

CABERNET SAUVIGNON VARIETY BEHAVIOURAL ANALYSIS IN ROMANIAN VINEYARDS AREAS UNDER THE CLIMATE CHANGE INFLUENCES

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Abstract

In the European Union, the change of wine grape variety for economic reasons in vineyards established under reconversion/ restructuring programs can be done after at least 10 years of vineyard exploitation. In the context of climate changes modifications in the microclimates of vine-growing areas are increasingly observed. Extreme climatic phenomena, with an impact on the harvest or the lifespan of grapevines, are becoming more and more aggressive, with quantifiable effects in the wine industry as well. We have carried out an analysis, on various aspects, of the behavior of the 'Cabernet Sauvignon' variety in the vine-growing areas of Romania. For comparison, the years 2018 and 2022 were analyzed, in the terms of cultivated areas and produced and marketed wines. Our analysis suggests that in the near future, in Romania, due to climate change, there will be vineyard areas where this variety will either no longer be cultivated, or it will be used only for the production of rosé wines or bulk red wines and oenological modelling according to consumption trends is neither economical nor justified.

Key words: climatic conditions, grapevines, production, trends, wines.

INTRODUCTION

Wine quality and yield are strongly influenced by climatic conditions and depend on complex interactions between temperature, water availability, plant material and viticultural techniques (Santos et al., 2020). In the case of vineyards in established wine-growing regions, growers have optimized yield and quality by choosing plant material and viticultural techniques according to local climatic conditions, but as the climate changes, these will need to be adjusted (Leeuwen et al., 2019). This is one of the reasons for our study, to present on the basis of sound numerical arguments, the inefficiency for the future of growing international varieties such as 'Cabernet Sauvignon' in Romanian vineyards.

The wine sector needs to take significant adaptation measures in the coming decades, given the undeniable evidence of global warming and extreme drought (Fraga, 2020). Only a small number of studies have developed multi-scalar and multi-lever approaches to quantify the feasibility and effectiveness of climate change adaptation. In addition, it was found that climate data sources were not explicitly presented in a systematic way that climate uncertainty was hardly taken into account (Naulleau et al., 2021). Temperature is an important environmental factor that influences almost all aspects of plant growth and development. Grapevines (*Vitis* spp.) are quite sensitive to temperature extremes. In the current century, temperatures are expected to rise continuously, with a

negative impact on viticulture. These consequences range from short-term effects on wine quality to long-term problems such as the suitability of certain varieties and the sustainability of viticulture in traditional wine-growing regions (Xenophon et al., 2020). Extreme temperatures affect grapevine physiology, as well as grape quality and production (Bois et al., 2014). ‘Cabernet Sauvignon’ is budding in the last decade of April, once every 20 years a week later or 2-3 days earlier (MADR, 2019). Some studies indicate a good suitability of grape varieties tested for cultivation in different wine growing areas from Romania in order to obtain a high quality wine, but in some years can only get current table wines due to changes in climatic conditions (Bora et al., 2014).

In this context, the paper presents an analysis of the evolution of ‘Cabernet Sauvignon’ production in the main wine-regions of Romania, with correspondence on administrative regions, in order to evidence the evolution of this grapevine variety among 2018-2022, and a projection for the future.

MATERIALS AND METHODS

In order to characterize the evolution of ‘Cabernet Sauvignon’ production, between 2018-2022, some indicators were used.

Table 1. Romanian Weather Stations and their elevation

Wine Regions and Vineyard Center	Meteo Station	County	Elevation (m)
North Lechința	Batoș	Bistrița-Năsăud	409.0
North-West Gerăușa	Satu-Mare	Satu-Mare	126.0
West Diosig	Săcueni	Bihor	130.0
West Șiria	Șiria	Arad	384.0
South-West Recaș	Lugoj	Timiș	124.9
South-West Doclin	Reșița	Caraș-Severin	229.5
South Craiova	Calafat	Dolj	55.0
South Drăgășani	Drăgășani	Olt	159.8
South-East Ostrov	Adamclisi	Constanța	112.0
South-East Constanța	Constanța	Constanța	36.6
East Vaslui	Vaslui	Vaslui	118.7
East Iași	Iași	Iași	61.6
Center Alba Iulia	Alba Iulia	Alba	249.3
Center Valea Călugărească	Ploiești	Prahova	160.5

The wine color and sugar content, the authorized surfaces, total yield in the main Romanian wine-regions, wine production in

PDO, IGP and varietals, certified wines, evolution by alcohol volume in wines by colour and sugar content were collected from National Research and Development Institute for Viticulture and Winemaking. Weather data were collected from the National Weather Administration stations for each wine region (Table 1). The period analysed in this study was 2018-2022. Climatic parameters/indices used in the evaluation and viticultural zoning are based on the assessment of the eco-pedoclimatic conditions in the representative wine-growing regions of Romania by the National Research and Development Institute for Viticulture and Winemaking (MADR, 2019; Order no. 594/2004).

The study was based on measurements regarding UV index, precipitations and maximum average temperature during growing season and minimum average temperatures during dormant season, data recorded by meteorological stations.

The data about ‘Cabernet Sauvignon’ parameters, collected from the National Office of Vine and Wine Products have been statistically processed and interpreted, building the trend line and setting up the forecast for the next years.

RESULTS AND DISCUSSIONS

In the last years, climatic conditions have had a significant impact on ‘Cabernet Sauvignon’ production. Extreme weather events such as heatwaves, droughts, and wildfires have affected grape yields and quality in some regions, leading to fluctuations in supply and pricing. Winemakers are increasingly focusing on adapting to these changing conditions through vineyard management techniques and technology.

The areas planted with the ‘Cabernet Sauvignon’ variety, producing grapes for wines with a Controlled Designation of Origin, are constantly decreasing, by the hundreds, while those producing grapes for wines with a Geographical Indication or varietal wines are increasing by the tens.

Areas that disappear from one year to the next either become wine grape producers for rose or red wines without a geographical indication and without a variety denomination, or are

replaced by varietal reconversion. Around 200 hectares have been replanted with varieties other than 'Cabernet Sauvignon' through the vineyard reconversion/restructuring plans (Figure 1).



Figure 1. Authorized 'Cabernet Sauvignon' surfaces (ha)

The significant increase in the production of 'Cabernet Sauvignon' wine grapes in the South-Eastern and Central areas reveals not only the viticultural potential of these areas, but also microclimatic changes that can enhance the typical qualities of this variety (Figure 2).

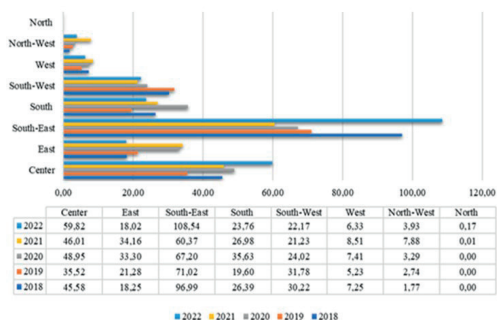


Figure 2. Romanian 'Cabernet Sauvignon' wine grape production in Romanian administrative regions (k quintals)

The same downward trend is observed in the quantities of wine produced and declared. Production of PDO wine is decreasing, GI wine production is slightly increasing, and varietal designation wine production is fluctuating, with a general upward trend (in three of the five years studied) (Figure 3). This fluctuation is showed also by the low value of $R^2=0.1604$ for the PDO 'Cabernet Sauvignon' wines during studied period. Regarding PGI wines and Varietal wines, the values of R^2 are a little bit higher than PDO wines, but the values showed also a fluctuation among the five years of studies (Figure 3).



Figure 3. Romanian declared 'Cabernet Sauvignon' wine production (k hl)

The extreme increase in the wine-growing areas of Central Romania and the Central-Sub-Carpathian Mountains in the category of wine without a variety denomination, denomination of origin or geographical indication is the result of the choice of production direction oriented towards quantity, to the detriment of quality, obtaining simple, less elaborate wines, implicitly less expensive and easier to sell on the bulk wine market (Figure 4).

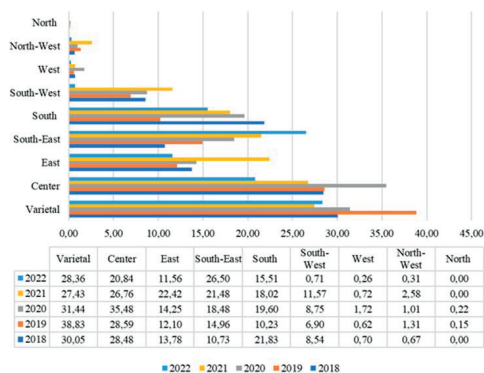


Figure 4. Evaluated 'Cabernet Sauvignon' wines for certification (k hl)

In recent years, regions formerly devoted to white wines have begun to produce interesting red wines, with 'Cabernet Sauvignon' being planted because of both its universality and its plasticity in making different types of wine. Its migration to areas such as the East and North-West shows a growing trend for Romanian red wines in these viticultural areas. Between 10.36 and 10.99% alcohol by volume, 'Cabernet Sauvignon' was only winemaked in 2020 and 2021. Rose and red wines were

produced in 2020 and only red wines in 2021 (Figure 5).

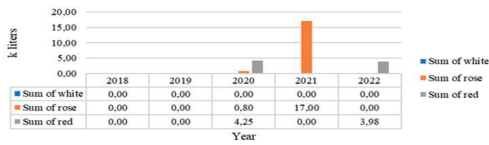


Figure 5. Wines of Cabernet Sauvignon (k liters), with alcohol content between 10.36-10.99% vol. alc.

Between 11.00 and 11.99% alcohol by volume, ‘Cabernet Sauvignon’ produced low quantities of rose wines compared to red wines. The years 2019, 2020 and 2021 gave the major quantities of red wines in this alcohol concentration range, with a peak in 2019 of 1,674.34 thousand liters (Figure 6).

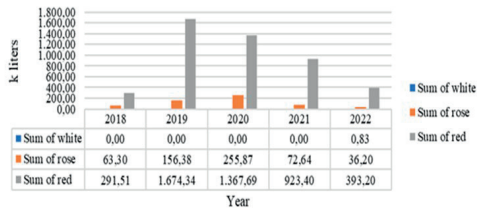


Figure 6. Wines of Cabernet Sauvignon (k liters), with alcohol content between 11.00-11.99% vol. alc.

Between 12.00 and 12.99% alcohol by volume, ‘Cabernet Sauvignon’ produced the highest quantity of white wine in the period studied, in 2020. Rose wines were obtained at almost the same level as red wines. However, the most red wines were produced from ‘Cabernet Sauvignon’ in 2021 (Figure 7).



Figure 7. Wines Cabernet Sauvignon (k liters), with alcohol content between 12.00-12.99% vol. alc.

Between 13.00 and 13.99% alcohol by volume, the level of rose wine production stabilises, with no significant differences in quantity from one year to the next. White wines are still made sporadically, in very small quantities. Red

wines are the most present, in almost constant quantities in the years studied, over 3,300 thousand litres, compared with the maximum quantity in the 12.00 - 12.99 % vol. range of 2,300 thousand litres (Figure 8).

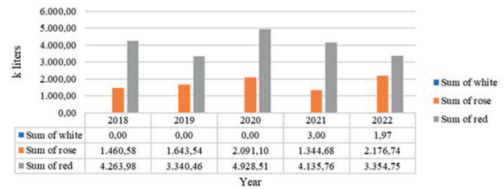


Figure 8. Wines of Cabernet Sauvignon (k liters), with alcohol content between 13.00 – 13.99 % vol. alc.

Between 14.00 and 14.99% alcohol by volume, fewer and fewer rose wines are being made. Red wines are the most popular, and their high alcohol content makes them suitable for ageing and long cellaring. The differences are very significant between the quantities of rose and red wine, and no white wines have been produced at all (Figure 9).

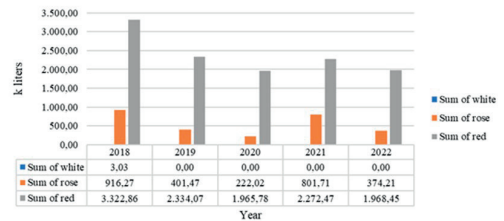


Figure 9. Wines of Cabernet Sauvignon (k liters), with alcohol content between 14.00 – 14.99 % vol. alc.

Between 15.00 and 15.99% alcohol by volume, rose wines are sporadic, white wines were not produced at all. In 2020 only red wines made from ‘Cabernet Sauvignon’ were produced. In the years 2020, 2021 and 2022 there is a quantitative constancy in the production of wine with this high alcohol (Figure 10).

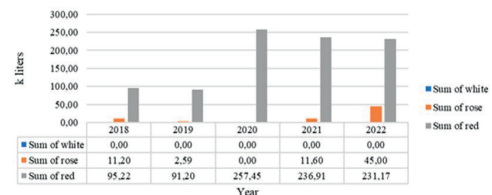


Figure 10. Wines of Cabernet Sauvignon (k liters), with alcohol content between 15.00 – 15.99 % vol. alc.

Between 16.00 and 16.99% alcohol by volume, no white or rosé wines were produced. In 2022, no ‘Cabernet Sauvignon’ mono-cepage wines were produced at this alcoholic strength. In 2018 and 2021 almost similar quantities of red wines were produced, around 80 thousand litres, much higher than in 2019 and 2020, when the figures were in the 10-15 thousand litres range (Figure 11).

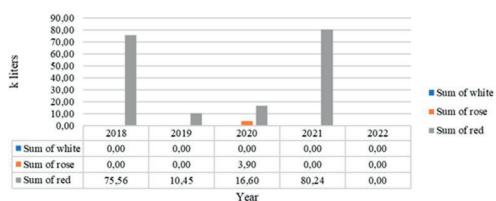


Figure 11. Wines of Cabernet Sauvignon (k liters), with alcohol content between 16.00-16.99% vol. alc.

In wine-growing Romania, ‘Cabernet Sauvignon’ accumulates between 10.39 and 16.55% alcohol by volume. Rose wines produced from this variety are constantly in the 3,000-thousand-liter range from one year to the next. Red wines, at around 9,000 thousand liters in four of the years studied, and decrease significantly in 2022.

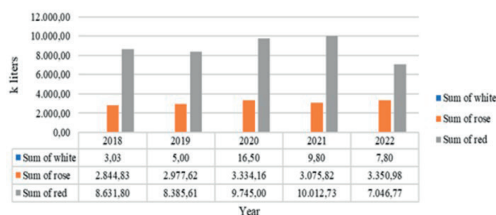


Figure 12. Wines of Cabernet Sauvignon (k liters), with alcohol content between 10.39-16.99% vol. alc.

It is evident that the share of wines of the variety studied is in the dry wine area, with an accent in red wines. However, from a quantitative point of view, rose wines are consistently in the middle of red wines, in the semi-dry range they are even, and in the semi-sweet range, they are almost balanced (Figure 13).

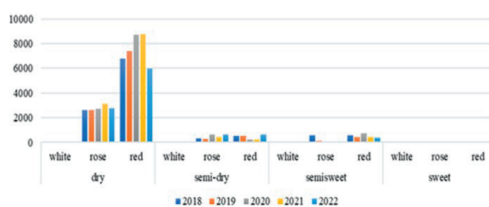


Figure 13. Classification by the colour and sugar content in Cabernet Sauvignon Romanian wines, between 2018-2022 (k liters)

This 2022 is the year in which most coupage and blending with ‘Cabernet Sauvignon’ took place, at the expense of mono-cepage wine (Figure 12).

The highest values of the UV Index were recorded in 2020 and 2022 in the Southern, South-Eastern and Sub-Carpathian Hills Viticultural Regions, with values between 15 and 20. In the South-West, North and Transylvanian Plateau the values remained relatively constant over the period studied, with a minimum of 11 (Lechinta) and a maximum of 16 (Alba Iulia). It is possible that the rapid and enhanced grape pigmentation due to flavonols observed in 2020 and 2022 in vineyards around Craiova or in Dobrogea is a consequence of systematic exposure to extreme ultraviolet radiation on many consecutive days during the veraison period of this wine grape variety (Figure 14).

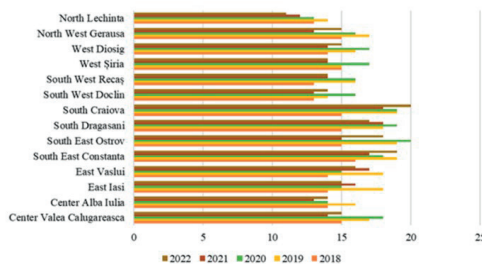


Figure 14. UV Index from different meteorological stations, during growing season, between 2018-2022

The most arid regions proved to be the South, South-East and East and in particular the Centre around the Valea Călugărească vineyard.

The precipitation regime during growing season, in 2020 was directly proportional to the hours of sunshine in the areas of the Danube Terraces and Oltenia Sands (Figure 15).

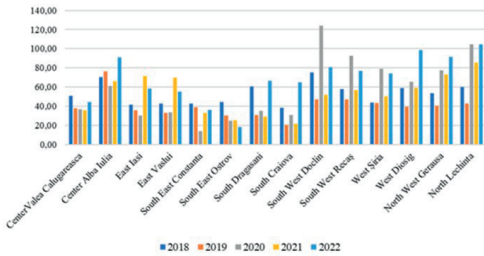


Figure 15. Precipitations from different meteorological stations, during July-September, between 2018-2022

Average minimum temperatures in 2018, during dormant period, were recorded in the North and East (-5°C), and the highest minimum temperatures were recorded in the West and Southeast (1°C) (Figure 16).

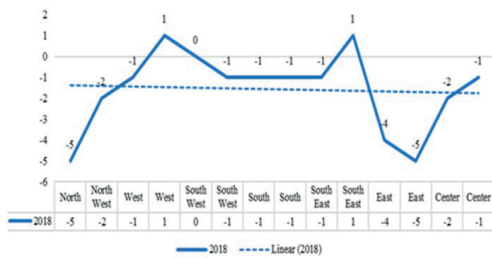


Figure 16. Average minimum temperatures (°C) during dormant period, in 2018

In 2019, the North and East again had the lowest average minimum temperatures, and the warmest cold season was record in the South. Most of the vineyard where ‘Cabernet Sauvignon’ plantings are located had average lows around (-3°C) (Figure 17).

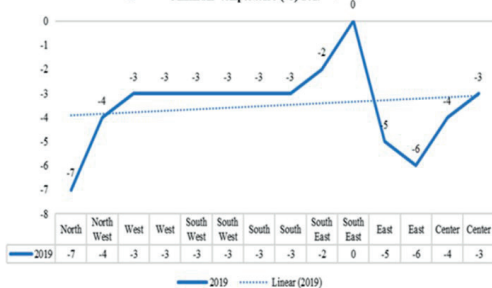


Figure 17. Average minimum temperatures (°C) during dormant period, in 2019

The year 2020 was more contrast, with negative peaks in areas where they were not expected: South-West, Centre (Figure 18).

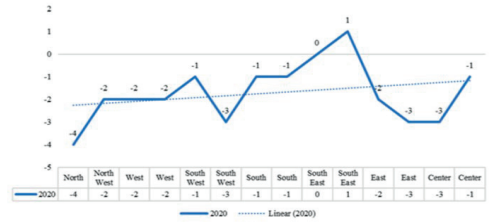


Figure 18. Average minimum temperatures (°C) during dormant period, in 2020

The Southeast becomes the warmest area in the cold season in 2021, with average lows of 2°C, during which time extremes in the North and East are 1°C warmer than in previous years (Figure 19).

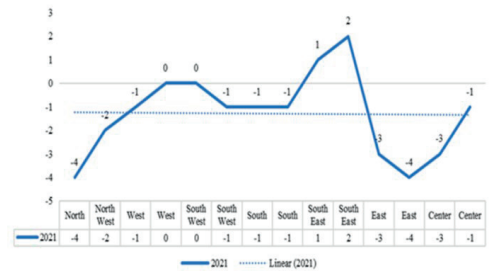


Figure 19. Average minimum temperatures (°C) during dormant period, in 2021

Diametrically opposite to 2018, the year 2022 shows a linear trend of increasing average minimum temperatures from North to South and from East Region to Centre, the lowest being (-7°C) and the highest 1°C. In 3 out of 5 years the trend is for increasing average minimum temperatures, with 2020 and 2022 even having steep increases from North to South (Figure 20).

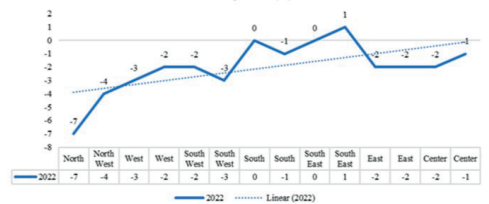


Figure 20. Average minimum temperatures (°C) during dormant period, in 2022

The average maximum temperatures for 2018 fluctuated from 27°C in the North to 31°C in the Southeast. Most values were around 29°C (in 4 viticultural centres), with the same frequency as values of 30°C, also in 4 viticultural centres (Figure 21).

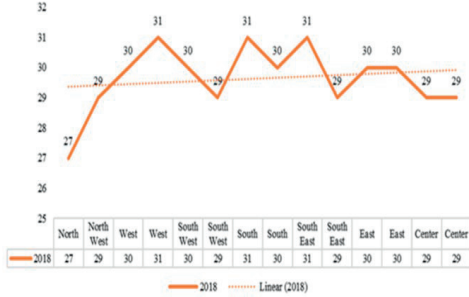


Figure 21. Average maximum temperatures (°C) during growing period, in 2018

In 2019, the average maximum temperatures during growing period (June - September) had the same linear trend as the minimum, with the greatest amplitude in the East, where the average minimum was (-6°C) and the average maximum 30°C (Figure 22). Several values of 31°C and even 32°C are already observed, which justifies us to consider 2019 as a year with a warm ripening season for ‘Cabernet Sauvignon’ grapes for West and South (Figure 22).

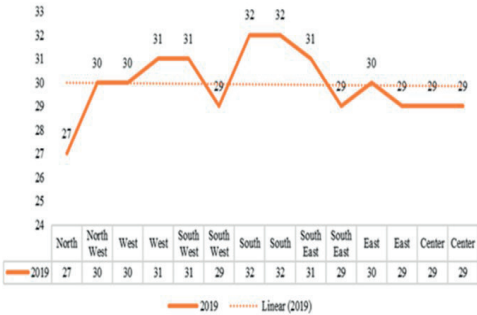


Figure 22. Average maximum temperatures (°C) during growing period, in 2019

The year 2020 was homogeneous, with 29°C in most wine-growing centres. The East was on trend, but the South-West matched the North at an average high of 26°C (Figure 23).

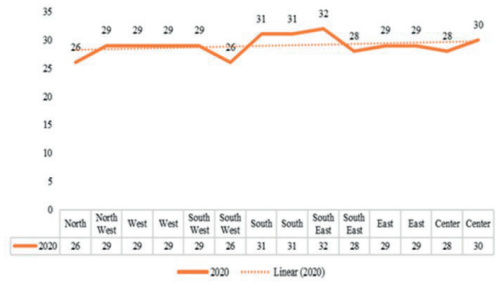


Figure 23. Average maximum temperatures (°C) during growing period, in 2020

In 2021, in all the wine-growing regions of Romania, average maximum temperatures were around 31°C, as it is shown in Figure 24. No extremes, no average temperatures below 26°C. The year 2022 was by far the warmest year. A year of extremes, 2022 had average maximum temperatures of 31-33°C in almost all wine-growing regions. The precipitation-rich areas of the North with 28°C, the South-West and the Transylvanian Plateau with 30°C lowered the total annual average by an insignificant amount (Figure 25).

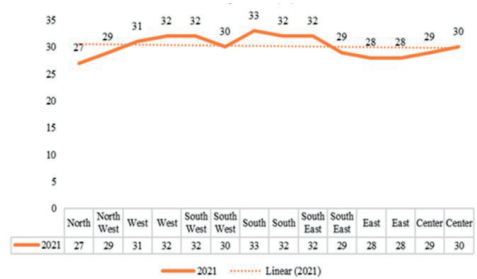


Figure 24. Average maximum temperatures (°C) during growing period, in 2021

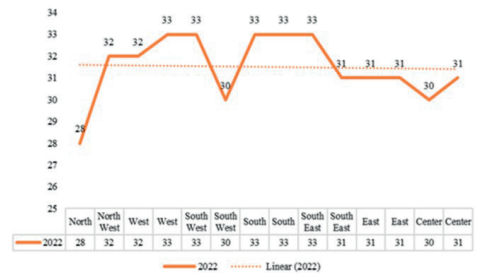


Figure 25. Average maximum temperatures (°C) during growing period, in 2022

All these climatic influences contribute to the main final product of the wine grapes, imprinting, in addition to its genetic inheritance, a large part of the soil characteristics, the benefits of modern technologies and the oenologist's skill. The trend of 'Cabernet Sauvignon' in Romania has been quite positive in recent years, reflecting both increased production and growing recognition on the international stage. Romanian winemakers have expanded the cultivation of 'Cabernet Sauvignon', especially in regions like Dealu Mare, Drăgășani, and Recaș. These areas benefit from favorable climatic conditions and diverse soil types, which contribute to the unique profiles of the wines produced there. Overall, the trend for 'Cabernet Sauvignon' in Romania is one of growth and increasing prestige, supported by a combination of quality production, favorable climatic conditions, and successful international marketing. This has led to a broader appreciation and higher demand for Romanian 'Cabernet Sauvignon' both locally and internationally.

CONCLUSIONS

'Cabernet Sauvignon' is grown in all wine-growing regions of Romania. In recent decades, the market demand for this wine has led to the selection of areas where typically, premium wines are obtained. Most producers have found deficiencies in the unbalanced accumulation of sugars compared to phenolic compounds and acidity, so more and more 'Cabernet Sauvignon' rose wine is being produced, and overripe grapes, with very high sugar content, are used in mixtures with other varieties, or the resulting wines enter blends. Single-vineyard 'Cabernet Sauvignon' wines are increasingly rare, dry, medium alcohol, high in anthocyanins and full-bodied. Experiments with 'Cabernet Sauvignon' "blanc de noir" wines are expanding in response of consumer demand, who increasingly appreciate thin, fine, low-alcohol, mostly white wines. Further planting of this variety in Romania must take into

account all the parameters necessary to obtain typical wines that correctly express its genetic potential and the imprint of the area.

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