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BUNCH LOAD AS A FACTOR ON THE QUALITY OF THE GRAPEVINE VARIETIES 'RIBIER' AND 'ITALIA'

SUMMARY

The application of ampelotechnical measures in table grape production profoundly affects grape yield and quality. This study aims to assess the influence of the ampelotechnical practice of bunch thinning on the yield and quality of Ribier and Muscat Italia grape varieties. The research was conducted over three consecutive years on production plantations of Ribier and Muscat Italia varieties grown on pergola training system with a planting distance of 2.5 x 2.5 m. The plantations are in full fertility, aged between 12-15 years, located in the Gevgelija-Valandovo vineyard, renowned as one of the most suitable sites for cultivating table grapes in the Republic of Macedonia. Three different bunch thinning variants were applied in both varieties: V1 (thinning to 4 bunches/m^2), V2 (thinning to 5 bunches/m^2), and V3 (thinning to 6 bunches/m^2). These were compared with the standard variant where no bunch thinning was performed.

Our research findings demonstrate that the applied ampelotechnical measure significantly impacts the average bunch and berry mass, transportability, must chemical composition, packed grape quantity, and organoleptic evaluation of the grapes. The average bunch mass of the Ribier variety ranges from 381,3 g in the standard (St) variant to 445,7 g in the V1 variant. Similarly, in the Italia variety, the bunch mass fluctuates between 607.3 g (St variant) and 703,0 g in the V1 variant, while the berry mass ranges from 7,5 g (St) to 8,5 g (V1). Moreover, the packed grape quantities range from 1,9 kg/m^2 in the standard variant to 2,31 kg/m^2 in the V2 variant for the Ribier variety, whereas for the Italia variety, the lowest amount of packed grapes was recorded in the V1 variant (2,65 kg/m^2), and the highest in the

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V3 variant (3,27 kg/m^2). Notably, the organoleptic evaluation of the grapes was influenced by bunch thinning. The V1 and V2 variants in both varieties received better ratings compared to the other variants, with the Ribier variety rated as excellent quality and the Italia variety as extra quality.

Keywords: table grapes, bunch thinning, bunch and berry mass, transportability, packaged grape quantity, organoleptic evaluation

INTRODUCTION

Modern table grape production extensively relies on the intensive implementation of ampelotechnical measures, which has garnered increasing attention, particularly among major table grape producers like Italy, California, South Africa, and Chile. Successful production of table grapes depends significantly on the meticulous and timely application of these measures (Prculovski, 2019).

Summer pruning, a technique ensuring quality yield and vegetative balance of the vine, enables the enhancement of the microclimate and facilitates timely and better ripening of the grapes (Di Lorenzo et al., 2011). Canopy management techniques, involving practices such as altering the position or number of shoots, leaves, or bunches, facilitate the achievement of the desired spatial arrangement, allowing for improved lighting and aeration (Dry, 2000).

Each ampelotechnical measure during green pruning directly impacts the production and technological characteristics of grape varieties. For instance, shoot and bunch pinching affect the distribution of photoassimilates (Mota et al., 2010), while defoliation affects air temperature, solar radiation frequency, and aeration in the bunch zone (Mandelli and Miele, 2003). Pinching and the reduction of bunches not only ensure a more uniform and faster ripening of the grapes but also result in a higher packing percentage of extra and first class grapes (Prculovski, 2021).

Optimizing crop (bunch) density of the vine is one of the fundamental factors for successful table grape production. An excessive number of bunches on the vine may reduce berry diameter and total sugar content (Somkuwar and Ramteke, 2010). Conversely, reduced vine density can lead to a decrease in yield, an increase in grain mass, and an improvement in grape chemical composition (Ezzahouani and Williams, 2003), including phenolic components and vegetative vigor (potential) (Kavoosi et al., 2009). Therefore, our research aimed to determine the ideal yield potential of Ribier and Italia varieties, as one of the most important late table grape varieties cultivated in the Republic of Macedonia.

MATERIAL AND METHODS

Our research was conducted on production plantations of Ribier and Italia varieties in the Gevgelija-Valandovo vineyard. These plantations, aged between 12 and 15 years, utilized a pergola training system with a planting distance of 2.5 x 2.5 m. Three variants were employed for each variety:

1. V1 – bunch thinning to 4 bunches/m^2
2. V2 – bunch thinning to 5 bunches/m^2
3. V3 – bunch thinning to 6 bunches/m^2

Comparisons were made with the standard (St) variant, where no thinning was applied. Other ampelotechnical measures such as pinching and defoliation were

implemented simultaneously across all variants. Proper pruning, with leaving four canes with eight buds and two buds per wine, was implemented uniformely for each of the variants including the standard, on both variety. Bunch load was reduced 7-14 days after blooming phenophase. The harvest took place when the bunches exeeded between 16 and 17 ^{o} Brix.

Averige bunch and berry mass, as well as bunch and berry mechanical properties (berry firmness and berry adherence strength) were exeminated. Total yield was classified in two categories (packeg grape and residue). The organoleptic evaluation was carried out by using ten-point system where the expers evaluated tast quality, consistency and external appearance.

Mean values, standard deviation and coefficient of variation were calculate based on the results. Our hypotheses was tested by using analysis of variance (ANOVA) while the mean values were compared using the LSD test.

RESULTS AND DISCUSSION

We assessed the impact of the ampelotechnical measure of bunch thinning by examining the mechanical composition and properties of bunches and berries, grape chemical composition, harvested grape quantity, and organoleptic evaluation. Detailed results can be found in Tables 1 and 2, presenting the average bunch and berry mass across each variant of the Ribier and Italia varieties.

Table 1 Ribier variety bunch and berry mass

	Bunch mass (g) Variant				**Berry mass (g)** Variant			
Year	St	V_1	V_2	V_3	St	V_1	V_2	V_3
2014	335,0	428,0	416,0	382,0	6,5	7,8	7,0	6,7
2015	400,0	462,0	431,0	402,0	6,5	8,2	7,5	6,9
2016	409,0	447,0	451,0	418,0	6,2	6,3	6,1	6,2
Mean x	381,3a	445,7b**	432,7b**	400,7a	6,4a	7,4b	6,9ab	6,6a
+ - ø		64,3	51,3	19,3		1,0	0,5	0,2
Index	100	117	113	105	100	116	107	103
SD	40,4	17,0	17,6	18,0	0,2	1,0	0,7	0,3
CV	10,6	3,8	4,1	4,5	3,0	13,4	10,7	5,2
LSD 0,05	29,35				0,74			
0,01	44,48				1,11			

The lowest recorded average bunch mass was 381,3 g in the standard variant, whereas the V1 variant exhibited the highest average mass of 445,7 g. In the case of the V2 variant, the average bunch mass was 432,7 g, and for the V3 variant, it was 400,7 g.

Regarding the Ribier variety, the average grain mass ranged from 6,4 g for the standard variety to 7,4 g for the V1 variety. Additionally, the V2 and V3 variants demonstrated berry masses of 6,9 g and 6,6 g, respectively.

Table 2 Italia variety bunch and berry mass

	Bunch mass (g) Variant				**Berry mass (g)** Variant			
Year	St	V_1	V_2	V_3	St	V_1	V_2	V_3
2014	611,0	674,0	690,0	641,0	7,1	8,1	7,4	7,2
2015	616,0	724,0	665,0	614,0	8,2	9,4	8,7	8,3
2016	595,0	711,0	684,0	659,0	7,2	8,1	7,9	7,7
Mean x	607,3a	703,0c	679,7bc	638,0ab	7,5a	8,5c	8,0b	7,7ab
+ - ø		95,7	72,3	30,7		1,0	0,5	0,2
Index	100	116	112	105	100	114	107	103
SD	11,0	25,9	13,1	22,6	0,6	0,8	0,7	0,6
CV	1,8	3,7	1,9	3,6	8,1	8,8	8,1	7,4
LSD 0,05	43,06				0,32			
0,01	65,23				0,49			

The average bunch mass for the observed years in the Italia variety ranged from 607,3 g in the St variant to 703 g in the V1 variant. The V2 variant demonstrated an average mass of 679,7 g, while the V3 u variant exhibited an average bunch mass of 638,0 g. Additionally, the average berry mass ranged from 7,5 g for the standard variant to 8,5 g for the V1 variant.

In both studied varieties, the impact of bunch thinning on the average bunch and berry mass was evident. The V1 variant in both varieties notably showed a statistically significant increase in average bunch and berry mass compared to the St and V3 variants, where the load on the vine was the highest. Various studies have addressed the application of this ampelotechnical measure and its influence on the production and technological characteristics of different varieties. Berkey et al. (2011), in their investigation of the impact of bunch thinning on Seyval Blanc variety production, observed variations in the effects of this measure across different years, attributing these differences to the management in previous production cycles. Several studies of different varieties have shown that the application of this measure leads to an increase in both bunches and berries when there are fewer bunches on the vine (Kavoosi et al., 2009; Somkuwar and Ramteke, 2010; Gil et al., 2013; Prculovski et al., 2021). They attribute this phenomenon to the increased concentration of photoassimilates directed towards the remaining bunches when there are fewer bunches per vine. The intensity of thinning must align with the cultivation conditions and varietal characteristics, as excessive thinning can result in a substantial yield reduction without enhancing quality (Prculovski et al., 2021; Avizcuri-Inac et al., 2013).

Bunch and berry mechanical properties show the resistance of bunches and berries to various mechanical forces. Berry firmness and adherence strength (the

attachment strength of the berry to the stem) were examined, considering their significance for table varieties, particularly in relation to grape transportability and refrigerated storage capabilities. Tables 3 and 4 present the results of the investigation into the mechanical properties of Ribier and Italia varieties.

Table 3 Bunch and berry mechanical properties of the studied variants of Ribier variety

	Variant					Index			
	Year	St	V_1	V_2	V_3	St	V_1	V_2	V_3
Berry firmness	2014	1 550	1 710	1 700	1 620				
	2015	1 530	1 730	1 610	1 560				
	2016	1 530	1 700	1 600	1 570				
	x	**1536a**	**1713c**	**1636b**	**1583ab**	**100**	**111**	**107**	**103**
	+ - ø		177	100	47				
	SD	11,5	15,3	55,1	32,1				
	CV	0,8	0,9	3,4	2,0				
Berry adherence strength	2014	683	691	655	613				
	2015	600	760	752	640				
	2016	620	714	680	658				
	x	**634a**	**722b**	**696ab**	**637a**	**100**	**114**	**103**	**100**
	+ - ø		88	62	3				
	SD	43,3	35,1	50,4	22,6				
	CV	6,8	4,9	7,2	3,6				

The berry firmness of the Ribier variety ranges from 1,536 g/cm^2 in the St variant to 1,713 g/cm^2 in the V1 variant. The V2 and V3 variants exhibit an average berry firmness of 1,636 g/cm^2 and 1,583 g/cm^2, respectively.

Additionally, the St variant is associated with the lowest berry adherence strength of 634 g/grain. A similar value was obtained for the V3 variant. The V2 variant demonstrated a 3% higher berry adherence strength compared to the standard variant, while the highest berry adherence strength was recorded in the V1 variant, exhibiting a 14% increase compared to the standard.

The berry firmness of the Italia variety (Table 4) ranges from 1,543 g/cm^2 in St variant up to 1,627 g/cm^2 in the V1 variant. Berry adherence strength on the Italia variety ranges from 690 g/grain (St variant) to 770 g/grain (V1 variant).

A statistically significant difference in the bunch and berry mechanical properties within the studied variants of the Italia variety was only observed in the V1 variant, particularly in terms of berry firmness. Similar significance was noted for this variant in terms of berry adherence strength. The coefficient of variation and the standard deviation, concerning the berry firmness property and berry adherence strength, did not exhibit significant differences among the variants. Detailed results of the tests conducted on the mechanical properties of this variety are presented in Table 4.

Table 4 Bunch and berry mechanical properties of the studied variants of Muskat Italia variety

		Variant				Index			
	Year	St	V_1	V_2	V_3	St	V_1	V_2	V_3
Berry firmness	2014	1 570	1 610	1 590	1 580				
	2015	1 520	1 600	1 570	1 540				
	2016	1 540	1 670	1 620	1 590				
	x	**1543a**	**1627b**	**1593ab**	**1570a**	**100**	**105**	**103**	**102**
	+ - ø		84	50	27				
	SD	25,2	37,9	25,2	26,5				
	CV	1,6	2,3	1,6	1,7				
Berry adherence strength	2014	690	760	745	710				
	2015	700	785	740	715				
	2016	680	765	710	690				
	x	**690a**	**770c**	**732bc**	**702ab**	**100**	**112**	**106**	**102**
	+ - ø		80	42	12				
	SD	10,0	13,2	18,9	13,2				
	CV	1,4	1,7	2,6	1,9				

The berry firmness and adherence strength of the studied varieties fall within the parameters of the varietal characteristics, a finding corroborated by the research of several authors in the region (Božinović, 2010; Roičev, 2012; Colapietra, 2006). A lower number of bunches per vine leads to an increase in berry firmness. This phenomenon is attributable to the enhanced availability of carbohydrates and other molecules, which, when integrated into the cell wall of the berries, contribute to their heightened firmness. Similar principles apply to minerals, such as calcium, which can be more effectively distributed among the bunches when there are fewer bunches per vine (Perez et al., 1998). Conversely, De Sousa Leao and Coelho De Lima (2017) did not establish a correlation between bunch thinning and berry firmness in their research.

Table grape varieties intended for fresh consumption are classified into two categories: packed grapes and waste. Packed grapes conform to the standards for packing and are divided into three categories: extra quality, first quality, and second quality. The waste comprises grapes that fail to meet the minimum standards for packed grapes and are typically utilized for various processing purposes. Production characteristics of table grapes, as indicated by the quantity of harvested grapes, are not assessed based on the total quantity of grapes harvested but rather on the quantity of packed grapes. The results confirm a close correlation between the amount of total harvested grapes and the number of bunches retained on the vine per square meter. A larger number of retained bunches leads to a higher yield. However, the quantity of packed grapes increases up to a certain threshold of load, beyond which it begins to decline. Consequently, the quantity of waste starts to increase. The specific load

threshold is primarily contingent upon the biological characteristics of the respective variety.

Our tests revealed notable disparities in the load threshold between the two tested varieties. Our objective was to determine the influence of vine load on the quantity and quality of table varieties and to ascertain the most suitable degree of vine load. Based on the yield results highlighted in Tables 5 and 6, it can be deduced that the highest quantity of total harvested grapes in the Ribier variety was observed in the St and V3 variants. However, these variants exhibited the largest quantity of waste and the lowest percentage of packed grapes compared to the other variants. The quantity of grapes harvested in the Ribier variety ranged from 2.34 kg/m^2 in the V1 variant to 2.79 kg/m^2 in the V3 variant, whereas the quantity of packed grapes ranged from 1.9 kg/m^2 in the standard variant to 2.31 kg/m^2 in the V2 variant. In the Ribier variety, bunch thinning demonstrated a statistically significant difference in the quantity of packed grapes in the V1 variant, particularly in the V2 variant compared to the standard, while the packed grapes of the V3 variant did not exhibit a statistically significant difference compared to the standard variant and the V1 variant.

Table 5. Influence of the number of bunches on the amount of grapes harvested in the studied variants of Ribier variety

Type	Year	Variant				Percentage (%)			
		St	V_1	V_2	V_3	St	V_1	V_2	V_3
	2014	1,84	2,02	2,21	2	67,2	87,1	81,5	70,9
	2015	1,96	2,08	2,27	2,06	71	91,2	85,7	72,5
Packed	2016	1,9	2,1	2,45	1,9	68,8	87,5	86	70,4
grapes	x	**1,9a**	**2,07b**	**2,31c**	**1,99ab**	**69,0**	**88,6**	**84,4**	**71,3**
kg/m^2	+ - ø		1,7	4,1	0,09				
	SD	0,6	0,4	1,2	0,8				
	CV	3,2	2,0	5,4	4,1				
	2014	0,9	0,3	0,5	0,82	32,8	12,9	18,5	29,1
	2015	0,82	0,2	0,38	0,78	29	8,8	14,3	27,5
	2016	0,86	0,3	0,4	0,78	31,2	12,5	14	29,6
Waste	x	**0,86d**	**0,27a**	**0,43b**	**0,79c**	**31,0**	**11,4**	**15,6**	**28,7**
	+ - ø		-0,59	-0,43	-0,07				
	SD	0,04	0,06	0,06	0,02				
	CV	4,7	21,7	15,1	2,5				
	2014	2,74	2,32	2,71	2,82				
	2015	2,76	2,28	2,65	2,84				
	2016	2,76	2,4	2,85	2,7				
Total	x	**2,76b**	**2,34a**	**2,74b**	**2,79b**	100	100	100	100
	+ - ø		-0,42	-0,02	0,03				
	SD	0,01	0,06	0,10	0,08				
	CV	0,4	2,6	3,8	2,7				

In the Italia variety, the V1 variant is characterized by the lowest content of harvested and packed grapes, as well as the lowest percentage of waste. Of the total quantity of grapes harvested, which amounts to 2.71 kg/m^2 in the case of the V1 variant, 2.65 kg/m^2 or 97.6% belongs to the category of packed grapes. The waste

category accounts for only 0.06 kg/m^2 or 2.4% of the total amount. Conversely, the V3 variant demonstrates the highest content of harvested and packed grapes, with a total quantity of packed grapes amounting to 3.58 kg/m^2. Among these, 3.27 kg/m^2 or 91.4% belongs to the category of packed grapes, while 0.31 kg/m^2 or 8.6% falls into the waste category. Statistical analysis within this variety revealed a significant difference concerning the quantity of packed grapes, particularly in the V2 variant and, notably, in the V3 variant when compared to the standard.

Table 6. Influence of the number of bunches on the quantity of harvested grapes in the studied variants of Muscat Italia variety

Type	Year	Variant				Percentage (%)			
		St	V_1	V_2	V_3	St	V_1	V_2	V_3
Packed grapes kg/m^2	2014	2,55	2,55	3,05	3,25	87,0	96,2	92,4	89,0
	2015	2,69	2,68	3,01	3,26	87,3	97,1	95,0	92,6
	2016	2,89	2,73	3,29	3,31	87,8	99,6	99,4	92,7
	x	**2,71a**	**2,65a**	**3,12b**	**3,27c**	**87,4**	**97,6**	**95,6**	**91,4**
	+ - ø		-0,6	4,1	5,6				
	SD	1,7	0,9	1,5	0,3				
	CV	6,3	3,5	4,9	1,0				
Waste kg/m^2	2014	0,38	0,10	0,25	0,40	13,0	3,8	7,6	11,0
	2015	0,39	0,08	0,16	0,26	12,7	2,9	5,0	7,4
	2016	0,40	0,01	0,02	0,26	12,2	0,4	0,6	7,3
	x	**0,39b**	**0,06a**	**0,14a**	**0,31b**	**12,6**	**2,4**	**4,4**	**8,6**
	+ - ø		-0,33	-0,25	-0,08				
	SD	0,01	0,05	0,12	0,08				
	CV	2,56	74,62	80,86	26,36				
Total kg/m^2	2014	2,93	2,65	3,30	3,65				
	2015	3,08	2,76	3,17	3,52				
	2016	3,29	2,74	3,31	3,57				
	x̄	**3,10b**	**2,71a**	**3,26b**	**3,58c**	100	100	100	100
	+ - ø		-0,39	0,16	0,48				
	SD	0,18	0,06	0,08	0,07				
	CV	5,83	2,16	2,40	1,83				

Several authors, such as Kavoosi et al. (2009) and Prculovski et al. (2021), studying the effects of bunch thinning observed a reduction in total yield but an increase in grape quality and quantity of packed grapes. Conversely, intensive thinning can cause a notable reduction in yield (Avizuri-Inac et al., 2013; Fanzone et al., 2011). The yields observed in our tests are within the parameters of the varietal characteristics studied by various authors in the region, including Božinović (2010), Avramov and Žunić (2001), and Žunić and Garić (2017).

The assessment of grape quality was conducted using standard organoleptic evaluation techniques. Our tests employed the 10-point system. The expert tasting committee evaluated the submitted samples of each variant based on external appearance, consistency, taste, as well as the typicity and authenticity of the variety, utilizing their senses of sight, taste, and smell. Additionally, table grape standards were defined for the studied varieties and variants, as outlined by the Codex Alimentarius Commission (2007).

The results of the tasting evaluation for the Ribier and Italia varieties are depicted in Charts 1 and 2. The results for the Ribier variety illustrate variations in the external appearance of the grapes, consistency, taste qualities, and the overall tasting score across the studied variants. The total tasting score for the variants in this variety ranges from 7.6 points for the St variant to 8.4 points for the V1 variant. Grapes from the V1 and V2 variants are classified as excellent quality, while those from the St and V3 variants as very good quality.

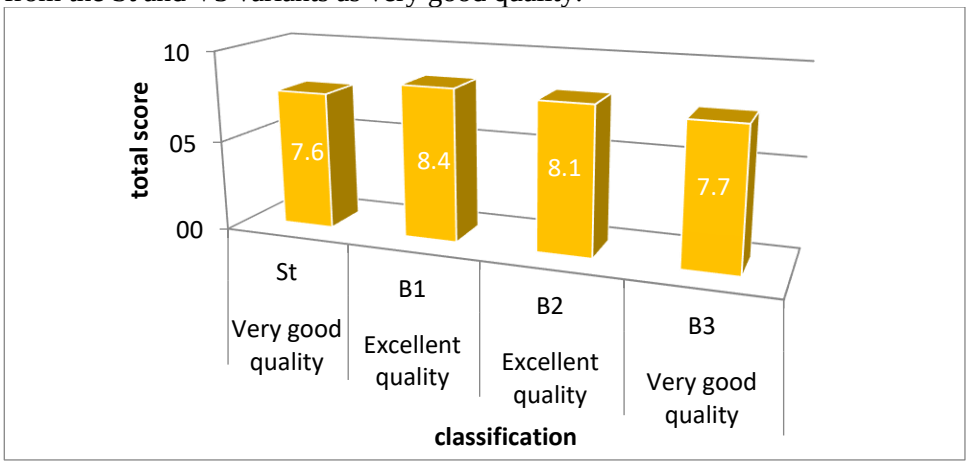

Chart 1. Total tasting score of the studied variants of Ribier variety

For the Italia variety, grapes from the V1 variant display the best external appearance, scoring 2.8 points, while grapes from the St variant exhibit the weakest external appearance, scoring 2.3 points.

The highest total score of 9.2 points was found in the V1 and V2 variants, whereas the lowest score of 7.9 points was observed in the St variant (Chart 2).

Grapes from the V1 and V2 variants are classified as exceptional quality, those from the V3 variant as excellent quality, and those from the St variant as very good quality.

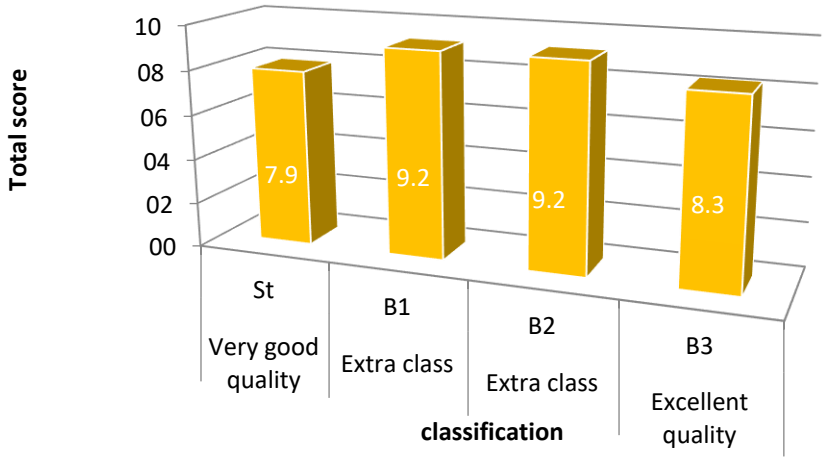

Chart 2. Total tasting score of the studied variants of Muscat Italia variety

CONCLUSIONS

The implementation of bunch thinning in the Ribier and Italia varieties, within the 7-14 day period after flowering, resulted in a significant increase in the average bunch and berry mass, enhanced transportability, increased quantity of packed grapes, and improved organoleptic evaluation. For the Ribier variety, thinning to 5 bunches/m^2 is recommended to attain the best quality grapes, while in the Italia variety, the optimal balance between yield and quality is achieved through thinning to 6 bunches/m^2.

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