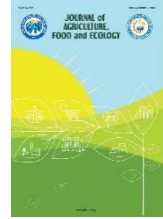




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Determination of Quality Characteristics of Grape Clusters on Summer Shoots Taken from Different Bud Levels: Ata Sarısı and Amasya Beyazı (*Vitis vinifera* L.)

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Abstract

This study was conducted to determine the quality characteristics of summer shoots with clusters originating from different bud levels in the Ata Sarısı and Amasya Beyazı grape varieties. In the trial vines, winter pruning was carried out in mid-March by leaving one short shoot (spur) (with two buds) at the head and one long pruned (cane) at different bud levels. All bunches on the spurs were cut and removed in mid-May, whilst on the long shoots summer shoots were selected according to different bud levels, with two summer shoots being selected and left on each. One of these shoots was the summer shoot left for the intended purpose (1st, 2nd, 3rd, 4th and 5th buds), and the clusters of this summer shoot were examined. The effects of different bud-sparing treatments on grape yield and cluster characteristics revealed statistically significant differences ($p<0.05$). According to the results of the Principal Component Analysis, the first two principal components explained 92.18% of the total variance, and it was determined that the treatments were clearly distinguishable in terms of yield and cluster characteristics. It was observed that grape yield reached its highest level with the 5th bud application. In contrast, the 1st and 2nd bud applications resulted in the lowest yield. Consequently, it was determined that the 5th bud application is recommended for the Ata Sarısı and Amasya Beyazı grape varieties in terms of both yield and quality.

Key words: Bud fruitfulness, cluster, summer shoot, vine

Öz

Farklı Tomurcuk Seviyelerinden Alınan Yaz Sürgünleri Üzerindeki Salkımların Kalite Özelliklerinin Belirlenmesi: Ata Sarısı ve Amasya Beyazı (*Vitis vinifera* L.)

Bu araştırma, Ata Sarısı ve Amasya Beyazı üzüm çeşitlerinde farklı göz seviyelerinden süren yazlık sürgün salkımlarının kalite özelliklerinin belirlenmesi amacıyla yapılmıştır. Deneme asmalarında, kış budaması mart ayı ortasında, başlar üzerinde bir ırgat (2 göz) ile farklı göz seviyelerinden budanmış bir bayrak dal bırakılmak suretiyle gerçekleştirilmiştir. Irgatlar üzerindeki bütün somaklar mayıs ayı ortasında kesilerek uzaklaştırılmış, bayraklarda ise farklı göz seviyelerine göre yazlık sürgün alım işlemi yapılarak üzerlerinde ikişer adet yazlık sürgün seçilerek bırakılmıştır. Bu sürgünlerden bir tanesi amaca yönelik olarak bırakılan yazlık sürgün (1., 2., 3., 4. ve 5. gözler) olup, bu yazlık sürgünün salkımları incelemeye alınmıştır. Farklı göz uygulamalarının üzüm verimi ve salkım özellikleri üzerindeki etkileri istatistiksel olarak anlamlı farklılıklar bulunduğunu göstermiştir ($p<0,05$). Temel Bileşen Analiz sonuçlarına göre ilk iki temel bileşen toplam varyansın %92,18'ini açıklamış ve uygulamaların verim ve salkım özellikleri bakımından net şekilde ayrıştığı belirlenmiştir. İki üzüm çeşidinde de üzüm veriminin, 5. göz uygulamasının en yüksek değer gösterdiği görülmüştür. Buna karşılık 1. ve 2. göz uygulamalarında ise en düşük verim grubunu oluşturmuştur. Sonuçta, Ata Sarısı ve Amasya Beyazı üzüm çeşitlerinde 5. göz uygulamasının verim ve kalite açısından öne çıktığı belirlenmiştir.

Anahtar Kelimeler: Asma, göz verimliliği, salkım, yazlık sürgün

1. Introduction

Viticulture is one of the world's oldest branches of agriculture, practised extensively in the latitudes of 30°-50° north and 30°-40° south, a region that includes Türkiye. In Türkiye viticulture, there was a 7.8% decrease in vineyard area and a 5.9% increase in grape production between 2018 and 2022 (Söylemezoğlu et al., 2025). According to Food Agriculture Organization (FAO) data for 2024, in terms of grape production area, Türkiye ranks fifth with 377,848 ha, following Spain, France, Italy and China; in terms of grape production volume, it ranks seventh with 3,380,000 tonnes, following China, Italy, France, the United States (US), Spain and India (FAO, 2025). In terms of grape production by region in Turkey, the Aegean region ranks first, followed by the Mediterranean region in second place and the South-Eastern Anatolia region in third. As the homeland of the vine, Türkiye is home to approximately 1,500 grape varieties. However, only 50-60 of these are commercially cultivated (Ağaoğlu, 1999). The province of Çanakkale is a significant agricultural production area, characterised by diverse climatic and soil conditions due to its location between the Marmara and Aegean regions. This geographical advantage offers considerable potential not only for the cultivation of many crop varieties in the province but also for viticulture (Şahin, 2025). The 'Ata Sarısı' and 'Amasya Beyazı' varieties, characterised by their large berries and aromatic flavour, are cultivated in the region for table use. They are characterised by rapid shoot growth (Çelik, 2006).

When referring to vine productivity, this refers to the productivity of the primary buds in the winter buds which first appear on the leaf axil shoots during the summer growth period that complete their developmental stages after the differentiation period and survive the dormant period to reach the following spring (Winkler et al., 1974; Çelik et al., 2018; Çoban and Dardeniz, 2023; Şahin et al., 2023). While some primary buds contain three cluster primordia, others may not form any at all. Winter buds that do not form cluster primordia are termed 'non-productive buds', and the summer shoots arising from these buds are referred to as 'non-productive shoots' (Çelik, 2022; Odabaşoğlu, 2024). It is known that the formation of cluster primordia varies depending on the vine's age and variety characteristics, the position of the winter bud on the one-year-old shoot, and the vine's nutritional status (Reynolds and Wardle, 1989; Çelik, 1999; Uyak and Doğan, 2018). Furthermore, research has shown that the yield at the base and tip of a vine shoot varies and is lower than that at the middle nodes of the annual shoot (Dardeniz and Kışmalı, 2005; Durmuş et al., 2016).

In viticulture, regular summer and winter pruning helps to maintain a balance between the vine's vegetative and generative growth. This enables the vineyard to produce balanced, high-quality and high-yield crops for as long as possible (Gutierrez-Gamboa et al., 2018; Çoban, 2023). Furthermore, in determining the yield and quality of the produce obtained from the vineyard, the importance of the balance between the leaf area directly exposed to the sun and the fruit weight is significant, in addition to summer and winter pruning (Candar et al., 2019; Özgür et al., 2021; Del Zozzo and Poni, 2024).

This study was conducted to determine the quality characteristics of summer shoots with clusters originating from different bud levels in the Amasya Beyazı and Ata Sarısı (*Vitis vinifera* L.) grape varieties.

2. Materials and Methods

This study was conducted over a two-year period at the Table Grape Varieties Research and Demonstration Vineyard (40° 4' 26.40"N latitude and 26° 21' 42.84"E longitude) within the Plant Production Research and Application Unit of the Faculty of Agriculture at ÇOMÜ Dardanos Campus. In the vineyard, the vines were trained using a single-cane, fixed-cordon trellis system with rows spaced 3.0 metres apart and plants 1.5 metres apart. The study utilised Ata Sarısı and Amasya Beyazı grape varieties grafted onto 22-year-old 5BB rootstocks grown under arid conditions. The vineyard has a clay-loam soil composition. Although rainfall is mostly concentrated in the autumn and winter months, the summer months are hot and dry. The region's annual rainfall totals 610 mm; the hottest months are July and August, with an average temperature of 25.4 °C.



Ata Sarısı was registered in 1988 because of the crossbreeding of the 'Beyaz Çavuş X Cardinal' grape varieties. It is a grape variety characterised by white, oval, crisp-textured, large berries with high visual appeal, containing 2-3 seeds, and featuring a conical cluster structure (Uslu and Samancı, 1998).



Amasya Beyazı is a grape variety characterised by its round, yellowish-green berries containing 1-2 seeds, large berries, mid-season ripening, and a conical cluster structure (Çelik, 2006).

In both years, mixed winter pruning was carried out in mid-March on the annual shoots, with short shoots (spur) pruned at the 2nd bud and long shoots pruned at the 1st, 2nd, 3rd, 4th and 5th buds. Subsequently, on each vine head, a shoot was always left to prevent the head from rising; all suckers on the shoots were removed by cutting them off in April for the Amasya Beyazı grape variety and in May for the Ata Sarısı grape variety. On the main shoots, summer shoots were selected according to different levels, with two summer shoots left on each main shoot. One of these shoots was a purpose-grown summer shoot (1st, 2nd, 3rd, 4th and 5th buds), and the buds on this summer shoot were not touched. On the research plot, cultural practices such as soil preparation, fertilisation and pest control were carried out in accordance with the appropriate techniques.

According to the Eichhorn–Lorenc (1977) phenological stages; for grape varieties that had reached harvest maturity (EL-38), the grapes from each vine were placed in separate bags and labelled during harvesting and were then taken immediately to the Pomology Laboratory of the Faculty of Agriculture's Department of Horticulture for analysis. Subsequently, for the cluster: average yield (g cluster⁻¹), cluster weight (g cluster⁻¹) (Isolab brand precision balance), cluster width (cm), cluster length (cm) (Tomax digital measuring device), cluster density (in accordance with OIV Standard No. 204) (OIV, 2009), berry weight (g berry⁻¹), berry width (mm), berry length (mm), luminance (L), Chroma (C), Hue angle (oh) (Konica Minolta Chroma Meter CR-400), and the total soluble solids (°Brix) of the grapes were measured using a digital refractometer Atago PAL-3; accuracy: ± 0.1% Brix (Tokyo, Japan) and expressed as °Brix. Titratable acidity (g L⁻¹ tartaric acid) was determined by titration with 0.1 mol L⁻¹ NaOH, while pH was measured in an AG 8603 digital potentiometer; pH accuracy ± 0.01 pH (Mettler Toledo, Schwarzenbach, Switzerland). and maturity index (TSS acidity-1) were examined. This study was designed as a randomised block design with four replicates, using one vine per replicate. The research results were analysed using analysis of variance (ANOVA) within the 'SAS 9.1.3. Portable' statistical software package, whilst the mean values for the treatments were evaluated using the LSD (Least Significant Difference) multiple comparison test at a significance level of $p < 0.05$. Furthermore, Principal Component Analyses (PCAs) were performed on cluster and berry characteristics, as well as physical and chemical parameters, using ggbiplot2 within R Studio 0.6.2 (Wickham, 2023).

3. Results and Discussion

We have not come across much literature relevant to the aim of our research on existing grape varieties. In this regard, we would like to state that we have had sufficient opportunity to discuss our research findings. In this respect, our research is significant in terms of providing inspiration for future studies.

The summer shoot cluster yields, as well as the physical and chemical properties of the clusters and berries, of the Ata Sarısı and Amasya Beyazı grape varieties, which were grown from different bud levels, showed statistically significant differences; the values are presented in Tables 1 and 2. Furthermore, the effects of different bud levels on grape yield and quality characteristics were also evaluated using PCA (Figures 1 and 2).

3.1. The physical and chemical properties of the Ata Sarısı grape variety

The Ata Sarısı grape variety formed statistically distinct groups across years in terms of grape physical (yield, berry and cluster characteristics) and chemical properties (TSS, acidity, maturity index, pH, L , C °h value) from summer shoots originating from different bud levels ($p < 0.05$) (Table 1). Average yield values were highest in the 3rd and 2nd buds (3969.5-3864.0 g vine⁻¹) and lowest in the 4th buds (3235.7 g vine⁻¹), with the 1st and 5th buds

(3776.5, 3487.6 g vine⁻¹) following with intermediate values.

Table 1. Physical, chemical and colour characteristics of the Ata Sarısı grape variety in the trial years

Table 1. Physical, chemical and colour characteristics of the Ata Sanat grape variety in the trial years												
Application	Yield (g vine ⁻¹)			Average cluster weight (g)			Cluster length (cm)					
	First year	Second year	Average	First year	Second year	Average	First year	Second year	Average			
1. buds	1993.4b	5559.5a	3776.5ab	272.4b	410.9b	341.6bc	16.8 c	19.4 bc	18.0c			
2. buds	2917.7a	4810.2ab	3864.0a	331.8a	375.5bc	353.6bc	17.9bc	18.1c	18.0c			
3. buds	3039.3a	4899.7ab	3969.5a	284.0ab	485.2a	384. 6ab	19.0 b	20.1ab	19.5b			
4. buds	2302.3b	4169.0b	3235.7b	304.1ab	512.8a	408.4a	20.9 a	20.9 a	20.9a			
5. buds	2154.5b	4820.7b	3487.6ab	297.1ab	351.3c	324.2c	18.7 b	20.35ab	19.5b			
*LSD _{0.05}	581.44	1052.2	576.59	52.975	69.385	61.078	1.5686	1.479	1.1289			
Application	Cluster width (cm)			Cluster density (1-9)								
	First year	Second year	Average	First year	Second year	Average						
1. buds	11.32 b	13.02 b	12.17 b	6.95 ab			7.31 ab	7.13				
2. buds	12.53 a	12.91 b	12.72ab	7.17 a			7.01 bc	7.09				
3. buds	12.13ab	14.01 a	13.07 a	6.78 b			7.17 bc	6.97				
4. buds	11.59 b	14.31 a	12.95 a	6.49 c			7.39 a	6.94				
5. buds	11.52 b	12.81 b	12.16 b	6.96 ab			6.93 c	6.95				
*LSD _{0.05}	0.880	0.7072	0.577	0.2656			0.3127	**Ns				
Application	Berry weight (g)			Berry length (mm)			Berry width (mm)					
	First year	Second year	Average	First year	Second year	Average	First year	Second year	Average			
1. buds	5.26 b	9.26 ab	7.26 b	22.54 b	27.41ab	24.97 b	18.70b	22.98ab	20.84 ab			
2. buds	5.64ab	9.13 ab	7.39 b	22.89 ab	27.43ab	25.16 ab	19.34ab	23.00ab	21.17 ab			
3. buds	6.29 a	9.00 ab	7.65ab	23.74 a	27.48ab	25.61 ab	19.92a	22.40b	21.16 ab			
4. buds	5.88ab	10.52 a	8.20 a	23.27 ab	29.02a	26.15 a	19.25ab	23.56 a	21.40 a			
5. buds	5.87ab	8.68 b	7.28 b	23.90 a	26.33b	25.11 ab	18.97b	22.10 b	20.54 b			
*LSD _{0.05}	0.8876	1.5404	0.7983	1.0942	1.7578	1.1821	0.756	1.0015	0.648			
Application	Total soluble solids (TSS. %)			Acidity (%)			Maturity index					
	First year	Second year	Average	First year	Second year	Average	First year	Second year	Average			
1. buds	12.89 a	16.56 ab	14.73 ab	0.893 a	0.540	0.717abc	43.41a	40.15ab	41.78 a			
2. buds	11.38 b	15.45 b	13.41 b	0.890 a	0.649	0.770 ab	41.30ab	43.11a	42.21 a			
3. buds	12.70 a	17.28 a	14.99 a	0.715 b	0.540	0.628 c	34.53c	35.85b	35.19 b			
4. buds	11.51 b	15.48 ab	13.50 ab	0.992 a	0.616	0.804 a	34.88bc	44.77a	39.83 ab			
5. buds	11.68 b	14.91 b	13.30 b	0.873 a	0.540	0.707 bc	42.08a	40.93ab	41.51 a			
*LSD _(0.05)	0.8377	0.7459	1.5046	0.1259	Ns	0.0948	6.6434	5.5259	5.0036			
Appl.	pH			L			C			%h		
	First year	Second year	Avg.	First year	2year	Avg.	First year	2yer	Avg.	First year	Second year	Avg.
1. buds	3.85a	3.86bc	3.86a	35.8a	37.7	36.8a	11.1ab	8.24	9.6ab	108.5b	117.1b	112.8b
2. buds	3.80a	3.84c	3.82a	35.3ab	37.90	36.6ab	11.1ab	8.27	9.7a	109.2ab	116.3b	112.8b
3. buds	3.68ab	3.96a	3.82a	34.29c	38.26	36.2ab	10.5b	7.85	9.18b	110.9a	120.2a	115.5a
4. buds	3.60b	3.79c	3.70b	34.6bc	36.57	35.5b	10.9ab	7.84	9.4ab	107.0b	111.7c	109.3c
5. buds	3.74ab	3.95ab	3.85a	34.9bc	38.40	36.6ab	11.4a	7.74	9.5ab	106.9b	121.4a	114.1ab
*LSD _{0.05}	0.1715	0.1007	0.086	0.9998	Ns	1.1963	0.7041	Ns	0.5158	2.3563	2.7886	2.011

*Means within a column with different letters are significantly different at 5 % level according to LSD test. **Non-significant (Ns), Appl.: Application, Avg: Average

3.2. The physical and chemical properties of the Amasya Beyazı grape variety

Summer shoots of the Amasya Beyazı grape variety originating from different bud levels formed statistically distinct groups in terms of the physical and chemical properties across years ($p < 0.05$) (Table 2). However, since their average grape yield values and berry characteristics were similar, no statistically significant difference was

detected ($p > 0.05$).

As evaluated in terms of cluster characteristics, the heaviest clusters (500.7 g and 488.1 g) and group a were obtained from the 3rd and 5th buds (9.0 cm), while the lightest clusters (340.51 g and 409.8 g) were observed in the 1st and 2nd buds. Based on cluster length characteristics, it was determined that the longest average cluster length was 20.59 cm in the 5th buds. The shortest average cluster length was observed in the 2nd buds (17.90 cm). The average cluster lengths for the other buds were determined to be 19.69 cm for the 3rd buds, 19.30 cm for the 1st bud, and 18.76 cm for the 4th bud. Regarding cluster width values, the widest clusters were found in the 3rd (13.66 cm), 5th (13.51 cm), and 4th (13.27 cm) buds; the narrowest cluster widths were found in the 1st (11.82 cm) and 2nd (12.32 cm) buds, respectively. When cluster density was examined, the highest cluster density was observed in the first buds (7.44) and the fifth buds (7.38). The lowest cluster density was observed in the third buds (7.16), while the second (7.32) and fourth (7.30) buds had average cluster densities that fell within the range

The highest TSS value was found in the 3rd buds (14.99%), while the lowest value was determined in the 5th buds (13.30%). As examined in terms of acidity (%), the highest value was found in the 4th buds (0.804%), while the lowest value was found in the 3rd buds (0.628%). Regarding maturity index parameters, the highest maturity index values and group a were obtained from the 1st buds (26.21); groups ab was determined from the 1st (23.25) and 3rd (21.39) buds, respectively, while group b was determined from the 2nd (18.47) and 4th (18.56) buds. These findings are consistent with the research findings of Dardeniz and Kışmalı (2005), Altın Dünya and Dardeniz (2023), and Odabaşoğlu (2024).

When colour parameters L , C , and $^{\circ}h$ were examined, statistically significant differences were observed between the years ($p < 0.05$) (Table 2).

Based on the two-year average values, the highest average L values were observed in the 3rd and 2nd buds (32.31; 32.15), forming group a; in the 1st and 2nd buds (31.70; 31.80), forming group ab; and in the 4th buds (31.20), forming group b.

As examining the C parameter, the highest value was observed in the 2nd buds (12.27), while the lowest value was found in the 5th buds (10.52).

Regarding the $^{\circ}h$, the highest values were obtained from the 5th (115.24) and 4th (115.06) buds, respectively, while the lowest values were found in the 3rd (113.10) buds.

3.3. Principal Component Analyses

Principal Component Analysis (PCA) was carried out to determine the relationship between the physical and chemical properties of grape bunches emerging from different bud levels on the summer shoots of the ‘Ata Sarısı’ and ‘Amasya Beyazı’ grape varieties and the variables under investigation.

The PC1 axis, which explains the highest proportion of variance, biologically represents the vine’s ‘Overall Yield Capacity and the extent of vegetative growth’ (cluster/berry size). Indeed, growth parameters such as yield, cluster weight, berry weight and berry size have moved in the same direction along this axis.

The PC2 axis, which describes quality and ripeness parameters, represents the simultaneous dynamics of primary metabolism (sugar/acid balance) and secondary metabolism (anthocyanin and colour pigment synthesis)

Ata Sarısı Grape Variety: The results of the Principal Component Analysis showed that the first principal component (PC1) explained 66.95% of the total variance, while the second principal component (PC2) explained 25.23%. The fact that the first two principal components together explained 91.80% of the total variance indicates that the grape clusters resulting from pruning at different bud levels on summer shoots were successfully distinguished in terms of vine yield, cluster, and berry characteristics.

Table 2. Physical, chemical properties, and colour characteristics of the Amasya Beyazı grape variety for the trial years

Appl.	Yield (g vine ⁻¹)			Average cluster weight (g)			Cluster length (cm)		
	First year	Second year	Avg.	First year	Second year	Avg.	First year	Second year	Avg.
1. buds	2326.5abc	3633.7 b	2980.1	330.9 ab	479.2 b	405.1 b	19.24 b	19.35 ab	19.30 b
2. buds	1352.2 bc	5352.7 a	3352.4	256.7 b	562.9 ab	409.8 b	17.29 c	18.50 b	17.90 c
3. buds	1249.0 c	5352.8 a	3300.9	305.9 b	695.6 a	500.7 a	18.84 b	20.53 a	19.69 ab
4. buds	2440.7 ab	5177.1 a	3808.9	301.1 b	605.4 ab	453.3 ab	18.07bc	19.45 ab	18.76 bc
5. buds	2819.4 a	4837.0 ab	3828.2	403.0 a	573.2 ab	488.1 a	20.63 a	20.55 a	20.59 a
*LSD _{0.05}	1191.5	1457.1	**Ns	83.692	139.59	76.589	1.2056	1.5885	1.1913
Appl.	Cluster width (cm)			Cluster density (1-9)					
	First year	Second year	Avg.	First year	Second year	Avg.			
1. buds	11.58 b	12.06 b	11.82 b	7.23 a	7.65	7.44 a			
2. buds	10.40 c	14.24 a	12.32 b	7.23 a	7.41	7.32 ab			
3. buds	12.06 ab	15.25 a	13.66 a	6.79 b	7.53	7.16 b			
4. buds	11.67 b	14.86 a	13.27 a	7.07 ab	7.52	7.30 ab			
5. buds	12.51 a	14.51 a	13.51 a	7.34 a	7.41	7.38 a			
*LSD _{0.05}	0.6391	1.4441	0.864	0.3708	Ns	0.2134			
Appl.	Berry weight (g)			Berry length (mm)			Berry width (mm)		
	First year	Second year	Avg.	First year	Second year	Avg.	First year	Second year	Avg.
1. buds	3.92	5.74	4.83	19.46	22.41	20.94	18.04	19.60	18.82
2. buds	3.44	5.57	4.51	18.56	21.72	20.14	17.51	19.76	18.64
3. buds	3.90	6.28	5.09	19.04	21.94	20.50	17.86	20.25	19.06
4. buds	3.53	5.95	4.74	19.17	22.46	20.82	17.81	19.92	18.87
5. buds	3.57	5.63	4.60	18.48	21.79	20.14	17.44	19.86	18.65
*LSD _{0.05}	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
Appl.	Total soluble solids (TSS. %)			Acidity (%)			Maturity index		
	First year	Second year	Avg.	First year	Second year	Avg.	First year	Second year	Avg.
1. buds	12.89a	16.56ab	14.73a	0.893a	0.540	0.717abc	14.72b	31.78ab	23.25ab
2. buds	11.38b	15.45b	13.41b	0.890a	0.649	0.770ab	12.90bc	24.03b	18.47b
3. buds	12.70a	17.28a	14.99a	0.715b	0.540	0.628c	18.30a	34.11a	26.21a
4. buds	11.51b	15.48ab	13.50b	0.992a	0.616	0.804a	11.69c	25.44ab	18.56b
5. buds	11.68b	14.91b	13.30b	0.873a	0.540	0.707bc	14.21b	28.58ab	21.39ab
Appl.	<i>L</i>			<i>C</i>			<i>h</i>		
	First year	Second year	Avg.	First year	Second year	Avg.	First year	Second year	Avg.
1. buds	30.33 ab	33.09 ab	31.7 ab	9.66 bc	11.85 b	10.75 c	117.75a	109.59b	113.6bc
2. buds	30.48 a	33.81 ab	32.15a	10.15 ab	14.39 a	12.27 a	117.03b	112.54a	114.7ab
3. buds	30.40 ab	34.22 a	32.31a	10.04 ab	12.52 b	11.28 bc	116.43c	109.76b	113.10c
4. buds	29.75 bc	32.66 b	31.21b	10.57 a	13.09 ab	11.83 ab	117.67b	112.45a	115.06a
5. buds	29.50 c	34.21 a	31.8 ab	9.10 c	11.93 b	10.52 c	116.50b	113.98a	115.24a
*LSD _{0.05}	0.6669	1.2269	0.7199	0.5968	1.4348	0.8125	1.2046	2.0904	1.1245

*Means within a column with different letters are significantly different at 5 % level according to LSD test. **Non-significant (Ns) Appl.: Application Avg: Average

The PC1 axis is positively correlated with grape yield, average cluster weight, cluster and berry length, and cluster and berry width, and represents overall yield performance. Treatments located on the right side of this axis are characterized by higher yields and more developed cluster and berry traits, while those on the left side exhibited lower performance. In this context, the 5th bud application achieved the highest positive value on the PC1 axis, demonstrating the highest grape yield and cluster and berry development. In contrast, the 1st and 2nd bud applications were in the negative region of PC1 and were observed to have low yield potential (Figure 1).

According to the results of the PCA conducted on the chemical parameters of the Ata Sarısı grape variety, the first two principal components explained 92.2% of the total variance, indicating that the quality parameters examined are largely represented along these two axes (Figure 2). The first principal component (PC1) explained 52.2% of the variance, while the second principal component (PC2) contributed 40.0%. Upon examining the PC1 axis, it was determined that Soluble Dry Matter (SDM), pH, *L* value (brightness), and the *h* angle took on positive loadings, while acidity, ripeness index, and the *C* value exhibited negative loadings. This indicates that PC1 represents an axis reflecting chemical ripeness and general quality characteristics in grapes.

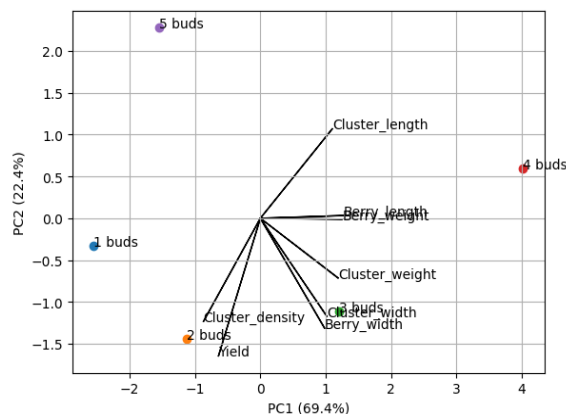


Figure 1. Principal component analyses (PCA) of yield, cluster and berry physical characteristics of the Ata Sarısı grape variety based on two-year average independent variables

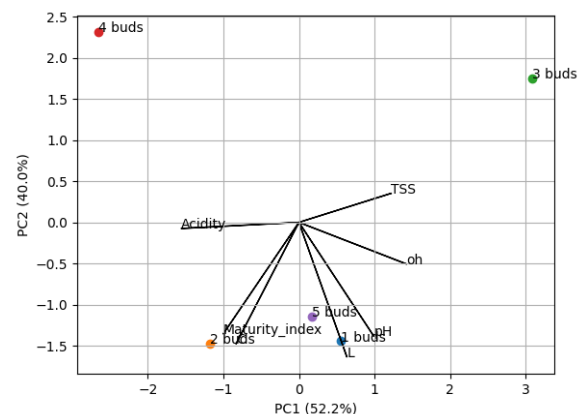


Figure 2. Principal component analyses (PCA) of total soluble solids, acidity, pH, ripeness index, and colour traits in the Ata Sarısı grape variety based on two-year average independent variables

On the PC2 axis, colour parameters are particularly influential. The fact that the *h* angle shows positive values while the *L* and *C* values show negative values indicates that this axis is more closely related to visual quality and colour changes. Upon examining the distribution of the treatments in the PCA biplot, it was observed that the third bud treatment was in the positive region of both PC1 and PC2 and was associated with high TSS and *h* values. This treatment was clearly distinguished from the others in terms of quality and ripeness. The fourth bud application took on a high positive value on the PC2 axis and was particularly associated with high acidity. The first and fifth bud applications were positioned in the positive direction on the PC1 axis, showing a relationship with pH and brightness values, while the second bud application was associated with the ripeness index and colour saturation (*C*).

Amasya Beyazı Grape Variety: To the results of the PCA conducted on the Amasya Beyazı grape variety, the first principal component (PC1) explained 46.8% of the total variance, while the second principal component (PC2) explained 26.3%. Together, the first two principal components account for 73.1% of the total variance and were found to be sufficient for explaining the relationships among the variables in the dataset. This result indicates that the PCA biplot can be effectively used in the evaluation of grape yield and quality characteristics. Accordingly, in the PCA biplot, the arrows represent the variables, while the points represent the treatments (pruning buds' levels). There is positive correlation between variable vectors pointing in the same direction and a negative correlation between those pointing in opposite directions. The proximity of the treatments to the variables indicates the strength of their relationship with the relevant traits.

In the PCA biplot analysis conducted for chemical parameters and colour characteristics, the axes indicate distinct biological processes. In this context, the PC1 axis biologically represents the 'level of development, metabolism and chemical ripening' in the cluster. The fact that the Total Soluble Solids (TSS) and titratable acidity values are positioned in exactly opposite directions on the axis highlights the chemical changes that occur during grape ripening.

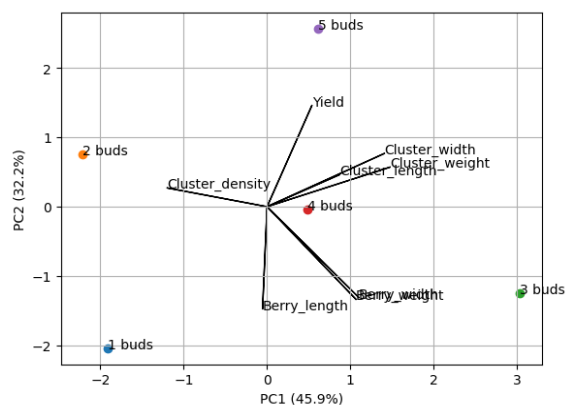


Figure 3. Principal component analyses (PCA) of yield, cluster and berry physical characteristics of the Amasya Beyazı grape variety based on two-year average independent variables

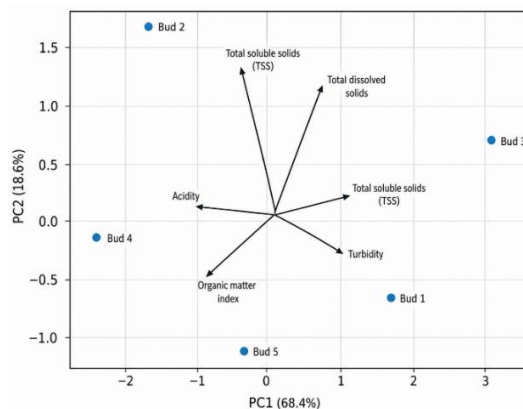


Figure 4. Principal component analyses (PCA) of total soluble solids, acidity, pH, ripeness index, and colour traits in the Amasya Beyazı grape variety based on two-year average independent variables

According to the PCA biplot analysis, the variables of grape yield, cluster weight, and cluster width loaded in the same direction, and a strong positive correlation was identified among them. In terms of these variables, the 4th and 5th bud treatments stood out. Berry size and berry width were grouped together as quality parameters and showed a close relationship, particularly with the 3rd bud treatment. The findings indicate that an increase in bud level plays a decisive role in both yield and quality characteristics (Figure 3).

To the results of the PCA conducted on the chemical parameters of the Amasya Beyazı grape variety, the first two principal components explained 86.98% of the total variance, indicating that the quality parameters examined are largely represented along these two axes (Figure 4). The first principal component (PC1) explains 68.38% of the total variance, while the second principal component (PC2) explains 18.60%. Upon examining Figure 4, it is observed that TSS (%) and the Maturity Index are aligned in the same direction, indicating a positive correlation between these two characteristics. In terms of the Acidity (%) variable, TSS (%) and the Maturity Index were positioned in the opposite direction. By being positioned in the opposite direction, these characteristics exhibited a negative relationship with maturity. In other words, it was observed that acidity decreased as maturity increased. In the grapes from the 3rd cluster (treatments), higher TSS (%) and Maturity Index values distinguished them from other treatments, representing a more advanced level of ripeness. In the 2nd and 4th clusters (treatments), however, they formed a separate group characterized by higher acidity and distinct colour traits. The fact that the third-bud region stands out due to its high TSS and advanced maturity index values provides a biological explanation for how the microclimate and light conditions at this level promote the accumulation of primary metabolic products.

Colour parameters (*L*, *C*, and *a*) showed a distribution primarily along the PC2 axis. Colour characteristics served as a secondary discriminating parameter, independent of chemical maturity.

Conclusion

The results of this two-year study, conducted to determine the effect of summer shoots from different bud levels on cluster yield and the physical and chemical properties of the berries in the Ata Sarısı and Amasya Beyazı grape varieties, are summarised below;

As examining the two-year average values for the Ata Sarısı grape variety, calculated as the average of the first and second clusters; the highest total grape yield per vine was observed in the third and second buds, the widest cluster width in the third and fourth buds, the longest cluster length, the highest average cluster weight, the highest average berry width, the highest berry length, and the highest berry weight were found in the 4th bud; the highest TSS values were found in the 2nd, 1st, 4th and 5th buds respectively; the highest pH values were found in the 1st, 5th, 2nd and 3rd buds; and the highest ripeness index values were found in the 2nd, 1st and 5th buds.

When examining the two-year average values for the Amasya Beyazı grape variety, based on the average of the first and second clusters; the widest cluster width was found in the 3rd, 5th and 4th buds, the longest clusters in the 5th buds, the densest clusters in the 1st and 5th buds, the heaviest clusters in the 3rd and 5th buds, the highest TSS (%) value in the 3rd buds, the highest acidity (%) value in the 4th buds, the highest pH value in the 1st buds.

The fact that the 5th bud position is strongly situated in the positive region of the PC1 axis in both the Ata Sarısı and Amasya Beyazı varieties, as shown in the graph, indicates that the summer shoots arising from this bud level have reached the highest biological vegetative-generative balance.

Consequently, following an assessment of the data obtained in terms of both yield and quality, it was determined that the 5th bud practice is recommended for the Amasya Beyazı and Ata Sarısı grape varieties.

Ethics approval:

Not applicable

Conflict of interest:

The authors declare no competing interests.

Authors' contributions:

Fieldwork, laboratory work, data collection and analysis, and manuscript writing: HK and AD, data analysis: HÇ.

Data availability statement:

All data generated or analysed during this study are included in this published article. The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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