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Viticultural practices influencing the yield and physicochemical composition of wines from the Pinot Noir variety cl. 777

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Abstract

The study aimed to evaluate the influence of specific viticultural and winemaking practices on the yield and physicochemical composition of wines from the Pinot Noir variety, clone 777, grown under non-irrigated conditions in the Sliven region of Bulgaria. Three variants were examined to assess how vine regulation practices affect grape and wine quality parameters. The findings demonstrated significant effects of inflorescence and bunch thinning on the accumulation of sugars, pH, and phenolic compounds. Variant V1, involving early inflorescence regulation, showed improved sugar content, balanced acidity, and higher anthocyanin concentration, resulting in wines with greater alcohol levels and extract content. Variant V2, characterized by bunch thinning during berry growth, enhanced phenolic and anthocyanin composition, contributing to more intense color and better aging potential. The control variant V0 displayed lower values across most qualitative parameters. Overall, the results confirm that moderate yield reduction through inflorescence or bunch regulation is an effective viticultural strategy to improve grape ripeness and wine quality in Pinot Noir under dry climatic conditions. These findings provide practical guidance for optimizing vineyard management to produce well-balanced, high-quality wines adapted to local terroir and climate variability.

Keywords: chemical compounds, Pinot Noir, anthocyanins, phenols

INTRODUCTION

Wine production and its quality are directly related to climatic conditions and depend on complex interactions between temperatures, humidity, precipitation, quality of planting material, and agrotechnical practices. In established wine-growing regions, grape growers have found a balance between yield and quality by selecting the appropriate variety-rootstock combination and applying a number of agrotechnical practices to suit local climatic conditions, but as the climate changes, cultivation practices will need to change (Orduna, 2010; Leeuwen & Darriet, 2016; Gutiérrez-Gamboa et al., 2021; Emurlova & Yoncheva, 2023).

Adaptation to higher temperatures involves changing planting material (e.g., rootstocks, varieties, and clones) and modifying agrotechnical practices (e.g., changing stem height, leaf area to bunch weight ratio, pruning timing) so that harvest dates are maintained at the optimal period of late September or early October in the northern hemisphere. Vines can be made more drought-tolerant by planting vines grafted onto drought-tolerant vine rootstocks (Cornelis van Leeuwen et al., 2019).

Polyphenolic compounds present in wine and grapes are known for their antioxidant and neuroprotective effects on human health. In addition to their benefits for human health, polyphenolic compounds, such as anthocyanins and tannins, are responsible for the organoleptic characteristics of wine. Anthocyanins are

responsible for the typical red color of grape skins and wine, and tannins are responsible for the body of wines (Rouxinol et al., 2023).

Good sunlight exposure to the leaves influences the aromatic composition of Sauvignon Blanc wines (Allen & Lacey, 1993). As the severity increases, the content of alcohol, sugar-free extract, phenolic compounds, and anthocyanins decreases, and the amount of total acids increases (Manis & Pandeliev, 2002).

Bunch thinning reduces the compactness of the grapes. The content of sugars, anthocyanins, total phenolics, and bunch mass is significantly higher with decreasing density. Titratable acidity content showed an inverse relationship. Compared to unthinned bunches, the sugar and anthocyanin content of the grape berry accelerated in the looser bunches during ripening. In addition, wines obtained from thinned bunches had a higher total phenolic index, higher anthocyanins, and lower titratable acidity. These results suggest that bunch thinning with a decrease in bunch compactness may control the accumulation of sugar in the fruit (Han et al., 2019).

Bunch thinning affects the reduction of the yield, improves the phenolic content of the grapes and therefore of the wine, and influences the aromatic wine profile. Despite the economic impact, bunch thinning is an important measure due to the improvement of the quality of the wine, especially to increase the number of compounds responsible for the typical aroma and color (Condurso et al., 2016).

The aim of this study is to access the effect of certain viticultural practices on the quality of the red wine variety Pinot Noir cl. 777.

MATERIALS AND METHODS

The experiment conducted in the first experimental year required the additional development of the presence of assimilable nitrogen in the grape must. The reason was that in the first year, we noticed a weak course of the violent fermentation of the grape must. The lack of nitrogen in the foliage of the vine plant during vegetation leads to a change in the biosynthetic cycle. This may be due to its insufficient amount in the soil or to severe drought during vegetation, and its insufficient transfer from the soil to the vine foliage. In 2022, the highest sugar content was recorded in V1 (27.0%). The control variant V0 had the lowest value, - 24.8% (Table 1).

RESULTS AND DISCUSSION

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Titratable acids are lowest in V2 (6.01 g/dm³). The control variant V0 has the highest values 7.10 g/dm³). The higher pH at V1 and V2 (3.37 and 3.39) reflects lower acidity of the must compared to the control variant V0 (3.28). The correction values show that the yield-controlled variants (V1 and V2) can lead to lower acid values in the final product, which positively affects the flavor balance. The highest anthocyanin content was observed in the control variant V0 (572.25 mg/kg). However, variants V1 and V2 also had significant values, suggesting good coloring content for the wine. For 2023, the highest sugar content was observed in V1 (24.25%), suggesting better grape ripeness in this variant. The control variant (V0) had the lowest content - 18.4%.

Table 1. Content of sugars, acids, digestible nitrogen, and pH in grape must for the period 2022-2023

Variant	Year	Sugars, %	TA, g/dm³	pH	TA g/dm³ after correction	Anthocyanins mg/kg grape berries	Assimilable nitrogen, mg/dm³
V_0	2022	24.8	7.10	3.28	-	572.25	-
	2023	18.4	7.46	3.03	-	515.38	164.71
	mean	21.6	7.27	3.15	-	543.81	-
	std	4.525	0.254	0.176	-	40.213	-
V_1	2022	27.0	6.54	3.37	6.09	479.50	-
	2023	24.2	6.44	3.25	-	626.50	98.83
	mean	25.6	6.49	3.31	-	553.00	-
	std	1.979	0.070	0.084	-	103.944	-
V_2	2022	26.6	6.01	3.39	5.52	409.50	-
	2023	21.3	7.37	3.13	-	609.88	115.3
	mean	23.9	6.68	3.26	-	509.69	-
	std	3.747	0.961	0.183	-	141.690	-

Lower acid content is observed in V1 (6.44 g/dm³), while V0 and V2 have relatively similar values. V1 shows a higher pH (3.25), which means lower acidity and a milder taste of the grape must. This also corresponds to the lower titratable acid content. The highest assimilable nitrogen content was recorded in V0 (164.71 mg/dm³), while V1 had the lowest value (98.83 mg/dm³). The highest anthocyanin content was observed in V1, which suggests a more intense color. The control variant had the lowest values (515.38 mg/kg). The relative density was similar for all variants and is typical of dry wines. The highest alcohol content was recorded in V1 (14.48%), which can be associated with the higher sugar content in the grapes of this variant (Table 2).

Residual sugars in wines of all variants indicate that alcoholic fermentation has proceeded normally and is fully completed. They are in minimal quantities and in the range for dry wines. Variant V1 has a slightly higher value (2.66 g/dm³). The content of total and sugar-free extract, which is responsible for the taste density and concentration of wines, is almost the same for 2022, in all variants in the experiment. This indicator in 2023 is the lowest in the control. V1 has the highest extract content, which gives greater density and structure to the wine. The volatile acid content is within optimal limits for quality wines, and this is an indication of proper alcoholic fermentation, without the development of any bacterial infections. The higher pH in V1 and V2 (3.53 and 3.51) is associated with lower acidity and a milder taste of the wines. The values are similar, with V1 having slightly higher acidity (6.87 g/dm³), which is important for the freshness of the wine. The lowest volatile acid content was observed in V1 (0.30 g/dm³). The highest anthocyanin content was recorded in V0 (403.38 mg/dm³), which contributes to a more intense color of the wine. It is noteworthy that the anthocyanin content in the wines is highest in the control in 2022, and in the second year of the experiment, an opposite trend is observed. A similar trend is observed in terms of color intensity in the wines of variants V1 and V2, which also have the highest content of coloring matter in the skins of the berries in the second year. The reason for this is that a probable part of the anthocyanins contained in the wines of variants V1 and V2 are in condensed forms, which cannot be determined with the bisulfite method used, which determines only free anthocyanins. This is confirmed by the high color intensity, especially in variants V1 and V2, which is an indication of the high content of coloring matter.

Table 2. Physico-chemical analysis of Pinot Noir wines, for the period 2022-2023

Indicators	Year	Variant		
		V_0	**V_1**	**V_2**
Relative density	2022	0.9928	0.9931	0.9928
	2023	0.9958	0.9939	0.9939
	mean	0.9943	0.9935	0.9933
	std	0.0021	0.0005	0.0007
Alcohol. vol.%	2022	13.99	14.48	14.21
	2023	10.59	13.94	13.06
	mean	12.29	14.21	13.63
	std	2.4041	0.3818	0.8131
Sugars. g/dm^3	2022	2.52	2.66	2.52
	2023	1.27	1.74	1.32
	mean	1.89	2.20	1.92
	std	0.8838	0.6505	0.8485
Total extract g/dm^3	2022	29.7	30.2	29.1
	2023	25.8	31.8	28.4
	mean	27.7	21.0	28.7
	std	2.7577	1.1313	0.4949
Sugar-free extract g/dm^3	2022	27.18	27.54	26.58
	2023	24.53	27.06	27.08
	mean	25.85	27.29	26.83
	std	1.8738	0.3394	0.3535
pH	2022	3.32	3.53	3.51
	2023	3.37	3.58	3.43
	mean	3.34	3.55	3.46
	std	0.0353	0.0353	0.0565
Titratable acids. g/dm^3	2022	6.79	6.87	6.7
	2023	6.61	6.90	6.69
	mean	6.70	6.88	6.69
	std	0.1272	0.0212	0.0070
Volatile acids. g/dm^3	2022	0.40	0.30	0.36
	2023	0.35	0.47	0.33
	mean	0.37	0.38	0.34
	std	0.0353	0.1202	0.0212
Free sulfur dioxide mg/dm^3	2022	10.08	7.2	7.2
	2023	11.86	11.86	13.34
	mean	10.96	9.53	10.27
	std	1.2586	3.2951	4.3416
Total sulfur dioxide mg/dm^3	2022	39.6	35.28	35.28
	2023	37.05	48.91	40.76
	mean	38.32	42.09	39.01
	std	1.8031	9.6378	3.8749

Anthocyanins. mg/dm^3		2022	403.28	364.00	373.63
		2023	332.50	442.75	538.13
		mean	367.89	403.37	455.88
		std	50.0490	55.6846	116.3190
Total phenols. mg/dm^3 as gallic acid		2022	1764.57	1769.03	1975.60
		2023	2299.00	2527.87	2958.91
		mean	2031.78	2148.45	2467.25
		std	377.8990	536.5809	695.3051
Color intensity		2022	9.34	8.51	8.75
		2023	10.43	14.24	14.92
		mean	9.88	11.37	11.83
		std	0.7707	4.0517	4.3628
Nuance of coloring		2022	0.658	0.672	0.679
		2023	0.580	0.735	0.609
		mean	0.619	0.703	0.644
		std	0.0551	0.0445	0.0494
Color, %	Yellow-brown	2022	35.44	36.08	36.69
		2023	32.31	37.08	33.58
		mean	33.88	36.58	35.14
		std	2.2132	0.7071	2.1991
	Red	2022	53.85	53.70	54.06
		2023	55.70	50.42	55.16
		mean	54.77	52.06	54.61
		std	1.3081	2.3193	0.7778
	Blue	2022	10.71	10.22	9.25
		2023	11.99	12.5	11.26
		mean	11.35	11.36	10.255
		std	0.9050	1.6122	1.4212

The highest phenolic content was recorded in V2 (1975.60 mg/dm³), which is important for the structure, taste, and storage of the wine. The highest color intensity was recorded in V0 (9.34), which is consistent with the higher anthocyanin content. The differences in shade are minimal and characteristic of young red wines. In general, each treatment (V0, V1, V2) has its advantages, but V1 and V2 are more suitable for obtaining balanced and high-quality wines. The control (V0) achieved the highest average yield of 9.955 kg/ha, confirming that unthinned vines maintain maximum total production capacity under non-irrigated conditions. In contrast, the regulated variants (V1 and V2) produced noticeably lower yields per hectare – 6.760 kg/ha (V1) and 8.080 kg/ha (V2), respectively. The reduction in yield is a direct consequence of limiting the number of inflorescences or bunches, which decreases overall fruit load but promotes better resource allocation and improved ripening uniformity. The decrease in yield between V1 and the control (approximately 32%) emphasizes the strong response of Pinot Noir to crop limitation under dry-farmed conditions. Despite the lower yield, variant V2 maintained a relatively high production level compared to V1, suggesting that moderate thinning offers a better compromise between productivity and grape quality potential. The year-to-year variation also influenced yield per hectare. In 2023, all

variants recorded higher productivity than in 2022, reflecting the influence of more favorable climatic conditions – particularly higher soil moisture availability and moderate summer temperatures (Mihaylov & Stalev, 2025).

CONCLUSIONS

The results of the physicochemical analysis of the wines from the studied variants are within optimal limits for quality red wines. The differences in the amount of anthocyanins contained in the wines of variants V1 and V2 cannot be determined by the bisulfite method used, which determines only free anthocyanins. This is confirmed by the high intensity of the color, especially in variants V1 and V2, which is an indication of the high content of coloring matter. The shade of color and the percentage of yellow-brown, red, and blue colors are close and within normal limits for young red wines. Variant V1 is distinguished by the highest alcohol content, total extract, and acidity. Variant V2 has the highest content of anthocyanins, phenols, and color intensity, making it suitable for the production of wines with better aging potential. The control variant V0 has lower values for most indicators, including alcohol content and phenols, making it a less pronounced wine compared to V1 and V2.

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