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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Phenological, Morphological and Pomological Characteristics of 'Samsun Güzeli' Pear Genotype on BA29 Rootstock

'Samsun Güzeli' Armut Genotipinin BA29 Anacı Üzerindeki Fenolojik, Morfolojik ve Pomolojik Özellikleri

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Abstract

Türkiye has many local pear cultivars; some of them do not have much production and propagation potential due to their low quality and undesirable vegetative and generative characteristics. However, those that are superior in terms of fruit quality and yield characteristics have found a place for themselves in both local and national markets. In this respect, the 'Samsun Güzeli' genotype, which is an important local cultivar, is an ideal cultivar with many features and has a high potential to spread its cultivation all over Türkiye and other countries. 'Samsun Güzeli' is an autumn genotype, can easily meet the high demand in local and international markets due to its attractive color, smooth fruit shape and high quality. Despite all these valuable features, this cultivar is still not well known in Türkiye. There is a great need to disseminate cultivation and research on this subject. This study mainly aimed to reveal the phenological, morphological and pomological characteristics of the 'Samsun Güzeli' local pear genotype grafted on BA29, a commercially traded rootstock in 2021-2022. The results showed that the 'Samsun Güzeli' pear genotype completed its phenological cycle in 255 days in 2021 and 228 days in 2022 in Samsun climatic conditions. Fruit set rate of the genotype was 12.05% and the average yield was 17306.23 kg ha^{-1}. It was also determined that the morphological characteristics averages were as the following; rootstock diameter 76.71 mm, trunk diameter 61.97 mm, trunk cross-sectional area 34.06 cm^2, tree height 253.12 cm, canopy volume 0.96 m^3, annual shoot length 37.19 cm and leaf area 11.74 cm^2. Averages values of pomological and chemical properties recorded as the following; fruit weight 114.60 g, fruit volume 109.90 ml, soluble solid content (SSC) 13.16%, acidity 0.33%, and pH 4.37. In the sensory evaluations, the highest scores were obtained by juiciness (6.32) in the year 2022 while scores of overall visual quality were lowest in both years. In conclusion, it can be said that the 'Samsun Güzeli' genotype performs adequately in terms of fruit yield and quality on the standard dwarf rootstock and conducting new studies might be beneficial to disseminate the genotype.

Keywords: Yield, Fruit quality, Vegetative growth, Characterization, Yield efficiency

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Öz

Çok sayıda yerel armut çeşidine sahip olan Türkiye'de bu armut çeşitlerinin bazıları düşük kaliteleri ve istenmeyen vejetatif ve generatif özellikleri nedeniyle çok fazla üretim ve yayılma potansiyeline sahip değillerdir. Ancak meyve kalitesi ve verim özellikleri bakımından üstün olanlar gerek yerel pazarlarda gerekse ülkesel pazarlarda kendilerine yer bulabilmişlerdir. Bu bakımdan önemli bir yerel çeşit olan 'Samsun Güzeli' genotipi birçok özelliği ile ideal bir yerel genotip olmakla birlikte yetiştiriciliği tüm Türkiye ve diğer ülkelerde yayılma potansiyeli yüksektir. Özellikle çekici rengi, düzgün meyve şekli ve güzlük bir çeşit olması dolayısıyla yerel ve uluslararası pazarlarda yüksek taleplere kolayca ulaşabilir. Sahip olduğu tüm bu değerli özelliklere rağmen bu genotip Türkiye'de hala iyi bilinmemektedir. Yetiştiriciliğinin yaygınlaştırılması ve bu konuda araştırmalar yapılmasına büyük ihtiyaç duyulmaktadır. Bu çalışmada 2021-2022 yıllarında BA29 anacı üzerine aşılı 'Samsun Güzeli' genotipinin fenolojik, morfolojik ve pomolojik özelliklerinin ortaya konulması asıl olarak amaçlanmıştır. Araştırma sonuçları 'Samsun Güzeli' armut genotipinin fenolojik döngüsünü Samsun iklim koşullarında 2021 yılında 255 gün, 2022 yılında 228 günde tamamladığını göstermiştir. Genotipin meyve tutum oranının %12.05 ve ortalama veriminin 17306.23 kg ha^{-1} olduğu saptanmıştır. Araştırmada genotipin morfolojik özelliklerinden ortalama anaç çapının 76.71 mm, gövde çapının 61.97 mm, gövde kesit alanının 34.06 cm^2, ağaç boyunun 253.12 cm, taç hacminin 0.96 m^3, yıllık sürgün uzunluğunun 37.19 cm ve yaprak alanının 11.74 cm^2 olduğu belirlenmiştir. Pomolojik ve kimyasal özelliklerinden, ortalama meyve ağırlığının 114.60 g, meyve hacminin 109.90 ml, suda çözünebilir kuru madde miktarının (SÇKM) %13.16, asitliğin %0.33 ve pH'nın 4.37 olduğu bulunmuştur. Duyusal olarak yapılan değerlendirmelerde en düşük puan her iki yılda da görsel kaliteden elde edilirken en yüksek duyusal puan sululuktan (6.32) 2022 yılında elde edilmiştir. Sonuç olarak, 'Samsun Güzeli' genotipinin meyve verim ve kalite bakımından standart bodur anacı üzerinde yeterli performans gösterdiği, genotipin yaygınlaştırılması için yeni çalışmaların yapılmasının uygun olacağı söylenebilir.

Anahtar Kelimeler: Verim, Meyve kalitesi, Vejetatif büyüme, Karakterizasyon, Verimlilik

1. Introduction

Pear is one of the most important temperate fruits and is adapted to wide range of climatic conditions (Bhat et al., 2021). World pear production was reported as 26.3 million tons in 2023, of which 19.2 million tons were produced by China, U.S.A, Argentina, and Türkiye that takes place in the 4th position (Anonymous, 2024a). Türkiye's pear production was reported as 551.086 tons in 2022 (Anonymous, 2024b). In order to get the optimum vegetative and generative developments from fruit trees, performing appropriate cultural practices, planting density and selection of proper rootstock/scion combination, according to ecological conditions are important strategies (Pasa et al., 2015). In modern orchards with high planting density, pear cultivars are grafted on quince rootstocks as they are less vigorous than both clonal and seedling pear rootstocks (Hancock and Lobos, 2008). The use of quince as rootstock for pear cultivars is recommended as they provide precocity and improved fruit quality, and they offer easier crop management such as pruning, spraying, and harvesting (Stern and Doron, 2009; Francescatto et al., 2014). With the use of quince rootstocks, it is easy to establish an orchard with around 2000 - 5000 trees ha^{-1} (Pasa et al., 2012; Jovanovic et al., 2023). This ensures the ideal yield performance of pear cultivars per area due to higher photosynthetic efficiency (Ladaniya et al., 2020). Based on previous studies, high-density orchards with quince clonal rootstocks provide more yield than conventional ones due to the maximum utilization of solar energy, nutrients and water (Ladaniya et al., 2021). European countries mostly use quince rootstocks to establish high-density planting pear orchards, as they have prominent features (Brewer and Palmer, 2011; Musacchi et al., 2021). With the use of quince rootstocks for pear cultivars, it is possible to increase quality as less fruit is produced per canopy volume, but the economic life of those pear orchards was reported to be shorter compared to ones established on pear rootstocks (Sansavini and Musacchi, 2002; Musacchi, 2008; Zhang et al., 2016; Musacchi et al., 2021). In Türkiye, where there are many local fruit varieties in different provinces, the pear is an important species with approximately 600 local varieties (Özçağıran et al., 2005; Gundogdu et al., 2021). Nevertheless, they don't have a high potential for expansion of cultivation due to their low qualities and other unwanted vegetative and generative features such as stone cells, rustiness, internal browning and thorniness. Fortunately, in case of many characteristics, the 'Samsun Güzeli' is an ideal local genotype with a high cultivation potential to be expand all around the Türkiye. Especially for its attractive color, pyriform shape and for being an autumn cultivar, 'Samsun Güzeli' can easily achieve high demand in the local and international markets. However, despite having all these valuable characteristics, 'Samsun Güzeli' is not a well-known genotype and there is a need for researches that explore its cultivation and contribute significantly to its expansion potential. This research focused on investigating the performance of 'Samsun Güzeli', a late ripening local pear genotype on BA29 quince rootstock in an orchard planted under high density, during two consecutive years.

2. Materials and Methods

2.1. Materials

The 'Samsun Güzeli' pear genotype that was grafted onto BA29 quince rootstock was used as material. The experimental pear orchard was established with grafted, one-year old saplings in 2018 at the Bafra Agriculture Research center of Ondokuz Mayis University (41° 33' 50" N; 35° 52' 21" E; altitude 20 m). The plants started to yield in 2020. Observations and measurements were performed in 2021 and 2022. The study area has a hot and humid climate in summers and a cool climate in winters, and precipitation mainly occurs in the late fall and early winter. According to long-term climatic data of Samsun/Bafra district, average maximum temperature is 26.2 °C, average minimum temperature is 3.3 °C, and average annual temperature is 14.1 °C in the study area (Anonymous, 2022).

2.2. Methods

Grafted plants were planted at a spacing of 3.5 m x 1.5 m (1910 tree ha^{-1}) and trained according to the modified leader system. The plants were supported with metal poles that allow a good anchoring to support the saplings against wind and tie up the branches to prevent breaking at the yielding age. Pear trees were irrigated regularly with pressure compensating drippers at 1.20 m intervals, with two driplines per row, one on each side of the tree row. Weed control, as well as pruning, was done regularly every year in the study area.

2.3. Phenological, morphological and pomological traits

In the study the BBCH scale defined for pome fruits by Meier et al. (1994) was used to describe and define phenological stages. Observed timing of phenological stages, such as beginning of bud break, before the flowering

stage, balloon stage, first flowering, full flowering, end of flowering, fruit set, fruit maturity (harvest) and leaf fall were presented in *Table 1*. The number of days from full flowering to harvest, the number of flowers per plant (pieces tree^{-1}), the number of flowers turned to fruit per plant (pieces tree^{-1}) and the fruit set ratio (%) were also determined according to previous studies (Maas, 2008; Pasa et al., 2015; Oliveira et al., 2016; Kurt et al., 2022a). Rootstock diameter (mm), trunk diameter (mm), trunk cross-sectional area (cm^2), tree height (cm), canopy width (West-East - cm), canopy length (North-South - cm), canopy height (cm), canopy volume (m^3), annual shoot length (cm), bud number in the annual shoot (pieces shoot^{-1}), leaf length (cm), leaf width (cm), leaf petiole length (cm), leaf petiole thickness (mm), and leaf area (cm^2) were determined according to previous studies as morphological observations (Ozturk and Ozturk, 2014; Kurt et al., 2022a). Pomological observations were made based on previously performed research (Massai et al., 2008; Akcay et al., 2009; Stern and Doron, 2009; Ozturk and Ozturk, 2014; Kucuker et al., 2015; Ozturk et al., 2022). Fruit weight (g) was measured in randomly harvested 30 fruits in each replication with 0.01 g sensitive digital balance (CAMRY L-500). Fruit width (mm), fruit length (mm), fruit height (mm), fruit stalk length (mm), fruit stalk thickness (mm), and fruit skin thickness (mm) were measured with a 0.01 mm digital caliper (Mitutoyo CD-20CPX). Fruit volume (ml) was calculated using a 1000 ml graduated cylinder. Fruit firmness (kg cm^{-2}) was evaluated with a hand penetrometer (EXTECH FHT 200- with 5/16 head) according to Ertürk et al. (2009). Total soluble solids (TSS, Brix) were measured with a digital refractometer (ATAGO, PAL-1), pH was measured with a digital pH meter (Milwaukee MW150 Max) and titratable acidity of fruit (expressed as % malic acid) was determined by titration using standard 0.1N NaOH solution (Kurt et al., 2022a). Fruit skin and flesh color indices: *L*, a*, b** (from white to black, green to red and blue to yellow chromaticity coordinate), chroma, and hue degree (h°) were measured from two different points on the equatorial part of the fruit with a colorimeter (Minolta, model CR-300, Tokyo, Japan) as described by (Erdem and Ozturk, 2012; Kurt et al., 2022a). The number of fruits (fruits tree^{-1}), yield per tree (kg tree^{-1}), yield per hectare (kg ha^{-1}), yield per trunk cross-sectional area (kg cm^{-2}), and yield per canopy volume (kg m^{-3}) were recorded to determine the yield performance of the 'Samsun Güzeli' pear genotype (Ozturk et al., 2022). A group of 12 experienced panelists evaluated the organoleptic properties of 'Samsun Güzeli' fruits. Samples were evaluated for juiciness, taste, aroma, and visual qualities (overall appearances; fruit shape and skin color density). Panelists scored these attributes on 7-point hedonic scale to indicate the degree of like or dislike with the lowest score (1) corresponding to do not like at all while the highest score (7) corresponding to extremely like (Pasquariello et al., 2013).

2.4. Data analysis

One-way analysis of variance and descriptive statistics of obtained data were done with IBM SPSS 21.0 program (SPSS Inc. Chicago, ABD. Correlation analysis of data was done with XLSTAT 2022 statistical package.

3. Results and Discussion

3.1. Phenological characteristics

Description of the phenological stages and phenological codes were recorded using BBCH growth stage identification keys for mono and dicotyledonous plants (Hack et al., 1992). The observed dates of phenological growth stages of the 'Samsun Güzeli' pear genotype grafted on BA29 rootstock were presented in *Table 1*.

The results showed that the 'Samsun Güzeli' genotype completed its phenological cycle, reaching the leaf fall stage (code 97) in 255 days in 2021, and in 228 days in 2022 in Samsun climatic conditions.

Vegetative cycle of 'Samsun Güzeli' genotype started on 10 March in 2021 and 10 April in 2022. In the year 2021, flower buds were visible (code 55) on 12 March. Balloon stage (code 57) and first flowering (code 60) occurred on 15 March and 30 March, respectively, while full flowering (code 65) took place on 04 April. The end of flowering (code 69) occurred on 20 April. The fruit set (code 72) occurred on 26 April. The fruit maturity (code 89) eventuated on 25 September.

In the year 2022, flower buds were visible (code 55) on 14 April. Balloon stage (code 57) and first flowering (code 60) occurred on 17 April and 19 April, respectively, while full flowering (code 65) took place on 23 April. The end of flowering (code 69) occurred on 05 May. The fruit set (code 72) occurred on 11 May. The fruit maturity (code 89) on 10 October.

The number of days from full flowering to harvest was recorded as 174 days in 2021 and 171 days in 2022. The number of flowers per tree was recorded as 521 in 2021 and 719 in 2022, while the number of flowers turned to fruit observed as 67.00 pieces tree^{-1} in 2021 and 86.67 pieces tree^{-1} in 2022. The fruit set ratio was recorded as 12.85% in 2021, while recorded as 12.85% in 2022 (*Table 1*).

Table 1. Observed dates of phenological stages of 'Samsun Güzeli' pear genotype on BA29 rootstock, in the years 2021-2022.

	Phenological growth stages (PGS) codes according to BBCH scale	Description	2021	2022
Phenological characteristics	07	Beginning of bud break (BB)	10 March	10 April
	55	Flower buds visible (FBV)	12 March	14 April
	57	Balloon stage (BS)	15 March	17 April
	60	First flowering (First flower open) (FiFO)	30 March	19 April
	65	Full flowering (at least 50% of flowers open, first petal falling) (FuF)	04 April	23 April
	69	End of flowering (all petals fallen) (EoF)	20 April	5 May
	72	Fruit set (fruit size up to 20 mm) (FS)	26 April	11 May
	89	Fruit maturity (Fruit ripe for consumption) (FM)	25 September	10 October
	97	Leaf fall (all leaves fallen) (LF)	20 November	24 November
		Days from full flowering to harvest (DFFTH)	174	171
		Number of flowers (per tree-^{1}) (NF)	521	719
		Number of flowers turned to fruit (pieces tree^{-1}) (NFTTF)	67.00	86.67
		Fruit set ratio (%) (FSR)	12.85	12.05

The studies conducted on phenology of fruit cultivars is crucial when introducing them to new environments, especially those that differ from their native environments (Oliveira et al., 2016). The phenological differences between cultivars were reported to be related to the genetic differences and climatic conditions in that fruit trees are grown (Osmanoğlu et al., 2013; Ozturk et al., 2016; Mertoğlu and Evrenosoğlu, 2017). In hot and dry weather, all fruit trees' flowers open quickly, while in cool and rainy weather, flowering continues on the same tree for 2 to 10 days (Özçağıran et al., 2005). In our research, we recorded the flowering period of 'Samsun Güzeli' genotype was for about 20 days.

3.2. Morphological characteristics

Records of morphological and leaf traits of the 'Samsun Güzeli', grafted on BA29 rootstock are presented in *Table 2* and it was demonstrated that the differences regarding morphological and leaf characteristics between two consecutive research years were statistically non-significant. The mean values of morphological characteristics recorded as follows; rootstock diameter 76.71 mm, trunk diameter 61.97 mm, trunk cross-sectional area 34.06 cm^2, tree height 253.12 cm, canopy width 188.28 cm, canopy length 150.85 cm, canopy height, 223.28 cm, canopy volume 0.96 m^3, annual shoot length 37.19 cm, number of buds in an annual shoot 16.72, leaf length 5.22 cm, leaf width - 3.25 cm, leaf petiole length 3.55 cm, leaf petiole thickness - 0.39 mm and leaf area 11.74 cm^2.

It has been reported that rootstock diameter significantly varies in different rootstocks (Giacobbo et al., 2010). Cetinbas et al. (2018) stated that both the rootstock effect and the cultivar effect were significant with regard to rootstock diameter. The stem diameter of the cultivars on vigorous rootstocks was observed to be superior to those on the rootstocks with weaker growth performance (Sugar and Basile, 2011). The trunk cross-sectional area reported to be varied based on the production years, cultivars, and rootstocks (Jovanovic et al., 2022). Tree height

Table 2. Morphological and leaf characteristics of 'Samsun Güzeli' pear genotype on BA29 rootstock.

	Characteristics	2021	2022	Mean	P-value*	CV%	Std. D. of Mean
Morphological	Rootstock diameter (mm)	74.90	78.51	76.71	0.104	3.56	2.734
	Trunk diameter (mm)	56.31	67.63	61.97	0.113	14.06	8.713
	Trunk cross-sectional area (cm^2)	32.66	35.45	34.06	0.109	6.25	2.128
	Tree height (cm)	237.41	268.83	253.12	0.129	9.85	24.927
	Canopy width (West East) (cm)	169.72	206.83	188.28	0.132	15.73	29.614
	Canopy length (North-South) (cm)	135.29	166.42	150.85	0.130	16.40	24.735
	Canopy height (cm)	210.65	235.92	223.28	0.201	10.21	22.804
	Canopy volume (m^3)	0.92	1.01	0.96	0.157	7.61	0.073
	Annual shoot length (cm)	34.91	39.46	37.19	0.433	16.81	6.252
	Number of buds in an annual shoot	15.44	18.01	16.72	0.164	13.00	2.174
Leaf	Leaf length (cm)	5.17	5.27	5.22	0.300	2.19	0.114
	Leaf width (cm)	3.07	3.43	3.25	0.290	11.64	0.378
	Leaf petiole length (cm)	3.42	3.67	3.55	0.355	8.12	0.288
	Leaf petiole thickness (mm)	0.38	0.41	0.39	0.204	5.62	0.022
	Leaf area (cm^2)	11.22	12.27	11.74	0.190	7.97	0.936

*: There were no statistically significant differences at P=0.05

was affected by the rootstocks and cultivars as reported by (Lepsis and Drudze, 2011). In evaluations of 'Seleta' pear cultivar performance on quince rootstocks and *Pyrus calleryana* pear seedlings, Giacobbo et al. (2018) found that all quince rootstocks reduced the tree height by 60% compared to *Pyrus calleryana* rootstock. Giacabbo et al. (2010) reported that rootstocks significantly affect the canopy volume of cultivars. We found that the canopy volume of 'Samsun Güzeli' was slightly similar to 'Santa Maria', reported as 0.26 - 1.02 m^3 by Engin (2011). Annual shoot length differs depending on rootstocks and cultivars; for example 'Abate Fetel' cultivar had 82.0 cm shoot length on seedling and 4.6 cm (the lowest) shoot length on BA29 (Castro and Rodriguez, 2002). Kurt et al. (2022b) reported that the leaf width of some standard pear cultivars grafted on different quince clone rootstocks varied between 23.98-28.81 mm and the leaf length varied between 35.56-49.20 mm. They determined the width and length of leaves as follows, respectively: 24.89 mm and 42.28 mm in 'Deveci'; 24.25 mm and 35.56 mm in 'Williams'; 28.81 mm and 49.20 mm in 'Santa Maria', and 23.98 mm and 48.46 mm in 'Abate Fetel'. Coban and Ozturk (2020) reported that the leaf length varied between 6.67 and 6.88 cm in terms of rootstock averages and between 6.42 and 7.23 in terms of cultivar averages. Results presented by Coban and Ozturk (2020) are also in line with Serttaş and Ozturk (2020), showing these differences are related to the genetic structures of rootstocks and cultivars. Serttaş and Öztürk (2020) recorded the highest leaf width (3.75 cm and 3.44 cm, respectively) in 'Deveci' and 'Santa Maria' and the lowest (3.40 cm and 3.34 cm, respectively) in 'Abate Fetel' and 'Williams' cultivars. We recorded the petiole length of 'Samsun Güzeli' as 37.20 mm, while Ozturk and Ozturk (2014) reported that of in 'Deveci' as 44.3 mm on BA29 and as 33.5 mm on pear seedling rootstocks. Similarly, Coban and Ozturk (2020) found that rootstocks and cultivars had a significant effect on petiole length. As in case of the petiole length, same conclusion on petiole thickness reached by Ozturk and Ozturk (2014) that petiole thickness of 'Deveci' cultivar varied (0.58mm to 0.76 mm) according to rootstocks and cultivars. Contrary to our findings, Coban and Ozturk (2020) obtained significantly higher values of petiole thickness in the rootstocks (0.97 - 1.27 mm) and in the cultivars (1.06 - 1.16 mm). Leaf area, which is generally used in fruit physiology studies, is an important criterion in determining respiration, transpiration, photosynthesis, light interception, water and nutrient use, flowering, fruit set, yield and quality in plants. And also leaf area is an important factor that determines the canopy volume efficiency of trees and fruit quality (Zhang et al., 2016). Leaf area of 'Samsun Güzeli' pear genotype varied from 11.22 cm^2 to 12.27 cm^2 in this study. Kurt et al. (2022b) reported that the leaf area of some standard pear cultivars varied between 6.24 and 10.64 cm^2. They observed that the leaf area was 7.63 cm^2 in 'Deveci', 6.24 cm^2 in 'Williams', 10.64 cm^2 in 'Santa Maria', and 8.68 cm^2 in 'Abate Fetel'. The determined leaf area in the study is partially similar to the leaf area determined by Kurt et al. (2022b) in some standard pear cultivars. These variations in reports may be attributed mainly to genetic differences.

3.3. Pomological and chemical characteristics

In two consecutive research years of 2021 and 2022, we found insignificant differences in case of pomological, chemical and color characteristics of the 'Samsun Güzeli' pear genotype grafted on BA29 rootstock (*Table 3*). The mean values of pomological, chemical, fruit skin and flesh color observations recorded as the following; fruit weight 114.60 g, fruit width 53.85 mm, fruit length 65.27 mm, fruit height 54.28 mm, fruit stalk length 22.66 mm, fruit stalk thickness 5.75 mm, fruit volume 109.90 ml, fruit skin thickness 0.26 mm, flesh firmness 3.39 kg cm^{-2}, total soluble solids 13.16%, acidity 0.33% and pH 4.37. Fruit skin L* 65.05, a* -3.92, b* 41.55, chroma 32.48, h^o 81.80, fruit flesh color L* 69.68, a* -0.75, b* 14.30, chroma 14.30 and h^o 91.85 (*Table 3*).

The size of the pear fruit is a critical marketing factor (Stern and Doron, 2009). The fruit weight, width, length and height of 'Samsun Güzeli' pear genotype on BA29 rootstock were 123.41 g, 51.87 mm, 62.55 mm and 51.05 mm, respectively, for 2021 and 105.78 g, 55.83 mm, 67.99 mm and 57.51 mm, respectively, for 2022. It should be pointed out that fruit weight of 'Samsun Güzeli' pear genotype was lower than other cultivars. The fruit weight of 'Santa Maria' on BA29 rootstock varied between 147.5 g and 169.4 g as reported by Erdem and Ozturk (2012) and from 140.0 to 156.2 g as reported by Kucuker et al. (2015). Ozturk et al. (2009) found the fruit weight 190.36 g in the 'Santa Maria' cultivar. The results determined in the study were partially similar to previous studies. These differences may be partly due to rootstock and cultivar effect as it pointed out by Kucuker and Aglar (2021).

Table 3. Pomological. chemical and color characteristics of 'Samsun Güzeli' pear genotype on BA29 rootstock.

Characteristics		2021	2022	Mean	P-value*	CV%	Std. D. of Mean
Pomological	Fruit weight (g)	123.41	105.78	114.60	0.138	12.41	14.224
	Fruit width (mm)	51.87	55.83	53.85	0.120	5.74	3.088
	Fruit length (mm)	62.55	67.99	65.27	0.198	7.47	4.874
	Fruit height (mm)	51.05	57.51	54.28	0.139	9.62	5.222
	Fruit stalk length (mm)	23.04	22.28	22.66	0.683	8.54	1.934
	Fruit stalk thickness (mm)	5.48	6.02	5.75	0.241	8.94	0.514
	Fruit volume (ml)	108.72	111.07	109.90	0.746	6.84	7.514
	Fruit skin thickness (mm)	0.28	0.24	0.26	0.291	15.20	0.040
	Flesh firmness (kg cm^{-2})	4.55	2.23	3.39	0.192	60.84	2.061
Chemical	Total soluble solids (%)	13.02	13.30	13.16	0.277	2.19	0.288
	Titratable acidity (%)	0.35	0.31	0.33	0.253	11.22	0.037
	pH	4.18	4.56	4.37	0.112	6.71	0.293
Fruit skin color	*L**	64.39	65.71	65.05	0.511	3.28	2.134
	*a**	-4.15	-3.69	-3.92	0.832	57.30	2.247
	*b**	41.91	41.18	41.55	0.688	4.56	1.894
	Chroma	31.81	33.15	32.48	0.351	4.86	1.579
	h^o	76.91	86.70	81.80	0.229	11.34	9.279
Fruit flesh color	*L**	71.72	67.63	69.68	0.370	7.12	4.962
	*a**	-0.83	-0.67	-0.75	0.474	30.30	0.227
	*b**	15.68	14.90	15.29	0.528	8.60	1.315
	Chroma	13.84	14.76	14.30	0.563	11.70	1.674
	h^o	90.85	92.84	91.85	0.291	2.29	2.107

*: There were no statistically significant differences at P=0.05

With regard to fruit stalk thickness the combination of Samsun Güzeli' pear genotype on BA29 quince rootstock resulted in higher values, i.e., 5.48 mm (2021) and 6.02 mm (2022) than the other similar studies. Fruit stalk thickness was recorded as 3.81 mm in 'Deveci'/QA combination and 4.12 mm in the 'Williams'/QA combination by Akcay et al. (2009). Uysal et al. (2016) reported that it varied from 3.94 to 4.75 mm in 'Deveci'/BA29 combination. And it was between 4.6 mm and 5 mm in 'Abate Fetel'/QA combination (Ozturk et al. (2016). Fruit stalk length was measured as 24.73 mm in 'Deveci'/QA and 29.43 mm in 'Williams'/QA

combinations by Akcay et al. (2009); as 31.54 and 32.56 mm in 'Deveci'/BA29 combinations by Uysal et al. (2016); 11.1 and 14.2 mm in 'Abate Fetel'/QA combinations by Ozturk et al. (2016).

Fruit firmness was reported to show variations according to rootstocks, growing years, and management practices in the pear orchards (du Plooy and Van Huyssteen, 2000; Urbina et al., 2003). Lepaja et al. (2014) found the fruit firmness of 'Santa Maria' 4.96 kg cm^{-2}. Ikinci et al. (2014) found that flesh firmness was highest in BA29 rootstock than in some other rootstocks. In our study the fruit firmness value was lower (2.33 kg cm^{-2}) than above mentioned cultivars which again may be the effect of cultivar and/or cultivar/rootstock combination.

The total soluble solids of pear fruits had a positive correlation with maturity, while acidity showed a negative relation (Kawamura, 2000). The rootstocks and research years significantly affected the TSS and acidity of the 'Shamiveh' pear cultivar (Askari-Khorosgani et al., 2019). Titratable acidity was reported between 0.39 and 0.47% in relation to rootstock and between 0.39and 0.42% in relation to year (Ozturk, 2021). It has been reported that the average pH of 'Santa Maria' pear cultivar was between 3.98 and 4 on BA29 rootstock by Erdem and Ozturk (2012) and between 3.98 and 4.06 on BA29 rootstock (Kucuker et al., 2015). The Crown structure and leaf area of the tree were mentioned to have a significant effect on fruit color (Ozturk, 2021), as the trees with lower crown parts can achieve more sunlight (Özçağıran et al., 2005).

3.4. Yield performance

Yield performance of the 'Samsun Güzeli' pear genotype grafted on BA29 rootstock are given in *Table 4*. Data obtained from 2-year study did not differ significantly with regard to yield performances of Samsun Güzeli'. Yield averages were recorded as 47.11 and 82.23 for number of fruits per tree; as 5.86 and 8.68 kg for yield per tree; as 13949.67 and 20662.80 kg for yield per hectare, 0.17 and 0.26 kg cm^{-2} for yield per trunk cross-sectional area and 5.90 and 8.70 kg m^{-3} for yield per canopy volume, respectively for the first and second year of the study.

Significant effect of rootstocks, cultivars, and their interactions on yield and fruit numbers mentioned by Maas (2008), Cabrera et al. (2015), Pasa et al. (2015), Kucuker and Aglar (2021) and Gill et al., (2011). Cabrera et al. (2015) reported that rootstocks significantly affected yield and 'Williams'/Farold 40 combination provided 190 ton ha^{-1} yield. Pasa et al. (2015) explained that the number of trees per area can affect the number of fruits per plant, yield, and yield efficiency in the 'Santa Maria' pear cultivar. Kucuker and Aglar (2021) reported that the yield of 'Santa Maria'/QA combination was between 3.80 and 7.60 kg $tree^{-1}$. Yield efficiency of 'Santa Maria'/QA combination ranged from 2.22 kg cm^{-2} to 2.97 kg cm^{-2} (Kucuker and Aglar, 2021), while ranged from 0.43 to 1.17 kg m^{-3} in 'Patharnakh', a cultivar of *Pyrus pashia* (Gill et al., 2011).

Table 4. Yield performance of 'Samsun Güzeli' pear genotype on BA29 rootstock.

Yield Performance	2021	2022	Mean	Sig.*	CV%	Std. D. of Mean
Number of fruits (per tree)	47.11	82.23	64.67	0.231	51.57	33.352
Yield per tree (kg)	5.86	8.68	7.27	0.370	47.13	3.427
Yield per hectare (kg)	13949.67	20662.80	17306.23	0.251	38.18	6.607
Yield per trunk cross-sectional area (kg cm^{-2})	0.17	0.26	0.22	0.341	51.67	0.111
Yield per canopy volume (kg m^{-3})	5.90	8.70	7.30	0.393	48.81	3.562

*: There were no statistically significant differences at P=0.05

3.5. Sensory evaluation

Sensory evaluations of the 'Samsun Güzeli' pear genotype grafted on BA29 rootstock were given in *Figure 1*. As is evident on the figure, there were no statistically significant differences between the years in terms of sensory attributes of fruit, based on 1 to 7 rating scale. Among the sensory attributes, however, the highest mean of liking score (6.32) was received from juiciness in 2022 and lowest score (3.57) from visual quality, in the same year.

Sensory evaluation has been defined as a scientific discipline used to evoke, measure, analyze, and interpret those reactions to the fruits as discern through the senses of sight, smell, taste, touch, and hearing (Pasquariello et al., 2013). Sensory evaluation of 'Samsun Güzeli' was performed to define the sensory attributes in relation to the

consumer preference, like juiciness, taste, aroma, and visual quality all of which subsequently have determining effect on eating quality of pears fruits (Zerbini, 2002).

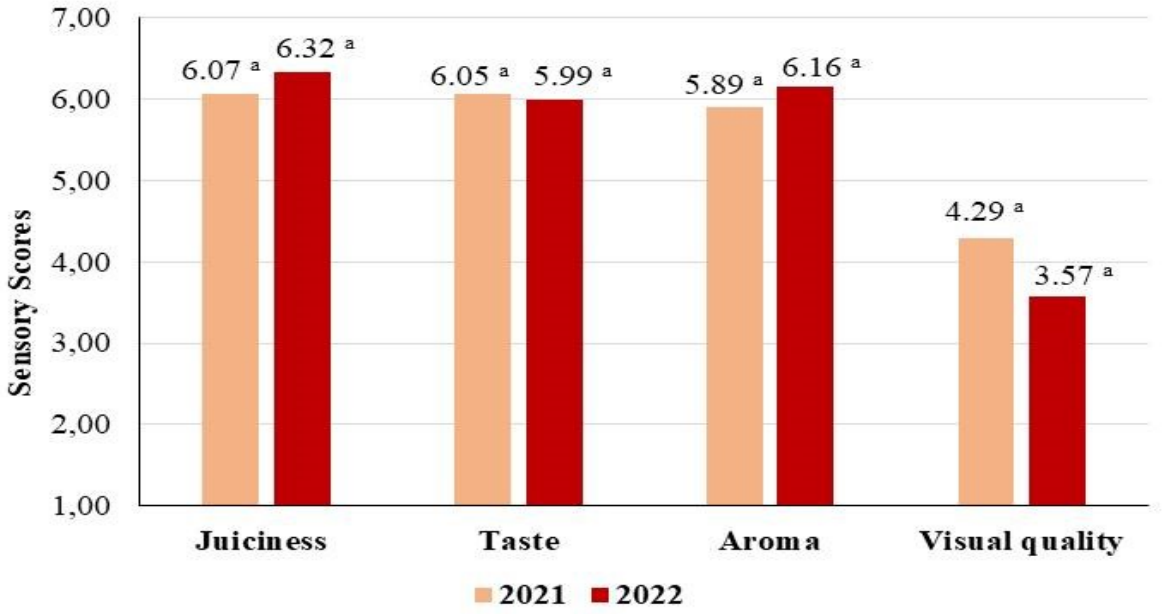

Figure 1. Sensory characteristics of 'Samsun Güzeli' pear genotype on BA29 rootstock.

Figure 2. 'Samsun Güzeli' pear genotype

The juiciness of pear fruit may be affected by the pectic enzymes (Pasquariello et al., 2013). Pectic enzymes are a group of enzymes responsible for pectin degradation in fruits. Although data generated from panelists may be vary and relationship between observed and sensory responses are also likely to be vary, it may be speculated that the favorable results can be indication of good maturity quality of this cultivar. Predieri et al. (2005) pointed out that aroma together with the taste, is major determinant of quality, and that these aromatic volatiles define the distinctive pear fruit flavor. When considering taste, sweetness, sourness, and aroma of pear fruit are important characteristics since these characters are associated with the composition of soluble sugars, organic acids, and

volatile compounds (Zerbini, 2002; Zhang et al., 2008). Pre-harvest factors, genetic differences, maturity at harvest, storage conditions, and fruit physiology are among the factors reported to affect the aroma of pear fruits (Rapparini and Predieri, 2002). The shape of pear fruits can range from round to elongated (Pasquariello et al., 2013). The external quality (visual appearance) of pears is closely related to shape, skin smoothness, color and general attractiveness and affects consumer demand (Özçağıran et al., 2005). As can be seen in *Figure 2*, the 'Samsun Güzeli' pear genotype has an attractive golden yellow-red color and a pyriform shape at maturity, and also has high consumer demand for this reason.

3.6. Correlation analysis

Additionally, a correlation-based technique (Pearson coefficient) was used to characterize the 'Samsun Güzeli' pear attributes in-depth and to assess relationships between dependent variables. The correlation patterns between the various features assessed in the study are represented in (*Figure 3*). The numerous parameters that were employed showed some positive and negative associations. It is found that number of flowers is highly significantly and positively correlated with fruit weight and fruit length.

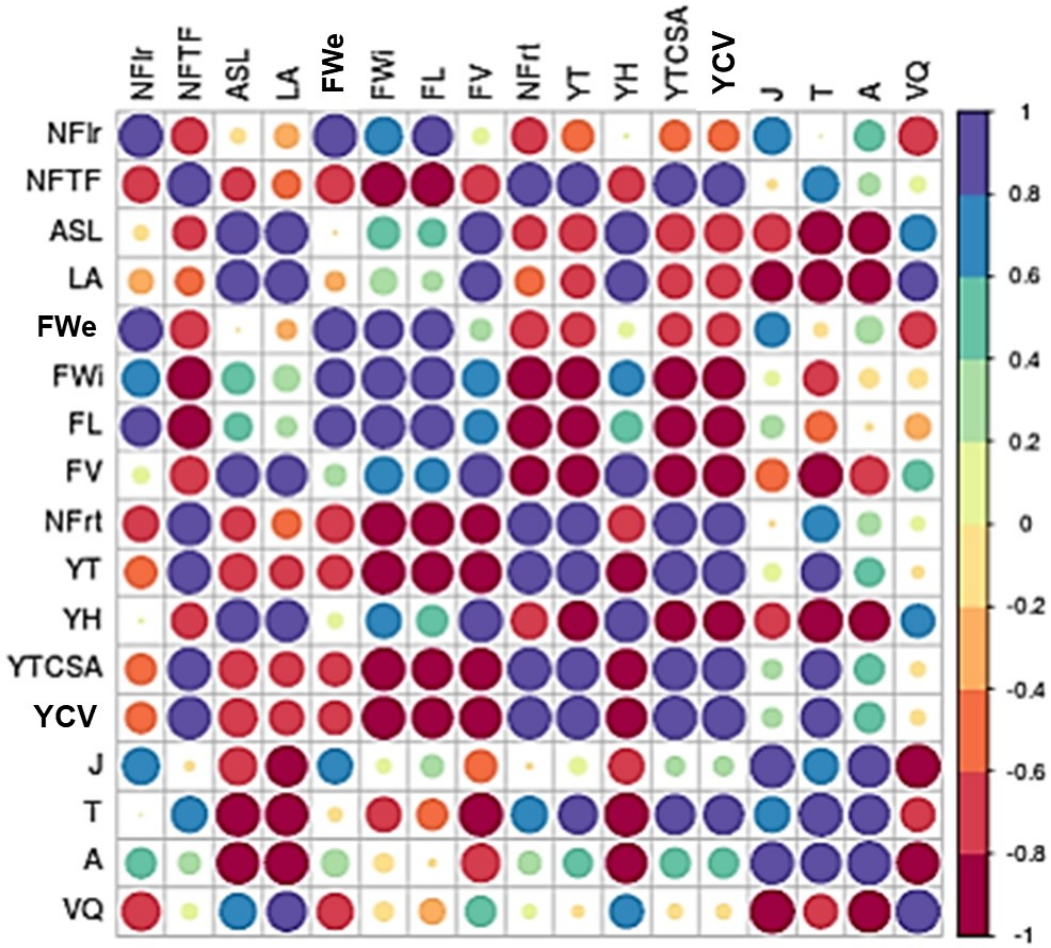

Figure 3. The figure shows the Pearson correlation coefficients between selected characteristics. The color and size of the circles reflect the strength of the correlation.

***NFlr**= Number of Flowers, **NFTF**= Number of Flowers Turned to Fruit, **ASL**= Annual Shoot Length, **LA**= Leaf Area, **FWe**= Fruit Weight, **FWi**= Fruit Width, **FL**= Fruit Length, **FV**= Fruit Volume, **NFrt**= Number of Fruits, **YT**= Yield per Tree, **YH**= Yield per Hectare, **YTCSA**= Yield per Trunk Cross Sectional Area, **YCV**= Yield per Canopy Volume, **J**= Juiciness, **T**= Taste, **A**= Aroma, **VQ**= Visual Quality.*

The number of flowers turned to fruit showed a strongly positive correlation with the number of fruit, yield per tree, yield per trunk cross-sectional area, and yield per canopy volume, on the other hand showed a strongly negative correlation with fruit width and fruit length. Annual shoot length had a strongly positive correlation with

leaf area, fruit volume, and yield per hectare. Both the number of fruit per tree and yield per tree showed a strongly negative association for fruit width and fruit length. A strongly positive correlation was found between the number of fruit and yield per tree with the yield per trunk cross-sectional area and yield per canopy volume. Fruit volume was found to be negatively strongly correlated with the yield per tree, number of fruits, yield per trunk cross-sectional area, yield per canopy volume and taste. Fruit aroma and taste characteristics had a strong negative correlation with annual shoot length and leaf area.

4. Conclusions

Vegetative cycle of 'Samsun Güzeli' pear genotype started with flower bud break on 10 March and lasted until leaf fall on 20 November in 2021, and on 10 April and lasted until leaf fall on 24 November in 2022. The first flowering in the mentioned year occurred on 19 April, while full flowering took place on 23 April. The number of flowers per tree was recorded as 719 in 2022 as 521 in 2021, while the number of flowers turned to fruit was observed as 86.67 per tree in the 2022. The average values of morphological characteristics recorded as the following; rootstock diameter 76.71 mm, trunk diameter 61.97 mm, trunk cross-sectional area 34.06 cm^2, tree height 253.12 cm, canopy width, length and height 188.28 cm, 150.85 cm, 223.28 cm, respectively, canopy volume 0.96 m^3, annual shoot length 37.19 cm, number of buds in an annual shoot 16.72 per shoot, leaf length and width 5.22 cm and 3.25 cm, respectively, leaf petiole length and thickness 3.55 cm, 0.39 mm, respectively and leaf area 11.74 cm^2. It may be speculated that results obtained for yield response of 'Samsun Güzeli' genotype on BA29 (7.27 kg tree $^{-1}$) could be used as a good basis for further research on this genotype.

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Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

Conflict of interest

The authors declare that there are no conflicts of interest with respect to the research, authorship, and/or publication of this article.

Authorship Contribution Statement

Concept: Öztürk, A., Faizi, Z.A.; Design: Öztürk, A., Faizi, Z.A.; Data Collection or Processing: Öztürk, A., Faizi, Z.A.; Statistical Analyses: Faizi, Z.A.; Literature Search: Öztürk, A., Faizi, Z.A.; Writing, Review and Editing: Öztürk, A., Faizi, Z.A.

References

Akcay, M. E., Buyukyilmaz, M. ve Burak, M. (2009). Marmara Bölgesi için ümitvar armut çeşitleri-IV. *Bahçe,* 38(1): 1-10. (In Turkish)

Anonymous (2022). Turkish State Meteorological Service. https://www.mgm.gov.tr/tahmin/il-ve-ilceler.aspx?m=SAMSUN#/ (Accessed Date: 25.05.2022).

Anonymous (2024a). Food and Agriculture Organization of the United Nations (FAO. http://faostat.fao.org/site (Accessed Date: 15.02.2024).

Anonymous (2024b). Türkiye Statistics Institute, (TURKSTAT). https://biruni.tuik.gov.tr/medas/?locale=tr (Accessed Date: 15.02.2024).

Askari-Khorosgani, Jafarpour, M., Hadad, M, M. and Pessarakli, M. (2019). Fruit yield and quality characteristics of 'Shahmiveh' pear cultivar grafted on six rootstocks. *Journal of Plant Nutrition,* 42(4): 323-332.

Bhat, R., Sharma, M. K., Simnani, S. A. and Singh, A. (2021). Effect of growth regulators on growth, yield and quality of pear cv. Carmen under high density planting. *International Journal of Current Microbiology and Applied Sciences*, 10(03): 2146-2153.

Brewer, L. R. and Palmer, J. W. (2011). Global Pear Breeding Programmes: Goals, Trends and Progress for New Cultivars and New Rootstocks. *Acta Horticulturae*, 909:105-119.

Cabrera, D., Rodríguez, P. and Zoppolo, R. (2015). Evaluation of quince and selected 'Farold®' pear rootstocks for commercial 'Williams B.C.' production in Uruguay. *Acta Horticulturae*, 1094: 159-162.

Castro, H. R. and Rodriguez, R. O. (2002). The behavior of quince selections as pear rootstocks for 'Abbé Fétel' and 'Conference' pear cultivars in the Rio Negro Valley, Argentina. *Acta Horticulturae,* 596: 363-368.

Cetinbas, M., Butar, S., Sesli, Y. ve Yaman, B. (2018). Armut fidanı üretiminde farklı çeşit/anaç kombinasyonlarının bazı fidan özelliklerine etkisi üzerine araştırmalar. *Gaziosmanpaşa Üniversitesi, Ziraat Fakültesi Dergisi,* 35 (Ek Sayı): 8-12. (In Turkish)

Coban, N. and Ozturk, A. (2020). Effect of rootstock and cultivars on some branch and leaf characteristics in pear. *Turkish Journal of Food and Agriculture Sciences,* 2(1): 15-22.

du Plooy, P. and van Huyssteen, P. (2000). Effect of BP1, BP3 and Quince A rootstocks, at three planting densities, on precocity and fruit quality of 'Forelle' pear (*Pyrus communis* L.). *South African Journal of Plant and Soil,* 17(2): 57-59.

Engin, K. (2011). *OHF x 333 ve Quince A anaçları üzerine aşılı Santa Maria ve Deveci Armut çeşitlerinde farklı terbiye sistemlerinin vejetatif ve generatif gelişim üzerine etkisi*. (Yüksek Lisans Tezi) Gaziosmanpaşa Üniversitesi, Fen Bilimleri Enstitüsü,Tokat. (In Turkish)

Erdem, H. ve Ozturk, B. (2012). Yapraktan uygulanan çinko'nun BA29 anacı üzerine aşılı armut çeşitlerinin verimi, mineral element içeriği ve biyokimyasal özellikleri üzerine etkisi. *Süleyman Demirel Üniversitesi Ziraat Fakültesi Dergisi,* 7(1): 93-106. (In Turkish)

Ertürk, Y., Güleryüz, M. ve Erdoğan, U. G. (2009). Quince A üzerine aşılı bazı armut çeşitlerinin İspir (Yukarı Çoruh Havzası) koşullarındaki verim ve gelişme durumlarının belirlenmesi. *Bahçe,* 38(1): 11-17. (In Turkish)

Francescatto, P., Pazzin, D., Gazolla, Nero. A., Fachinello, J. and Giacobbo, C. (2014). Evaluation of graft compatibility between quince rootstocks and pear scions. *Acta Horticulturae,* 872:253-259.

Giacobbo, C. L., Fischer, D. L. O. and Uberti, A. (2018). Rootstocks as possible alternative uses for pear trees cultivar select. *Horticulture International Journal,* 2(3): 84-86.

Giacobbo, C. L., Gazolla, Neto, A., Pazzin, D., Francescatto, P. and Fachinello, J. C. (2010). The assessment of different rootstocks to the pear tree cultivar 'Carrick'. *Acta Horticulturae,* 872:353-358.

Gill, P. P. S., Dhillon, W. S., Singh, N. P. and Singh, S. (2011). The influence of canopy architecture on light penetration, soil temperature and fruiting in sub-tropical pear. *Journal of Agrometeorology,* 13(2): 157-159.

Gundogdu, M.A., Gur, E. and Seker, M. (2021). Comparison of aroma compounds and pomological characteristics of the fruits of 'cv. Mondial Gala' and local apple genotype 'Gelin' cultivated in Çanakkale, Turkey. *Journal of Tekirdag Agricultural Faculty,* 18(1): 10-20.

Hack, H., Bleiholder, H., Buhr, L., Meier, U., Schnock-Fricke, U., Stauss, R., Weber, E. and Witzenberger, A. (1992). Einheitliche codierung der phänologischen entwicklungsstadien mono- und dikotyler pflanzen. – Erweiterte BBCH-skala, allgemein –. *Nachrichtenbl. Deut. Pflanzenschutzd*., 44(12): 265-270. (In German)

Hancock, J. F. and Lobos, G. A. (2008). Pears. In: Temperate Fruit Crop Breeding: Germplasm to Genomics, Eds. Hancock, J. F., Springer, New York, U.S.A. doi: 10.1007/978-1-4020-6907-9_10.

Ikinci, A., Bolat, I., Ercisli, S. and Kodad, O. (2014). Influence of rootstocks on growth, yield, fruit quality and leaf mineral element contents of pear cv. 'Santa Maria' in semi-arid conditions. *Biological Research,* 47(1): 1-8. https://doi.org/10.1186/0717-6287-47-71

Jovanovic, M., Milosevic, T., Milošević, N., Ercişli, S., Glišić, I., Paunović, G. and Ilić, R. (2023). Tree growth, productivity, and fruit quality attributes of pear grown under a high-density planting system on heavy soil. A case study. *Erwerbs-Obstbau,* 65: 25-34. https://doi.org/10.1007/s10341-022-00671-0.

Kawamura, T. (2000). Relationship between skin color and maturity of Japanese pear 'Housui'. *Japanese Society of Farm Work Research*, 35(1): 33-38. https://doi.org/10.4035/jsfwr.35.33

Kucuker, E. and Aglar, E. (2021). The effect of the different training systems on yield and vegetative growth of 'Santa Maria' and 'Deveci' pear cultivars. *Yuzuncu Yıl University Journal of Agricultural Sciences,* 31(4): 870-875. https://doi.org/10.29133/yyutbd.940463

Kucuker, E., Ozturk, B., Ozkan, Y. ve Yıldız, K. (2015). Yapraktan üre uygulamasının farklı armut (*Pyrus communıs* L.) çeşitlerinde verim, meyve kalitesi ve bioaktif bileşikler üzerine etkisi. *Niğde Üniversitesi Mühendislik Bilimleri Dergisi,* 4(2): 78-86. (In Turkish)

Kurt, T., Öztürk, A. and Faizi, Z. A. (2022a). Survival rate of young pear trees in different rootstock and cultivar combinations under field conditions: Preliminary results. *Anadolu Tarım Bilimleri Dergisi,* 37(2): 405-420. https://doi.org/10.7161/omuanajas.1091137

Kurt, T., Öztürk, A. and Faizi, Z. F., (2022b). Determination of phenological and morphological characteristics of some standard pear cultivars on different quince clonal rootstocks. *The Black Sea Journal of Sciences*, 12(2): 782-801. https://doi.org/10.31466/kfbd.1153780

Ladaniya, M. S., Marathe, R. A., Das, A. K., Rao, C. N., Huchche, A. D., Shirgure, P. S. and Murkute, A. A. (2020). High density planting studies in acid lime (*Citrus aurantifolia* Swingle). *Scientia Horticulturae,* 261: 108935. https://doi.org/10.1016/j.scienta.2019.108935

Ladaniya, M. S., Marathe, R. A., Murkute, A. A., Huchche, A. D., Das, A. K., George, A. and Kolwadkar, J. (2021). Response of Nagpur mandarin (*Citrus reticulata* Blanco) to high density planting systems. *Scientific Reports,* 11(1): 1-11. https://doi.org/10.1038/s41598-021-89221-4

Lepaja, L., Kullaj, E., Lepaja, K., Shehaj, M. and Zajmi, A. (2014). Fruit quality parameters of five pear cultivars in Western Kosovo. *Agriculture & Food,* 2: 245-250.

Lepsis, J. and Drudze, I. (2011). Evaluation of seven pear rootstocks in Latvia. *Acta Horticulturae,* 903: 457-462. https://doi.org/10.17660/ActaHortic.2011.903.62

Maas, F. (2008). Evaluation of Pyrus and quince rootstocks for high density pear orchards. *Acta Horticulturae,* 800: 599-609. https://doi.org/10.17660/ActaHortic.2008.800.80

Massai, R., Loreti, F. and Fei, C. (2008). Growth and yield of 'Conference' pears grafted on quince and pear rootstocks. *Acta Horticulturae*, 800: 617-624. https://doi.org/10.17660/ActaHortic. 2008. 800.82

Meier, U., Garf, H., Hack, H., Hess, M., Kennel, W., Klose, R., Mappes, D., Seipp, D., Stauss, R., Streif, D. and van den Boom, T. (1994). Pome Fruits (*Malus domestica* Borkh. and *Pyrus communis* L.). In: Growth Stages of Mono- and Dicotyledonous Plants BBCH Monograph, Eds: Meier U., Julius Kühn-Institut (JKI), Quedlinburg, Germany. Pp. 204. https://doi.org/10.5073/20180906-075119

Mertoğlu, K. ve Evrenosoğlu, Y. (2017). Ateş Yanıklığı (*Erwinia amylovora*) hastalığına dayanıklılık ıslahında, hastalığa karşı testlenmiş F1 melez armut popülasyonunun fenolojik ve meyve özellikleri. *Tekirdağ Ziraat Fakültesi Dergisi,* 14(3): 104-115. (In Turkish)

Musacchi, S. (2008). Training Systems and Soil Management for Southern European Pear Orchards. *XXVII International Horticultural Congress, International Symposium on Enhancing Economic and Environmental Sustainability of Fruit Production in a Global Economy*, 31 August, P. 447-457. Seoul, Korea.

Musacchi, S., Iglesias, I. and Neri, D. (2021). Training systems and sustainable orchard management for European pear (*Pyrus communis* L.) in the Mediterranean area: A review. *Agronomy,* 11(9): 1765.

Oliveira, I. V. D. M., Lopes, P. R. C. and Silva-Matos, R. R. S. D. (2016). Phenological characterization of pear trees (*Pyrus communis* L.) 'Princesinha' under semi-arid conditions in the northeastern Brazil. *Revista Brasileira de Fruticultura,* 39(3): e-598.

Osmanoğlu, A., Şimşek, M. ve Şanlı, A. (2013). Bazı standart armut çeşitlerinin Bingöl ekolojisindeki performansı üzerinde bir araştırma. *Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi,* 23(3): 222-228. (In Turkish)

Özçağıran, R., Unal, A., Ozeker, E. ve İsfendiyaroglu, M. (2005). Armut. Ilıman İklim Meyve Türleri (Yumuşak Çekirdekliler) Cilt-II. Ege Üniversitesi Ziraat Fakültesi Yayınları, Bornova-İzmir, Türkiye. (In Turkish)

Ozturk, A. (2021). Farklı anaçlar üzerine aşılı 'Deveci'armudunun büyüme ve meyve kalite özellikleri. *Bağbahçe Bilim Dergisi,* 8(3): 179-187. (In Turkish)

Ozturk, A. and Ozturk, B. (2014). The rootstock influences growth and development of 'Deveci' Pear. *Turkish Journal of Agriculture and Natural Science,* 1: 1049-1053.

Ozturk, A., Demirsoy, L. ve Demirel, G. (2016). Seçilmiş bazı armut genotiplerinin Samsun ekolojisindeki fenolojik özelliklerinin belirlenmesi. *Bahçe,* 45(1): 1084-1089. (In Turkish)

Ozturk, A., Faizi, Z. A. and Kurt, T. (2022). Performance of some standard quince varieties under ecological conditions of Bafra, Samsun. *Yuzuncu Yıl University Journal of Agricultural Sciences,* 32(2): 320-330. https://doi.org/10.29133/yyutbd.1058908

Ozturk, I., Ercisli, S., Kalkan, F. and Demir, B. (2009). Some chemical and physico-mechanical properties of pear cultivars. *African Journal of Biotechnology,* 8(4): 687-693.

Pasa, M. D. S., Fachinello, J. C., Schmitz, J. D., Souza, A. L. K. D. and Franceschi, É. D. (2012). Desenvolvimento, produtividade e qualidade de peras sobre porta-enxertos de marmeleiro e *Pyrus calleryana*. *Revista Brasileira de Fruticultura,* 34(3): 873-880. https://doi.org/10.1590/S0100-29452012000300029 (In Potoguese)

Pasa, M. S., Fachinello, J. C., Rosa, Júnior, H. F., Franceschi, E., Schmitz, J. D. and Souza, A. L. K. (2015). Performance of 'Rocha' and 'Santa Maria' pear as affected by planting density. *Pesquisa Agropecuária Brasileira,* 50: 126-131. https://doi.org/10.1590/S0100-204X2015000200004

Pasquariello, M. S., Rega, P., Migliozzi, T., Capuano, L. R., Scortichini, M. and Petriccione, M. (2013). Effect of cold storage and shelf life on physiological and quality traits of early ripening pear cultivars. *Scientia Horticulturae,* 162: 341-350. http://dx.doi.org/10.1016/j.scienta.2013.08.034

Predieri, S., Gatti, E., Rapparini, F., Cavicchi, L. and Colombo, R. (2005). Sensory evaluation from a consumer perspective and its application to 'Abate Fetel' pear fruit quality. *Acta Horticulturae,* 671: 349-353.

Rapparini, F. and Predieri, S. (2002). Volatile constituents of 'Harrow Sweet' pears by dynamic headspace technique. *Acta Horticulturae,* 596: 811-816.

Sansavini, S. and Musacchi, S. (2002). European pear orchard design and HDP management: a review. Acta Horticulturae, 596: 589-601. https://doi.org/10.17660/ActaHortic. 2002. 596.103

Serttaş, S. ve Ozturk, A. (2020). Armut fidanlarının morfolojik özellikleri üzerine anaçların ve çeşitlerin etkisi. *Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi,* 6 (2): 175-185. (In Turkish)

Stern, R. A. and Doron, I. (2009). Performance of 'Coscia' pear (*Pyrus communis*) on nine rootstocks in the north of Israel. *Scientia Horticulturae,* 119(3): 252-256. https://doi.org/10.1016 /j.scienta.2008.08.002

Sugar, D. and Basile, S. R. (2011). Performance of 'Comice' pear on quince rootstocks in Oregon, USA. *Acta Horticulturae,* 909: 215-218. https://doi.org/10.17660/ActaHortic.2011.909.23

Urbina, V., Dalmases, J., Pascual, M. and Dalmau, R. (2003). Performance of `Williams' pear on five rootstocks. *Journal of Horticultural Science & Biotechnology,* 78(2): 193-196. https://doi.org/10.1080/14620316.2003.11511605

Uysal, E., Sağlam, M. T. ve Buyukyilmaz, M. (2016). Deveci armut çeşidinde farklı azot uygulamalarının verim ve bazı kalite özellikleri üzerine etkisi. *Bahçe,* 44(1): 1-13. (In Turkish)

Zerbini, E. P. (2002). The quality of pear fruit. *Acta Horticulturae,* 596: 805-810. https://doi.org/10.17660/ActaHortic.2002.596.139

Zhang, H. and Wang, J., Ye, S. (2008). Prediction of soluble solids content, firmness and pH of pear by signals of electronic nose sensors. *Analytica Chimica Acta,* 606: 112-118.

Zhang, J., Serra, S., Leisso, R. S. and Musacchi, S. (2016). Effect of light microclimate on the quality of 'd'Anjou' pears in mature open center tree architecture. *BioSystems Engineering,* 141: 1-11. https://doi.org/10.1016/j.biosystemseng.2015.11.002