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RESEARCH ON SOME METHODS OF CANOPY MANAGEMENT TO MITIGATE THE EFFECTS OF CLIMATE WARMING AT GRAPEVINE

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Abstract

The study was conducted in 2017-2019 in the experimental plantation of the USAMV Bucharest, on the most widespread Romanian grape variety, 'Feteasca regală clone 21 Bl', grafted on the rootstock 'Kober 5 BB', to monitor how green operations - severe shoot topping and leaf removal above the bunch area - causes an effective delay in the accumulation of sugars in the grapevine berries. The green operations have been performed when berry sugar content reached about 14-15.5°Brix. The severe shoot topping at beginning of veraison increased competition of the lateral shoots, contributed to the delay of grapes maturity. Defoliation consisted in removing 30-40% of the vine leaves located above the grape floor (the most active photosynthetically). The results obtained on the qualitative parameters were compared with the control on which no intervention was applied. During the three years, there were lower accumulations of sugars in the berries at the time of harvesting the grapes, both in the case of severe shoot topping (21.8°Brix) and in leaf removal (21.5°Brix), compared to the control (22.8°Brix).

Key words*: canopy management, climate change, grapevine.*

INTRODUCTION

The multitude of effects of global warming has led, in the last decade, to the development of strategies for adapting the grapevine culture, which provide for a series of measures in the long, medium and short term.

Short-term measures refer to the application of pruning (Novello & de Palma, 2013; Frioni et al., 2016; Zheng et al., 2017; Moran et al., 2018), to the application of green operations (Stoll et al., 2009; Filippetti et al., 2011; Martinez de Toda & Balda, 2013; Poni et al., 2013; Palliotti et al., 2014; Quénol et al., 2014; Parker et al., 2016; Caccavello et al., 2019; Silvestroni et al., 2019; Holzapfel et al., 2020; Lopez-Granados et al., 2020), as well as in soil maintenance works (Brîndușe et al., 2013; Șerdinescu et al., 2013; Enache & Donici, 2014; Șerdinescu & Brîndușe, 2014, and others).

Good results were also obtained by using plant growth regulators (Davies et al., 2015) and antitranspirants (Palliotti et al., 2013b; Gatti et al., 2016).

The main measures are to delay the ripening of grapes leading to a reduction in excessive accumulations of sugars, maintaining titratable acidity at normal values, which leads to obtaining wines with a medium, balanced alcohol content.

Lower accumulations of sugars in berries can also be obtained by reducing the "leaf area: fruit weight ratio" to values less than 0.5-0.8 m^2/kg by some works and green operations (defoliation, shoot topping etc.).

The research carried out in Valea Călugărească, for the 'Cabernet Sauvignon' variety, confirmed that at low values of the "leaf area:fruit weight ratio" (6-8 cm^2/g grape, respectively 0.6-0.8 m^2/kg) obtained sugar concentrations of 180-185 g/L, compared to 197-205 g/L, at optimal values of 1.0-1.7 m^2/kg (Belea, 2008).

Research by Palliotti et al. (2013a) for the Sangiovese variety in central Italy, with the removal of 30-35% of the leaf surface of the vine (from the middle - upper part) when the sugar concentration of the must was 16-17°Brix determined for the variety 'Sangiovese' reduced it by 1.2°Brix when the grapes were harvested, without affecting the titratable acidity, the content of anthocyanins and total polyphenols.

Shoot topping and increased competition from grapevine lateral shoot can contribute to

delaying grape ripening. Through the late shoot topping one week after the grape veraison, Filippetti et al. (2011) obtained a significant reduction in the concentration of sugars in the must, without changing the pH, organic acids, the content of anthocyanins in the skins of the berries and the tannins in the seeds.
The aim of this study was to investigate the influence of some green operations (shoot topping and leaf removal) on delay of grape maturation, as a measure to mitigate the effects of global warming.

MATERIALS AND METHODS

Plant material and experimental conditions
The experiment was carried out during the vegetation period of 2017, 2018 and 2019 in the experimental vineyard located in the southern part of Romania, at the University of Agronomic Sciences and Veterinary Medicine Bucharest (N Lat.: 44° 47' 07"; E Long.: 26° 07' 28"; alt. 87 m).
The plantation where the experiment took place was established in 1994, with 'Fetească regală' variety, clone 21 Bl, grafted on 'Kober 5 BB' rootstock, spaced by 2.2 m (inter-row) and 1.2 m (intra-row), with a density of 3787 plant ha-1. The vines are trained as bilateral cordon with a spur pruning system and loading of 12 buds/m2 and the support system is of the vertical monoplane type. The plantation is located on a plane surface with reddish preluvosol soil and rows direction N-S. Phytosanitary treatments against to control diseases and pests have been applied in accordance with local standard practice.

Phenological data
The four main phenophases (budburst, flowering, veraison, harvesting maturity) were followed, according to BBCH (**B**ioligische **B**undesansalt und **Ch**emische Industrie), modified under the COST Action FA1003 "East-West Collaboration for Grapevine Diversity Exploration and Mobilization of Adaptive Traits for Breeding" (Rustioni et al., 2014).
Data were recorded at which 50% of buds, flowers, grapes reached the respective phenological stages (BBCH 008 - budburst; BBCH 605 - flowering; BBCH 801 - veraison and BBCH 809 - berries ripe for harvest).
Canopy management techniques used in research
On three consecutive rows, three intervals were selected (3 repetitions of 10 vine), on which three different foliage management techniques were applied, including control, severe topping and leaf removal above the floor with grapes.
→ Control (C) - no green operations (topping shoots or leaf removal) were applied to these vines.
→ Severe shoot topping (T) and leaf removal (LR) have been applied on 28.07.2017, 24.07.2018 and 31.07.2019 (Figures 1 and 2).
The green operations were performed manually in the veraison phenophase, corresponding to the phenological stage BBCH 85 - the berries become translucent or colored and softening (Lorenz et al., 1994) and up to an average concentration of soluble sugars in berries between 14.0-15.5°Brix.
The severe topping of the shoots applied in July and the increased competition of the lateral shoot contributed to the delay of the ripening of the grapes.
Also, the defoliation applied after veraison, by removing the 50-60 day old leaves (the most photosynthetic active), from the middle part of the vegetal wall, determined a slowing down of the sugar accumulation. Defoliation consisted in the removal of 30-40% of the leaves of the vine, and created a 35-40 cm vertical window without leaves above the bunch area, keeping a few leaves at the canopy apex.

Quantitative and qualitative parameters examine in research
The grapes were harvested during the three years of observations between September 4-12.
At harvesting, for control and each experimental variant, determinations were made on quantitative (grape weight - grams, berry weight - grams, yield - kg/vine) and qualitative parameters (sugar content - ºBrix, titratable acidity - g/L tartaric acid). Sugar concentration in grapes was measured by using an Atago digital refractometer. The results were expresed in ºBrix. Titratable acidity was determined by titrating with 0.1 N NaOH using an Pellet digital biurette, and expresed as g/L tartaric acid.

Statistical analysis

Each data set was analyzed using analysis of variance, the statistical One Way ANOVA, and the mean values of the experimental and control variants were compared post-hoc Tukey HSD $p<0.05$. Results of the seasonal evolution of sugar content and titratable acidity are shown as means ± standard error.

Figure 1. The topping of shoots of 'Fetească regală' variety

Figure 2. The leaf removal above the bunch area at 'Fetească regală' variety

RESULTS AND DISCUSSIONS

Climatic conditions

The climatic indicators were determined for experimental period (2017-2019) comparatively with reference period (1981-2010) after the recommendations of National Meteorological Administration (Dima et al., 2019).

Table 1 shows an obvious global warming during the experimentation period, especially during the vegetation period of the vine. Thus, the largest differences are found in the case of maximum annual temperatures (1.4°C), those during the growing season (1.38°C) and during the summer (June-August) (1.1°C). At the same time, there was a decrease in rainfall during the vegetation period (on average by 14%), especially in 2018 (by 27%).

Table 1. The main climatic parameters and bioclimatic indices during the experimentation period (2017-2019) compared to the reference period (1981-2010)

Climatic parameters and bioclimatic indices	Average	Years			Average
	1981-2010	2017	2018	2019	2017-2019
Average annual temperature, ºC	11.55	11.74	12.21	12.92	12.29
Average temperature in the growing season (IV-X), ºC	18.07	17.99	19.33	18.53	18.62
Average temperature in summer (VI-VIII), ºC	22.50	22.78	22.83	23.05	22.90
Average temperature in the warmest month, ºC	23.32	23.80	23.87	23.60	23.74
Average annual minimum temperature, ºC	5.03	5.44	6.38	6.57	6.13
Average minimum temperature, in the growing season (IV-X), ºC	10.42	10.80	12.01	11.40	11.40
Average minimum temperature in summer (VI-VIII), ºC	14.47	15.60	15.84	15.60	15.66
Average of absolute minimum temperature, ºC	-17	-20	-12.2	-15.4	-16.1
Average annual maximum temperature, ºC	17.05	18.04	18.03	19.28	18.45
Average maximum temperature in the growing season (IV-X), ºC	24.46	25.22	26.66	25.63	25.84
Average maximum temperature in summer (VI-VIII), ºC	29.01	30.01	29.81	30.50	30.11
Average maximum temperature in the warmest month, ºC	29.87	30.16	28.87	29.64	29.56
Annual total precipitation, mm	608	661	623	529	604
Total precipitation in the growing season (IV-X), mm	428	415	312	385	371
Total precipitation in summer (VI-VIII), mm	198	155	228	142	175
Huglin index (HI)	2346	2408	2646	2458	2504
Winkler index (WI)	1726	1710	1997	1825	1844
Cool night index (CNI)	10.45	12.16	11.30	10.60	11.35

Values below 2400 units of the Huglin index, determine a titratable acidity generally higher

than 5.5-6 g/L, while Brix is generally lower than 22%, which lead to harmonious light-bodied wines, with less than 13% vol. alcohol, typical for 'Fetească regală' variety. Values higher than 2400 units lead to more unbalanced wines with higher alcohol concentration, sometimes over 13.5% vol. alcohol and the mandatory need for acidity corrections (Bucur et al., 2019).

The development of the main phenophases

The greatest variation from one year to another was found in flowering and harvest maturity, these phenophases being more influenced by climate variability (Table 2). It can also be seen, that, grapes veraison (50% of berries softening) was recorded on average on DOY 209 (July 28) with variations between DOY 205 (July 24) and DOY 212 (July 31).

Table 2. Mean day of year (DOY) of the phenological stages (budburst; flowering; veraison and harvest) and the corresponding standard deviations (SD in days), for 'Fetească regală' variety (2017-2019)

Year	Budburst (50%)	Flowering (50%)	Veraison (50%)	Harvest maturity
2017	101	148	210	247
2018	103	136	205	255
2019	104	151	212	251
Mean	103 ± 1.53 (April 13)	145 ± 7.97 (May 25)	209 ± 3.61 (July 28)	251 ± 4 (September 8)

Larger differences were found in harvest maturity, on average on DOY 251 (September 08), with variations between DOY 247 (September 04) and DOY 255 (September 12).

The effect of green operations applied

Table 3 shows insignificant differences between variants each year, in terms of the average weight of a grape and yield.

Defoliation resulted in a significant reduction in the average weight of the berry each year (on average 2.17 g compared to 2.29 g in the control).

Regarding the accumulation of sugars in the berries, in each year of experimentation a significant reduction of its content was found, on average from 22.8°Brix at control, to 21.5°Brix at leaf removal. A similar reduction was found in the case of the application of severe shoot topping (21.8°Brix).

Compared to the control, in which every year there was an accentuated reduction in titratable acidity (4.8-4.9 g/L tartaric acid). In the case of severe shoot topping this parameter was maintained at normal values (6.6-6.8 g/L tartaric acid).

Following the application of defoliation, the acidity took on low values (5.1-6.3 g/L tartaric acid), but higher than the control.

Acidity values less than 6 g/L tartaric acid, lead to flat white wines, fade which requires corrections of this parameter.

Table 3. Grapes quantitative and qualitative parameters at harvesting time for Fetească regală variety* (2017-2019)

Year	Variant	Grape weight, grams	Berry weight, grams	Yield, kg/vine	Brix, %	TTA, g/L tartaric acid
2017	Control	100.7 ± 2.4^{a}	2.25 ± 0.1^{a}	3.9 ± 0.1^{a}	22.6 ± 0.1^{b}	4.9 ± 0.1^{b}
	Severe shoot topping	112.5 ± 4.3^{a}	2.28 ± 0.1^{a}	4.2 ± 0.2^{a}	21.7 ± 0.2^{a}	6.8 ± 0.3^{a}
	Leaf removal	105.6 ± 4.3^{a}	2.16 ± 0.1^{a}	4.2 ± 0.2^{a}	21.3 ± 0.2^{a}	5.3 ± 0.4^{b}
2018	Control	101.9 ± 2.4^{a}	2.40 ± 0.1^{b}	3.9 ± 0.2^{a}	22.7 ± 0.1^{b}	4.8 ± 0.1^{b}
	Severe shoot topping	107.3 ± 5.2^{a}	2.42 ± 0.1^{b}	4.3 ± 0.3^{a}	21.8 ± 0.3^{a}	6.6 ± 0.2^{a}
	Leaf removal	101.2 ± 5.0^{a}	2.20 ± 0.1^{a}	4.0 ± 0.2^{a}	21.5 ± 0.2^{a}	6.5 ± 0.1^{a}
2019	Control	104.4 ± 2.2^{a}	2.22 ± 0.1^{a}	3.9 ± 0.1^{a}	23.0 ± 0.2^{b}	4.9 ± 0.1^{b}
	Severe shoot topping	103.1 ± 7.3^{a}	2.25 ± 0.1^{a}	3.9 ± 0.2^{a}	22.0 ± 0.3^{a}	6.7 ± 0.2^{a}
	Leaf removal	101.1 ± 4.6^{a}	2.14 ± 0.1^{a}	3.8 ± 0.3^{a}	21.7 ± 0.1^{a}	5.1 ± 0.3^{b}
Overall	Control	102.3 ± 1.3^{a}	2.29 ± 0.1^{b}	3.9 ± 0.1^{a}	22.8 ± 0.1^{b}	4.9 ± 0.1^{c}
	Severe shoot topping	107.6 ± 3.2^{a}	2.32 ± 0.1^{b}	4.1 ± 0.2^{a}	21.8 ± 0.2^{a}	6.7 ± 0.1^{a}
	Leaf removal	102.6 ± 2.4^{a}	2.17 ± 0.1^{a}	4.0 ± 0.2^{a}	21.5 ± 0.1^{a}	5.6 ± 0.3^{b}

*One Way ANOVA, post-hoc Tukey HSD $p<0.05$.

CONCLUSIONS

Global warming which has been more pronounced in recent years has determined an exaggerated accumulation of sugars in the grapevine berries, under the conditions of accentuated degradation of the titratable acidity (under the 6 g/L tartaric acid) which required corrections.

As a means of avoiding this situation, winegrowers have the application of green operations at their disposal which have in these circumstances, through their application and intensity, favourable effects to avoid excessive accumulations of sugars, with the possibility of obtaining balanced wines.

In the conditions of degradation of the titratable acidity, the defoliation (on a portion of 35-40 cm above the grapes) and the severe topping when the grapes reached maturity proved to have a favourable influence (14-15.5°Brix).

Both green operations have proved their efficacy in the normal ripening of grapes under experimental conditions.

The reduction of the average weight of the grape berries, induced by the defoliation, can have a positive influence on the accumulation of aromatic compounds in the peel, especially in the varieties subjected to a pre-fermentative maceration.

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