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Influence of crop loading on berries composition in Cabernet Sauvignon variety

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Abstract The study was carried out to investigate during three growing seasons (2016/2017, 2017/2018 and 2018/2019) the crop loading influence on the composition of Cabernet Sauvignon berry. To estimate the effect of crop load on berry composition, field samples were individual harvested and processed separately. The crop load of 10, 20, 30 and 40 buds was applied to the same vines for three consecutive growing seasons. The different crop loading induced the variability of production; the qualitative decrease of berry chemical composition, as a result of crop load increasing was observed only in the seasons with climate variability characterized by lower temperatures. It was found that the influence of climate exceeded the effects of pruning, and the berry chemical composition was variable depending on weather in each growing season. Higher than average temperatures, had a minor influence on berry composition, especially during the ripening period. In growing seasons with lower than average temperatures, the quality of grape berries was higher than average. The average grape yield/vine was significantly higher during 2016/2017 growing season comparing with 2017/2018 and 2018/2019 growing seasons, due to the variability of temperature and precipitation. The amount of sugar was significantly influenced by the interaction between the crop load and the climate from each growing season. Excepting the first year of research (2016/2017), the titratable acidity was very significant (93%) influenced by crop load and climate. There are many grape berry parameters which prove that crop load between 30 and 40 buds per cane generate a balanced vine.

Key words

berries, crop load, climate, vines, sugars, acidity

Grapes growing and vinification have a very long history, with evidence as early as 5000 BC., in Europe, and are the most important fresh fruit crop in the world, mostly (66%) cultivated for grape wine production [22]. During the growing season vines are subjected to pruning and thinning for canopy and grape yield management [17]. The relationship between production and the grape quality has been studied quite intensively depending on climate in different regions of the world [18]. Although grape production is the most commonly used parameter for vineyard evaluation, yield components provide more complete understanding of the impact that vine management practices have on berry components [5,24]. The crop load, the number of shoots and the number of bunches on each shoot, are some of the components with major implications in the yield quality [20]. The crop load directly influences the grape yield; climate variability, especially during the flowering stage, such as rain, cool weather or cloudiness, can greatly decrease production due to lower pollination and fertilization [4, 8]. The level of pruning and weather conditions can have variable effects on yield and shoot development [16]. There is a strong relation between vine canopy, grape yield and berry components [25, 27]. More severe pruning leads to an increase in the shoots number, respectively the leaf area [3]. The grape yield per vine increases similar to crop load up to a certain level after which the growth is slowed down or even decreases. Some research, such those of Dunn and Martin (2000) [11] showed that severe pruning favoured berry development in Cabernet Sauvignon and Chardonnay varieties. Developed grape berries are the largest reserve of nutrients; pruning such as pinching back shoot tips and snip the entire sucker from grape vine trunks reduce competition for nutrients and provide the transport of carbon needed for berry development in disfavour of vegetative growth [20, 31]. The main components of grape berries are represented by water and sugars [6, 9]. In must, around 90% of dry matter is represented by sugars [2]. The amount of grape sugar measured at

harvest represents the potential alcohol of the wine [10, 19].
The aim of the research was to analyse the influence of crop load and climate variability during three growing seasons, (2016 -2019) on grape berry quality (berry weight, sugars, total acidity) in Cabernet Sauvignon variety.

Material and Method

Cabernet Sauvignon variety was planted in 2000, on their own roots, in a private vineyard from Buteni area, Arad County. The vines chosen for the research, depending on the ratio between the weight of the grapes and the weight of the pruning wood, had moderate vigour with Ravaz Index values in the range between 5 and 10.
The planting density was 2963 vines per hectare, with a distance of 2.25 m inter-rows and 1.5 m between vines, simple Guyot training and with north-south orientation. The crop load was about 36 buds (on average 24 buds /meter) on four canes. Grape yield, number of bunches and their average weight was recorded at harvest. The number of bunches at harvest was related to the crop load from the beginning of the growing season. Before pruning, the canes were counted and the pruned ones were weighed. The average weight of the canes and the ratio between the grape yield and pruning weights were calculated.
The grape berries were sampled randomly from the top, middle and bottom of the selected bunches on both sides of the trellis. Berry weight, soluble solids (SS) and titratable acidity (TA) were analyzed from berries sampled in the harvest day from each of the four replicates in the randomized block design. The samples were crushed by hand in plastic bags and the juice filtered and analyzed. Soluble solids were analyzed using a hand-held refractometer (to measure ° Brix). Titratable acidity was analyzed using an Orion Star T910 Titrator.
Data analysis was performed using general analysis of variance (ANOVA) in GraphPad Prism 7.04 (GraphPad Software Inc., 2017). The significant difference after Fisher's test was calculated at the 5 percent probability.

Results and discussion

Air temperature during vine development is one of the most important factors in controlling the time and duration of growing stages [14, 15, 21]. Weather during research (2016-2019) was analyzed for maximum daily temperature, minimum daily temperature, average maximum and minimum temperatures and average monthly precipitation.
The amount of precipitation in the months of the 2016/2017 season was very small in June and July and relatively normal in April-May and September. Regarding the values of the minimum temperature, they were quite low in the phenophases of bud break, during shoot growth and flowering stages, but also in September at the beginning of ripening stage. However, the months of vegetation were also marked by maximum temperatures during the day that exceeded 34°C in June, July, becoming hot on several days in August.
Higher temperatures favour berries ripening slowly, decrease photosynthesis and limit sugar supply carry to the berries, according to the research results of Greer and Weedon (2013) [14].

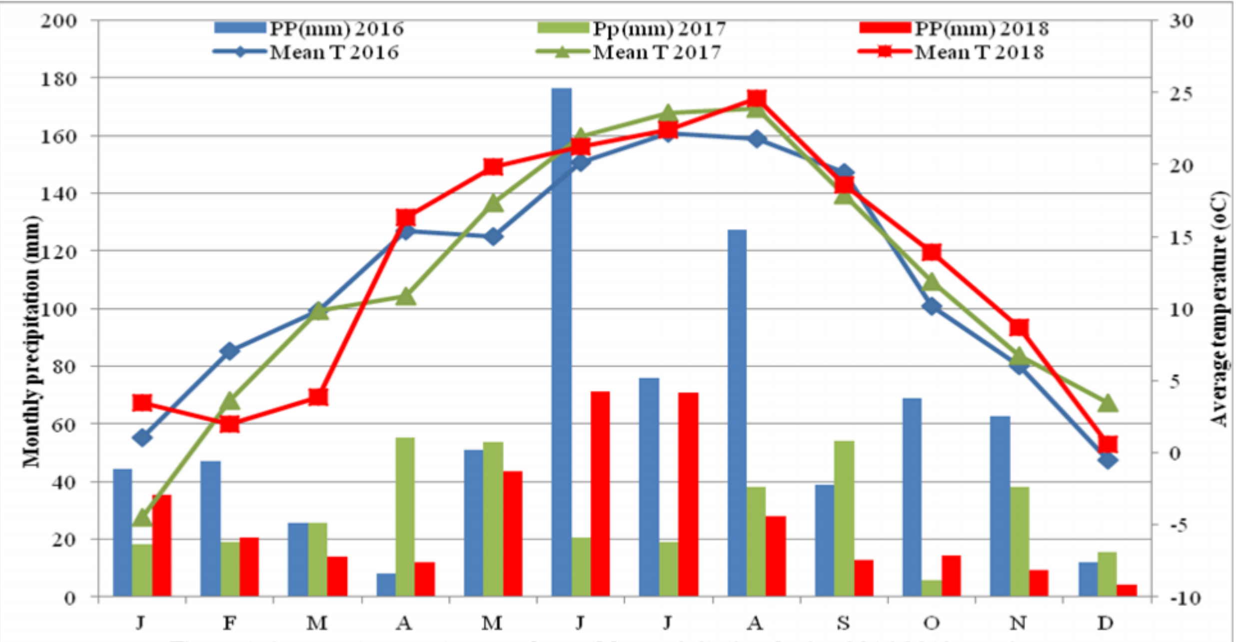

Figure 1. Average temperatures and monthly precipitation during 2016-2019 growing seasons

Unlike the previous year, the months of May - July of the 2018 season, were enough amount of precipitation, associated with temperatures of 32 - 33°C which favoured the development of canopy (figure 1). The buds outbreak was marked by very low minimum temperatures during the night (-18°C) and insignificant precipitation. During the ripening stage, high temperatures during the day associated with low rainfall and low temperatures during the night favoured the accumulation of sugars and decreased acidity.
The distribution of precipitation during 2018/2019 growing season was irregular over the months; an excess of humidity was observed in July (175.7 mm); 2019 was warm, with high maximum temperatures over the year including during the winter months. The minimum temperatures were not low either, with a minimum of -13°C in January. Only minimal positive temperatures were recorded in the growing months. Very high temperatures, around 30°C, were recorded in the ripening months of September-October, and for better berry quality, grapes were harvested during the night. (For clearer figure, only average temperatures and monthly precipitations were exposed).
During the 2019 growing season, for the 10 buds crop load resulted the lowest bunches weight (96.4 g) and a maximum of 120.2 g for 30 buds crop load (figure 2). Fertility, quantified in bunch per node, was significantly influenced by the interaction between crop load and climate.

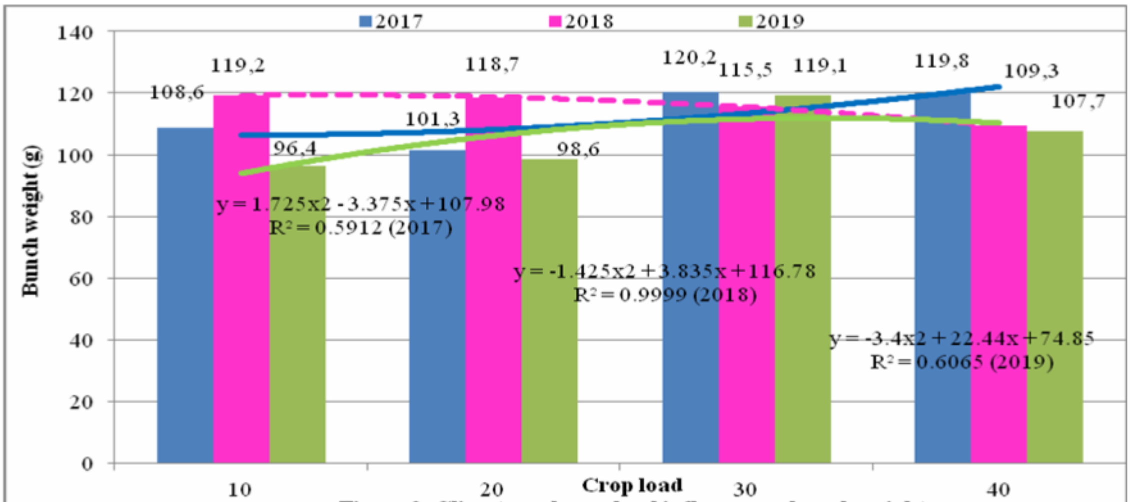

Figure 2. Climate and crop load influence on bunch weight

Crop load influences the bunch weight by 99% in 2018, while in the other two growing season, bunch weight was less controlled by crop load. In other varieties like Crimson Seedless, Fawzi et al. (2010) [12] found that bud fertility decreased, and the bunch weight less, when crop load on vine increased; Porika et al. (2015) [26] reported in Red Globe cultivar that crop load has negative influence on bunch quality. The significant influence of higher crop load on bunch weight was observed by Zamboni et al. (2015) [31] in Pinot Noir and Sauvignon.
During the 2017 season, for the crop load of 10 buds resulted higher number of bunches / node compared to other crop loads. During the 2019 season, there were no significant differences in fruiting depending on the fruiting load (figure 3).

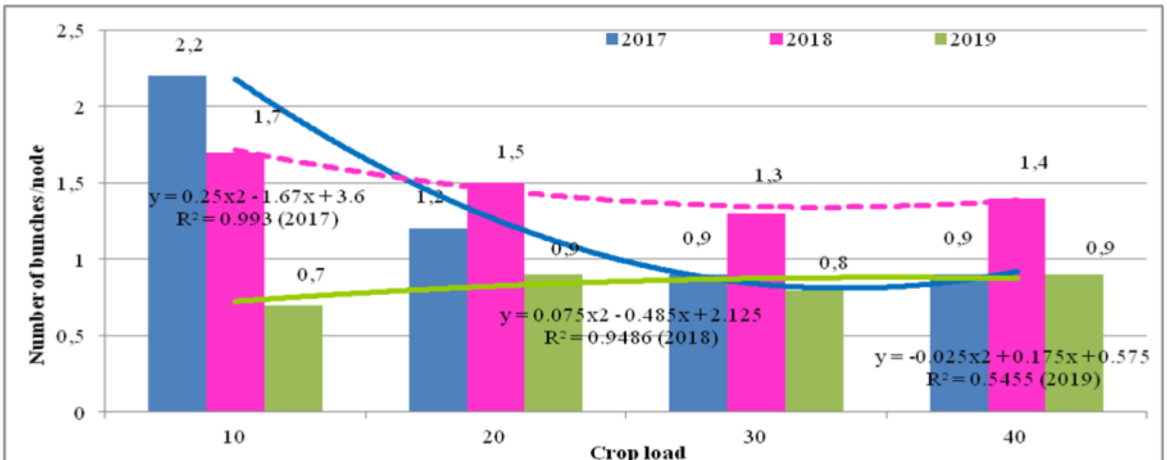

Figure 3. Climate and crop load influence on number of bunches/node

In both growing seasons 2016/2017 and 2017/2018 the number of bunches per node was significantly influenced by crop load (over 99% in 2017, and 95% in 2018). Lower influence of crop load on bud fertility was observed in 2019.

The increase of bunch number per vine resulted in higher grape yield/vine (figure 4).

Yield for a crop load of 10 buds/vine and 20 buds per vine were not significantly different from each other, but at 30 buds per vine and 40 buds per vine was significantly different from all other variants.

In all three growing seasons, crop load had a major influence on grape yield /vine (over 99%). The result is confirmed by the research of Singhrot et al., (1977) [28] which found in Thompson Seedless that yield per vine increased when the intensity of pruning decreased. Spayd and Morris (1978) [30] found that a higher crop load (60 +10) did not influence the number of bunches per node, berries per cluster or berry weight in Thompson Seedless variety. The same opinion concerning the crop load has Morris and Cawthon, (1980) [23] in their study regarding the Thompson Seedless and Niagara varieties vine vigour. Crop load has no significant interaction with pruning seasons on grape yield in cv. Sugrathirteen from Brazil [13] and no significant differences concerning the number of bunches/vine between growing seasons.

The average grape yield/vine was significantly higher during 2016/2017 growing season comparing with 2017/2018 and 2018/2019 growing seasons, due to the variability of temperature and precipitation which were decisive. Crop load has a different influence on yield parameters, depending on variety and climate. In a large research on Sauvignon Blanc variety, Dixon (2009) [7] found that crop load significantly influence the budburst with very little influence on yield parameters such as bunch weight, number of berries per bunch, or berry weight.

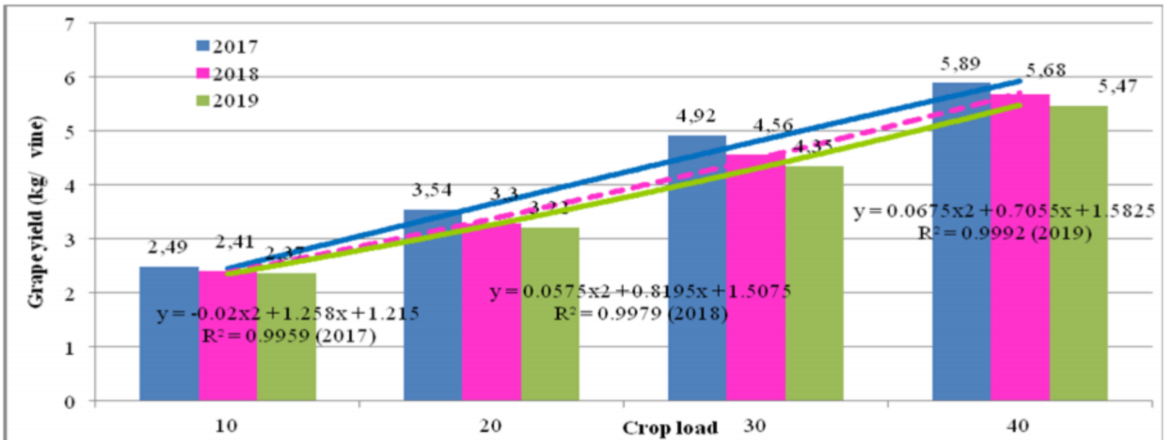

Figure 4. Climate and crop load influence on grape yield/vine (kg)

The amount of sugar was significantly influenced by the interaction between the crop load and the climate from each growing season (figure 5).

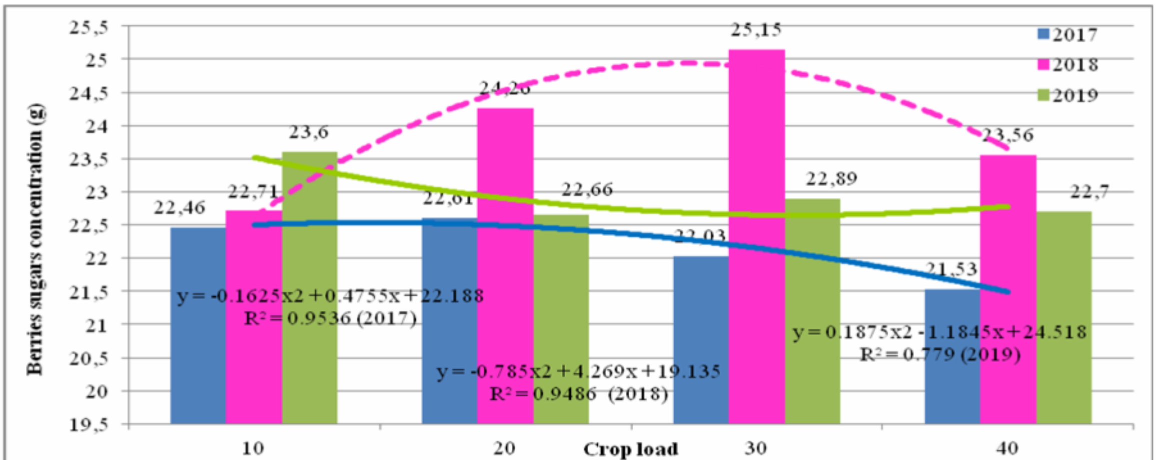

Figure 5. The effect of crop load and climate on the berries sugars concentration (g)

During the first growing season, sugars decreased as the number of buds increased; in the second growing season (2018), the sugars increased up to the level of 30 buds per cane and then decreased from 40 buds per cane. During 2018/ 2019 growing season there was no

significant effect of crop load, but the sugar had a decreasing trend as the fruiting load increased.
Also, the titratable acidity (TA) was significantly influenced by the interaction between different crop load and the climate from each growing season (figure 6). During the 2016/2017 growing season there were no significant differences between the crop load variants; during the 2017/2018 growing season, the titratable acidity values for crop load of 40 buds per cane were significantly lower compared to the other experimental variants. During the 2018/2019 growing season, the titratable acidity decreased as the crop load successively increased.
Studying the Cabernet Sauvignon variety, Dobrei et al. (2016) [8] found that grape berry sugar was less sensitive to crop load variability.

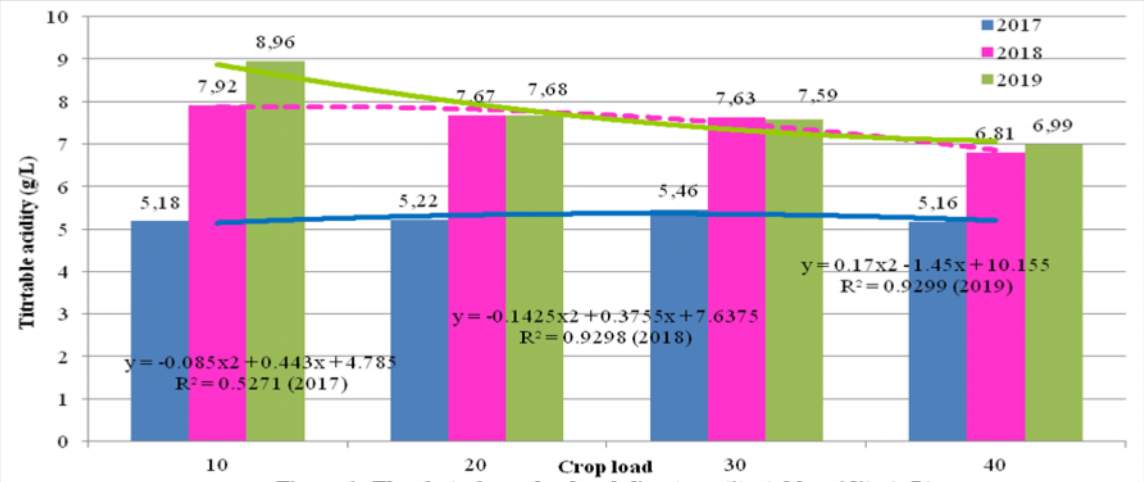

Figure 6. The efect of crop load and climate on titratable acidity (g/L)

Excepting the first year of research (2016/2017), the titratable acidity was very significant (93%) influenced by crop load and climate (figure 6).
The different effect of bud-load for each cultivar/variety is confirmed in Thompson seedless and Beogradska besemena table grape varieties by Baiano and Terracone (2012) [1]; in Beogradska lower crop load decreased titratable acidity while in Thompson seedless increased the soluble solid concentration. The effect of crop load observed during two growing season by Zamboni et al. (1996) [31] in three Italian grape wine varieties (Pinot Noir, Pinot Gris and Sauvignon) was irrelevant on sugar concentration, pH and titratable acidity in the must. An increased acidity was found in cv Sharad Seedless by Somkuwar and Ramteke (2007) [29], correlated with an increased number of bunches per cane (vine).

Conclusions

The most important result of the current study was the high influence of the weather from each season on the composition of Cabernet Sauvignon berries in relation to crop load.
Depending on the season, factors such as average rainfall (2017), higher temperatures in (2019) or lower temperatures during night (2018) influenced more the grape development and their composition than the crop load. Higher average temperatures during the growing season caused higher grape production associated with a higher crop load, with minor effect on sugar concentration and low titratable acidity. There are many grape berry parameters which prove that crop load between 30 and 40 buds per cane generate a balanced vine.

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