THE EVOLUTION OVER TIME OF THE DEVELOPMENT OF VEGETATION PHENOPHASES OF THE VINE VARIETIES CULTIVATED IN THE COPOU IAŞI WINE CENTER IN THE CONTEXT OF CLIMATE CHANGE

EVOLUȚIA ÎN TIMP A DESFĂŞURĂRII FENOFAZELOR DE VEGETAȚIE A SOIURILOR DE VIȚA DE VIE CULTIVATE ÎN CENTRUL VITICOL COPOU IAŞI, ÎN CONTEXTUL SCHIMBĂRILOR CLIMATICE

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Abstract. *In the last 20 years there has been a tendency of change in the evolution of climatic factors, which makes it increasingly difficult to accurately predict the timing of vegetation phenophases in vines. Their dynamic analysis, in close correlation with the evolution of climatic factors specific to Iasi vineyard, from 2000 to 2019, showed that they were conditioned by the level and action of climatic factors and the hereditary specificity of cultivated varieties. The increase of temperature values (average annual temperature, average temperature in the first and second decades of June, average temperature in July, etc.), determined the advance of the onset of phenophases and shortened their duration, especially in dry years.*
Key words: climate change, phenology, grapevine

Rezumat. *În ultimii 20 de ani s-a constatat o tendință de modificare în evoluția factorilor climatici, ceea ce face tot mai dificilă prognozarea exactă a momentului declanşării fenofazelor de vegetație la vița de vie. Analiza în dinamică a acestora, în strânsă corelație cu evoluția factorilor climatici specifici podgoriei Iaşi, din perioada 2000 – 2019, a evidențiat faptul că acestea au fost condiționate atât de nivelul şi acțiunea factorilor climatici cât şi de specificul ereditar al soiurilor cultivate. Creşterea valorilor temperaturilor (temperatura medie anuală, temperatura medie din decadele I şi II ale lunii iunie, temperatura medie din luna iulie, etc.), a determinat devansarea momentului declanşării fenofazelor şi scurtarea duratei de derulare a acestora, cu precădere în anii secetoşi.*
Cuvinte cheie: schimbări climatice, fenologie, viță de vie

INTRODUCTION

Climate change, which is currently occurring globally, experts say will become more pronounced in the coming decades and will obviously influence the biology of horticultural species, especially vines. Thus, there will be important changes in the zoning of vine and rootstock varieties (Condei *et al.,* 2017). The

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long-term study of the dynamics of vegetation phenophases in close correlation with environmental conditions is one of the best ways to quantify climate change (Jones *et al.*, 2010; Tomasi *et al.*, 2011; Biasi *et a*l., 2019). The researches carried out in our country have highlighted changes regarding the development and duration of the main vegetation phenophases, the quality of grape production and implicitly the physico-chemical and organoleptic characteristics of the obtained wines (Dobrei *et al*, 2015; Irimia *et al.*, 2017; Nistor *et al*., 2019).

MATERIAL AND METHOD

In order to study the impact of climate change on the viticultural ecosystem of Iaşi vineyard - Copou viticultural center, the climatic data from 2000 - 2019 were analyzed in correlation with the development of vegetation phenophases (budding, flowering, entering in ripening and grape maturation) in mainly cultivated varieties: Aligote , Fetească albă, Fetească regală, Muscat Ottonel, Chardonnay, Sauvignon blanc, Cabernet Savignon, Arcaş, Chasselas dore.

RESULTS AND DISCUSSIONS

Climate change produced globally has determined certain trends in our country as well. Temperature is the climatic factor that determines the area of spread of the vine culture, the onset and passage of vegetation phenophases, the establishment of the crop system, the quantity and quality of production. In recent years, there has been an increase in its temperature values throughout the country. Thus, for the vineyards located at the northern limit of vine cultivation, such as the Iaşi vineyard, the average annual temperature registered, in certain years, values of over 11°C, which determines the displacement of the favorable area for vine cultivation. to the north of the country, increasing the suitability for red varieties and obtaining quality wines.

The climate analysis of the last 20 years indicates an a*verage annual temperature* of 10.5°C, with a maximum value of 11.6°C in 2019 and a minimum of 9.5°C in 2001, a significant warming recording especially in the winter and summer seasons (tab. 1). *The average temperature in the first and second decades of June*, an important factor in the onset, intensity and duration of flowering, recorded an average value of 20.1°C, with a minimum of 16.9°C in 2006 and a maximum of 22,8°C in 2007. *The average temperature in the warmest month (July)*, which is a criterion for assessing the conditions for increasing the quality of grapes, was, on average, 22.3°C, with an increasing trend in recent years reaching a maximum value of 25.4°C in 2012. As this indicator increases, higher concentrations in sugars, flavors, color, phenolic substances, etc. can be obtained.

Another vegetation factor that influences the growth and development of vines is humidity. Excess precipitation has a negative influence on the flowering phenophase, when the phenomenon of millet and beading occurs frequently, the percentage of tied flowers decreases, and in the leek phenophase it leads to grain cracking. In periods of poor rainfall, the growth of shoots is slowed, the grains

remain small and withered, and yields are diminished quantitatively and qualitatively. In recent years there has been a reduction in the volume of rainfall, especially during the growing season and a very uneven distribution. During the study period, the smallest amount was 180.6 mm in 2015 and the highest was 533.2 mm in 2001.

Table 1

Values of climatic elements with direct influence on vine phenology from the period 2000 - 2019

Climatic elements analyzed	Iasi vineyard		
	Media	**Min.**	**Max.**
Global heat balance, (Σt°g)	**3321.7**	3099.9	3652.8
Active heat balance, Σt°a)	**3222.2**	2984.1	3596.3
Useful thermal balance, (Σt°u)	**1523.8**	1298.4	1856.3
Average temperature in I and II decades of June	**20.1**	16.9	22.8
The average temperature in July, °C	**22.3**	20.5	25.4
The average temperature in August, °C	**21.7**	19.8	23.5
The average temperature in September, °C	**16.3**	14.2	18.9
Average annual temperature T°C	**10.5**	9.5	11.6
Average maximum temperatures in August,°C	**28.2**	25	31.1
Number of days with temp. maximum > 30°C	**33.4**	9	60
Σ annual rainfall, mm	**572.1**	365.5	748
Σ precipitation during the growing season, mm	**363.9**	**180.6**	533.2
Σ hours of insolation in the vegetation, hours	**1482.1**	1336.7	1603.2
Duration of the bioactive period, number of days	**175.2**	165	189
The real heliothermal index (RHI)	**2.3**	1.8	2.8
Hydrothermal coefficient (HC)	**1.1**	0.5	1.8
Bioclimatic index (Ibcv)	**8.3**	4.5	16.3
Oenoclimatic aptitude index (OAI)	**4592.7**	4107.8	5058.2
Huglin heliothermal index (HI)	**2181.1**	1900.4	2541
Night cooling index (NC)	**11.5**	10.1	13.9

The values of the synthetic indicators from the Copou-Iass wine center indicate a favorable area for the cultivation of vines, balanced, with very good favorability for the cultivation of varieties for quality white and red wines.

The observations made between 2000 and 2019, regarding the evolution of the vegetation phenophases traversed by the main varieties in the assortment, in direct relation with climatic factors, highlight the fact that they were conditioned by the level and action of climatic factors and hereditary specificities of varieties.

For the varieties from the Iasi vineyard assortment (Aligoté, Fetească albă, Fetească regală, Sauvignon blanc, Chardonnay, Muscat Ottonel, Cabernet Sauvignon and Chasselas doré), **the budding** occurred in the last decade of April or in the first decade of May. It took place at the earliest on April 10, 2016 at the Fetească alba variety and at the latest at Cabernet Sauvignon on May 7, 2011 (tab. 2).

The useful thermal balance that conditioned the budding phenophase was variable from one year to another, with values, on average, of 32.1°C for the early varieties and up to 56.5°C for the late ones.

Table 2

The evolution of the development of budding and flowering phenophases

Year	Budding				Flowering			
	White varieties		Red varieties		White varieties		Red varieties	
	Date	Σ t° useful	Date	Σ t° useful	Date	Σ t° useful	Date	Σ t° useful
2000	17-Apr	47.4	20-Apr	73.3	27-May	279.9	30-May	292.3
2001	21-Apr	25.4	26-Apr	34.0	9-Jun	230.0	17-Jun	295.4
2002	24-Apr	32.1	30-Apr	50.8	2-Jun	282.9	9-Jun	300.6
2003	29-Apr	30.9	4-May	74.9	3-Jun	374.7	9-Jun	397.6
2004	23-Apr	26.8	27-Apr	35.8	10-Jun	263.0	16-Jun	318.8
2005	23-Apr	30.3	28-Apr	39.0	15-Jun	304.8	19-Jun	338.8
2006	25-Apr	39.9	29-Apr	50.3	13-Jun	249.5	18-Jun	280.9
2007	12-Apr	18.4	28-Apr	30.3	2-Jun	330.3	5-Jun	345.0
2008	14-Apr	25.5	22-Apr	45.6	7-Jun	253.3	12-Jun	286.4
2009	21-Apr	40.8	25-Apr	41.1	2-Jun	242.7	7-Jun	287.5
2010	25-Apr	19.5	30-Apr	33.2	6-Jun	278.9	11-Jun	335.2
2011	28-Apr	34.5	7-May	53.9	5-Jun	270.6	8-Jun	290.4
2012	25-Apr	63.2	2-May	147.9	25-May	257.6	6-Jun	269.0
2013	22-Apr	23.9	27-Apr	68.2	21-May	283.4	30-May	295.7
2014	20-Apr	18.6	27-Apr	47.2	4-Jun	248.9	8-Jun	261.5
2015	21-Apr	27.7	27-Apr	55.4	3-Jun	299.5	9-Jun	344.5
2016	**10-Apr**	42.9	17-Apr	74.1	2-Jun	255.4	7-Jun	260.8
2017	12-Apr	19.0	27-Apr	31.7	2-Jun	250.8	7-Jun	298.3
2018	14-Apr	60.1	21-Apr	95.5	21-May	267.4	26-May	289.6
2019	22-Apr	15.0	29-Apr	48.7	7-Jun	292.2	11-Jun	308.6
X	-	32.1	-	56.5	-	275.8	-	304.8

In recent years, as a result of the increase in air temperature values, there is a tendency to delay the moment of budding and a shortening of the period of its development. Thus, in the dry years, implicitly in those with milder winters, the budding took place in the first and second decade of April (2000, 2007, 2008, 2016, 2017, 2018).

In order for **the flowering** to start, the vine varieties need a certain amount of heat, the minimum level at which the flowers open is 15°C, and the optimum is 25...26°C. High temperatures, above 30°C, around the flowering period, determine the development of this phenophase in an accelerated rhythm, over a short period of time, considerably reducing the gap between varieties (varieties bloom simultaneously). Lower temperatures stagger flowering over a longer period of time, extending the duration of the phenophase.

The multiannual phenological observations performed on the varieties in the assortment attest that the beginning of flowering took place at the earliest at the end of May in the years: 2000, 2012, 2013 and 2018, and in the other years in the first and second decade of June (tab. 2). It was noted that within the same variety, flowering can last between 6 and 12 days, the sum of the useful temperatures required to start flowering being, on average, 275.8°C for white varieties and 304.8°C for red varieties. In the case of this phenophase, too, there is a tendency to overtake due to the increasing values of air temperatures and a shortening of its development period. Regarding the analyzed varieties, Feteasca

alba blossomed the earliest on May 21, 2018, followed by Feteasca regală and Aligoté varieties, and the latest was June 18, 2006, when all varieties bloomed almost simultaneously.

The verraison is the beginning of the ripening of the grapes and is a process that appears suddenly, marked by the accumulation of sugars in the grains, the epicarp changes color, the grain becomes transparent and begins to soften. In the Copou Iasi wine center, the verraison between 2000 and 2019 occurred between July 20 (2013) and August 10 (2005) and lasted between 5 and 19 days depending on the variety and year. In the dry years, the ripening started faster, respectively in the last decade of July (2003, 2004, 2007, 2009, 2010, 2012, 2013, 2017 and 2018) and occurred in a shorter time, and in the rainy years (2001, 2005) in the second decade of August (tab. 3). The useful thermal balance that conditioned the lever phenophase had average values between 661.1°C and 733.5 ° C.

Table 3

The evolution of the development of leech and maturation phenophases

Year	Verraison				Ripening			
	White varieties		Red varieties		White varieties		Red varieties	
	Date	Σ t° useful	Date	Σ t° useful	Date	Σ t° useful	Date	Σ t° useful
2000	5-Aug	744.1	16-Aug	853.3	17-Sep	433.5	25-Sep	304.2
2001	6-Aug	627.7	24-Aug	778.9	17-Sep	386.6	25-Sep	224.3
2002	1-Aug	697.8	5-Aug	713.1	10-Sep	388.7	28-Sep	400.9
2003	27-Jul	608.5	10-Aug	681.9	14-Sep	455.8	23-Sep	368.6
2004	28-Jul	519.0	6-Aug	551.2	20-Sep	450.5	6-Oct	410.9
2005	10-Aug	618.4	28-Aug	753.6	10-Sep	289.3	30-Sep	232.0
2006	5-Aug	628.1	15-Aug	694.6	20-Sep	403.5	3-Oct	372.3
2007	23-iul	708.9	29-iul	767.0	3-Sep	512.7	16-Sep	484.6
2008	2-Aug	611.7	8-Aug	628.7	15-Sep	458.7	10-Oct	437.5
2009	29-Jul	691.2	5-Aug	740.9	9-Sep	446.9	30-Sep	506.9
2010	25-Jul	589.7	1-Aug	608.9	9-Sep	523.6	16-Sep	477.0
2011	2-Aug	631.7	8-Aug	659.7	20-Sep	497.1	26-Sep	467.1
2012	23-Jul	752.3	1-Aug	804.8	2-Sep	546.7	10-Sep	473.7
2013	20-iul	564.7	31-iul	631.5	10-Sep	528.7	17-Sep	446.1
2014	3-Aug	633.3	12-Aug	718.5	22-Sep	513.3	30-Sep	399.5
2015	4-Aug	768.4	14-Aug	862.3	12-Sep	483.5	23-Sep	426.1
2016	5-Aug	792.1	15-Aug	862.1	10-Sep	419.1	27-Sep	426.5
2017	31-Jul	686.2	12-Aug	816.4	11-Sep	500.5	29-Sep	420.5
2018	21-Jul	665.2	6-Aug	806.8	13-Sep	628.3	3-Oct	530.7
2019	2-Aug	683.3	11-Aug	734.9	13-Sep	500.5	4-Oct	508.5
	-	661,1	-	733,5	-	468,4	-	415,9

Due to the high values of air temperatures, the large number of days with maximum temperatures higher than 30°C in July and August (eg 60 days in 2007) and the water deficit in the soil, there was an obvious tendency to overtake ripening phenophase.

The full maturity of the grapes evolves depending on the variety and climatic conditions. The varieties from the Iasi vineyard assortment, during the analyzed period, reached full maturity at the earliest in the first decade of

September, and at the latest in the first decade of October. The useful thermal balance that conditioned the maturation phenophase had average values between 415.9°C and 468.4°C. This phenophase took place over 3-5 weeks.

CONCLUSIONS

The climate analysis of the last 20 years indicates an increase in the average annual temperature of up to 10.5°C, with a maximum value of 11.6°C in 2019 and a minimum of 9.5°C in 2001, compared to 9.8°C normal value, a significant warming being registered, especially in the winter and summer seasons.

The multiannual phenological observations made on the varieties in the assortment show that, in the dry years, implicitly in those with milder winters, the budding took place in the first and second decade of April, the flowering took place at the earliest at the end of May, and in other years in the first and second decades of June. The verraison also began in the last decade of July, and ripening at its earliest in the first decade of September and by the first decade of October.

The creation and permanent updating of climate and phenological databases is an important step in optimizing the zoning of the vine, as well as a starting point in issuing possible scenarios in the context of climate change.

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REFERENCES

1. **Biasi R., Brunori E., Ferrara C., Salvati L., 2019** - *Assessing Impacts of Climate Change on Phenology and Quality Traits of Vitis vinifera L.: The Contribution of Local Knowledge*. Plants no.8, 121.
2. **Condei Ghe., Serdinescu A., Pîrcălabu L, Ciolacu M., Toti M., 2017** – *Terroir-ul viticol- de la concept la implementare*. Editura Ceres, 127 **p**
3. **Dobrei A.G., Dobrei A., Nistor, E., Sala F., Mălăescu M., Drăgunescu A., Camen D., 2015** - *Research concerning the qualitative potential of the wines obtained from different grape-growing ecosystems*. J. Hort. Forest. Biotech. 19, 103- 107.
4. **Irimia L.M., Patriche C.V., Roşca B., Cotea V., 2017** - *Modifications in climate suitability for wine production of Romanian wine regions as a result of climate chan*ge. 40th World Vine and Wine Congress, June 2017, Sofia, Bulgaria. pp. 32-33.
5. **Jones G. V., Webb L. B., 2010** - *Climate Change, Viticulture, and Wine: Challenges and Opportunities',* Journal of Wine Research, 21: 2, pp: 103 — 106.
6. **Nistor E., Dobrei A.G., Dobrei A., Camen D., 2019 -** *Growing Season Climate Variability and its Influence on Sauvignon Blanc and Pinot Gris Berries and Wine Quality: Study Case in Romania (2005-2015)*. S. Afr. J. Enol. Vitic., Vol. 39, No. 2, pp 196- 207
7. **Tomasi D., Jones G.V., Giust M., Lovat L., Gaiotti,F., 2011** - *Grapevine phenology and climate change: relationships and trendsin the Veneto Region of Italy for 1964–2009*. American Journal of Enology and Viticulture 62, 329–339