation to the ecology in which it is grown. On the other hand, the effects of ecological conditions in terms of yield and fruit quality differ according to fruit species and varieties (Karaat, 2019).

It is possible to achieve high yield and quality from orchards established with standard varieties. Especially today, certified nursery trees and other supports make walnut cultivation attractive. In addition, the establishment of new orchards is encouraged with special afforestation projects in Türkiye carried out on lands that have lost their treasury and forest characteristics. Therefore, due to the positive contribution of the rural economy, this species has also become popular among the producers.

At the same time, walnut, which is economically valuable, is an important part of diet programs. It is known that consumption is on the rise thanks to an awareness of healthy living that has developed in society. In this respect, the increasing interest in walnut makes its cultivation preferable. As is known, yield and quality changes depending on genotype, ecological conditions and cultural practices.

In this study, it was aimed to determine whether it is possible to grow walnut varieties economically in Kale (Denizli) district in terms of yield and some fruit characteristics. In this way, the sustainability of the cultivation of varieties was revealed.

MATERIALS AND METHODS

This study was conducted in a commercial orchard at an altitude of 791 m in Kale district of Denizli province between 2021-2022. Bursa-95, Chandler, Pedro, Şebin, Topak, Yalova-1 and Yavuz walnut varieties were used as the plant material. The trees were 12 years old and were in the yield period. In addition, cultural practices such as fertilization, pruning, irrigation, disease and pest control were carried out in the orchard.

As phenological observations, foliage, male and female flowering and harvest time were recorded. Foliage is the period when lateral buds are approximately 2.5 cm in 80-90% of the tree. Male inflorescence is expressed as the period when male catkins actively produce pollen. Female inflorescence is when 80-90% of female flowers have a receptive stigma as indicated by when the stigma turns from yellow to brown. Harvest dates were also determined.

Thirty harvested fruits were separated from green peels, washed and dried in the shade. Analyses were made in the laboratory of the Department of Horticulture, Faculty of Agriculture, Ege University. Average nut and kernel weight were determined with a precision balance (0.01 g) then the kernel ratio (%) was calculated. Shrinkage rate (%) was determined. The width, height and length of the nut were measured using a digital caliper sensitive to 0.01 mm. For yield, the total amount of nuts was recorded for each tree at harvest time (kg tree⁻¹). Fruit color was measured by a CR400 model Minolta colorimeter in CIE L* a* b* and the values of chroma (C*) and hue angle (h°) were calculated by using the $C^* = (a^{*2} + b^{*2})^{1/2}$, $h^\circ = \tan^{-1}(b^*/a^*)$ formula (McGuire, 1992).

For pomological analyses, the experiment was carried out according to analysis of variance of randomized block designs, with three replications and three trees per replication. The data were subjected to analysis of variance using IBM SPSS Statistics for Windows, Version 19.0. Significant

differences between averages were defined by Duncan test at the $P < 0.05$ significant level.

RESULTS AND DISCUSSION

Phenological observations were made in Kale ecology for 2 years. In this context, dates belonging to parameters such as foliation, blooming date of male and female flowers and harvest date were recorded. Data on phenological observations are presented in Table 1.

Foliation was detected on 10-20 April in walnut varieties. It was determined that male flowers bloomed in the first half of April. Female flowers were observed after about 1-2 weeks. Firstly, male flowering was observed in walnut varieties. It was determined that foliation and female flowers bloomed with an interval of about 1 week. Chandler variety bloomed about 1 week later than other varieties. The harvest date was on 20 October in 2021 and 28 October in 2022.

The effect of ecological conditions on nut quality differs according to the species and varieties. The increase in the number of trees and the amount of production depends on the determination and recommendation of walnut varieties suitable for ecological conditions. Adaptation studies for the determination of varieties suitable for the region are important for increasing production. In previous studies with different walnut genotypes, data similar

to our findings were obtained (Sütyemez and Kaşka, 2002; Gerçekçiöğlü *et al.*, 2019; Güller, 2020; Oruç, 2020; Sütyemez *et al.*, 2021; Sütyemez *et al.*, 2022).

Important nut characteristics of walnut varieties are given in Table 2. All the analyzed features showed statistical differences according to the average of two years. Accordingly, considering these average for each variety, in terms of nut weight, the heaviest walnuts were from Yalova-1 with 16.50 g, whereas the lightest were from Pedro with 10.64 g. A similar situation to nut weight was recorded in kernel weight. Kernel weight varied between 4.98 g (Pedro) and 8.14 g (Yalova-1). With regard to kernel ratio, Yavuz (54.15%) was first statistically, followed by Topak (52.75%) and Bursa-95 (51.53%) varieties in the same group. The lowest kernel ratio was calculated for Pedro (46.92%).

The greatest nut width was measured in Yalova-1 with 34.87 mm. On the other hand, the greatest nut length and height were obtained in Topak variety, 35.93 mm and 45.53 mm, respectively. In contrast, Pedro variety ranked in last place in terms of nut size.

Regarding shell thickness, Yavuz, Bursa-95 and Şebin had the thinnest shells, followed by Chandler and Pedro in the same statistical group. However, Topak and Yalova-1 had a thicker shell than the others. This property is essential in determining the ease of shell cracking and the resulting kernel quality.

Table 1. The phenological observations of walnut varieties grown in Kale (Denizli) province.
Çizelge 1. Kale (Denizli) yöresinde yetiştirilen ceviz çeşitlerinin fenolojik gözlemleri.

Variety Çeşit	Year/Yıl	Foliation/Yapraklanma	Male flower/Erkek çiçek	Female flower/Dişi çiçek	Harvest/Hasat
Bursa-95	2021	12.04	05.04	15.04	20.10
	2022	10.04	08.04	18.04	28.10
Chandler	2021	15.04	09.04	20.04	26.10
	2022	20.04	14.04	25.04	30.10
Pedro	2021	12.04	05.04	18.04	25.10
	2022	18.04	10.04	20.04	28.10
Şebin	2021	10.04	06.04	15.04	21.10
	2022	18.04	10.04	22.04	28.10
Topak	2021	10.04	05.04	15.04	21.10
	2022	10.04	08.04	18.04	28.10
Yalova-1	2021	12.04	05.04	18.04	20.10
	2022	18.04	08.04	20.04	28.10
Yavuz	2021	10.04	07.04	20.04	21.10
	2022	18.04	10.04	22.04	28.10

Table 2. Some nut characteristics of walnut varieties grown in Kale (Denizli) province.

Çizelge 2. Kale (Denizli) yöresinde yetiştirilen ceviz çeşitlerinin bazı kabuklu meyve özellikleri.

Variety Çeşit	Year Yıl	Nut weight (g) Ceviz ağırlığı	Kernel weight (g) İç ağırlığı	Kernel ratio (%) İç randımanı	Nut width (mm) Meyve genişliği	Nut length (mm) Meyve uzunluğu	Nut height (mm) Meyve yüksekliği	Shell thickness (mm) Kabuk kalınlığı
Bursa-95	2021	12.68	6.65	52.66	32.40	32.93	39.03	1.58
	2022	14.89	7.49	50.41	33.90	33.24	42.08	1.48
	Average Ortalama	13.79 ±1.22c*	7.07± 0.22b	51.53 ±3.52ab	33.15 ±0.24b	33.09 ±0.14c	40.55 ±1.24d	1.53 ±0.09a
Chandler	2021	12.62	5.86	46.44	32.61	34.54	42.84	1.49
	2022	12.93	6.82	52.88	32.83	34.57	40.92	1.67
	Average Ortalama	12.78 ±0.50d	6.34 ±0.33c	49.66 ±0.81bc	32.72 ±0.59b	34.56 ±0.33b	41.88 ±0.66c	1.58 ±0.08ab
Pedro	2021	10.39	5.14	49.47	29.49	29.72	33.33	1.51
	2022	10.88	4.83	44.37	29.53	29.99	34.10	1.68
	Average Ortalama	10.64 ±0.94e	4.98 ±0.35e	46.92 ±1.85c	29.51 ±1.45d	29.86 ±0.51e	33.72 ±0.45f	1.59 ±0.03ab
Şebin	2021	10.76	4.41	40.92	28.60	31.46	38.90	1.36
	2022	13.24	6.98	52.68	33.25	33.17	38.58	1.72
	Average Ortalama	12.00 ±0.60d	5.69 ±0.30d	46.79 ±0.86c	30.93 ±0.21c	32.31 ±0.09d	38.74 ±1.02e	1.54 ±0.14a
Topak	2021	14.17	7.92	55.92	31.40	34.56	44.70	1.41
	2022	16.25	8.04	49.58	31.99	36.69	46.36	1.95
	Average Ortalama	15.21 ±0.79b	7.98 ±0.37a	52.75 ±0.67ab	31.69 ±0.42c	35.63 ±0.76a	45.53 ±0.31a	1.68 ±0.05b
Yalova-1	2021	13.88	7.49	54.01	33.95	33.20	41.36	1.28
	2022	19.13	8.78	45.91	35.80	36.27	45.77	2.03
	Average Ortalama	16.50 ±0.40a	8.14 ±0.28a	49.96 ±0.44bc	34.87 ±0.40a	34.73 ±0.68b	43.56 ±0.51b	1.65 ±0.06b
Yavuz	2021	14.52	8.07	55.53	31.78	34.70	46.27	1.39
	2022	12.64	6.66	52.76	30.28	33.84	39.88	1.64
	Average Ortalama	13.58 ±0.70c	7.36 ±0.51b	54.15 ±1.08a	31.03 ±0.50c	34.27 ±0.57b	43.07 ±0.15b	1.51 ±0.04a

*Differences between means were determined by Duncan test and indicated in lower case ($P \leq 0.05$). Mean \pm Standard Error.

*Ortalamalar arası fark Duncan testi ile belirlenmiştir ve küçük harf ile gösterilmiştir ($P \leq 0.05$). Ortalama \pm Standart Hata.

Kernel color parameters measured according to varieties are shown in Table 3. According to the average of two years, the color value differences are statistically significant. L^* values, which express lightness and darkness in fruit, varied within the limits of 40.04 (Bursa-95) and 55.32 (Chandler). Considering the L^* value, among the examined cultivars, the lightest color was in Chandler. Other cultivars with slightly darker color than the Chandler cultivar were included in the same statistical group. The a^* value represents (+) red and (-) green on the horizontal axis. It is possible to

evaluate the $+a^*$ value as an indicator of kernel darkening and as a color parameter that is desired to be as low as possible. Accordingly, this value was found to be low in Bursa-95 (13.52), but high in Chandler (7.76). Chandler ranked first statistically in terms of the b^* value, which represents the light yellow color. The decrease in C^* value in Bursa-95 variety (26.76) compared to Chandler variety (29.86) indicates a decrease in saturation value. Also, the highest h° value (refers to the color tone) was calculated in Chandler variety.

Table 3. Color values of walnut varieties grown in Kale (Denizli) province.
Çizelge 3. Kale (Denizli) yöresinde yetiştirilen ceviz çeşitlerinin renk değerleri.

Variety Çeşit	Year Yıl	L*	a*	b*	C*	h°
Bursa-95	2021	33.70	13.85	19.87	24.23	55.07
	2022	46.37	13.18	26.14	29.28	63.24
	Average Ortalama	40.04 ±0.56b [#]	13.52 ±0.38d	23.00 ±1.32d	26.76 ±1.04c	59.15 ±2.09e
Chandler	2021	52.90	7.87	28.78	29.84	74.71
	2022	57.73	7.65	28.89	29.89	75.18
	Average Ortalama	55.32 ±0.75a	7.76 ±0.52a	28.84 ±0.50a	29.86 ±0.62a	74.94 ±0.72a
Pedro	2021	37.12	13.91	23.28	27.14	59.03
	2022	46.71	10.63	24.38	26.63	66.33
	Average Ortalama	41.92 ±4.31b	12.27 ±0.47c	23.83 ±2.03cd	26.88 ±1.50c	62.68 ±3.05d
Şebın	2021	44.23	9.78	28.16	29.87	70.75
	2022	45.74	12.25	24.97	27.83	63.84
	Average Ortalama	44.99 ±8.64b	11.01 ±1.89b	26.57 ±1.78b	28.85 ±1.15ab	67.29 ±4.42b
Topak	2021	37.68	11.96	22.79	25.77	62.01
	2022	50.51	10.59	31.77	33.50	71.61
	Average Ortalama	44.09 ±2.99b	11.27 ±0.63bc	27.28 ±3.91ab	29.64 ±3.70a	66.81 ±3.27bc
Yalova-1	2021	33.23	12.83	23.79	27.04	61.64
	2022	50.43	11.85	27.62	30.06	66.78
	Average Ortalama	41.83 ±1.40b	12.34 ±0.35c	25.71 ±0.87bc	28.55 ±0.61ab	64.21 ±1.50cd
Yavuz	2021	36.77	12.42	23.30	26.41	61.91
	2022	45.92	11.80	25.82	28.40	65.45
	Average Ortalama	41.35 ±2.02b	12.11 ±0.25c	24.56 ±1.03cd	27.41 ±0.92bc	63.68 ±1.15d

Differences between means were determined by Duncan test and indicated in lower case ($P \leq 0.05$). Mean ± Standard Error.

Ortalamalar arası fark Duncan testi ile belirlenmiştir ve küçük harf ile gösterilmiştir ($P \leq 0.05$). Ortalama ± Standart Hata.

Considering other research on the examined parameters, a two-year study conducted on an 18-year-old Chandler walnut cultivar in Kaman District of Kırşehir, gave 31.95 mm nut thickness, 31.63 mm nut width, 38.74 mm nut height, 10.27 g nut weight, 4.51 g kernel weight, 1.05 mm shell thickness and 44% kernel ratio values. It was stated that there were significant differences between the other varieties and years in the research in question (Çoban, 2020); however, in our study, the values were higher. In the same variety, it was also

determined that the nut size changes depending on altitude in the Uşak region. In addition, nut and kernel weights varied between 8.77 – 13.35 g and 4.14 – 5.40 g, respectively (Büyüksolak *et al.*, 2020).

Bilgin *et al.* (2018) studied the performances of Şebın, Chandler and Pedro varieties in the ecology of İzmir province Menemen. Accordingly, nut width, length and height were found as 34.61, 33.26, and 32.52 mm; 37.74, 40.09, and 38.97 mm; and 32.44, 34.75, and 35.58 mm, respectively. Nut

weight (10.42 – 10.98 – 11.32 g) and shell thickness (1.32 – 1.42 – 1.40 mm) were also measured. On the other hand, the kernel ratio value is an economically important parameter in walnuts, as in all nuts. This feature is calculated as 35.00% for Sebin, 40.70% for Chandler and 47.00% for Pedro. In this study conducted in Kale ecology, it was determined that this value was higher than observed in the Menemen ecology.

In Kırşehir, nut weight, kernel weight, kernel ratio and shell thickness values were found to be 17.33 g, 8.56 g, 49.43%, 1.54 mm, 37.63 mm, 52.25 mm and 39.23 mm in Yavuz variety, whereas they were 12.83 g, 6.28 g, 48.93%, 1.83 mm, 34.11 mm, 44.44 mm and 35.31 mm in the Şebın variety, respectively. In terms of color parameters, L*, a*, b*, C* and h⁰ values were measured as 40.62, 10.99, 21.86, 24.53 and 62.99 for Yavuz cultivar; and 39.33, 13.93, 24.53, 28.35 and 59.88 for Şebın cultivar (Bayazit and Caliskan, 2018). In our study, lower values of nut properties were determined. In terms of color values, both varieties gave better results.

Among the seven different walnut varieties cultivated in our country, the highest nut and kernel weight was found in Yalova-1 (18 and 8 g), while the lowest was determined in Şebın (8 and 5 g). In addition, the kernel ratio of Şebın (59%) was the highest in the first year. The lowest L* value was determined in Yalova 1 and brighter color was measured in other varieties. On the other hand, the a value, which is the indicator of red color, was

higher for this variety. The b* value, which is a yellow color indicator, was found to be low in Şebın. It is desired by the authors that the L and b color values are high for walnut (Bakkalbaşı *et al.*, 2010). It has been emphasized that climatic conditions and cultivation techniques may cause this situation. On the other hand, kernel color is an important quality parameter that emerges as a result of both cultivar characteristics and post-harvest processes. In general, the findings obtained from walnut varieties in Kale ecology are compatible with previous studies conducted in different ecologies.

CONCLUSION

Walnut is one of the most important riches of Türkiye. It is a valuable nut in human nutrition. The adaptation of the varieties to the region where they are grown is of primary importance. This situation necessitates adaptation studies of the varieties to the region. As is known, nut characteristics occur as a natural result of the interaction of cultural practices such as genotype, environmental conditions, irrigation, fertilization and pruning and their effect on plant metabolism. In this study, it was determined that Yalova-1 and Topak cultivars were superior to other cultivars in terms of the generally examined characteristics. On the other hand, Pedro and Şebın varieties took the last place. In order to express the findings obtained in this research more clearly, it would be beneficial to continue the study by taking into account the yield and climate data.

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