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Effect of green pruning on the fruitfulness of winter buds, quantity and quality of yield in Cabernet Franc cultivar

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Abstract. *A study was conducted to investigate the effect of bunch normalization and defoliation on winter eye fertility, quantity and yield quality in Cabernet Franc. It was found that the application of green pruning resulted in an increase in mass per bunch and per 100 grains, but a decrease in yield per vine. The sugar content increased slightly in the green pruned variants. In the two-year period of the study, high temperatures and low rainfall during the growing season reduced the effect of bunch rationing and defoliation on grape yield and quality. There was no significant difference in grape quality between the treatments under high temperatures. After the hot and dry year of 2021, lower values of the actual fertility indicators - percentage of fruiting shoots and fertility coefficient - were observed in 2022.*

Keywords: green pruning, vine, fertility, yield, grape quality, Cabernet Franc

Introduction

Viticulture and viniculture are the defining sub-sectors of Bulgarian agriculture and food industry. The future of the wine sector is linked to the production of wines with protected designation of origin (PDO) and protected geographical indication (PGI). In order to produce quality grapes and wine, the varieties must be correctly located according to their agrobiological characteristics. To obtain quality grapes and wine, the cultivars are necessary to have proper geographical location, according to their agrobiological characteristics. It is necessary to apply a cultivation technology in which the vines are optimally loaded with **winter buds** and green prunings are carried out, which improve the individual load of the vines with bunches and improve the light and air regime. Studies have been conducted on the impact of green prunings on the development, yield and quality of grapes in different cultivars (Nedelkovski et al., 2018; Nedelkovski, 2018; Roychev et al., 2018; Ivanov and Roychev, 2018; Ivanov et al., 2018).

Actual fertility is an indicator that shows the average number of bunches per shoot. In a study by Zinni et al. (2023), the fertility of winter eyes on the fruiting stalk was found for a two-year period when defoliation was applied at the pea stage, with 1-2 winter eyes being the least fertile, as well as 11-12 and 5-6 winter eyes being the most fertile.

In years with warmer temperatures, more sugars accumulate, but with recorded sugars greater than 25-26 degrees Brix, it is not photosynthesis that causes the high sugar concentration, but the loss of water from evaporation itself (Keller, 2009; Keller, 2010). The same author in 2005 (Keller, 2005) found that bunch thinning and its timing had little or no effect on shoot growth, leaf area, number of bunches and bunch weight.

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Wang et al. (2021) found that fertility was mostly affected by winter eye sunshine during the growing season and considered that applying shoot thinning, bunch thinning and leaf removal in Semillon and Shiraz (*Vitis vinifera* L.) cultivars could affect fertility. According to them, the size of the inflorescences is interrelated with the growth of the shoots, and by changing the microclimate of the vine one can potentially manipulate the size of the bunches. They are of the opinion that climatic conditions influence not only the growth of the current year but also the fruiting of winter eyes and, hence, the potential yield for the following year.

Crop load regulation is widely accepted as an important method of vineyard management for quality wine. However, there is little information on its effectiveness in warm and dry climates. According to Keller (2015) differences in vegetative growth, yield formation and fruit composition within varieties are primarily due to the season and climatic conditions under which the growing season takes place (including weather and soil moisture) rather than yield or crop load. Climate change is a challenge for all wine growing regions, water scarcity is leading to unsustainability in the sector. There is an early start of the phenophases, different phenophase lengths, lower yields and lower quality grapes (Rafique et al., 2022).

A study examining future changes in temperature, rainfall and the resulting bioclimatic indices for zoning viticulture in Europe found that, if the trend towards higher temperatures continues, there will be regions that will cease growing vines if adaptive measures are not implemented to make irrigation more efficient, while other regions will have to change the varietal composition of grapes by selecting varieties that are adapted to warmer climates (Pathak, 2018; Cardell et al., 2019).

A number of authors (Poni and Bernizzoni, 2010; Palliotti et al., 2011; VanderWeide et al., 2021), consider that leaf removal early in the season (before flowering) serves as an effective tool for improving fruit quality in several *Vitis vinifera* cultivars. According to them, green pruning positively influences the fight against grape rot, bunch compactness, for higher Brix of must, and total phenolic and anthocyanin concentrations. According to Lee and Skinkis (2013), Zheng et al. (2017) and Alessandrini et al. (2018), leaf removal before flowering contributes to improve vine microclimate, vine yield, grape composition and wine quality.

The aim of the present study was to determine the influence of some green pruning on yield quantity and quality in Cabernet Franc cultivar grown in the Stara Zagora region.

Material and methods

The study was conducted with vines of Cabernet Franc cultivar, grown in the medium-stemmed Guyot formation at a planting distance of 2.20/0.80 m, with a supporting structure / supporting wire at a height of 60 cm and 2 auxiliary pairs of wires every 40 cm in the land of the village of Rakitnitsa. The vines are 10 years old. Winter pruning was with a load of one vine with a total number of winter eyes 28. Each vine was left at 4 bunches with 2 winter buds each and 2 fruiting twigs with the length of 10 winter eyes- in three variants, with 3 replication each, 15 vines each.

- no green prunings;
- with a normalization of bunches per vine of 15 pieces /in the "pea" phase/;
- with bunching of 15 bunches per vine (in the "pea" phase) and defoliation in the bunch zone (in the "grain-shearing" phase).

For each variant of the study, the values of the following indicators were determined: yield per vine (kg), mass per bunch (g), mass per 100 grains (g), sugar content (%) and titratable acids (g/dm^3) (Bulgarian ampelography, 1990). The mathematical comparison of the above-mentioned variants on the studied parameters was performed by means of one-factor analysis of variance and evaluation of their mean values by Duncan's method using IBM Statistics SPSS 24 statistical software.

With the Meteobot mini meteorological station during the growing season, the average daily values of climatic factors by month for: air temperature (°C), soil temperature at 30 cm depth (°C), rainfall /mm/ and relative humidity (%) were recorded and processed in Excel 2007. In the "grain formation" phase, the actual fertility indices were recorded. On each vine per variant, the percentage of developed winter eyes, undeveloped eyes, fruiting and non-fruiting shoots, number of clusters per shoot were recorded. After grape harvest, the average mass per bunch and the average yield per vine, as well as the average mass per 100 grains, were recorded per variant. The chemical composition of the grapes was analysed by the following methods: sugars (g/dm^3) - Dujardin's areometer and titratable acids (g/dm^3) - titration with NaOH.

Results and discussion

The two years of the study were characterized as very warm. The beginning of the growing season in 2021 started early - already in the second ten days of March (Table 1), and during the months of July and August, the average day and night air temperature reached almost 30°C for ten days on end. The soil temperature at a depth of 30 cm had almost the same values. These temperature conditions combined with the minimum amount of precipitation and the low atmospheric humidity slowed down the physiological processes in the plants and caused premature partial leaf fall, as a result of which the time of reaching the technological maturity of the grapes was significantly delayed and the sugar content in the grapes was lower in comparison with 2022 (Table 4). This confirms that the vitality of the vine is directly affected by the climatic conditions of the vegetation. There are studies in this area that find that high temperatures lead to a greater number of hot days and water deficit (Fraga et al., 2012; Schultze and Sabbatini, 2019; Van Leeuwen et al., 2019) and the consequences on the physiological climate change processes lead to overheating of the vine's organs, their abnormal functioning, cause sunburns and danger of desiccation, desiccation of the vine. Green pruning can be used as a tool to control growth and ripening, influencing phenolic content and accumulation of sugars in the desired direction (Poni et al., 2023).

In 2022, the vegetation began in the last ten days of March (Table 2), and the values of the average day-night temperature in the following months were 3-4°C lower than the previous year. The temperature of the soil at a depth of 30 cm was also lower, which provided slightly better conditions for the development of the root system of the vines even in the presence of more precipitation.

Table 1. Temperature of air and soil at 30 cm, air humidity and precipitation in 2021

Months	Decades	Air temperature, ˚C	Temp. at 30 cm, ˚C	Air humidity, %	**Precipitation, mm**
	I	7.4	6.2	68.6	12.4
III	II	11.8	9.1	62.4	1.7
	III	12.3	11.8	64.6	1.6
	I	12.7	12.6	66.3	15.2
IV	II	17.6	15.2	67.2	12.4
	III	18.8	15.4	65.4	3.4
	I	19.5	17.2	64.38	3.2
V	II	20.9	19.1	68.74	7.1
	III	21.6	20.7	65.2	4.8
	I	20.82	20.67	67.90	2.5
VI	II	19.13	19.01	78.42	30.75
	III	26.4	24.82	69.59	14.25
	I	25.24	25.12	61.49	8.5
VII	II	27.51	27.22	56.33	0
	III	27.34	27.22	50.57	2.2
	I	29.23	28.98	50.31	15.5
VIII	II	26.36	28.01	54.62	9.25
	III	24.24	25.69	64.76	12.0
	I	20.18	22.84	56.67	0
IX	II	22.54	22.78	53.81	0
	III	17.75	20.70	60.78	1.75
	I	13.17	17.20	95.20	29.0
X	II	11.98	13.99	88.14	118.5
	III	11.28	12.99	75.78	10.0
	I	11.28	12.88	90.38	11.0
XI	II	7.64	9.93	80.52	1.6
	III	8.01	9.24	82.49	4.25

Table 2. Temperature of air and soil at 30 cm, air humidity and precipitation in 2022

Months	Decades	Air temperature, ˚C	Temperature at 30 cm, ⁰C	Air humidity, %	Precipitation, mm
III	I	2.3	5.07	74.68	22.5
	II	2.13	4.66	53.78	2.75
	III	11.31	8.70	49.57	0
IV	I	13.31	12.3	62.46	26.5
	II	9.73	12.24	66.29	19.5
	III	16.22	14.86	66.96	4.0
V	I	14.02	15.06	65.90	4.5
	II	18.99	18.44	63.96	12.0
	III	21.53	21.69	66.82	8.5
VI	I	22.64	23.51	78.87	14.0
	II	21.24	22.68	71.83	68.75
	III	24.43	25.12	62.38	0.75
VII	I	24.66	26.43	59.13	6.0
	II	24.54	26.23	48.14	0
	III	28.35	29.94	50.74	5.25
VIII	I	26.68	27.71	52.22	0.25
	II	26.61	27.96	55.36	2.25
	III	25.87	26.86	61.47	28.75
IX	I	22.18	24.21	66.29	18.0
	II	20.50	22.12	60.67	27.75
	III	17.63	19.16	61.25	1.25
X	I	16.71	18.50	60.94	2.25
	II	14.47	16.92	65.67	0
	III	16.15	16.54	61.01	0
XI	I	13.91	15.44	72.43	0
	II	11.29	12.72	85.42	14.0
	III	8.06	10.77	81.23	35.75

Table 3. Indicators for actual fruitfulness

year	Percentage of buds	Percentage of fruiting shoots	Fruitfulness coefficient
2021	74.28	88.72	1.42
2022	68.61	85.38	1.33

The percentage of developed winter eyes in 2021 was higher - 74.28% compared to 2022 - 68.61%, due to the smaller amount of precipitation at the beginning of the growing season (Table 3). The worse conditions /high air and soil temperatures at a depth of 30 cm, and extremely insufficient amount of precipitation/ for the development of the vines, the setting of inflorescences in the winter eyes and the ripening of the grapes in the summer and autumn of 2021 are the reason in 2022 the percentage of fruiting shoots and the fertility coefficient to have lower values. Therefore, the number of bunches per vine in 2022 in the variant without green pruning is smaller. Climatic conditions influence not only the growth of the current year, but also influence the fruiting of winter buds, and hence the potential yield and fertility for the following year (Vasconcelos et al., 2009; Wang et al., 2021; Monteiro et al., 2022). The formation of the yield component is formed in two consecutive years (Guilpart et al., 2014; Keller, 2015).

Our research confirms that temperature, light, water status are factors that influence the formation of the reproductive structure during the two years of growth and development (Vasconcelos et al., 2009; Li-Mallet et al., 2016). The fertility of the winter eyes is not a constant value (Magalhães, 2015) and can provide the potential yield of the vine for the next growing season (Dry, 2000; Meneguzzi et al., 2020; Monteiro et al., 2022).

The yield from one vine and in the two years of study was the highest in the variants without green pruning - 1638 g and 1659 g (Table 4). In the variants with thinning, the number of bunches (in the “pea” phase) yield is lower due to their reduction to 15. There is an increase in the mass of one bunch and of 100 grains. The mass of one bunch and of 100 grains also increases slightly in the case of the norming of the bunches and defoliation (in the “veraison” phase).

The differences between the options are more

Table 4. Grape yield and quality

Year	Variants	Replications	Yield per vine g	Weight of a bunch g	Weight of 100 grapes g	Content of	
						Sugars g/dm^3	Titratable acids g/dm^3
2021	Without green pruning	I	1652	59	99.4		
		II	1664	64	96.2		
		III	1584	66	95.6		
		average	1638	63	97.1	225	6.38
	Thinning	I	1080	72	101.2		
		II	1020	68	101.4		
		III	1005	67	105.0		
		average	1035	69	102.5	225	6.00
	Thinning and defoliation	I	1095	73	103.6		
		II	1065	71	100.4		
		III	990	66	100.5		
		average	1050	70	101.5	226	6.13
2022	Without green pruning	I	1620	81	101.6		
		II	1558	82	101.2		
		III	1776	74	104.2		
		average	1659	79	102.3	238	6.60
	Thinning	I	1320	88	110.2		
		II	1215	81	111.8		
		III	1290	86	106.0		
		average	1275	85	109.3	243	6.42
	Thinning and defoliation	I	1350	90	112.6		
		II	1380	92	114.6		
		III	1275	85	111.2		
		average	1335	89	112.8	241	6.43

significant in 2022, when temperature conditions were more optimal compared to 2021 and there was more precipitation. Bunch thinning is a green pruning that is applied to improve the ratio between quality and quantity of yield. In our study, the mass per bunch and per 100 grains values were higher in 2022 compared to 2021, due to better temperature conditions and more rainfall.

Bunch thinning affects the ratio of quantity and quality of grapes, reduction of load increases the concentration of soluble solids content, pH values, anthocyanins and phenolic compounds (Peña-Neira et al., 2007; Valdés et al., 2009), the left bunches ripen faster and improve their composition (Frioni et al., 2017).

The observed partial premature defoliation in the late summer and early autumn of 2021 delayed the technological maturity of the grapes and was the reason for the lower and almost uniform sugar content. Accumulation of sugars favours the variant in 2022, due to the more optimal climatic conditions in the second half of the growing season compared to 2021, the content of sugars in the grapes in all three variants is higher, with differences also observed. With the applied green pruning, we have found differences with the control in terms of mass of one bunch and mass of 100 grains, which were established for both years of the study. Regarding the accumulation of sugars, it was found that green prunings can influence their higher content, but the temperature conditions during ripening are the factor on which sugar accumulation directly depends.

Applying cluster thinning and defoliation to the two years of the study, it can be summarized that the fruitfulness of the Cabernet Franc variety depends on the climatic conditions under which the winter buds are laid. Green pruning should be applied according to the climatic conditions of the current year. The effect of applying thinning in the “pea” phase and defoliation in the “veraison” phase has a higher potential on qualitative and quantitative indicators of grapes in the presence of optimal climatic conditions.

Conclusion

In years with high temperatures and low rainfall, the effect of green pruning on grape yield and quality is minimal. Under the influence of high temperatures, there is no significant difference in grape quality between the different variants. After a hot and dry year, in the following growing season lower values of the indicators of actual fertility - percentage of fruiting shoots and fertility coefficient - were observed. Green pruning leads to an increase in the mass per bunch, per 100 grains, in the sugar content of the grapes.

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