THE EVOLUTION OF CLIMATIC CONDITIONS BETWEEN 1989 AND 2021 IN REPRESENTATIVE VINE AREAS OF ROMANIA

EVOLUŢIA CONDIŢIILOR CLIMATICE DIN PERIOADA 1989 – 2021, ÎN AREALELE VITICOLE REPREZENTATIVE ALE ROMÂNIEI

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Abstract. *In order to study the impact of global climate changes on the viticultural ecosystem of the vineyards: Iaşi, Dealu Mare, Târnave, Dealu Bujorului, Murfatlar and Odobeşti a database spanning 33 years (1989 – 2021) was created. This database will be used to optimize the zonation of vine varieties for the expansion of the viticultural areas and the replanting of existing ones. In order to establish the ecoclimatic potential for the viticultural areas, climatic factors for vine culture were analyzed and categorized within favorability classes. Thus, all vineyards were classified in favorability class I for the thermal factor (average annual temperature, average temperature in July, useful heat balance), which indicates an abundance of these resources, with the possibility of obtaining quality white and red wines.*
Key words: vineyard, viticultural ecosystem, climatic conditions

Rezumat. *Pentru a studia impactul schimbărilor climatice globale asupra ecosistemelor viticole ale podgoriilor: Iaşi, Dealu Mare, Târnave, Dealu Bujorului, Murfatlar şi Odobeşti a fost realizată o bază de date pe o perioadă de 33 de ani (1989 – 2021). Aceste baze vor fi folosite la optimizarea zonării soiurilor de viţă-de-vie în perspectiva extinderii suprafeţelor viticole şi a replantării celor deja existente. Pentru a stabili potenţialul ecoclimatic pe areale viticole, în lucrare, au fost analizaţi factorii climatici restrictivi pentru cultura viţei-de-vie şi s-a facut încadrarea în clase de favorabilitate. Astfel, toate podgoriile au fost încadrate în clasa de favorabilitate I pentru factorul termic (temperatura medie anuală, temperatura medie din luna iulie, bilanţul termic util), ceea ce indică o abundenţă a acestor resurse, cu posibilitatea obţinerii de vinuri albe şi roşii de calitate.*
Cuvinte cheie: podgorie, ecosistem viticol, condiţii climatice

INTRODUCTION

The qualitative and quantitative potential of the vine varieties is different depending on the area where they are grown, being influenced by the culture technology used and also by the climatic conditions (Pomohaci *et al*, 2000). Climate

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changes have determined major changes in the spatial distribution of wine-growing areas, as well as on the favorability of culture for grapevine varieties. Recent researches have highlighted the shift of the area of favorability for the cultivation of the vine towards the north of the country, the tendency to increase the suitability for the cultivation of the red varieties sometimes to the detriment of the white ones, as well as changes in the productive potential of the varieties (Irimia, 2012).

Considering these trends and the knowledge of the possible negative effects on the vines, future zonation of vine requires the reconsideration and the application of technological measures to minimize the negative effects of climate changes (Bucur and Dejeu 2016).

MATERIAL AND METHOD

The databases created in the 6 vineyards studied include the following factors: thermal regime (average, maximum and minimum values), rainfall regime (annual and during the growing season), actual insolation, duration of the bioactive period and synthetic climate indicators. To assess the heliothermal and water resources of a vineyard or wine-growing center, a series of synthetic ecological indicators were used: the real heliothermal index, the hydrothermal coefficient, the bioclimatic index of the vine, the oenoclimatic suitability index, the Huglin heliothermal index, the cooling index of the nights. To evaluate the ecological favorability of the studied vineyards, the rating system proposed by Irimia L. and Rotaru Liliana 2009 was used.

RESULTS AND DISCUSSIONS

The evolution of temperatures.

The influence of temperature is important both on the sum of degrees (global, active and useful thermal balance) and on certain temperature levels (minimum, maximum, average). In the vineyards of our country, a global heat balance is recorded between 2700 – 3600 ºC, the active one between 2600 and 3500 ºC, and the useful one between 1000 and 1700 ºC (Oşlobeanu *et al.* 1991).

In 1989 – 2021 period, *the global heat balance ($\sum t^o g$)*, in the studied vineyards, recorded average values between 3256.8 ºC in the Iasi vineyard and 4806.4 ºC in the Murfatlar vineyard (tab. 1). This fact shows us that the conditions are ensured for ripening grapes up to the V and VI eras in the Iasi vineyard and up to the VII era in Murfatlar. *The active thermal balance ($\sum t^o a$),* considered the biological threshold of grapevine growth, varied between 3146.8 ºC (Iasi) and 4311.4 ºC (Murfatlar). *The useful thermal balance ($\sum t^o u$)* had values between 1455.0 ºC (Târnave vineyard) and 2190.9 (Murfatlar).

The average annual temperature for the analyzed period was 10.3 ºC in Iasi, a similar value was also recorded in the Târnave vineyard (10.6 ºC), and higher values were in the Dealu Mare vineyards (12.2 ºC) and Murfatlar (13.2 ºC). *The absolute minimum temperatures* in the air ranged from -27.2°C in the Iasi to -18.8 ºC in Dealu Mare vineyard.

Table 1

The main climatic elements in the studied vineyards (1989 – 2021)

Climatic elements analyzed	Iaşi	Dealu Mare	Târnave	Dealu Bujorului	Murfatlar	Odobeşti
Global heat balance, (Σt°g)	3256,8	3551,0	3296,0	3627,0	4806,4	3537,2
Active heat balance, Σt°a)	3146,8	3508,0	3243,1	3565,0	4311,4	3365,7
Useful heat balance, (Σt°u)	1472,7	1742,0	1455,0	1798,0	2190,9	1656,4
Average temperature July, °C	22,0	23,6	21,5	25,2	25,7	23,0
the absolute minimum temperature in the air,°C	-27,2	-18,8	-24,7	-25,5	-22,0	-22,1
Average annual temperature T°C	10,3	12,2	10,6	11,6	13,2	11,4
Absolute maximum temperature in the air,°C	42,3	26,9	41,6	41,5	44,0	39,4
Σ annual precipitation, mm	584,3	637,1	620,2	461,9	512,7	629,5
Σ of precipitation during the vegetation period, mm	389,9	405,4	428,6	292,9	315,4	406,6
Σ hours of insolation during the vegetation period, hours	1470,6	1487	1371,8	1328,8	1617,1	1563,8
Average maximum temperatures in August,°C	27,7	29,5	29,6	29,5	30,8	31,9
Medium temperature decades I and II June	19,7	21,2	19,2	21,6	22,8	20,6
No. days with maxim temp. > 30°C	27,8	33,8	33,4	40,7	52,3	37,0
Duration of the bioactive period, no. days	172,8	187,7	174,2	181,9	188,4	181,2
The real heliothermal index (IHr)	2,2	2,4	1,4	2,3	3,7	2,6
Hydrothermal coefficient (HC)	1,3	1,1	1,3	0,9	0,8	1,2
The vine bioclimatic index (Ibcv)	7,6	8,2	6,8	9,7	13,4	7,9
The oenoclimate aptitude index (IAOe)	4481,8	4691	4563,6	4705,3	5192,8	4773,3
The Huglin heliothermal index (IH)	2103,4	1861	2799,9	2292,2	3209,9	2575,1
Indicele de răcire a nopţilor (IF)	11,2	12,7	10,1	10,9	12,8	9,0

The maximum temperature recorded in 1989 - 2021 period in the air was above 40 ºC in the majority of vineyards studied, in Murfatlar was 44.0 ºC in 2000, in Iasi 42.3 ºC in 2007, in Târnave vineyard 41.6 ºC in 2012 and at Dealu Bujorului 41.5 ºC also in 2012. The optimal temperature for the activity of grapevine photosynthesis is between 25 - 30 ºC, and temperatures higher than 40 - 42 ºC are restrictive for its culture.

The average temperature of the warmest month (July) constitutes a criterion for assessing the quality conditions of the grapes. Under the conditions of Romania, the lower limit is 18.5 ºC, and the upper limit is 23.2 ºC. As this value increases, higher concentrations of sugars, flavors, color, phenolic substances, etc. can be obtained. During the analyzed period, it had an average value of 21.5 ºC in the Târnave vineyard and 25.7 ºC in the Murfatlar vineyard.

The average maximum temperature in August is a limiting factor only when it exceeds 34.0 ºC. In Iasi, it was 27.7 ºC with an increasing trend in recent years and up to 31.9 ºC in the Odobeşti vineyard.

The average temperature in the first and second decades of June, which conditions the date of flowering and the duration of this phenophase, in the conditions of the viticultural ecosystems studied, had medium values between 19.2 ºC (Târnave) and 22.8 ºC (Murfatlar). The lower biological threshold for flowering is between 15 and 17 ºC, and the optimal temperature for this phenophase is 20 - 25 ºC (Ţârdea and Dejeu, 1995). *The number of days with maximum temperatures higher than 30.0 ºC* varies in the conditions of our country within very wide limits (7 - 42). In the vineyards studied, it was between 27.8 days (Iasi), 33.4 days (Târnave), 33.8 days (Dealu Mare), 37.0 days (Odobeşti), 40.7 days (Dealu Bujorului) and 52.3 days (Murfatlar).

The sum of the hours of insolation during the vegetation period, under normal ecoclimatic conditions, in the vineyards and vine centers of our country is between 1200 and 1600 hours. Values below 1200 hours are considered restrictive. In the analyzed areas, a values of 1328.8 hours were recorded at Dealu Bujorului and up to 1617.1 hours at Murfatlar and intermediate values were recorded in the other vineyards.

The duration of the bioactive period (days), during the analyzed period, varied between 172.8 days in Iasi and up to 188.4 days in the Murfatlar vineyard.

The evolution of precipitation. The annual precipitations, during the analyzed period, were on medium, from 461.9 mm at Dealu Bujorului and up to 637.1 mm at Dealu Mare. In recent years, we are witnessing on a decrease in the precipitation regime, compared to the multi-annual average, with an uneven distribution of them during the year noted. Precipitation during the vegetation period was from 292.9 mm at Dealu Bujorului to 428.6 mm in the Târnave vineyard. The least precipitation was recorded in the Dealu Bujorului vineyard and the most in the Dealu Mare and Târnave vineyard.

Synthetic ecoclimatic indicators.

The real heliothermal index (IHr), on the territory of our country, has values between 1.35 and 2.70. Their growth indicates rich heliothermic resources, which ensures the possibility of ripening grapes for late varieties. During the analyzed period, this index had average values from 1.4 in the Târnave vineyard to 3.7 in Murfatlar. There is a trend of its growth in recent years.

The hydrothermal coefficient (HC) in our country, has values between 0.7 - 1.8, lower values indicate the need for irrigation, both for table varieties and for wine varieties. In the areas studied, it had values between 0.8 (Murfatlar) and 1.3 (Iasi and Târnave).

The vine bioclimatic index (Ibcv) in the vineyards of our country shows a pronounced variation from 4.0 in the vineyards in the north of the country to the value of 15.0 in the south. Small values (4-6) mean low heliothermic resources, on the background of higher water resources and vice versa. In the analyzed period, this index had an medium value of 6.8 in the Târnave vineyard and 13.4 in Murfatlar, intermediate values were recorded in the other areas.

The oenoclimate aptitude index (IAOe), in our country it has values

between 3700 and 5200. In the studied vineyards, this index varied between 4481.8, in Iasi, an area with medium favorability for the production of red wines, and 5192.8 in the Murfatlar vineyard, a very favorable area for the production of red wines, but which can be exploited, especially for the cultivation of varieties for table grapes. *The Huglin heliothermal index*, for the viticultural areas analyzed, it had an average value of 1861.0 in the Dealu Mare vineyard, belong to the "temperate climate class" and the value of 3209.9 in the Murfatlar vineyard belong to the "very hot climate class". In the other areas, intermediate values which have been recorded place them in the "warm temperate climate zone" (Iasi, Dealu Bujorului) and "warm climate" (Târnave, Odobeşti). *Night cooling index (IN)*, it had values between 9.0 in Odobeşti, "climate with very cold nights" and 12.8 in Murfatlar, "climate with cold nights".

In order to evaluate the ecological favorability of the studied vineyards, the most important restrictive ecological factors for grapevine culture were taken into account: the average annual temperature, the average temperature in July, the useful heat balance, the actual insolation, the amount of precipitation during the period of vegetation, duration of the bioactive period, real heliothermic indices, viticultural bioclimatic indices and oenoclimatic aptitude indices (tab. 2).

Table 2

Favorability classes and credit scores for the representative ecoclimatic factors in the wine growing areas studied (Irimia and Rotaru, 2009)

Climatic elements analyzed	Iaşi	Dealu Mare	Târnave	Dealu Bujorului	Murfatlar	Odobeşti
Average annual temperatureT°C	I/10	I/10	I/10	I/10	I/10	I/10
Average temperature in July, °C	I/10	I/10	I/10	I/10	I/10	I/10
Useful heat balance, (Σt°u)	I/10	I/10	I/10	I/10	I/10	I/10
Σ hours of insolation during the vegetation period, hours	II/8	II/8	III/5	III/5	I/10	I/10
Σ of precipitation during the vegetation period, mm	I/10	III/5	III/5	I/10	I/10	III/5
Duration bioactive period, no. days	III/5	II/8	III/5	II/8	II/8	II/8
The real heliothermal index (IHr)	II/8	I/10	III/5	I/10	I/10	I/10
The vine bioclimatic index (Ibcv)	II/8	I/10	II/8	I/10	I/10	II/8
The oenoclimate aptitude index (IAOe)	II/8	I/10	II/8	I/10	I/10	I/10

Thus, all the vineyards were classified in favorability class I for the thermal factor (average annual temperature, average temperature in July, useful heat balance), which shows us an abundance of these resources, with the possibility of obtaining white and red quality wines.

According to the amount of precipitation during the vegetation period, the areas were classified in the first class of favorability with moderate values (250 - 390 mm), in Murfatlar, Dealu Bujorului and Iași, in the third class of favorability, with values higher than 390 mm in the other vineyards (Dealu Mare, Târnave and Odobeşti). According to the sum of the hours of real insolation, the vineyards were classified in favorability class I (Murfatlar and Odobeşti), favorability class II (Iasi, Dealu Mare) and favorability class III (Târnave and Dealu Bujorului).

Regarding the duration of the bioactive period, its average values place the studied vineyards in favorability classes II and III. The values of the synthetic climate indicators (IHr, Ibcv, IAOe) placed the vineyards in favorability class I for Murfatlar, Dealu Mare, Dealu Bujorului and partially Odobeşti, and in favorability class II the vineyards of Iasi and Târnave.

CONCLUSIONS

The evolution of climatic factors from the viticultural ecosystems analyzed, determined by global warming by increasing the average annual temperature, decreasing the precipitation regime, increasing the frequency of dry years, phenomens that especially characterized the last two decades, have determined significant changes in the coefficients and multiannual bioclimatic indices, as follows:

- the increase in the values of the real heliothermal index (IHr), which ensures the ripening of the grapes even in late varieties;
- the decrease in the values of the hydrothermal coefficient (CH), in all areas, as a result of the registration of smaller and smaller amounts of precipitation during the growing season, which substantiates the need to irrigate the varieties for the table but even the moderate irrigation of the varieties for the wine;
- the increase in the values of the vine bioclimatic index (Ibcv), which indicates increased heliothermic resources against the background of lower water resources during the growing season;
- the increase in the values of the oenoclimatic aptitude index (IAOe), which indicates favorable conditions for the production of white and red wines, in all the studied areas.

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