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STUDY OF THE IMPACT OF CLIMATE CHANGE ON THE QUANTITY AND QUALITY OF HARVEST IN THE MURFATLAR VINEYARD CONDITIONS

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Abstract

Changes of the climate regime due the temperatures, sunstroke and rainfall, fall within the global context, but with the specifics of the geographical area where the vineyard is located. The study carried out between November 2015 and October 2018 in the Murfatlar vineyard showed that the average global temperature value increased, and during the vegetation period there was a pluviometric excess and an increase in the frequency of extreme phenomena as a consequence of climate change. From climatic point of view, during the vegetation period in the years 2016 and 2017 high heliothermal resources were recorded, and the year 2018 was characterized by a poor heliothermal regime. The effects of these changes were significantly reflected in the quantity and quality of grape production in Murfatlar vineyard varieties: 'Columna', 'Mamaia' and 'Feteasca neagra', demonstrating that there is an interference between the environmental factors and the obtained production.

Key words*: grapevine, climatic indicators, quality.*

INTRODUCTION

A topical issue is the climatic changes recorded in the last decades and their influence on the quality and quantity of the grape production. In the specialty literature, research on the impact of climate change on grapevine, as compared to annual plants is relatively low (Schultz, 2000; Jones, 2005; White et al., 2006).

Climate change falls within the global context, but with the peculiarities of the geographical region where the vineyard is located. Thus, in order to obtain high quality crops, climatic conditions of maximum favorability are required, such as grape ripening at an optimum level of sugars, acidity and flavor, in order to obtain a superior quality wine (Dejeu, 2010).

The purpose of this paper was to evaluate the climatic conditions from 2016-2018 compared to the multiannual average and their influence on the quality of the grapes and implicitly of the obtained wines.

MATERIALS AND METHODS

The research was carried out at the Murfatlar Research Station for Viticulture and Oenology, during the years 2016-2018, on the Columna, Mamaia and Feteasca Neagra varieties. The varieties have been grafted on the Berlandieri X Riparia Teleki 4 root-stock - Selection Oppenheim 4-4, the vines were pruned in classic Guyot, with a total of 36 buds/vine, S-E exhibition with a 3% slope. Soil, calcic chernozem, with a medium texture, has a humus percentage of 2.3%. The cultivated plot of the Columna variety was established in 1992 and the one with Mamaia in 2002, both have the orientation in the E-V direction and the planting distance of 2.2 / 1.2 m. The one cultivated with the Feteasca neagra variety was established in 2011, with a N-S direction and a 2.2 / 1.1 m planting distance.

Climate data was recorded with our own weather station, a Weather Master 2000, produced by Environdata, Australia, and includes daily observations of maximum and minimum temperatures, insolation and precipitation calculated based on a number of climatic indicators commonly used in viticulture.

The quality of the harvest was assessed by determining the sugar content of must and total acidity. For the physicochemical analyzes of the wines were used common, standardized methods: alcoholic strength, total and volatile acidity, reducing sugars, total dry and non-reducing extract. The polyphenolic composition (total anthocyanins and polyphenols) was performed by spectrophotometric methods using the UV-VIS spectrophotometer. Anthocyanins content in wine was determined by the Ribereau Gayon-Stonestreet method (1976), the readings being performed at wavelength λ = 520 nm. The total of polyphenols (mg GAE/l) was determined by the Singleton-Rossi method (1965) with the Folin-Ciocalteau reagent at 675nm.

For statistical calculations SPSS Statistics 17.0 software package was used, Duncan test being applied for the degree of significance of 5%.

RESULTS AND DISCUSSION

The measurements made during the period 2016-2018, compared to the average of the years 1991-2010, showed that the average monthly temperature recorded an increase with values ranging from 3,1-5 °C which led to a thermal surplus with maximum absolute: 38.7 °C in 7-VIII-2016, 40.5 °C in 30-VI 2017 and 37.4 °C in 31-VIII-2018, and the absolute minimum temperature that reached the biological threshold of vine resistance - 15 °C (January 1, 2016 and January 9, 2017), and in 2018 the absolute minimum was -12.8 °C on March 1 (Table 1).

Table 1. Evolution of the main climatic elements during the period 2016-2018

Climate elements	Years Average 1991-2010	2015-2016	2016-2017	2017-2018
Global Thermic Balance (˚C)	4470.6	5757.8	5303.8	5379.6
Active Thermic Balance (˚C)	3832.7	5216.1	4826.9	4815.5
Sum of useful temperatures, (˚C)	1747.3	2676.1	2515.0	2427.2
Sum of annual rainfall, mm	436	492.0	483.6	696.2
Sum of rainfall during the vegetation period, (mm)	275.7	253.8	333.2	370.1
Rainfall no. > 0,1 mm		97	76	111
Rainfall no. > 5 mm		32	29	41
Rainfall no. > 10mm		16	17	22
Relative humidity of air (%)	73	78	78	84
Total sunstroke, (hours)	2176.5	2095.9	2142.2	1946.0
Active sunstroke, (ore)	1763.2	1714.8	1527.2	1487.1
Average annual temperature (˚C)	11.4	16.4	14.5	14.6
Temperatura medie anuala din perioada de (˚C)	18,3	23,3	22,4	21,7
Average month temperature: July, ˚C August, ˚C September, ˚C	22.6 22.6 17.6	28.2 26.9 21.9	27.1 27.8 23.0	26.4 26.9 21.7
Maximum absolute temperature in the air, ˚C		38.7 7-VIII	40.5 30-VI	37.4 31-VIII
No. days with maximum temperature > 30˚C		100	82	54
The absolute minimum temperature in the air, ˚C		-15.0 1- I	-15.0 9-I	-12.8 1- III
The hydrothermic coefficient	1.0-1.9	0.6	0.7	0.8
Bioclimatic index	5.0-15.0	13.7	10.9	8.7
Index of oenoclimatic ability	3700 - 5200	5946	5926.2	5125.2
No. of active vegetation days		204	187	200
Global characterization of the year		Dry year in the ripening period of grapes	Normal year	Rainy year

In 2018, the number of days with absolute maximum temperatures above 30˚C decreased to 54 from 100 in 2016 due to the increase in rainfall days (696.2 mm versus 492 mm in 2016). In 2016 the sum of rainfall in the vegetation period had values close to normal: 253.8 mm. In 2017 and 2018, they recorded a plus of 57 mm and 94 mm respectively, compared to 275.7 mm (normal value for this period) and had a higher frequency in June and July (2017 and 2018) and August 2018 (Fig. 1).

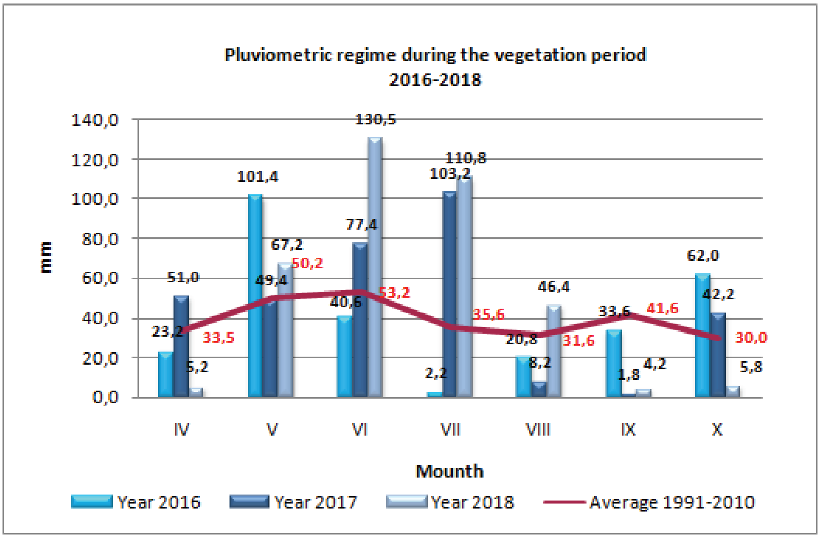


Figure 1. Evolution of precipitation during the vegetation period 2016-2018

Carrying out the characterization of climatic elements from the perspective of the initiation of binary and tertiary ecological indices, it can be said that year 2016 was a year of moisture deficiency during the grape maturing period. Year 2017 was a year with normal heliothermal resources, and 2018 was a year with surplus water resources (a rainy year).

Generally, in the Murfatlar viticultural area, the bursting of buds is triggered in the second half of April. In 2016, as a result of the excessively high thermal energy active balance and the recorded pedological and atmospheric drought, the bursting of buds started earlier in the first decade of April, one week earlier. In the other years, the phenomenon triggered a specific pathway of the area (Table 2). The blossoming took place in the last decade of May and the first decade of June with a very high intensity amid heavier and more intense heliothermic conditions for this period.

During this time, the pedologic and atmospheric drought, installed in July and August 2016, and at the end of July and early August 2017, determined the varieties studied to show a tendency to start the veraison very early (the first half of the month August).

The duration of the ripening process is different depending on the variety, the climatic conditions and agrotechnical method applied, being 25-30 days for the early varieties, 40-50 days for the medium ones and 50-60 days for the late ones (Obloşteanu et al., 1980; Oprea, 1995).

Full maturity for all varieties was reached in the second half of September. The maturing period amounted to 40-50 days and the technological maturity (variety harvest) in the years 2016 and 2017 was achieved 1-2 days after it.

In 2018, it took a longer period to reach technological maturity because the grape sugar accumulation was slower as a result of the pluviometric surplus and low sunstroke, recorded during the ripening period of the grapes. In Table 2 it can be observed that the triggering of the vegetation phenophases is almost simultaneous, and there were no big differences between varieties (3-5 days).

The pluviometric surplus created by torrential rains registered in May, June - 2016 and 2017 helped to preserve the vigor of the plants, but also to maintain a high atmospheric humidity. which favored disease attack. Including the late 2017 frost (-1.8˚C from 19.04, -1.9˚C from 21.04 and -1.1˚C from 23.04), which affected 3-5% of the already burst varieties (Feteasca neagra and Mamaia).

Another meteorological phenomenon with major repercussions on grapevine plantations and grape production was the hail that accompanied the rainstorms of 16 and 17.06.2018 and 22.07.2018 and affected the foliage and grapes. The wounds produced on leaves, sprouts and grapes, pluviometric excess during the vegetation period (370.1 mm), low sunstroke (1487.1 hours versus 1714.8 hours-multiannual average) contributed to the lowest harvest of the study period: 2.08 kg/ha in the Columna variety, 2.21 kg/ha in the Feteasca neagra variety and 2.38 kg/ha in the Mamaia variety.

The largest outputs were obtained in 2017, a normal year in terms of the evolution of climatic factors.

Analyzing from a qualitative point of view the results obtained in the three years of study, it was observed (Table 3) that the best accumulations in sugars were recorded in Feteasca neagra (228 g/l), Mamaia (218 g/l) and Columna (198 g/l) in 2016. Lower values were recorded in 2018, ranging from 177-196 g/l. The total acidity recorded quite low values ranging from 4.28-5.92 g/l tartaric acid, normal values for the ecosystem of Murfatlar viticultural center.

Table 2. Development of vegetation phenophases

Variety	Year	Burst of buds	Flowering	Veraison	Full maturity	Harvest date
		Data				
Feteasca neagra	2016	8.04	3.06	8.08	21.09	22.09
	2017	19.04	7.06	14.08	20.09	22.09
	2018	22.04	27.05	8.08	22.09	24,09
Columna	2016	11.04	4.06	9.08	20.09	22.09
	2017	27.04	10.06	16.08	21.09	21.09
	2018	24.04	30.05	6.08	21.09	26.09
Mamaia	2016	10.04	4.06	10.08	19.09	21,09
	2017	20.04	9.06	17.08	21.09	21.09
	2018	24.04	29.05	3.08	24.09	29.09

Table 3. Grape harvest quality in the three-year study period

Variety	**Year**	**Kg/vine**	**Quality level**				
			Sugar (g/)	**Acidity (g/l ac. tartric)**	**Varietal**	**VIGR***	**VDOC ****
					144.6-178.5	**178.6-187.0**	**>187.1**
Columna	2016	2.3±0.2 (ab)	198.1±0.2 (a)	4.28±0.23 (c)			x
	2017	2.52±0.2 (a)	180.9±0.1 (b)	4.89±0.28 (b)		x	
	2018	2.08±0.1 (b)	176.6±0.3 (c)	5.92±0.31 (a)	x		
Feteasca neagra	2016	2.41±0.1 (b)	227.9±0.1 (a)	5.06±0.18 (a)			x
	2017	2.83±0.2 (a)	212.9±0.1 (b)	5.32±0.25 (a)			x
	2018	2.21±0.1 (b)	195.9±0.2 (c)	4.43±0.20 (b)			x
Mamaia	2016	2.38±0.1 (b)	218.0±0.2 (a)	4.77±0.31 (a)			x
	2017	2.92±0.2 (a)	199.1±0.1 (b)	5.21±0.26 (a)			x
	2018	1.9±0.1 (c)	186.4±0.1 (c)	4.16±0.22 (b)		x	

Average values ± standard errors (n=3). The letters in the brackets show the statistical difference among results for p<0,05.For the same compound, a common letter for 2 or more variants shows no significant difference among them.

**VIGR= Wine with a recognized geographic indication, **VDOC= Wine with a registered designation of origin*

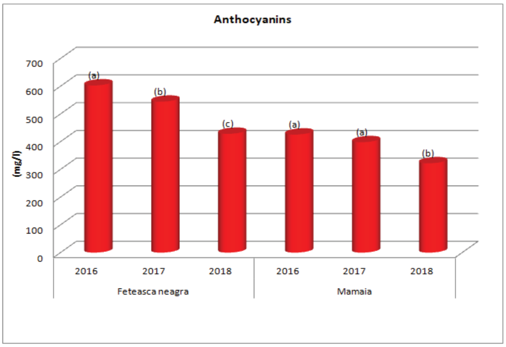
As can be seen in Table 4, the wines obtained showed an hight alcoholic content in 2016, ranging from 12.5-13.23% vol, considering that the wines fermented until the sugar was exhausted and had become dry 4.0 g/l). The best values of the alcoholic concentration were recorded in the Feteasca neagra variety, followed by the Mamaia variety and the Columna. The wines showed a balanced acidity ranging from 5.20-7.98 g/l of $C_4H_6O_6$ depending on the qualitative potential of the studied varieties. Volatile acidity values are very important because they indicate the state of health of the wine and condition the quality category in which it can fit. In this study, volatile acidity oscillated between 0.36-0.68 g/l CH_3COOH which confirms that volatile acids were formed only during alcoholic and malolactic fermentations. In general, the non-reducing extract of Romanian quality wines must have values ranging from 17-30 g/l, depending on the specificity of the vineyard, the variety and the conditions of the year. For the analyzed varieties, the non-reducing extract showed values ranging from 19.0-26.4 g/l, normal values for young white and red wines, similar results were obtained by other researchers (Artem et al., 2013, Ranca et al., 2013, Artem et al., 2015).

Table 4. Physico-chemical characteristics of wines obtained during the three years of study

Variety	Vintage	Alcoholic strength (% vol)	Reducing sugars (g/l)	Total acidity (g/l ac tartric)	Volatile acidity (g/l ac acetic)	Total extract (g/l)	Non-Reducing Extract (g/l)
Columna	2016	11.41±0.2 (a)	2.3±0.1 (a)	7.22±0.21 (b)	0.53±0.11 (a)	22.1±0.2 (a)	19.8±0.2 (a)
	2017	10.4±0.1 (b)	1.5±0.1 (b)	7.72±0.25 (ab)	0.36±0.15 (a)	20.5±0.1 (b)	19.0±0.1 (b)
	2018	10.2±0.1 (b)	1.2±0,2 (c)	7.98±0.30 (a)	0.44±0.18 (a)	19.7±0.1 (c)	18.5±0.1 (c)
Feteasca neagra	2016	13.23±0,2 (a)	3.0±0.2 (a)	6.54±0.18 (b)	0.68±0.20 (a)	29.4±0.2 (a)	26.4±0.2 (a)
	2017	12.3±0.1 (b)	1.8±0.1 (b)	6.62±0.12 (ab)	0.38±0.13 (b)	26.0±0.1 (b)	24.2±0.2 (b)
	2018	11.3±0.2 (c)	1.6±0.2 (b)	6.87±0.15 (a)	0.48±0.15 (ab)	24.2±0.2 (c)	22.6±0.1 (c)
Mamaia	2016	12.5±0.1 (a)	2.9±0.1 (a)	5.2±0.19 (a)	0.68±0.11 (a)	25.2±0.2 (a)	22.3±0.1 (a)
	2017	11.6±0.1 (b)	1.6±0.1 (b)	5.31±0.24 (a)	0.38±0.19 (b)	22.1±0.1 (b)	20.5±0.1 (b)
	2018	10.8±0.1 (c)	1.5±0.1 (c)	5.44±0.26 (a)	0.55±0.12 (ab)	21.3±0.1 (c)	19.8±0.2 (c)

Average values ± standard errors (n=3). The letters in the brackets show the statistical difference among results for p<0,05. For the same compound, a common letter for 2 or more variants shows no significant difference among them

In 2016, due to the climatic conditions with slightly lower temperatures during the vegetation period and with precipitations closer to the average of the last 10 years, the accumulation of color compounds was superior, the total anthocyanins registered values of 602.8 mg/l (for Feteasca neagra) and 425.6 mg/l for Mamaia compared with 2018 when the anthocyanin content was only 428.3 mg/l (Feteasca neagra) and 322.0 mg/ l for Mamaia. Regarding total of polyphenols, the situation was similar, but with smaller variations. Thus, the total polyphenols content was 1257 mg/l for Feteasca Neagra and 859 mg/l for Mamaia in 2016, decreasing in 2018 to 978 mg/l for Feteasca Neagra and 645 mg/l for Mamaia similar results were obtained by other researchers (Artem et al., 2014).



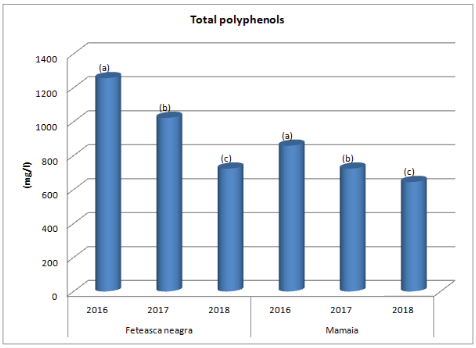


Figure 2. Phenolic potential of the Feteasca neagra and Mamaia varieties in the three years of study

CONCLUSIONS

The increase in temperature values influenced the beginning of the bursting of the buds in the first half of April, a week earlier than the Murfatlar's wine-growing season (the last decade of April);

The pedological and atmospheric drought installed in July and August 2016 and at the end of July and early August 2017 determined the varieties studied to show a tendency to start veraison very early (first half of August)

The pluviometric excess and the low sunstroke of the grapes maturing period (in 2018) influenced the quantity and quality of the production of grapes - the smallest yields were obtained with the lowest sugar content, and the red wines the lowest content anthocyanins and total polyphenols.

The quality of the grapes and the wines obtained have qualitative characteristics that allow them to be classified as quality wines. Regarding the phenolic potential given by the total anthocyanins and polyphenols, it reflects in the first place the characteristics of the variety, but also the footprint of the viticultural area and of the climatic conditions.

Knowing the interference of environmental factors with wine production helps to develop practices that tend to diminish the impact of extreme climatic phenomena, preventing and diminishing the effects on the quantity and quality of grape production and implicitly on the quality of wines.

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