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RESEARCH CONCERNING THE REACTION OF VINES TO VARIABLE CLIMATIC CONDITIONS

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Abstract

Among the effects of climate change are the increase in the average annual temperature, the increase in the frequency of extreme meteorological phenomena, the reduction of the amount or the uneven distribution of precipitation during the period of vegetation, periods of drought betwixt the climatic factors, the water regime associated with the ambient temperature are determining environmental factors that affect all aspects of plant growth and development and have the most significant impact on the quality and the quantity of the production obtained. The grapevine has developed response mechanisms to cope with water stress and high temperature. These mechanisms include adaptations of a morphological, anatomical, physiological, biochemical nature that allow the vine to overcome periods of environmental stress but affect the quantity and quality of production. This paper presents the results of the studies on the response of the vines to the variable climatic conditions in the wine-growing area for the production of D.O.C. wines Banu Mărăcine.

***Key words**: climatic conditions, vines, response mechanisms.*

INTRODUCTION

Vitis vinifera (L) is a species sensitive to climate change (Battaglini et al., 2009; Van Leeuwen et al., 2019). The climate traces the dominant characteristics of the wine-growing area, imposes the assortment of varieties and the direction of production (Dobrei et al., 2018; Dejeu et al., 2008; Marăcineanu et al., 2021) Schultz at al., 2010). Ecoclimatic conditions determines the growth and fruiting and gives uniqueness to the grapes obtained in a certain area (Bora et al., 2014; Costea et al., 2015; Gladstones, 1992; Rotaru et al., 2010; Webb et al., 2013). In order to perform durable viticulture, studies were made trying to identify the reaction mechanisms of grapevine under conditions of climate change (Battaglini et al., 2009; Boutin et al., 2012; Prieto et al., 2020). Numerous researches have highlighted the effect of temperature on the intensity of physiological processes, metabolism and on berry composition (Bonada & Sadras 2015; Bucur & Dejeu, 2017; Căpruciu et al., 2022; Costea et al., 2010, Sweetman et al., 2014; Yamane et al., 2006). Among the physiological processes, photosynthesis is considered to be the first process affected by temperature variations. For vines the optimum temperature for photosynthesis is between 25 and 35 °C (Burzo et al., 2005; Xenofon et al., 2020). Higher or lower temperatures have the effect of reducing the intensity of photosynthesis. The grapevine has an internal adaptation mechanism to combat heat stress. Studies on the effects of high temperatures on gas exchange demonstrated that temperatures above 40°C caused a sustained reduction in photosynthesis, which was attributed 95% to a reduction in stomatal conductance (Cichi D.D., 2006; Greer & Weedon, 2012). The reduction of stomatal conductance is one of the first reactions to thermal stress. Most of all, heat stress is often accompanied by seasonal drought stress. Stomatal closure, which also reduces transpiration, is a first defense mechanism against potential desiccation (Burzo et al., 2005; Greer & Weedon, 2012). However, transpiration is irreplaceable. Even a low transpiration rate can cause the leaf temperature to drop by a few degrees, which in some cases is the difference between growth and wilting (Anconelli & Battilani, 2000; Greer, 2020). Weather conditions throughout the year have a greater influence than other factors (such as soil and cultivars) on grapevine development and berry composition (Drappier et al., 2019). Berries produced under water deficit conditions were smaller and characterized by a higher skin-to-flesh ratio (Triolo et al., 2019; Ubalde et al., 2010). The variability of climatic conditions generates potential risks to which winegrowers must respond by adapting the technology of grapevine culture (Neethling et al., 2017). Due to the perennial nature of grapevine culture, adaptation strategies must take into account both the long-term impact short as well as the long term of climate change, based on the specificity of the crop area (Duchene et al., 2010; Leeuwen & Darriet, 2016; Quénol, 2014). The choice of plant material, of the varieties best adapted to the specifics of the culture area, is a valuable way to implement these strategies.

MATERIALS AND METHODS

The observations and determinations were carried out in the wine-growing center Banu Mărăcine, a wine-growing center located in the demarcated area for the production of wines with the Controlled Designation of Origin (DOC) "Banu Mărăcine", in a 7 year old vineyard, in the Fetească neagră variety grafted on Teleki 4 the selection Oppenheim 4 rootstock (SO4), with 2 x 1.2 m planting distance, semi-high growth, Single cordon training system, 12 bud/m^2, without irrigation.

In accordance with the research topic proposed, the observations and determinations focused on: monitoring climatic factors for the evaluation of the favourableness of the study year (2021) and studying the influence of the climatic conditions characteristic to the study years on the physiological and bioproductive parameters. For the evaluation of the climatic conditions, the meteorological data from the weather station located in the Banu Maracine wine center as well as the data provided by WorldWeatherOnline were used.

The effect of the varied climatic resources was evaluated through the analysis of the physiological indicators, and bioproductive parameters: evolution of weight, volume, acidity and sugar content of berries during ripening.

The determination of the physiological indicators (the intensity of transpiration and photosynthesis, stomatal conductance) was made with Lci-pro equipment during the vegetation period, in the second decade of each month.

In order to highlight the effect of the hot temperatures on stomatal conductance and transpiration the determinations were made in two days with different thermal profile (day with normal temperature and day with hot temperature, > 40^0C)

RESULTS AND DISCUSSIONS

For a better appreciation of the value of the main climatic determinants from the experiment period, they are presented together with the multiannual average values for the period 2010-2022 (Figures 1-6)

Comparing the average monthly temperatures recorded during the experiment period (Figure 1) with the multi-year average (Figure2), higher values of the temperatures are found, especially in the period from June to September, months in which the average temperature values for the year 2021 were about 2 degrees Celsius higher, values which determined changes in the manifestation of the studied physiological processes.

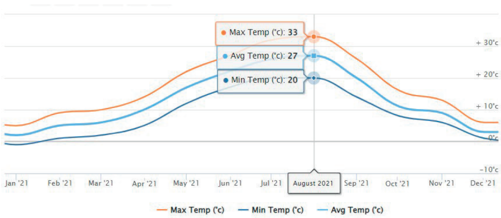

Figure 1. Monthly maximum, average and minimum temperatures during the experimentation period

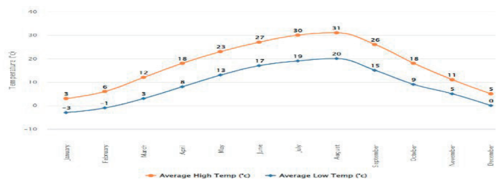

Figure 2. Average temperature (2010-2022)

The recorded values of insolation indicate the favourability of the crop year for vines, with higher insolation values being registered between July and September, a fact that influenced the determined physiological and bioproductive indices (Figure 3).

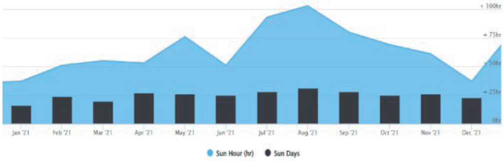

Figure 3. Sun hours and Sun days during the experiment period

Regarding insolation, no significant differences were recorded during the experiment period compared to the multiannual average.

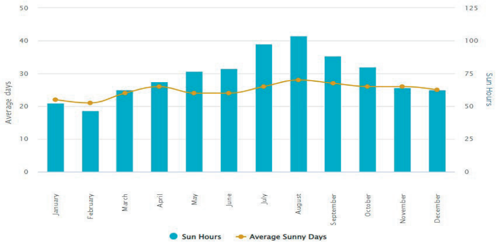

Figure 4. Average Sun hours and Sunny days (2010-2022)

Studying the data on precipitation during the experimentation period (Figure 5) a larger amount is found in the first part of the vegetation, period April-June, and the lack of useful precipitation (over 10 mm) during the ripening period (August-September).

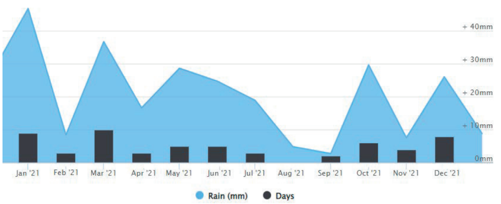

Figure 5. Rainfall amount and rainy days during the experimentation period

Lower precipitation values for the year 2021 are also found compared to the multi-year average (2010-2022) for the entire duration of the vegetation period - Figure 6.

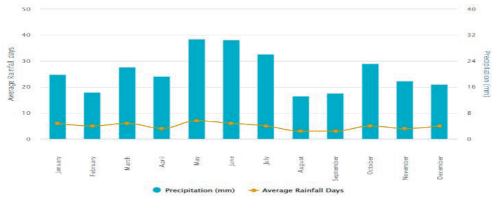

Figure 6. Average rainfall monthly amount and rainy days (2010-2021)

The determinations of the physiological indicators carried out dynamically, during the vegetation period, show the increase in the intensity of the physiological processes (photosynthesis and transpiration) until July when they reach values of 7.5 µ mol/m^2/s respectively 3.9 mol/m^2/s - Figure 7. Starting with August as a result of the specific climatic conditions of the year (lack of precipitation and temperatures above the multiannual average, the intensity of transpiration is reduced more compared to the intensity of photosynthesis.

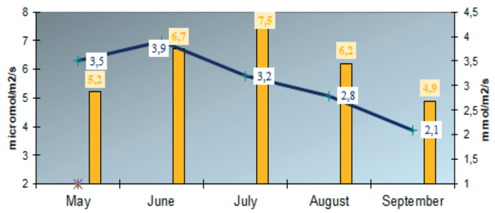

Figure 7. The the intensity of photosynthesis and transpiration in monthly dynamics throughout the vegetation period

Starting with August as a result of the specific climatic conditions of the year (lack of precipitation and temperatures above the multiannual average, the intensity of transpiration is reduced more compared to the photosynthesis rate which remains at around 6.2 respectively 4.9 µ mol/m^2/s - Figure 7.

The determinations made during a day with a climate profile specific to the heat wave, with temperatures over 40^{0}C, showed the correlation that existed between the intensity of transpiration and the stomatal conductance. On 29.07.2021, when the determinations made revealed temperatures at the leaf level of almost 44^{0}C, it was possible to determine, at the same time, the variation in the values of transpiration and stomatal conductance (Figure 8).

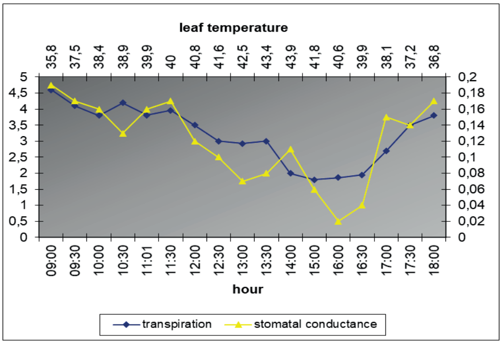

Figure 8. Transpiration intensity and stomatal conductance in day with on a day with hot temperatures

From the determinations made, we notice that the stomatal conductance has a more pronounced decrease in values compared to transpiration. At the same time, it can be observed that the 2 indices do not always keep the same trend, there are moments when the stomatal conductance values have more intense increases (Figure 8). The closing of the stomata is an adaptation mechanism that prevents dehydration, reducing sweating. They do not close completely during the entire duration of high temperatures, there are moments of higher intensity of gas exchange that alternate with moments of lower intensity. This fact also allows transpiration with less intensity but can contribute to regulating the temperature of plants affected by hot temperatures.

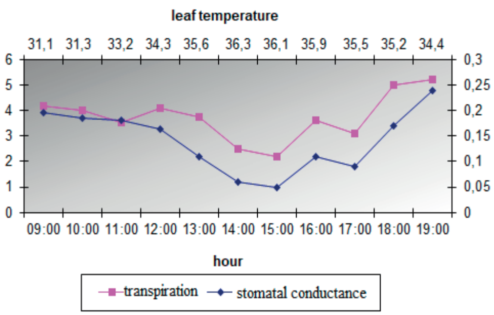

Figure 9. Transpiration intensity and stomatal conductance in day with normal thermal profile

The determinations made on a day with normal thermal profile (22.07.2021) highlights stomatal conductance transpiration and transpiration and transpiration and transpiration values on a day with a normal thermal profile in which the values of the two physiological indices are not affected by excessive temperatures (Figure 9). At temperatures that do not reach restrictive values, the stomata allow gas exchange and transpiration with normal intensities depending on the other environmental factors.

As a result of interaction with the variable climatic conditions, the vine plants react by regulating the physiological and biochemical processes that result in quantitative and qualitative changes at the level of the whole plant and especially of the grape.

The analysis of the determinations made on the Fetească neagra variety regarding the bioproductive indicators that are the subject of this study, highlights the dependence of reaching the moment of maturity on the environmental conditions, which determine a different rate of growth of the berries, of the accumulation of substances that determine the quantity and quality of production. Figure 10 shows the dynamic evolution of berry weight and volume during ripening (from the beginning of berry colouring to harvest).

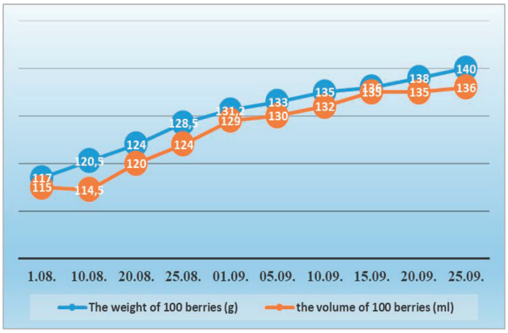

Figure 10. The dynamic evolution of the weight and volume of the berries during ripening

Analysing figures 10 and 11, we can see that the very small amounts of precipitation from July to September had a greater influence on the quantitative characteristics of the grapes, with the grapes having smaller dimensions and volume than normal (Figure 10). As for the quality indices, they were not negatively influenced (Figure 11). This fact could be explained by the existence of a quantity of accessible water in the soil, due to the precipitation from the first phases of vegetation. It can be noted that in 2021, about 80% of the total precipitation was recorded in the first phenological stages.

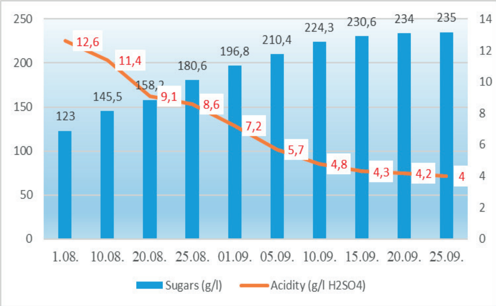

Figure 11. Evolution of sugar content and acidity of berries during maturation

Argument in this regard is the carbohydrate content recorded on September 25 - 235 g/l, under the conditions of an acidity of 4 g/l H_2SO_4 - Figure 11.

The Fetească neagră variety taken in the study demonstrated a high accumulation potential, the sugar parameter increasing by 113 g/l in the period 1.08.-25.09. under the conditions of a final acidity of 4 g/l.

In the climate context of year 2021, insolation (including the heat component) had the highest rate of participation in the development of physiological reactions generating a high level of quality, a result also influenced by the reduced amount of precipitation in the second part of the vegetation period.

CONCLUSIONS

The climate has a determining role on the growth and development of the vine. Among the most common effects of the variation of climatic conditions on the vine are those related to the change of phenology and the duration of the vegetation period, influencing the intensity of physiological processes and metabolism, and finally determining quality and quantity of production. Knowing and modelling the action of these changes can be a key tool for planning viticultural management practices under conditions of a climate characterised by a high level of variability.

The diversity of climatic conditions during the research period was reflected in the variations of the studied physiological and bioproductive indicators.

The Fetească neagră variety has interacted with environmental conditions, expressing its adaptive potential in a specific way.

In the conditions of the year 2021, as a result of the precipitation that fell at the beginning of the vegetation period, the studied variety faced the dry temperature wave, without major impact.

Under the conditions of temperatures over 40^0C, the stomatal conductance was significantly reduced, but the stomata continued to open, allowing transpiration to occur with a lower intensity. This fact contributed to maintaining the temperature of the plants during the respective period.

In conclusion, the 2021 vintage did not meet the conditions for a high level of production, but it can be considered a high-quality production year.

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