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INFLUENCE OF CLIMATE VARIABILITY ON GROWTH, YIELD AND QUALITY OF GRAPES IN THE SOUTH PART OF ROMANIA

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Abstract

The aim of this paper was to evaluate the trends of changes in climatic parameters and the effect of climate variability on vegetative growth, yield and quality of grapes in Bucharest (44°47'N; 26°07'E). There were examined the trends of changes in temperature, precipitation and the annual minimum temperature from 1961 to 2013 and from 1998 to 2013 - the production and quality of grapes of 'Feteasca regala' variety. Between 1961-2013 the annual temperature was higher than average with 1.0^{0}C, in the growing season (April-October) the average temperature was higher with 1.1^{0}C and in the summer time with 1.9^{0}C. There were established correlations between some climatic parameters and pruning weight, yield, sugar accumulation, titratable acidity etc. The temperature increase was associated with higher must sugar content, especially in the summer (from June to August). Also, more frequency of the minimum harmful temperatures for grapevine (under -20°C) was observed during the last decade. Grape production was correlated with the precipitations from the period March-May, and those of summer negatively influenced sugar accumulation in grape berries. In the last 16 years (1998-2013) there was a significant increase in the values of Winkler Index; maximum yield of grapes was obtained at values of this index comprised between 1600 and 1800; when the value was higher, the yield and must acidity decreased significantly. Maximum grape yields were obtained at values of Huglin Index comprised between 2300 and 2500; at higher values, there were registered significant decreases of the yield and of the must acidity as well as increased accumulation of sugars in berries.

Key words: *climate change; growth; quality; viticulture; yield*

INTRODUCTION

The grapevine is one of the cultivated plants most affected by climate change. Global warming, that is so obvious in the last two decades, has led to a number of positive effects on the physiology of plants (Burzo and Dobrescu 2011) on the production of grapes and on its quality (Cotea et al., 2008; Dejeu et al., 2008; Bucur et al., 2012), but also some negative effects, due to water stress (Bock et al., 2011; Carbonneau, 2011), obtaining less balanced wines, given the lack of acidity, the accumulation of a high concentration of sugar (and a higher alcohol content), decreased aging potential of wines, premature oxidation of white wines, increased variability vintages, flavoring changes, affecting the typicity of wines.
Given the predictions in the field, on the intensification of this phenomenon in the future, several scenarios were developed to adapt the viticulture to climate changes.
In viticulture, there are widely used a number of indicators for climatic zoning works, for studying phenophases development, for assessing the favourability of a specific area for quality viticulture: Winkler Index (1944); Huglin Index (1978) etc. (Winkler et al., 1974; Huglin, 1978). In the latest years, these indices have been widely used to study the effects of climate change on yield and quality in viticulture and winemaking (Neethling et al., 2012).
The study aims to note the evolution in time for the period 1961-2013(53 years), of the main elements of climate and bioclimatic indicators, in the context of climate change and their impact on yield and quality of grapes.
This study allows a better understanding of the current climate and a foresight of the consequences of climate changes on viticulture.

MATERIALS AND METHODS

The data recorded at Bucharest-Baneasa station (44°43'N; 26°10'E) were used for the present study. The present analysis relies on the observation data recorded during 53 years (1961-2013).

The climatic data analysed represents the average temperature, the minimum temperature and the maximum temperature, as well as the precipitations.

The climatic data allow the analysis of climate evolution over a long period of time, as well as the characterization and quantification of global warming in the area of Bucharest.

The temperature data were also used to calculate two bioclimatic indices, including the Growing degree-days (or Winkler Index, WI), Huglin heliothermal Index (Huglin Index - HI), (Winkler et al., 1974; Huglin, 1978). Winkler Index was calculated according to the equation: $\sum[(T_{max}+T_{min})/2-10ºC]$, for the period April – October (Winkler et al., 1974).

Huglin Index is calculated using the formula: $\sum[(Tavg-10ºC)+(Tmax - 10ºC)]/2 \cdot k$, for the period April-September (k = day length coefficient, varying from 1,02 to 1,06 between 40° and 50° latitude).

In the experimental plantation of the Horticulture Faculty within University of Agronomic Sciences and Veterinary Medicine of Bucharest, it was conducted an experiment during 1998 - 2013. The plantation was established in 1994, with 'Feteasca regala' variety, clone 21 Bl, grafted on Kober 5 BB, planted at distances of 2.2/1.2 m (3787 vines/ha), with spur pruning cordon and loading of 10 eyes/sqm.

Based on the data regarding temperature, precipitations, Winkler Index, Huglin Index and values of pruning wood, grape yield, accumulation of sugars, titratable acidity of must at 'Feteasca regala' variety in a long-term experience (1998-2013) there were determined the following correlations between: precipitations in spring (III-VI) and the annual wood eliminated at pruning; average temperature in the growing season (IV-X) and yield; average temperature in summer (VI-VIII) and sugar and titratable acidity; precipitations in winter (XII-II) and yield; precipitations in spring (III-V) and yield; Winkler Index and yield; WI and titratable acidity; Huglin Index and yield; HI and sugar accumulation in berries; HI and titratable acidity.

RESULTS AND DISCUSSIONS

Climate variability. As a consequence of annual average temperatures evolution during 1961-2013, there was a significant trend of increasing it by about 1°C (Figure 1). The average temperature increase was more obvious in the last two decades.

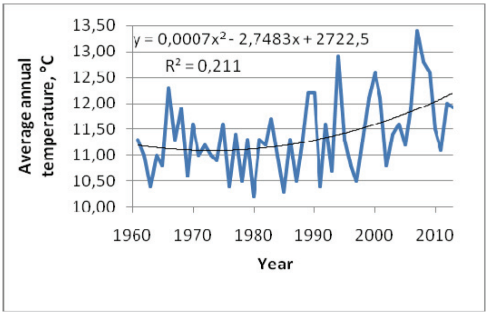

Figure 1. Evolution of the average annual temperature (°C) for the period 1961-2013

The evolution of average temperature during the growing season (IV-X) also highlights a significant increasing trend over the 53 years of observations (Figure 2). From 1961 to 2013, the average temperature in April-October increased by 1.1° C.

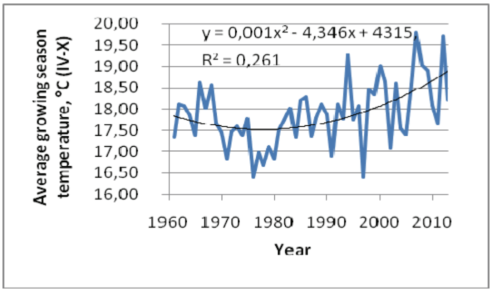

Figure 2. Evolution of the average temperature in the growing season (IV-X) for the period 1961-2013

The warming is even more accentuated during summer (VI-VIII), highlighted by a difference of 1.9ºC and the highest degree of significance (Figure 3).

The climate changes also act through an increased frequency of accentuated winter frosts. In our case we noticed an increased frequency during the last decade of minimum harmful temperatures for grapevine (< -20°C), but also by lower values (Figure 4).

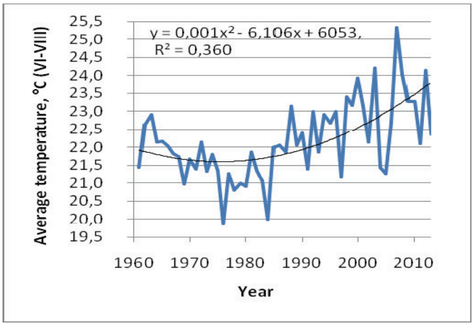

Figure 3. Evolution of the average temperature in summer, °C (VI-VIII, 1961-2013)

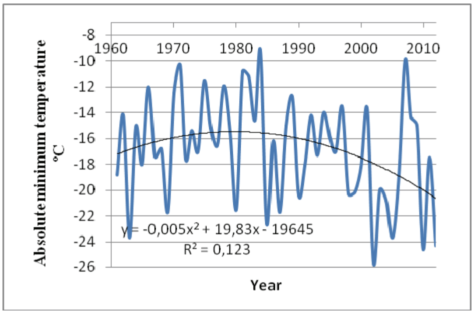

Figure 4. The absolute minimum temperature evolution, °C (1961-2013)

Regarding the evolution of the annual precipitation in the period 1961-2013 (Figure 5), of the precipitations during the growing season - IV-X (Figure 6) there are no significant changes, except for higher variations from one year to another.

The influence of climate changes on grapevine. Climate variability has influenced the growth, development of phenophases, grape production and quality.

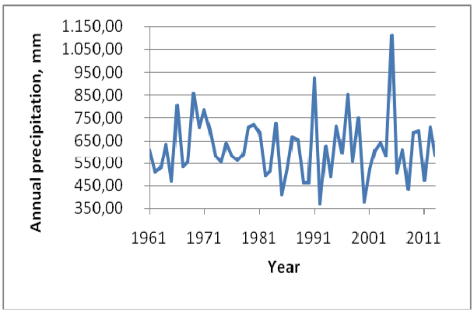

Figure 5. Evolution of the annual precipitations (mm) for the period 1961-2013

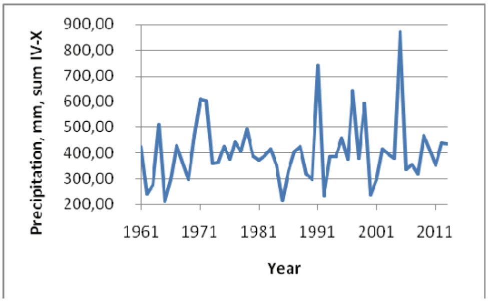

Figure 6. Evolution of the precipitations (mm) in the growing season (1961-2013)

Between the average temperature in the growing season (IV-X) and the grape yield, there was highlighted a significant parabolic correlation (Figure 7). The highest yields of grapes were obtained at average temperatures in the growing season between 17.5 - 19.0°C; above 19.0°C there has been a downward trend in the yield.

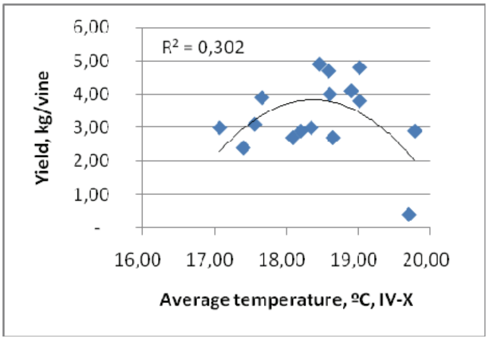

Figure 7. Correlation between average temperature in the growing season (IV-X) and the grape yield (kg/vine) (1998-2013)

The highest accumulation of sugar was obtained at an average temperature of more than 23°C in summer (Figure 8).

Extreme temperatures during maturation lead to an acceleration of the ripening process, at an increased sugar content, resulting in higher levels of alcohol or residual sugar content in wine, in conditions of a faster decomposition of acidity.

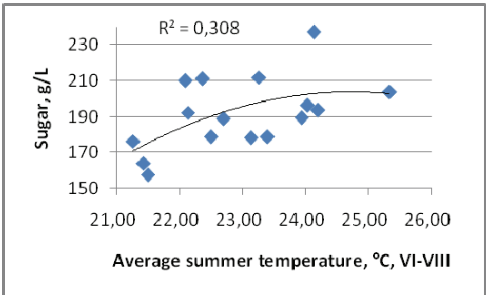

Figure 8. Correlation between average temperature in summer (VI-VIII) and sugar accumulation (1998-2013)

High temperatures in summer (VI-VIII) have a significant negative influence on acidity (Figure 9). At average temperatures of above 23.5°C in summer, titratable acidity falls below 4.0 g/L H_2SO_4, being necessary to correct the acidity of the must. Decreasing the acidity can have a negative impact on wine typicity and its capacity of aging.

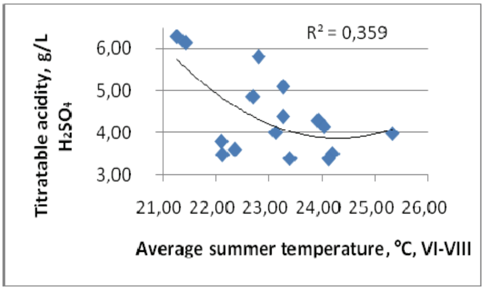

Figure 9. Correlation between average summer temperature (VI-VIII) and titratable acidity (1998-2013)

Between the amount of precipitations recorded in spring (III-V) and the pruning wood there was evidenced a significant correlation (Figure 10).

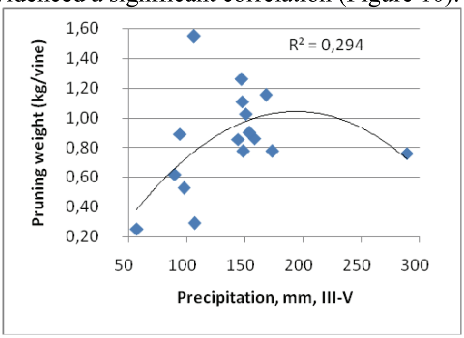

Figure 10. Correlation between the precipitations in spring (mm, III-V) and pruning weight (kg/vine) (1998-2013)

Between the precipitations in winter (XII-II) and the grape yield, there was highlighted a distinctly significant correlation (Figure 11). The highest yields of grapes were obtained at precipitations values situated, in winter, between 80 to 160 mm.

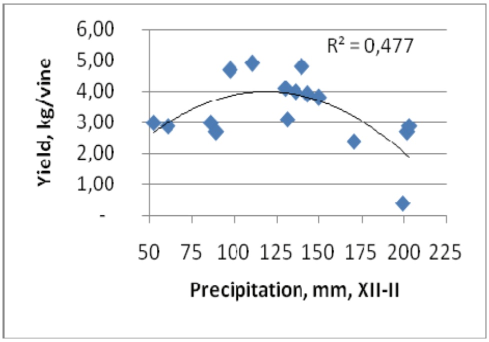

Figure 11. Correlation between the precipitations in winter (mm, XII-II) and yield of grapes (kg/vine) (1998-2013)

A distinctly significant parabolic correlation was also determined between the amount of precipitations in spring (III-V) and grape yield (Figure 12).

Winkler Index (WI) values increased significantly in the last 16 years (1998-2013), from values of 1700 to 1830 (Figure 13).

The highest yields of grapes were obtained at Winkler Index values between 1600 and 1800 (Figure 14).

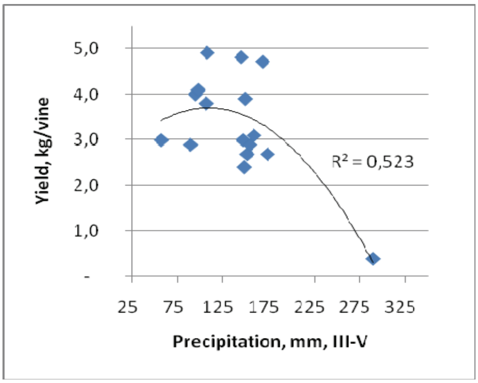

Figure 12. Correlation between the precipitations in spring (mm, III-V) and yield of grapes (kg/vine) (1998-2013)

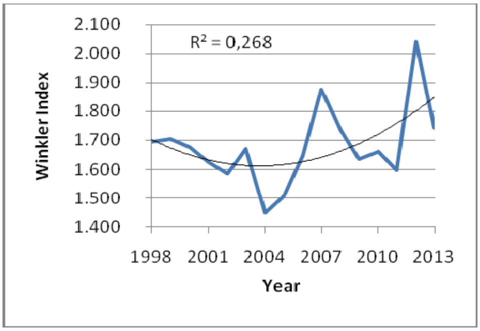

Figure 13. Evolution of the Winkler Index in the period 1998-2013

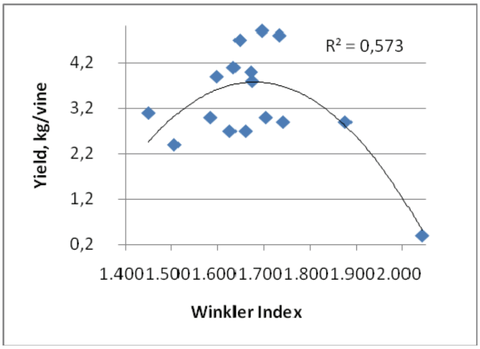

Figure 14. Correlation between the Winkler Index values and yield of grapes (1998-2013)

As Winkler Index values increase from 1400 to 2000, the titratable acidity of the must decreases significantly (Figure 15). At values of WI higher then 1800, titratable acidity of the must decreases significantly.

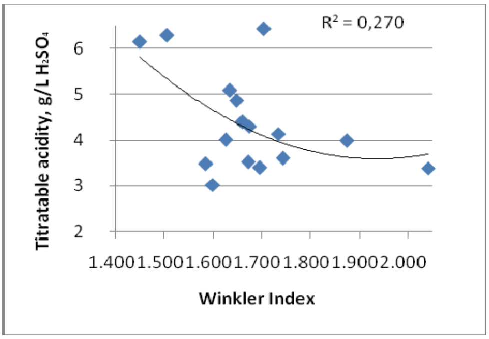

Figure 15. Correlation between the Winkler Index values and titratable acidity (1998-2013)

Between Huglin Index (HI) values and grape yield there has been established a distinctly significant correlation (Figure 16). At HI values of over 2600, specific to warm climate, grape production decreases significantly.

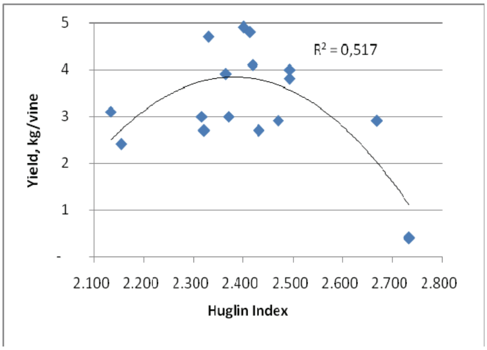

Figure 16. Correlation between the Huglin Index values and yield of grapes (1998-2013)

It was also found a significant increase in the accumulation of sugar in berries, while the index values increase (Figure 17).

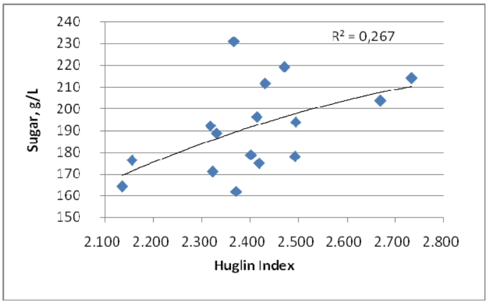

Figure 17. Correlation between the Huglin Index values and sugar content (1998-2013)

Between Huglin Index values and titratable acidity of the must there has been determined a distinctly significant negative correlation (Figure 18). At values of HI higher than 2600, titratable acidity of the must decreases below 4.0 g/L, requiring its correction.

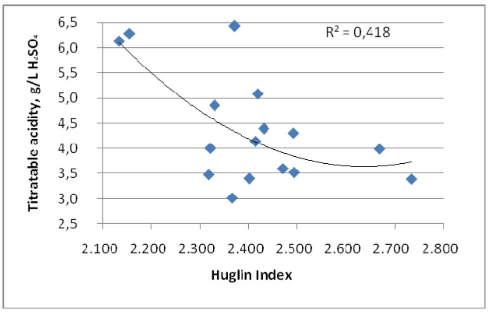

Figure 18. Correlation between the Huglin Index values and titratable acidity (1998-2013)

CONCLUSIONS

Between 1961-2013, it was registered an increase of the average annual temperature with 1.0°C, of the average temperature in the growing season (April-October) with 1.1°C and of the summer temperature with 1.9°C.

The temperature increase was associated with higher must sugar content, especially in summer (from June to August).

Also, a higher frequency was observed during the last decade of the minimum harmful temperatures for grapevine (under -20°C).

Winkler and Huglin indices have increased in recent years to values specific for warm climate.

The temperature rising during the ripening of the grapes results in an acceleration of the maturation, a quicker decomposition of the acids, an increase in sugar content, and it can also result in a loss of wine typicity.

Since it is expected that this trend of temperature rising continues in the future and that the ripening period of the grapes takes place in warmer conditions, there are necessary adjustments of the viticulture development strategies under the new conditions.

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