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Bazı Armut Genotiplerine Ait Meyvelerde Değişen İklim Koşullarında Bazı Pomolojik ve Biyokimyasal Özelliklerin Değişimi

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ÖZ

Günümüz koşullarında, kuraklık, iklim değişikliği vb. şartlar üretimi ve ürün kalitesini ciddi bir şekilde etkilemeye başlamıştır. Bu durumu ortaya koymak amacıyla, farklı 10 farklı armut genotipi, burukluk durumuna göre, buruk olan (B) genotipler ve buruk olmayan (D) genotipler olarak gruplandırılmıştır. Genotiplerin pomolojik ve biyokimyasal ölçümleri değerlendirilmiştir. Buruk (B) ve buruk olmayan (D) genotiplerin (en, boy, ağırlık, alt ve üst renk, sertlik), meyve üst ve alt kabuk renk ölçümleri (L, a, b, C ve h°), suda çözünür kuru madde (SÇKM), pH, titre edilebilir asitlik (TEA), C vitamini, fenolik madde içeriği ve antioksidan kapasite değerlerinin ortalaması gruplar arasında istatistiksel olarak karşılaştırılmıştır. Kabuk alt renk a, kabuk üst renk L, b ve °h değerlerinin yüksek olduğu genotipler buruk olmayan (D) genotipler iken, kabuk alt renk °h, kabuk üst renk a değerlerinin yüksek olduğu genotipler buruk olan (B) genotipler olmuştur. Biyokimyasal ölçümler sonucunda belirlenen SÇKM değeri, buruk genotiplerde istatistiksel olarak yüksek, pH değeri ise buruk olmayan genotiplerde yüksek bulunmuştur. Titre edilebilir asitlik (TEA) ve C vitamini ortalama değerleri, buruk genotiplerde istatistiksel bakımdan buruk olmayanlara göre yüksek olmuştur. Toplam fenol ve antioksidan kapasite ise gruplar arasında istatistiksel olarak önemli bir fark oluşturmamıştır.

Anahtar Kelimeler: Armut, genotip, stres faktörleri, *Pyrus communis*

Alterations in Selected Pomological and Biochemical Characteristics of Fruits from Certain Pear Genotypes Under Changing Climatic Conditions

ABSTRACT

Under prevailing environmental conditions, stressors such as drought and climate change have emerged as significant factors impacting agricultural productivity and crop quality. To investigate this phenomenon, ten distinct pear genotypes were classified into astringent (A) and non-astringent (N) categories based on their inherent astringency levels. Pomological and biochemical characteristics of the genotypes were systematically analyzed. A comparative statistical analysis was performed on mean values of pomological traits (fruit width, length, weight, upper/lower surface coloration, firmness), peel color parameters (L*, a*, b*, chroma [C*], hue angle [°h]), soluble solid content (SSC), pH, titratable acidity (TA), vitamin C concentration, total phenolic content, and antioxidant capacity between the two groups. Genotypes exhibiting elevated a* values in lower peel coloration and higher L*, b*, and °h values in upper peel coloration were categorized as non-astringent (N). Conversely, genotypes with increased °h values in lower peel coloration and elevated a* values in upper peel coloration were classified as astringent (A). Biochemical analyses revealed significantly higher SSC in astringent genotypes, whereas non-astringent genotypes demonstrated greater pH levels. Mean TA and vitamin C concentrations were statistically higher in astringent genotypes compared to non-astringent counterparts. However, total phenolic content and antioxidant capacity showed no statistically significant intergroup differences.

Keywords: Pear, genotype, stress conditions, *Pyrus communis*

INTRODUCTION

Among the *Pyrus* species cultivated worldwide, *Pyrus communis* L. is the most economically important and widely cultivated species in commercial production [1, 2]. However, accurately determining the total number of pear species globally poses a significant challenge due to their high propensity for interspecific hybridization, which has led to the emergence of numerous hybrids with complex taxonomic classifications. The genetic characterization of these species remains incomplete, primarily due to their limited morphological diversity, the lack of clearly defined diagnostic traits,

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and the widespread occurrence of interspecific hybridization. Consequently, assessing the genetic diversity within the genus *Pyrus* is inherently complex and remains an ongoing area of research [3].

According to the 2023 FAO data, global pear production amounted to 26,507,458 tons, with China being the largest producer at 19,852,600 tons. Other major producers included Argentina (653,838 tons), the United States (603,730 tons), Turkey (534,513 tons), South Africa (481,357 tons), Belgium (381,310 tons), the Netherlands (354,000 tons), Spain (288,030 tons), India (271,000 tons), and Italy (255,700 tons) [4].

Drought imposes significant physiological constraints and disrupts critical biochemical processes, resulting in substantial reductions in crop yield and quality. Water scarcity is becoming an increasingly prevalent challenge in fruit-growing regions, particularly those characterized by Mediterranean climates [5].

It has been reported that different levels of water stress significantly restrict morphological and physiological responses in various pear species (*P.biossieriana*, *P.communis*, *P.glabra*, *P.salicifolia* and *P.syriaca*), leading to reductions in leaf relative water content, net photosynthetic rate, stomatal conductance, transpiration rate, and intercellular carbon dioxide concentration [6].

Global climate change has led to an increase in the duration and intensity of drought, resulting in the emergence of hotter and drier conditions in climatic zones, including Turkey. Plants respond to abiotic stress factors such as drought, high temperatures, and salinity by inducing physiological and metabolic changes that minimize the adverse effects on their growth and development [7].

The selection of drought-resistant genotypes is one of the most effective approaches to addressing drought-related challenges [8]. Due to its resilience to drought, pears have a widespread global distribution and rank as the second most cultivated fruit species after apples. Temperature is generally considered the most critical factor influencing the phenological stages of fruit trees in temperate climates [9, 10]. In essence, higher temperatures accelerate biochemical reactions, which in turn extend the growing period and impact the phenological development of plants [10].

The aim of this study is to evaluate the effects of stress factors (such as drought and climate change) under current conditions on both the pomological properties (width, length, weight, lower and upper color, firmness) and biochemical parameters (soluble solid content (SSC), pH, titratable acidity (TA), vitamin C, total phenolic content, and antioxidant capacity) of newly developed pear genotypes with the potential to be introduced as cultivar candidates. By conducting this comparative analysis, the study will also determine the susceptibility of these candidate cultivars to climate and temperature variations across different regions, thereby facilitating more informed cultivar recommendations.

MATERIALS AND METHODS

In this study, pear fruits and fruit juice samples from ten different genotypes harvested in 2021 were utilized. The research was conducted using ten hybrid pear genotypes obtained from the hybrid pear plot located at S.S. Odemis Bademli Arboriculture and Agricultural Development Cooperative in Bademli Village, Odemis District, Izmir Province. The average temperature and precipitation data for the region over the past five years, as well as the specific values recorded in 2021, were analyzed. In April 2021, during the flowering period, the recorded maximum and minimum temperatures were either higher or lower than the five-year average. Additionally, these extreme temperature fluctuations were accompanied by a significant decrease in precipitation levels, which continued throughout May, remaining well below the long-term average rainfall patterns (Tables 1 and 2).

Table 1. Monthly temperature and precipitation averages for Izmir-Odemis, Bademli village (2017-2022) based on data from the Odemis Tepe Meteorological Station

Months	Temperature (°C)			Rainfall (mm)
	Average	Maximum	Minimum	Sum
January	6,46	18,74	-5,65	100,04
February	8,71	20,45	-3,47	57,52
March	9,99	24,05	-3,25	43,72
April	15,38	31,43	0,62	27,60
May	20,87	38,39	6,55	32,32
June	23,77	37,49	10,30	34,76
July	26,87	39,89	13,73	3,25

Table 2. Monthly temperature and precipitation averages for Izmir-Odemis, Bademli village in 2021 (based on data from the Odemis Tepe Meteorological Station)

Date/Time	Temperature (°C)			Rainfall (mm)
	Average	Maximum	Minimum	Sum
January	8,17	21,38	-6,40	134,40
February	8,89	21,90	-5,65	15,60
March	8,40	23,25	-3,56	77,40
April	14,78	33,51	-1,99	9,40
May	21,60	37,85	7,32	0,20
June	22,81	37,82	8,97	29,80
July	27,60	41,30	14,35	2,40

In this study, ten genotypes were used, each represented by a specific code based on their parental cross (main parent × pollinator) and classified according to their fruit taste as either astringent (A) or non-astringent (N). The genotypes are listed in the following table (Table 3). In none of the types with the characteristics described below was astringency in fruit flavor identified until the years when extreme heat and drought were observed.

Table 3. Genotypes used in the study and their characteristics

Genotype No	Main Parent × Pollinator	Astringency Status
24-59	Santa Maria × Bursa	N (non-astringent)
27-580	Santa Maria × Kaiser Alexandre	N (non-astringent)
22-384	Santa Maria × Akca	N (non-astringent)
2-11-19	Kieffer × Santa Maria	N (non-astringent)
1-22-2	Mustafabey × Guz	N (non-astringent)
2-15-93	Magness × Santa Maria	A (astringent)
2-15-94	Magness × Santa Maria	A (astringent)
27-599	Santa Maria ×Kaiser Alexandre	A (astringent)
2-12-97	Kieffer Serbest	A (astringent)
1-23-22	Mustafabey × Moonglow	A (astringent)

•24-59: A type harvested at the end of August, medium in size, with a slight red blush. It has white flesh, is juicy, sweet, and flavorful.

•27-580: A large type harvested at the end of August, exhibiting a slight red blush. It has white flesh with a slightly gritty texture. It is sweet and flavorful.

Figure 1. Fruits of genotype no. 24-59

Figure 2. Fruits of genotype no. 27-580

•22-384: A type harvested from mid- to late August, characterized by small fruit with a red blush. It has creamy-white flesh with a gritty texture, and is sweet and flavorful.

•2-11-19: A medium-sized type harvested at the end of August, exhibiting a slight red blush. The fruit flesh is creamy in color, buttery in texture, juicy, and flavorful.

Figure 3. Fruits of genotype no. 22-384

Figure 4. Fruits of genotype no. 2-11-19

•1-22-2: A small-sized type harvested from late July to late August, characterized by a red blush. The fruit flesh is creamy-white in color, sweet, juicy, and flavorful.

•2-15-93: A very large-sized type harvested in the first half of September, exhibiting a red blush. The fruit flesh is creamy in color, sweet, juicy, and flavorful.

Figure 5. Fruits of genotype no. 1-22-2

Figure 6. Fruits of genotype no. 2-15-93

•2-15-94: A very large-sized type harvested in the first half of September, exhibiting a very slight red blush. The fruit flesh is creamy in color, juicy, and flavorful.

•27-599: A very large-sized type harvested at the end of August. It has white flesh with a slightly gritty texture, and is sweet and juicy.

•2-12-97: A medium-sized type harvested in mid-August, exhibiting a slight red blush. The fruit flesh is creamy in color, juicy, and flavorful.

•1-23-22: A type harvested in the first half of August, characterized by small fruit with a slight red blush. The fruit flesh is creamy in color, sweet, juicy, and flavorful.

Figure 7. Fruits of genotype no. 2-15-94

Figure 8. Fruits of genotype no. 27-599

Figure 9. Fruits of genotype no. 2-12-97

Figure 10. Fruits of genotype no. 1-23-22

In this study, all pomological parameters were measured and recorded from ten fruits per genotype, representing the average values for each genotype. Fruit width and length were measured at the widest points of the fruit using a caliper and recorded in millimeters (mm). Fruit weight was determined using a precision scale and recorded in grams (g). Fruit flesh firmness was measured using a hand penetrometer (GY-3) with a 7.8 mm probe and recorded in kg/cm². Peel color values (upper and lower peel) were determined at two symmetrical points on each fruit using a colorimeter (Handheld 3nh Colorimeter-NR110), and recorded as L, a, b, C, and h° values.

Chemical analyses were conducted on the fruit juice samples of the genotypes. Soluble solid content (SSC%) was measured using a hand refractometer, and the value displayed on the screen was recorded as SSC%. pH levels were determined using a Jenco portable pH meter [11]. Titratable acidity (TA) was analyzed by diluting and filtering a portion of the fruit juice with distilled water, followed by titration with 0.1 N NaOH until the pH reached 8.1. The consumed NaOH volume was used to calculate the acidity value, which was expressed as g/100 g malic acid equivalent [12]. Total phenolic content was determined using the Folin-Ciocalteu method and expressed in GAE L^{-1} (Gallic Acid Equivalents per Liter) [13]. Antioxidant capacity was measured using the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay [14]. Vitamin C analysis was performed using the volumetric titration method, and the results were expressed as mg/100 mL [15].

The determination of phenolic compounds was conducted using an Agilent 1260 model HPLC system equipped with a UV detector. Chromatographic separation was performed using an ACE-C18 column (4.6 mm × 150 mm, 5 µm). Detection wavelengths were selected based on the maximum absorption of the phenolic compounds being analyzed. Chlorogenic acid and ellagic acid were detected at 330 nm, while quercetin was detected at 360 nm [16].

The study was designed based on a completely randomized plot design. The effects of astringency status on the examined characteristics among different genotypes were analyzed using the two-sample t-test procedure in the Minitab 17 statistical software, with a 5% significance level.

FINDINGS AND DISCUSSION

The pomological and chemical analyses of ten pear genotypes, which have been exposed to more extreme temperatures since April 2021 compared to the average temperature and precipitation over the past five years, are presented below.

In the present study, ten pear genotypes were assessed for key pomological characteristics. The mean fruit width measured 72.80 mm in astringent genotypes and 69.10 mm in non-astringent genotypes, with no statistically significant intergroup difference observed. Similarly, mean fruit length was 89.90 mm in astringent genotypes and 88.00 mm in non-astringent genotypes, showing no significant variation between groups. Mean fruit weight averaged 252.0 g in astringent genotypes and 194.60 g in non-astringent genotypes; however, this difference also lacked statistical significance. Flesh firmness values averaged 5.88 kg/cm² in astringent genotypes and 5.18 kg/cm² in non-astringent genotypes, with no statistically significant disparity detected between the groups (Table 6).

Table 4. Pomological analyses of the genotypes

Genotype No	Flavor	Fruit Width (mm)	Fruit Length (mm)	Fruit Weight (g)	Fruit Flesh Firmness (kg/cm²)	Mean Values of Sub-Skin Color Parameters					Mean Values of Surface Skin Color Parameters				
						L	a	b	C	°h	L	a	b	C	°h
24-59	D	81,20	100,40	285,00	6,30	70,28	-6,05	38,18	42,57	100,91	71,19	15,73	32,83	36,47	61,71
27-580	D	77,59	103,75	216,00	5,10	87,68	-8,96	45,10	45,73	100,15	71,68	16,94	34,38	37,78	62,83
22-384	D	60,85	75,63	130,00	3,40	74,23	3,37	45,12	45,61	85,45	57,88	21,96	28,60	35,96	52,90
2-11-19	D	78,07	80,63	276,20	6,24	71,63	-7,05	39,77	43,79	102,43	70,55	5,64	37,22	40,61	84,04
1-22-2	D	47,97	79,83	65,66	4,85	74,16	1,18	45,46	45,73	88,56	58,74	21,76	29,99	37,59	54,28
2-15-93	B	82,79	105,01	295,46	5,90	73,98	-11,73	42,34	43,95	105,59	52,89	22,95	24,84	36,70	48,09
2-15-94	B	80,53	94,40	260,30	6,77	68,58	-4,38	40,09	40,93	93,78	56,98	27,58	29,87	36,59	42,01
27-599	B	92,00	120,10	504,00	7,80	70,19	-9,73	39,67	40,51	103,73	43,62	22,40	23,66	33,75	41,73
2-12-97	B	62,90	70,39	140,01	4,78	86,52	-9,65	45,87	46,88	101,89	74,45	18,02	36,20	39,78	63,79
1-23-22	B	45,77	59,40	59,71	4,15	70,44	-10,73	41,68	43,09	104,58	46,89	23,94	25,03	35,55	43,14

Table 5. Chemical analyses of the genotypes

Genotype No	Flavor	SSC (%)	pH	TEA (mg/100 ml)	Vitamin C (mg/100 ml)	Total Phenolic Content (mg gallic acid/L)	Antioxidant Capacity (% Inhibition)
24-59	D	17,10	4,46	0,15	0,07	175,70	78,31
27-580	D	15,83	2,92	0,35	0,08	602,89	77,87
22-384	D	17,20	4,75	0,10	0,07	905,13	78,09
2-11-19	D	13,10	2,94	0,28	0,07	208,68	71,76
1-22-2	D	16,80	2,63	0,32	0,08	191,03	54,91
2-15-93	B	19,13	3,78	0,21	0,12	150,25	47,96
2-15-94	B	20,03	2,88	0,30	0,13	251,53	77,98
27-599	B	16,67	2,95	0,27	0,10	191,80	61,86
2-12-97	B	15,17	2,18	0,42	0,14	749,09	77,00
1-23-22	B	20,57	2,93	0,33	0,14	206,87	76,42

Table 6. Comparison of mean pomological data of the genotypes

Genotype	Fruit Width (mm)	Fruit Length (mm)	Fruit Weight (g)	Fruit Flesh Firmness (kg/cm²)	Mean Values of Sub-Skin Color Parameters					Mean Values of Surface Skin Color Parameters				
					L	a	b	C	°h	L	a	b	C	°h
Astringent (B)	72,80	89,90	252,00	5,88	73,94	-9,24 B	41,93	43,07	101,92 A	55,00 B	22,98 A	27,92 B	36,47	47,80 B
Non-astringent (D)	69,10	88,00	194,60	5,18	75,60	-3,50 A	42,73	44,69	95,50 B	66,01 A	16,40 B	32,60 A	37,68	63,20 A
P value	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	*	*	*	*	N.S.	*

*p<0.05 is statistically significant; n.s. = not significant

The a* value of the lower peel color averaged -9.24 in astringent genotypes and -3.50 in non-astringent genotypes, with the difference being statistically significant. Non-astringent genotypes exhibited significantly higher values compared to astringent genotypes. For the hue angle (h°), non-astringent genotypes averaged 95.50, while astringent genotypes averaged 101.92, with the latter group showing significantly higher values. In contrast, no statistically significant differences were observed between the groups for the lightness (L*), b* value, chroma (C*) of the lower peel color, indicating that these traits did not vary significantly between astringent and non-astringent genotypes.

No statistically significant difference was observed between the groups for the chroma (C*) value of the upper peel color. However, significant differences were detected for other color parameters. The lightness (L*) value averaged 55.00 in astringent genotypes and 66.01 in non-astringent genotypes,

with non-astringent genotypes exhibiting significantly higher values. For the a* value, non-astringent genotypes averaged 16.40, while astringent genotypes averaged 22.98, with the latter group showing significantly higher values. Conversely, the b* value averaged 27.92 in astringent genotypes and 32.60 in non-astringent genotypes, with non-astringent genotypes demonstrating significantly higher values. Similarly, the hue angle (h°) averaged 47.80 in astringent genotypes and 63.20 in non-astringent genotypes, with non-astringent genotypes again forming the higher-value group. All these differences were statistically significant (Table 6).

In non-astringent genotypes, the average soluble solid content (SSC) was 16.01%, whereas in astringent genotypes, it was 18.31%, and this difference was statistically significant. Astringent genotypes formed the higher-value group. The average pH value was 2.95 in astringent genotypes and 3.54 in non-astringent genotypes, with the difference being statistically significant. Non-astringent genotypes formed the higher-value group. The average titratable acidity (TA) was 0.24 g/100 mL in non-astringent genotypes and 0.31 g/100 mL in astringent genotypes, and the difference was statistically significant, with astringent genotypes forming the higher-value group. The average vitamin C content was 0.07 g/100 mL in non-astringent genotypes and 0.13 g/100 mL in astringent genotypes, with the difference being statistically significant. Astringent genotypes formed the higher-value group. Although the average phenolic content and antioxidant capacity of astringent genotypes differed from those of non-astringent genotypes, this difference was not statistically significant (Table 7).

Table 7. Comparison of mean biochemical data of the genotypes

Genotype	SSC (%)	pH	TEA (mg/100 ml)	Vitamin C (mg/100 ml)	Total Phenolic Content (mg gallic acid/L)	Antioxidant Capacity (% Inhibition)
Astringent (B)	18,31 A	2,95 B	0,31 A	0,13 A	310	68,20
Non-astringent (D)	16,01 B	3,54 A	0,24 B	0,07 B	417	72,19
P value	*	*	*	*	N.S.	N.S.

*$p<0.05$ is statistically significant; n.s. = not significant

Yang et al. [17] conducted a similar study on this topic, aiming to elucidate the growth and development mechanisms of Yulu Xiang pear under drought stress. They observed an increase in the regulated expression of malate dehydrogenase in the leaves of drought-stressed groups. Their findings demonstrated that prolonged drought stress weakens the antioxidant system and disrupts photosynthetic pigment synthesis. Javadi et al. [18] reported that under drought stress conditions, total soluble sugars (TSS) accumulated in the leaves of nine Asian and one European pear genotype. Liu et al. [19] investigated the effect of high temperature on the sorbitol mechanism in pear leaves and fruit flesh. They found that sorbitol accumulation in the fruit flesh showed greater stability under high temperatures, and sucrose content in the fruit flesh also increased significantly under high-temperature conditions. Brahem et al. [20] examined the phenolic composition of the fruit flesh and peel of different pear varieties (8 Tunisian sweet varieties, 8 European sweet varieties, and 3 French astringent varieties). They concluded that Tunisian sweet pears contained a high proportion of polymerized procyanidins, while French pears were even richer in procyanidins. Additionally, the polyphenol concentrations in the peel were found to be up to six times higher than those in the fruit flesh.

Asayesh et al. [21] subjected grafted and non-grafted pear plants to testing to determine the antioxidant defense systems under drought stress. Two pear rootstocks, ‘Dargazi’ and ‘Pyrodwarf’, were used as non-grafted plants, while the grafted plants consisted of the ‘Dargazi’ and ‘Louise Bonne’ varieties grafted onto the same ‘Dargazi’ and ‘Pyrodwarf’ rootstocks. The plants were subjected to different irrigation regimes: control (100% irrigation), moderate stress (60% irrigation), and severe drought stress (30% irrigation). Growth and chlorophyll fluorescence characteristics, certain oxidative stress markers, and enzymatic and non-enzymatic antioxidant parameters were examined in plants exposed to different water regimes. Water stress, particularly at severe levels, directly affected anthocyanin, total phenolic content, total flavonoid content, catalase, and ascorbate peroxidase activity, while high guaiacol peroxidase activity was observed in grafted combinations. Overall, non-grafted rootstocks exhibited greater oxidative stress compared to grafted combinations, as indicated by a significant increase in hydrogen peroxide (H_2O_2) and malondialdehyde levels, along with the accumulation of certain enzymatic and non-enzymatic factors. In contrast, grafted combinations demonstrated better tolerance, primarily through the enzymatic antioxidant defense system. In our study, similar to

this study, no significant difference was observed in total phenol and antioxidant capacity values.

From these studies, it is evident that under different stress conditions, varieties and genotypes exhibit distinct responses and demonstrate varying patterns in terms of substance accumulation.

CONCLUSION

In our study, when comparing astringent (A) and non-astringent (N) genotypes, it was observed that non-astringent (N) genotypes had higher values for flesh color a, peel color L, b, and °h, while astringent (A) genotypes exhibited higher values for flesh color °h and peel color a. Among the biochemical measurements, total soluble solids content (SSC) was statistically higher in astringent genotypes, whereas pH was higher in non-astringent genotypes, contrary to SSC. Titratable acidity (TA) and vitamin C average values were statistically higher in astringent genotypes compared to non-astringent ones. Total phenol and antioxidant capacity did not show statistically significant differences among the genotypes. Although the differences in taste among the genotypes were not consistently noticeable every year, they were distinctly observed in the samples collected in 2021. This variation can likely be attributed to the differing responses of the genotypes to climatic conditions. The genotype No.22-384 (Santa Maria × Akça) stood out from the other genotypes under changing climate conditions in terms of SSC, pH, phenolic content, and antioxidant capacity. In this regard, it is considered to have the potential to contribute significantly to national agriculture.

REFERENCES

1. Bell, R.L., Zwet, T. 1996. September. Breeding for host resistance to pear psylla: evaluation of parental germplasm. In: Eucarpia Symposium on Fruit Breeding and Genetics 484:471-476.
2. Hancock, J.F., Lobos, G.A. 2008. Pears. In: Temperate fruit crop breeding: germplasm to genomics (pp:299-336). Dordrecht: Springer Netherlands.
3. Wolko, Łukasz, et al. 2010. Genetic diversity of European pear cultivars (*Pyrus communis* L.) and wild pear (*Pyrus pyraster* (L.) Burgsd, inferred from microsatellite markers analysis. Genetic Resources and Crop Evolution 57(6):801-806.
4. FAO, 2023. Food and Agricultural Organization (https://www.fao.org/faostat/en/#data/qcl) (Erişim Tarihi 16.01.2025).
5. Lopez, Gerardo, et al. 2011. Fruit thinning in 'Conference' pear grown under deficit irrigation: Implications for fruit quality at harvest and after cold storage, Scientia Horticulturae 129(1):64-70.
6. Babaei, Lavin, et al. 2021. Impact of drought stress on photosynthetic response of some pear species. International Journal of Horticultural Science and Technology 8(4):353-369.
7. Öztürk, N.Z. 2015. What is known and new approaches in plant responses to drought stress. Turkish Journal of Agriculture-Food Science and Technology, 3(5), 307-315.
8. Shalaby, E.E., Epstein, E., Qualset, C.O. 1993. Variation in salt tolerance among some wheat and triticale genotypes. Journal of Agronomy and Crop Science, 171(5), 298-304.
9. Wielgolaski, F.E. 1999. Starting dates and basic temperatures in phenological observations of plants. International Journal of Biometeorology, 42, 158-168.
10. Chmielewski, F.M., Müller, A., Bruns, E. 2004. Climate changes and trends in phenology of fruit trees and field crops in Germany, 1961-2000. Agricultural and Forest Meteorology, 121(1-2), 69-78.
11. Karaçalı, İ. 2002. Preservation and marketing of horticultural products. Ege University. No:494.
12. Anonymous, 1984. AOAC, Official methods of analysis. 14. U.S. Association of official analytical chemists (AOAC).
13. Singleton, V.L., Rossi, J.A. 1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am. J. Enol. Viticult. 16(3):144-158.
14. Thaipong, K., Boonprakob, U., Crosby, K., Cisneros-Zevallos, L., Byrne, D.H. 2006. Comparison of ABTS, DPPH, FRAP, and ORAC assays for estimating antioxidant activity from guava fruit extracts. J. Food. Compos. Anal. 19:669-675.
15. Spinola, V., Mendes, B., Camara, J.S., Castilho, P.C. 2013. Effect of Time and Temperature on Vitamin C Stability in Horticultural Extracts, UHPLC-PDA vs Iodometric Titration as Analytical Methods, LWT-Food Science and Technology, 50(2):489-495.
16. Wen, D., Li, C., Di, H., Liao, Y., Liu, H. 2005. A universal HPLC method for the determination of phenolic acids in compound herbal medicines. J. Agr. Food. Chem. 53(17), 6624-6629.

17. Yang, Sheng, et al. 2020. Transcriptome survey and expression analysis reveals effects and metabolic pathways of Yuluxiang Pear in response to drought stress.
18. Javadi, T., Arzani, K., Ebrahimzadeh, H. 2006. Study of proline, soluble sugar, and chlorophyll a and b changes in nine Asian and one European pear cultivar under drought stress 27. International Horticultural Congress-IHC 2006: International Symposium on Asian Plants with Unique Horticultural 769.
19. Liu, Dongfeng, et al. 2013. High temperature alters sorbitol metabolism in *Pyrus pyrifolia* leaves and fruit flesh during late stages of fruit enlargement, Journal of the American Society for Horticultural Science 138(6):443-451.
20. Brahem, Marwa, et al. 2017. Characterization and quantification of fruit phenolic compounds of European and Tunisian pear cultivars. Food Research International 95:125-133.
21. Asayesh, Z.M., Arzani, K., Mokhtassi-Bidgoli, A., Abdollahi, H. 2023. Enzymatic and non-enzymatic response of grafted and ungrafted young European pear (*Pyrus communis* L.) trees to drought stress. Scientia Horticulturae, 310, 111745.