HortiS (2022) 38(3):85-94
http://doi.org/10.16882/HortiS.1166929

HORTICULTURAL STUDIES

RESEARCH PAPER

Earliness, Yield, and Fruit Quality Attributes of Low-Chilling Peach-Nectarine Cultivars with the Application of Low Biuret Urea and Calcium Nitrate

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Article History
Received 08 June 2022
Accepted 25 August 2022
First Online 29 August 2022

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Keywords
Bud break
Low chilling
Peach-nectarine
Yield components

Abstract

This study aimed to determine the effects of low biuret urea and calcium nitrate application on earliness, fruit set, yield, and fruit quality characteristics in 'Astoria', 'Maya' peaches, and 'Garbaja' nectarine cultivars. In the study, Bud Feed (low biuret urea 15%) and calcium nitrate (calcium oxide 12% and total nitrogen 7%) were applied 35 days before bud break. In this study, flowering and fruit set, harvest times, fruit yield, and quality characteristics were evaluated. The source of temperatures used to calculate chill accumulation (expressed as hours below 7°C and chill unit) and growing degree hours was investigated. Bud Feed application provided earliness of 2 days in 'Astoria' and 'Garbaja' cultivars and 3 days in 'Maya' cultivar. This application was showed positive effect on flowering and final fruit set in all cultivars compared to control plants. The application was more effective in increasing the yield per tree by 33.72% ('Astoria'), 41.00% ('Maya'), and 52.18% ('Garbaja'). Bud Feed application was improved fruit size in 'Garbaja' and 'Astoria' cultivars, whereas provided more intense fruit skin color in 'Maya' and 'Garbaja' cultivars. These results showed that bud feed and calcium nitrate application can be used to prevent yield and fruit quality losses in peach-nectarines in warm winter under Mediterranean climate conditions.

1. Introduction

Türkiye has a wide range of products in terms of horticultural crops due to its geographical location and different climate and soil characteristics (Tüzel and Öztekin, 2015). It has wide ecological differences from the temperate climate to the Mediterranean climate, allowing for early, mid-season, and late-season cultivation (Bayazit et al., 2021; Çalışkan et al., 2021a).

Peach-nectarines are one of the most produced fruits in the world after apples. Early peach-nectarine cultivars with attractive fruits and regular yields have increased remarkably, in recent years. The Southern Aegean and Mediterranean Regions of Türkiye have a subtropical climates. Due to their climatic characteristics, these regions have large areas and advantages in early fruit growing with low chilling requirements. Early peach production leads to high economic value in April and May under both protected and open areas in this region. Currently, the open vase system is commonly used as the orchard system for peach cultivation in Türkiye. However, diverse high-density systems are used for commercial peach production (Çalışkan et al., 2021a).

Türkiye produces 3.23% of the world's peach-nectarine production with 830,577 tons. (FAO, 2022). The Mediterranean region produces 25.76% of this production. The Mediterranean coastline of Turkey is quite a favorable location for early fruit cultivation because of the advantages of its favorable ecology. In this region, the cultivar of some stone fruit species such as peach, apricot, and plum ripen about 10-15 days earlier than other areas of Türkiye as well as from important fruit growing countries of Europe such as Spain and Italy. (Caliskan et al., 2012). This is due to differences in latitute, considering that one latitute degree leads to 4-5 days of earliness or delay. (Kaşka et al., 1981).

Fruit consumers prefer cultivars having high quality in the fresh fruit market. The most crucial point is that the fruits that arrive early to the market are preferred because they do not have alternatives and, as a result, are sold at high prices (Erez et al., 2000).

Shortly, it is predicted that peach-nectarine production will increase, especially in the Mediterranean region. The relatively warmer winters in this region show that we should consider the chilling requirements of the cultivars (Kaşka, 2001; Çalışkan et al., 2021a). Serious problems such as irregular flowering, bud drop, bareness on the branch, insufficient fruit set, and decrease in yield occur in stone fruit species such as peach/nectarine with the insufficient chilling requirement (Weinberger, 1950; Viti et al., 2013). Especially as a result of the fluctuations in winter temperatures in the Eastern Mediterranean Region of Türkiye, the chilling durations that take place over 700 hours over the last 40 years decreased to less than 400 hours in the last years. This fluctuation is a serious problem for early stone fruit species in the region.

Campoy et al. (2011) indicated that if global warming continues, the problems in meeting the chilling requirements of plants will continue to increase due to the reduction in the winter cold. However, in case of insufficient chilling duration in fruit species, adequate fruit set and yield can be obtained with applications (such as DNOC, mineral oils, hydrogen cyanamide, gibberellins, KNO_3, $CaNO_3$, thiourea) that allow the plant to come out of rest (Engin et al., 2004; Son and Küden, 2005; Zhuang et al., 2015; Imrak et al., 2016). Hydrogen cyanamide, which is the most effective of these applications, is banned by many countries as it is in Türkiye, for human health and environmental pollution. Therefore, it is necessary to explore alternate applications.

This study aims to determine the effects of Bud Feed application on fruit set, yield, and fruit quality in early 'Astoria', 'Maya' peach, and 'Garbaja' nectarine cultivars.

2. Material and Method

2.1. Plant materials and experiment design

This study was carried out in the research and application area of Hatay Mustafa Kemal University, Faculty of Agriculture, Department of Horticulture, Hatay, Türkiye, in the 2019-2020 season. In the study, 'Astoria' and 'Maya' peaches and 'Garbaja' nectarine (PSB Producción Vegetal, Spain) that grafted on the rootstock of Garnem (*Prunus dulcis* × *Prunus persica*) were used. The saplings were planted at 2.5 m × 3.0 m in rows and spacing in May 2017.

In cultivation, an open vase with four main branches was used with a wire support system. This system has 20-25 fruit branches on each main branch and the branches were cut regularly every year, 2–3 on buds after harvesting (Hoying et al., 2007). Technical and cultural processes such as fertilization, disease, and pest control of the research area were applied as standard. The soil pH of the study area was 7.81, and the soil structure has a sandy-clay structure with 39.5% sand, 25.3% clay, and 6.10% lime content. The total salt content of the soil was in the salt-free class with values of 0.035-0.041%.

2.2. Treatment

In the study, Bud Feed (Stoller Türkiye, İzmir) application containing 15% low biuret urea was applied as 6 L 100 L^{-1} in three replications and one plant in each replication. The application was carried out 35 days before the bud burst (January 10). In addition, 5 L 100 L^{-1} $CaNO_3$ (including calcium oxide 12% and total nitrogen 7%) was added to increase the effectiveness of the application (Çalışkan et al., 2021b). Control trees were sprayed with water. The period in which 50% of the bud burst was taken as the exit date from the rest (Küden and Kaşka, 1992).

2.3. Heat requirements

Heat requirements were investigated by adding the growing degree hours (GDH), and temperatures above 4.5°C were taken into account (Richardson et al., 1975). Temperatures above 25°C were not taken into account in this assessment. Growth temperature totals were calculated as GDH1 (up to 30 days after full bloom) and GDH2 (from full bloom to harvest).

2.4. Phenological stages

Budburst, first flowering (5% flowering), full flowering (70% flowering), and end of flowering (90% petal fall) were observed. In addition, flowering rate (%), first fruit set rate (%), and final fruit set rate (%) were evaluated according to Westwood (2009).

2.5. Fruit quality and Yield Parameters

Peach fruits were harvested as described by Kader (1999) when the cultivar-specific color and fruit size were formed and the amount of total soluble solids (TSS) exceeded 10%. Fruit quality analyzes were carried out on a total of 30 fruits with three replications and 10 fruits in each replication.

These analyzes included the fruit weight (g), fruit dimensions (diameter, length, and height; mm), seed weight (g), flesh/seed ratio, total soluble solids (TSS), pH, and titratable acid (%) measurements. Fruit skin and flesh color measurements were evaluated by colorimeter (CR-300, Minolta) as L, a*, b*, *C* (Chroma), and *h*° (hue) values. Fruit skin and flesh colors were measured in two opposite directions for each fruit (Caliskan et al., 2012). Yield characteristics such as yield per tree (kg $tree^{-1}$), yield per trunk cross-sectional area (kg cm^{-1}), and yield per hectare (t ha^{-1}) were investigated.

2.6. Statistical evaluation

The data on the effects of Bud Feed application on fruit set, yield, and fruit quality characteristics of each variety were compared with the T-test in the SAS package program (SAS Institute, Cary, NC, USA). In addition, the LSD multiple comparison test (P<0.05) was used to compare the cultivar averages.

3. Results and Discussion

3.1. Phenological observations and temperature data

The effects of Bud Feed application on the phenological stages of 'Astoria', 'Maya', and 'Garbaja' cultivars were presented in Figure 1. In 'Astoria', Bud Feed application provided 2-day earliness in bud bloom, budburst, and full bloom periods (February 10, 13, and 28, respectively), compared to control plants, while it provided 3-day earliness in the first flowering and end-bloom periods of the variety (21 February and 02 March, respectively). Harvest time for this cultivar with Bud Feed application was 2 days earlier than the control plants. While Bud Feed application was 2 days earlier (11 and 22 February, 8 May, respectively) for the first flowering and harvest date compared to control plants in the 'Maya' cultivar, this application resulted in 3 days earliness (29 February) in the full flowering of the cultivar (Figure 2).

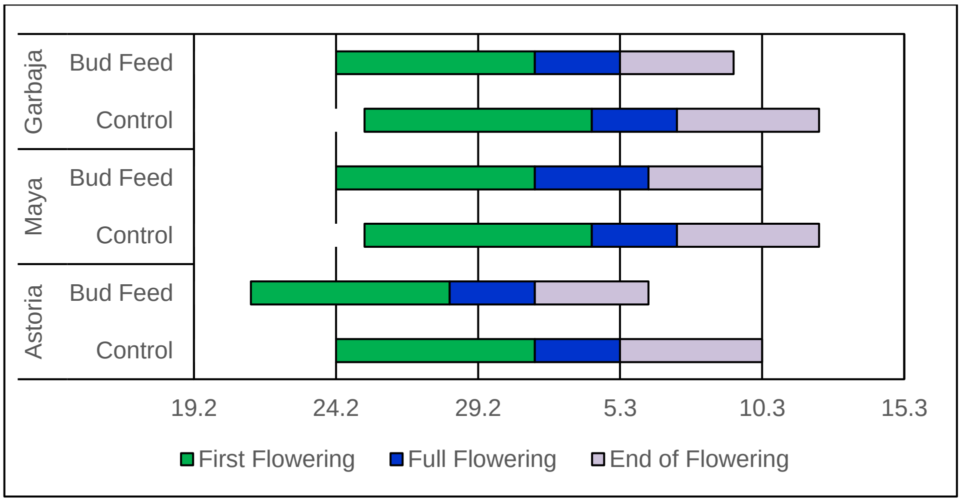

Figure 1. Effect of Bud Feed application on some phenological stages of 'Astoria', 'Maya', and 'Garbaja' cultivars.

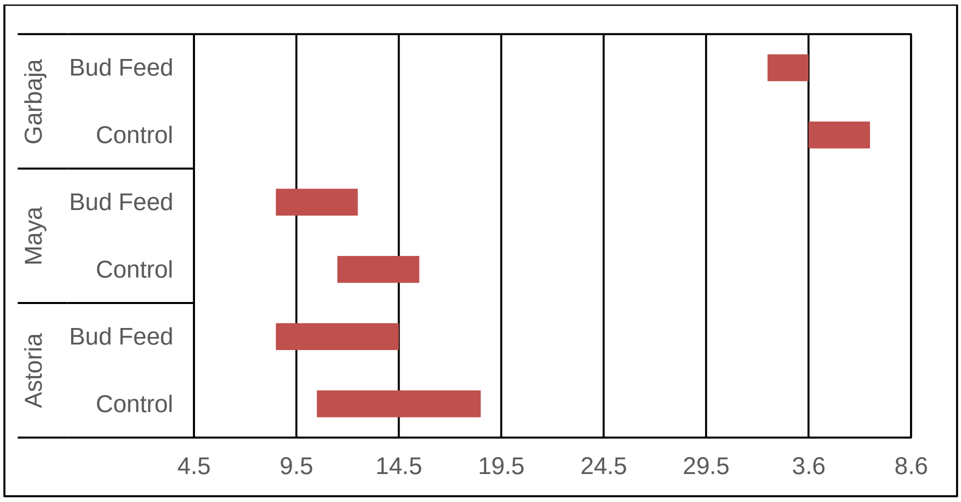

Figure 2. Effect of Bud Feed application on harvest times of 'Astoria', 'Maya', and 'Garbaja' cultivars.

The effect of Bud Feed application on phenology stages in ‘Garbaja’ revealed as earliness between 1 and 3 days compared to the control. These results were consistent with the results of other researchers (George et al., 1992; Tang et al., 2019). In addition, Eroğul et al. (2021) reported that Bud Feed + Sett (12% Cao+0.5% B) application 30 days before flowering in ‘0900 Ziraat’ cherry cultivar was 7-8 days earlier in full blossoming compared to control plants. However, Campoy et al. (2011) indicated that bud break treatments such as hydrogen cyanamide and winter oil did not affect flowering time in the ‘Early Maycrest’ peach cultivar. These differences show that the results may differ depending on the fruit species, genotype and application time, and intensity of the applications. In addition, Viol et al. (2022) showed that long flowering periods are symptoms of insufficient chilling during the winter in peach grown in subtropical regions. Bud Feed applied peach-nectarines were harvested 2-3 days earlier than control plants. The data was in agreement with the results of George et al. (1993), who indicated that low chilling peaches applied to bud break were harvested 1-3 days earlier than control plants. Besides, Singh and Banyal (2020) reported that bud break applications in early peach cultivars showed earliness up to 13-14 days. This effect may be due to the early flowering of the trees, the rapid occurrence of phenological stages, and climatic conditions. In the ‘Astoria’ cultivar, chilling duration was 349 chill hour (CH) and 542 chill unit (CU) in control plants, while it was 337 CH and 518 CU in Bud Feed treated trees (Table 1). However, the chilling duration of ‘Maya’ and ‘Garbaja’ cultivars occurred as 354 CH and 552 CU occurred in control plants, whereas it occurred as 349 CH and 542 CU in Bud Feed applied plants. This result is because Bud Feed applied to peach-nectarine cultivars provides 1 to 2 days earlier bud bursting. Campoy et al. (2011) indicated that the correct application of dormancy-breaking agents is critical for the reveal the effect of the applications and preventing phytotoxicity.

The 3-day early maturation that occurs with Bud Feed application in all cultivars was because of the growing degree hours in the first 30 days (GDH1) after full bloom (Lopez and Dejong, 2007) and the growing degree hours from full bloom to harvest (GDH2) (Bolat and Ikinci, 2020) are higher. Indeed, the GDH1 values of ‘Astoria’, ‘Maya’, and ‘Garbaja’ cultivars applied in Bud Feed were 7.875, 7.528, and 8.395, respectively, whereas it was 7.632, 7.395, and 6.392, respectively in control plants of these cultivars (Table 2). Similarly, GDH2 values of ‘Astoria’, ‘Maya’, and ‘Garbaja’ cultivars (18.022, 17.973, and 25.246, respectively) applied Bud Feed was found to be higher than the GDH2 values of control plants (17.792, 17.963, and 23.021, respectively). These results were in agreement with Çalışkan et al. (2021c), who showed that the GDH1 and GHD2 values of the ‘Madison’ apricot cultivar were higher in trees treated with Bud Feed + $CaNO_3$, resulting in early fruit ripening.

3.2. Flowering and fruit set rates

The effects of Bud Feed application on fruit set and yield characteristics of 'Astoria', 'Maya' and 'Garbaja' cultivars were statistically significant (Table 3). Bud Feed application increased flowering rates (81.82%, 83.43%, and 77.78%, respectively) in ‘Astoria’, ‘Maya’, and ‘Garbaja’ cultivars compared to the control (66.44%, 80.40%, and 55.15%, respectively). According to the average of the cultivars, the flowering rate (81.92%) in the ‘Maya’ cultivar was higher than in the ‘Astoria’ (75.33 %) and ‘Garbaja’ (66.47%) cultivars.

The first fruit set rate in all cultivars was higher in trees treated with Bud Feed (15.75%, 6.25%, and 5.25%, respectively) than in the control plants. Similarly, bud feed application increased the final fruit set relative to control plants. According to the average data, the first fruit set and the final fruit set percentages were higher in ‘Astoria’ (11.00% and 8.38%, respectively) than in ‘Maya’ (5.44% and 3.48%, respectively) and ‘Garbaja’ (4.50 and 2.40, respectively) cultivars. Westwood (2009) reported

Table 1. Effect of Bud Feed and calcium nitrate application on the chilling duration of cultivars until bud break (2019-2020 season).

Months	Astoria			
	Bud Feed		Control	
	Chill hour	Chill unit	Chill hour	Chill unit
December	102	121	102	121
January	170	236	170	236
February	65	161	77	185
Total	337	518	349	542
Months	Maya and Garbaja			
	Bud Feed		Control	
	Chill hour	Chill unit	Chill hour	Chill unit
December	102	121	102	121
January	170	236	170	236
February	77	185	82	195
Total	349	542	354	552

Table 2. Effect of Bud Feed and calcium nitrate application on growing degree hours (GDH) of cultivars.

Months	Astoria			
	Control		Bud Feed	
	GDH1	GDH2	GDH1	GDH2
February	-	-	0.232	0.232
March	6.880	7.345	7.340	7.343
April	0.752	7.592	0.303	7.595
May	-	2.855	-	2.852
June	-	-	-	-
Total	7.632	17.792	7.875	18.022
Months	Maya			
	Control		Bud Feed	
	GDH1	GDH2	GDH1	GDH2
February	-	-	0.182	0.182
March	6.632	7.344	7.346	7.343
April	0.763	7.591	-	7.595
May	-	2.858	-	2.853
June	-	-	-	-
Total	7.395	17.793	7.528	17.963
Months	Garbaja			
	Control		Bud Feed	
	GDH1	GDH2	GDH1	GDH2
February	-	-	-	-
March	6.392	7.341	7.348	7.347
April	-	7.592	1.047	7.595
May	-	7.446	-	7.446
June	-	0.642	-	2.858
Total	6.392	23.021	8.395	25.246

Table 3. Effects of Bud Feed and calcium nitrate application on fruit set and yield characteristics of cultivars.

Cultivars	Application		Mean
	Bud feed	Control	
Flowering (%)			
Astoria	81.82 a[(1)]	69.44 b	75.33 b[(2)]
Maya	83.43 a	80.40 b	81.92 a
Garbaja	77.78 a	55.15 b	66.47 c
Initial fruit set (%)			
Astoria	15.75 a	6.25 b	11.00 a
Maya	6.25 a	4.63 b	5.44 b
Garbaja	5.25 a	3.75 b	4.50 b
Final fruit set (%)			
Astoria	12.75 a	4.00 b	8.38 a
Maya	3.63 a	3.33 b	3.48 b
Garbaja	2.50 a	2.29 b	2.40 b
Yield (kg tree^{-1})			
Astoria	33.95 a	22.50 b	28.23 a
Maya	15.73 a	9.28 b	12.51 b
Garbaja	10.35 a	4.95 b	7.65 b
Yield (kg cm^{-2})			
Astoria	0.33 a	0.24 b	0.28 a
Maya	0.13 a	0.06 b	0.09 b
Garbaja	0.09 a	0.06 b	0.07 b
Yield (t ha^{-1})			
Astoria	56.3 a	37.3 b	46.5 a
Maya	26.1 a	15.4 b	20.7 b
Garbaja	17.1 a	8.2 b	12.6 b

[(1)] Means followed by equal letters, in the rows, do not differ by Student's T, at 5% probability.
[(2)] Means followed by equal letters, in the columns, do not differ by LSD test, at 5% probability.

that fruit sets should be between 10-15% for adequate yield in peach. The 'Astoria' cultivar in this study was included in the specified rates. However, fruit set rates were low in 'Maya' and 'Garbaja' cultivars. This is due to chilling deficiency leading to poor-uneven bud break, poor foliage, and abnormal flowers, resulting in poor fruit set (Erez, 1987; Çalışkan et al., 2021a). The results from this study were consistent with the results that bud-break treatments increased flowering (Campoy et al., 2011) and fruit set formation (Mohamed and Sherif, 2015; Kotb et al., 2019). However, Chen and Beckman (2019) reported that the effects of bud break application can be changed to genotype, tree

Table 4. Effect of Bud Feed and calcium nitrate application on fruit quality characteristics of cultivars.

Cultivars	Application		Mean
	Bud Feed	Control	
	Fruit weight (g)		
Astoria	171.23 a[(1)]	154.97 b	163.10 a[(2)]
Maya	143.38 a	133.58 b	138.48 b
Garbaja	163.68 a	158.87b	161.28 a
	Fruit diameter (mm)		
Astoria	76.1 a	67.5 b	71.8 c
Maya	68.6 b	89.7 a	79.2 b
Garbaja	94.3 a	92.2 a	93.2 a
	Fruit length (mm)		
Astoria	75.7 a	68.3 b	71.9 c
Maya	65.8 b	87.5 a	76.6 b
Garbaja	95.0 a	94.7 b	94.9 a
	Fruit height (mm)		
Astoria	73.0 a	63.7 b	68.4 b
Maya	63.8 a	79.5 b	71.6 b
Garbaja	87.9 b	89.1 a	88.5 a
	Fruit firmness (kg-force)		
Astoria	5.83 b	8.13 a	6.98 a
Maya	7.02 b	7.03 a	7.03 a
Garbaja	4.97 a	4.73 b	4.85 b
	Seed weight (g)		
Astoria	10.72 a	10.56 b	10.64 b
Maya	10.82 a	10.04 b	10.43 b
Garbaja	12.36 a	12.01 b	12.19 a
	Flesh/seed ratio (%)		
Astoria	15.03 a	13.80 b	14.42 a
Maya	12.25 b	12.31 a	12.28 b
Garbaja	12.25	12.25	12.25 b
	Total soluble solids (%)		
Astoria	10.17 a	9.83 b	10.00 b
Maya	10.17 b	10.43 a	10.30 b
Garbaja	11.87 a	10.55 b	11.21 a
	pH		
Astoria	3.32 a	3.21 b	3.27 a
Maya	3.33 a	3.27 b	3.30 a
Garbaja	3.05 b	3.11 a	3.08 b
	Acidity (%)		
Astoria	1.19 b	1.23 a	1.21 b
Maya	0.93 b	1.00 a	0.97 c
Garbaja	1.68 a	1.35 b	1.52 a

[(1)] Means followed by equal letters, in the rows, do not differ by Student's T, at 5% probability.
[(2)] Means followed by equal letters, in the columns, do not differ by LSD test, at 5% probability.

age, shoot type, and application time. In addition, nitrogen compounds, including amino acids, were constituted at low levels in the buds during the dormancy stage and reached maximum levels just before bud opening (Imrak et al., 2016). An increase in the amino acids contents, such as proline and arginine, and of growth-promoting hormones, such as auxins and gibberellins, occurred in the buds after the bud break applications (Seif El-Yazal et al., 2014). This can be associated with an increase in flowering and fruit set of bud break applications.

3.3. Fruit quality characteristics

The results of the effects of Bud Feed application on fruit quality in 'Astoria', 'Maya', and 'Garbaja' cultivars were presented in Table 4. Fruit weight values of 'Astoria', 'Maya', and 'Garbaja' cultivars were higher in Bud Feed application (171.23 g, 143.38 g, 163.68 g, respectively) than in plants of these cultivars in control. The 'Astoria' and 'Garbaja' cultivars had the highest average fruit weight (163.10 g and 161.28 g, respectively). Bud Feed applied 'Garbaja' and 'Astoria' cultivars had the highest fruit diameter (94.3 and 76.1 mm, respectively) and fruit length (95.0 and 75.7 mm, respectively).

The highest fruit height in the 'Astoria' (73.0 mm) and 'Maya' (63.8 mm) was found in Bud Feed treated plants. According to the average data, fruit diameter, fruit length, and fruit height were highest in the 'Garbaja' cultivar (93.2, 94.9, and 88.5 mm, respectively). Fruit size in peaches is one of the most important quality parameters and the increase in fruit size positively affects the commercial value of the fruit. The genetic capacity of the cultivar, fruit thinning, and cultural applications affect the fruit size of the peach (Crisosto and Costa, 2008).

Increasing fruit size, especially in varieties suitable for early cultivation, is one of the critical factors in cultivation. In this study, positive Bud Feed on fruit quality characteristics of peach cultivars will create useful results in practice. Bound and Jones (2004) reported that since fruit from early-blooming flowers has a faster initial growth rate than fruit from later flowers, progress in flowering may result in larger fruit. Similarly, Eroğul et al. (2021) showed that the fruit weight of the control trees in the '0900 Ziraat' cherry cultivar was 8.63 g, while it increased to 10.69 g in Bud Feed + 12% Cao + 0.5% B application. These results were similar to those obtained by Ferreira et al. (2022), who indicated that bud break applications in peach have the effect of increasing fruit weight and size. Besides, our results were in agreement with the results of the different fruit species such as apple (Chauhan et al., 2018), fig (Gaaliche et al., 2017), and apricot (Çalışkan et al., 2021b).

Flesh firmness was highest in 'Astoria' and 'Maya' cultivars in control plants (8.13 kg-force and 7.03 kg-force, respectively), whereas it was highest for 'Garbaja' (4.97 kg-force) in Bud Feed applied plants. Comparing the average fruit firmness, 'Maya' and 'Astoria' cultivars had firmer fruits (7.03 kg-force and 6.98 kg-force, respectively). Bud Feed application increased the seed weight (10.72 g, 10.82 g, and 12.36 g, respectively) in all cultivars compared to the control. The 'Garbaja' cultivar had the highest average seed weight (12.19 g). The highest flesh/seed ratio was found in Bud Feed application (15.03%) in the 'Astoria' cultivar, while it was the highest in control (12.31%) for the 'Maya' cultivar. The effect of bud feed application on flesh/seed ratio in the 'Garbaja' was statistically insignificant. 'Astoria' had the highest average flesh/seed ratio (14.42%). Similarly, Mohamed and Sherif (2015) indicated that the application of hydrogen cyanamide in the 'Florda Prince' peach cultivar decreased the fruit firmness. Our data was compatible with the results of Çalıskan et al. (2021b), that Bud Feed application reduced the fruit firmness of apricot cultivars.

While the highest TSS content was measured in 'Astoria' and 'Garbaja' cultivars (10.17% and 11.87%, respectively) applied Bud Feed, the highest TSS content in 'Maya' cultivar was measured in control fruits (10.43%). The highest average TSS content was in the 'Garbaja' cultivar (11.21%). These results were similar to the findings of Mohamed & Sherif (2015) and Kotb et al. (2019) that bud break applications increased TSS content in peach.

The highest pH values were detected in 'Astoria' and 'Maya' (3.32 and 3.33, respectively) treated with Bud Feed (Table 4). However, the highest pH in the Garbaja cultivar (3.11) was found in the control fruits. According to the average pH values, 'Maya' and 'Astoria' cultivars had the highest pH values (3.30 and 3.08, respectively). Bud Feed applications were reduced titratable acidity in 'Astoria' and 'Maya" cultivars (1.23% and 1.00%, respectively). According to the cultivar average, titratable acidity was the highest in 'Garbaja' (1.52%), whereas it was lowest in 'Maya' (0.97%). These results showed that the effect of the bud feed application on the acid content of the fruit varied depending on the cultivar. Ferreira et al. (2022) displayed that nitrogen fertilizer and calcium nitrate treatments in the 'Douradão' peach cultivar increased the acid content of the fruit. Bettiol Neto et al. (2014) reported that the effects of bud break treatments on fruit quality may be due to the uniformity and density of bud growth, flowering, and fruiting, and decreasing the harvest period. In addition, Leonel et al. (2014) showed that the chemical content of the fruit, such as soluble solids, pH, and titratable acidity is probably associated with the shortening of the harvest time, which can have a positive or negative effect, based on the climatic conditions in the fruit development stages.

Bud Feed application in peach-nectarine cultivars affected fruit skin and flesh color at different levels depending on the cultivar (Table 5). Bud Feed application increased the fruit skin color brightness (L) for 'Maya' and 'Garbaja' cultivars (47.83 and 73.49, respectively) compared to control (45.73 and 66.31, respectively). However, the L value for the 'Astoria' cultivar was higher in the control (56.68) than in the Bud Feed application (55.00). In the comparison of the averages of the cultivars, the 'Garbaja' cultivar had a brighter fruit skin color (69.90). The highest a* value showing red (positive value)-green color (negative value) in 'Astoria' was obtained from the Bud Feed application (20.67), while the highest a* value in 'Maya' and 'Garbaja' were obtained from the control (31.19 and 32.68, respectively). The mean a* value of 'Maya" and 'Garbaja' cultivars (31.03 and 28.89, respectively) was higher than 'Astoria' (19.20). Positive b* value showing yellow color was highest in 'Maya' and 'Garbaja' cultivars applied Bud Feed (25.32 and 18.91, respectively) compared to control. The average b* value was higher in the 'Astoria' cultivar (31.98). The *C* value indicating the intensity of the color (lower values indicate the intensity of the color) was more intense in 'Maya' and 'Garbaja' cultivars (39.96 and 32.55, respectively) applied Bud Feed than in control. However, the most intense fruit skin color was detected in the control plants (39.50) in the 'Astoria'. According to the average C values, the 'Garbaja' (32.90) had a more intense fruit skin color. Fruit skin color *h*° value was higher (68.00 and 39.60) in Bud Feed application for 'Garbaja' and 'Maya' cultivars. It was higher in the control (39.58) for 'Astoria'. The average *h*° value of the cultivars was the highest in 'Garbaja' (62.43).

The brightest flesh color (L value) of 'Astoria' and 'Garbaja' cultivars was determined in the Bud Feed application (79.07 and 72.68, respectively). In the 'Maya' cultivar, the brightest fruit flesh color value was in control (79.16). The mean L value in the fruit

Table 5. Effect of Bud Feed application on fruit skin and flesh color characteristics of cultivars.

Cultivars	Application: Bud Feed	Application: Control	Mean
	Fruit skin color		
	L		
Astoria	55.00 b[1]	56.68 a	55.84 b[2]
Maya	47.83 a	45.73 b	46.78 c
Garbaja	73.49 a	66.31 b	69.90 a
	a*		
Astoria	20.67 a	17.72 b	19.20 b
Maya	29.87 b	32.19 a	31.03 a
Garbaja	25.09 b	32.68 a	28.89 a
	b*		
Astoria	31.43 b	32.53 a	31.98 a
Maya	25.32 a	24.02 b	24.67 b
Garbaja	18.91 b	20.72 a	19.82 c
	C		
Astoria	39.58 a	39.50 b	39.54 a
Maya	39.96 b	40.77 a	40.37 a
Garbaja	32.55 b	39.25 a	35.90 b
	h°		
Astoria	55.35 b	60.38 a	57.87 b
Maya	39.60 a	35.82 b	37.71 c
Garbaja	68.00 a	56.85 b	62.43 a
	Fruit flesh color		
	L		
Astoria	79.07 a	77.12 b	78.10 a
Maya	78.91 b	79.16 a	79.04 a
Garbaja	72.68 a	71.01 b	71.85 b
	a*		
Astoria	-7.19 b	-6.03 a	-6.61 b
Maya	-7.56 b	-6.38 a	-6.97 b
Garbaja	-7.31 b	-7.23 a	-7.27 a
	b*		
Astoria	51.30 a	50.84 b	51.07 a
Maya	50.96 a	50.70 b	50.83 a
Garbaja	43.40 a	41.79 b	42.60 b
	C		
Astoria	51.82 a	51.26 b	51.54 a
Maya	51.53 a	51.11 b	51.32 a
Garbaja	47.39 a	43.02 b	45.21 b
	h°		
Astoria	97.99 a	96.67 b	97.33 a
Maya	98.45 a	96.05 b	97.25 a
Garbaja	94.20 a	93.75 b	93.98 b

(1) Means followed by equal letters, in the rows, do not differ by Student's T, at 5% probability.
(2) Means followed by equal letters, in the columns, do not differ by LSD test, at 5% probability. LSD, least significant difference.

flesh of 'Astoria' and 'Maya' cultivars (78.10 and 79.04, respectively) was higher than 'Garbaja' (71.85). The negative a* value representing green color was the lowest in the control (-6.03, -6.38, and -7.23, respectively) in all cultivars (Table 5). Similarly, according to the cultivar averages, 'Astoria' and 'Maya' cultivars had the lowest flesh color a* value (-6.61 and -6.97, respectively). Fruit flesh color was more yellow (b*) in 'Astoria' and 'Maya', and 'Garbaja' cultivars treated with Bud Feed (51.30, 50.96, and 43.40, respectively). 'Astoria' and 'Maya' cultivars had the highest flesh color b* value. However, in all cultivars, the flesh color density was the highest in the control fruits with low C and *h*° values. Also, the 'Garbaja' had the most intense fruit flesh color.

In peach-nectarines, fruit skin color characteristics are used to determine fruit maturity and harvest time. In addition, fruit color in peaches-nectarines is one of the important characteristics that affect consumer preferences (Crisosto and Costa, 2008). In this study, Bud Feed application had positive effects on the formation of red color on the fruit skin, but this differed depending on the cultivar. These findings were similar to the results obtained by Çalışkan et al. (2021b), who showed that the Bud Feed application in 'Mikado' and 'Mogador' cultivars increased the orange color intensity as well as the red color formation in the fruit peel. Raffo et al. (2014) reported that optimal color intensity in the 'New Star' cherry cultivar treated bud break applications for harvest one week was earlier than the control plants. However, Eroğul et al. (2021) indicated that Bud Feed and Erger applications did not adversely affect the fruit skin color characteristics of the '0900 Ziraat' cherry cultivar.

3.4. Yield variables

The highest yield per tree, yield per trunk cross-section, and yield per hectare had the cultivars 'Astoria' (33.95 kg tree^{-1}, 0.33 kg cm^{-1}, and 56.3 t ha^{-1}, respectively), 'Maya' (15.73 kg tree^{-1}, 0.13 kg cm^{-1}, and 26.1 t ha^{-1}, respectively), and 'Garbaja' (10.35 kg tree^{-1}, 0.09 kg cm^{-1}, and 17.1 t ha^{-1}, respectively) applied Bud Feed (Table 3). Average data showed that the 'Astoria' cultivar was the highest yield per tree, yield per trunk cross-section, and yield per hectare (28.23 kg tree^{-1}, 0.28 kg cm^{-1}, and 46.5 t ha^{-1}, respectively). Similar to these results, Ferreira et al. (2022) showed that nitrogen fertilizer and calcium nitrate applications for bud break in the 'Douradão' peach cultivar increased the yield by 30.92% compared to control plants. In addition, these results were consistent with the findings that bud break applications increased fruit yield in peach (George et al., 1992), pistachio (Ghrab and Ben Mimoun, 2014), fig (Theron et al., 2011; Gaaliche et al., 2017), cherry (Sheard et al., 2009), kiwifruit (Veloso et al., 2003). The high yield in plants applied with the bud break may be due to an increase in flowering and higher fruit set percentages.

4. Conclusion

The accumulation of chilling hours is essential for the breaking of the dormancy stage in the buds of stone fruits such as peach-nectarine, apricot, and sweet cherry. However, due to the increasing effect of global warming in recent years, especially in the Mediterranean region of Türkiye, there has been a decrease in winter cold and this can cause significant decreases in yield. Thus, there is a need for studies on bud break applications that can prevent yield and quality loss in early cultivars. Low biuret urea (Bud Feed) and calcium nitrate application increase fruit set, yield, and fruit quality in early ripening 'Astoria' and 'Maya' peach and 'Garbaja' nectarine cultivars. This application provides earliness of 2 days in 'Astoria' and 'Garbaja' cultivars and 3 days in 'Maya' cultivar at harvest time. The harmful effects of these compounds on the environment are much less than chemical applications may also encourage their widespread use.

Acknowledgments

Many thanks to Canan Yılmaz (Stoller Türkiye, İzmir) and İzzet Parlar (Parlar Fidancılık, İzmir, Türkiye) for their support to achieve this study.

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