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RESEARCHES ON SITUATION AND TRENDS IN CLIMATE CHANGE IN SOUTH PART OF ROMANIA AND THEIR EFFECTS ON GRAPEVINE

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Abstract

In this study we analyzed data from three meteorological stations situated in Romania's south part (Bucharest, Constanta and Craiova), in the period 1977-2016. There were calculated several primary climate parameters (annual average temperature; average temperature in the growing season; average temperature in summer; average maximum temperature in the warmest month; average minimum temperature in the coldest month; annual precipitations; precipitations in summer), and bioclimatic indices (Huglin Index, Winkler Index and Cool Night Index). It has also pursued the evolution in time (19 years), of Feteasca regala, the most common grapevine cultivar in Romania, in close connection with the evolution of climatic parameters. In the period studied, it was found a highly significant trend for average temperatures (annual, during the growing season, summer, and maximum) and Huglin and Winkler indices.The results show the role of the variability, from year to year, of the warmer temperature, which affects grape production and its quality. The increase trend of the grapes sugar content was found to be highly significant (r = 0.809^{***}). Reducing titratable acidity of the must under 4 g/L, observed during the last decade, requires acidification measures.

Key words: *grapevine, climate change, effects, trends.*

INTRODUCTION

Vitis vinifera L. is a species which is very sensitive to climate change, considered to be a bioindicator.

Studies in recent decades have highlighted, in most vineyards, significant heating influence on the development of grapevine phenophases, on the main physiological processes, vegetative growth, grape production and quality (Jones et al., 2005; Cotea et al., 2008; Ranca et al., 2008; Irimia et al., 2015).

Climate change, particularly the temperature, influences the composition of grapes and increased sugars accumulation, acidity reduction, the content of anthocyanins in grape skins and the flavor precursors (Cichi et al., 2006; Palliotti et al., 2015).

In the main vineyards of the country, there was found an increase in average air temperature in the period 2000 - 2010, with values between 0.7 and 2.1ºC. The biggest differences were recorded in the vineyards Dealu Mare, Targu Bujor and Murfatlar, highlighting their tendency to aridity (Burzo, 2014).

Following global warming, there was found a change in the evolution of the annual biological cycle of grapevine, with completion faster phenophases (veraison and maturation of the grapes), which is often forced, and with significant consequences on the product quality, which are not always positive (Rotaru et al., 2013).

Grape maturation is accelerated by high temperatures. Sugar accumulation increases with temperature, but certain secondary metabolites such as anthocyanins and aroma precursors are adversely affected by high temperatures.

The annual sequence of phenological stages of grapevine is commonly observed to be accelerated with an increase in temperature (Duchêne and Schneider, 2005).

High concentrations of sugars in berries are not due to photosynthesis and their translocation from leaves and woody parts of the vine, but to water loss through evaporation (Keller, 2015).

Lowering the titratable acidity of the must under 4.0 g/L as a result of global warming requires the addition of tartaric acid to produce balanced wines and to enhance microbiological stability, causing a more expensive winemaking process.

According to the projections of the Intergovernmental Panel on Climate Change (IPCC, 2014), which considers a temperature increase of 1 - 3.7ºC by the end of the century, it is necessary to elaborate strategies for the adaptation and mitigation of climate change.

The objective of the current paper is to present and to evaluate the situation and trends of climate change for the period 1977 – 2016 in three centers situated in Romania's south part (Bucharest, Constanta and Craiova) and their effects on grapevine.

MATERIALS AND METHODS

We used observation data with a complete daily series from 1977-2016 of 3 meteorological stations situated in Romania's south part (Bucharest, Constanta and Craiova).

There were calculated and analysed 10 primary climate parameters and bioclimatic indices (Table 1): annual average temperature; average temperature in the growing season (IV-X); average temperature in summer (VI-VIII); average maximum temperature in the warmest month (July): average minimum temperature in the coldest month (January); annual precipitations; precipitations in summer; Huglin Index, Winkler Index and Cool Night Index.

Table 1. List of climatic parameters and bioclimatic indices

Variable	Description (Equation)	Months
T average I-XII (ºC)	Annual average temperature	I - XII
T average IV-X (ºC)	Growing season temperature	IV - X
T average VI-VIII (ºC)	Summer temperature	VI - VIII
T maximum VII (ºC)	Average maximum temperature in July	VII
T minimum I (ºC)	Average minimum temperature in January	I
P I-XII (mm)	Annual total precipitation	I - XII
P VI-VIII (mm)	Summer total precipitation	VI - VIII
Huglin Index (ºC units)	Σ[(Tavg-10°C) + (Tmax-10°C)] / 2 x k	IV- IX
Winkler Index (ºC units)	Σ[(Tmax+Tmin) / 2 - 10°C]	IV - X
Cool Night Index (ºC)	$Tmin_{sept}$	IX

Vine reaction to climate change was traced during the period 1998-2016 within a 1.0 ha vineyard planted in 1994 at the University of Agronomic Sciences and Veterinary Medicine of Bucharest, at 2.2/1.2 m distance, with Feteasca regala cv (clone 21 Bl) / Kober 5 BB. Vines were trained to a bilateral cordon at 0.7 m and spur pruned with a load of 10 buds / sqm.

The statistical calculations were conducted using Microsoft Excel and interpretation of the data was performed by the methodology presented by Botu and Botu, 2003.

RESULTS AND DISCUSSIONS

Climate change. Analysing primary climate parameters and bioclimatic indices, there were obtained the data presented in Table 2. During the last four decades significant warming trends were observed in the three centers studied. Similar trends were found for Huglin and Winkler indices

According Huglin Index values, the two centers from Muntenia and Oltenia (Bucharest and Craiova) are included in warm temperate climate class (HI + 1), whereas the Black Sea coast (Constanta) is at the limit between the warm temperate and the temperate climate (HI - 1) (Tonietto and Carbonneau, 2004).

The largest increase in temperature trends during 1977 - 2016 were found in Constanta (+ 2.15 ... + 3.65°C).

Following the evolution of annual precipitation reveals a non significant trend for Bucharest and a significant one for Constanta (highy significant trend) and for Craiova (significant trend). Regarding the evolution of the summer precipitations, there was observed a non-significant trend for all three centers.

Cool night Index values (represented by the average minimum temperatures in September) were not significantly affected by climate change, maintaining the areas studied in class climate with very cool nights (CI + 2, Tonietto and Carbonneau, 2004), except for the Black Sea coast (cool nights CI + 1). These conditions ensure, in addition to good grape ripening, also high aromatic and phenolic potential (varieties for red wines).

Following anomalies of average temperatures during the growing season from the multiannual average (Figure 1) there is a significant heating tendency in all 3 studied centers.

Table 2. Trend over the period 1977-2016 and trend per decade
of primary climatic parameters and bioclimatic indices

Location	Variable	Mean and standard deviation	Trend over the period 1977-2016	Trend per decade	R^2
Bucharest	T average I-XII (ºC)	11.51±0.75	+ 1.3	+ 0.35	0.223**
(44.75N; 26.11E; 91 m)	T average IV-X (ºC)	17.97±0.78	+ 1.3	+ 0.35	0.218***
	T average VI-VIII (ºC)	22.37±1.11	+ 2.1	+ 0.52	0.302***
	T maximum VII (ºC)	29.73±1.75	+ 3.1	+ 0.77	0.254***
	T minimum I (ºC)	-5.41±2.46	-	-	NS
	P I-XII (mm)	618.3±149.4	+ 72	+ 18	NS
	P VI-VIII (mm)	193.1±70.8	-	-	NS
	Huglin Index (ºC units)	2337±189	+ 375	+ 93	0.348***
	Winkler Index (ºC units)	1705±168	+ 265	+ 66	0.217***
	Cool Night Index (ºC)	10.52±1.40	-	-	NS
Constanța	T average I-XII (ºC)	11.34±0.93	+ 2.15	+ 0.54	0.521***
(44.33N; 28.43E; 25 m)	T average IV-X (ºC)	17.33±0.92	+ 2.15	+ 0.54	0.594***
	T average VI-VIII (ºC)	21.63±1.21	+ 3.25	+ 0.81	0.653***
	T maximum VII (ºC)	28.23±1.82	+ 3.65	+ 0.91	0.376***
	T minimum I (ºC)	-3.53±1.97	-	-	NS
	P I-XII (mm)	448.4±124.1	+ 200	+ 50	0.241***
	P VI-VIII (mm)	116.9±67.14	-	-	NS
	Huglin Index (ºC units)	2060±213	+ 440	+ 110	0.391***
	Winkler Index (ºC units)	1712±189	+ 445	+ 111	0.489***
	Cool Night Index (ºC)	12.30±1.53	+ 2.80	+ 0.70	0.265***
Craiova	T average I-XII (ºC)	11.51±0.77	+ 1.70	+ 0.42	0.423***
(44.31N; 23.86 E; 195m)	T average IV-X (ºC)	17.91±0.83	+ 1.50	+ 0.37	0.310***
	T average VI-VIII (ºC)	22.15±1.12	+ 2.40	+ 0.60	0.402***
	T maximum VII (ºC)	29.62±1.93	+ 3.50	+ 0.87	0.303***
	T minimum I (ºC)	-4.83±2.46	-	-	NS
	P I-XII (mm)	570.8±189.0	+ 195	+ 48	0.092*
	P VI-VIII (mm)	166.2±82.2	+ 50	+ 12.5	NS
	Huglin Index (ºC units)	2306±209	+ 435	+ 108	0.387***
	Winkler Index (ºC units)	1693±178	+ 350	+ 87	0.310***
	Cool Night Index (ºC)	11.55±1.91	-	-	NS

NS indicate trend that are not significant and *, **, and *** indicate significance at the 0.10, 0.05 and 0.01 levels, respectively.

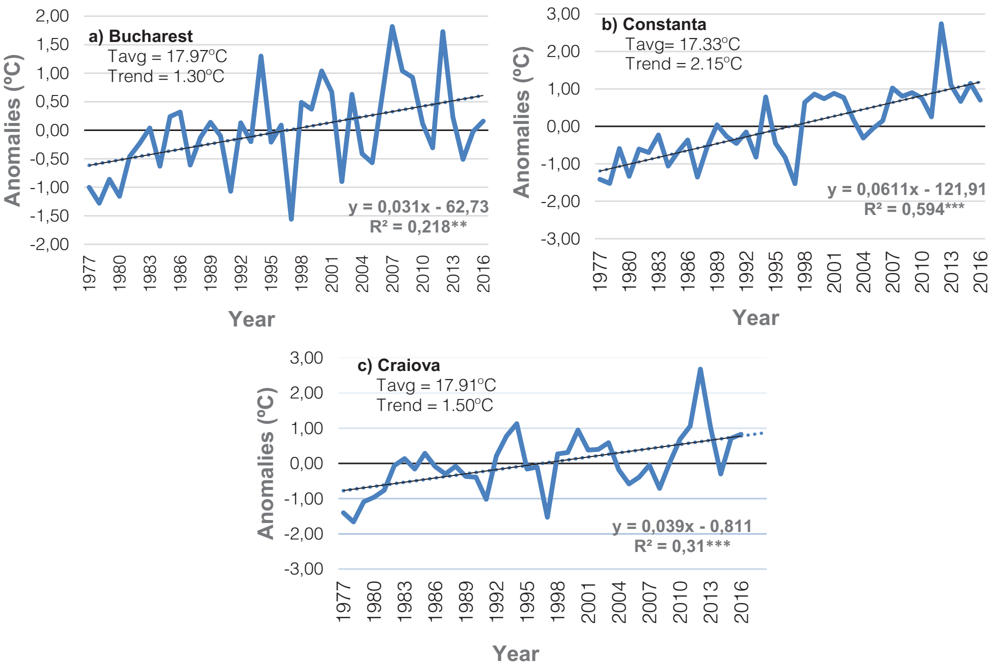

Figure 1. Registered growing season temperature anomalies in the period 1977-2016 for:
a) Bucharest; b) Constanta and c) Craiova; Tavg is the average growing temperature (April - October)

Grapevine behaviour. Climate warming has had different effects on the production of grapes (kg/vine), sugar accumulation (g/L) and titratable acidity (g/L H_2SO_4) of the grape, at Feteasca regala cultivar (Figures 2, 3, 4).

From Figure 2, it can be noted a high variability in grape yield from year to year and a slight reduction trend caused mainly by the minimum temperatures, harmful to vines during the dormant period (Tmin < -20ºC) in recent years (2005; 2010; 2012; 2015 and 2016). The frequency and intensity of these temperatures was discussed in a previous paper (Bucur and Dejeu, 2016).

From Figure 3, it is observed a highly significant trend of sugar content in berries. The statistical analysis of the data shows that sugar content depends on climatic suitability, which explains 65.5 % of the variance.

Regarding the titratable acidity of the grape must, it is found to its insignificant reduction over 19 years (Figure 4). However, in the last decade it was observed a reduction in titratable acidity of the must under 4 g/L, requiring acidification measures.

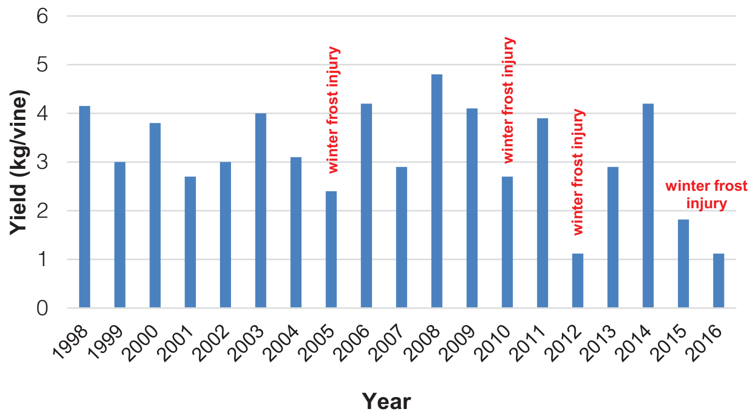

Figure 2. Evolution of grape yield (kg/vine) at Feteasca regala cultivar in the period 1998 - 2016

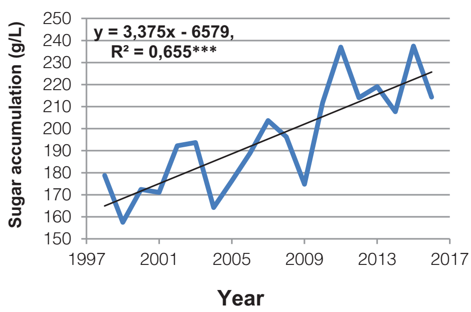

Figure 3. Evolution of sugar accumulation (g/L) at Feteasca regala cultivar in the period 1998-2016

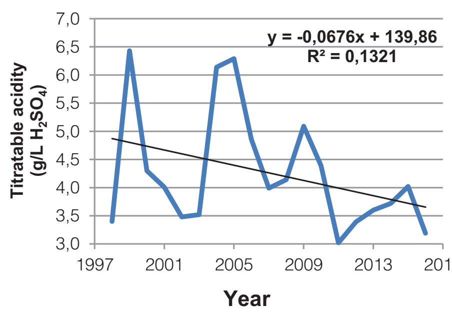

Figure 4. Evolution of titratable acidity (g/L H_2SO_4) of grape must at Feteasca regala cultivar in the period 1998-2016

CONCLUSIONS

During the last four decades, significant warming trends were observed in the three studied centers. This trend of temperature increase is almost certainly going to continue in a future warmer climate.

The results on Feteasca regala grapevine responses to climate change (high variability and trend to reduce grape yield, a highly significant increase of sugar content, reducing must acidity) are very important for the winegrowers because this is the most widely grown cultivar in Romania.

The results of this study provide the necessary information for viticultural zoning in the new conditions. Starting from the current situation of global warming and predictions for the future, in viticulture there should be implemented mitigation and adaptation measures.

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