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Research Article

Performance of Some Standard Quince Cultivars under Ecological Conditions of Bafra, Samsun

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Abstract: This study was carried out to determine the phenological, morphological, pomological, and yield characteristics of some standard quince cultivars. The earliest flowering occurred in 'Limon', and the earliest harvest was recorded in 'Gördes' cultivar. There were statistical differences between cultivars and years in terms of the examined characteristics. The highest rootstock diameter was observed in 'Limon', and the highest stem diameter was recorded in 'Gördes' quince cultivar. In the study, fruit weight varied between 334.91-377.93 g, geometric diameter varied between 86.02-87.26 mm, flesh firmness varied between 11.33-11.71 kg cm^{-2}, TSS content varied between 11.88-12.70 %, pH varied between 3.31-3.62, titratable acidity varied between 0.51-0.62 %. Fruit number per tree, yield per tree, yield per stem cross-section area, and yield per crown volume were higher in 'Limon' than in other cultivars. Among the cultivars, fruit number ranged from 33.07 to 51.62 tree $^{-1}$, yield ranged from 9.82 to 15.41 kg tree $^{-1}$, yield efficiency ranged from 0.61 to 0.95 kg cm^{-2}, and yield per crown volume ranged from 8.78 to 12.01 kg m^{-3}. Differences between cultivars in terms of L*, a*, and chroma were observed. While, no differences were determined between cultivars in terms of b* and hue^{o}. Among the cultivars, L* value varied from 62.58 to 76.83, the chroma varied from 33.10 to 45.11, and the hue^{o} varied from 111.98 to 115.06. As a result of the study, it can be said that the fruit yield and quality characteristics of 'Limon' cultivar were higher than the other cultivars.

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1. Introduction

The origin of quince (*Cydonia oblonga* Mill.) is Northern Iran, the Caspian Sea region, South Caucasus, and Anatolia. Also, Crimea, Northern Greece, Turkestan, Southern regions of Europe, and extending to North Africa, are said to be centers of origin as can be found in the wild form of in those areas (Ozcagiran et al., 2005). Quince, which is a pome fruit, has been more limited both in terms of distribution as well as a production area and amount compared to other pome fruits such as apple and pear (Ozcagiran et al. 2005; Bolat and Ikinci, 2015). According to FAO's 2019 data, 666 589 tons of quince is produced on a 93 699 ha area in 37 different countries, and Türkiye has a share of 27.1% in the world quince production with a production of 180 542 tons. China (125 480 tons, 18.8%), Uzbekistan (84 937 tons, 12.7%), and Iran (81 594 tons, 12.2%) followed Türkiye in terms of production amount.

Türkiye, which supplies 41.4% of the world's quince with an amount of 15 698 tons, is in the first place in quince export among 55 countries (FAOSTAT, 2021).

The use of vegetative propagation methods such as cuttings and adventive shoots in the quince, as it is a self-fertile fruit type that is very productive, easy to harvest and store, and without pollinator problems, has caused the number of varieties to be limited (Ozbek, 1978; Ercan and Ozkarakas, 2005; Ozcagiran et al., 2005). Quince varieties such as 'Bardak', 'Demir', 'Limon', 'Bencikli', 'Tekkeş', 'Midilli', 'Ege 22', and 'Eşme' are among the quince cultivars commercially are grown in Türkiye. Quince, which is less likely to be damaged by late spring frosts due to late flowering, can be grown in home gardens as a mix or in orchards in almost every region of Türkiye (Ozcagiran et al., 2005).

Quince fruits, whose fruit structure and ripening are similar to apples and pears, never soften excessively. In addition to its fresh consumption can be processed as jam, marmalade, fruit juice, canned food, etc. Quince, is also used as a dwarf rootstock for pear in moist soils (Ozbek, 1978; Ercan et al., 1992; Ozcagiran et al., 2005). Adaptation studies on quince are so less compared to apples and pears, and even it is pome fruit with the highest production after apples and pears.

Quince, which is a native plant of Anatolia, can be grown in almost all regions up to an altitude of 1 000 m (Ozcagiran et al., 2005). Quince production in Türkiye follows an increasing tendency every year, except for the years when extreme climatic conditions are experienced. Türkiye quince production amount was 189 251 tons in an area of 7 737 hectares in 2020, which Sakarya (103 238 tons, 54.6%) was the first in quince production, followed by Bursa (15 616 tons, 8.3%) and Denizli (7 312 tons, 3.9%) (TSI, 2021). The Black Sea Region has a share of 4.2% in the production area of pome fruits with 4.4% production amount in Türkiye, while it has a share of 3.1% in the quince production area and 5.4% in the production amount. In the Black Sea Region, which ranks 4th in quince production in Türkiye, Samsun ranks 3rd (12.0%) in Black Sea Region quince production after Amasya (36.1%) and Corum (13.2%). In the quince production of Türkiye, Samsun ranks 17th with 1 232 tons quince production (Ozturk and Serttas, 2021). In the province of Samsun, the Bafra district ranks 3rd with a total of 12 270 quince trees, of which 6 150 fruitings and 6 120 non-fruiting, with the production of 160 tons in 0.9 hectares (TSI, 2021). It is essential to determine the cultivation potential of new quince cultivars in the district and to reveal their performance in the production of quince, since the ecological conditions of the district are suitable and it has brought good income to the producer in recent years.

The objective of this study was to determine some phenological, morphological, pomological, and chemical properties of 'Gördes', 'Ekmek', and 'Limon' quince cultivars under ecological conditions of the Bafra district of Samsun.

2. Material and Methods

2.1. Materials

This study was carried out at the Bafra Agricultural Research Center of Ondokuz Mayis University (41°33'50" N, 35°52'23" E, and 20 m altitude) in 2018. Orchard was established with 1-year-old saplings at 3.5x3.5 m distances. In the study, 'Gördes', 'Ekmek', and 'Limon' quince cultivars grafted on BA-29 quince clone rootstock were used. The plants were irrigated with drip irrigation between 15 May to 15 September. Fertilization was done with 15-30-15+ME fertilizer at the beginning of summer and 20-20-20 NPK-containing fertilizer in autumn with drip irrigation. Weed control was carried out by mulching the black ground on the row and regularly breaking the weeds with a rotovator between the rows. The properties of experimental area soil were recorded as 2.73-10% clay (low), 13.21-20% silt (moderate), 6.5-20% sand (moderate), pH 7.5 (slightly alkaline), 0.2-0.3 dS m^{-1} salt (no salt), 0.3-0.5 organic matter (low), 3-6% lime ($CaCO_3$) (less), 0.03-0.06% N (less), 5-10 ppm P (medium) level and the soil depth was more than 1 meter.

2.2. Methods

2.2.1. Phenological observations

Phenological observations such as flower bud burst, first flowering, full flowering, and fruit set and harvest date in the examined quince cultivars were carried out according to Yarılgac (2001) and Ercan and Ozkarakas (2005). In addition, the number of days from full flowering to harvest was determined according to these phenological dates.

2.2.2. Morphological investigations

Rootstock diameter (mm) by measuring 10 cm below the grafting union with a digital caliper (Mitutoyo CD-20CPX) sensitive to 0.01 mm at the end of the growing season of all trees in each replication in each cultivar, trunk diameter by measuring the trunk from approximately 20 cm above the soil level (mm) was determined. Plant height (cm) was determined by measuring the distance between the soil level and the top of the shoot with a tape measure. In addition, crown width (cm), crown length (cm), and crown height (cm) were measured to determine the crown volume (m^3) and the trunk cross-sectional area (cm^2) using the trunk diameter (Ozturk and Ozturk, 2014; Kucuker and Aglar, 2021).

2.2.3. Pomological investigations

In the examined quince cultivars, 30 fruits were randomly harvested from each replication when the lint on the peel surface could be easily wiped off by hand and when the color of the fruit skin turned yellow. Fruit weight of the harvested fruits was determined by a digital scale (Weightlab WL-3002L) sensitive to 0.01 g, fruit width (mm), fruit length (mm), and fruit height (mm) were determined with a digital caliper sensitive to 0.01 mm, and the geometric diameter of the fruit was calculated (Ozturk et al., 2015). Flesh firmness (kg cm^{-2}) was determined using a hand penetrometer (Bicasa, Italy) with an 8 mm tip from two areas along the equatorial region of the fruit where the peel was removed. In the juice obtained from fruits, the amount of total soluble solids content (TSS, %) was determined by using a digital hand refractometer (Atago PAL-1, Japan), pH was determined by a digital pH meter (PHSJ-4A, China), and titratable acidity (%) was determined by the titration method (% malic acid) with 0.1 N NaOH (Kılıc et al. 1991). L*, a*, b*, chroma, and hue^o values in the fruit peel from both sides of the equatorial part of the fruit were determined with a color measuring device (Konica Minolta CR 300, Japanese).

In the examined cultivars, the number of fruits per tree (piece) by counting the fruits on each tree before harvest, the yield per tree (kg) by weighing the harvested fruit, and yield per cross-sectional area (kg cm^{-2}) was calculated as yield per tree divided by the trunk cross-sectional area. Also, yield per crown volume yield (kg m^{-3}) was calculated as yield per tree by dividing the crown volume (Bolat et al., 2019).

2.2.4. Statistical analysis

The research was established in a randomized block design with 3 replications and 5 plants in each replication. The obtained data were analyzed in the IBM SPSS 21.0 statistical package program, and the differences between the averages were determined by the 'Duncan Multiple Comparison Test' at $p<0.05$ level.

3. Results and Discussion

The earliest flower bud burst in quince cultivars grown in Bafra ecological conditions occurred on 10 April in 2020 and 13 March in 2021. In both experimental years, the first flowering and full flowering occurred in Limon at the earliest and in 'Ekmek' quince cultivars at the latest. Fruit set was observed in 'Gördes' at the earliest and in Limon quince at the latest during the experiment. In the research, the earliest fruit harvest in 2020 was observed in 'Gördes' variety on 29 September, Limon on 10 October at the latest while 'Gördes' on 5 October at the latest in 2021, followed by Limon quince on 18 October. The cultivar with the lowest number of days from full bloom to harvest in both experimental years was 'Gördes' (160 days and 150 days, respectively), and the cultivar with the highest number of days (174 days and 167 days, respectively) was recorded Limon quince (Table 1). In the research, it was determined that the phonological properties differ according to the cultivars and years. In the quince, Tekintas et al. (1991) cited that in local quince cultivars grown in the Van district, bud bursting was 4-5 May, full flowering was 24-28 May, and fruit harvest was 5-18 October; Koyuncu et al. (1999) reported that bud bursting was 08-14 May, first flowering was 14-20 May, full flowering was 22-25 May, end of flowering was 24-27 May, harvest date was 17-18 October, the number of days from full flowering to harvest was 146 - 148 days in Ekmek cultivar grown in Van district. Ercisli et al. (1999) reported that the fruit ripening date in quince varies according to varieties and years, and they reported that in some quince cultivars grown in Oltu (Erzurum) district, the earliest harvest occurred between 7-10 October in Ekmek cultivar and 23-27 October in Anzavdere genotypes at the latest. In quinces grown

in Gevaş (Van) district, flower bud burst on May 2-5, full bloom on May 15-20, fruit harvest on October 6-16 were occurred, and the number of days from full bloom to harvest varied between 143-151 days (Yarılgac, 2001). Ercan and Ozkarakas (2005) determined that the first flowering of 31 quince varieties and types selected from the Aegean Region was between 15 March to 10 April, full flowering between 23 March to 30 April and fruit harvest between 4 October to 28 November. The first flowering on 10-28 April, full bloom on 15 April - 2 May, the end of flowering on 22 April - 07 May, and the fruit harvested on 30 Sep - 5 Oct from Eşme and Limon quince cultivars in Tokat ecological conditions (Gercekcioglu et al., 2014). Eşme cultivar at ecological conditions of Şanlıurfa showed, bud burst on 19-26 March, the first flowering on 22-30 April, the full flowering on 27 April-7 May, harvest on 24 Oct. - 03 Nov., and the number of days from full flowering to harvest reported 180 days (Bolat and Ikinci, 2015). It can be said that the results of the phenological observations determined in our research are compatible with studies of others. It can be mentioned that the difference in phenological characteristics is due to the cultivar and the district where Quince is grown (Koyuncu et al., 1999; Ozcagiran et al., 2005). In the research, flowering and fruit set occurred shortly after the bud burst in 2020 (approximately 25 days), while in 2021, this period lasted for about 50-55 days. It can be said that this situation is due to the temperature difference between years. As a matter of fact, Ozbek (1978) stated that the flowering time varies according to the climatic conditions of the year, latitude, altitude and he also noted that the flowering period of a tree changes according to the weather conditions, as all the flowers on the tree open in a short time in hot and dry weather, unlike the flowering in the same tree could take longer in cool and rainy weather.

The effect of cultivars and production years on rootstock and stem diameter were significant. Average rootstock diameter varied between 57.35 to 62.63 mm in cultivars and 44.86 to 74.05 mm in years average. 'Limon' quince cultivar had the highest rootstock diameter (62.63 mm). The stem diameter varied between 45.54 to 50.49 mm in cultivar averages and 34.87 to 62.14 mm in terms of years average. The highest stem diameter (50.49 mm) was observed in the 'Gördes' quince (Table 2). Tatari et al., (2020) reported that rootstock diameter ranged from 8.80 mm to 11.06 mm in 3-year-old promising hybrid quince genotypes in Isfahan (Iran) ecological conditions. Bolat and Ikinci (2015) noted that the stem diameter ranged between 5.22 cm and 12.30 cm of 'Eşme' quince cultivar grown in Şanlıurfa ecological conditions during the 5-12 years of the experiment. Rootstock diameter obtained value was higher in the study than Tatari et al. (2020), and the trunk diameter was similar to the results of Bolat and Ikinci (2015). It can be said that the differences in results are due to the genetic structure and ecological differences of the growing region.

Table 1. Phenological features of some quince cultivars under Bafra ecological conditions

Cultivars	Flower bud burst date	First flowering date	Full flowering date	Fruit set date	Harvest date	Number of days from full flowering to harvest
				2020		
Gördes	12 April	16 April	23 April	1 May	29 September	160
Limon	10 April	14 April	20 April	5 May	10 October	174
Ekmek	12 April	18 April	24 April	3 May	1 October	171
				2021		
Gördes	15 March	3 May	7 May	10 May	5 October	150
Limon	13 March	1 May	5 May	15 May	18 October	167
Ekmek	15 March	5 May	8 May	13 May	10 October	161

The effect of the cultivars on the tree height in the examined quince cultivars was insignificant, but the research years were significant. The tree height was observed between 244.30 to 259.07 cm (Table 2).

Table 2. Morphological features of some quince cultivars under Bafra ecological conditions

Years	Cultivars	Rootstock diameter (mm)	Stem diameter (mm)	Tree height (cm)	Trunk cross section area (cm^2)	Crown volume (m^3)
2020	**Gördes**	47.92±2.9 c*	36.13±0.9 c	236.33±4.6 bc	10.26±0.5 c	0.52±0.3 c
	Limon	44.80±1.7 cd	35.30±1.1 c	234.05±5.3 bc	9.80±0.5 c	0.60±0.1 c
	Ekmek	41.86±0.9 d	33.19±0.4 c	230.10±8.7 c	8.65±0.2 c	0.54 ±0.1c
2021	**Gördes**	68.84±1.1 b	64.85±3.1 a	281.80±5.4 a	33.16±3.1 a	4.12±0.3 a
	Limon	80.46±1.6 a	55.77±0.9 b	273.13±8.7 a	24.67±3.4 b	4.41±0.1 a
	Ekmek	72.85±0.2 b	65.80±1.1 a	258.50± 8.5 ab	33.99±0.5 a	3.66±0.1 b
Factor Means						
Cultivar	**Gördes**	58.38±9.8 b	50.49±6.1 a	259.07±6.1 a	21.71±1.3 a	2.32±1.9 ab
	Limon	62.63±9.6 a	45.54±6.9 b	253.59±2.8 a	17.24±0.9 b	2.50±2.1 a
	Ekmek	57.35±7.5 b	49.49±7.1 ab	244.30±3.9 a	21.32±1.3 ab	2.10±1.7 b
Year	**2020**	44.86±4.1 b	34.87±1.8 b	233.49±6.9 b	9.57±1.1 b	0.55±0.2 b
	2021	74.05±5.4 a	62.14±6.5 a	271.14±7.1 a	30.61±6.0 a	4.06±0.4 a
Probability						
Year		0.001	0.001	0.001	0.001	0.001
Cultivar		0.019	0.001	0.214	0.043	0.050
Year x Cultivar		0.003	0.043	0.052	0.046	0.099

*: values within the same columns followed by different letters were significantly different ($p < 0.05$) for each parameter.

The tree height was observed 2.34-2.76 m in the 3-year-old 'Eşme' quince cultivar grafted on the quince seedling and 2.49-2.80 m in the Limon quince cultivar at the ecological conditions in Tokat (Gercekcioglu et al., 2014). The same researchers stated that the difference between the production years, especially the results of the following years compared to the first year, was due to the differences in the age and growth vigor of the trees. The effects of research years and varieties on trunk cross-sectional area and crown volume were significant. The highest trunk cross-sectional area was in 'Gördes' (21.71 cm^2) and the lowest (17.24 cm^2) in 'Limon' cultivar. The highest crown volume was in the 'Limon' (2.50 m^3) and the lowest (2.10 m^3) in the 'Ekmek' cultivar. According to the research years, the trunk cross-sectional area varied between 9.57-30.61 $cm^{2,}$ and the crown volume varied between 2.10-2.50 m^3 (Table 2). Bolat and Ikinci (2015) stated that, the trunk cross-sectional area changes according to the years, found that the trunk cross-sectional area of 'Eşme' quince cultivar was 21.41 cm^2 in 5-year-old plants and 118.83 cm^2 in 12-year-old plants in Şanlıurfa ecological conditions. Gercekcioglu et al., (2014) stated that the crown volume varies according to years and cultivars, and they reported that the crown volume was 1.75-2.16 m^3 in 'Esme' and 1.93-2.16 m^3 in Limon quince cultivars in Tokat ecological conditions. Researchers have pointed out that the difference in cultivars is due to genetic structure and growing conditions. In contrast, the difference in terms of years is due to the age of the trees and ecological conditions. Although the examined cultivars in the study were three years old, slightly higher stem cross-sectional area and crown volume were determined compared to studies including similar cultivars of the same age in different ecological conditions. We can attribute this situation to the fact that the research area has the ideal sandy-loam soil structure and climatic characteristics desired by the quince and the regular annual maintenance operations such as irrigation, fertilization, and weed removal.

The cultivars and research years had significant effects on fruit weight in the study. The fruit weight varied between 334.91 g (Limon) - 377.93 g (Gördes) in terms of cultivar averages and 276.34 g - 431.34 g in terms of research years average (Table 3). The fruit weight of quince cultivars observed 209.4-272.0 g in quinces from Van district by Tekintas et al. (1991); 205.3 g (Limon) - 435.0 g (Midilli) in Aegean Region by Ercan et al. (1992); 255.56 g-530.0 g in Oltu district by Ercisli et al. (1999); 168.9-203.1 g in the Van district by Koyuncu et al. (1999); 121.84-350.96 g in Gevaş (Van) district by Yarılgac (2001); 198.3-452.8 g in Aegean Region by Ercan and Ozkarakas (2005); 257.4-510.4 g in Marmara Region by Buyukyilmaz and Yalcınkaya (2007); 269.4-409.6 g in Kalecik clones by Dumanoglu et al. (2009); 196.93-461.62 g in Çukurova conditions by Kuden et al. (2009); 194.01-297.86 g in Spain by Rodriguez-Guisado et al. (2009); 265.4-415.9 g in some quince clones by Legua et al. (2013); 330.08 g (Eşme) - 352.86 g (Limon) by Gercekcioglu et al. (2014) in Tokat ecology; 349.26 g in Şanlıurfa

conditions by Bolat and Ikinci (2015); 175.12-329.44 g by Erçisli et al. (2015); 88.0-573.0 g by Pinar et al. (2016) in quinces in Egirdir conditions; 135.63-530.74 g by Koc and Keles (2018) in Yozgat conditions. Fruit weight seems to be consistent with previous studies.

Table 3. Pomological features of some quince cultivars under Bafra ecological conditions

Years	Cultivars	Fruit weight (g)	Fruit width (mm)	Fruit length (mm)	Geometric diameter (mm)
2020	**Gördes**	432.30±9.1 a*	91.21±2.1 a	103.73±5.8 a	94.31±2.5 a
	Limon	403.51±3.2 b	92.01±2.1 a	91.42±2.7 ab	90.14±2.1 ab
	Ekmek	458.20±9.4 a	94.18±1.4 a	98.22±2.1 ab	93.90±0.7 a
2021	**Gördes**	323.55±5.4 a	76.00±3.6 b	86.33±7.3 b	80.22±5.4 b
	Limon	266.31±4.9 b	78.33±1.4 b	90.33±1.9 ab	81.91±0.9 b
	Ekmek	239.17 ±9.5 b	80.67±5.7 b	92.00±4.9 ab	85.20±5.6 ab
Factor Means					
Cultivar	**Gördes**	377.93±6.1 a	83.61±5.3 a	95.03±4.1 a	87.26±6.4 a
	Limon	334.91±7.5 b	85.17±5.6 a	90.88±3.6 a	86.02±5.1 a
	Ekmek	348.68±6.3 b	87.43±5.4 a	95.11±4.7 a	89.55±7.7 a
Year	**2020**	431.34±2.8 a	92.47±3.1 a	97.79±7.9 a	92.78±3.4 a
	2021	276.34 ±3.8 b	78.33±6.3 b	89.56±8.2 a	82.44±7.4 b
Probability					
Year		0.001	0.001	0.049	0.001
Cultivar		0.001	0.495	0.589	0.600
Year x Cultivar		0.001	0.957	0.234	0.040

*: values within the same columns followed by different letters were significantly different ($p < 0.05$) for each parameter.

There was an insignificant effect of cultivars on fruit width, fruit length, and geometric diameter in this study. The fruit width varied between 83.61 - 87.43 mm among the cultivars, fruit length 90.88 - 95.11 mm, and geometric diameter between 86.02 - 89.55 mm (Table 3). Ercisli et al. (1999) in the quinces of Oltu district reported, fruit width 78.98-102.37 mm, fruit length 72.58-121.24 mm; Koyuncuoglu et al. (1999) in Ekmek quince cultivar observed, fruit width 7.38-7.57 cm, fruit length 8.35 cm; Yarılgac (2001) said that, fruit width was 5.83-8.19 cm, fruit length was 5.64-9.81 cm in Gevas district quinces; Dumanoglu et al. (2009) in Kalecik quince clones in Ankara ecological conditions expressed which, fruit width was 77.3-88.3 mm, fruit length was 92.9-112.6 mm; Rodriguez-Guisado et al. (2009) recorded that, in quince clones originating from Spain fruit width was 74.53-86.07 mm, fruit length was 76.01-85.62 mm; Gercekcioglu et al. (2014) in Eşme and Limon quinces observed that, fruit width was 81.16-90.89 mm, fruit length was 93.63-111.38 mm; according to Bolat and Ikinci (2015) Esme quince cultivar had a fruit width of 87.62 mm, a fruit length of 98.64 mm, and a fruit volume of 429.32 cm^3; Pinar et al. (2016) examined fruit width of 63.0 mm, fruit length of 50.0 mm; Koc and Keles (2018) said that fruit width was 6.32-9.36 cm, fruit length was 5.32-10.84 cm; Uzun et al. (2020) reported that fruit width was between 44.81-79.25 mm and fruit length was between 55.62-94.03 mm in quince genotypes collected from Kayseri district. Emphasizing that the variety has a significant effect on fruit sizes, Ercisli et al. (2015) found that fruit width was 68.56-90.53 mm, fruit length was 75.32-91.68 mm, the geometric diameter was 70.72-90.98 mm, and fruit volume was 185.39-391.98 cm^3 in the quince cultivars they examined. It can be said that the results about fruit sizes obtained from the research are compatible with similar previous studies.

There was no significant effect of cultivars and research years on the fruit firmness of the examined quince cultivars. The fruit flesh firmness ranged between 11.33-11.71 kg cm^{-2} in the study. The cultivars and research years had significant effects on TSS, pH, and acidity. In terms of cultivar averages, TSS content varied between 12.70-11.88%, pH 3.31-3.62, acidity 0.51-0.62%. The highest TSS (12.70%) in 'Ekmek', pH (3.62), and acidity (0.62%) in 'Limon' were determined (Table 4).

Table 4. Chemical features of some quince cultivars grown under Bafra ecological conditions

Years	Cultivars	Flesh firmness (kg cm^{-2})	Total Soluble Solid (%)	pH	Titratable acidity (%)
	Gördes	11.58±0.3 a*	12.67±0.8 b	3.15±0.1 d	0.47±0.1 d
2020	**Limon**	11.50±0.3 a	12.93±0.8 ab	3.56±0.1 bc	0.49±0.2 d
	Ekmek	11.67±0.2 a	13.20±0.2 a	3.18±0.1 d	0.48±0.1 d
	Gördes	11.17±0.8 a	11.53±0.1 d	3.96±0.1 a	0.61±0.2 b
2021	**Limon**	11.92±0.4 a	10.83±0.1 e	3.68±0.1 b	0.75±0.1 a
	Ekmek	11.00±0.1 a	12.20±0.2 c	3.44±0.1 c	0.55±0.1 c
Factor Means					
	Gördes	11.38±0.9 a	12.10±0.6 b	3.56±0.4 a	0.54±0.1 b
Cultivar	**Limon**	11.71±0.6 a	11.88±1.1 b	3.62±0.1 a	0.62±0.1 a
	Ekmek	11.33±0.4 a	12.70±0.6 a	3.31±0.4 b	0.51±0.1 b
Year	**2020**	11.58±0.4 a	12.93±0.3 a	3.30±0.2 b	0.48±0.1 b
	2021	11.36±09 a	11.52±0.6 b	3.69±0.2 a	0.63±0.1 a
Probability					
Year		0.523	0.001	0.001	0.001
Cultivar		0.622	0.001	0.001	0.001
Year x Cultivar		0.474	0.001	0.001	0.001

*: values within the same columns followed by different letters were significantly different ($p < 0.05$) for each parameter.

Ercisli et al. (1999) reported that the flesh firmness was 1.21-3.86 kg (with a 5 mm tip), TSS was 11.80-16.00%, the pH was 3.53-4.06, the acidity was 0.51-2.06% in quinces from Oltu district; Koyuncu et al. (1999) noted that the flesh firmness was 7.79-8.74 kg cm^{-2}, the TSS was 12.16-14.20%, the pH was 3.11-3.39, the acidity was 1.45-1.70% in the Ekmek cultivar grown in Van district; Yarılgac (2001) cited that, flesh firmness was 9.01-10.74 lb (with 11.1 mm tip), The TSS was 9.95-17.80%, pH was 3.11-6.65, acidity was 0.59-1.41% in the Gevaş district; Ercan et al. (2005) reported that, the flesh firmness was 6.25-14.50 lb cm^{-2} (with 11.1 mm tip), TSS was 11.75-17.10% in quinces collected from the Aegean Region; Buyukyilmaz and Yalcınkaya (2007) cited that, the fruit firmness was 4.80-6.88 kg, the TSS was 14.7-15.9%, the acidity was 1.01-1.85 g 100 ml^{-1}; Dumanoglu et al. (2009) noted that, the flesh firmness was 64.7-80.2 N, the TSS was 12.8-16.5%, the acidity was 0.9-1.5% in Kalecik quince clones under Ankara ecological conditions; Kuden et al. (2009) determined that, the TSS was 12.85-17.28%, acidity was 0.71-1.22% in quinces under Pozanti (Adana) ecological conditions; Rodriguez-Guisado et al. (2009) cited that, TSS was 15.0-17.20%, pH was 3.96-4.09, acidity was 4.03-5.46 g L^{-1} in quince clones originating from Spain; Legua et al. (2013) cited that flesh firmness was 4.73-9.85 kg cm^{-2} (with 8 mm tip), TSS was 13.40-18.63%, acidity was 5.28-9.54 g malic acid L^{-1}; Gercekcioglu et al. (2014) reported that the flesh firmness of Eşme and Limon quince cultivars was 36.30-39.21 lb, the TSS was 13.37-13.93%, pH was 2.71-3.26, acidity was 8.38-12.91 g L^{-1} In the ecological conditions of Tokat; Szychowski et al. (2014), who reported that fruit firmness was 5.08-11.60 kg, TSS was 11.3-15.5%, pH was 2.82-3.05, acidity was 0.99-1.56% in Spanish quince clones; Bolat and Ikinci (2015) reported that the flesh firmness was 7.73 kg cm^{-2} (with 8 mm tip), TSS was 15.60%, pH was 3.49, acidity was 0.63% of Eşme cultivar in Şanlıurfa condition; Pinar et al. (2016) cited that fruit firmness was 5.08-11.60 kg, TSS was 11.3-15.5%, pH was 2.82-3.05, acidity was 0.99-1.56% in some important quince cultivars; Uzun et al. (2020) reported that the TSS varied between 9.00-18.00% and acidity between 0.61-2.40% in quinces collected from Kayseri district. It can be said that the results obtained from the research are compatible with the results of similar studies used in the research, some of which are also used, and the differences that arise are caused by the genetic structure, ecology, rootstock, and care conditions.

Except for yield on crown volume, cultivars had a significant effect on the number of fruits per tree, yield per tree, and the yield on trunk cross-sectional area in this study. The effects of the research years on the number of fruits per tree, yield per tree, the yield on the trunk cross-sectional area, and the yield on the crown volume were significant (Table 5).

Table 5. Yield performance of some quince cultivars grown under Bafra ecological conditions

Years	Cultivars	Fruit number (pieces tree $^{-1}$)	Yield (kg tree $^{-1}$)	Yield per trunk cross sectional area (kg cm^{-2})	Yield per crown volume (kg m^{-3})
2020	**Gördes**	15.76±0.2 c*	6.82±0.3 e	0.67±0.1 bc	13.21±0.4 a
	Limon	24.62±1.5 c	9.94±0.7 cd	1.03±0.1 a	19.27±3.1 a
	Ekmek	17.43±1.1 c	7.96±0.2 de	0.92±0.1 a	15.18±2.2 a
2021	**Gördes**	54.87±1.5 b	17.77±0.8 b	0.55±0.1 cd	4.36±0.4 b
	Limon	78.62±6.1 a	20.88±1.3 a	0.87±0.2 ab	4.74±0.3 b
	Ekmek	48.70±1.2 b	11.67±0.7 c	0.34±0.1 d	3.18±0.1 b
Factor Means					
Cultivar	**Gördes**	35.31±2.1 b	12.29±6.1 b	0.61±0.1 b	8.78±1.9 a
	Limon	51.62±3.1 a	15.41±6.2 a	0.95±0.2 a	12.01±2.1 a
	Ekmek	33.07±1.7 b	9.82±2.2 c	0.63±0.3 b	9.18±1.7 a
Year	**2020**	19.27±4.3 b	8.24±1.5 b	0.87±0.2 a	15.89±0.2 a
	2021	60.73±4.7 a	16.77±4.3 a	0.59±0.2 b	4.09±0.4 b
Probability					
Year		0.001	0.001	0.001	0.001
Cultivar		0.001	0.001	0.003	0.341
Year x Cultivar		0.004	0.001	0.013	0.484

*: values within the same columns followed by different letters were significantly different ($p < 0.05$) for each parameter.

The number of fruits varied between 33.07-51.67 tree $^{-1}$ and the yield per tree varied between 9.82-15.41 kg, the yield on trunk cross-sectional area varied between 0.61-0.95 kg cm^{-2}, and the yield on the crown volume varied between 8.78-12.01 kg m^{-3} in the examined cultivars. The highest number of fruits per tree, yield per tree, the yield on trunk cross-section area, and the yield on crown volume were determined in Limon (51.62 tree $^{-1}$, 15.41 kg tree $^{-1}$, 0.95 kg cm^{-2}, and 12.01 kg m^{-3}, respectively) (Table 5). Ercan et al. (2005) reported that yield per tree ranged between 31.61-178.50 kg in the unknown rootstock and age of quince cultivars; Buyukyilmaz and Yalcınkaya (2007) noted that yield in trunk cross-sectional area was 0.33-4.61 kg for promising quince cultivars for the Marmara Region; Gercekcioglu et al. (2014) cited that number of fruits per tree was 7.22-23.44 and the yield per tree was 2.5-6.33 kg in Eşme and Limon quince cultivars in the ecological conditions of Tokat; Bolat and Ikinci (2015) reported that the yield per plant varies between 5.1-47.6 kg and the yield per trunk cross-sectional area varies between 219.46-400.52 g cm^{-2} due to the research years in Eşme cultivar in Sanliurfa district. The number of fruit per tree and the yield were generally higher in the second year than in the study's first year. It is stated that the number of fruits per tree and the yield increase as progress the age of trees (Gercekcioglu et al., 2014; Bolat and Ikinci, 2015). It was determined that the yield on trunk cross-sectional area and crown volume was higher in the first year of the study than in the second year. In this case, it is thought that the trunk cross-sectional area and crown volume increased faster (approximately 4 times increase) in the second year compared to the first year of the study. According to this fast increase, the fact that the yield did not increase in the same way was effective in lowering these values compared to the first year.

The effect of cultivars on L*, a*, and chroma of fruit skin color characteristics of quince cultivars examined in the study was significant, but the effect on b* and hue^{o} was insignificant. The L* value, which expresses the brightness of the fruit skin in quince varieties, was the highest in the Limon (76.83) and the lowest in the 'Ekmek' (62.58). The a* value was the highest (-14.66) in the 'Gördes' and the lowest (-17.69) in the 'Limon'. The b* value, which represents the yellowness of the bark, ranged from 28.50 to 46.77. The chroma value, which is the saturation of the color, was the highest (45.11) in the 'Gördes' and the lowest (33.10) in the 'Ekmek'. The hue^{o} value varied from 111.98 to 115.06 (Table 6).

Table 6. Fruit skin color values of some quince cultivars under Bafra ecological conditions

Years	Cultivar	L*	a*	b*	Chroma	Hue^o
2020	**Gördes**	50.49±0.9 d*	-13.29±0.2 a	26.72±0.2 a	31.93±0.7 d	118.08±.04 a
	Limon	68.59±1.5 b	-18.53±0.2 c	35.18±1.1 a	38.94±1.1 bc	118.11±0.1 a
	Ekmek	58.38±0.1 c	-16.34±0.1 b	31.45±0.2 a	31.81±0.8 d	115.84±0.5 ab
2021	**Gördes**	84.01±2.8 a	-16.02±0.6 b	30.27±2.2 a	58.28±3.0 a	105.88±0.2 c
	Limon	85.07±1.2 a	-16.85±0.1 b	58.37±1.4 a	40.29±0.1 b	112.02±0.5 b
	Ekmek	66.77±2.4 b	-18.69±0.7 c	36.97±0.6 a	34.40±1.3 cd	113.53±3.7 b
Factor Means						
Cultivar	**Gördes**	67.25±1.8 b	-14.66±1.6 a	28.50±2.4 a	45.11±1.4 a	111.98±6.7 a
	Limon	76.83±0.9 a	-17.69±0.9 b	46.77±2.1 a	39.61±1.4 b	115.06±3.4 a
	Ekmek	62.58±0.5 c	-17.51±1.5 b	34.21±2.8 a	33.10±2.2 c	114.68±3.7 a
Year	**2020**	59.15±0.9 b	-16.05±2.2 a	31.12±3.8 a	34.22±3.7 a	117.34±1.2 a
	2021	78.62±0.5 a	-17.18±1.4 b	41.87±6.5 a	44.32±4.4 b	110.48±4.5 b
Probability						
Year		0.001	0.007	0.254	0.001	0.001
Cultivar		0.001	0.001	0.273	0.001	0.086
Year x Cultivar		0.001	0.001	0.628	0.001	0.011

*: values within the same columns followed by different letters were significantly different ($p < 0.05$) for each parameter.

The hue^o value close to 0 indicates the color change from red to a distance from 0 indicates the change of color from yellow to green (McGuire, 1992). Dumanoglu et al. (2009) noted that the hue^o value in the fruit peel of Kalecik quince clones was 88.5-100.2 in the ecological conditions of Ankara; Gercekcioglu et al. (2014) cited that L* value varied between 69.76-81.52, a value varied -19.40 to -4.47, b value varied 54.66-63.40 of Ekmek and Limon quince grown in Tokat ecological condition; Ercisli et al. (2015) stated that the L* value varied between 79.63-81.49, a* value varied between -3.07 to -6.38, b* value varied between 56.47-65.14, chroma varied between 56.83-65.22, hue^o varied between 92.70-96.47 in quince cultivars grown in Coruh Valley. It is stated that chroma and hue^o values are the most effective parameters in defining the color characteristics, and color of the fruit skin is the most important indicator of maturity and external quality in quince (Ozcagiran et al., 2005; Ercisli et al., 2015). It can be said that the results determined in the research are compatible with previous studies carried out in similar ecology.

4. Conclusion

The quince cultivars were grafted on BA-29 quince clonal rootstock and were investigated the adaptation to the region where this research was carried out in Bafra (Samsun) ecological conditions. The highest fruit weight was obtained from 'Gördes', the highest TSS content was obtained from 'Ekmek', and the highest acidity was obtained from 'Limon' quince. The highest number of fruits per tree, yield per tree, and yield per trunk cross-section area and crown volume were obtained from the 'Limon' quince cultivar. Since the research was carried out in the 2nd and 3rd years following the sapling planting, the trees were young trees that had not yet fully yielded. In order to obtain more precise results about the performance of the cultivars, it may be appropriate to continue the trial and make a decision based on the long-term data to be obtained. As a result of the research, it can be said that the fruit yield and quality characteristics of 'Limon' quince cultivar were better than the other examined quince cultivars.

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