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THE QUANTITATIVELY AND QUALITATIVELY POTENTIAL OF THE WINE GRAPE HARVEST IN RELATION WITH THE CLIMATE CHANGE

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Abstract

The style of wine produced in a region is a result of the baseline climate, while the climatic variability determines differences in the quality of the vintage. The production and quality of wines is likely to be affected by changes in meteorological and climatic conditions. Potential quantitatively evaluated on the basis of potential yield and qualitative potential has been defined by the weight and volume of grain, sugar, acidity, gluco-acidimetric index. In the present paper, we have investigated the relationships between climatic variability and the quantitatively and qualitatively potential of the grape production and wine quality in the Dealu Mare Valea Calugareasca. Regarding the yield potential of the grape production was found that the rate of increase was 0.28-0.74 kg/vine and the growth rate of gluco-acidimetric index was 0.5-1.0. Analysis of average air temperature ranges reveals changes in all seasons: significant warming of about 1.2°C during summer and 0.8°C in spring, and a slight cooling trend of 0.4°C was noted in autumn.

***Key words**: climatic conditions, qualitative potential, sugar, acidity.*

INTRODUCTION

Climate change involves reducing greenhouse gas emissions and adapting ecological systems to the effects of climate variability. The Intergovernmental Panel on Climate Change V (IPCC-Climate Change 2013/AR-5, WG I-Physical Science Basis, SPM) published in 2013, mentions that global average air temperature has increased by about 0.85ºC in the last 100 years (1850-2012), the period 2001-2013 being one of the warmest of the data series since 1850.

Also, the number of hot days increased frequency of heat waves recorded a growth trend evident in most of Europe.

Annual rainfall amounts showed a variable distribution in time and space (increase/decrease) and dry periods followed by heavy rainfall brief generating floods and floods is growing fast.

The wine climate has an essential role in grape ripening. Over the last 20 years has experienced significant changes due to climate change.

The average global temperature could increase by up to 4.5°C, but the best estimate is 2.5°C, if the amount of CO_2 in the atmosphere doubled (Houghton et al., 1992). Global warming is 0.6°C in the past three decades and 0.8°C in the last century.

The reality of climate change is admitted by the vast majority of the scientific community (IPCC, 2014). The viticulture is highly dependent upon climatic conditions during the growing season. The climatic conditions vary from one year to the other. These variations induce the "vintage effect", year-to-year variations in yield, quality, and typicity (Cornelis van Leeuwen & Darriet, 2016). Sugar accumulation increases with temperature (Coombe, 1987), but certain secondary metabolites, like anthocyanins, are negatively affected by high temperature (Kliewer and Torres, 1972). Grape acidity, in particular the malic acid content, decreases in high temperature (Coombe, 1987).

MATERIALS AND METHODS

Climate data used in this analysis are for the Research Institute for Viticulture and Enology Valea Calugareasca station for 1936 to 2018. The data consist of daily observations of the monthly average temperature, maximum temperature, minimum temperature and rainfall.

The simulation of computer climate scenarios allows the prognosis of future climate trends. Computer simulations of the climate system can be accomplished using general circulation patterns that show the global climate response to changes in the composition of the atmosphere.

Climate changes occurred gradually until now it seems that it will be produced all graduated modifications in the future. So, there were used programs RCP 4.5 and RCP 8.5, in order to predict global warming by the year 2100, with a view of adaptation and to counter their impact.

RESULTS AND DISCUSSIONS

The analysis of the thermal values for the period 1936-2018 indicates that the average annual air temperature increased over the last 38 years by 1.0°C (1981-2018/11.8°C) over the whole analyzed period (1936-1980/10.8°C), which exceeds the average global warming of 0.85°C in the last 100 years (1850-2012), according to AR 5 (IPCC, 2013). In the last 38 years, in our country the warmest year was 2007 (13.7°C), and the coldest 1942 (9.0°C) (Figure 1).

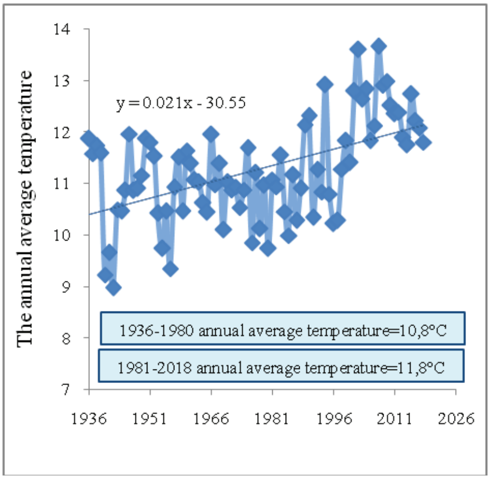

Figure 1. The trend of the average annual air temperature during the period 1936-2018

Jones and Alves (2012) mentioned that a region with a mean temperature during the vegetation season of 15.0°C, which is heated by 1°C, will be able to experiment with several varieties suitable for a faster rippening.

In the coldest month of the year, respectively January, the monthly average temperature increased over the last 38 years (1981-2018) by 1.9°C, compared to the period 1936-1980, and the warmest July, by 1.3°C (Figures 2 and 3).

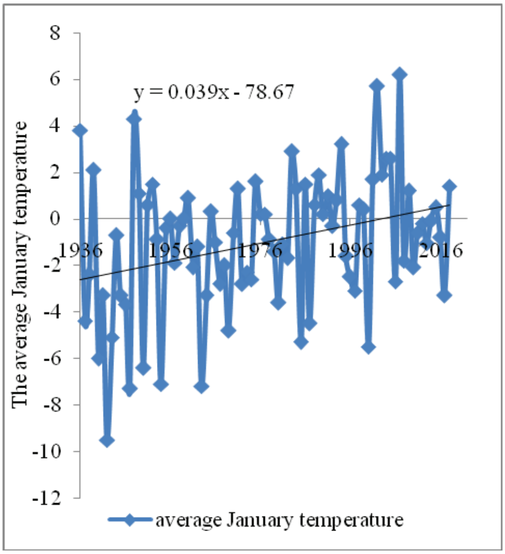

Figure 2. The trend of the average annual air temperature in January between 1936 and 2018

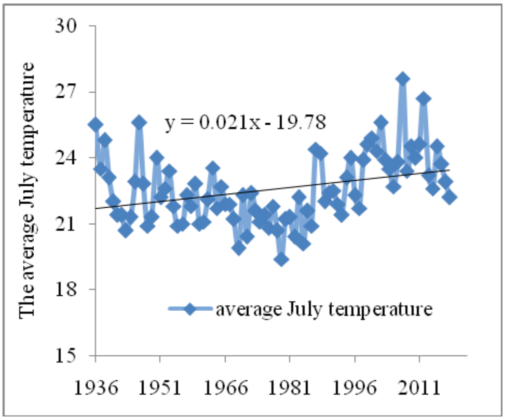

Figure 3. The trend of the average annual air temperature in July between 1936 and 2018

Table 1 shows in ascending order the warmest years recorded during the period 1936-2018 in Valea Calugareasca, 18 of them being reported during the period 2000-2018, when the positive thermal deviations were 2.7°C to 0.1°C compared to the climatic multi-annual average of the analyzed period of 11.3°C.

Table 1. The warmest years between 1936 and 2018

Year	The average annual temperature (°C)	Deviation (°C)
1961, 1968, **2000**	11.4	0.1
1952, 1958, 1983	11.5	0.2
1937, 1939, 1960	11.6	0.3
1938, 1975, **2014**	11.7	0.4
1951, 1999, **2005**, **2018**	11.8	0.5
1936, 1950, **2013**	11.9	0.6
1946, 1966	12.0	0.7
1989, **2006**, **2017**	12.1	0.8
2016	12.2	0.9
1990	12.3	1.0
2011, **2012**	12.4	1.1
2010	12.5	1.2
2003	12.6	1.3
2015	12.7	1.4
2001, **2004**	12.8	1.5
1994, **2008**	12.9	1.6
2009	13.0	1.7
2002	13.6	2.3
2007	13.7	2.4

The 2007 year marks the warmest year with a positive thermal deviation of 2.4°C compared to 1936-2018 and the second place with 5 years ago from 2001-2009 (2001, 2002, 2004, 2008 and 2009) with an annual average of 1.4°C above the average of 11.3°C.

Rainfall is the main source of water for the growth and development of vineyards, and the most significant elements of this meteorological parameter are the quantitative variability, the distribution and the spatio-temporal distribution.

The analysis of rainfall data reveals the fact that, from a pluviometric point of view, there was a trend of decreasing annual rainfall in the period 1981-2018 compared to the period 1936-1980.

The average multiannual rainfall (January-December) calculated for the period 1936-1980 is 624 l/mp. Between 1981 and 2018, annual rainfall decreased by 10 mm. The driest year is 1945 (294.6 l/mp), and the most rainy year 2005 (1079.2 l/mp) (Figure 4).

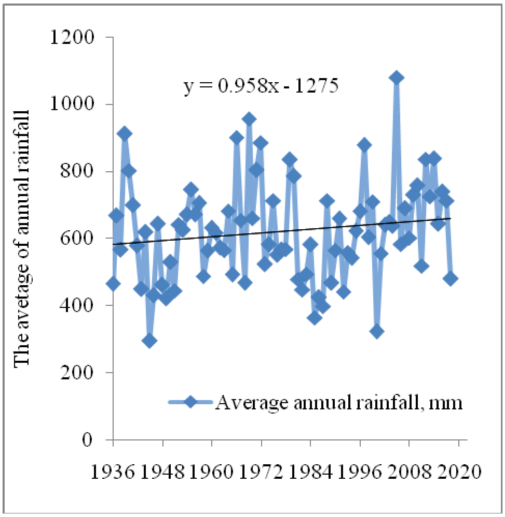

Figure 4. The trend of the average annual rainfall between 1936 and 2018

For vineyards, the quantities of rainfall that fall during the vegetation period and their distribution by phenological phases are particularly important.

During the vegetation period, rainfall may also present quantitative fluctuations and distribution (Figure 5).

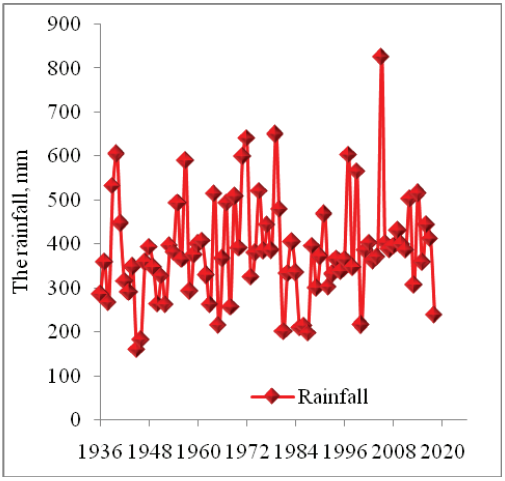

Figure 5. The trend of the rainfall during vegetative period between 1936 and 2018

The growing season (Apr.-Sept.) average rainfall was 48.5 mm in April, 63.2 mm (May), 79.9 mm (June), 76.3 mm (July), 61.6 mm (August) and 50 mm (September) in the period 1981-2018, comparative with 46.4 mm in April, 76.0 mm (May), 94.6 mm (June), 75.2 mm (July), 56.9 mm (August) and 41.3 mm (September) in the period 1936-1980.

The potential of grape harvest is a result of the interaction of natural, biological and agronomic factors and its level is the criterion for determining the destination for capitalizing the production of grape for wine.

Cabernet Sauvignon variety recorded an increase in the production of grapes from 2.30 kg/vine in the period 1936-1980 to 3.05 kg/vine in the period 1981-2018 (Figure 6).

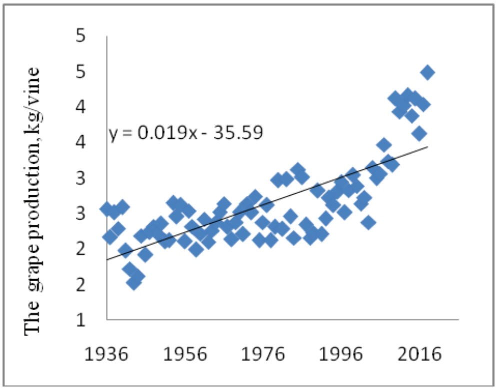

Figure 6. The trend of the grape production between 1936 and 2018

Potential quantitatively evaluated on the basis of potential yield has been defined by the sugar and acidity.

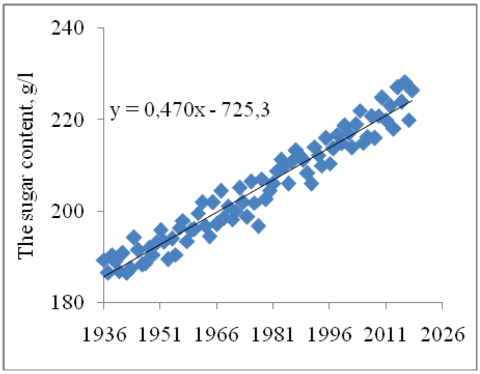

Figure 7. The sugar content of the grape between 1936 and 2018

Increasing the average air temperature by 1.3°C caused an increase in sugar accumulation by 20 g/l (196 g/l between 1936 and 1980; 216 g/l between 1981 and 2018), as well as a decrease in acidity by 0.92 g/l (5.54 g/l between 1936 and 1980; 4.62 g/l between 1981 and 2018) (Figures 7 and 8).

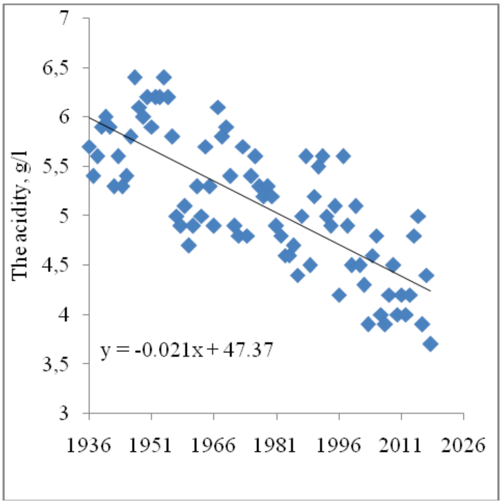

Figure 8. The acidity content between 1936 and 2018

Predictable Effects in Climate Change Scenarios

Climate change is a major challenge for viticulture in the coming decades.

In the recent past, wine quality has increased in most wine-growing regions because of higher temperatures and more frequent water deficits, while yields have decreased.

If the tendency continues, quality might be negatively affected in the near future.

Growers need to implement adaptive strategies to continue the production of high-quality wines at economically acceptable yields in a warmer and dryer climate.

The impact of projected global warming on the Valea Calugareasca wine industry was investigated using spatial modelling techniques. Expected shifts in annual average temperature between present day and the year 2050 will be in the order 0.2 to 1.5°C.

By 2100, the projected increase in annual average temperature in viticultural areas is 0.4 to 3.5°C (Figure 9).

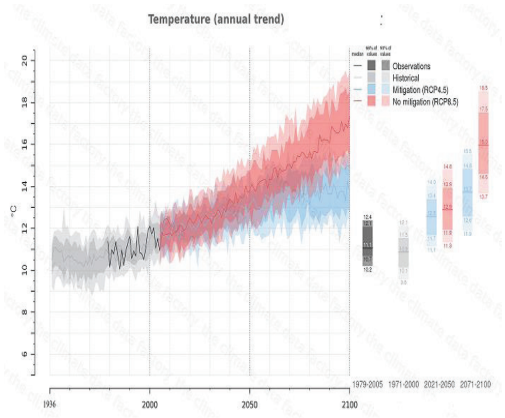

Figure 9. Results from one climate model projection showing average temperature

Regarding the maximum air temperature between present day and the year 2050 will be 1.2 to 1.5°C, and by the year 2100 it will be 2.5 to 3.0ºC (Figure 10).

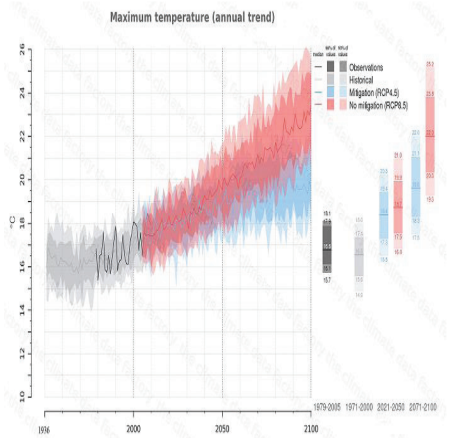

Figure 10. Results from one climate model projection showing maximum temperature

Higher temperatures will increase evapotranspiration. Modifications in rainfall patterns are difficult to predict. It is likely that rainfall will be subject to great regional and temporal variations. Of particular importance are the annual precipitations, the distribution of which will be very irregular, long periods of drought (Figure 11).

An increase in radiation can cause sunburn on grapes, particularly in the prevéraison phase. An increase in UV-B radiation might be favorable in red wine production because of increased skin phenolics but can impair white wine quality and induce atypical aging.

The solar radiation will increase by 30-60 w/m^2 until 2100 (Figure 12).

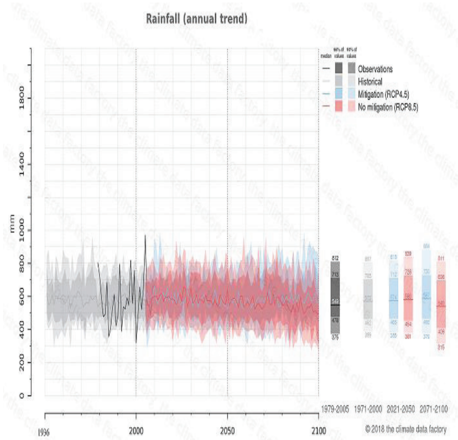

Figure 11. Results from one climate model projection showing average rainfall

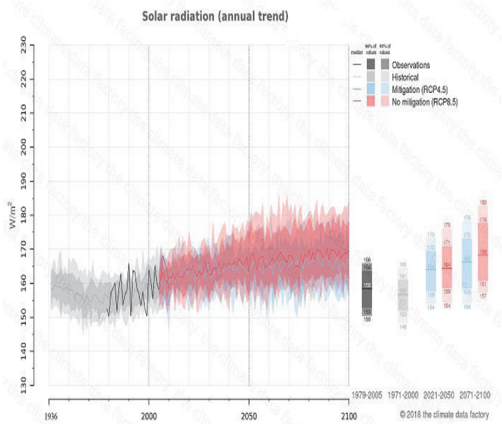

Figure 12. Results from one climate model projection showing solar radiation

CONCLUSIONS

Climate change is a major challenge for viticulture in the coming decades. In the recent past, wine quality has increased in most wine-growing regions because of higher temperatures and more frequent water deficitswhile yields have decreased. If the tendency continues, quality might be negatively affected in the near future.

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