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EFFECT OF DIFFERENT SPRING PLANTING PERIODS ON POMOLOGICAL AND PHYTOCHEMICAL CHARACTERISTICS OF SOME STRAWBERRY VARIETIES

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Abstract: The study was carried out at Bilecik Seyh Edebali University Agricultural Application and Research Center during the period of 2020-2021. Its objective was to assess the influence of different planting dates (27 March, 10 April, 27 April, 15 May) on the pomological and phytochemical attributes of diverse strawberry cultivars (Albion, Pineberry, Monterey, and Portola). The goal was to determine the optimal spring planting periods and varieties that are well-suited for the region. The Monterey and Albion varieties achieved the highest average fruit weight during the third period, with weights of 14.76 g and 15.92 g, respectively. The Monterey variety exhibited the greatest pH level at 3.88, whilst the Pineberry had the lowest pH level at 3.67. The concentration of soluble solids ranged from 4.73% to 8.56% among the different varieties, and from 5.82% to 6.15% throughout the different planting periods. The Monterey variety exhibited the highest anthocyanin concentration (117.73 µg Plg-3-glu g^{-1} dw) among the various strawberry varieties, while the fourth planting period showed the highest content (84.65 µg Plg-3-glu g^{-1} dw) among the different times. The concentration of soluble solids ranged from 4.73% to 8.56% among the different varieties, and from 5.82% to 6.15% throughout the different planting periods. The Monterey variety exhibited the highest anthocyanin concentration (117.73 µg Plg-3-glu g^{-1} dw) among the various strawberry varieties, while the fourth planting period showed the highest content (84.65 µg Plg-3-glu g^{-1} dw) among the different periods.

Keywords: Anthocyanin, Colour, *Fragaria ananassa* L., Phenolic content, Planting time

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1. Introduction

The strawberry is a highly significant berry fruit, notable for its distinctive flavor, appearance, and abundant nutritional value (Dzhanfezova et al., 2020). Due to its extensive adaptability and the development of several breeds through selective breeding, this crop can be cultivated in every agricultural location worldwide, ranging from Ecuador to Siberia (Ağaoğlu, 1986). The significance of temperate climate zones in terms of crop productivity and quality is widely acknowledged (Rubinstein, 2015).

In the 2022, world strawberry production was 95 million tons, and Türkiye ranked third with approximately 730000 tons of strawberry production (FAO, 2022). Upon regional analysis, the Mediterranean region emerges as the foremost, followed by the Aegean and Marmara regions while cultivation is mostly done under cover in the Mediterranean, open cultivation is known to be common in the Aegean and Marmara regions (Oguz and Pirlak, 2019).

The growing popularity of strawberry agriculture worldwide is accompanied by increased breeding endeavors aimed at creating novel varieties. The primary objectives of strawberry breeding include enhancing productivity, size, fragrance, durability, firmness of the fruit, resistance to diseases and pests, adaptability to day-neutral or short-day environments, timing of ripening, and compatibility with different soil types. Recent breeding research has incorporated its health benefits, as indicated (Kafkas, 2004; Ozturk Erdem and Cekic, 2017). Before profitably cultivating these produced cultivars in a different region or ecologically, it is necessary to conduct adaptation studies. The importance of variety adaptation in profitable strawberry cultivation in the recognition that varieties change in response to evolving cultivation systems and ecological conditions in strawberry production.

Many researchers have continued out to determine suitable varieties and planting periods in almost every region for this purpose (Atasay et al., 2006; Balci and Demirsoy, 2006; Ozguven and Yilmaz, 2009; Sezer, 2010; Serce et al., 2012; Alan, 2013; Saracoglu, 2013; Aksu, 2015; Ergun, 2015; Gunduz and Bayazit, 2017; Gecer et al., 2018; Oguz and Pirlak, 2019; Soysal et al., 2019; Ceran, 2023). Several strawberry production research has focused on the Marmara region, which holds

significant economic importance for our country. Gunay (2004), Sarac (2009), Gul (2011), and Ozok (2021) conducted studies that yielded useful insights on this agricultural technique in the region.

The province of Bilecik is located in the southeast of the Marmara region, with agriculture area accounting for about 29.4% of the total land area. Furthermore, within this agricultural land, approximately 11.5% is specifically allocated for fruit cultivation. Due to the presence of three distinct climate types and soil structures in Bilecik province, the range of items cultivated in this limited region is highly diverse. Despite the favorable climate of Bilecik for strawberry cultivation, there is a lack of scientific study, resulting in growers only growing a single type in a limited region. A crucial factor for achieving success in strawberry growing is the first assessment of the appropriate types for the specific region and the optimal timing for planting. The goal of this research was to enhance strawberry production in the Bilecik province and surrounding areas. This was achieved by identifying the suitable type and optimal planting period, as well as evaluating their pomological properties and phytochemical contents, which have significant implications for human health.

2. Materials and Methods

The study was carried out at the Agricultural Application and Research Center of Bilecik Seyh Edebali University throughout the years 2020-2021. Ciltar Agricultural Enterprise Ltd. şti obtained chilled seedlings of Albion, Pineberry, Monterey, and Portola varieties to be used as plant material.

Strawberry seedlings were planted in a triangular arrangement on 70-cm-wide tubes with drip irrigation pipes. The tubes were covered with black plastic mulch and the seedlings were placed 30 cm apart in both rows and columns. The plantings in 2020 occurred on four specific dates: March 27 (1st term), April 10 (2nd term), April 27 (3rd term), and May 15 (4th term).

The Gecit Kusagı Agricultural Research Institute conducted a soil study in the research area. As a result, the soil in the study area is somewhat alkaline (pH: 8.02), calcareous (4.68%), loamy (55%), salt-free (dS m^{-1} = 0.162), low in organic matter (1.51%), and high in phosphorus (kg da^{-1} = 14.4). The potassium level was found to be adequate (51.72 kg da^{-1}). Since planting, an equal amount of fertilizer has been applied to each plant (Sarıdas, 2018).

Temperature, precipitation, and humidity values for Bilecik province, where the study was done, were obtained from the Bilecik Meteorology Directorate for 2020 and 2021. The average temperature in 2020 was determined to be 13.7 °C and 13.3 °C in 2021.

In the first growing season (in 2020), flowers and stolons that occurred during that year were removed throughout the vegetation period to promote stronger development of the plants (Ağaoğlu, 1986). Harvest began on May 10, 2021, and while average fruit weight (g/fruit), fruit diameter/length (mm), pH, titratable acidity (%), and water-soluble dry matter amount (%) were analyzed (Cemeroğlu, 2007; Oguz and Pirlak, 2019). The total antioxidant amount was calculated using the TEAC (Trolox equivalent antioxidant capacity) method (Ozgen et al., 2006), the total anthocyanin amount was calculated using Giusti and Wrolstad (2005), and the total phenolic substance amount was calculated using Saracoglu and Ozgen (2015). The Minolta brand color measuring device (CR-300 model) and the Hunter color measurement system were used to measure L* (brightness), a* (red/green), and b* (yellow/blue) on the outside of the fruit (Sacks and Shaw 1994; Gunduz and Ozdemir 2003).

The experiment was conducted with three replications using a randomized block design, where each replication consisted of 20 plants. After conducting variance analysis, the application averages were compared using the LSD multiple comparison test. The statistical investigations utilized the MSTAT-C package application.

3. Results and Discussion

Adaption studies have been conducted in our country for many years to establish the region's best variety and planting season. Research on the Marmara region began in the late 1900s and has since progressed with the development of new varieties (Erenoglu and Seniz, 1999; Erenoglu et al., 2000; Gunay, 2004; Kaleci and Gunay, 2006; Sarac, 2009; Gul, 2011; Ozok, 2021).

This study examined the quality and phytochemical characteristics of four strawberry varieties cultivated in Bilecik during different spring planting periods in 2020 and 2021. The objective was to identify the most suitable strawberry variety for each planting period.

The trial's first harvest occurred on May 10, 2021, in all four planting periods, with the Portola variety harvesting in the first (March 27) and second (April 10) planting periods, and the Monterey variety harvesting in the third (April 27) and fourth (May 15) planting periods.

The Pineberry cultivar had its first harvest on May 17, later than other varieties. Kaleci and Gunay (2006) determined in their two-year study using seven strawberry varieties under Çanakkale conditions that the first harvest date was in mid-May in the first productive year, and the harvest date was one week later due to ecological conditions in the second year. Gul (2011) observed that the first harvest occurred on June 3 in the low tunnel and on June 6 in open cultivation in his study assessing the yield and development parameters utilizing several day-neutral strawberry cultivars in open and low tunnel circumstances in Tekirdağ ecosystem. In 2002-2003, Günay (2004) conducted a study to determine acceptable strawberry cultivars in open and greenhouse environments in Çanakkale climate conditions. According to the study, the first harvest under open cultivation conditions occurred on the Tuda variety on May 9, 2002, and on the Elsenta variety on May 12, 2003. In a study on the morphological and pomological properties of neutral and short-day strawberry types in Bursa, Ozok (2021)

reported the first harvest date as 11-20 May. The study revealed that the first harvest date was comparable to other studies conducted in the region.

It is known that fruit size in strawberries is a characteristic of the variety. However, it is known that ecological, genetic factors, planting, and care conditions affect fruit size (Hancock, 1999). According to Table 1, the Albion variety had the highest fruit weight with 13.32 g, followed by Monterey with 12.88 g, Portola with 10.38 g, and Pineberry varieties with 6.96 g. There was no significant statistical disparity observed when comparing the second, third, and fourth quarters. The fourth period, occurring on May 15, exhibited the highest mean fruit weight of 11.98 g. It was closely followed by the third period on April 27, which had an average fruit weight of 11.94 g. The second period on April 10 had a slightly lower average fruit weight of 11.22 g. The first period on March 27 had the lowest average fruit weight of 8.42 g. The information is presented in Table 1. The third period (27 April) yielded the highest average fruit weight in the Monterey (14.76 g) and Albion (15.92 g) varieties, while the fourth period (15 May) produced the highest average fruit weight in the Pineberry (8.22 g) and Portola (12.14 g) varieties. Across all four categories, the initial period (March 27) has the smallest fruit weight, as indicated in Table 2. Our study, as well as other studies conducted by Cekic and Aksu (2012), Ruan et al. (2013), and Wan et al. (2014), have found that the Albion variety is considered huge due to its high demand in the Bilecik region.

Mısır (2016) observed that fruit weights varied between 10.0-12.7 g in an adaptation study utilizing three strawberry varieties in Samsun ecological conditions, 12.6 g in the Albion strawberry variety and 12.4 g in the Monterey variety. Fruit weights ranged from 4.80 to 17.81 g, with the Monterey 17.81 g, the Portola 15.96 g, the Albion 13.04 g, and the Pineberry variety 6.19 g, according to Ozok (2021).

A study conducted in the USA utilized refrigerated seedlings to investigate the effects of different planting seasons (March, April, May, June, July, August, and September) on yield. The findings indicated that the crop output decreased when the planting period prolonged beyond the month of May. Based on their research, Moore and Bowden (1968) determined that the months of March, April, and May had the most favorable conditions for planting, resulting in the largest crop yields. Conversely, September was shown to have the least favorable conditions, leading to the lowest yields. Saracoglu (2013) conducted a study to assess the quality and yield of neutral and short-day strawberry cultivars in the Tokat-Kazova region. The study aimed to determine the optimal planting time for these varieties. He discovered that planting periods had no effect on yield in biennial cultivation, but they did have an impact on productivity in annual cultivation. In their study conducted in Eskisehir, Oguz and Pirlak (2019) employed the Albion, Kabarla, San Andreas, Sweet Ann, and Redlans Hope cultivars for planting throughout seven distinct time intervals. The objective of their research was to determine the optimal variety and planting schedule. The study's results revealed a decline in fruit weight and yield following the third planting session on May 25. Additionally, it was determined that the optimal time for planting was between April 25 and May 10.

The results of the variance analysis indicated that there were statistically significant differences in the length and diameter of the fruits, depending on their variety and time periods. There was no statistically significant distinction observed among the Monterey, Albion, and Portola varieties when analyzing Table 1. The Monterey variety has the largest fruit, measuring 26.41 mm, followed by the Albion (25.85 mm), Portola (25.76 mm), and Pineberry (20.60 mm) variety. The Albion variety had the longest fruit length, measuring 37.52 mm. The Monterey variety had a fruit length of 31.68 mm, the Portola variety had a fruit length of 28.83 mm, and the Pineberry variety had the shortest fruit length at 18.60 mm. Table 2 demonstrates that the Monterey variety yielded fruits with the largest diameter (29.10 mm) and length (34.10 mm) on April 27, during the third planting period, while the lowest measurements were observed during the first planting period. The Pineberry variety exhibited its maximum fruit diameter of 21.16 mm during the fourth planting period. Conversely, its minimum fruit diameter of 20.50 mm was observed during the second planting period, and its minimum fruit length of 17.80 mm was recorded during the third planting period.

According to Ozok (2021), fruit diameter values in the Bursa ecosystem ranged from 19.93 mm (Bursa Derekızık) to 31.83 mm (Yalova-416), while fruit length values varied from 23.98 mm (Pineberry) to 48.75 mm (Mindoir). In this investigation of the performance of several strawberry cultivars during varying planting times, Saracoglu (2013) found that the planting periods' average fruit length and diameter were not statistically significant. The study's findings showed that in the first yield year, the average fruit diameter was 34.07 mm and its length was 41.14 mm, whereas in the second yield year, the average fruit diameter was 28.91 mm and its length was 30.03 mm. The research indicates that strawberry fruit sizes vary depending on the ecological factors, varietals, and cultural processes.

Table 1 displays the variance analysis results, which indicate that there are statistically significant differences in pH level depending on the planting seasons and variety. The Monterey variety exhibits the highest pH level of 3.88, whereas the Pineberry variety demonstrates the lowest pH level of 3.67. The pH levels for the planting periods were recorded to be highest at 3.85 on April 27, 2020, during the third planting period, and lowest at 3.77 on April 10, during the second planting period.

There was no significant change observed in planting seasons, even though there was a substantial difference in the titratable acid ratio across types (Table 1).

Table 1. Average values of the examined features

		FW	FD	FL	pH	TTA	TSS	TEAC	TA	TF
Various	Monterey	12.88 a	26.41 a	31.68 b	3.88 a	0.59 c	5.17 b	20.03 a	117.73 a	2511.62 c*
	Pineberry	6.96 c	20.60 b	18.60 c	3.67 c	1.02 a	8.56 a	8.54 d	15.26 d	2307.18 d
	Albion	13.32 a	25.85 a	37.52 a	3.86 a	0.74 b	5.47 b	13.19 b	62.83 c	2760.37 b
	Portola	10.38 b	25.76 a	28.83 b	3.79 b	0.59 c	4.73 b	9.58 c	77.28 b	2987.31 a
	LSD	2.07	2.09	3.68	0.06	0.10	0.73	0.37	5.53	127.80
Period	1	8.42 b	22.38 b	25.37 b	3.81 ab	0.73	5.93	9.76 d	60.66 c	3022.38 a
	2	11.22 a	24.43 ab	29.79 a	3.77 b	0.76	6.15	14.66 a	58.73 c	2683.08 b
	3	11.94 a	25.96 a	30.74 a	3.85 a	0.72	5.82	14.12 b	69.07 b	2710.09 b
	4	11.98 a	25.85 a	30.73 a	3.78 b	0.73	6.04	12.82 c	84.65 a	2150.93 c
	LSD	2.06	2.08	3.68	0.06	NS	NS	0.38	5.52	127.80

*: Letters are statistically significant at the 5% level. FW= fruıt weight (g), FD= fruit diameter (mm), FL= fruit length (mm), TA (%)= total titratable acid, TSS (%)= total soluble solids, TEAC= total antioxidant capacity (µmol TE/g ta); TA= total anthocyanin (µg Plg-3-glu/g ta); TF= total phenolic amount (µg GAE/g ta), NS= non-significant.

Table 2. Average values of variety and planting period interactions of the examined traits

Various	Period	FW	FD	FL	pH	TTA	TSS	TEAC	TA	TF
Monterey	1	9.70	24.06	28.93	3.91	0.53	5.10	11.46 e	100.50 c	3593.06 a*
	2	13.56	27.33	33.43	3.84	0.63	4.90	23.20 a	120.20 b	2371.96 de
	3	14.76	29.10	34.10	3.87	0.58	5.06	23.60 a	112.43 b	2176.96 ef
	4	13.5	25.13	30.23	3.88	0.61	5.60	21.86 b	137.76 a	1904.46 fg
Pineberry	1	6.06	21.10	19.36	3.63	0.98	7.75	8.43 gh	18.30 h	3451.96 a
	2	6.84	20.50	18.86	3.63	1.03	9.30	7.73 h	9.36 h	1684.46 g
	3	6.68	20.63	17.80	3.75	0.98	8.56	9.06 fg	16.00 h	1936.13 fg
	4	8.22	21.16	18.36	3.68	1.06	8.63	8.93 fg	17.36 h	2156.13 ef
Albion	1	9.88	20.73	28.03	3.92	0.80	6.55	9.50 f	42.26 g	2634.73 cd
	2	13.50	25.13	38.06	3.82	0.77	5.86	18.80 c	54.36 f	3170.30 b
	3	15.92	29.46	42.73	3.87	0.75	4.96	12.93 d	60.10 f	3400.30 ab
	4	14.00	28.06	41.23	3.82	0.63	4.50	11.53 e	94.60 cd	1836.13 g
Portola	1	8.04	23.63	25.13	3.76	0.59	4.30	9.63 f	81.56 e	2409.73 de
	2	10.90	24.73	28.80	3.75	0.59	4.53	8.90 fg	50.96 fg	3505.56 a
	3	10.40	24.63	28.26	3.89	0.57	4.66	10.86 e	87.73 de	3326.96 ab
	4	12.14	30.03	33.10	3.73	0.59	5.43	8.93 fg	88.86 de	2706.96 c
	LSD	NS	NS	NS	NS	NS	NS	0.74	11.04	255.7

*: Letters are statistically significant at the 5% level. FW= fruıt weight (g), FD= fruit diameter (mm), FL= fruit length (mm), TA (%)= total titratable acid, TSS (%)= total soluble solids, TEAC= total antioxidant capacity (µmol TE/g ta); TA= total anthocyanin (µg Plg-3-glu/g ta); TF= total phenolic amount (µg GAE/g ta), NS= non-significant.

The Pineberry variety had the highest titratable acidity rate (1.02%) among all the varieties. The Pineberry variety had the highest titratable acidity rate (1.02%) among all the varieties, but the planting period had the second-highest rate (0.76%) among all the planting periods (Table 2). When investigating the correlation between variety and planting period, it was found that the Pineberry variety exhibited the highest titratable acidity rate (1.06%) during the fourth planting period. Multiple studies have reported that the titratable acidity range was 0.34–1.43% (Gündüz 2003, Gündüz and Özdemir 2012, Gündüz and Gökçek 2019).

Significant changes were seen across different types when analyzing the variance analysis result for the total soluble solids (TSS) content. However, no distinction was discovered between planting seasons, as shown in Table 1. The total soluble solids range from 5.82% to 6.15% across different planting seasons and varieties, with a range of 4.73% to 8.56% (Table 1). According to Table 2, the Pineberry variety had the highest TSS content of 9.30% during the second planting period on April 10th. On the other hand, the Portola variety had the lowest TSS content of 4.30% during the first planting period on March 27th.

In a study done in Bursa ecological conditions, the strawberry cultivars exhibited a range of total soluble solids content, from 6.4% to 9.9%. The titratable acidity content ranged from 0.53% to 0.91%, while the pH levels varied between 3.60 and 4.02. The total soluble solids, titratable acid, and pH values were measured to be 9.9%, 0.91%, and 3.67 in the Pineberry variety, 8.8%, 0.79%, and 3.82 in the Albion variety, 8.6%, 0.74%, and 3.82 in the Portola variety, and 8.0%, 0.53%, and 4.02 in the Monterey variety, respectively. In the study investigating the production and quality features of strawberry varieties (Albion, Camarosa, Festival, Rubygem, Fortuna, Kabarla) in Malatya (end of March), the average weight of fruit during the spring planting season ranged from 7.63 to 11.7 g. The soluble solid content ranges from 7.58% to 10.00%, the titratable acidity is between 0.21% and

0.35%, and the pH ranges between 3.10 and 3.79 (Ozok, 2021).

Our study has been determined to be consistent with other research conducted in different areas.

The total antioxidant content, as measured by the TEAC method, exhibited statistically significant differences among different cultivars and time periods. The Monterey cultivar exhibited the most elevated antioxidant concentration, measuring at 20.03 mol TE/g. It was succeeded by Albion with a concentration of 13.19 mol TE/g, Portola with 9.58 mol TE/g, and Pineberry with 8.54 mol TE/g. When analyzing the variety period interaction table, there was no significant statistical difference observed between the second and third periods in the Monterey variety. The highest TEAC amount was achieved during the second phase, measuring 14.66 mol TE/g. This was followed by the third period with 14.12 mol TE/g, the fourth period with 12.82 mol TE/g, and the first period with 9.76 mol TE/g.

The Monterey variety exhibited the highest concentration of anthocyanins, measuring 117.73 g Plg-3-glu g^{-1}. Conversely, the fourth period had the lowest concentration, measuring 84.65 g Plg-3-glu g^{-1}. According to the variety period interaction table, the Monterey variety had the highest Plg-3-glu g^{-1} concentration of 137.76 g in the fourth period, while the Pineberry variety had the lowest concentration of 9.36 g in the second period. Although there was no significant variation observed among the different planting times, the Pineberry variety exhibited a relatively low level of anthocyanin compared to other varieties.

The total phenolic quantity in the Portola variety was found to be the greatest among varieties at 2987.31 g GAE g^{-1}, and the highest among planting rotations at 3022.38 g GAE g^{-1} in the first period. When the variety period interaction table was investigated, the second period in the Portola variety was judged to be the highest, and the second period in the Pineberry variety was determined to be the lowest. In their investigation using 20 different strawberry varieties, Capocasa et al. (2009) discovered that total antioxidant and phenolic component concentrations were connected to genotype rather than growing conditions. Studies show that genetic structure, rather than environmental factors, influences antioxidant and phenol content (Singh et al., 2011; Sarıdas, 2018).

The color of the strawberries' surface is an important criterion for determining their quality. The vibrant and deep red hue that enhances the market worth of strawberries is attributed to the presence of anthocyanidins, specifically pelargonidin-3-glycoside and cyanidin-3-glycoside (Kosar et al., 2004; Lopez-da Silva et al., 2007). The L, a, and b values were utilized to ascertain the external (side and tip) and internal hue of the fruit. The statistical analysis in Table 3 did not find any significant relationship between color values and planting season. Although the color of the fruit's outer side was not found to have a significant impact on the different varieties, the highest L value for the outer side surface was observed in Albion (43.57), followed by Monterey (20.83) and Portola (19.10). Similarly, the highest L value for the outer end surface was found in Pineberry (41.68), followed by Portola (27.74) and Albion (20.13). Lastly, the highest L value for the inner surface was obtained from Pineberry (43.73), followed by Monterey (23.95) and Albion (21.27).

In a study conducted in the Tokat, Saracoglu (2013) found that the impact of planting times on the L and b values of fruit exterior color was statistically insignificant in both years. The fruit's external color intensity was seen to be greater during the initial year's planting season in August, as compared to other time periods. The L value was determined by research conducted in various ecological conditions to range from 33.7 to 39.8 (Gunduz and Ozdemir, 2003), 30.5 to 35.8 (Ozdemir et al., 2006), and 52.7 to 75.1 (Misir, 2016).

In their study, Oguz and Pirlak (2019) found that the L value in the ecological conditions of Eskisehir was determined to be 31.33 when planted in the sixth period (10 July), 25.40 when planted in the fourth period (10 June), and the average L value of the Albion variety was 25.82. The variation in color values, regarded as a crucial quality parameter, is presumed to be attributable to environmental factors.

Table 3. Average fruit color (L, a, b) values

		Exterior /Side			Exterior / Bottom			İnternal		
		L	a	b	L	a	b	L	a	b
Various	Monterey	43.13	20.83	15.53	31.26 ^{b}	24.25 ^{a}	19.43	35.09 ^{b}	23.95	20.08 ^{a*}
	Pineberry	34.95	20.57	17.76	41.68 ^{a}	16.22 ^{b}	18.45	43.73 ^{a}	17.23	13.83 ^{b}
	Albion	43.57	17.59	14.89	33.38 ^{b}	26.01 ^{a}	20.13	33.21 ^{b}	22.67	21.27 ^{a}
	Portola	40.85	22.23	19.10	30.43 ^{b}	27.74 ^{a}	20.12	29.88 ^{b}	22.54	19.27 ^{a}
	LSD	5.82	4.72	2.66	1.86	4.97	NS	2.93	NS	1.33
Period	1	42.09	19.85	16.18	33.93	25.02	20.50	35.21	22.64	20.18
	2	39.48	21.10	16.63	32.25	23.41	19.77	37.52	22.58	19.29
	3	37.72	21.36	17.71	34.10	21.28	17.73	36.42	17.89	16.39
	4	43.21	18.91	16.76	36.48	24.52	20.13	32.78	23.27	18.58
	LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS

*= Letters are statistically significant at the 5% level, NS= non-significant.

Studies have shown that fruit color is influenced by factors such as genotype, temperature, and light source (Proctor and Creasy, 1971; Creasy, 1966; Batu et al., 1997). Specifically, when day and night temperatures are high (30/22°C), fruit color tends to be darken. Research has found an association between lower temperatures (18/12 °C) and a lighter color (Shiow and Camp, 2000).

4. Conclusion

In the study conducted with four different strawberry varieties across four various planting periods under the ecological conditions of Bilecik. It aimed to determine the pomological and phytochemical features of these varieties. Upon analyzing the interaction between variety and time, it was concluded that the planting period did not possess any statistically significant significance. In this region, the cultivation of the Albion variety has been found to excel in terms of fruit weight and quality parameters, as demonstrated in our study. Although the Albion variety is widely utilized, the Monterey and Portola varieties can be recommended as suitable alternatives. As a result of the study, it has been found that the optimal time for spring planting is during the third phase, namely on April 27th. The recently introduced Pineberry variety in our country has been characterized by its small fruit weight and soft fruit flesh, prompting the exploration of various evaluation methods.

Author Contributions

The percentage of the author(s) contributions is presented below. The author reviewed and approved the final version of the manuscript.

	S.Ö.E.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

References

Ağaoğlu S. 1986. Üzümsü Meyveler. Ankara Üniversitesi, Ziraat Fakültesi yayınları, No: 984, Ankara, Türkiye, ss: 123.

Aksu HD. 2015. The performance of some strawberry cultivars in Niksar province. MSc Thesis. Tokat Gaziosmanpaşa University, Institute of Science, Tokat, Türkiye, pp: 60.

Alan F. 2013. Research on performance of some neutral day strawberry (Fragaria × ananassa) cultivars grown in kayseri conditions. MSc Thesis. Erzurum Ataturk University, Institute of Science, Erzurum, Türkiye, pp: 70.

Atasay A, Turemiş N, Demirtaş I, Goktas A. 2006. Yield and quality parameters of some strawberry cultivars with summer planting in Eğirdir (Isparta) conditions. In: II. Ulusal Üzümsü Meyveler Sempozyumu, September 14-16, Tokat, Türkiye, pp: 100-105.

Balci G, Demirsoy H. 2006. A study on comparing classical and organic strawberry growing system in terms of yield and fruit quality. In: II. Ulusal Üzümsü Meyveler Sempozyumu, September 14-16, Tokat, Türkiye, pp: 94-99.

Batu A, Thompson AK, Ghafir SAM, Abdel-Rahmen NA. 1997. Minolta ve hunter renk ölçüm aletleri ile domates, elma ve muzun renk değerlerinin karşılaştırılması. Gıda, 22(4): 301-307.

Capocasa F, Diamantia J, Mezzetti B, Tulipani S, Battino M. 2009. Breeding strawberry (Fragaria×ananassa Duch) to increase fruit nutritional quality. Biofactors 34: 67-72.

Cemeroglu B. 2007. Gıda Analizleri. Gıda Teknolojisi Yayınları, Ankara, Türkiye, pp: 682.

Ceran MB. 2023. Determination of the yield and quality characteristics of some strawberry varieties growed in the open field of Yahyali (Kayseri) ecological conditions. MSc Thesis, Erciyes University, Institute of Science, Kayseri, Türkiye, pp: 55.

Creasy LL. 1966. The role of low temperature in anthocyanine synthesis in macintoch apples. American Soc Horticul Sci, 93: 716-724.

Cekic C, Aksu HD. 2012. Bazı çilek çeşitlerinin Niksar ekolojisindeki (Kelkit Vadisi) performansları. In: IV. Ulusal Üzümsü Meyveler Sempozyumu, October 03-05, Antalya, Türkiye, pp: 340-341.

Dzhanfezova T, Barba-Espín G, Müller R, Joernsgaard B, Hegelund JN, Madsen B, Larsen DH, Vega MM, Toldam-Andersen TB. 2020. Anthocyanin profle, antioxidant activity and total phenolic content of a strawberry (Fragaria × ananassa Duch.) genetic resource collection. Food Biosci, 36: 100620.

Erenoglu B, Bas M, Ufuk S, Erbil Y. 2000. Marmara bölgesine uygun yeni çilek çeşitlerinin seçimi. Atatürk Bahçe Kültürleri Merkez Araştırma Enstitüsü, Bilimsel Araştırma ve İncelemeler, Ankara, Türkiye, pp: 128.

Erenoğlu B, Seniz V. 1999. Melezleme ile elde edilen çileklerde verim ve kalite farklılıkları üzerinde araştırmalar. Türkiye III. Ulusal Bahçe Bitkileri Congresi, September 14-17, Ankara, Türkiye, pp: 52-56.

Ergun M. 2015. Agronomic evaluation of the some strawberry cultivars, were cultivated under high tunnel under Menemen conditions. MSc Thesis. Ege University, Institute of Science, İzmir, Türkiye, pp: 100.

FAO. 2022. Food and Agriculture Organization of the United Nations. URL: http://www.fao.org/faostat/en/#data/QC. (accessed date: January 14, 2024).

Gecer K, Gundogdu M, Basar G. 2018. Determining yield of some strawberry cultivars in ecology of Merzifon (Amasya). Iğdır Univ J Inst Sci Technol, 8(2): 11-15.

Giusti MM, Wrolstad RE. 2005. Characterization and

measurement of anthocyanins by uv-visible spectroscopy. Unit F1.2. In: Wrolstad RE, Schwartz SJ (eds.). Handbook of food analytical chemistry. Wiley, New York, US, pp: 19–31.

Gul A. 2011. Investigation of growth characteristics of some day neutral strawberry cultivars in low tunnel conditions in Tekirdağ region. MSc Thesis. Namık Kemal University, Institute of Science, Tekirdağ, Türkiye, pp: 40.

Gunay S. 2004. Researches on determining the favorable strawberry (Fragaria spp.) cultivars for Çanakkale conditions. MSc Thesis. Canakkale Onsekiz Mart University, Institute of Science, Çanakkale, Türkiye, pp: 85.

Gunduz K. 2003. The effect of some strawberry cultivars cultivated in field and high tunnel in Amik Plain conditions to yield, quality and earliness. MSc Thesis. Mustafa Kemal University, Institute of Science, Hatay, Türkiye, pp: 125.

Gunduz K, Özdemir E. 2003. Amik Ovasında Yüksek Tünel ve Açıkta Yetiştirilen Çileklerde Renklenmenin Objektif Yöntemle Belirlenmesi. IV. Ulusal Bahçe Bitkileri Congresi, September 08-12, Antalya, Türkiye, p: 120-122.

Gunduz K, Bayazit S. 2017. Phenotypic variability in strawberry cultivars from different breeding program. Mustafa Kemal Univ J Agri Sci, 22(2): 35-48.

Gunduz K, Gokcek O. 2019. Determination of yield and fruit quality characteristics of strawberries grown in soilless and soil medium in glasshouse. Bahce, 48(Special Number 1): 6.

Gunduz K, Ozdemir E. 2012. The effects of different production places on earliness index, yield and fruit quality characteristics of some strawberry genotypes. J Agri Fac Ege Univ, 49: 27-36.

Hancock JF. 1999. Strawberries. Crop Production Science in Horticulture Series, 11. CABI, Wallingford, UK.

Kafkas EN. 2004. Detection of aroma compounds of some strawberry genotypes and relationships between aroma compounds and fruit quality characters. PhD Thesis. Çukurova University, Institute of Science, Adana, Türkiye, pp: 334.

Kaleci N, Gunay S. 2006. Determining phenological, pomological and yield characterıstıcs of some strawberry cultivars grown in Çanakkale ecological conditions. Bahce, 35(1-2): 47-54.

Kosar M, Kafkas E, Paydas S, Baser KHC. 2004. Phenolic composition of strawberry genotypes at different maturation stages. J Agri Food Chem, 52: 1586-1589.

Lopes Da Silva F, Escribano-Bailon MT, Alonso JJP, Rivas-Gonzalo JC, Santosbuelga C. 2007. Anthoccyanin pigments in strawberry. LWT Food Sci Technol, 40: 374-382.

Misir D. 2016. Adaptation of some strawberry cultivars. MSc Thesis. Ondokuz Mayis University, Institute of Science, Samsun, Türkiye, pp: 95.

Oguz FG, Pirlak L. 2019. Determination of strawberry planting times and cultivars in Eskişehir conditions. J Bahri Dagdas Crop Res, 8(1): 148-157.

Ozdemir E, Gunduz K, Serçe S. 2006. Determination of yield, earliness and quality parameters of some strawberry types on Amik plain. Bahce, 35(1- 2): 29-37.

Ozgen M, Reese RN, Tulio AZ, Miller AR, Scheerens JC. 2006. Modified 2,2- azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) method to measure antioxidant capacity of selected small fruits and comparison to ferric reducing antioxidant power (FRAP) and 2,2'-Diphenyl-1-picrylhydrazyl (DPPH) methods. J Agri Food Chem, 54(4): 1151-1157.

Ozguven AI, Yilmaz C. 2009. Pomological and morphological traits of some strawberry cultivars under Adana ecological conditions. Alatarım, 8(2): 17-21.

Ozok N. 2021. Pomological and morphological traits of some strawberry cultivars under Bursa ecological conditions. MSc Thesis. Uludağ University, Institute of Science, Bursa, Türkiye, pp: 125.

Oztürk Erdem S, Cekic C. 2017. Strawberry breeding from past to today. Gaziosmanpasa J Sci Res, 6(3): 105-115.

Proctor JTA, Creasy LL. 1971. Effect of suplementary light on anthocyanin synthesis in “Mcintoch” apples. American Soc Horticul Sci, 96: 523-526.

Ruan J, Lee YH, Yeoung YR. 2013. Flowering and fruiting of day-neutral and everbearing strawberry cultivars in high-elevation for summer and autumn fruit production in Korea. Hort Environ Biotechnol, 54: 109-120.

Rubinstein MA. 2015. Taiwan: A New History. Taylor and Francis, London, UK, pp: 534.

Sacks E, Shaw DV. 1994. Optimum allocation of objective color measurement for evaluating fresh strawberries. J Amer Soc Horticul Sci, 119(2): 330-334.

Sarac BP. 2009. Comparison of some generative and vegetative growth characteristics of day neutral strawberry cultivar fern (Fragaria × ananassa) with short day strawberry cultivars. MSc Thesis. Namık Kemal University, Institute of Science, Tekirdağ, Türkiye, pp: 40.

Saracoglu O, Ozgen M. 2015. The effect of different harvest period on fruit quality and phytochemical properties of short and day neutral strawberries. Turkish J Agri Food Sci Technol, 3(7): 545-54.

Saracoglu O. 2013. Determination of yield and quality performans of some neutral and short day strawberry cultivars in Kazova. PhD Thesis. Tokat Gaziosmanpasa University, Institute of Science, Tokat, Türkiye, pp: 169.

Sarıdaş MA. 2018. Determination of yield, quality properties of selected strawberry genotypes obtained by cross breeding and molecular characterization. PhD Thesis. Cukurova University, Institute of Science, Adana, Türkiye, pp: 338.

Serce S, Ozdemir E, Gunduz K, Saracoglu O, Kaya O, Ozgen M. 2012. Bazı çilek çeşitlerinin Antakya koşullarında cam seradaki verim ve meyve kalite özelliklerinin belirlenmesi. IV. Ulusal Üzümsü Meyveler Symposium, October 3-5, Antalya, Türkiye, pp: 432-440.

Sezer L. 2010. Yield and quality parameters of two strawberry cultivars with summer planting in Kızıltepe (Mardin) conditions. MSc Thesis. Cukurova University, Institute of Science, Adana, Türkiye, pp: 58.

Shiow YW, Camp MJ. 2000. Temperatures after bloom affect plant growth and fruit quality of strawberry. Sci Horticul, 85: 183-189.

Singh A, Singh BK, Deka BC, Sanwal SK, Patel RK, Verma MR. 2011. The genetic variability, inheritance and inter-relationships of ascorbic acid, β-caroten, phenol and anthocyanin content in strawberry (Fragaria × ananassa Duch.). Sci Horticul, 129: 86-90.

Singleton VL, Rossi JL. 1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Amer J Enol Viticult, 16(3): 144-158.

Soysal D, Demirsoy L, Demirsoy H. 2019. Yield and quality characteristics of some strawberry varieties. Bahce, 48(1): 45-50.

Wan H, Liang YP, Kong LM, Liu JX, Gao ZQ, Wang LR, Tao P. 2014. Performance of twelve ıntroduced strawberry cultivars in Kunming, Yunnan province. Acta Horticul, 1059: 127-132.