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CLIMATE CHANGE TRENDS IN SOME ROMANIAN VITICULTURAL CENTERS

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Abstract

The evolution of temperature indicators, more pronounced in the north of Romania, clearly shows a gradual warming trend, mainly during the growing season, especially during the ripening of the grapes. There have been highlighted relatively large differences between the values of the main bioclimatic indicators of the country's wine regions, as well as a stronger growth trend of these ones in the northern areas and at the Black Sea. The viticultural region of Dobrogea hills profits by maritime influences that limit summer temperature extremes and winter frost. There is evidence that in many regions, day temperature increased more than night temperature. Results show that Romanian viticulture will benefit from climate change. Given these trends and knowing their possible negative effects on vine physiology, production and quality, the future viticultural zoning requires reconsideration, and the application of technological measures to minimize the negative effects of climate change.

Key words: *climate change, Romanian viticulture, temperature indicators.*

INTRODUCTION

Grapevine is very responsive to global warming, which is expected to keep on increasing, thus having a lot of effects.

Many studies made on the impact of climate change on viticulture, in most of the wine regions, revealed the effects on the phenological stage development, on the quality of grapes and on the quantity of production (Cotea et al., 2008; Bucur and Dejeu, 2013; Burzo, 2014).

Vineyards in Romania grow under temperate - continental climate, with frequent occurences of extreme climatic conditions and with some regional variations.

Out of all the environmental factors, temperature seems to have the most profound effect on viticulture, both during the growing season, and during winter (Simion et al., 2008; Jones and Webb, 2010).

Prolonged high temperature during the maturation of grapes determined a high level of sugar accumulation, the loss of acids through respiration (Burzo et al., 2005; Jones, 2005; Dejeu et al., 2008; Schultz and Jones, 2010).

Under the conditions of very high temperatures during grapes' ripening, the metabolism of vines can be inhibited, causing reduced accumulation of metabolites, and affecting, this way, the flavour and the colour of the wine (Mori et al., 2007; Sadras and Moran, 2012; Martinez de Toda and Balda, 2015).

Given the predictions on the intensification of global warming in the future, several scenarios were developed to adapt viticulture to this phenomenon (Malheiro et al., 2010; Carbonneau, 2011; Şerdinescu et al., 2013; Quénol et al., 2014; Costa et al., 2015; Fraga et al., 2015).

The objectives of this study were to investigate the differences between one and another wine region, about bioclimatic indices, the trends on global warming recorded over a period of time (38 years, 1977-2014) and their influence on grape production.

MATERIALS AND METHODS

For this study, there were used weather data recorded at seven stations from Romania's main wine regions (Craiova, Constanta, Bucharest-Baneasa, Timisoara, Cluj-Napoca, Oradea and Iasi), for a period of 38 years (1977-2014).

Table 1 presents the geographical coordinates of the meteorological stations from the centers presented in the present study.

Table 1. Geographical coordinates of the studied centers

No.	Meteorological station	Latitude	Longitude	Altitude (m)
1.	Craiova	44.31 N	23.86 E	195
2.	Constanța	44.33 N	28.43 E	25
3.	Bucharest-Baneasa	44.48 N	26.,11 E	91
4.	Timișoara	45.76 N	21.25 E	88
5.	Cluj-Napoca	46.77 N	23.60 E	335
6.	Oradea	47.03 N	21.90 E	140
7.	Iași	47.17 N	27.63 E	104

Monthly average temperatures were used to calculate a set of indices meant to describe the climatic structure of Romanian wine regions, using a set of bioclimatic indices commonly used in viticulture such as: average annual temperature (AVG-AN-T); average temperature in the growing season (IV-X, AVG-T-GS); cool night index (CI); average minimum temperature (AVG-MIN-T); average maximum temperature (AVG-MAX-T); average temperature in summer (VI-VIII, AVG-T-S); maximum temperature in the warmest month (T-JUL); minimum temperature in the coldest month (T-JAN); Huglin index (HI) and Winkler index (WI).

The cool night index (CI) is represented by the minimum temperature in September.

Huglin index (HI) was calculated using the formula: $\Sigma[(Tavg-10°C) + (Tmax-10°C)] / 2 \cdot k$, for the period April - September (k = day length coefficient, varying from 1.02 to 1.06 between 40° and 50° latitude (Huglin, 1978).

Winkler index (WI) was calculated according to the equation: $\Sigma[(Tmax+Tmin)/2-10°C]$, for the period April - October (Winkler et al., 1974).

RESULTS AND DISCUSSIONS

The spatial structure of the climatic indices analysed in the whole country shows a clear north-south pattern (Table 2). The average annual temperature (AVG-AN-T) ranges from 9.12°C (Cluj-Napoca) to 11.48°C (Bucharest-Baneasa).

The average growing season temperatures (AVG-T-GS) ranges from 15.08°C (Cluj-Napoca) to 17.96°C (Bucharest-Baneasa), including Romania's viticultural regions, in intermediate and warm climate-maturity groupings, as defined by Jones G.V. (2007), favorable for optimum maturity of cultivars, such as Chardonnay, Sauvignon, Merlot, Cabernet Sauvignon, Viognier, Syrah etc.

The cool night index (CI) ranged from 8.76°C in Cluj-Napoca to 12.16°C in Constanța, including our country's viticulture, in very cool nights class (CI+2), according to which grapes could be found with a high potential for colour and aromas (Tonietto and Carbonneau, 2004).

The average minimum temperature ranged from 3.64°C in Cluj-Napoca to 6.44°C in Constanta, while the lowest average maximum temperature was also observed in Cluj-Napoca (14.63°C) and the highest in Bucharest-Baneasa (17.02°C).

The largest differences were observed in values of maximum temperature in July, from 25.8°C in Cluj-Napoca to 29.72°C in Bucharest-Baneasa.

The heat accumulation indices HI and WI produced similar results.

Following the evolution in time of the main climatic variables related to temperature, for the 7 centers (Table 3) between 1977-2014 (38 years), there were revealed some significant trends, especially for the average temperature in summer (AVG-T-S), Huglin index (HI) and the average temperature in the growing season (AVG-T-GS).

The development was generally insignificant for cool night index (CI), for average minimum temperature (AVG-MIN-T) and for minimum temperature in the coldest month (T-JAN).

The most significant increase of thermal parameters over time was found in the northern areas (Cluj-Napoca, Iași) and at the seaside (Constanța).

If until 30-40 years ago, climatic conditions in northern Romania were considered unfavorable for grapevine varieties for red wines, more pronounced global warming registered in the last 20 years and the experience of the last years ensure the success of these varieties.

Between Huglin index values (HI) and grape yield of Fetească regală cultivar in Bucharest experimentations (Bucur and Dejeu, 2013), during 17 years (1998-2014), there has been established a distinctly significant correlation (Figure 1).
At HI values of over 2600°C, specific to warm climate, grape yield decreases significantly.
At high levels of air temperature during the growing season, there has been o downward trend in the grape yield.

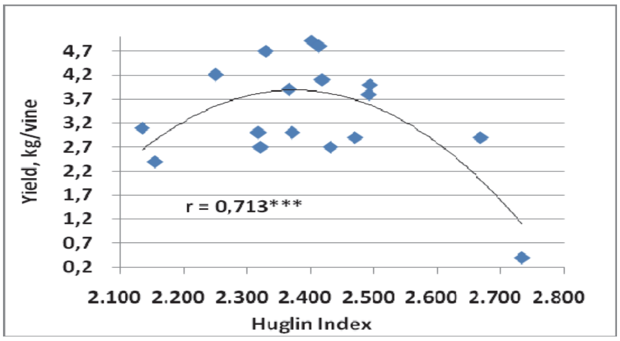

Figure 1. Correlation between the Huglin Index values and yield of grapes (1998-2014)

Table 2. Climatic caracteristics of 7 centers situated in most of Romania's viticultural regions; values are mean±sd (1977-2014)

No.	Variable	Craiova	Constanța	Bucharest-Baneasa	Timișoara	Cluj-Napoca	Oradea	Iași
1	AVG - AN - T	11.46±0.74	11.28±0.87	11.48±0.76	11.27±0.71	9.12±0.97	10.83±0.85	10.23±1.00
2	AVG - T - GS	17.87±0.83	17.28±0.92	17.96±0.80	17.26±0.71	15.08±0.92	16.78±0.88	16.77±0.97
3	C I	11.43±1.89	12.16±1.43	10.45±1.39	10.88±1.50	8.76±1.41	10.67±1.43	10.03±1.61
4	AVG - MIN - T	5.91±0.78	6.44±0.87	5.04±0.63	5.85±0.61	3.64±0.71	5.65±0.85	4.96±0.71
5	AVG - MAX - T	17.01±1.18	16.07±1.04	17.02±1.01	16.76±0.89	14.63±1.71	16.01±0.93	15.52±1.54
6	AVG - T- S	22.09±1.12	21.58±1.22	22.35±1.14	21.09±0.92	18.86±1.18	20.54±1.10	21.00±1.29
7	T - JUL	29.51±1.91	28.21±1.85	29.72±1.84	28.42±1.78	25.80±2.21	27.66±1.88	28.02±2.38
8	T - JAN	- 4.81±2.48	-3.57±2.00	- 5.33±2.47	-3.84±2.43	-6.26±2.59	-4.04±2.87	-6.00±3.10
9	HI	2295±208	2062±207	2331±191	2159±191	1759±263	2062±210	2093±261
10	WI	1685±178	1710±194	1703±172	1553±152	1088±211	1450±188	1450±209

AVG - AN - T: average annual temperature (°C); AVG - T - GS: average temperature in the growing season (IV-X, °C); CI: cool night index (°C); AVG - MIN -T: average minimum temperature (°C); AVG - MAX -T: average maximum temperature (°C); AVG -T- S: average temperature in summer (VI-VIII, °C); T - JUL: maximum temperature in the warmest month (°C); T- JAN: minimum temperature in the coldest month (°C); HI: Huglin index (°C); WI: Winkler index (°C)

Table 3. Trends of some climate variables in 7 different centers from Romania; correlations intensity between thermal variables (°C) and time (1977-2014)

No.	Variable	Craiova	Constanța	Bucharest-Baneasa	Timișoara	Cluj-Napoca	Oradea	Iași
1	AVG - AN - T	0.604***	0.696***	0.457**	0.473**	0.780***	0.630***	0.637***
2	AVG - T - GS	0.525***	0.761***	0.495**	0.533***	0.730***	0.632***	0.714***
3	C I	NS	0.471**	NS	NS	NS	0.308*	NS
4	AVG - MIN - T	NS	0.748***	NS	0.456**	NS	0.659***	NS
5	AVG - MAX - T	0.649***	0.620***	0.559***	0.494***	0.840***	0.571***	0.653***
6	AVG - T- S	0.605***	0.808***	0.574***	0.626***	0.794***	0.661***	0.740***
7	T - JUL	0.510***	0.672***	0.560***	0.534***	0.706***	0.530***	0.674***
8	T - JAN	NS	NS	NS	NS	NS	0.408**	NS
9	HI	0.592***	0.736***	0.582***	0.530***	0.793***	0.589***	0.714***
10	WI	0.526***	0.732***	0.494**	0.533***	0.734***	0.642***	0.714***

AVG - AN - T: average annual temperature (°C); AVG - T - GS: average temperature in the growing season (IV-X, °C); CI: cool night index (°C); AVG - MIN - T: average minimum temperature (°C); AVG - MAX - T: average maximum temperature (°C); AVG - T- S: average temperature in summer (VI-VIII, °C); T - JUL: maximum temperature in the warmest month (°C); T - JAN: minimum temperature in the coldest month (°C); HI: Huglin index (°C); WI: Winkler index (°C); ***, **, *, NS = p < 0.01%; < 0.1%; < 1%; not significant

CONCLUSIONS

In the context of climate change, Romania's temperate-continental climate is affected more frequently by heat waves in summer and cold waves in winter.
The highest warming trends were observed for nothern viticultural regions (Transylvania and Moldavia) and for the seaside.

Usually, the values of cool night index are not significantly affected by climate change, including viticultural regions in climate class CI + 2 (very cool night), except for the seaside.
These conditions could ensure a good level of grape ripening for the varieties cultivated nowadays and high potential for colour and aromas.

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