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RESEARCH ON CLIMATE TRENDS IN THE AREA OF ODOBEŞTI VINEYARD

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Abstract

The reality of climate change is accepted by the vast majority of the scientific community (IPCC, 2014). Among human activities, agriculture - especially viticulture - is highly dependent on climatic conditions during the growing season. This paper aims to address a complex study on the evolution / trend of the main annual climate indicators and during the vegetation period (air temperature, precipitation, insolation, air hygroscopicity) and climate indicators with synthetic character (Ihr, CH, Ibcv , IAOe) in the viticultural area of Odobeşti vineyard. The climatic data analyzed in this study were recorded at the weather station of R.S.V.O. Odobeşti, in the period 1946-2020, during 75 years. The analysis of the recorded data highlighted clear trends in the evolution of climatic factors in the Odobeşti wine ecosystem, which certifies the reality of phenomena specific to climate change, with a direct impact on the vegetative and productive potential of vineyards. There is an increase in the annual and average values of the analyzed climatic indicators and an increasing frequency of extreme climatic phenomena.

Key words*: climate change, climate indicators, grapevine, Odobeşti.*

INTRODUCTION

Climate plays a vital role in the terroir of a particular wine region, as it strongly controls the canopy microclimate, vine growth, vine physiology, grain yield and composition, which together determine the attributes and typicality of wine (Santos et al., 2020).

Each main wine region of the world can be characterized by average climatic conditions that are the drivers of the typicality of the region's wine. However, new challenges are expected to arise due to climate change, as the cultivation of vines is deeply dependent on weather and climate conditions.

Global warming is a phenomenon that has strongly characterized the last decades with the effect of disrupting the evolution of natural factors of ecosystems. In the case of wine ecosystems, changes in temperature and expected rainfall can lead to changes in vegetation periods, variety zoning and many other changes that cannot be predicted at present, but which can increase over time and have a negative impact. Predictions based on global climate patterns show that we can expect more frequent occurrence of extreme weather events, and the associated risks and harms may become significant (Van Leeuwen et al., 2016). The main effects of climate change are: increased temperature during the growing season; increase in growing degree-days; increase in mean temperature during fruit ripening; increase in mean temperature of the warmest month of the growing season; increase in mean temperature of the coldest month of the growing season; increass in length of the growing season (frost-free days); occurrence of extreme winter minimum temperatures; increases in precipitation for July through October; increase in precipitation seasonality (coefficient of variation); change in the aridity index (Gladstones, 2011; Roehrdanz and Hannah, 2016).

These changes may reshape the geographical distribution of wine-growing regions, while the typicality of wine may also be threatened in most cases. Climate change will thus require the implementation of timely, appropriate and cost-effective adaptation strategies, which must be sufficiently planned and adapted to local conditions for effective risk reduction (Fraga et. al., 2012).

In this context, the paper present an analysis of the evolution of the main climate indicators and climate indicators with synthetic character recorded in 1946-2020 period in the viticultural area of Odobeşti vineyard.

MATERIALS AND METHODS

Odobeşti vineyard is located in the area of the curvature subcarpathians whose climate strongly influences the climate of the vineyard, having three wine centers: Odobeşti, Jariştea and Boloteşti. It occupies the hilly area parallel to the Vrancea Mountains, which includes the city of Odobeşti, under the shelter of the highest hill, Măgura Odobeştilor (996 m) with the famous plains Șarba, Vărsătura, Pădureni and Scânteia (Figure 1). The Odobeşti wine center is delimited by the parallel 45° 46" north latitude and the meridian 27° 40" east longitude at an altitude of 150 m.

In order to evaluate and characterize the climatic tendencies in the viticultural area of Odobeşti vineyard, the evolution of the main annual climatic indicators was analyzed (average air temperature, sum of precipitations, sum of sunlight hours, hygroscopicity of air, etc.), thermal and hydric regime of vegetation period (average temperature, amount of precipitation, average temperature of the hottest month - July, average maximum temperatures in August, number of days with temperatures above 30ºC) and synthetic climate indicators: heliothermal index - Ihr (Branas, 1946), the hydrothermal coefficient - CH (Seleaninov, 1936), the bioclimatic index of the vine - Ibcv (Constantinescu, 1964), the oenoclimatic aptitude index - IAOe (Teodorescu, 1978).

The climatic data recorded at the weather station of R.S.V.O. Odobeşti in the years 1946-2020 were analyzed. The data collected over 75 years were centralized in a database used to calculate the main climate balance and synthesis indicators. The values for two periods were calculated and compared: the period 1946-2000 (55 years) and 2001-2020 (20 years).

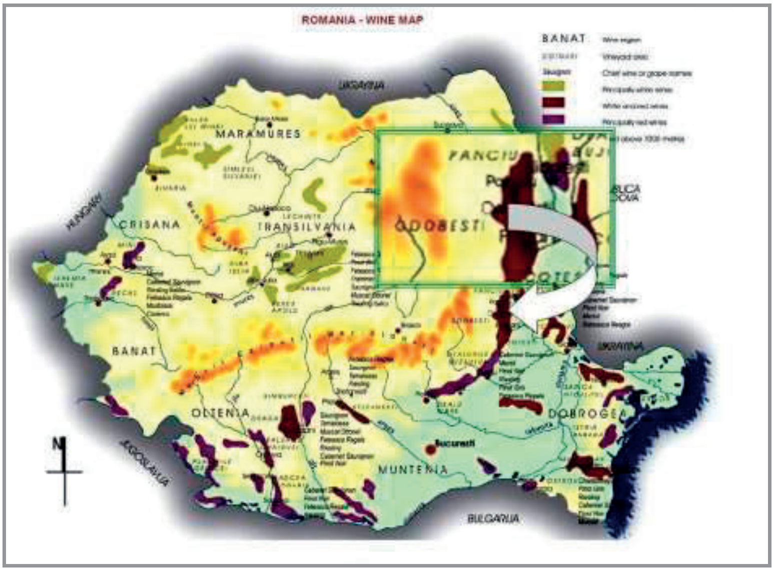

Figure 1. The viticultural area of Odobeşti vineyard

RESULTS AND DISCUSSIONS

The evolution of the thermal regime. Global climate warming, a phenomenon that has strongly characterized the last decades, has considerably influenced both the evolution of the annual thermal regime and the thermal regime during the vegetation period in the viticultural ecosystem of Odobeşti vineyard (Figure 2). The analysis of the data recorded during the study period (1946-2020) found that the average annual temperature had a general upward evolution with a clear upward trend in the last 20 years, when a surplus of 0.7ºC was recorded, compared to the average for the period 1946-2000 (Table 1). If in the period 1946-2000 (55 years), 11 years were recorded with values of the average annual air temperature above 11ºC, representing a frequency of 20.00%, in the last two decades (2001-2020), were recorded recorded 14 years with values of average annual air temperature above 11ºC, representing 70.00%. The increase of the average annual air temperature has been demonstrated more and more strongly in the last 7 years (2014-2020), a period in which values of over 12ºC, and even 13ºC (2015, 2020) were constantly registered.

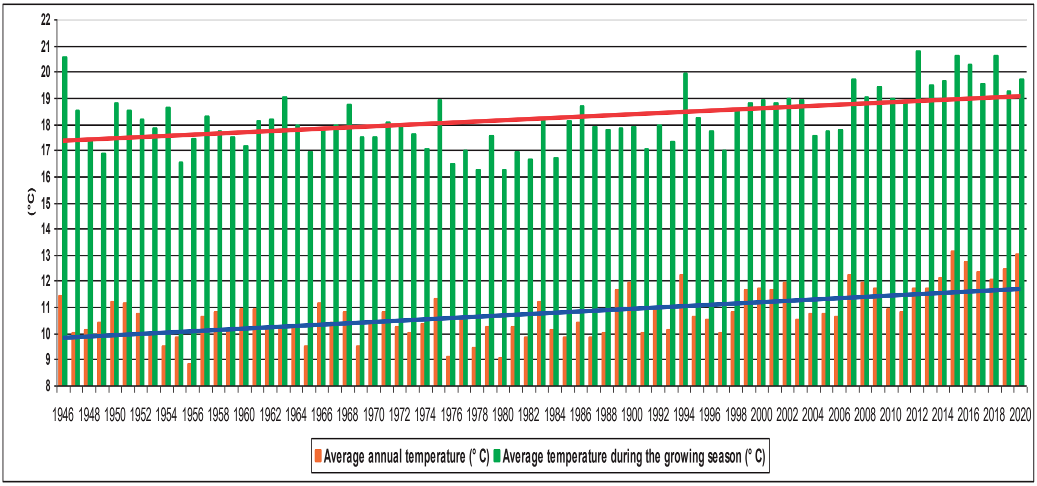

Figure 2. Evolution of the average annual temperature and of the average temperature during the vegetation period (Odobeşti, 1964-2020)

Table 1. Characteristics of the evolution of the thermal regime in the Odobeşti vineyard (1946-2020)

Climate indicator	Characteristics	Period	
		1946-2000 (55 years)	2001-2020 (20 years)
Average annual air temp. (°C)	Mean ºC	10.4	11.7
	No. years with temp.. > 11ºC	11	14
	Frequency (%)	20.00	70.00
Average air temp. during the growing season (°C)	Mean	17.8	18.3
	No. years with temp. > 19ºC	2	11
	Frequency (%)	3.64	55.00
Average air tem. in the warmest month (July)	Mean	21.7	22.1
	No. years with temp. > 23ºC	7	11
	Frequency (%)	12.73	55.00
Average air temp. of the maxime in August	Mean	27.3	28.1
	No. of years with temp.> 29ºC	10	13
	Frequency (%)	18.18	65.00
Nr. days with temperatures > 30ºC (average value)		23..3	42.9
∑ºt active during the veg. period		3143	3295
∑ºt useful during the veg. period		1488	1660

The values of the average air temperature during the vegetation period (April-September) also registered an ascending evolution, more accentuated in the last two decades (18.3ºC), with a surplus of 0.5ºC compared to the period 1946-2000 (17.8ºC). The incidence of years with average air temperature during the vegetation period > 19ºC was 55.00% (11 years) in the last twenty years, compared to 3.64% (2 years) in the period 1946-2000. From the analysis of the data presented in figure 2 it is found that if in the period 1946-2000 the years with values of average air temperature above 19 ºC were exceptions, in the last twenty years they have become a constant.

The average temperature of the warmest month (July) increased on average by 0.4 ºC during the years 2001-2020 (22.1ºC), compared to the average value recorded in the period 1946-2000 (21.7ºC). Also, the average maximum temperatures in August increased by 0.8ºC in the period 2001-2020 (28.1ºC) compared to the average value in the period 1946-2000 (27.3ºC), and the frequency of years with average temperatures of August highs > 29ºC increased from 18.18% (10 years) in the period 1946-2000 to 65.00% (13 years) in the period 2001-2020. Another important indicator that confirms the intensity of the global warming phenomenon is represented by the number of days with temperatures higher than 30ºC, whose average value increased from 23.93 days in the period 1946-2000 to 42.90 days in the period 2001-2020, representing an average increase of 18, 97 days/year (Figure 3).

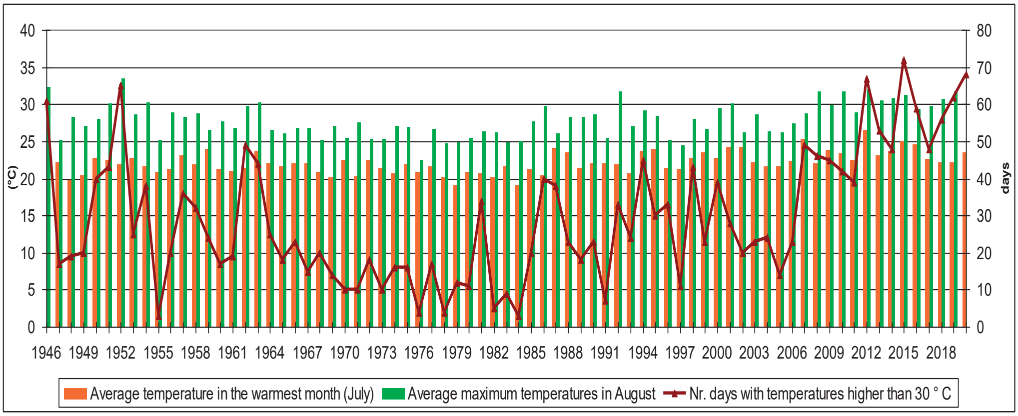

Figure 3. Evolution of the indicators of the thermal regime during the summer (Odobeşti, 1964-2020)

Thermal balance indicators during the vegetation period, respectively the sum of the degrees of active temperature (∑ºt active) and the sum of the degrees of useful temperature (∑ºt useful) also had a more ascending evolution in the last two decades (Figure 4).

The analysis of the data presented in table 1 shows an increase in the value recorded for the active heat balance during the vegetation period on average by 152 ºC in the last two decades (3295ºC), compared to the period 1946-2000 (3143ºC).

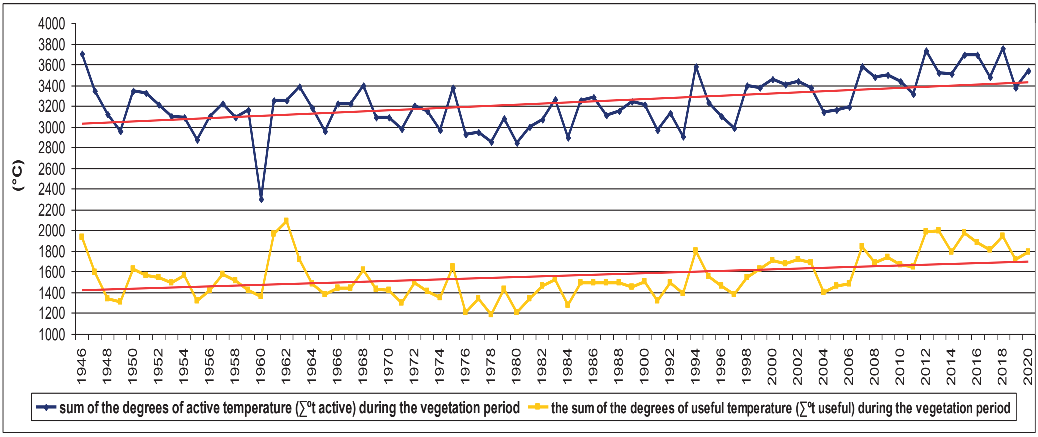

Figure 4. Evolution of thermal balance indicators during the vegetation period (Odobeşti, 1964-2020)

The evolution of the precipitation regime. The sum of the annual precipitations and the amount of precipitations fallen during the vegetation period registered an ascending trend (Figure 5). It is observed that in the first part of the period studied (1946-1968), with two exceptions (years 1954 and 1966), the values for the sum of annual precipitation did not register large differences from one year to another. Starting with 1969 year, the values recorded for this indicator showed significant differences, alternating a period of 2-4 rainy years with 1-2 years drier. The driest years recorded in the study period (1946-2020) were recorded in years 1946, 1952, 1986, 1994 and 2020.

The average amount of annual precipitation recorded in the last 20 years (644.6 mm) increased compared to the average value for the period 1946-2000 (608.0 mm) by 36.6 mm (Table 2). The incidence of years with total annual rainfall greater than 600 mm increased by 6.36% in the last two decades (50.00%) compared to 1946-2000 period (43.64%).

Also, the frequency of years with annual rainfall less than 450 mm increased by 5.91% in the last 20 years (15.00%) compared to 1946-2000 period (9.09%).

Thus and the value for the average amount of precipitation recorded during the vegetation period has increased in the last two decades (411.0 mm) by 30.3 mm compared to the average value for the period 1946-2000 (380.7 mm).

The frequency of years with precipitation values recorded during the vegetation period less than 250 mm decreased by 2.73% in the last 20 years compared to 1946-2000 (12.73%).

Table 2. Characteristics of the evolution of the rainfall regime in the Odobeşti vineyard (1946-2020)

Climate indicator	Characteristics	Period	
		1946-2000 (55 years)	2001-2020 (20 years)
The annual rainfall	Average amount (mm)	608.0	644.6
	No. years with average amount > 600 mm	24	10
	Frequency (%)	43.64	50.00
	No. years with average amount < 450 mm	5	3
	Frequency (%)	9.09	15.00
The rainfall during the growing season	Average amount (mm)	380.7	411.0
	No. years with average amount < 250 mm	7	2
	Frequency (%)	12.73	10.00
	Percentage of annual rainfall (%)	62.64	64.18

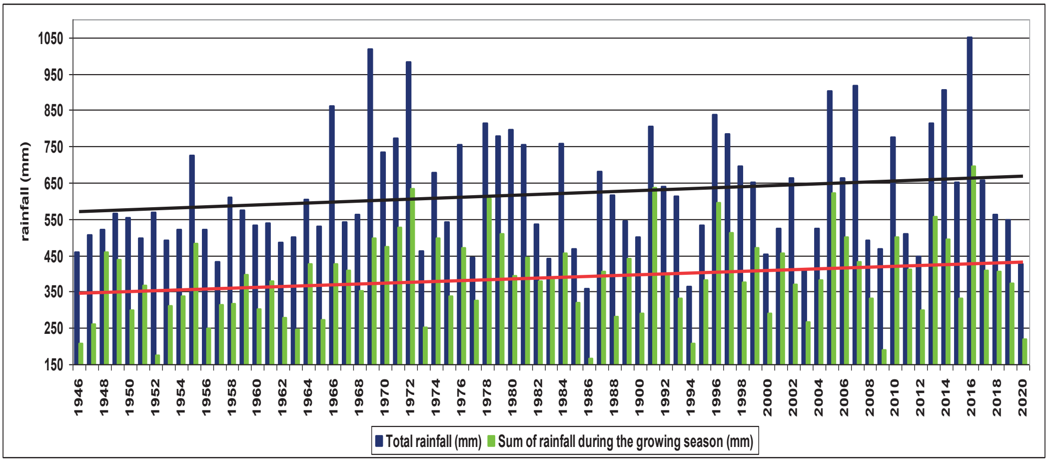

Figure 5. Evolution of the precipitation regime in the area of Odobeşti vineyard (1964-2020)

A very important indicator regarding the precipitation regime is the distribution of precipitations during the year. In the period of years 1946-2000, the amount of precipitation registered during the vegetation period of the vine represented on average 62.64% of the total annual precipitation, increasing on average by 1.54% in the last 20 years (64.18%). The unbalanced distribution of annual precipitation reported to the vegetation period was recorded in 1946, 1952, 1956, 1969, 1986, 1988, 2007 and 2009.

The evolution of the insolation and air hygroscopicity. The sum of the hours of sunshine and the hygroscopicity of the air during the vegetation period are other important indicators for the grapevines (Figure 6).

The average value calculated for the duration of sunshine during the vegetation period in the last two decades is 1586 hours, on average 126 hours higher compared to the average of years 1946-2000 (1586 hours).

Thus, and for the humidity of the air during the vegetation period there was an average increase of 3.4%, from 63.1% average value in the period years 1946-2000 to 66.5% in the last two decades (2001-2020).

Table 3. Characteristics of the evolution of the sum of sunlight hours and the hygroscopicity of air in the vegetation period in the Odobeşti vineyard (1946-2020)

Climate indicator	Characteristics	Period	
		1946-2000 (55 years)	2001-2020 (20 years)
The sum of sunlight hours in the vegetation period	Average value (hours)	1460	1586
The hygroscopicity of air in the vegetation period	Average value (%)	63.1	66.5

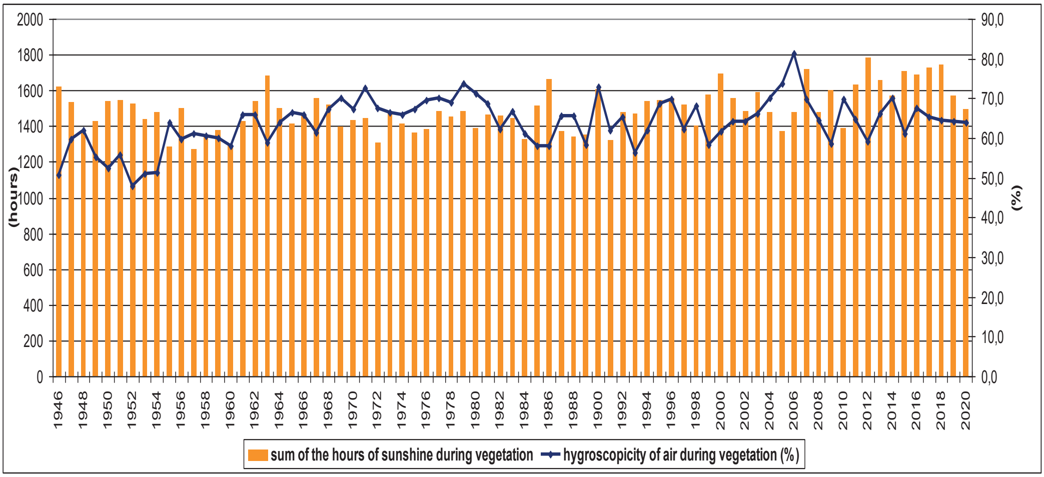

Figure 6. Evolution of the insolation and air hygroscopicity in the area of Odobeşti vineyard (1964-2020)

The evolution of synthetic climate indicators. For the assessment of the heliothermal and hydric resources of a vineyard, a series of synthetic indicators are used that integrate the combined action of two or three ecoclimatic factors (Ţârdea and Dejeu, 1995). The main climatic indicators with synthetic character important for the vine culture are: the heliothermal index - Ihr (Branas, 1946), the hydrothermal coefficient - CH (Seleaninov, 1936), the bioclimatic index of the vine - Ibcv (Constantinescu, 1964), the aptitude index oenoclimatics - IAOe (Teodorescu, 1978). The evolution of the synthetic climatic indicators in the viticultural area of the Odobeşti vineyard in the period 1946-2020 is presented in Figure 7.

The real heliothermal index (IHr) is calculated according to the formula:

$$IH_r = \sum t^o_u \times \sum i_r \times 10^{-6}$$

where: $\sum t^o u$ - the sum of the useful temperature degrees during the vegetation period; $\sum ir$ - the sum of the hours of insolation during the vegetation period.

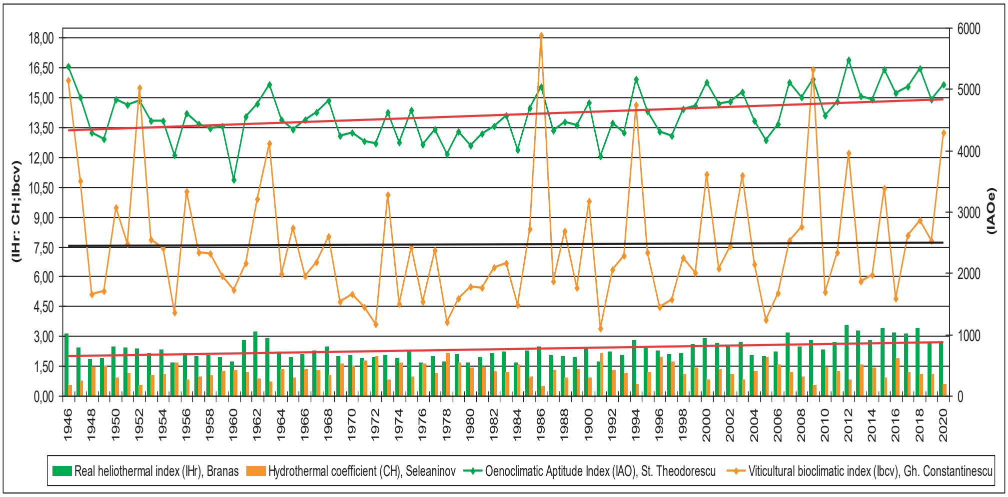

Figure 7. Evolution of the synthetic climate indicators in the area of Odobeşti vineyard (1964-2020)

In the environmental conditions of our country, the real heliothermal index varies between the limits of 1.35-2.70, the highest values being found in the southern vineyards with increased heliothermal availability (Oşlobeanu et al., 1991).

In the ecoclimatic conditions of the Odobeşti vineyard, the real heliothermal index registered an ascending evolution, the average value calculated for the last 20 years (2.78) increased by 0.6 compared to the average value calculated for the period years 1946-2000 (2.18) (Table 4).

The hydrothermal coefficient (CH) is calculated according to the formula:

$$CH = (\sum p / \sum t^o{}_a) \times 10$$

where: ∑p - the sum of the precipitations during the vegetation period; ∑ta - the sum of the degrees of active temperature during the vegetation period.

CH values in Romania vary between 0.6 and 1.8, and at minimum values (0.6-0.7) the vine culture becomes economical in irrigated regime (Ţârdea and Dejeu, 1995).

Under the conditions of the Odobeşti vineyard, the hydrothermal coefficient registered a slightly downward evolution, the average value calculated for the last 20 years (1.19) decreased by 0.4 compared to the average value calculated for the period years 1946-2000 (1.23).

The bioclimatic index of the vine (Ibcv) integrates the combined action of temperature, insolation and humidity and is calculated according to the formula:

$$Ibcv = (\sum t^o{}_u * \sum i_r) \times (\sum p * N_{zv})/10$$

where: ∑ta - the sum of the degrees of useful temperature during the vegetation period; $\sum i_r$ - the real insolation during the vegetation period; ∑p - the sum of the precipitations during the vegetation period; Nzv - the number of days in the vegetation period.

In the conditions in our country the Icbv values vary between 4 and 15 (Ţârdea and Dejeu, 1995). In the Odobeşti vineyard the values of the viticultural bioclimatic index had a slightly ascending trend, the average value for the last two decades (8.15) increasing by 0.75 compared to the average value calculated for the period years 1946-2000 (7.40).

The oenoclimatic aptitude index (IAOe) determines the degree of climate favorable that a region has to synthesize anthocyanins in grapes and, in general, to produce red wines.

The oenoclimatic aptitude index is calculated according to the formula:

$$IAOe = T + I - (P - 250)$$

where: T - sum of degrees of active temperature in the range 01.IV - 30. IX; I - the sum of the hours of insolation in the same interval; P - the sum of precipitation from the same period.

Table 4. Characteristics of the evolution of synthetic climate indicators in the Odobeşti vineyard (1946-2020)

Synthetic climate indicator	Period /average value	
	1946-2000 (55 years)	2001-2020 (20 years)
The heliothermal index - IHr (Branas, 1946)	2.18	2.78
The hydrothermal coefficient - CH (Seleaninov, 1936)	1.23	1.19
The bioclimatic index of the vine - Ibcv (Constantinescu, 1964)	7.40	8.15
The aptitude index oenoclimatics - IAOe (Teodorescu, 1978)	4472	4890

On the Romanian territory, the values of this index are between 3700 and 5200, the viticultural areas with values of over 4600 present favorable conditions for the production of red wines (Teodorescu et al., 1987).

Due to the climatic conditions registered in the Odobeşti vineyard in the last 20 years, the value of the oenoclimatic aptitude index also had an ascending evolution.

It increased on average from 4472 in the period years 1946-2000, to 4890 in the last two decades, changing the classification of the viticultural area of the Odobeşti vineyard in the region with medium favorability for the production of red wines in a favorable area for this production direction.

CONCLUSIONS

The annual thermal regime and during the vegetation period registered a surplus of 0.7ºC, respectively 0.5ºC in the last two decades compared to the period 1946-2000.

Other indicators that confirm the intensity of the global warming phenomenon are the average temperature of the warmest month (July), the average maximum temperatures in August and the number of days with temperatures higher than 30ºC, whose value increased on average by 18.97 days/year in the last 20 years.

The regime of annual precipitation and during the vegetation period registered an increase in the last two decades, with the accentuation of the unbalanced distribution, alternating 2-4 rainy years with 1-2 drier years.

Climate indicators with synthetic character (Ihr, Icbv, IAOe) have had an ascending evolution in the last two decades, the value of IAOe classifying the viticultural area of Odobeşti vineyard in the area with favorable conditions for obtaining red wines.

The analysis of the data registered in the last 20 years in the Odobeşti viticultural ecosystem, highlighted clear trends in climate evolution, which certify the reality of the phenomena specific to climate change.

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