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Impact of Cluster Thinning on Yield Features and Wine Quality of Black Shesh Grapevine Cultivar in Lis, Mat, at North-Eastern Part of Albania

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ABSTRACT— Cultivation practices are considered as the main factors which affect the product quantity and quality of all plants. The aim of this paper is to present how the cluster thinning contribute on yield features and wine quality of the autochthonous Black Shesh red wine grapevine cultivar. The study was conducted during three consecutive years, 2019-2021. A RCBD with three replications and three variants with a plot size of 10 vines for variant was used. Three cluster thinning (CT) treatments were applied: control (no CT), 25% CT, and 50% CT. Cluster thinning was applied at berries pea-size (stage 75), consisting on removing the upper clusters on shoots. Leaf area per vine, number of clusters per vine, yield per plant, cluster weight, berry weight, TSS, TA, pH of must and wine, alcohol fraction for volume, wine color intensity, total phenolics, total and individual anthocyanin content, were recorded for a 3-year period. There was observed that two CT treatments significantly accelerated grape ripening by 5 and 9 days, reduced grape production per plant, raised cluster weight and berry weight, raised TSS content in must, while TA was reduced. Wine produced form CT treatments showed higher color intensity, higher alcohol content per volume, lower acidity, higher total and individual anthocyanin content. The highest quality wine, considering alcohol content per volume, total phenolics content, total and individual anthocyanin content, was achieved by 50% CT.

KEYWORDS: grapevine, cluster, thinning, wine, quality.

1. INTRODUCTION

Grape yield and quality are strongly determined by climate, soil and cultural management practices including pruning, crop load, thinning, girdling, etc [3], [22]. Vegetative and productive growth of grapevine is under competition, especially if they are not well balanced or if there are limited nutritional resources [19]. [9] have found that excessive crop load significantly affect grape composition and wine quality because delay grape ripening and reduce grape and wine quality. Cluster thinning, shoot thinning and combination of both practices significantly affect the grape yield, grape composition and wine quality of “Corot Noir” [20]. Shoot and cluster thinning ifluenced vegetative growth, fruit yield and wine quality of “Sauvignon blanc” grapevine cultivar, including sensory attributes such as herbaceous aroma, providing a biological rationale for the relevance of crop load and wine quality relations [14]. [2] showed that cluster thinning, consisted on 30% and 60% of upper clusters on shoots at veraison, reduced the grape yield by 19% and 40%, increased cluster weight and leaf area/fruit weight and accelerated grape maturity by 7 to 14 days at Merlot grapevine cultivar. Wines produced by cluster thinning treatments showed higher alcohol content, lower acidity, higher total phenolics and anthocyanins concentration and higher color intensity. [4] showed that 50% cluster thinning and 50% leaf removal one month after blooming increased the phenolic composition of wines indicated by increases of total anthocyanins, total phenolics and total resveratrol content, including free resveratrol and its derivatives, and antioxidant capacity at Chambourcin red grapevine hybrid [16]. The level of phenolic compounds and other pigments vary in fruits according to the cultivar, season, agroclimatic regions, management practices (conventional or organic), stage of fruit development, tissue type flesh or peel), and biotic or abiotic strees conditions [25]. Cluster thinning practice yielded the lowest weight and number of berries per cluster, but total soluble solids, total and individual anthocyanins increased significantly on table grape cv. “Horoz Karasi” [10].

Cluster thinning and basal leaf removal substantially improved fruit and wine composition in cool-climate conditions for Merlot, Cabernet franc and Cabernet Souvignon, and enhanced intensities of several aroma and retrosonal descriptors (e.g., black fruit, black pepper, tobacco) and reduced some others (e.g., bean/pea, mushroom) [17]. [12] has indicated that cluster thinning performed at different stages of berry development showed a great importance on berry growth and grape composition of cv Sauvignon Blanc, which is of critical interest to the winemaker seeking to maximize muscat character. Anthocianins, flavonoids and tannins are compounds which affect the color intensity of grape juice and wine, as well as the wine quality [5]. [15] have found that cluster thinning is a management practice which can be used to improve grape and red wine quality, especially increase of anthocyanins, total soluble solids, and polyphenols, with a great importance for aging wines.

Black Shesh is one of the oldest autochthonous grape cultivars being used through centuries as one of the most widespread red wine cultivar, especially in the central, northern and north-western part of Albania. Due to the high environmental adaptability and its typical very demanded wine by consumers, which is very popular, Black Shesh continues to dominate the variety structure of new vineyards, occupying about 980 ha vineyards or 8.86% of the total vineyard area (11057 ha) [6]. Producing special and high quality wines by indigenous Albanian cultivars seems to be the most competitive way for Albania, rather than high quality wines by international grapevine cultivars.

2. Material and methods

The study on the effects of cluster thinning of Black Shesh red wine grapevine cultivar was conducted during three consecutive years, 20129-2021, in Lis, Mat, in the North-eastern part of Albania, in a 14-years old vineyard and a planting density of 3330 vines ha^{-1} (2.5 m x 1.2 m), with a total area of 1.6 ha, under the ownership of Aleksander Radani. The experimental plot was situated in an uniform hill with a sloping gradient of 5-6%, 472 m elevation, in geographical coordinates 41º37’39”N and 20º5’7”E. Vines were trained according to Espalier Cordon system, with four catching wires positioned 80, 120, 160, and 200 cm above the ground. A Randomized Complete Block Design (RCBD) with tree replications and three variants (cluster thinning treatments), with a plot size of 10 vines for each treatment was used. Cluster thinning was applied at berries pea-size (stage 75), consisting on removing upper clusters on shoots. Three applied cluster thinning treatments were: V1 = control (no cluster thinning was used), V2 = 25% cluster thinning (25% CT), leaving 2 clusters/shoot, and V3 = 50% cluster thinning (50% CT), leaving 1 cluster/shoot.

Measurement of the main vein length of the mature leaf (N1) was carried out in July 10-20, each year on the same day, and determination of the mature leaf area (m^2/vine) was determined as described by [18].

For each variant (treatment) and replication was measured cane pruning weight at winter pruning, in February. At harvest were determined the number of clusters for vine (NCV), grape yield (kg/vine), mean cluster weight

(MCW) (g), mean berry weight (g), total souble solids content (TSSC), titratable acidity (TTC), and pH. Mean cluster weight (MCV) was calculated from yield and clusters for vine, while one hundred berries were randomely chosen for each treatment and each replication for mean berry weight determination. Samples for must analysis were performed after destemming and crushing of berries. Soluble solids (^{o}Brix) were measured by a digital refractometer, while titratable acidity (g L^{-1} tartaric acid), pH of must and wine, and alcohol fraction for volume, were determined using IPGRI methods [8].

Pomace and must fermentation was carried out after destemming and crushing of berries. Must was treated with 60 mg L^{-1} SO_2, was poured into 5 L glass fermentors, and was preserved at 25-28^{o}C for six days. After fermentation and maceration, pomace was pressed by a mecanichal press. Wines were taken for analysis sixty days later. Total phenolics content (TPC) was determined using colorimetric method, described by [7]. Total anthocyanins content in wines (WTAC) was determined using bisulphate bleaching method, while free individual anthocyanins content was determined as described by [1]. Wine color intensity (WCI) was evaluated measuring the optical density at 420 and 520 nm, using UV/VIS spectrophotometer (WCI = $\sum (OD_{420} + OD_{520})$). Differences between variants were tested by ANOVA test, while relationship between different vine and wine indicators was tested using correlation relationship [13].

3. Results and discussion

3.1 Effect of cluster thinning on productivity indicators

Observed results showed that cluster thinning accelerated the grape ripening by 5 days for V2 (25% CT) and 9 days for V3 (50% CT), compare to control. Grape ripening (harvesting time) was September 16, September 20, and September 25 for V3, V2, and V1 (control – no cluster thinning). Yield per vine was reduced significantly in both cluster thinning treatments. Yield reduction was 31.3% for variant 3 (CT 50%), and 16.2% for variant 2 (CT 25%), compare to control. Yield reduction was lower than the cluster thinning rate due to the raise of berries and bunch weight following cluster thinning. Observed data were similar to [21] for cultivar "Kallmet", [2], [11], [15], [24]. Mean cluster weight was raised by 17.3% and 43.1%, while mean berry weight was raised by 11% and 21.4%, for V2 and V3, respectively, compare to control (Table 1).

Table 1. Estimated yield and other productivity indicators, according to different cluster thinning treatments (mean values, different letters indicate significant difference at $p \leq 0.05$).

Treatments	Yield		Cluster weight		Berry weight	
	kg vine^{-1}	%	g	%	g	%
V1 (Control)	5.26 a	100.00	270.2 c	100.00	2.6 c	100.00
V2 (CT 25%)	4.47 b	84.98	316.7 b	117.3	2.88 b	111.00
V3 (CT 50%	3.62 c	68.82	386.6 a	143.1	3.157 a	121.4

3.2 Effect of cluster thinning on vegetative growth indicators

Cluster thinning affected significantly vegetative growth indicators of red wine grapevine cultivar Black Shesh. Leaf area per vine (m^2) was raised by 16.4% for Variant 2 (CT 25%), and 20.3% for Variant 3 (CT 50%). Leaf area/yield ratio was inversely proportional to the grape yield/vine. Control showed the lowest leaf area/yield ratio (1.22), while variant 3 (CT 50%) showed the highest leaf area/yield ratio (2.27). There were observed significant differences between treatments for the leaf area/yield ratio (Table 2). Winter pruning weight/vine did not significantly differ between cluster thinning treatments, but they differed with control. Yield/pruning weight was decresed significantly at both cluster thinning treatments by 22.3% for V2 (25% CT) and 40.1% for V3 (50% CT), compare to control.

Table 2. Estimated vegetative growth and vegetative/productive indicators, according to different cluster thinning treatments (mean values, different letters indicate significant difference at p≤0.05).

Treatments	Leaf area		Leaf area/yield		Pruning weight		Yield/pruning weight	
	m^2/vine	%	m^2/kg	%	kg/vine	%	kg kg^{-1}	%
V1 (Control)	6.83 b	100	1.29 c	100	0.86 b	100	6.11 a	100
V2 (CT 25%)	7.95 a	116.4	1.78 b	138	0.94 a	109.3	4.75 b	77.7
V3 (CT 50%)	8.22 a	120.3	2.27 a	176	0.99 a	115.1	3.66 c	59.8

3.3 Effect of cluster thinning on berry composition (chemical-technological indicators)

After destemming, crushing of berries and juice filtration, there were measured total soluble solids, titratable acidity and pH. There was observed that, even though harvest was advanced nine days for CT 50% treatment and five days for CT 25%, compare to control, the highest value of total soluble solids (°Brix) was obtained in CT 50% treatment by 21.0°Brix, while for CT 25% it was 20.6°Brix, and 19.4°Brix for control (Table 3). [23] suggest that high yield delays grape ripening and more time is required for the soluble solids to reach a given degree Brix. The highest value of titratable acidity (6.7 g L^{-1}) and the lowest pH (3.12) was measured for control compare to both cluster thinning treatments, indicating slower grape ripening. Titratable acidity and pH reduction in cluster thinning treatments may be as a consequence of larger increase of berries size, weight and volume from veraison to harvest, which were confirmed by some other authors as well [2], Kamiloglu, 2011; [15].

Table 3. Grape berry composition (soluble solids, titratable acidity and pH), according to different cluster thinning treatments (mean values, different letters indicate significant difference at p≤0.05).

Treatments	Total Soluble solids		Titratable acidity		pH	
	°Brix	%	gr L^{-1}	%	value	%
V1 (Control)	19.4 b	100.00	6.7 a	100.00	3.12	100.00
V2 (CT 25%)	20.6 a	106.18	6.5 b	95.52	3.18	101.9
V3 (CT 50%)	21.0 a	108.24	6.1 c	91.04	3.3	105.8

3.4 Effect of cluster thinning on wine composition

Cluster thinning affected the wine composition as well as berry composition. Alcohol concentration in wine was in the right proportion with sugar concentration (total soluble solids), while the titratable acidity was almost the same as the berry titratable acidity. Alcohol content was higher in CT 50% (13 vol %), followed by CT 25% (12.2 vol %). Total phenolics content, total anthocyanins content, and color intensity of wine differ significantly between treatments. There were obtained higher values of these indicators in CT 50% (Table 4).

Table 4. Mean values of wine composition, according to different cluster thinning treatments (mean values, different letters indicate significant difference at p≤0.05).

Treatments	Alcohol (vol %)	Titratable acidity (g L^{-1})	Total phenolics (mg L^{-1})	Total anthocyanins (mg L^{-1})	Optical density 420 nm	Optical density 520 nm	Color intensity
V1 (Control)	11.5 c	6.6 a	1542 c	430 c	0.342	0.368	0.698 c
V2 (CT 25%)	12.2 b	6.3 b	1697 b	468 b	0.354	0.382	0.718 b
V3 (CT 50%)	13.0 a	5.9 c	1845 a	516 a	0.396	0.396	0.754 a

Cluster thinning had affected the individual anthocyanins concentration, as well. The highest concentration of the most important individual anthocyanins was obtained in CT 50%, while the lowest values were obtained in control (no CT). Cluster thinning significantly increased the concentration of delphinidin-3-monoglucoside, cyanidin-3-monoglucoside and petunidin-3-monoglucoside, while the concentration of the most abundant individual anthocyanins, malvidin-3-monoglucoside, did not differ significantly between treatments. Obtained data are similar to [4] on cv. Nebbiolo, and [21] on cultivar "Kallmet", indicating that cluster thinning affects not only the total anthocyanins content, but the specific accumulation of individual anthocyanins as well, resulting on different anthocyanins profile of grapes and wines (Table 5).

Table 5. Mean values of individual anthocyanins concentration, according to different cluster thinning treatments (mean values, different letters indicate significant difference at p<0.05).

Treatments	Delphinidin-3-monoglucoside (mg L^{-1})	Cyanidin-3-monoglucoside (mg L^{-1})	Petunidin-3-monoglucoside (mg L^{-1})	Malvidin-3-monoglucoside (mg L^{-1})
V1 (Control)	2.1 c	0.3 c	5.4 c	29.2
V2 (CT 25%)	4 b	0.4 b	8.2 b	29.2
V3 (CT 50%)	5.8 a	0.6 a	10.4 a	29.4

There was observed a strong relationship between the vegetative and productive features of grapes and wines, such are leaf area/vine (*LAV*), yield (*Y*), cluster weight (*CW*), must soluble solids content (*MSSC*), pruning weight (*PW*), wine alcoholic content (*WAC*), total wine anthocyanins concentration (*TWAC*), wine color intensity (*WCI*), wine delphinidin-3-monoglucoside (*Delph*), cyanidin-3-monoglucoside (*Cyan*), petunidin-3-monoglucoside (*Petun*), and malvidin-3-monoglucoside (*Malv*), etc, as result of different cluster thinning levels. Correlation coefficient varies from 0.8 to 0.9, which indicates that changes of one indicator affect changes to the other one (Table 6).

Table 6. Relationship between vine and wine indicators, expressed by the correlation coeficient

	LAV	*Y*	*CW*	*MSSC*	*PW*	*WAC*	*TWAC*	*WIC*	*Delph*	*Cyan*	*Petun*	*Malv*
LAV	1											
Y	0.887	1										
CW	0.879	1	1									
MSSC	0.964	0.924	0.943	1								
PW	0.916	**0.999**	**0.999**	0.934	1							
WAC	0.844	0.984	0.996	0.876	0.992	1						
TWAC	0.968	0.992	0.984	0.984	0.988	0.966	1					
WCI	0.947	0.994	0.990	0.962	0.996	0.972	0.992	1				
Delph	0.924	0.996	0.994	0.944	**0.999**	0.980	0.990	**0.999**	1			
Cyan	0.877	0.998	0.998	0.924	0.992	0.996	0.966	0.988	0.996	1		
Petun	0.956	0.996	0.996	0.964	0.994	0.974	**0.999**	**0.999**	0.998	0.982	1	
Malv	0.994	0.849	0.814	0.978	0.864	***0.844***	0.920	0.876	0.864	0.894	0.996	1

4. Conclusions

Under Mati's agroecological conditions, cluster thinning at berries pea-size (stage 75) by 25% and 50% reduced significantly yield, increased leaf area/yield ratio, accelerated grape ripening, increased total soluble solids content, decreased titratable acidity and pH, while improved wine color intensity, alcoholic content and wine total and individual phenolics composition. Cluster thinning by 50% was followed by the highest levels of total phenolics, total anthocyanins, most individual anthocyanins, and color intensity of the wine. For a higher wine quality and an adequate aging, there was a need of more than 2.273 m2 leaf area kg-1 grape. Even though by cluster thinning 50% was obtained a higher wine quality, this canopy management practice was followed by a large loss of vine crop. Each vinegrower and wine producer has to find their optimal balance into their vineyard according to the desired wine style.

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