THE IMPACT OF CLIMATE CHANGES ON GRAPEVINE

Liliana PIRCALABU[1], Marian ION[1], Georgeta TUDOR[1], Irina BALANESCU[1]

e-mail: alexandrinalster@gmail.com

Abstract

The viticultural climate of terroir influences the physiology of grapevine and the ripening of the grapes. The researches performed at the IC-DVV Valea Calugareasca have shown that over the past 32 years, the climate has changed in the meaning that heating resources increased and the rainfall resources decreased. It has registered, also, years with hot summers which significantly influenced the grapevine. The researches were carried out in the Valea Călugărească viticultural center within seven viticultural plantations with the varieties Olivia, Negru aromat, Mamaia, Feteasca neagra 4 Vl, Columna, Grasa de Cotnari 4 Pt. The changes in the viticultural climate determined a delayed development of the vegetative phenophases, especially of the rippening and the maturation of the grapes phenophases (by approximately 1-5 days), which especially influenced the quality of the grape production. The grape production obtained was in accordance with the productivity of the vine stumps, the highest productions being obtained in the case of the varieties Feteasca neagra 4 Vl (2.088 kg / but), Mamaia (2.244 kg / but) and only 1.558 kg / but at Columna variety.

Key words: viticultural climate, climate change, quantitative and qualitative potential

The average annual air temperature increased in the period 1989-2021 by 1.3°C, compared to the average 1936-1988 (10.8°C), a value that exceeds the average global warming of 0.85°C in the last 100 years, according to the report AR 5 (IPCC 2013). Climatic conditions vary from year to year, variations that induce the "vintage effect" in yield, quality and typicality (Van Leeuwen *et al*, 2015). The accumulation of sugar increases with temperature (Coombe, 1987), but certain secondary metabolites are adversely affected by the high temperature (Kliewer and Torres, 1972). From the point of view of the pluviometric regime, there was a general tendency of decreasing the annual quantities of precipitations, as well as an inappropriate distribution, creating for the vine critical periods from a physiological point of view, which is reflected not only on the grape production.

During hot summers, vine phenology has changed in that way in which the period between two phenophases was shortened greatly. The changes in the viticultural climate determined a delayed development of the vegetative phenophases, especially of the rippening and the maturation of the grapes phenophases (by approximately 1-5 days), which especially influenced the quality of the grape production.

MATERIAL AND METHOD

The study was realized in the years 2020-2022, in DOC Dealu Mare-Valea Calugareasca viticultural area specialized in the cultivation of black grapes. The analysis was performed on Olivia, Negru aromat, Mamaia, Feteasca neagra 4 Vl, Columna, Grasa de Cotnari 4 Pt varieties.

The viticultural climate parameters analyzed were: monthly climate parameters (air temperature, absolute minimum temperature, maximum temperature), bioclimatic indicators (global, active and useful balance, real heliothermic index, bioclimatic index), precipitation and insolation. The evaluation of the climate parameters was made by comparative analysis of annual and multiannual values, the evaluation scale having 3 levels: poor, good and very good, established on the basis of a score. Grape yield potential was quantitatively assessed as yield (kg) per vine and grape weight. Qualitatively, the grape harvest was assessed by the gluco-acidimetric index and the number of anthocyanins (mg/kg grapes)

RESULTS AND DISCUSSIONS

The meteorological data recorded in the period 1989-2021 indicate a thermal regime characterized by average annual temperatures oscillating between 10.2°C (1996) and 14.9°C (2020), a global heat balance that oscillated between 3186°C (1997) and 3926°C (2012), a sum of active temperatures between 3186°C (1997) and

[1]Research Institute for Viticulture and Enology Valea Calugareasca, Romania

3901°C (2007) and a sum of useful temperatures between 1381°C (1991) and 2107°C (2012). The minimum absolute air temperature oscillated between -10.8°C (2019) and -18.8°C (2006), with no large eye loss, which would obviously affect the grape production or the vegetative state of the vine (*table 1*).

Table 1

The main climatic elements of the Dealu Mare vineyards (1989 – 2021)

Climatic elements analyzed	Average	Minimum	Maximum
Global thermal balance, (Σt°g)	3,551	3,186	3,926
Active thermal balance , Σt°a)	3,508	3,186	3,901
Useful thermal balance , (Σt°u)	1,742	1381	2,107
Average temperature in July, °C	23.6	21.4	27.6
Average temperature in August, °C	23.5	20.4	26.8
Average temperature in September , °C	18.2	14.2	22.3
Absolute minimum temperature in the air,°C	-13.8	-18.8	-10.8
Average annual temperature,°C	12.2	10.2	14.9
Maximum temperature in the air,°C	24.7	22.4	26.9
Sum of annual precipitation, mm	637.1	321	1079
Sum of prercipitation during the growing season, mm	405.4	216	825
Sum of insolation during the growing season, ore	1487	1243	1704
Average maximum temperatures in August,°C	29.5	24.9	38.6
Average temperature in the I and II decades of June	21.2	19	24.5
Number of days with maximum temperature > 30°C	33.8	21	67
Duration of the bioactive period, number of days	188	161	203
Real heliothermic index (IHr)	2.4	1.79	2.86
Hidrothermal coefficient (CH)	1.1	0.61	1.83
Bioclimatic index (Ibcv)	8.2	3.4	13.5
Oenoclimatic aptitude index (IAOe)	4,691	4,021	5,076
Huglin heliothermic index (IH)	1,861	1,586	2,440
Night cooling index (IF)	12.7	5.5	15.7

The analysis of climate data for the entire period highlights the increase in the annual frequency of tropical days (daily maximum >30°C) and the decrease in the annual frequency of winter days (daily maximum <0°C), as well as the significant increase in the average summer minimum temperature and the maximum winter and summer temperature.

Precipitation is the main source of water for the growth and development of the vine, and the most significant elements of this meteorological parameter are the quantitative variability, distribution and spatio-temporal distribution. The insufficiency of the precipitation, as well as their improper distribution, create critical periods for the vine from a physiological point of view, which is reflected not only on the production of grapes in that year, but also on future harvests.

Precipitation data indicate average annual amounts of precipitation of 637 mm, with a minimum of 321 mm in the year 2000 and a maximum of 1079 mm in the year 2005. The precipitation during the growing season summed up on average 405 mm, oscillating between 216 mm in 2000, a year characterized by an obvious deficit of precipitation (below the threshold of 250 mm considered optimally ecological) and 825 mm in 2005.

The bioclimatic index of the vine (Ibcv) presented an average value of 8.2, with limits of variation between 3.4 (2005), a value that indicates low heliothermic resources on the background of high-water resources and 13.5 (2000), a value that indicates high heliothermic resources against the background of deficient water resources.

The real heliothermic index (Ihr) showed an average value of 2.60, with ranges ranging from 2.37 (2004) to 2.86 (2003), values indicating high heliothermic resources, favorable for ripening of grapes. The real heliothermic index (IHr) presented an average value of 2.40 with limits of variation between 1.79 (1999) and 2.86 (2003), falling within the limits specific to the vineyards in our country, respectively 1.35-2.70). The high values of this indicator express the favorability for the cultivation in the Valea Calugareasca wine-growing area of the varieties for red wines.

The night cooling index (IF) averaged 12.7 with ranges ranging from 5.5 (2000) to 15.7 (2011), falling into the cold-night climate classes (IF3:12-15) and very cold nights (IF4: <12).

The Enoclimatic Aptitude Index (IAOe) showed an average value of 4691 with ranges ranging from 4021 (1997) to 5076 (2000). With the exception of 1997, in all the years studied there were registered favorable conditions for obtaining red wines. These climatic resources and ecoclimatic indicators underline the existence of very favorable conditions for the cultivation of grape varieties for high-quality red wines.

During the analyzed period, in the Valea Calugareasca wine-growing area, the assessment of

the climate parameters allowed the identification of the following types of climate:

-type 1 - weak: the years 1999, 2000, 2006, 2010, 2011, 2017, 2018 and 2022

- type 2 - good: the years 2001, 2003, 2004, 2005, 2013, 2014 and 2020

- type 3 - very good: the years 2002, 2007, 2008, 2009, 2012, 2015, 2016, 2019 and 202.

The frequency of the weak climate was 33%, of the good climate of 29% and of the very good climate of 38%.

The changes in the wine-growing climate also influenced the development of the vegetative phenophases and the maturation of the grapes, which in most of the last 5 years (2017-2021) were carried out 7-14 days earlier, compared to the multiannual normal data.

The quantitative potential of the varieties showed varietal specificity, Negru aromat reducing its production from poor to very good, on average by 0.16 kg/vine, Feteasca neagra 4 Vl. with 2.53 kg/vine, Mamaia with 2.94 kg/vine and Olivia with 1.72 kg/vine, and the varieties for quality white wines they reduced their production by 2.28 kg/vine (Columna), respectively 4.03 kg/vine (Grasa de Cotnari 4 Pt., (*Ttable 2*).

Table 2

The grape production

Quantitative potential/variety	Negru aromat	Fetească neagră 4 Vl.	Mamaia	Olivia	Columna	Grasa de Cotnari 4 Pt.
Poor	2.940	4.620	5.181	3.267	3.835	5.913
Good	2.386	3.321	3.960	2.640	2.688	3.512
Very good	1.780	2.088	2.244	1.548	1.558	1.880

The average weight of a grape was variable from the poor level to the very good level with 22 (Negru aromat), 35 grams (Olivia), 55 grams (Mamaia and Columna), 62 grams (Grasa de Cotnari 4 Pt.) and 70 grams (Feteasca neagra 4 Vl) (*table 3*).

The quality improved from the poor level to the very good level by increasing the sugar content with 3.96 % in Negru aromat, 2.2% in Fetească neagră 4 Vl., 7.5% in Mamaia, by 6.2% in Olivia, and 8.2% per Grasa de Cotnari 4 Pt (*table 4*).

Table 3

The average weight of a grape

Quantitative potential/variety	Negru aromat	Fetească neagră 4 Vl.	Mamaia	Olivia	Columna	Grasa de Cotnari 4 Pt.
Poor	111	186	157	121	137	156
Good	105	123	147	108	112	118
Very good	89	116	102	86	82	94

Table 4

The sugar content in grapes

Quantitative potential/variety	Negru aromat	Fetească neagră 4 Vl.	Mamaia	Olivia	Columna	Grasa de Cotnari 4 Pt.
Poor	218	221	196	213	185	213
Good	224	224	199	218	194	220
Very good	227	226	212	227	204	232

Regarding the content of total polyphenols, it improved from poor to very good with 173 g EAG/l, 302 g EAG/l (Negru aromat), 323 g EAG/l (Mamaia) and 449 g EAG/l (Feteasca neagra 4 Vl.) (*table 5*).

Table 5

The content of total polyphenols of grapes

Quantitative potential/variety	Negru aromat	Fetească neagră 4 Vl.	Mamaia	Olivia
Poor	1320	1277	957	1027
Good	1324	1360	1250	1130
Very good	1622	1726	1280	1200

In recent years the pedological and atmospheric hydric stress has negatively influenced all the physiological and biochemical processes in the plant, with major implications on the growth processes and productivity of the vines. The long period of drought associated with a high thermal regime and an air hygroscopicity of less than 40%, installed during the period of intense growth of shoots and grapes, led to a drastic

reduction of photosynthesis, an intensification of breathing and sweating. In these conditions, the hydric stress determined the forced entry into the scorched phenophase even in the late-ripening varieties. The phenomenon of dehydration (raisining) of berries began to be evident in all varieties.

CONCLUSIONS

The grape production has been influenced by climate change. High temperatures and precipitation in lower quantities have affected grape production and vegetative growth is lower.

The quantitative potential of the varieties showed varietal specificity, Negru aromat reducing its production from poor to very good, on average by 0.16 kg/vine, Feteasca neagra 4 Vl. with 2.53 kg/vine, Mamaia with 2.94 kg/vine and Olivia with 1.72 kg/vine, and the varieties for quality white wines they reduced their production by 2.28 kg/vine (Columna), respectively 4.03 kg/vine (Grasa de Cotnari 4 Pt) growth of the shoots was much reduced (more than 50% in the case of sensitive varieties), there is a sharp debilitation of the vines and an early cessation of the berry growth (the weight of the berry, in most varieties is lower by 40-50%). The high temperatures, the

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