THE PHENOLOGICAL SPECTRUM OF SOME VINE VARIETIES CULTIVATED IN ODOBEŞTI VINEYARD IN THE CONTEXT OF CLIMATE CHANGE

SPECTRUL FENOLOGIC A UNOR SOIURI DE VIŢĂ-DE-VIE CULTIVATE ÎN PODGORIA ODOBEŞTI ÎN CONTEXTUL SCHIMBĂRILOR CLIMATICE

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Abstract. *In the last 20 years there has been a tendency to change in evolution 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 Odobeşti vineyard, from 2000 to 2019, highlighted the fact that they were conditioned both by the level and action of climatic factors and by the hereditary specifics 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, vineyard.

Rezumat. *În ultimii 20 de ani s-a constatat o tendinţă de modificare în evoluţia factorilor climatici, ceea ce face tot mai dificilă prognozarea exactă a momentului declanşării fenofazelor de vegetaţie la viţa-de-vie. Analiza în dinamică a acestora, în strânsă corelaţie cu evoluţia factorilor climatici specifici podgoriei Odobeşti, din perioada 2000 – 2019, a evidenţiat faptul că acestea au fost condiţionate atât de nivelul şi acţiunea 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, viţă-de-vie, podgorie.

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 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

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(Jones *et al.*, 2010; Tomasi *et al.*, 2011; Biasi *et al.*, 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 Odobeşti vineyard, the climatic data from 2000 - 2019 were analyzed in correlation with the development of vegetation phenophases (budburst, flowering, veraison and full maturity) for the main cultivated varieties: Galbenă de Odobeşti, Şarba, Băbească gri, Fetească albă, Fetească regală, Frâncuşă, Fetească neagră.

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 thermal values throughout the country. Thus, in the Odobeşti vineyard, located in the south of Moldova, a vineyard with a vocation for white varieties, the average annual temperature registered, in certain years, values of over 13.0°C, which indicates an increase in the degree of favorability for cultivating red varieties and obtaining quality wines.

The climate analysis of the last 20 years indicates an *average annual temperature* of 11.7°C, with a maximum value of 13.1°C in 2015 and a minimum of 10.5°C in 2003, a significant record of warming, 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 21.0°C, with a minimum of 17.6°C in 2006 and a maximum of 23.7°C in 2018. *The average temperature in the warmest month (July)*, which is a criterion for assessing the conditions for growing grape quality, was on average 23.3°C, with an upward trend in recent years reaching a maximum of 26.4°C in 2012. As this indicator increases, higher concentrations of sugars, flavors, color, phenolic substances, etc. can be obtained.

Another vegetation factor that influences the growth and development of vines is humidity. Excess rainfall has a negative influence on the flowering phenophase, when the phenomenon of honeycomb and beading occurs frequently, the percentage of tied flowers decreases, and in the veraison phenophase it leads to the cracking of the berries. During periods of low rainfall, the growth of shoots is slowed down, the grains remain small and withered, and yields are diminished both quantitatively and qualitatively. Although in the last 20 years have not seen a reduction in the volume of rainfall compared to the multiannual average, there has been an uneven distribution of them, especially during the growing season.

During the study period, the smallest amount of precipitation during the vegetation period was 187.0 mm in 2009 and the highest was 693.4 mm in 2016, the average of the period being 414.4 mm.

Table 1

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

Climatic elements analyzed	Odobeşti vineyard		
	Average	Min.	Max.
Global heat balance, (t°g)	**3683.3**	3379.2	4215.0
Active heat balance, (t°a)	**3461.0**	3142.1	3749.3
Useful thermal balance, (t°u)	**1740.6**	1401.1	1993.1
Average temperature in I and II decades of June	**21.0**	17.6	23.7
The average temperature in July, °C	**23.3**	21.5	26.4
The average temperature in August, °C	**23.2**	20.8	24.7
The average temperature in September, °C	**18.1**	15.3	21.1
Average annual temperature T°C	**11.7**	10.5	13.1
Average maximum temperatures in August,°C	**29.8**	26.1	31.9
Number of days with temp. maximum > 30°C	**42.9**	14	72
Σannual rainfall, mm	**645.8**	409.7	1049.0
Σprecipitation during the growing season, mm	**414.4**	187.0	693.4
Σhours of insolation in the vegetation, hours	**1595.7**	1368.0	1782.6
Duration of the bioactive period, number of days	**187.3**	169	209
The real heliothermal index (RHI)	**2.8**	2.1	3.5
Hydrothermal coefficient (HC)	**1.2**	0.5	2.0
Bioclimatic index (Ibcv)	**8.0**	3.8	16.4
Oenoclimatic aptitude index (OAI)	**4892.2**	4163.0	5471.3
Huglin heliothermal index (HI)	**2277.7**	1882.1	2597.5
Night cooling index (NC)	**12.9**	11.0	15.1

The values of the synthetic indicators from the Odobeşti vineyard indicate an area with high potential for the cultivation of vines, balanced, with a 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 vegetation phenophases to 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 vine varieties from Odobeşti vineyard (Galbenă de Odobeşti, Şarba, Fetească albă, Fetească regală, Băbească gri, Frâncuşă and Fetească neagră), **the budburst** took place most frequently in the second and third decade of April. The earliest took place on April 5, 2016 at the Fetească albă variety and at the latest at Fetească neagră on April 30, 2011 and 2019 (tab. 2).

The useful thermal balance that conditioned the onset of the budding phenophase was variable from one year to another, with values on average of 42.3°C for early varieties and up to 52.4°C for late ones.

As a result of the increase of the air temperature values, in the last years, there is a tendency to advance the moment of budding and a shortening of the period of its development. Thus, in dry years, implicitly for those with milder

winters, budburst took place in the first decade of April (2000, 2002, 2003, 2008, 2009, 2016, 2017).

Table 2

The evolution of the development of budburst and flowering phenophases

Year	Budburst				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	9-Apr	33.5	12-Apr	33.5	1-Jun	362.5	3-Jun	378.1
2001	15-Apr	54.7	20-Apr	56.0	23-May	188.8	29-May	229.2
2002	7-Apr	45.2	11-Apr	45.2	29-May	309.5	3-Jun	356.5
2003	10-Apr.	28.8	15-Apr	29.7	1-Jun	342.7	4-Jun	371.8
2004	11-Apr	50.7	20-Apr	61.0	4-Jun	238.5	9-Jun	253.3
2005	22-Apr	53.0	26-Apr	54.4	5-Jun	248.7	11-Jun	282.6
2006	17-Apr	22.9	24-Apr	37.0	5-Jun	219.0	8-Jun	230.7
2007	16-Apr	25.7	22-Apr	28.4	17-May	135.9	28-May	264.3
2008	7-Apr	30.3	11-Apr	44.3	27-May	273.8	2-Jun	310.7
2009	10-Apr	36.1	14-Apr	36.5	25-May	231.4	29-May	269.1
2010	17-Apr	35.6	20-Apr	41.0	1-Jun	254.5	5-Jun	281.4
2011	25-Apr	36.9	30-Apr	59.7	4-Jun	267.6	7-Jun	283.8
2012	18-Apr	60.5	21-Apr	66.1	20-May	244.5	25-May	284.3
2013	23-Apr	42.4	25-Apr	59.2	20-May	288.8	23-May	305.0
2014	13-Apr	62.3	19-Apr	70.0	1-Jun	292.2	6-Jun	324.0
2015	16-Apr	34.9	20-Apr	57.0	26-May	290.3	2-Jun	338.6
2016	5-Apr	45.2	8-Apr	65.5	28-May	288.3	30-May	292.3
2017	10-Apr	44.4	15-Apr	61.3	30-May	273.3	2-Jun	295.7
2018	14-Apr	58.9	17-Apr	75.3	17-May	285.7	23-May	323.6
2019	25-Apr	44.0	30-Apr	66.9	1-Jun	228.6	6-Jun	253.8
x	-	**42.3**	**-**	**52.4**	**-**	**263.2**	**-**	**296.4**

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 made on the varieties studied show that the beginning of flowering took place at the earliest in the second decade of May (2007 and 2018) and in other years this phenophase was recorded in the third decade of May, the first the decade of June (tab. 2). It was observed that within the same variety, flowering can last between 5 and 10 days, the sum of the useful temperatures required to start flowering being, on average, 263.2°C for white varieties and 296.4°C for red varieties. And in the case of this phenophase there is a tendency to exceed due to increasing values of air temperature and shortening its development period. Regarding the analyzed varieties, Fetească albă bloomed the earliest on May 17, 2007 and 2018, followed by the varieties

Fetească regală and Şarba, and the latest was June 8, 2006, when all varieties bloomed almost simultaneously.

The veraison 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 Odobeşti vineyard, the veraison between 2000 and 2019 occurred between July 17 (2007) and August 15 (2003) and lasted between 5 and 17 days depending on the variety and year. In the dry years, the ripening started faster, respectively in the last decade of July (2001, 2007, 2008, 2009, 2010, 2012, 2013, 2014, 2015, 2016, 2018 and 2019) 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 757.3°C and 866.3° C.

Table 3

The evolution of the development of veraison and maturation phenophases

Year	Veraison				Full 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	14-Aug	877.1	19-Aug	956.1	15-Sep	357.8	25-Sep	337.2
2001	25-Jul	697.6	1-Aug	760.8	17-Sep	673.8	20-Sep	599.8
2002	8-Aug	902.0	12-Aug	900.0	19-Sep	423.4	23-Sep	408.5
2003	15-Aug	892.1	19-Aug	916.8	18-Sep	332.5	23-Sep	321.4
2004	4-Aug	653.0	10-Aug	675.8	10-Sep	374.3	20-Sep	367.3
2005	9-Aug	705.4	14-Aug	720.0	12-Sep	341.9	18-Sep	356.4
2006	12-Aug	781.6	15-Aug	799.4	20-Sep	382.8	2-Oct	439.2
2007	17-Jul	782.2	30-Jul	889.5	15-Sep	781.5	20-Sep	585.2
2008	30-Jul	733.2	6-Aug	769.0	17-Sep	603.1	25-Sep	560.9
2009	27-Jul	742.5	10-Aug	893.9	17-Sep	624.9	27-Sep	519.8
2010	30-Jul	708.5	14-Aug	916.1	18-Sep	598.6	28-Sep	425.2
2011	1-Aug	682.7	16-Aug	814.9	15-Sep	532.0	30-Sep	497.6
2012	23-Jul	822.7	2-Aug	952.1	24-Aug	490.4	15-Sep	560.9
2013	20-Jul	683.2	3-Aug	850.9	9-Sep	656.9	18-Sep	528.6
2014	29-Jul	706.9	13-Aug	909.3	11-Sep	607.5	25-Sep	494.5
2015	21-Jul	712.5	13-Aug	1023.6	10-Sep	745.0	20-Sep	461.9
2016	26-Jul	785.1	4-Aug	904.7	1-Sep	509.1	12-Sep	507.0
2017	1-Aug	820.3	12-Aug	963.8	2-Sep	441.6	14-Sep	391.0
2018	20-Jul	772.0	4-Aug	908.5	22-Aug	445.1	16-Sep	551.2
2019	26-Jul	684.7	8-Aug	800.8	26-Aug	428.0	16-Sep	525.7
x	**-**	**757.3**	**-**	**866.3**	**-**	**517.5**	**-**	**472.0**

Due to the high values of air temperatures, the large number of days with maximum temperatures higher than 30°C in July and August (e.g 72 days in 2015) 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. During the analyzed period, the vine varieties from the Odobeşti vineyard assortment reached full maturity at the earliest in the last decade of August (2012, 2018 and 2019) and at the latest at the beginning of

October (2006). The useful thermal balance that conditioned the full maturation phenophase had average values between 517.5°C and 472.0°C. This phenophase occurred in 2-6 weeks.

CONCLUSIONS

1. The climate analysis over the last 20 years in the Odobeşti viticultural ecosystem indicates an increase in average annual temperature by 1.0°C to 11.7°C, with a maximum of 13.1°C in 2015 and a minimum of 10.5°C in 2003, compared to the normal value of 10.7°C, a significant warming being recorded, especially in the winter and summer seasons.

2. The multiannual phenological observations made on varieties studied show that in dry years, implicitly for those with milder winters, budburst took place in the first decade of April, flowering took place in the second decade of May at the earliest, and in other years in the third decade of May, the first decade of June. The veraison also began in the second decade of July and ripening at its earliest in the last decade of August and by the last decade of September.

3. The permanent updating of climate and phenological databases is an essential step in reconsidering the zoning of the vine, in the current context of climate change.

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