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CLIMATE VARIABILITY AND CANOPY MANAGEMENT INFLUENCE ON GRAPE BERRIES QUALITY IN MERLOT AND PINOT NOIR VARIETIES

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Abstract

The aim of the study was to investigate the climate and canopy management effects on Merlot and Pinot Noir berries quality, from Minis vineyards, Romania. During four growing seasons (2016-2019), crop load and cluster thinning were investigated on double Guyot training system. For grape berries composition analysis samples were individual harvested on each vine. Each season was applied for both varieties the same winter pruning level, for 10, 20, 30 and 40 crop load. For vine balance, bunches were removed in three stages of the growing season: fruit set, lag phase and 20% veraison. Crop load associated with climate from growing season influenced the grape berries composition concerning the sugar, titratable acidity and pH, more than cluster thinning treatments. Weather within growing season override the canopy management practices: cold and wet weather in the spring decrease the grape production while warm weather mainly in the ripening time had little effect on Merlot and Pinot Noir berries composition. Therefore, cluster thinning is expensive with high production losses and small increase in grape berries qualities to can balance the profit of winemakers.

Key words: *climate, crop load, growing season, Merlot, Pinot Noir.*

INTRODUCTION

Grapevine is cultivated more than 4,000 years B.C. and has about 60 wild species across Europe, North America and Asia (Zohary and Hopf, 2000). The story of vine spreading around the world is related to the Europeans colonies; Columbus and other explorers, brought *Vitis vinifera* to Mexico and then throughout Latin America, on California, Australia, or to Far East (Buxó, 2008). About 1,600 years ago, some North American hybrids were created and selected specifically to withstand *Phylloxera* (Arnold et al., 2005). Planted in Europe, these varieties have led to a spectacular increase in grape yield and, consequently, in wine production. The story of wine is, in fact, just as old as grape growing (Grassi et al., 2003). Egyptian inscriptions mention the production and storage of wine, the Etruscans and the Greeks were delighted with Bachus's drink, and the Romans created powerful vine-growing areas throughout almost the entire empire, but especially in some areas of nowadays France, Germany and Austria (Guasch-Jané et al., 2013). Around 4,000 different varieties of table grapes and wine grapes are grown today in the world and 1368 are included in commercial production (Robinson et al., 2012).

Relationship of climate variability and viticulture

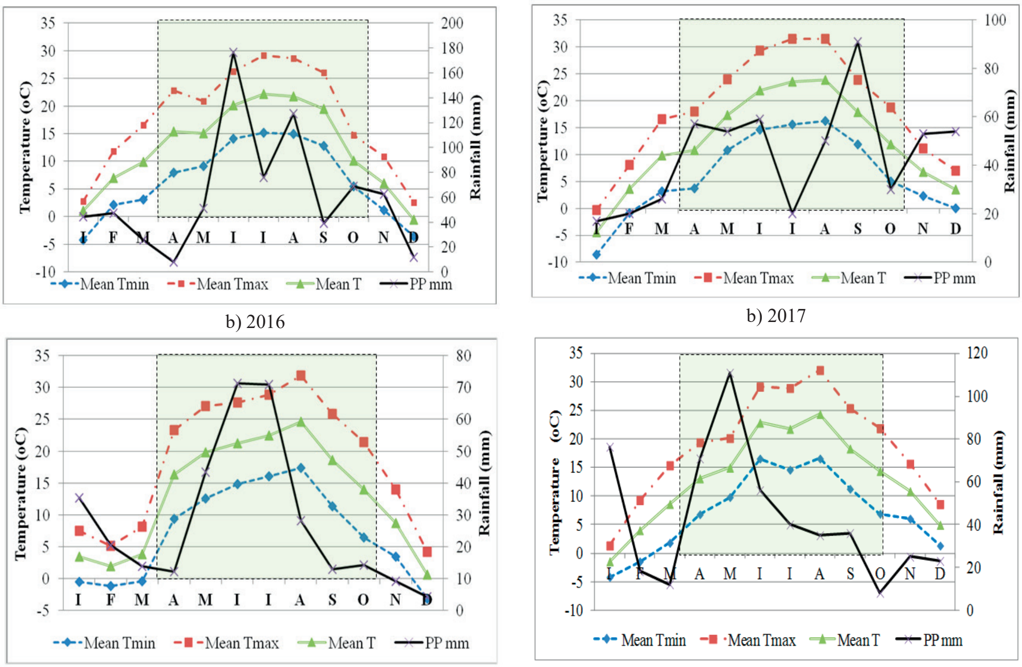
Connection between grape yield and berries composition has been studied extensively but climate variability from last decades require new research in grape growing regions to found the best management practices in vineyards (Kliewer and Dokkozlian, 2005; Sipiora, 2009). During the grapevine growing seasons there are many possibilities for interventions in vine and canopy development through different management practices. Two common practices like winter pruning and cluster removal involve variation in berries development and further berries and wine composition (King et al., 2015). Vine balance and yield are strongly influenced by weather. Global warming is increasingly evident in recent decades but climate variability during growing stages has major influence on vines and grapes growth and development (Nistor et al., 2018). Grapevine growing regions are “moving up” for some cultivars towards potential northern areas, while many traditional wine regions will not be suitable anymore for wine grapes (Mozell and Thach, 2014).

MATERIALS AND METHODS

Minis vineyard is located in the west of Romania on the Siria-Lipova alignment, bordered by the Zarand Mountains in the east, which drop from 800 m to the surrounding hills and plains. Soils from vineyards area are cambisols characterized by accumulated layer of humus, clay, iron oxides, or soluble salts. First soil layers are sandy loam form on medium parent material texture, and are different from brown clay to regosols.

Vineyard is southern exposure; climate in the area has a Mediterranean influence that brings long, warm and dry autumns. During the ripening period, the average monthly temperature ranged between 22.5-23.6°C (July-August) and 18.56°C in September. The average temperature during the growing season is 17.2°C (Figure 1). Most rainfall is recorded in May, June and July, a humidity favourable for fungal infections. The vine and row spacing was 1.5 x 2.5 m. In pruning trial at the Minis Vineyard with Merlot and Pinot Noir varieties, four types of crop load were imposed: 10, 20, 30 and 40 buds per vine, and bunches were removed in three stages of the growing season: fruit set, lag phase and 20% veraison. Each treatment was replicated three times with six vines per replicate plot design.

Vines were pruned to double Guyot system. The ratio of clusters removed ranged between 10 and 30% over four growing seasons in time of fruit set, lag phase and 20% veraison. Clusters from lateral shoots were removed. Temperature and rainfall data were collected from the Minis Research weather station during 2016-2019.



c) 2018

d) 2019

Figure 1. Temperature and rainfall in Minis area, during 2016-2019

Measurements for berries quality were conducted immediately after samples collecting. The chemical parameters of berries (sugars, titratable acidity, and pH) were

subsequently made in the laboratory. For sugars, the digital refractometer HI96811 was used and expressed in Brix scale. For the determination of acidity, the acids in the must were neutralized with NaOH 0.1 n solution in the presence of 1% phenolphthalein, with a semi-automatic titrator and the required volume was recorded. The acidity was expressed in g/L. The pH value in the must was measured before titration.
Data were analyzed using SAS ver. 9.13 (SAS Institute Inc., Cary, NC 27513, USA). A randomized design and statistical significance establish at 5% level. Significant differences were assessed by two ways - ANOVA.
The objectives of the paper were to examine several canes pruning level with variable number of crop load per vine and cluster removal effect on grape berries composition in Merlot and Pinot Noir varieties, during 2016-2019 growing seasons.

RESULTS AND DISCUSSIONS

High canopy vigor and shading can have negative impact on inflorescence development, poor fruiting set, ripening and fruit quality (Feng et al., 2015). Imbalanced canopies can be managed by trellising, training systems, pruning, or thinning practices (Archer & Van Schalkwyk, 2007). Merlot variety has high yield potential but can often reach excess vigor produced by lateral shoots; to avoid overshadow/over cropping pruning and thinning operations can balance the grape yield (Spayd et al., 2002). On the contrary, Pinot Noir is less vigorous variety, with smaller grapes and yield, but cluster tinning is believed to increase the berries quality and ripening (Nistor et al., 2019).
The average yield after cluster thinning at fruit set stage in Merlot and Pinot Noir was lower in all four growing seasons compared to the control (Figure 2).
Grape yield was higher in 2016, a season with better climate for grapevine than other years during fruit set, favourable for higher clusters, and larger berries.
Crop removal influence on grape yield and each growing stage was higher in 2017 when winter cold and later frost from the spring damaged buds and young shoots respectively.
Grape yield/vine decrease in all thinning treatments compared with the control and was very significantly lower in Minis vineyard than yield/vine recorded by King et al. (2025) in Merlot variety (3.80-6.68 kg/vine) for the same thinning treatments.
In other researcher's opinion (Kliewer et al. 1983; Palliotti et al., 2000; Bubola et al., 2011), yield decrease in lower rate after cluster thinning due to the increase of cluster and berries weight.

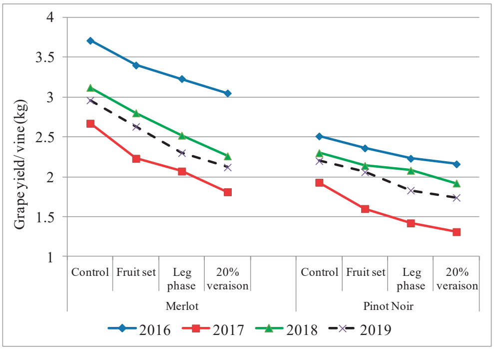


Figure 2. Effect of crop removal (CR) on Merlot and Pinot Noir grape yield/vine (kg), in 2016-2019 growing seasons

Obviously, cluster thinning reduce the number of clusters and the yield per vine relative to the control in all thinning treatments, with differences induce by temperature and rainfall during growing season from each year, but without significant difference between cluster removal treatments, which means that the treatment in each variety was evenly applied (Figure 3).

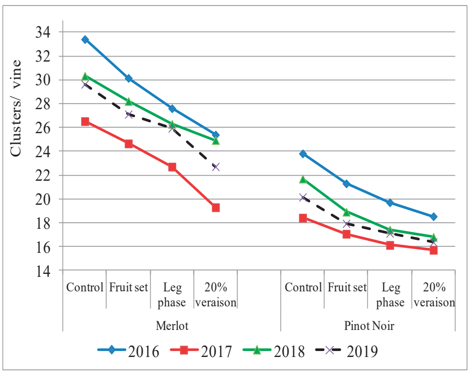


Figure 3. Effect of crop removal (CR) on Merlot and Pinot Noir clusters/vine, in 2016-2019 growing seasons

Cluster number/vine was in close relation with the results of King et al. (2015) which reported after cluster thinning during fruit set cluster number/vine between 23.1 and 29.9; in 20% veraison treatment, cluster number also ranged between close values (22.6 -26.0) compared with Merlot from Minis vineyards.
Cluster weight was higher by 30-40% in 2016 compared with the unthinned control in other research years (excepting 2018 when the cluster weight increased around 48% in Merlot) when clusters were removed during fruit set stage.

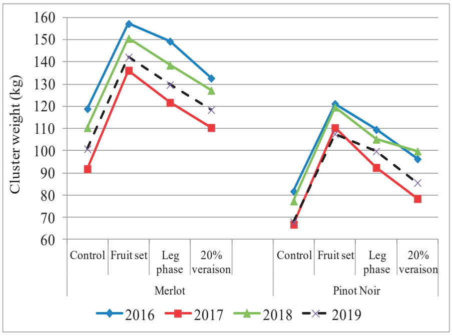


Figure 4. Effect of crop removal (CR) on Merlot and Pinot Noir clusters/vine, in 2016-2019 growing seasons

In Pinot Noir, cluster thinning in fruit set stage show higher cluster weight than control. In the balanced growing season 2016 compared with the result from the other research years, indicate that climate from growing season had greater influence than treatments on cluster weight. The growing season 2017 was characterized as the worst year in viticulture since 1961, cold and wet in the spring (poor fruit set), very hot and dry in July and very hot and wet in harvest time.
Results concerning the influence of thinning treatments and growing season on cluster weight are similar in Pinot Noir with those reported by Mawdsley et al. (2018) and Dobrei et al., (2013). For the same topic, research results are very different: Nuzzo and Matthews (2006) found no differences between cluster thinning and un-thinning treatments, whereas Reynolds et al. (1994) reported an improved cluster weight.
Must composition in Merlot and Pinot Noir at harvest for all four seasons is presented in figures 4, 5, 6. Grape berries composition was influenced both by thinning time and year of growing season. In the unbalanced year 2017 there was no effect of cluster thinning on sugars, pH or titratable acidity (TA).
In 2019 even the grape yield was lower than 2018, because of cold and wet April and May with problems in floral and berries development, was the best year for berries quality.
Due to the very high temperatures during the day (28-30ºC) the harvest was made more at night at 18-20°C, the quality of the berries was higher, considered as the best of the last 38 years. In all four growing seasons the effect of cluster removal treatments on must composition had lower significance compared with climate, but °Brix and pH were higher and titratable acidity was lower compared with the unthinned control.
Cluster thinning at 20% veraison in both Merlot and Pinot Noir variety increased sugar concentration in berries (Figure 5).

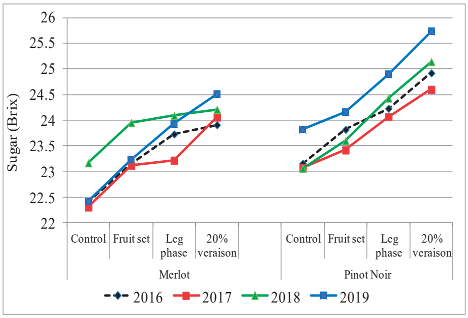


Figure 5. Cluster thinning influence on must sugar concentration in Merlot and Pinot Noir at harvest, during 2016-2019 growing seasons

The higher sugar (°Brix) associated with lower titratable acidity without significant influence of thinning treatment, was confirmed in 2019. The same association was reported in Merlot variety by King et al. (2015). Cluster thinning in veraison period favours the faster maturation and improves the berries composition because vegetative growth is reduced and sugar concentration increased (Reynolds et al., 2007). Mota et al., (2010) recommended after research in cluster thinning in Merlot variety grown in Brazil, to practice only shoot trimming for increase sugars in berries without cluster removal.

The pH is one of the grape quality parameter with impact on taste, flavour or colour stability of wines (Boulton, 1980).
Results (Figure 6) show that pH was influenced mostly by growing season 2017 with heavy rainfall in ripening stage and less by cluster thinning treatments, with the lowest values in both Merlot and Pinot Noir varieties.

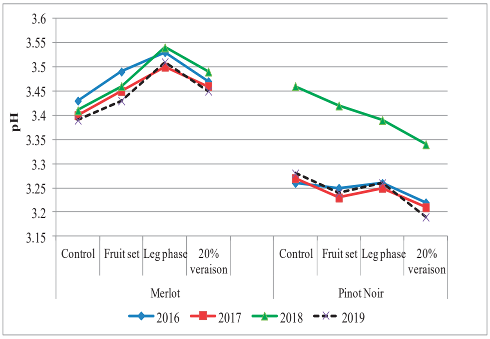


Figure 6. Cluster thinning influence on must pH in Merlot and Pinot Noir at harvest, during 2016-2019 growing seasons

The pH value in Pinot Noir variety was influenced by dry spring and autumn associated with cluster thinning in 2018, when were found the highest pH levels in grape must.
The juice pH affects the taste, sugar / acid balance and stability of the wines; in red wine also affects colour (Dami et al., 2006). It is determined by the balance between the main anions (malate and tartrate) and the presence or absence of major cations (mainly K).
Thus, it is important to achieve the proper balance of potassium in grapes. In France, for example, the levels of potassium accepted in the wine of French wines are between 1-2.5 g/L, resulting in the final wine 0.7-1.6 g/L (Anderson et al., 2008). High pH values can also change the colour of anthocyanin solutions - responsible for the colour of red wine - by changing the structure of the anthocyanin molecule, which becomes bluer and therefore less desirable (Peterlunger et al., 2002).
A high pH in must result in wines with a flat taste and red wines with a brown colour. A pH higher than 3.6 is undesirable because has negative effect on a number of wine quality characteristics (Prajitna et al., 2007).

Warm growing seasons (2016, 2018, and 2019) influence the titratable acidity (TA) concentration (Figure 7).
Wet and cold weather from the late spring associate with cluster thinning in fruit set stage from 2019 growing season, influenced the most titratable acidity which had the lowest level in the research period in both Merlot and Pinot varieties. Highest level of titratable acidity was registered in 2017 growing season
The level of acidity is special trait for the taste of any wine. The acidity gives the wine a fresh and clean taste. Together with the sugar, the acidity of the grape juice represents an important guide for the quality of the wine. Acids - malic and tartaric - account for over 90% of total TA (organic acids) acidity in grapes (Boulton et al., 1999).

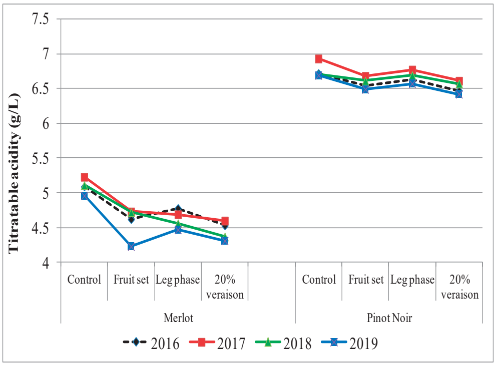


Figure 7. Cluster thinning influence on must TA in Merlot and Pinot Noir at harvest, during 2016-2019 growing seasons

In the hot climate, in grapes exposed to direct sunlight for longer periods, the malic acid content decline during maturity is the highest (Bergqvist et al., 2001). On the contrary, grapes grown in low temperature areas have higher concentration of malic acid in wine (Cirami, 1973).
Wine with higher acidity (> 10 g/L equivalent TA) is sour taste and requires de-acidification (Bardi et al., 1997). In hot environments, titratable acid become too low (< 6-7 g/L TA), thus producing a soft wine (Sadras et al., 2013). The aromatic components, which are part of titratable acids, are important in the sensory or organoleptic quality of the vintage wine. In any type of wine there are usually over 500 of these

substances, all of which are found in minimal quantities (Sadras et al., 2013).
Canopy microclimate is strongly influenced by pruning and crop load; short summer pruning improved cluster exposure to light and ventilation while the *Botrytis cinerea* incidence is reduced (Kliewer and Dokkozlian, 2005; Dobrei et al., 2014). The highest sugar (ºBrix) was recorded in Pinot Noir from 2019 growing season and at 30 buds/vine crop load (Figure 8). The most balance growing season for sugar concentration in both varieties was 2018.
In Pinot Noir sugar concentration was more balanced over the years regardless the crop load. On opposite, sugar concentration in Merlot was influenced by crop load mostly by short (10 buds/vine) and long (40 buds/vine) pruning treatments.
During 2014-2015 growing seasons, Dobrei et al. (2016), found in Pinot Noir for 30 buds/vine crop load lower sugar limits between 197 and 237 g/L, while in Merlot sugar concentration in must was higher for 40 buds/vine crop load and ranged from 190 to 224 g/L; in both years titratable acidity (g/L) steadily increased with crop load in Pinot Noir and decrease in Merlot.
In Merlot variety, with more vigorous canopy than Pinot Noir, pH values were higher for the same crop load. Temperature variability from day/night in growing seasons from last years, associated with high crop load changed the titratable acidity level in grape berries.
The lower pH the cleaner fermentation will be and the wine less spoiled (Dobrei et al., 2016). None of the pH values exceed 3.6 values; therefore the wine from both varieties was high quality without astringency. A study of Kliewer (1973) stated that the rise of pH is associated with warm nights during growing season.
The lower titratable acidity was balanced with yeasts during fermentation about 11%.

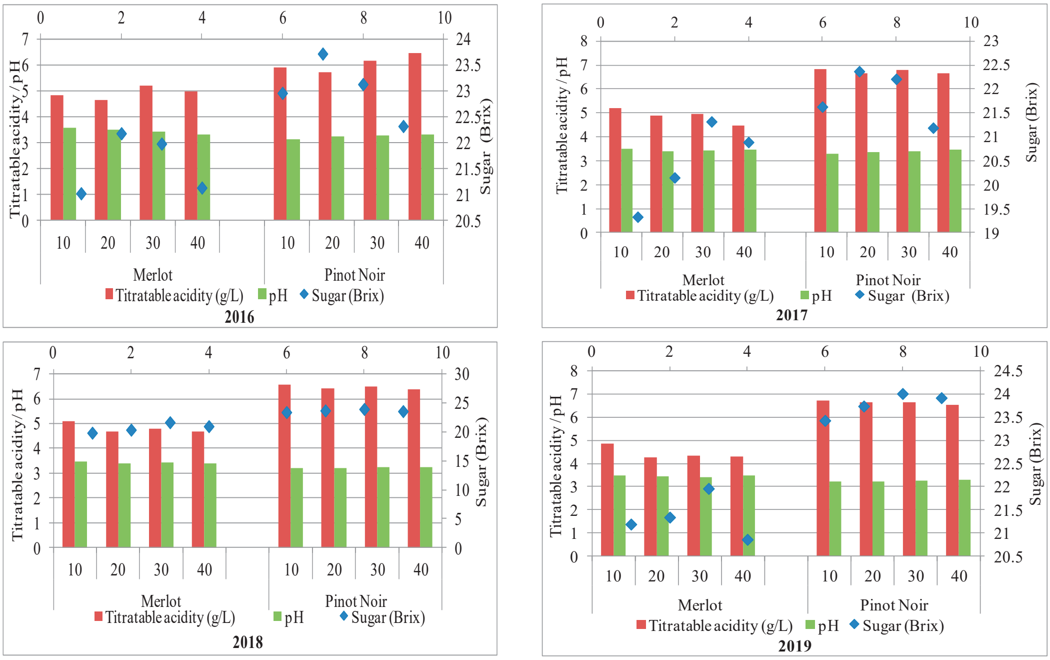


Figure 8. Summary for crop load influence on must components in Merlot and Pinot Noir varieties during 2016-2019 growing seasons

CONCLUSIONS

Both crop load and cluster thinning are frequently used in grapevine growing management, but are expensive and with high yield losses when cluster thinning is applied. Crop loss was higher in 2017 when late spring frost affects buds and then rainy weather the flowering stage. In the same growing season rainy days from ripening stage decrease the berry composition and was the worst year in viticulture in the last 60 years.

On the contrary, in the growing season 2019 - even the yield was lower by 10-12 % then 2018 - result the higher quality berries composition from last 40 years. Cluster thinning increase ripening and sugar concentration whereas TA is decreased, but not influence major the pH. In response to crop load, cluster thinning and climate variability influence, the response of two varieties was different as regards the yield and berry composition. In the conclusion, cluster thinning is expensive with high production losses and small increase in grape berries qualities to can balance the profit of winemakers; cluster removal in vineyards from areas with more and more hot growing seasons is not efficient.

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